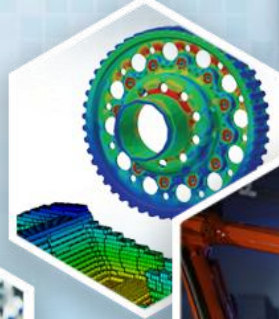


Infrastructure & Construction (I&C) Working Group Overview

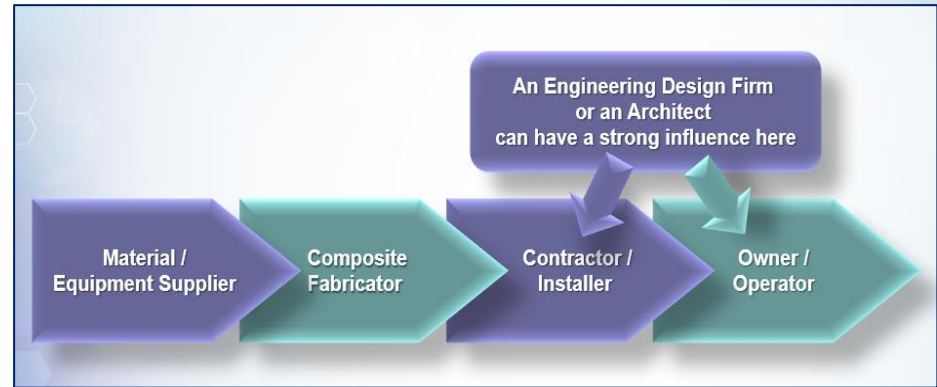
Joe Fox, FX Consulting LLC
John Unser, Composite Applications Group
June 29, 2022



History of the I&C Working Group



- ◆ The I&C working group was formed in October 2020
 - ◆ Infrastructure became a new focus area for IACMI
- ◆ The working group has members representing the entire value chain for I&C
 - ◆ 86 people have opted in
 - ◆ Need more downstream members



- ◆ The working group has held 8 meetings to date

Some Key Activities that Will Be Covered Today



- ◆ Collecting & disseminating Information about Infrastructure legislation & opportunities
- ◆ Putting together an I&C strategy for IACMI
- ◆ Creating & funding R&D projects for I&C
- ◆ Increasing awareness of FRP composites in the I&C community

Infrastructure is a Hot Topic!



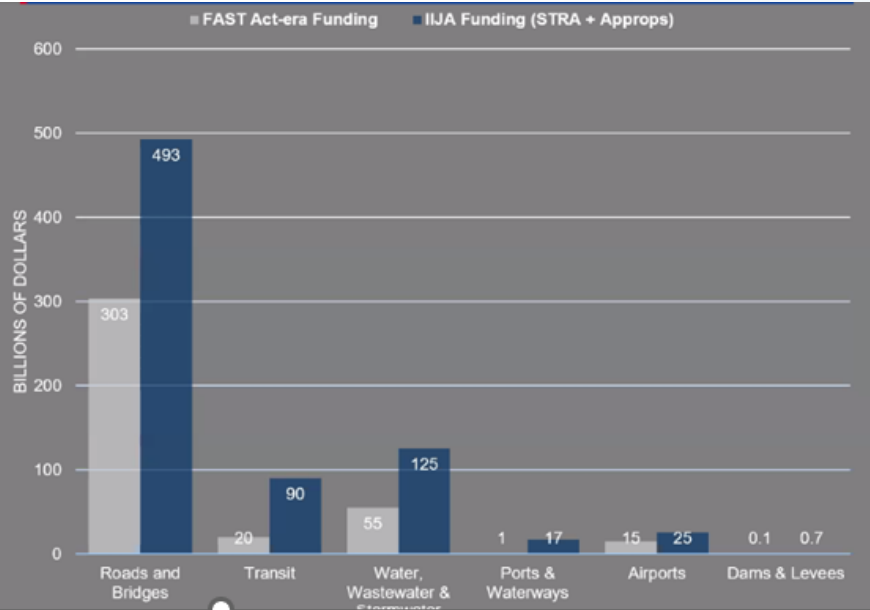
- The Infrastructure Investment & Jobs Act (IIJA) passed in November
 - aka “The Infrastructure Bill”

\$1.2 trillion

5 years

Invests in all 17 Report Card categories

The largest investment in the resilience of physical and natural systems in American history.

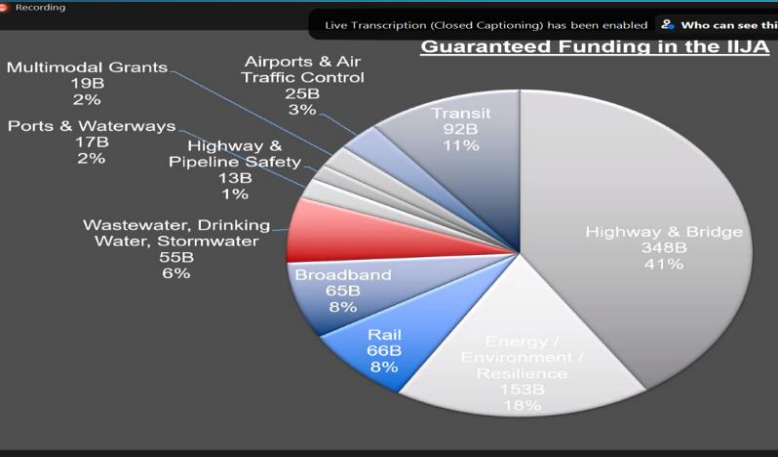


Collecting & Disseminating About the Infrastructure Bill



- ◆ What's in the Infrastructure bill that passed?
 - ◆ How and where is the \$ going to be spent?
- ◆ What funding opportunities exist for Infrastructure-related R&D?
 - ◆ For IACMI and for its members
- ◆ The American Society of Civil Engineers (ASCE) has been an extremely useful source of information

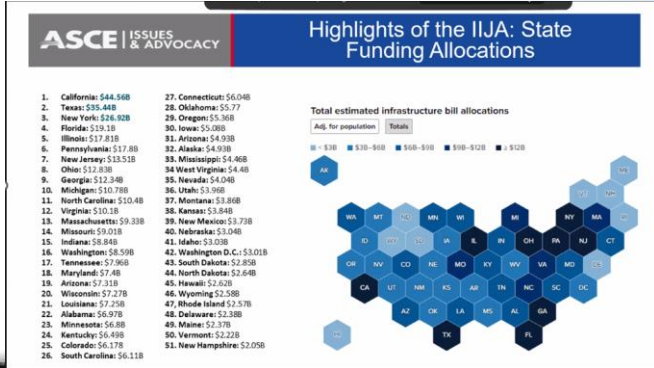
Collecting & Disseminating About the Infrastructure Bill



Highlights of the IIJA Roads, Bridges & Water

- ☑ A five-year, \$383.4 billion reauthorization of core federal highway and bridge programs.
This represents a 34% increase from FAST Act funding levels.
- ☑ New programs to address significant bridge repair, rehabilitation, and replacement
- ☑ A pilot to test a national vehicle miles travelled tax
- ☑ Increase in multimodal freight funding
- ☑ The largest investment in clean water infrastructure in our history, including removal of lead pipes in communities across the U.S.

New Proposed Infrastructure Funding	ASCE Report Card Category
\$110 Billion for Roads, Bridges, Major Projects	Bridges, Roads
\$11 Billion for Pipeline Modernization, Trucking Safety, and Traffic Safety	Energy, Roads
\$39 Billion for Public Transit Repair	Transit
\$66 Billion for Passenger and Freight Rail Repair and Expansion	Rail, Transit
\$7.5 Billion for Electric Vehicle Charging Infrastructure	Roads, Energy
\$7.5 Billion for Low Carbon and Electric Buses and Ferries	Transit, Ports
\$17 Billion for Port Infrastructure	Ports, Inland Waterways
\$25 Billion for Airport Maintenance and Resilience	Aviation
\$50 Billion for Cyber Resiliency, Wildfire Management, Flood Mitigation, Coastal Resiliency, Weatherization, and Ecosystem Restoration	Broadband, Dams, Energy, Levees, Stormwater
\$55 Billion for Water Infrastructure	Drinking Water, Stormwater, Wastewater
\$65 Billion to Bridge the Digital Divide	Broadband
\$21 Billion in Environmental Remediation	Hazardous Waste
\$73 Billion for Nation's Power Infrastructure	Energy



How Will the Money be Spent?



**\$ for Construction projects
to repair existing infrastructure**

Bridge Repair

Removal of lead pipes

Grid hardening

Ports

Dams

EV Charging Stations

**Hundreds of billions of \$
\$ for all 17 categories of the ASCE Report Card**

Funding for R&D

**Grant programs for
innovative technologies**

Applied R&D

Demonstration programs

Centers of Excellence

Tens of billions of \$

Some Key Activities that Will Be Covered Today



- ◆ Collecting & disseminating Information about Infrastructure legislation & opportunities
- ◆ Putting together an I&C strategy for IACMI
- ◆ Creating & funding R&D projects for I&C
- ◆ Increasing awareness of FRP composites in the I&C community

Mission of the I&C Working Group



- ◆ Focus on addressing **technoeconomic barriers** to mass adoption of composites in I&C applications in partnership with similarly aligned organizations
- ◆ Key barriers being addressed by the working group:
 - ◆ Cost-competitiveness / Life Cycle Costs
 - ◆ Education / Awareness
 - ◆ Lack of Codes & Specifications
 - ◆ Sustainability
 - ◆ Performance Issues

Objectives of the I&C Working Group



Spur the use of FRP composites in Infrastructure & Construction applications by reducing or removing barriers to their adoption. This will be accomplished by:

Cost

- Illustrating the life cycle cost benefits of FRP composites relative to traditional materials of construction

Education

Increasing the awareness of FRP composites in the civil engineering and construction communities

Standards & Tools

- Assisting in the creation and dissemination of new standards, specifications and modeling & simulation tools that help design engineers become more comfortable designing with composites
- Creating, managing and publicizing industry-led

Performance

- Demonstration projects that illustrate the benefits of FRP composites
- Research projects that improve the performance of FRP composites

An Important Short Term Objective



- ◆ Show how I&C fits into the strategy for DOE renewal
 - ◆ Decarbonization, reduction of emissions
 - ◆ Lower energy consumption relative to steel and concrete

- ◆ Outline the plans for I&C in IACMI 2.0
 - ◆ New materials & processes that lower energy requirements/emissions
 - ◆ Scale/validation of promising new technologies
 - ◆ Gaps that IACMI can fill

Some Key Activities that Will Be Covered Today



- ◆ Collecting & disseminating Information about Infrastructure legislation & opportunities
- ◆ Putting together an I&C strategy for IACMI
- ◆ **Creating & funding R&D projects for I&C**
- ◆ Increasing awareness of FRP composites in the I&C community

A Parallel Path Strategy



1. Identify & secure funding for I&C-related projects
 2. Develop a list of potential I&C projects
 - ◆ Research projects or
 - ◆ Demonstration projects
- ◆ Rationale: Have projects that are already well-defined once funding becomes available

Identifying & Pursuing Funding for I&C Projects



- ◆ A funding sub-committee has been formed
 - ◆ Keeping a close watch on grants.gov
- ◆ Looking for partnership opportunities
 - ◆ State DOTs
 - ◆ Universities

Center for Accelerating Innovation

Search Accelerating Innovation

FFRRA Home / OIG / Accelerating Innovation / Every Day Counts / EDC Call for Suggestions

CAI Home Every Day Counts STIC Network AID Demonstration AMR Program Resources

Every Day Counts Call for Ideas

Identify proven, market-ready and underutilized innovations for accelerated deployment in EDC in 2023-2024.

Deadline: April 11, 2022

Learn more >

UNIVERSITY TRANSPORTATION CENTERS PROGRAM

FY 2022 NOTICE OF FUNDING OPPORTUNITY

Opening Date: May 25, 2022
Requested Date for Letter of Intent: July 1, 2022
Required Application Due: August 25, 2022

Transportation Resilience and Adaptation Centers of Excellence

The bill establishes 10 regional university-led *Transportation Resilience and Adaptation Centers of Excellence*. Centers would advance R&D that improves surface transportation resilience to natural disasters and extreme weather. This includes supporting climate vulnerability assessments; R&D on new materials, data, tools; workforce development and training; and new infrastructure design, operations, and maintenance standards. Each COE would receive \$10 million annually for fiscal years (FY) 2022

R&D Projects Submitted for Consideration



- Proposals for 9 projects have been submitted so far

These projects will be described briefly



	Date Proposed	Normalized vote
Rural infrastructure	8/17/21	315
Trimer resin	8/17/21	294
Recycled wind blades	10/5/21	196
SOG applications of FRP rebar	4/27/22	190
Elium rebar	8/17/21	160
Creep of FRP rebar	10/5/21	155
Pedestrian/bike walkways for bridges	4/27/22	119
Graphene for I&C	10/5/21	14
Benefit-Cost Analysis	6/28/22	TBD

- and the first one has just been approved by the Consortium Council for launch!

Trimer Project: Fire-Resistant Resins for I&C



- Project team = Orenco + Trimer Technologies
- The team submitted an Idea Paper in April
- The Consortium Council approved the project yesterday**
- Scope:** Conduct a series of FR tests with Trimer NFUSE resin and glass/core reinforcements. Scaling to 10' x 10' assemblies.
 - E1354- Cone Calorimetry Testing (at UDRI)
 - E84- Standard Test Method for Surface Burning Characteristics of Building Materials (at SWRI)
 - E119- Standard Test Methods for Fire Tests of Building Construction Materials (at SWRI)

IACMI Idea Paper

Date: 4/1/22

Project Title: Fire Resistance (FR) Testing of Trimer Resin for Infrastructure & Construction Applications

Project Partner Lead Organization: Orenco Composites

POC Name: Andy Bridge

E-mail: abridge@orencocomposites.com

Phone: 425-218-8770

Lead IACMI Technology Area: UDRI

POC Name: Alex Morgan

E-mail: Alexander.Morgan@udri.udayton.edu

Phone: 937-229-3079

Additional Industrial Project Partners: Trimer Technologies, LLC

POC Name: Henry Sodano

E-mail: hsodano@trimerllc.com

Phone: 480-205-1202

This is the first project to receive IACMI Resource Pool funding (\$27K)

Potential Applications in I&C

- Bridges, including pedestrian bridges
- Enclosures for Micro Data Centers
- Tunnels
- Utility / Power Poles
- Train / Subway Station Platforms
- Communication Towers
- Heliports / Vertiports
- Enclosures for Remote Power
- Building Facades
- Prefabricated Balconies
- Accessory Dwelling Units
- Industrial Small Buildings



Recycling of Wind Turbine Blades into I&C Applications



- Can end-of-life wind turbine blades be used in I&C applications?
 - Selective & unselective disassembly
- Pursuing recycling technology developed by RiversEdge Composites
 - Grinding in a hammer mill
 - Compression molding into panels
- Interaction with two other working groups
 - Wind Energy
 - Circular Economy



Some Key Activities that Will Be Covered Today



- ◆ Collecting & disseminating Information about Infrastructure legislation & opportunities
- ◆ Putting together an I&C strategy for IACMI
- ◆ Creating & funding R&D projects for I&C
- ◆ Increasing awareness of FRP composites in the I&C community

ASCE Webinar on Designing with FRP



An Introduction to Designing with Fiber-Reinforced Polymer (FRP) Composites for Civil and Environmental Engineers

Prof. [Dayakar Penumadu](#)

Prof. [Francisco De Caso](#)

Prof. [Bill Davids](#)

Joe Fox, [Ph.D](#)

University of Tennessee

University of Miami

University of Maine

FX Consulting

M.ASCE

M.ASCE

M.ASCE

M.ASCE

dpenumad@utk.edu

fdecaso@miami.edu

william.davids@maine.edu

foxconsulting147@gmail.com

ASCE | KNOWLEDGE
& LEARNING

Distribution of the webinar materials outside of your site is prohibited. Reproduction of the materials and pictures without a written permission of the copyright holder is a violation of the U.S. law.

April 4, 2022

Motivation for Today's Webinar

- Designing with FRP is not typically taught in undergraduate civil engineering curricula
- As a result, civil engineers are not as familiar with designing with FRP composites
- **Motivation for this webinar:** Make civil engineers more comfortable designing with FRP composites
- Today, you will see numerous case studies where FRP composites have been designed for use in Infrastructure applications



FRP Bridge



iDock



FRP Girders



FRP Rebar

ASCE Webinar on Designing with FRP

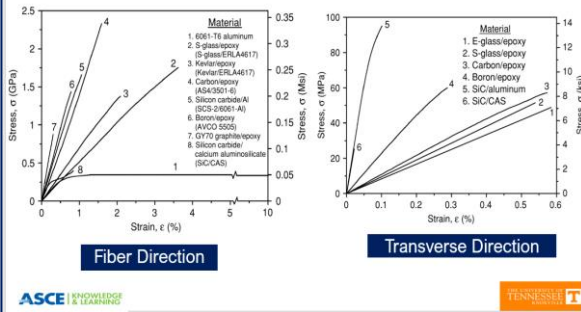
Dayakar Penumadu, University of Tennessee



Getting Started with Design: Basic Composite Materials, Mechanics & Properties



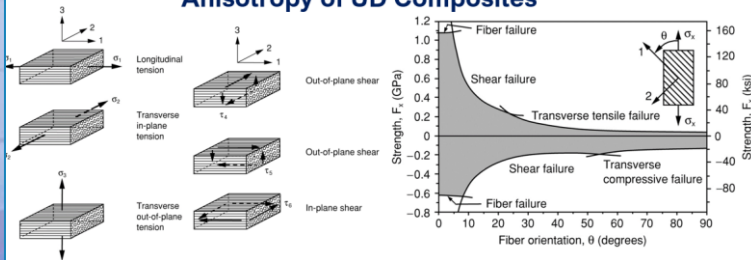
Stress-Strain Curves of Typical Unidirectional Composites in Fiber Direction



TENSILE STRESS-STRAIN

	Steel	GFRP	CFRP
Yield Stress ksi (MPa)	40-75 (276-517)	N/A	N/A
Tensile Strength ksi (MPa)	70-100 (483-690)	70-230 (483-1600)	87-535 (600-3690)
Elastic Modulus ksi (GPa)	29 (200)	5.1 - 7.4 (35-51)	15.9 - 84 (120-580)
Yield Strain %	0.14-0.25	N/A	N/A

Anisotropy of UD Composites



2018-07-09 Composite Materials Handbook Volume 2 - Revision H R-484

An updated online "How-TO" of the second volume of the CMH-17 compo handbook contains...
 The Composite Materials Handbook, CMH-17, is an all-encompassing reference tool that contains over 1,000 records of the latest test data for polymer matrix, metal matrix, ceramic matrix, and structural sandwich composites. CMH-17 provides information and guidance necessary for the design and fabrication and from composite materials. It includes properties of composite materials that meet specific data requirements as well as guidelines for design, analysis, material selection, manufacturing, quality control, and repair.
 Its primary purpose is to provide the engineering professionals involved in testing, data reduction, and reporting of property data for current and emerging composite materials.

Publisher: SAE International
 Special: Published by SAE International with a Product Code of R-484, ISBN of 978-0-7880-9480-7, and 1498 pages in a softbound binding.



You can also get the values you need from handbooks

ASCE Webinar on Designing with FRP

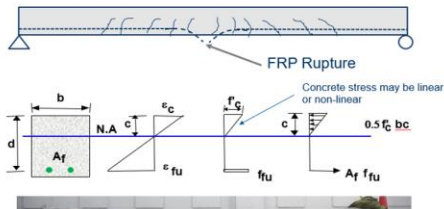
Francisco De Caso, University of Miami



Design & Implementation of FRP-RC

1. Design Approach: Flexure

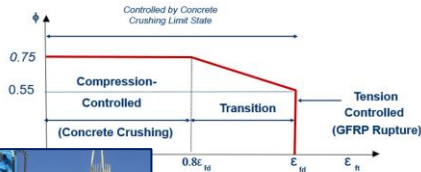
- Tension-controlled: FRP rupture



3. Design Fundamentals: AASHTO

- Strength reduction factor

$$\phi = \begin{cases} 0.55 & \text{for } \epsilon_{ft} \leq \epsilon_{fd} \\ 1.55 - \frac{\epsilon_{ft}}{\epsilon_{fd}} & \text{for } 0.80\epsilon_{fd} < \epsilon_{ft} < \epsilon_{fd} \\ 0.75 & \text{for } \epsilon_{ft} \geq 0.80\epsilon_{fd} \end{cases}$$



(AASHTO 2.5.5.2)



FRP Rebar

3. Design Fundamentals: Critical Parameters

- $\Phi_c \Phi_T \Phi_s$ Phi-factors
- C_E Environmental coef.
- C_c Creep Rupture Strength coef.
- C_f Fatigue Strength coef.
- c_c Spacing for Crack Control coef.
- C_b Bond coef.
- w crack width limit



Case studies



6. Halls River Bridge



6. Flagler Beach, FL (SR-A1A)

ASCE Webinar on Designing with FRP

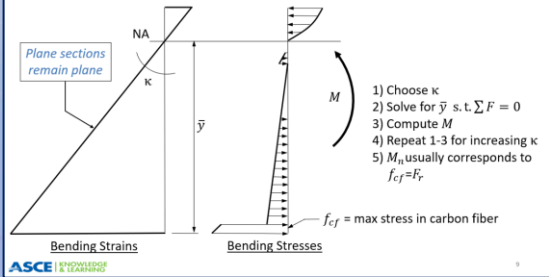
Bill Davids, University of Maine



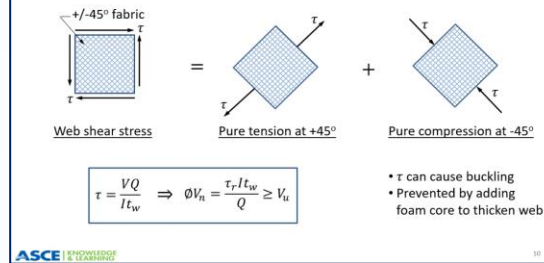
Design of GBeam FRP Girders for Bridge Superstructures



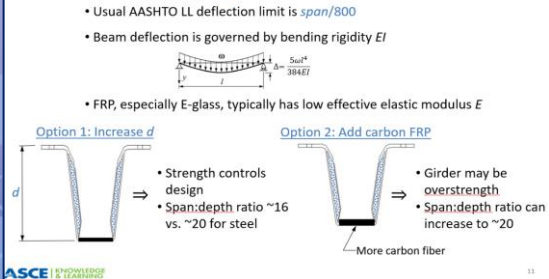
Design for Moment



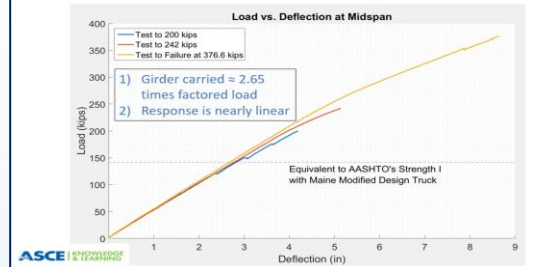
Design for Shear



Design for Deflection



Validation of Design



Grist Mill Bridge in Summer, 2021





Case study



Accessing the Presentation

- The entire presentation can be accessed in the Microsoft Teams folder for the I&C working group






Documents > General			
	Name ▾	Modified ▾	Modified By ▾
	ASCE education initiative	October 15, 2021	foxconsulting147
	August 17, 2021 meeting	August 13, 2021	foxconsulting147
	February 18, 2021 Meeting	March 8, 2021	Deborah Robbins

- Opting into the working group will give you access to this folder

- Meeting summaries
- Other information of interest



	Master file for ASCE webinar on Designing ...	March 30
	Master file for ASCE webinar on Designing ...	March 30
	Post-test for Designing with FRP webinar 0...	April 12

Plans Going Forward



- ◆ Assist with the effort to secure DOE renewal
 - ◆ Show how I&C fits into the strategy for IACMI 2.0
 - ◆ What gaps can IACMI address?
- ◆ Continue to pursue funding for I&C projects
 - ◆ Watch grants.gov for opportunities
 - ◆ Strengthen relationships with state DOTs
- ◆ Launch the Trimer project
 - ◆ FR testing at UDRI and SWRI

Opting into the I&C Working Group



◆ If you would like to “opt in” to the I&C working group, send an e-mail to these 3 people:

- ◆ Kim Hoodin khoodin@iacmi.org
- ◆ John Unser john@compositeapplicationsgroup.com
- ◆ Joe Fox foxconsulting147@gmail.com

Thank you!