ERDC
Engineer Research and Development Center

Polymer Composite Materials for the Repair and Maintenance of Navigation Structures

2013 Locks Maintenance Workshop
Huntington, WV

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US Army Corps of Engineers

Outline

- Background
  - Thermoset and Thermoplastic Composites
  - Nav Structures / Nav Systems
  - Collaborators
- Field Demonstrations
- R&D Focus
- Products

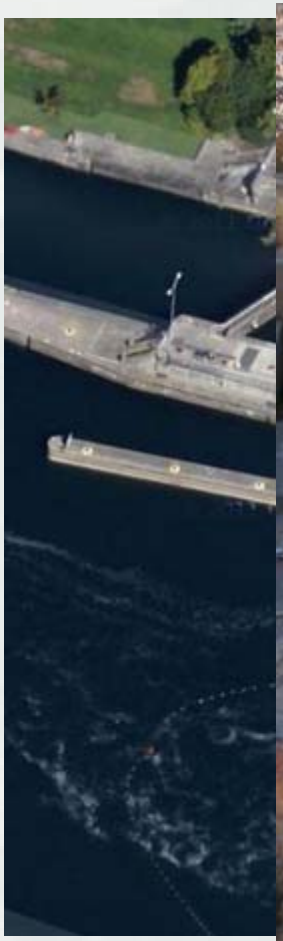
Background

- **Problem/Objectives**: 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. New Work Unit initiated in FY12 under Nav Structures focused on the used of FRP composites for rapid repair of navigation structures. Additional funding opportunity presented itself in FY12 under Nav Systems to demonstrate and showcase the use of FRP composite materials in low risk but useful applications.

- **Collaborators**:
  - ERDC-CHL
  - Districts: Huntington, Louisville, Mobile, Nashville, and Seattle
  - NSF Center for the Integration of Composites into Infrastructure
    - West Virginia University, Rutgers University, NC State, U of Miami

Current Demonstrations

- **FRP Composite Miter Blocks for small lock on Washington Lake Canal, WA.** Blocks are 39 feet long on upper service gate and 19 feet long on lower service gate.



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Current Demonstrations

FRP Composite Miter Blocks for small lock on Washington Lake Canal, WA.

- **Technologies to be demonstrated:**
  - **Miter block assembly to meet design needs**
  - **Use 3-D stitched fabrics**
- **Laboratory screening tests to determine acceptable performance to design requirements scheduled to commence late-January 13**
- **Door frame test fixture fabricated to conduct laboratory testing**
- **Targeted field installation is April 2013**

FRP Miter Block Test

Miter gate FRP blocks (left-hand side) mounted on revolving and stationary gates

FRP miter block on rotating door on left and stationary FRP block on right

Miter gate FRP blocks (left hand side) on revolving and stationary door segments

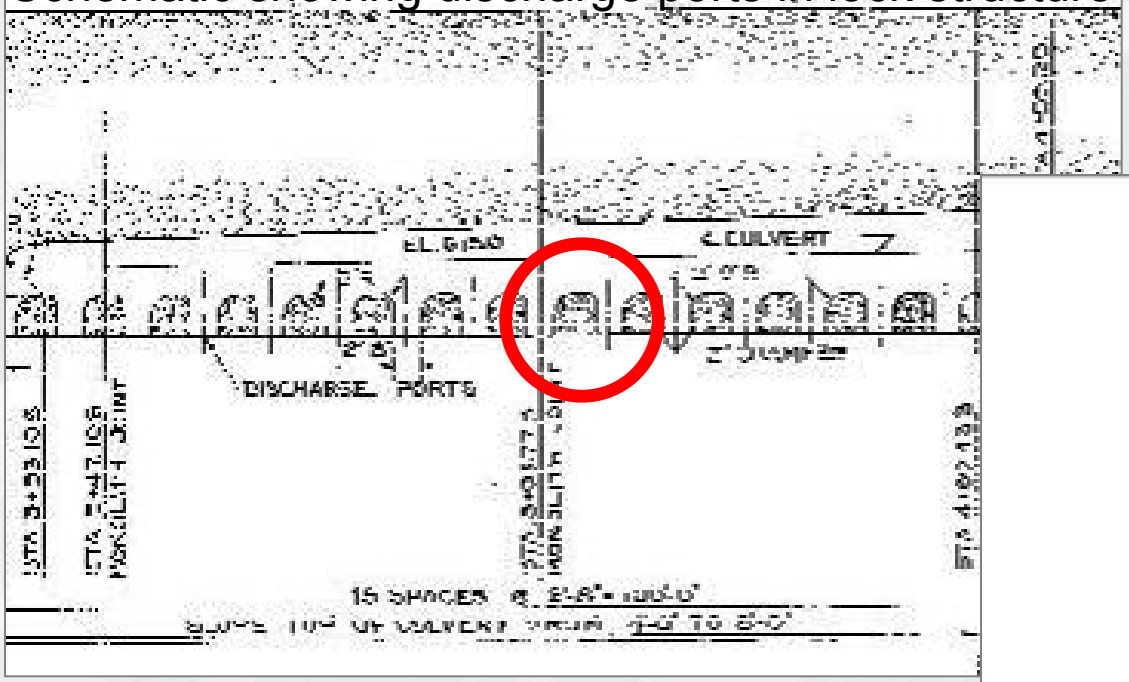
Miter gate FRP blocks (right side) on revolving (left) and stationary (right) door segments

FRP Miter Block Test

Current Demonstrations

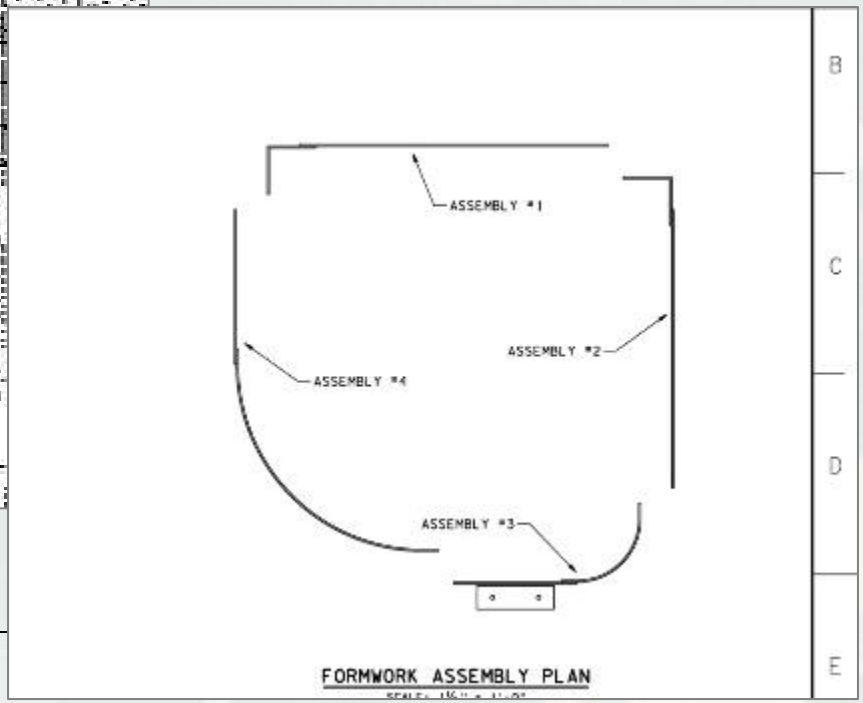
- **Repair concrete discharge ports at Chickamauga Dam in Tennessee.** Structural movement due to alkali aggregate reaction has caused cracks to develop on columns that define the discharge ports. Will repair using polymer mastic grout and composite wrap that cure underwater. Easier and more durable repair than using steel jackets and grout.

Schematic showing discharge ports in lock structure



Cracking concrete columns

Steel repair shell



Current Demonstrations

Repair concrete discharge ports at Chickamauga Dam in Tennessee.

Example cracking at exit ports.

Driver applying composite wraps on concrete piles underwater.

Current Demonstrations

Repair concrete discharge ports at Chickamauga Dam in TN.

- **Technologies to be demonstrated:**
  - **Water curing glass-fiber reinforced polymer fabrics and prepegs being investigated.**
- **Laboratory screening tests**
  - **To determine strength, cure, bondability, and durability in field exposure conditions**
  - **Laboratory screening tests currently underway**
- **Application of composite repair materials planned for July 13 timeframe**

Laboratory Testing to Determine and Compare Properties of Underwater-Cure FRP Composites

Concrete Cylinders for FRP Wrap Testing

Underwater Wrapping of Concrete Cylinders

Underwater Primer Application

Underwater Circumferential Banding (pressure application) over GFRP Wrap

Current Demonstrations

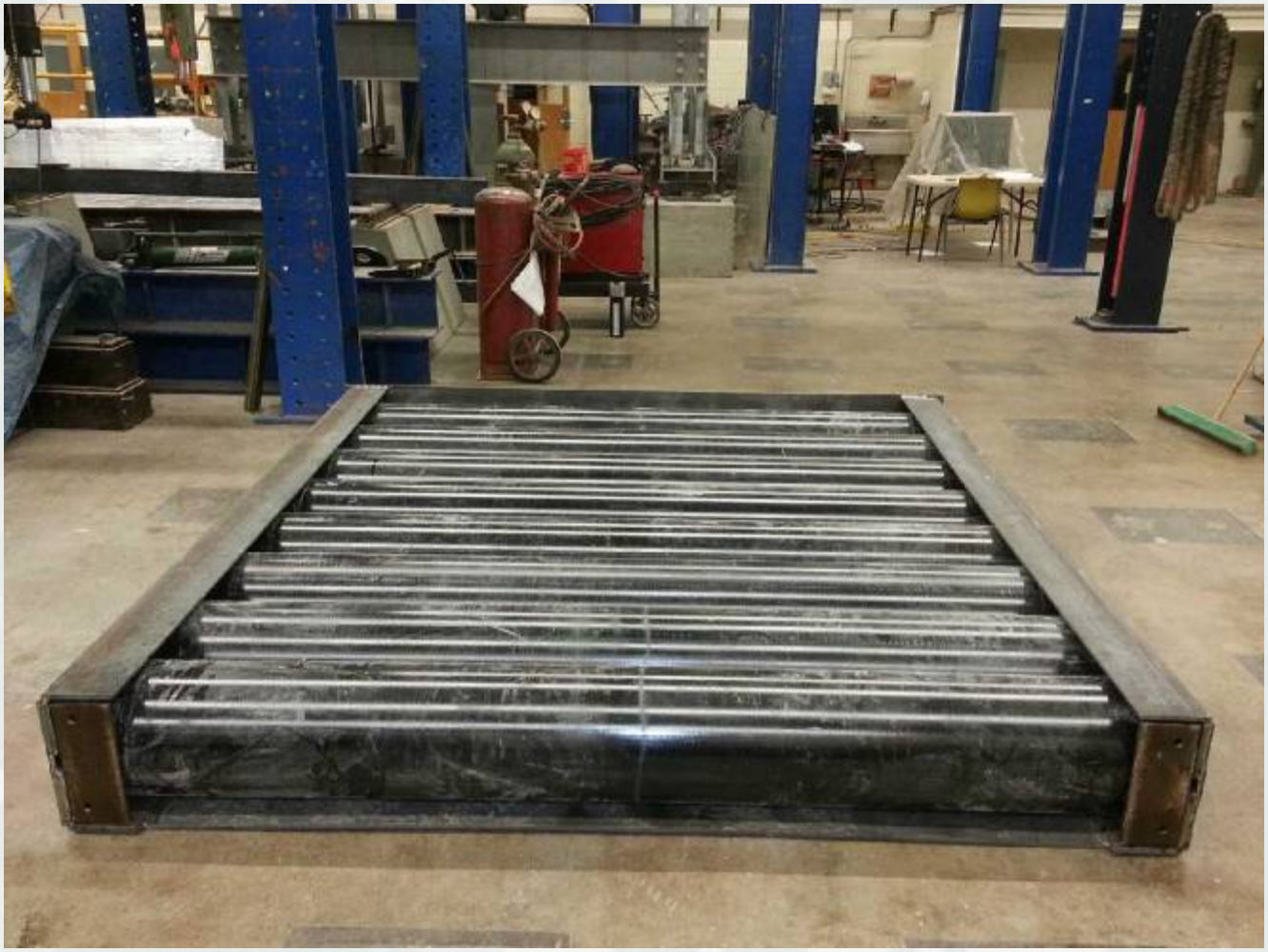
- **Recess Filler Panels at Willow Island Locks and Dam, Ohio.** Steel panels costly, heavy, and they corrode.

Current Demonstrations

Recess Filler Panels at Willow Island Locks and Dam, OH

- **Technologies to be demonstrated:**
  - **Fabrication of replacement panels using off-the-shelf materials and shapes**
- **Laboratory screening tests to determine acceptable performance to design requirements**
  - **Design revised based on field input to include protection FRP scheme with steel frame encasement**
  - **Lab tests scheduled to commence late January 2013**
- **Plan to deliver composite filler panels for field installation by March-April 13**

FRP Pipes, Steel Frame Fabrication, and Pipe Placement



FRP Pipes in Steel Casing
((Note: End plates are bolted & any FRP pipes/Sheets can be slid out or replaced, if there is local damage during service)

FRP Pipes and Top sheet in Steel Casing
(Note: End plates are bolted & any FRP pipes/Sheets can be slid out or replaced, if there is local damage during service)

FRP Recess Protection Panel Test

FRP Recess Protection Panel Test

Current Demonstrations

- **Abrasion - Resistant Overlays for Tainter Gates at Heflin Dam, AL.** Swirling debris quickly damages traditionally used vinyl coatings.

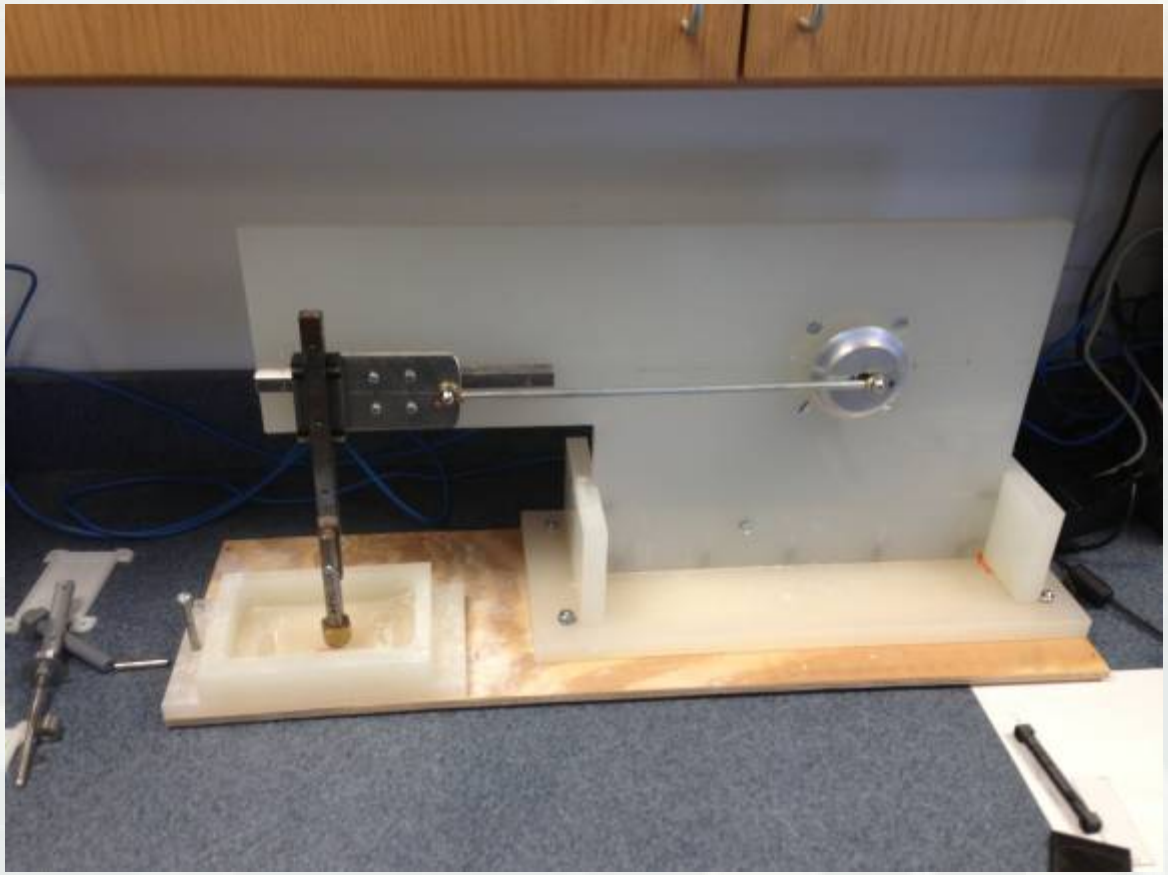
Use organic and ceramic composites for overlays

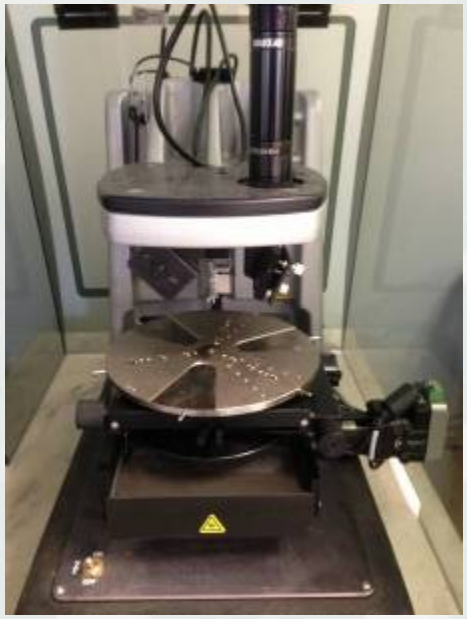
Current Demonstrations

Abrasion - Resistant Overlays for Tainter Gates at Heflin Dam, AL.

- **Technologies proposed to be demonstrated:**
  - **Ceramic composite coating (West Virginia University)**
  - **Filled, abrasion-resistant coating**
  - **Organic composite coatings (Custom, proprietary)**
- **Laboratory screening tests to compare performance of candidate systems to standard vinyl coating – underway**
- **Field Inspection Completed 17 October 12**
- **WVU currently conducting laboratory testing to compare abrasion resistance**
- **Application of demo materials planned for April-May 13 (when painting crew gets back to Heflin Dam)**

Laboratory Abrasion Testing





Reciprocating Abrading Steel Ball System (L) with Computerized Control & Profilometer (R)
(Note: the tank will accommodate both securing of specimen and conditioning with liquid)

Different Coatings Abraded with Reciprocating Steel Ball System

ARC 855 (Ceramic Composite)

Dura Plate

CoE Vinyl 3-a-z

Tar Guard

CoE Vinyl 5-e-z

Current Demonstration

- **Replace Frozen Rollers on Lift Gates at Bankhead Lock & Dam in AL.** The reaction rollers will cease up due to corrosion and drag when gate is raised or lowered. Will design a repair using polymer composite glides with no moving parts.

Current Demonstrations

Replace Frozen Rollers on Lift Gates at Bankhead Lock & Dam in AL.

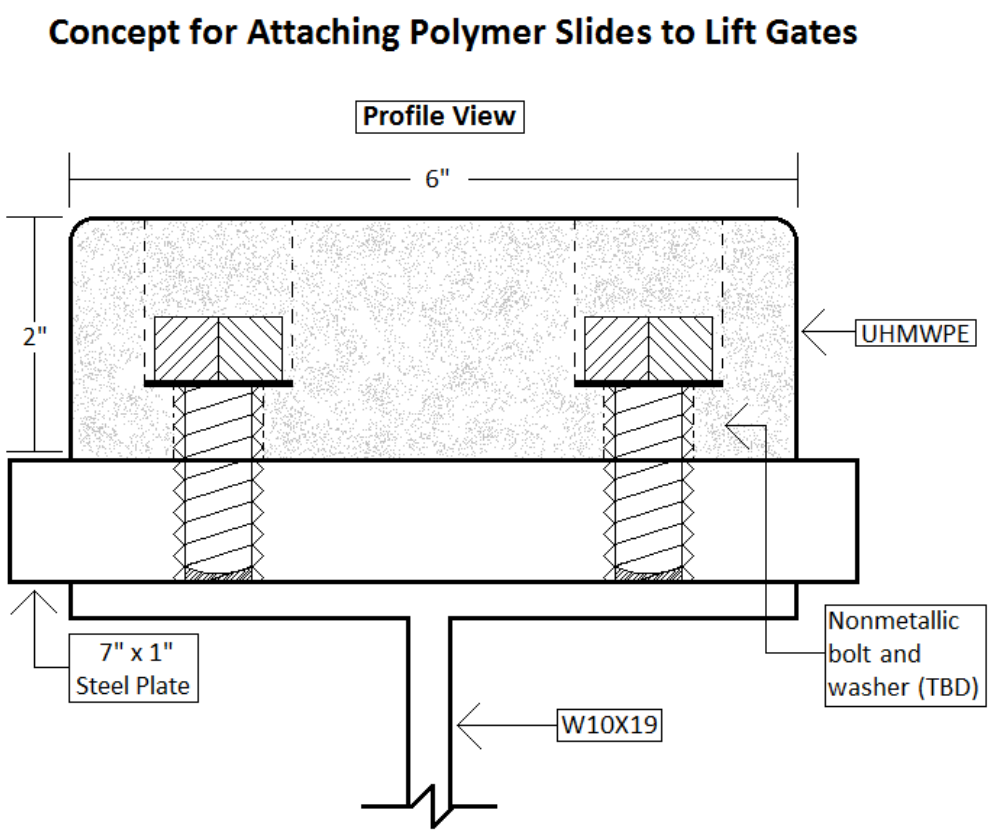
Replacing wheels on floating mooring bits with polymer slides.

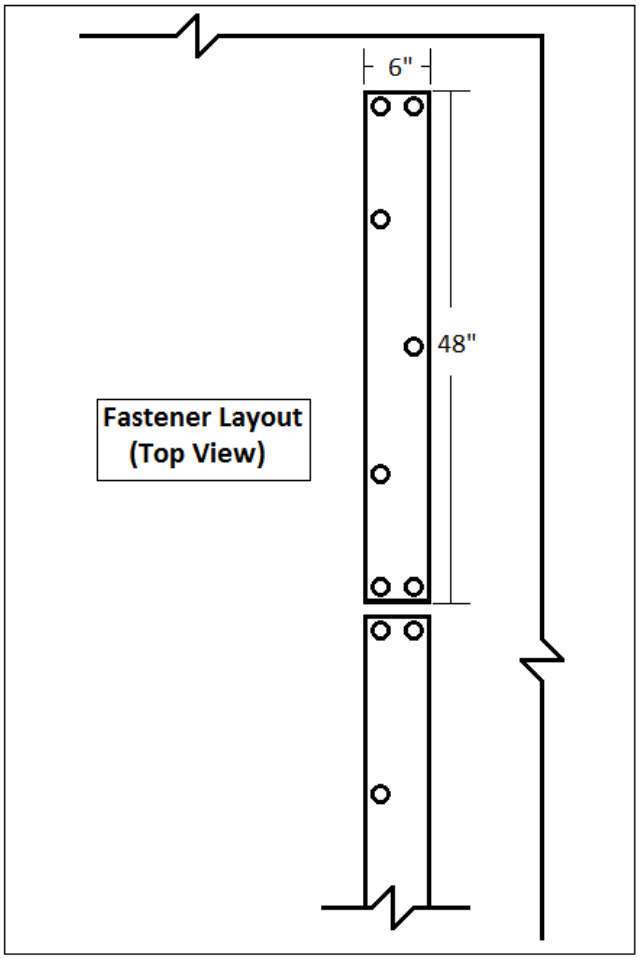
Current Demonstrations

Replace Frozen Rollers on Lift Gates at Bankhead Lock & Dam in AL.

- **Technologies to be demonstrated:**
  - **Reinforced high density polyethylene, UHMWPE, or cross-linked PE**
  - **Fabricate skid plates and polymeric bearing for test**
- **Site visit early December 2012 and met with site engineers**
- **Polymer slides supported on each side of the gate to replace rollers**
  - **Investigating different shapes and fastening techniques**
- **Implementation April-May 13**

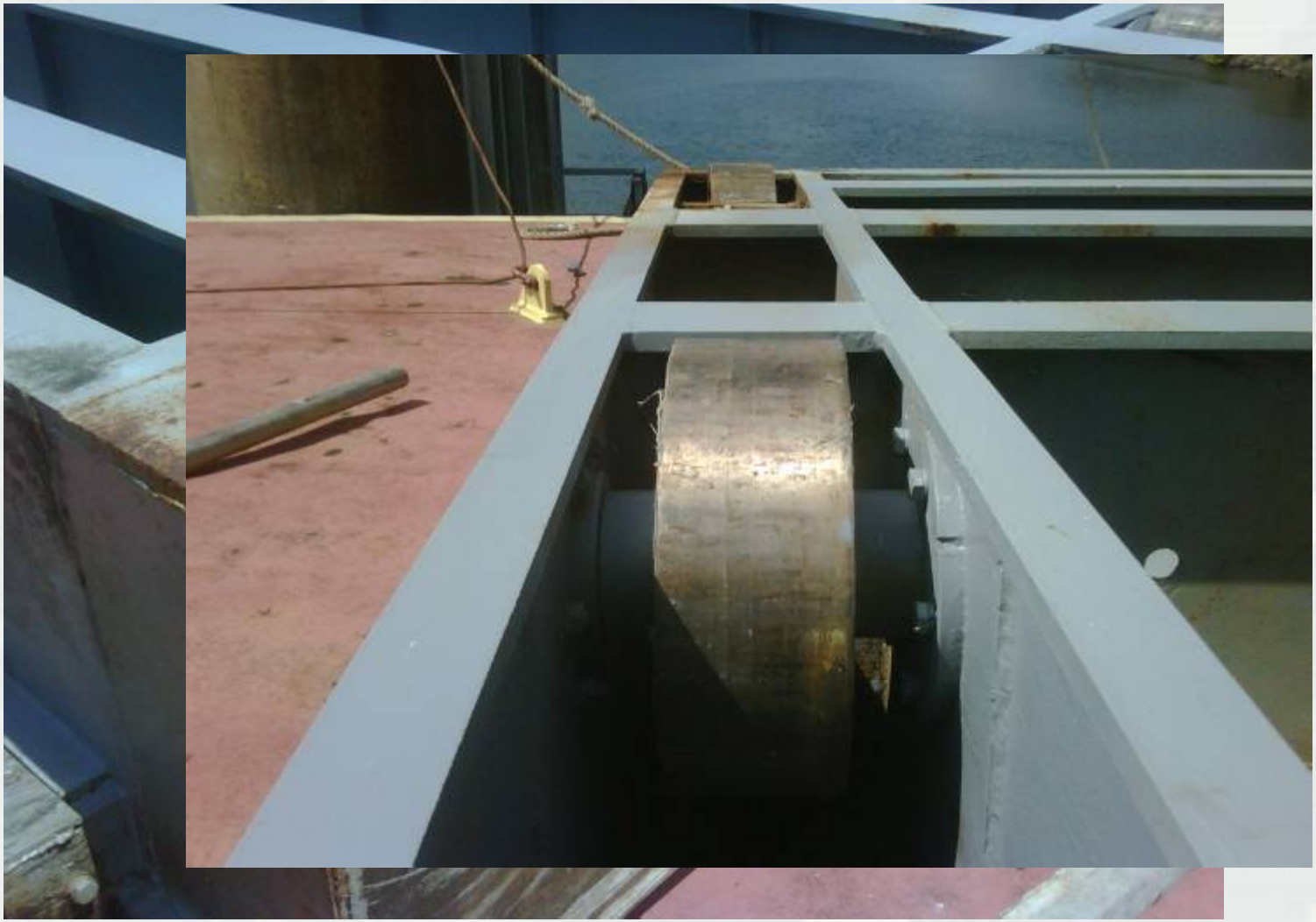
Concept for Slides





Bolt-through design

Concept for Slides



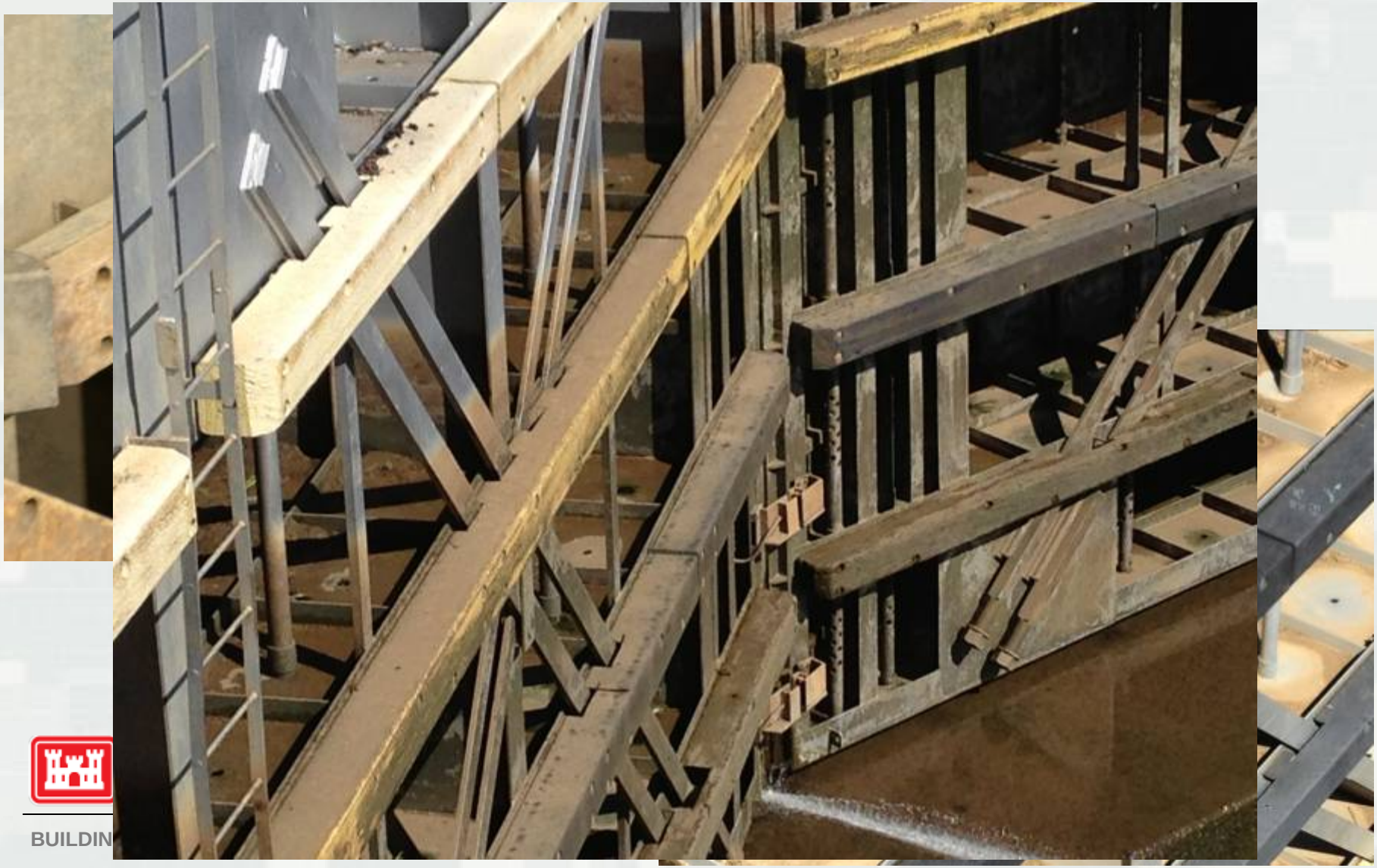
How to support?

FY13 Product Development Nav Structures

- **FRP Composite Timbers for Guide Walls and Gates.** Lack of guidance and mixed success with use.

FY13 Product Development Nav Structures

- **FRP Composite Timbers for Guide Walls and Gates.**



FY13 Product Development Nav Structures

- **FRP Composite Timbers for Guide Walls and Gates.**

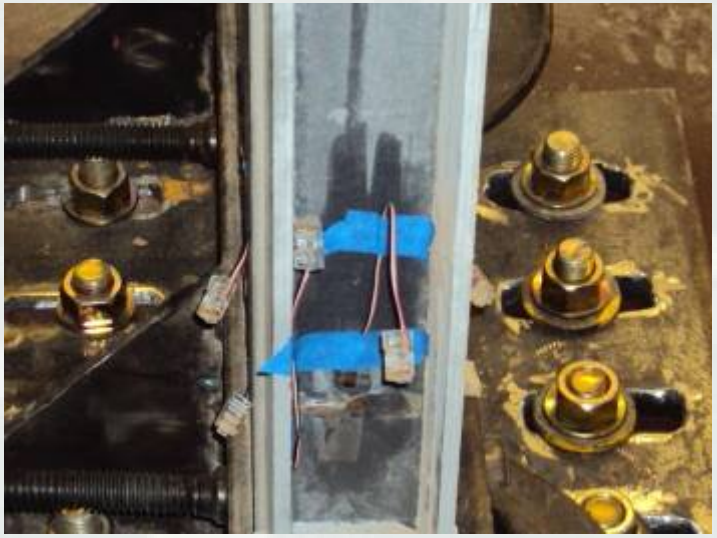
FY13 Product Development Nav Structures

- **FRP Composite Wicket Gates.** At Locks and Dam #52, 487 timber wicket gates, rapid deterioration, costly to replace.

FRP Wicket Gate Test

Steel Blocks and Adjustable Angle System bolted to Load Frame for testing 2’x10’ wicket gate (in excess of 600 kip load frame capacity over 4 bolts)

Strain gages on flange (near support)



Strain gages on web (near support)

Deliverables / Products in FY13

- Field demonstrations scheduled for completion July13.
- Selection Guide based on results of demonstrations.
- Technical report that includes economic analysis regarding demonstration results and benefits.
- Articles and topics in e-News and Civil Works webinars and Workshops as well as Tech Notes where appropriate.

Discussions/Questions ???

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