

# FRP Composite Miter Block and Wicket Gate Installations



Engineer Research and Development Center

## 2016 Locks Maintenance Workshop

Jonathan Trovillion

Richard Lampo

Jeff Ryan

Engineer Research and Development Center – Construction Engineering Research Laboratory

10FEB16



US Army Corps of Engineers®

# Outline

- ▶ **Background**
  - **What are Composites**
  - **Potential Benefits of Use**
  
- ▶ **Composite Miter Blocks**
  
- ▶ **Composite Wicket Gates**
  
- ▶ **Questions**



# Background

- **DEFINITION:**

**Composite Material: A combination of two or more materials (reinforcing elements, fillers, and matrix binder), differing in form or composition on a macroscale. The constituents retain their identities; that is, they do not dissolve or merge completely into one another although they act in concert. Normally, the components can be physically identified and exhibit an interface between one another.**

- **OPPORTUNITY:**

**Fiber reinforced polymer (FRP) composites offer the potential for repair of critical components of navigation systems at a reduced cost and greater durability than traditionally used materials.**

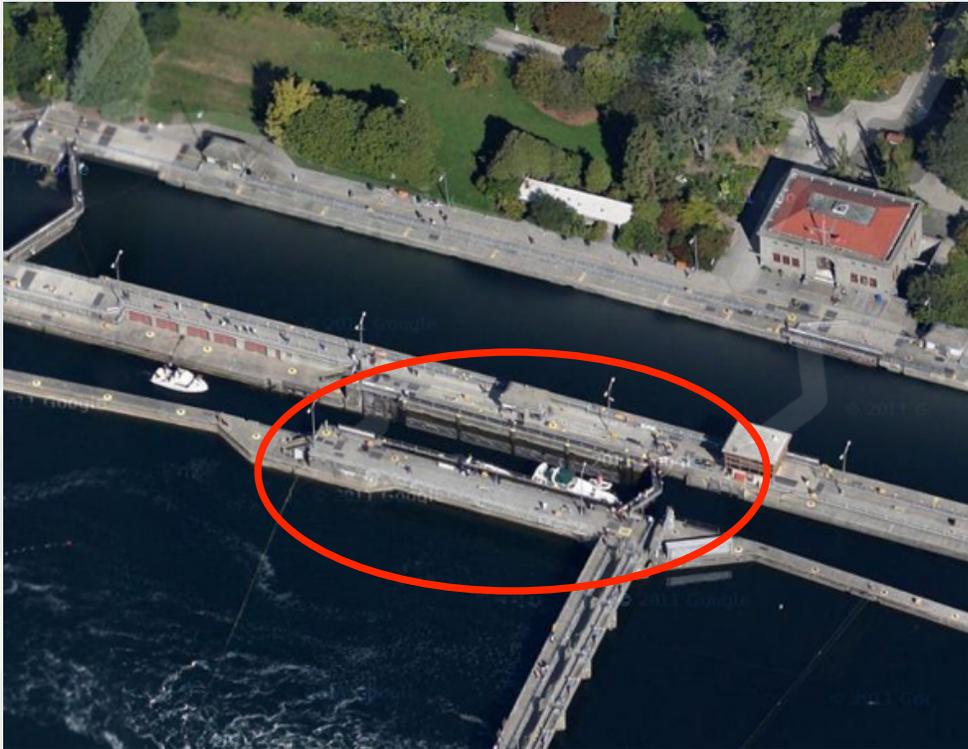
# Potential Benefits for the Use of FRP Composites

- **Light Weight / High Strength**
- **Corrosion Resistant**
- **Rot and Insect Resistant**
- **Durable**
- **Very-low Maintenance**
- **Environmentally Friendly**
- **Offer Modular / Rapid Construction or Repair**
- **Avoid Lengthy / Costly Shutdowns**
- **An “Engineered” Product**



# FRP Miter Blocks

- **FRP Composite Miter Blocks for small lock on Washington Lake Canal, WA.** Corrosion of steel miter blocks can lead to leakage and gate misalignment.



**Small lock at Hiram  
Chittenden (Washington Lake  
Canal) Locks, Seattle, WA.**



BUILDING STRONG®

**Corroded steel miter blocks.**



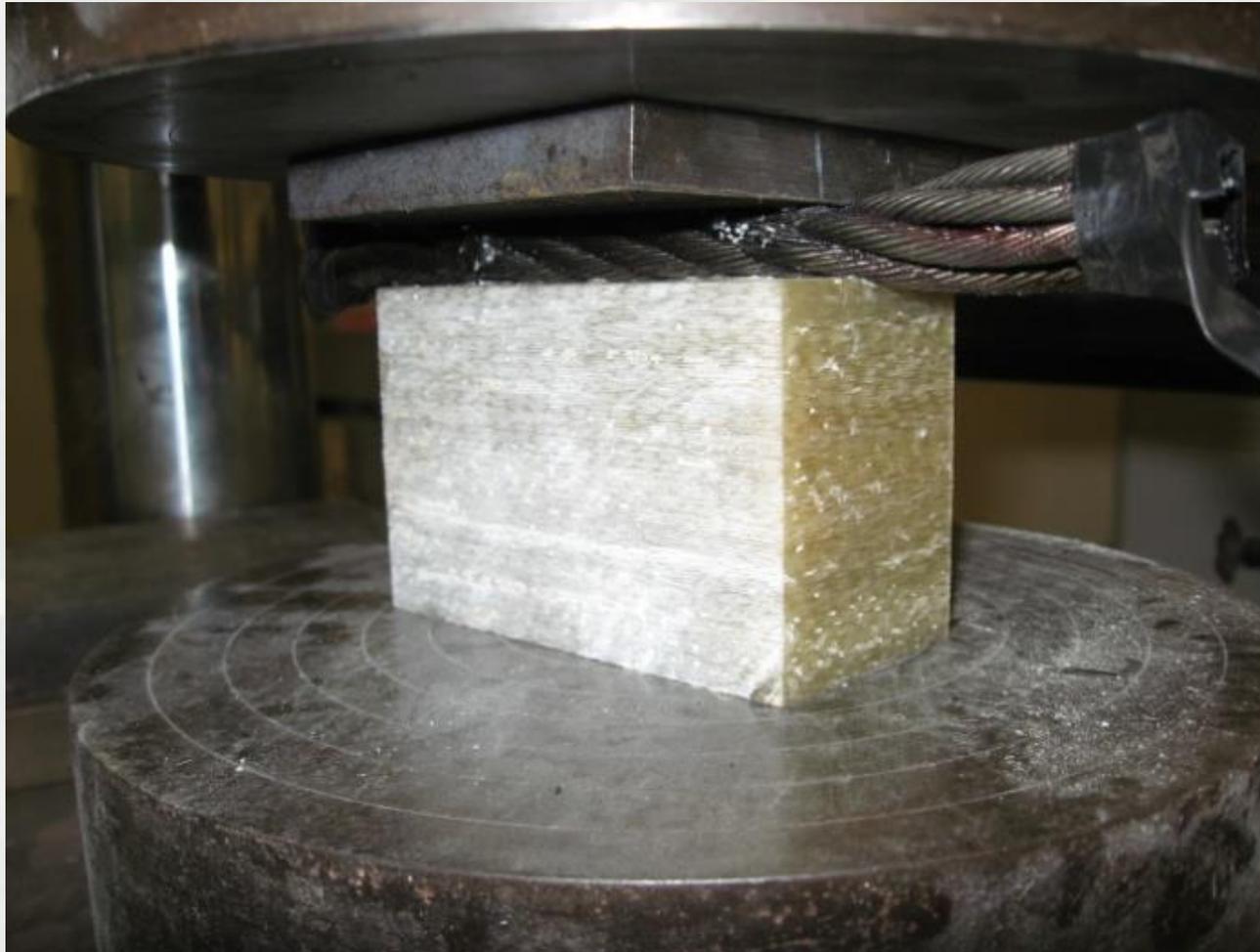
*Innovative solutions for a safer, better world*

# Selected FRP Miter Block-Stresses in 3-Directions

Group	Load Direction	Failure Stress	Failed Specimen	Comments
IV	Along the mitering surface	~ 51 ksi		Specimen: (4"x2.5"x.75") Loading surface: (4"x0.75")
	Between the steel channel edge surfaces	~ 22 ksi		Specimen: (4"x2"x1.5") Loading surface: (2"x1.5")
	Along the length (height direction in the gate)	~ 29 ksi		Specimen: (2"x2"x1.5") Loading surface: (2"x1.5")

Note: 1.4 ksi is required on the mitering surface vs. ~ 51 ksi (available)

# Behavior When Pinching Foreign Object



BUILDING STRONG®



*Innovative solutions for a safer, better world*

# Results of Miter Block Pinch Tests

No	Specimen picture & dimension	Foreign Objects (Wire) Type	Diameter of the foreign object	Failure	Indentation on miter surface after testing	Load Deflection response
1	 (2"x4"x0.8")	 Rebar	0.75"	None		0.12" at 50 kips
2	 Steel Plate(tested) (2"x4"x0.5")	 Rebar	0.75"	None		0.07" at 50 kips and 0.21" at 150 kips
3	 (2"x4"x0.8")	 Smooth steel bar	1.75"	None		0.13" at 50 kips
4	 (2"x4"x2.5")	 Steel cable	0.75"	None		0.21" (includes cable deflection) at 50 kips, 0.3" at 100 kips, 0.39" at 150 kips, i.e., ~0.09" for every 50 kips

# Condition of Steel Blocks



**Very corroded existing steel blocks.**



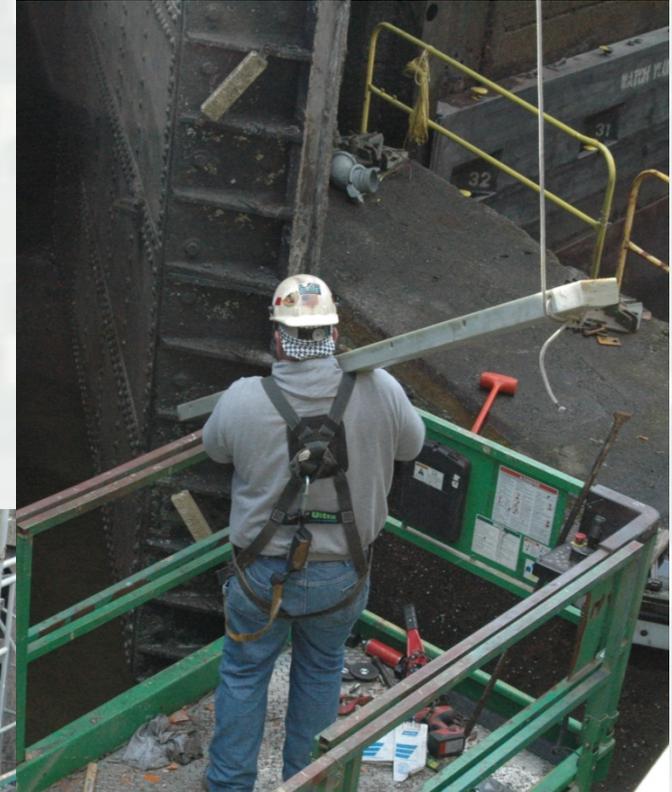
**Previous attempts to repair with epoxy material not very successful – repair lasted but a few months.**



**BUILDING STRONG®**

*Innovative solutions for a safer, better world*

# Installing the Blocks



**Lightweight, easier and safer to handle than steel.**



**BUILDING STRONG®**

**ERDC**

*Innovative solutions for a safer, better world*

# FRP Composite Wicket Gates

**Problem:** Timber wicket gates: rapid deterioration, costly to replace. Stepping stone to future design and application of other larger FRP composite gates and valves. Prototype designs are being developed using thermoset composites. Installed in Peoria Lock and Dam in Aug 2015.



**Traditional wooden wickets showing deterioration**



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

# Peoria Lock and Dam



The Peoria Lock and Dam on the Illinois River, located near Creve Coeur, is 600 ft. long by 110 ft. wide with a maximum lift of 11 ft. and an average lift of 6 ft. The dam is comprised of a Chanoine wicket dam, the navigable pass type, with an overall length of 570 ft. and a single 84 ft. long submersible Tainter gate. The wicket dam is 432 ft. long containing 108 wicket gates.



BUILDING STRONG®



*Innovative solutions for a safer, better world*

# Composite Wicket Gates

## Design Considerations

**Worked with WVU and Rock Island District folks to develop design concepts for composite gates.**

- **Same dimensions as timber gates**
- **Same weight and balance**
- **Use existing steel hardware: Prop rod, horse, bail etc.**
- **Infuse as single monolithic unit**



**Currently used timber wickets.**



**BUILDING STRONG®**

**ERDC**

*Innovative solutions for a safer, better world*

# Composite Wicket Gates

## Fabrication and Lab Testing of Initial Prototype

Layup in the mold.



Tested to twice the working load of a timber wicket.

After resin infusion but before clean-up.



BUILDING STRONG®



*Innovative solutions for a safer, better world*

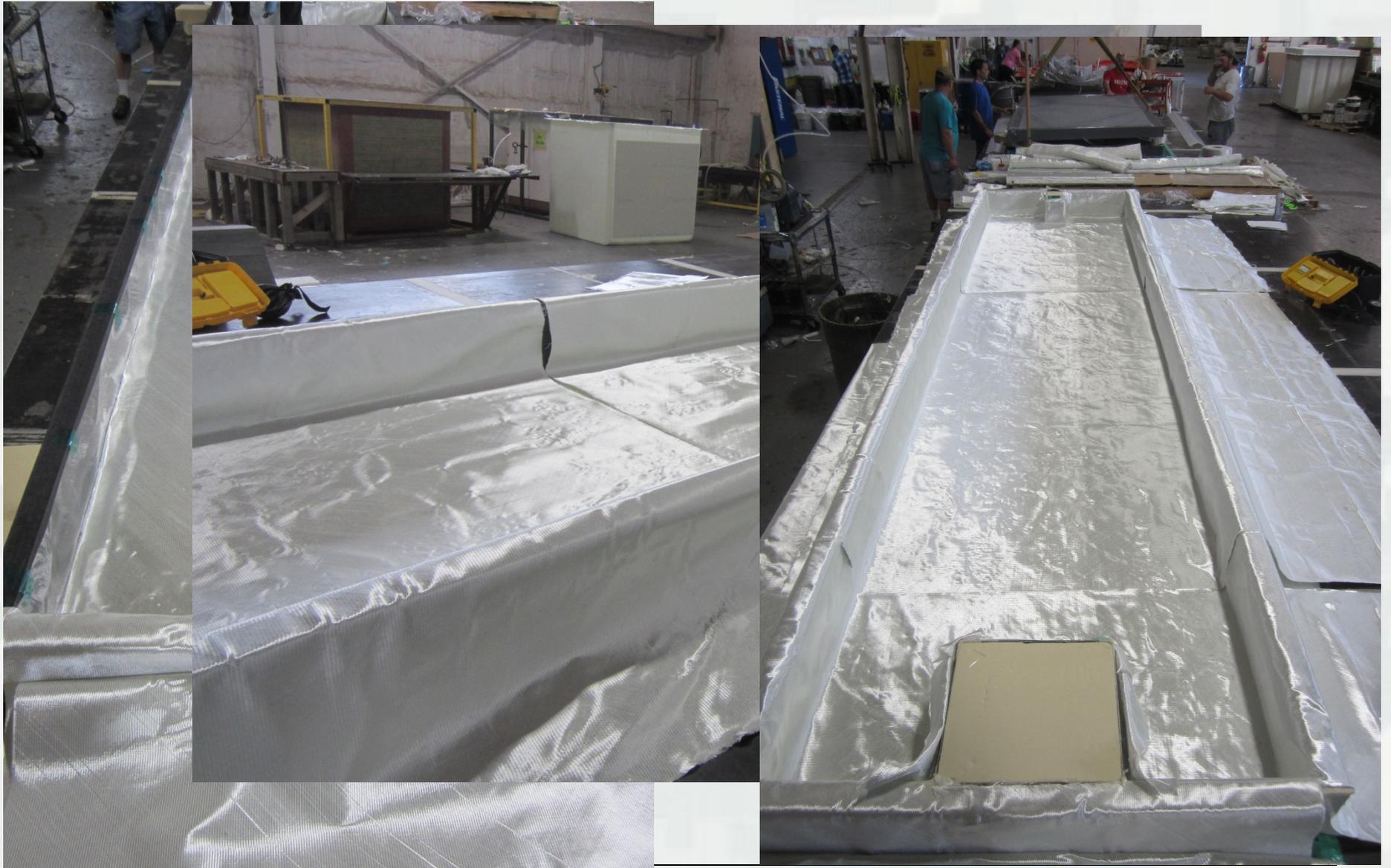
# Infusion Preparation



BUILDING STRONG®

*Innovative solutions for a safer, better world*

# Layup



BUILDING STRONG®

*Innovative solutions for a safer, better world*

# Placing the Core



BUILDING STRONG®

*Innovative solutions for a safer, better world*

# Top Plate Fabric & Resting Blocks



BUILDING STRONG®



*Innovative solutions for a safer, better world*

# Vacuum Bagging

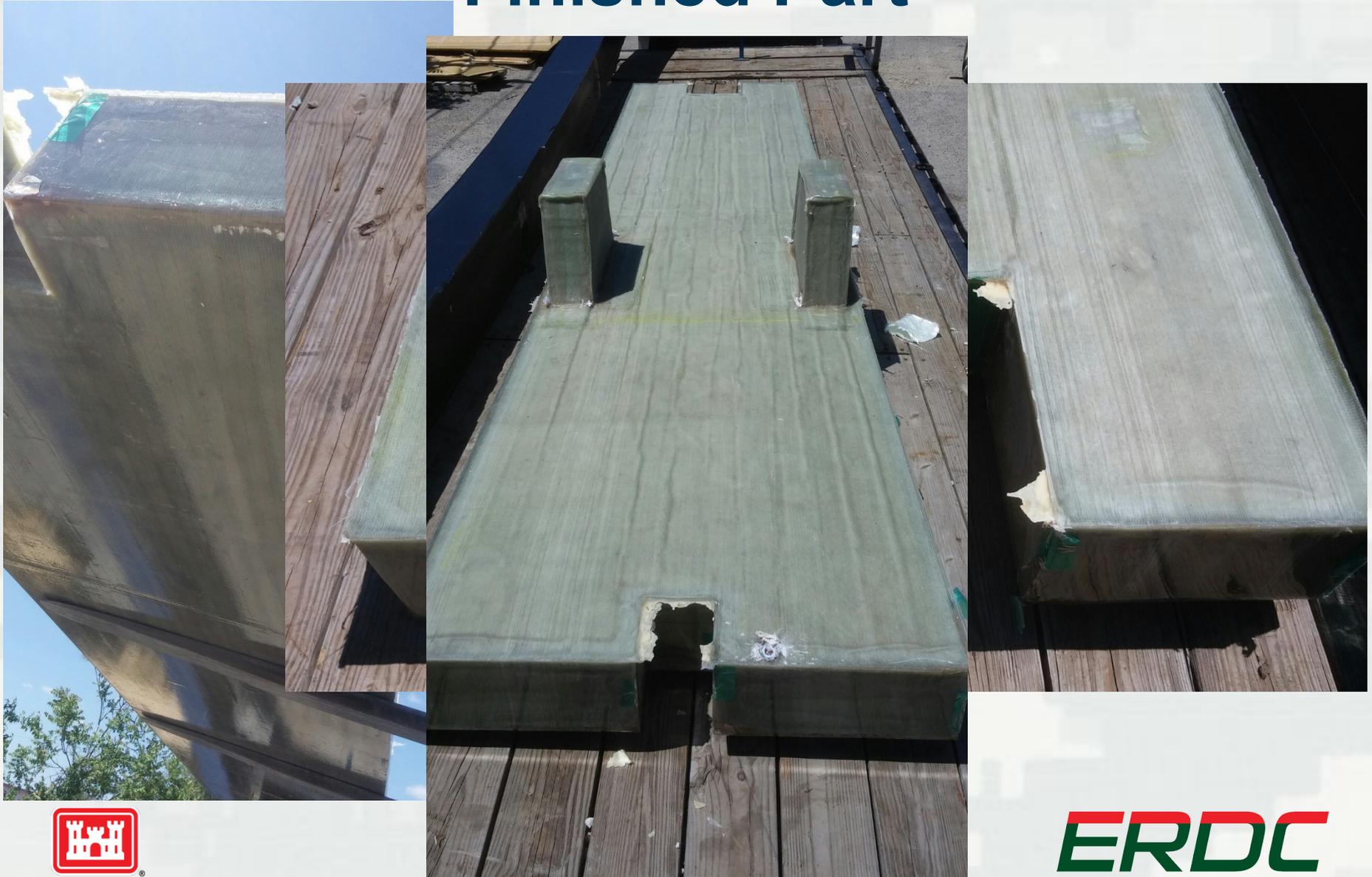


BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

# Finished Part



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

# Composite Wicket Gates

- Fabrication of two additional prototype gates using agreed upon design changes, including UHMWPE on sides and face.
- Three gates to be installed, one with steel angles on the edges as used in the lab testing and two with UHMWPE on upstream face and sides for abrasion-protection.



**Gate #2 after demolding but before trimming and attaching steel hardware; yellow UHMWPE for better visibility.**

**IWW Installed 3 composite wickets during Aug15 maintenance activities.**

# Composite Wicket Gate Installation



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

# Composite Wicket Gate Installation



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

# Composite Wicket Gate Installation



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

# Composite Wicket Gate Installation



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

# Composite Wicket Gate Installation



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

# Composite Wicket Gate Installation



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

# Composite Wicket Gate Installation



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

# Composite Wicket Gate Installation



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*

# Composite Wicket Gate Installation



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*



BUILDING STRONG®

*Innovative solutions for a safer, better world*

# Questions ???

Jonathan Trovillion

[Jonathan.c.trovillion@usace.army.mil](mailto:Jonathan.c.trovillion@usace.army.mil)

217-373-4551

Richard Lampo

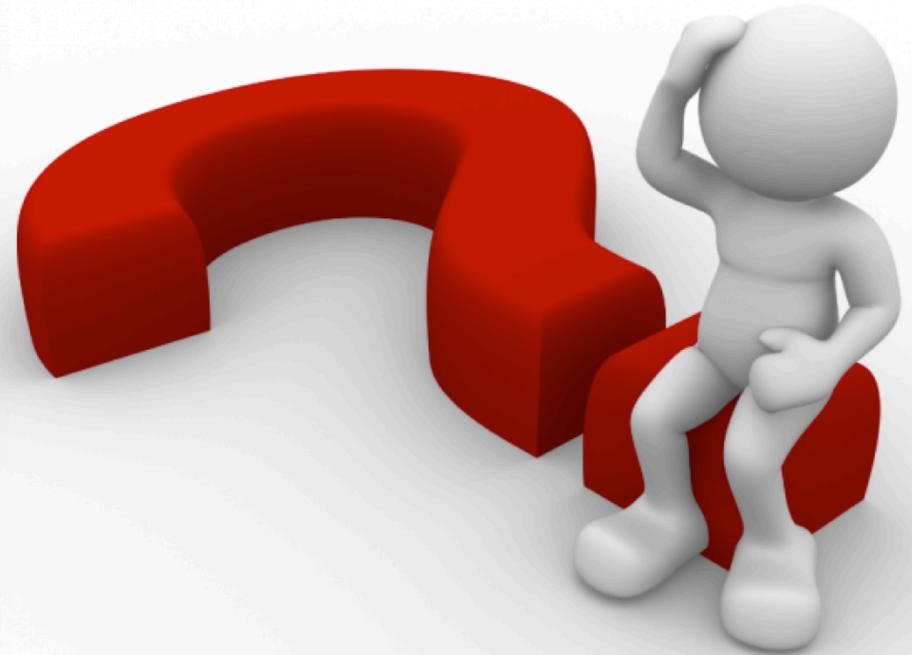
[Richard.g.lampo@usace.army.mil](mailto:Richard.g.lampo@usace.army.mil)

217-373-6765

Jeffrey Ryan

[Jeffrey.p.ryan@usace.army.mil](mailto:Jeffrey.p.ryan@usace.army.mil)

217-373-3479



BUILDING STRONG®

**ERDC**

*Innovative solutions for a safer, better world*