ERDC
Engineer Research and Development Center

Composite Materials for Steel H-Pile Bridge Repair

Lock Maintenance Workshop

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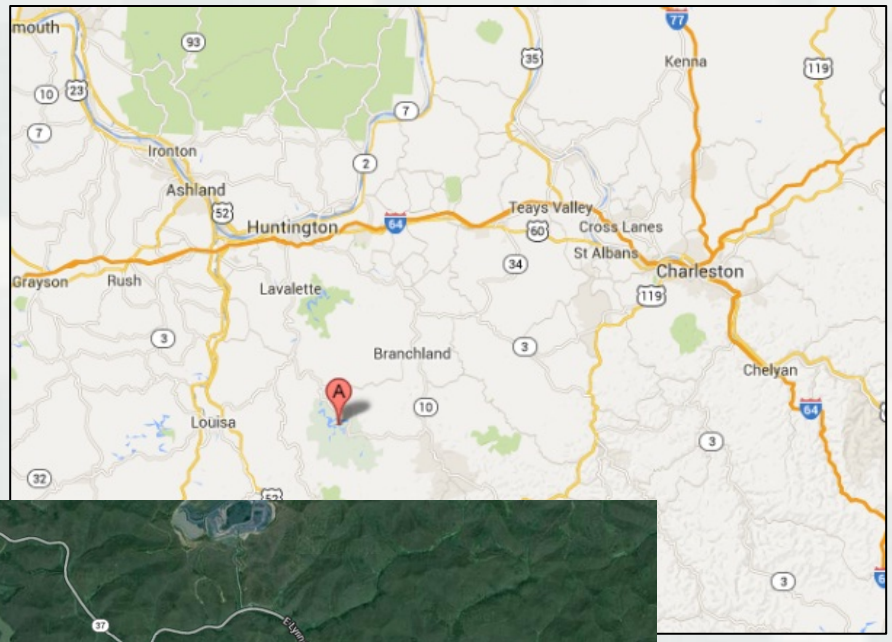
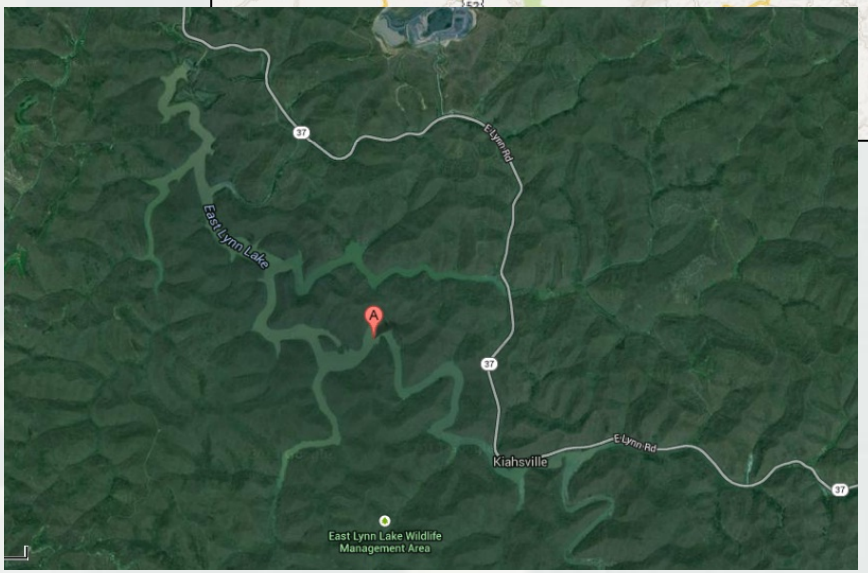
US Army Corps of Engineers®

Location

- Huntington District
- East Fork of Twelvepole Creek, East Lynn Lake, WV
- 35 mile south of Huntington, WV
- Constructed in 1970
- Camping
- Fishing
- Hiking
- Outdoor Recreation





East Fork Bridge

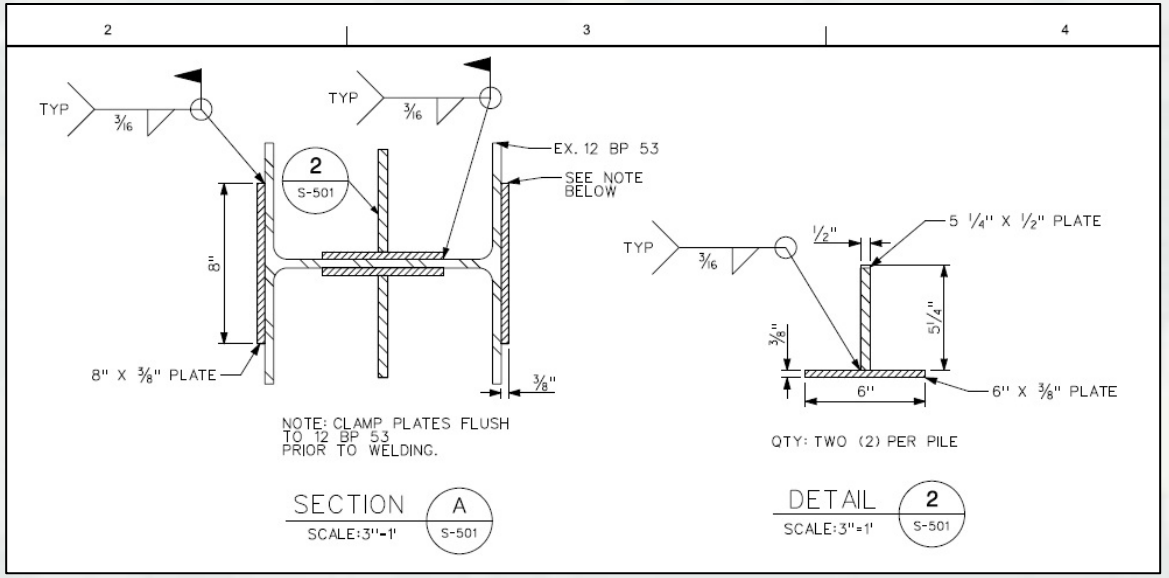
- **Built 1969**
- **Main access to Campground**
- **Length = 127 ft.**
- **Two lane, continuous reinforced concrete slab**
- **4 piers, 5 H-piles each**
- **8 ft. above seasonal pool, 14 ft. above winter pool**
- **Designed for H-15-44 Loading**

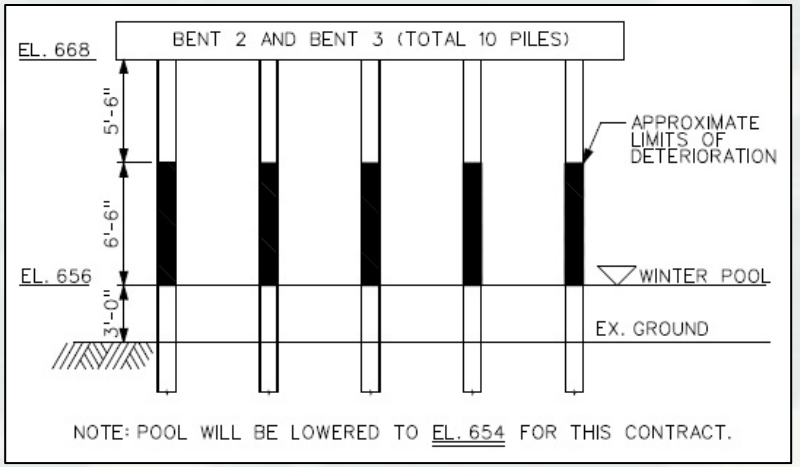
Problem

- **Active Corrosion – 2005 biennial inspection**
- **By 2009, corrosion progressed**
  - **Began 5′ 6″ below concrete cap**
  - **Extended 1′ to 2′ below winter pool line to mud line**
  - **4/16″ loss of 7/16″ flange**

Traditional Repair

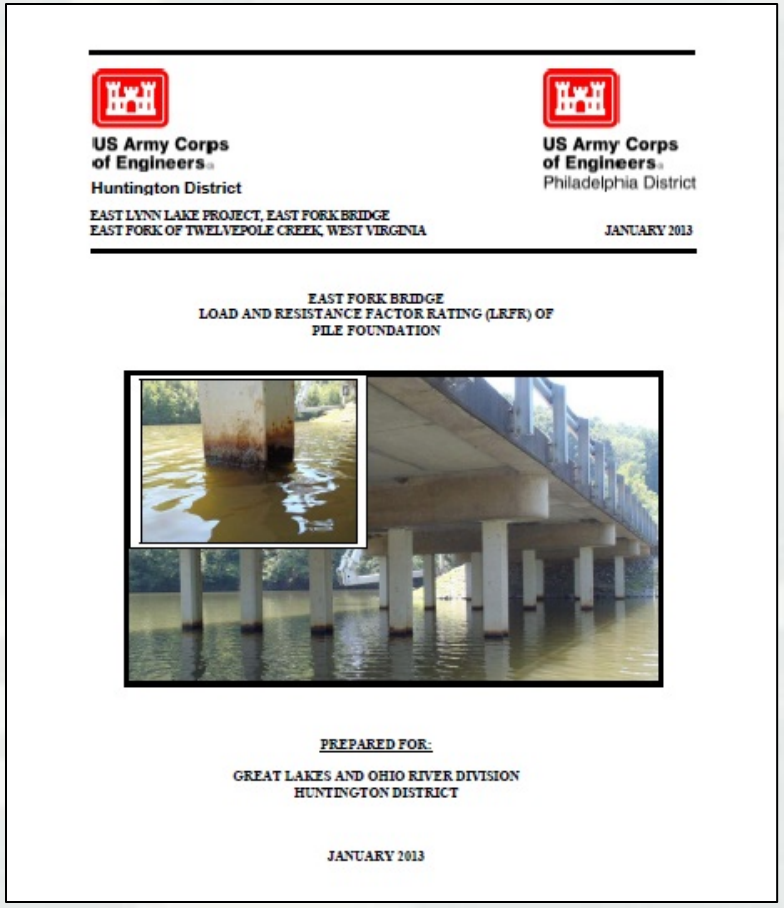
- **Engineering Huntington District**
- **Developed plans and specifications to repair**
  - **Sand Blasting**
  - **Welding new structural steel**
  - **Repainting**
- **Total Cost = $350 k**
- **Problem: No O&M money**





2013 Load Rating Analysis

- **Extreme Corrosion Loss – 50% in areas**
- **Philadelphia District performed analysis**
  - **Used section loss measurements**
- **Result**
  - **6 ton max**
  - **Single lane use**
  - **10 mph limit**
- **Effect**
  - **Large Campers and Boats banned from use**
  - **Difficult to enforce in environment**
  - **Extremely unhappy users**



US Army Corps of Engineers
Huntington District

US Army Corps of Engineers
Philadelphia District

EAST LYNN LAKE PROJECT, EAST FORK BRIDGE
EAST FORK OF TWELVEPOLE CREEK, WEST VIRGINIA

JANUARY 2013

EAST FORK BRIDGE
LOAD AND RESISTANCE FACTOR RATING (LRFR) OF
PILE FOUNDATION

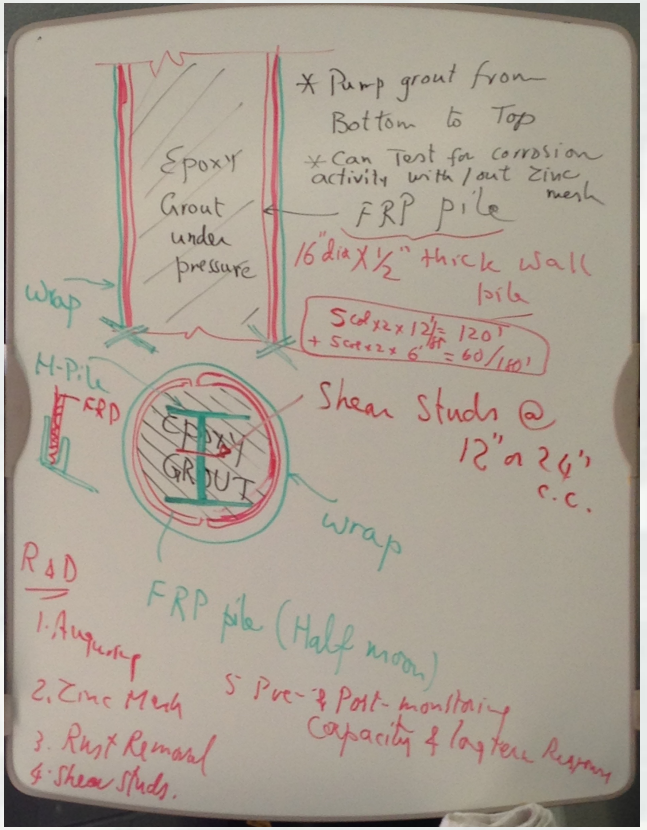
PREPARED FOR:

GREAT LAKES AND OHIO RIVER DIVISION
HUNTINGTON DISTRICT

JANUARY 2013

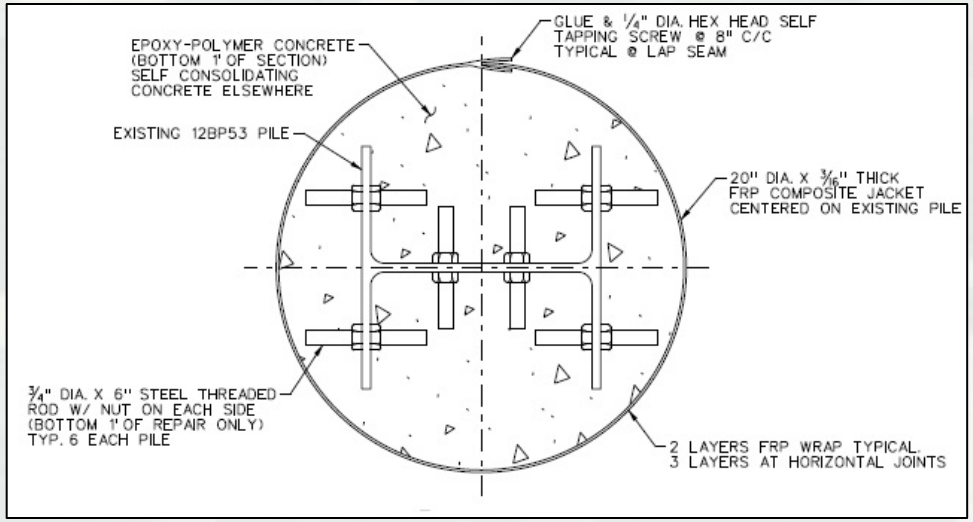
Innovative Solution

- **Team**
  - CELRH Engineering Construction Division
  - ERDC Construction Engineering Research Laboratory
  - WVU Constructed Facilities Center
  - East Lynn Lake O&M
- **Needed a quick solution**
  - Required a great deal of communication and collaboration
- **Proposed Repair Materials**
  - Fiber reinforced polymer (FRP) wrap (Air Logistics – Aquawrap) – Chickamauga Dam
  - FRP Shell (Simpson Strong-Tie FX-70 Jacket)
  - Epoxy Grout
  - Self consolidating concrete



Repair Procedure

- **De-water Bridge Piles**
  - Dug channel between piers 2 & 3
  - Water pump out
- **Erect scaffolding**
- **Dig out H-piles**
  - 1′ below corrosion line
  - Pressure wash H-piles
- **Drill and install shear studs**
  - 3/16″ X 6″ threaded steel rod w/ nut on each side
  - Located 11″ below corrosion line
- **20″ diameter FRP shell w/ 3/16″ thickness placed**
  - Tongue & Groove joint glued and fastened w/ SS screws
  - Epoxy Grout poured



Repair Procedure (cont.)

- **Continue installing shells up piles**
  - **Tongue & Groove glued**
  - **Bell of shell dropped over lower section**
  - **Tongue & Groove fastened along w/ bell to lower shell**
- **Slots cut in upper shell near concrete cap**
- **Concrete pour spouts assembled and installed**
  - **Wood**
  - **Fastened with tie downs**

Repair Procedures (cont.)

Repair Procedure (cont.)

- **FRP Wrap around shells**
  - 2 layers with 3 layers around horizontal seams
  - Wrap is impregnated with a moisture cure urethane resin
  - Required water to be constantly sprayed during wrapping
- **Apply stricture banding**
  - 3 to 4 wraps required
  - Perforation tool used to make holes to allow gases from chemical reaction to escape
  - 2 hour cure time before removal of stricture banding
- **Stricture banding removed after cure**

Repair Procedure (cont.)

Repair Procedure (cont.)

- **Self Consolidating Concrete Pumped In**
- **Mortar Applied to fill in gap between repair materials and concrete cap**
- **Mortar wrapped**
- **Epoxy coating applied**
- **Scaffolding Removed**
- **Dirt back filled**
- **Riprap placed**

Repair Procedure (cont.)

Sensors

- **Corrosion**
  - Two (2" X 2") steel plates imbedded 2" apart in a 3" X 3" concrete block
- **Temperature & Humidity**
  - 2 Sensirion SHT1x embedded in 3" x 3" concrete block
- **Strain Gauges**
  - Beam
    - 2 Vishay w/ ¼" length to measure axial strain of pile
  - FRP Wrap
    - 2 Vishay w/ ¼" length to measure axial and hoop strain of wrap
  - Concrete
    - 2 Vishay w/ 4" length to mounted to bottom of concrete pile cap

Load Test

- **Load Test Conducted with 19 ton WV DOT truck**
- **Decreased beam stress by a factor of 10 from pre-repair levels while using twice the load**
- **Increased load capacity 2.2 times original design load capacity**

Load Test Data

			Normalized Stresses (psi/kip of truck load)				Reduction	
			Static Testing		Dynamic Testing			
Sensor	Location	Type	Pre-repair	Post-repair	Pre-repair	Post-repair	Static	Dynamic
Strain 1	Bent 2 Pile 3	Beam - Axial	-19.3	-1.9	-20.6	-5.7	10%	28%
Strain 2	Bent 2 Pile 3	Beam - Axial	-20.6	-2.0	-22.8	-6.2	10%	27%
Strain 3	Bent 2 Pile 4	Beam - Axial	-16.5	-1.2	-15.1	-5.1	7%	34%
Strain 4	Bent 2 Pile 4	Beam - Axial	-17.3	-1.7	-15.8	-5.3	10%	33%
Strain 5	Bent 1 Pile 3	Beam - Axial	-11.0	-2.0	-13.1	-4.3	18%	33%
Strain 6	Bent 1 Pile 3	Beam - Axial	-11.0	-1.9	-13.1	-4.2	17%	32%
Strain 7	Bent 2 Pile 3	Wrap - Axial	N/A	-0.1	N/A	0.7	N/A	N/A
Strain 8	Bent 2 Pile 3	Wrap - Hoop	N/A	0.3	N/A	-2.7	N/A	N/A
Strain 9	Bent 2 Upstream	Concrete Cap	ND	0.4	ND	0.4	N/A	N/A
Strain 10	Bent 2 Downstream	Concrete Cap	ND	0.6	ND	0.7	N/A	N/A

Benefits

- **Short 6 wk construction duration**
  - **Vast majority of work took 1.5 weeks**
- **Smaller labor force**
  - **9-12 people at any given time, but could have been done with 6**
- **Construction cost savings of 35% from conventional repair**
  - **$115k vs $350k**
- **Low maintenance**
  - **No need for repainting**
  - **Materials encase steel H-piles and arrest corrosion**
- **Longer life**
  - **Composite repaired H-piles lifetime expectancy to exceed life of bridge deck**
  - **Original repair had a lifetime expectancy of just 10-15 years**

Awards

- **2014 Great Lakes and Ohio River Division Engineering Excellence Award**
- **2014 USACE Innovation of the Year Award**
- **ERDC CERL Excellence in Operational Support Award**

Team

- **ERDC-CERL:** Rich Lampo, Jeff Ryan, Henry Diaz-Alvarez
- **WVU:** Dr. Hota GangaRao, Mark Skidmore, Dr. Ray Liang, P. Vijay, Dr. Udaya Halabe
- **EC:** John Clarkson, Chris Chandler, Patrick Luff, Jerry Casto, Anna Hayes
- **OR:** Dale Smith, Leslie Stone-Smith, Jeremy Leslie, Howard Dyer, David Blankenship, Barley Fink, William Riffe, Waitman (Jay) Davis Jr., Justin Pyles, Stacy Turner, Willie Mills, Bryce Davis, Aaron Harmon, Scott Kinzel, and Jake Pauley

Questions ???