Composites Bridge Design Workshop:

Design of Fiber-Reinforced Polymer (FRP) Composites Bridges
Using AASHTO and Other Specifications

Date: December 7, 2022
Time: 8:00 a.m. to Noon Eastern

Continuing Education Credit: Attendees will receive a certificate stating that they have attended four hours of continuing educational classes.

Workshop Objectives and Who Should Attend

The objectives of this workshop are to familiarize attendees with the background and code provisions related to design of fiber-reinforced polymer (FRP) composites bridges and to provide cutting edge material and product advancements to design and specify FRP composites products that can assist attendees when building new composites bridges for ABC applications.

The workshop will be taught jointly by academics and industry professionals to deliver the material in the most practical and informative manner. The material is intended for bridge design engineers who would like to have deeper understanding of design provisions. InDesign is consistent with the latest version of AASHTO LRFD Bridge Design Specification and existing FRP design codes.

Workshop Organizer: John Busel, American Composites Manufacturers Association (ACMA)

Workshop Instructors: John Busel, Gregg Blaszak, Bill Davids, Anthony Diba, Ronald Grefhorst, Scott Reeve, Ken Sweeney, Dustin Troutman

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Fiber-reinforced polymer (FRP) composites are a proven innovative and durable material that has been used in more than 500 bridges in North America for over 25 years. Because they are lightweight and able to be prefabricated, composites are faster to install, have reduced assembly and installation time resulting in lower costs for new construction as well as retrofitting existing structures, and require minimal disruption during repairs and upgrades to bridges that are already in service.

The following are tentative topics to be included in the workshop. Complete copies of the materials to be presented at the workshop will be provided to the attendees.

1- Design of FRP Bridge Tub Girders Using AASHTO LRFD Bridge Design Specifications – 90 minutes)

Description: The objective of this section is to familiarize the attendees with the development, design, and construction of FRP Tub Girder Bridges. Best fabrication practices and available resources to assist with economical design of FRP Bridges in the context of accelerated bridge construction (ABC) technology are discussed.

a. <u>Testing & Development</u>: **Bill Davids, Ph.D., P.E., University of Maine** *(30 minutes)*
   - Motivation for girder development
   - Girder Cross-Sectional Architecture
   - Girder Flexure Testing
   - Shear Connector Development
   - Web Shear Strength
   - Field Load Test

b. <u>Design</u>: **Ken Sweeney, P.E., ENV-SP, President; Anthony Diba, Design Engineer, AIT Bridges** *(60 minutes)*
   - Deep overview of an FRP tub girder design (Westerly, RI Bridge)
     - FRP Materials used
       - Material Properties
       - Reduction Factors
     - Cross-Section Optimization
     - Moment Capacity Calculations
     - Shear Capacity Calculations
     - Distribution Factors & Loads Applied
     - Deflections
     - Fabrication of Girders & PBU’s
     - Construction

Learning Objectives

- Provide development, design, and construction of FRP Bridges and the latest advances in the design and construction of FRP Bridges.
- Review fabrication practices and available resources to assist with economical design of FRP Bridges in the context of accelerated bridge construction
- Provide deeper understanding of design provisions for designing FRP Tub girders

2- **Lightweight, Prefabricated Cantilever Sidewalks for Shared Use Paths on Vehicle Bridges (Scott Reeve; Dustin Troutman; Gregg Blaszak, P.E., Creative Composites Group – 60 minutes)**

Description: Cantilever sidewalks can be quickly installed on vehicle bridges to provide shared-use paths to accommodate recreational and commuter users. These sidewalks consist of lightweight, prefabricated FRP structural panels that can be quickly installed on beam supports attached to the vehicle bridge. Case study summaries will be shown for the different types of decking and attachment designs used on previous sidewalks. Design details and calculations will be explained for one of the larger sidewalks that was part of DOT vehicle bridge rehabilitation projects for the Higgins Ave. Bridge, Missoula, MT. The 14-ft-wide sidewalk totals 448 ft in length over three bridge spans. The deck attached to both I-beam stringers and the concrete superstructure. The exterior railing attached to the exterior FRP curb.

While stepping through the calculations and drawings, any items that are specific to FRP will be highlighted. This will alert drawing reviewers to FRP pertinent details to look for when using FRP decking. A secondary case study will show the use of FRP floor beams to further reduce the dead load.

The review will include:

- Requirements
- Decking and support structure layout
- Panel details and features
- Connections
- Material design property process
  - Deflection analysis
  - Strength and safety factor calculations
  - Shop drawings
  - Installation procedures

Learning Objectives

- See how lightweight FRP structures enable large sidewalk areas to be quickly installed
- Explore the design features available in FRP decking and sidewalks
- Understand the attachment methods and installation processes
- Learn the details in FRP design calculations
- Know what FRP-specific items to scrutinize when reviewing design submittals

3- **Design & Engineering Methodology for InfraCore® FRP Vehicular Bridges (Ronald Grefhorst, Design Lead, FiberCore Europe – 60 minutes)**

Description: Fiber Reinforced Polymer (FRP) bridges are gaining traction for infrastructure applications for their promise of having a high specific tensile strength and high resistance to adverse environmental influences such as (salt) water and corrosion.

However, the structure of the material and resulting anisotropic properties present specific challenges to the designer. Similar to concrete, the occurrence of damage (either from production defects or initiated in use) is a fact of life. Especially for the application in bridges, a design must be selected that is not only efficient and cost-effective, but inherently robust. It is therefore of the utmost importance that the materials and the associated failure modes are well understood. The design must fully exploit the strengths of the materials, while the less favorable properties of the materials are properly compensated for.

InfraCore® bridges are developed with precisely these principles in mind. InfraCore bridges are multibeam structures in which the potential Achilles' heel of FRP (the effects of matrix failure and damage growth) are limited and inconsequential for the performance and safety of the bridge. InfraCore incorporates the lessons learned from previous applications of FRP while still being structurally efficient. To be cost-effective and to ensure short lead times, the design and production processes are highly standardized and supported by specialized, easy to use tooling.

In over a decade, FiberCore Europe has installed more than 1,400 bridges built using the InfraCore® technology, in most European countries, and expanding worldwide. The technology has matured over these years and FRP is now a fully accepted material in many countries, alongside traditional materials such as steel and concrete. There are guidelines in place for the application and in Europe, the development of a new Eurocode part is underway.

This section focuses on the materials, their functioning in relation to the application of bridge building, what design aspects must be taken into account and how InfraCore® technology is a natural way to overcome the issues commonly associated with the application of FRP in the field of bridge building. Furthermore, design for the serviceability and ultimate limit states will be discussed in relation to the behavior of the materials and structure. An LRFD approach will be taken to illustrate the principles presented for a design case of a segmented, rural road bridge. Experiences from testing and results from advanced simulations (FEA) underpinning the design will be presented, as well as the tools utilized in the design process.

Learning Objectives

- Understanding of InfraCore® FRP technology and behavior under vehicle loads
- Explanation of design and analysis tools
- Understanding of actual case study design application

4- **Overview of FRP Bridge Application Case Histories (John Busel, FACI – 30 minutes)**