

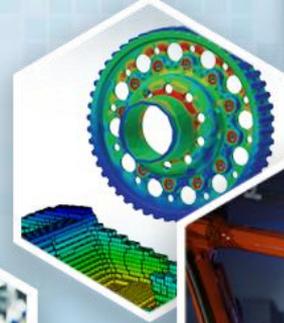
Welcome to the Infrastructure IACMI Working Group

Dale Brosius, IACMI

John Unser, IACMI

Joe Fox, FX Consulting

October 8, 2020



Consortium Working Groups



- ◆ **Mission – Focus on addressing technoeconomic barriers to mass adoption of composites in partnership with similarly aligned organizations**
- ◆ **Formation**
 - ◆ Topic based, ideally formed organically from the membership
 - ◆ Members include industry, academic, national laboratory at all levels of consortium
 - ◆ Elect chair, meet at least 4x per year, more if desired by group
 - ◆ Opportunity to align with external entities (ACMA, ACC, other organizations)

◆ Principal Activities

- ◆ Identify key technical and cost challenges and possible solutions to those
- ◆ Conduct roadmapping as needed specific to topical market or technology focus
- ◆ Inform funding agencies (DOE, DOD, etc.) of priority R&D needs
- ◆ Propose projects for funding – using working group funds or IACMI pool funding
- ◆ Propose mini-conferences or other activities, possibly with outside entities
- ◆ Report activities and successes at IACMI member meetings and other forums, including trade press and conferences

Agenda for the Remainder of the Session



◆ Background Information

Joe Fox

- ◆ The Need
- ◆ The Opportunity
- ◆ The Fit with Composites & with IACMI
- ◆ Voice of the Customer Information

◆ Group Discussion

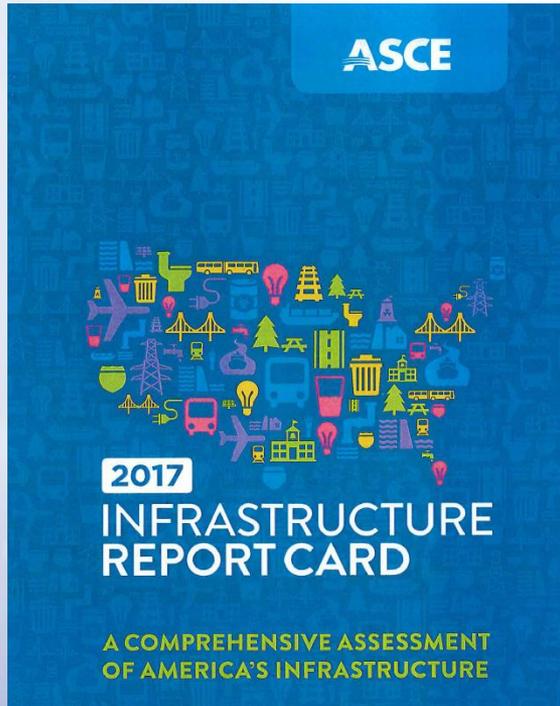
John Unser

- ◆ Scope of the Working Group (poll)
- ◆ Challenges We Should / Can Address (poll)
- ◆ The Path Forward (poll)

The Need



- There is a huge need for repair of our nation's infrastructure



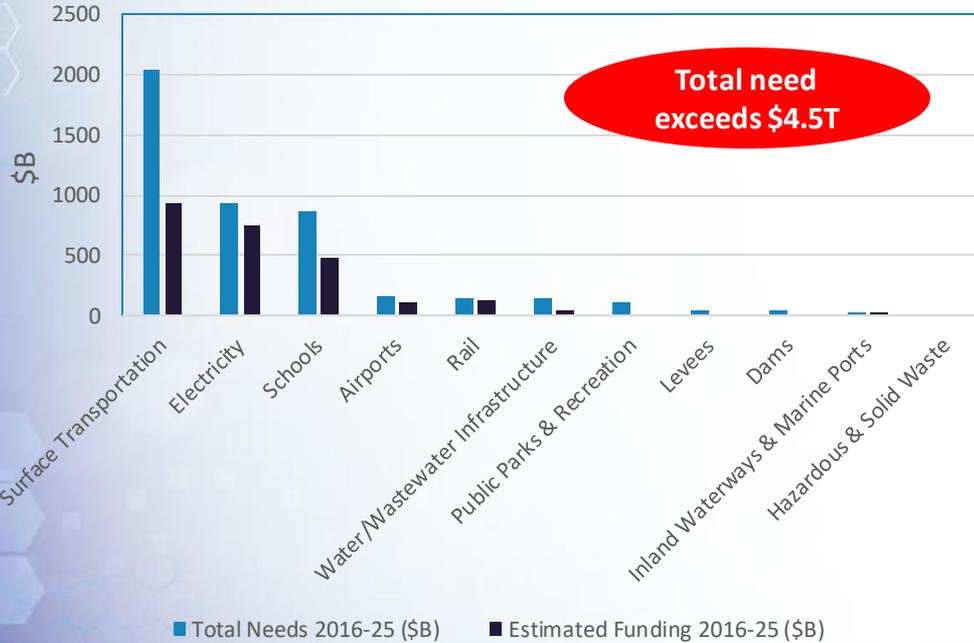
2017 Infrastructure Grades

AVIATION	D	PARKS AND RECREATION	↓ D+
BRIDGES	C+	PORTS	↑ C+
DAMS	D	RAIL	↑ B
DRINKING WATER	D	ROADS	D
ENERGY	D+	SCHOOLS	↑ D+
HAZARDOUS WASTE	↑ D+	SOLID WASTE	↓ C+
INLAND WATERWAYS	↑ D	TRANSIT	↓ D-
LEVEES	↑ D	WASTEWATER	↑ D+

The Opportunity: Information from ASCE



Infrastructure Opportunities
from ASCE 2017 Infrastructure Report Card



	Total Needs 2016-25 (\$B)	Estimated Funding 2016-25 (\$B)
Surface Transportation	2042	941
Electricity	934	757
Schools	870	490
Airports	157	115
Rail	154	125
Water/Wastewater Infrastructure	150	45
Public Parks & Recreation	114	12
Levees	50	10
Dams	45	5.6
Inland Waterways & Marine Ports	37	22
Hazardous & Solid Waste	7	4
Totals	4560	2527

The Fit

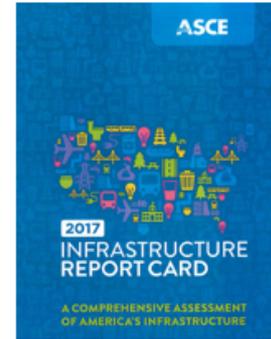


- With FRP
- With IACMI

Connecting FRP Composites to ASCE's *Infrastructure Report Card* and *Future World Vision*

Joe Fox
Infrastructure Working Group
IACMI Fall Review
October 8, 2020

**Joe is scheduled to give this
webinar to the Central Ohio
chapter of ASCE on November 4**



Many Opportunities for Improvement

2017 Infrastructure Grades

 AVIATION	D	 PARKS AND RECREATION	↓ D+
 BRIDGES	C+	 PORTS	↑ C+
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 INLAND WATERWAYS	↑ D	 TRANSIT	↓ D-
 LEVEES	↑ D	 WASTEWATER	↑ D+

Bridge Construction

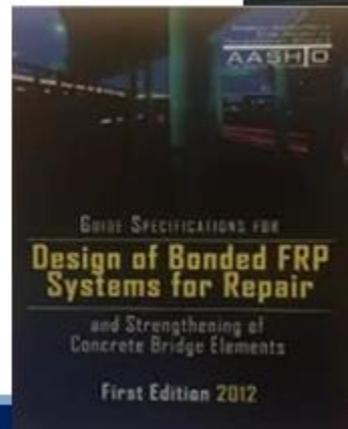
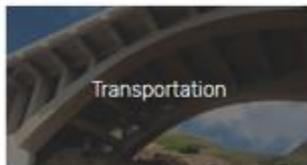
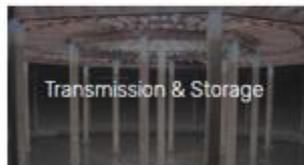
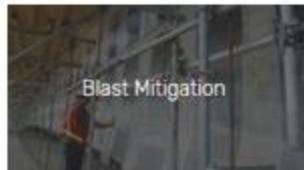
- More than 500 bridges have been constructed with FRP composites and/or FRP rebar-reinforced concrete
- 22 states and Canada



Courtesy of Advanced Infrastructure Technologies

Strengthening of Bridges

- FRP wraps have been used to strengthen and repair bridges
 - Usually CFRP
 - Improved resistance to earthquakes
- Other examples of FRP strengthening



Pedestrian Bridges and Walkways

- Pedestrian bridges are lightweight and durable
- Plans are underway to add a pedestrian walkway to the famous Newport RI bridge
 - Lightweight addition to an existing structure



Courtesy Composite Advantage

Indian Lake, Ohio



Courtesy of Composite Advantage

Lake Tahoe

More Opportunities for Improvement



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 INLAND WATERWAYS	↑ D	 TRANSIT	↓ D-
 LEVEES	↑ D	 WASTEWATER	↑ D+

Inland Waterways, Dams & Levees

 DAMS	0
 INLAND WATERWAYS	↑ 0
 LEVEES	↑ 0



FRP Locks



FRP Wicket Gates

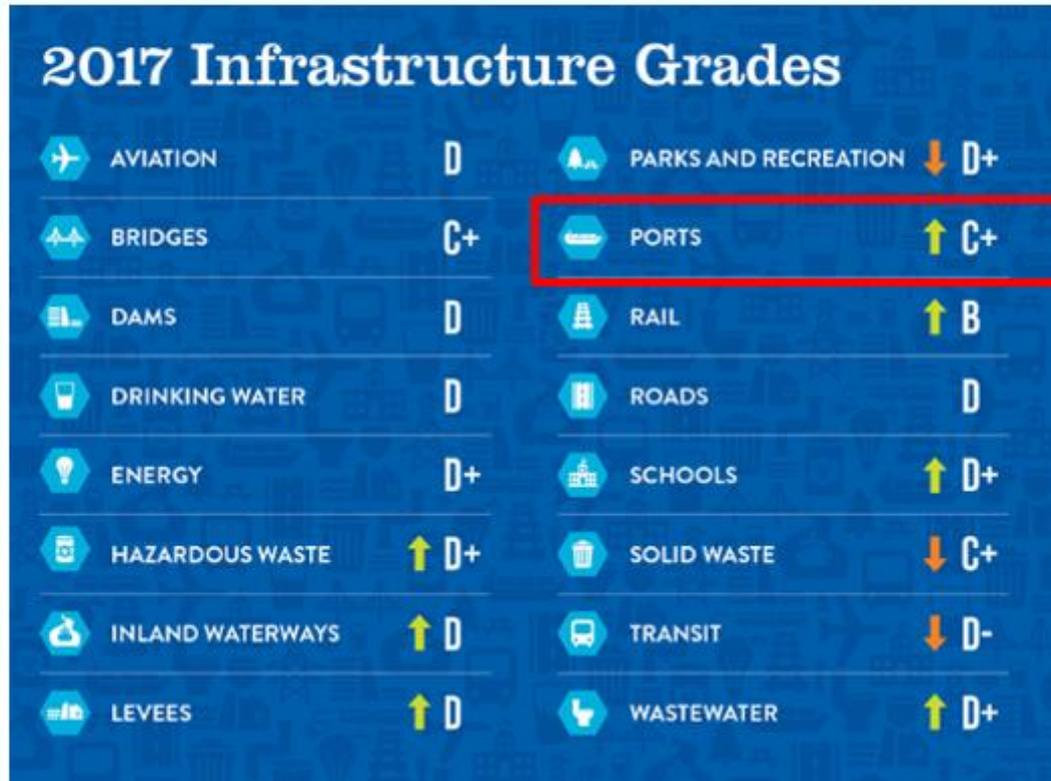


Bridge Protection



Navigation Aids with FRP Piles

More Opportunities for Improvement



Ports



Piers



Pilings



Fenders



Dolphins

More Opportunities for Improvement

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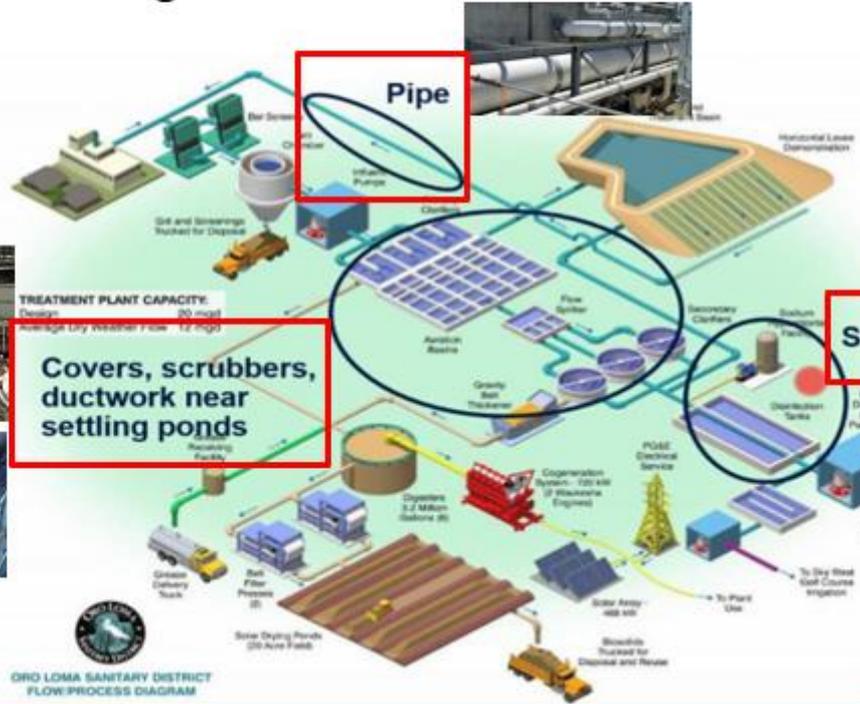
Improving Water Infrastructure with FRP

- Drinking Water
 - Pipes suitable for potable water
 - Corrosion-resistant, no lead
 - Pass NSF 61
- Repair of pipes
 - Trenchless repair with Cured-in-Place Pipe (CIPP)



Improving Wastewater Infrastructure with FRP

- Corrosion-resistant FRP can be used with bleach, strong acids and strong bases in wastewater treatment plants



Stairways, grating, handrails, elevated walkways throughout the facility



Covers, scrubbers, ductwork near settling ponds

Storage Tanks – NaOCl, HCl, NaOH



All pictures courtesy of INEOS Composites

FRP's Fit with ASCE's *Future World Vision*

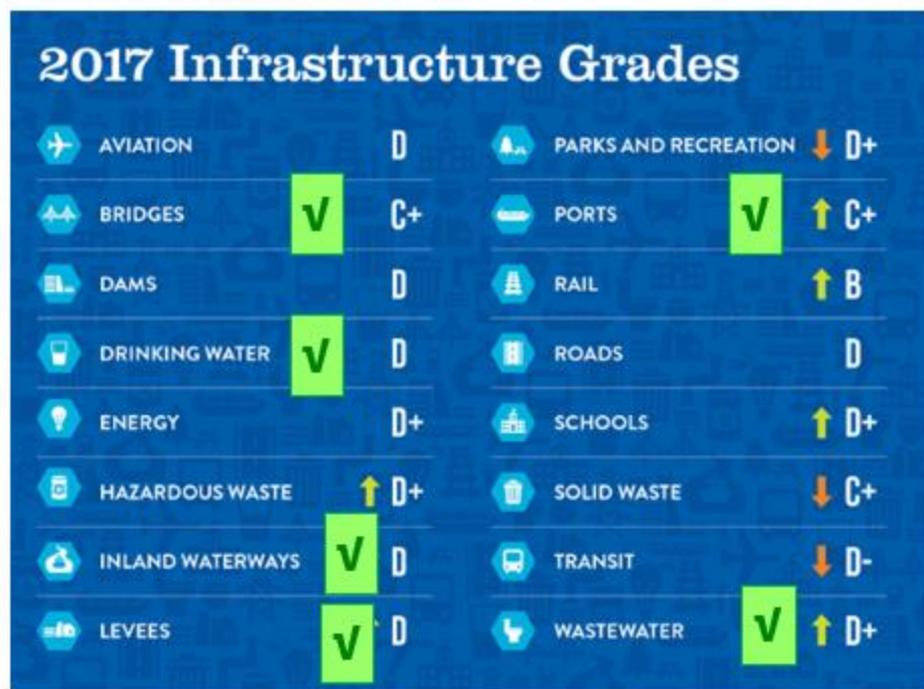


- There is also a good fit with ASCE's vision for cities of the future



To Summarize

- There is an extremely good fit between FRP composites and our nation's infrastructure needs, **today** and in the future



The Fit



- With FRP
- With IACMI

Infrastructure Technologies within IACMI domain

Current (2020) status of IACMI's core competencies

VISION 2025 – IACMI enabled technology, work force & economic development

Resilient infrastructure



Disaster resiliency

Modular building Elements



Smart buildings

Architectural innovations



Modular bridge

Culverts and piping



Corrosion resistant

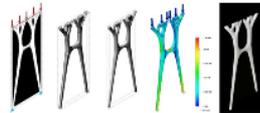
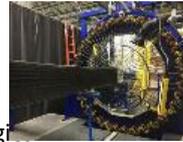
Mobile medical facilities



Precast elements

Energy efficient construction

- ✓ Pultrusion, Braiding, Filament winding, preforming
- ✓ Large panel compression, Double belt lamination.
- ✓ Injection molding
- ✓ Large scale infusion, liquid molding
- ✓ Carbon fiber technologies (textile grade, pitch)
- ✓ Recycling technologies
- ✓ Sandwich technologies
- ✓ NDE and inspection technologies
- ✓ Material intermediates, new resins, additives, fibers
- ✓ Advanced thermoplastics
- ✓ Additive manufacturing – molds, concrete printing, freeform winding
- ✓ Hybrid manufacturing
- ✓ Design, modeling & simulation generative designs



- Hybrid pultrusions – varying and curved
- Robotic winding AM, windings
- Hybrid structures – ‘Materials By Design’
- Rebar technologies
- Precast – inserts, smart elements, rapid erection
- Repair and retrofit for culverts and piping
- Concrete-composite advances
- 50% of greater recycled content enabled
- Automation, sensing advanced structures, NDE established
- Modular standardized building elements
- Retrofit and new construction for natural disaster resiliency-tornadoes, hurricanes, earthquakes
- Mobile medical facilities infrastructure
- Close ties to ACMA, construction network
- Target 10 small businesses incubate from IACMI enabled work
- 1000 work force trained in composites for infrastructure

Bridge Location

- ◆ Located near Wartburg, TN
- ◆ Two lane road medium traffic
- ◆ Current bridge is 22 ft wide and 12 ft long
- ◆ Plan to expand the bridge to 25 ft wide and 16 ft long
- ◆ Bridge is part Y and long vehicles that need the extra width
- ◆ Longer length helps in flooding



IACMI-Led Demonstration Project

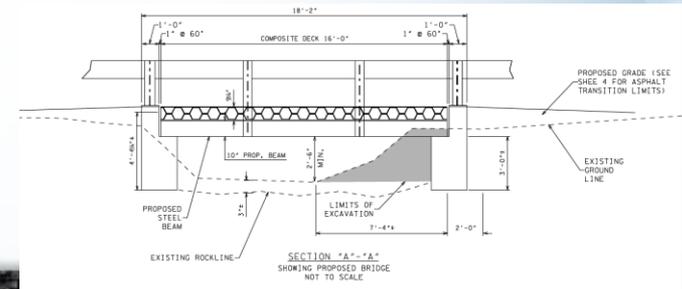


- ◆ IACMI The Composites Institute (case study)
- ◆ Morgan County Road Superintendent (customer)
- ◆ McKinney Excavating (installer)
- ◆ Structural Composites (bridge deck builder)
- ◆ Composites Application Group (coordinator)
- ◆ University of Tennessee Knoxville (monitoring)
- ◆ Steffen Engineering (deck design)
- ◆ Neel-Schaffer, Inc. (local bridge designer)
- ◆ Materials donation: Luna (sensors), Interplastic (resin), Superior/METYX (fiberglass), Acralock (adhesives)



Joe Miller

Morgan County Road Superintendent



The Challenges



- ◆ What are the barriers to further adoption of composites in Infrastructure?
- ◆ Voice of the Customer
 - ◆ Infrastructure sessions at CAMX
 - ◆ Feedback from ASCE

Infrastructure Speakers & Panels at CAMX



Game Changing Infrastructure Challenges: New Solutions & Opportunities



Tim Lattner

Director, Office of Design
Florida Department of Transportation

Building Bridges Along the Atlantic [Panel]



Darrell Evans, P.Eng.

A/Assistant Director, Capital Projects
Prince Edward Island Department of Transportation



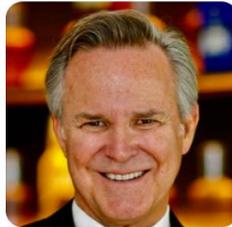
Wayne Frankhauser

Bridge Program Manager
Maine Department of Transportation



Chase C. Knight

Corrosion & Composite Materials Engineer
Florida Department of Transportation



Steve McNamara

President
ANZAC CONTRACTORS, INC.



Antonio Nanni

Professor & Chair
University of Miami



Steve Nolan

Senior Structures Design Engineer
Florida Department of Transportation

Feedback from ASCE

Jerry Buckwalter

**ASCE Chief Operations and
Strategy Officer**
gbuckwalter@asce.org



The Future World Vision Platform



An Immersive Storytelling Experience
Combine the power of a 4D environment with a powerful narrative to immerse users inside interactive future community scenarios

Narratives at the Macro- and Micro-Scale
Experience the CityWorld at both the human-centric street view and the systems-based infrastructure macro view

5 Fully Developed Future Worlds
Explore pressing issues that engineers face today and will face in the next 50 years: **Mega City, Floating City, Rural City, Frozen City and Off-Planet City**



ASCE
AMERICAN SOCIETY
OF CIVIL ENGINEERS

**Future World Vision:
Infrastructure Reimagined**
May 2019



FUTURE WORLD VISION
The Floating City

0:01 / 0:34

<https://www.futureworldvision.org/future-worlds/floating-city/>
Text=Created%20using%20Future%20World%20Vision%27s%20combination%20of%20future-scenario.as%20rising%20sea%20levels%20threaten%20coastal%20city%20flo

Challenges from the sessions on Infrastructure at CAMX



Issue	Sub-Issue	Lattner FDOT	Evans Canada	Frankhausr Maine	Nolan FDOT	Knight FDOT	Buckwalter ASCE
Cost	Higher upfront costs / CAPEX						X
	Additional \$ needed for testing	X					
Education/Awareness	Design Inexperience	X	X	X			
	Contractor Inexperience		X	X			
Sustainability	More Life Cycle Analyses				X		X
	End-of-life disposal		X				X
	Re-usability						X
Supply Chain	Scalability of production	X					
	Long lead times	X					
	Engineering/Tech Support		X	X			

Challenges from the sessions on Infrastructure at CAMX



Issue	Sub-Issue	Lattner FDOT	Evans Canada	Frankhausr Maine	Nolan FDOT	Knight FDOT	Buckwalter ASCE
Performance	Creep & Fatigue	X					
	Elastic Modulus	X					
	Consistency					X	
	Reliability					X	
	Fire Resistance						
	uv Resistance						
Constructability	Connectors / couplings	X			X		
	Bent bars	X			X		
	Field Repair		X				
Lack of codes & specifications				X			

Agenda for the Remainder of the Session



◆ Background Information

Joe Fox

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◆ Group Discussion

John Unser

- ◆ Scope of the Working Group (poll)
- ◆ Challenges We Should / Can Address (poll)
- ◆ The Path Forward (poll)

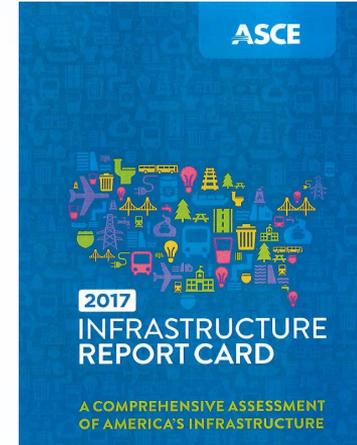
Poll #1: Which Segments Should be in Scope?



Vote for up to 5 categories.

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INLAND WATERWAYS	↑ D	TRANSIT	↓ D-
LEVEES	↑ D	WASTEWATER	↑ D+



Poll #2b: Which barriers should IACMI address?



- Rank your top 3 categories
- Life Cycle Cost Analysis
- Education / Awareness
- Sustainability / Recycling
- Supply Chain Considerations
- Lack of Codes, Specifications
- Performance Issues
- Constructability Issues
- Other (specify)

Infrastructure Technologies within IACMI domain

Current (2020) status of IACMI's core competencies

VISION 2025 – IACMI enabled technology, work force & economic development

Resilient infrastructure



Disaster resiliency

Modular building Elements



Smart buildings

Architectural innovations



Modular bridge

Culverts and piping



Corrosion resistant

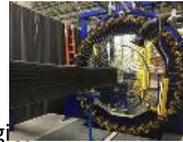
Mobile medical facilities



Precast elements

Energy efficient construction

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- ✓ Injection molding
- ✓ Large scale infusion, liquid molding
- ✓ Carbon fiber technologies (textile grade, pitch)
- ✓ Recycling technologies
- ✓ Sandwich technologies
- ✓ NDE and inspection technologies
- ✓ Material intermediates, new resins, additives, fibers
- ✓ Advanced thermoplastics
- ✓ Additive manufacturing – molds, concrete printing, freeform winding
- ✓ Hybrid manufacturing
- ✓ Design, modeling & simulation generative designs



- Hybrid pultrusions – varying and curved
- Robotic winding AM, windings
- Hybrid structures – ‘Materials By Design’
- Rebar technologies
- Precast – inserts, smart elements, rapid erection
- Repair and retrofit for culverts and piping
- Concrete-composite advances
- 50% of greater recycled content enabled
- Automation, sensing advanced structures, NDE established
- Modular standardized building elements
- Retrofit and new construction for natural disaster resiliency-tornadoes, hurricanes, earthquakes
- Mobile medical facilities infrastructure
- Close ties to ACMA, construction network
- Target 10 small businesses incubate from IACMI enabled work
- 1000 work force trained in composites for infrastructure

Draft Objectives



- ◆ Support effort to educate the civil engineering community about composites
- ◆ Expose the community to composites by building demonstration structures with relatable value
- ◆ Collect data for life cycle cost analysis to support decision-making in favor of composites
- ◆ Support the development of standards
- ◆ Develop the workforce
- ◆ Broaden awareness via project-based STEM outreach

Poll #3: Meeting Frequency



◆ How often should this working group meet?

◆ Quarterly (4x per year)

- ◆ IACMI virtual member meeting - week of February 15, 2021
- ◆ SAMPE Long Beach – May 24-27, 2021
- ◆ IACMI summer meeting Detroit – week of July 19, 2021
- ◆ CAMX Dallas – October 18-21, 2021

◆ Bi-monthly (6x per year)

- ◆ Four meetings above plus two additional meetings

◆ Monthly (12x per year, or 11x if December skipped)

- ◆ Four meetings above plus virtual in other months

We Need More of this Type of Analysis



Life Cycle Cost Analysis

Advances in Civil Engineering Materials

Thomas Cadenazzi,¹ Giovanni Dotelli,² Marco Rossini,³ Steven Nolan,⁴ and Antonio Nanni³

DOI: 10.1520/ACEM20180113

Life-Cycle Cost and Life-Cycle Assessment Analysis at the Design Stage of a Fiber-Reinforced Polymer-Reinforced Concrete Bridge in Florida



Homosassa, FL 2017-19 (GFRP-RC & CFRP-PC)
Five-span vehicular bridge

- Halls River Bridge under construction in Homosassa, FL north of Tampa
- Continuous deck with 5 spans
 - 186' long, 58' wide

Next Steps



- ◆ Each attendee will receive a follow-up e-mail with the recording of the meeting and a brief summary of the meeting. You will be asked to respond to let IACMI know if you wish to continue to be part of the Infrastructure working group.
- ◆ The next meeting will be scheduled based on the feedback from poll #3.



**Thank you for
attending!!**