CFR Polymer is Perfect Rehab for Ohio Levee System Culvert

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Presentation Outline

- Introduction to FRP
- Project Background
- Installation
- Inspection
- Conclusion

Fiber-Reinforced Polymer (FRP)

The Tyfo® fiber-reinforced polymer (FRP) system are designed to increase the structural performance of existing PCCP, RC and steel pipes. Fibrwrap® Construction, an Aegion company, is the exclusive installer of the Tyfo ® FRP pipeline repair system for pipelines.

CFRP Rehabilitation Capabilities

<u>Pressure range</u>

Up to 400+ psi

Vacuum pressure

(to 14.7 psi)

<u>Diameter range</u>

Medium – Large pipe

30” to 252” (internal)

Glass Fiber Systems

- Glass Fibers
  - Tyfo® SEH-51A
  - Tyfo® WEB
  - Tyfo® BC
- Epoxies
  - Tyfo® S Epoxy
  - Tyfo® SW1S Epoxy
  - Tyfo® S-T Epoxy
  - Thickened Tyfo® S and Tyfo® S-T Epoxies

Tyfo® SEH-51A

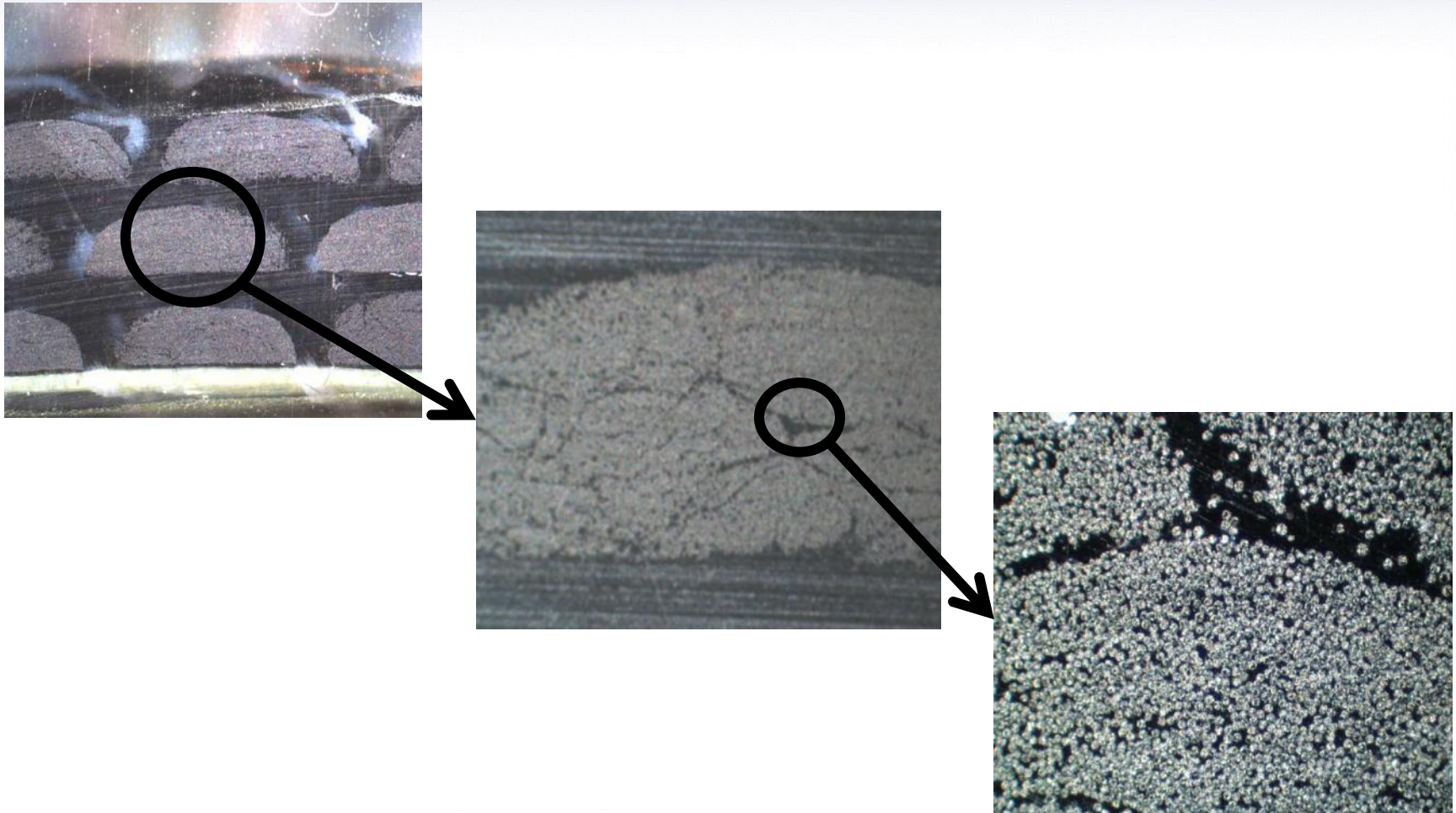
Tyfo® SCH Systems – Carbon Fiber Systems

- Carbon Fibers
  - Tyfo® SCH-41
  - Tyfo® SCH-41-2X
  - Tyfo® SCH-Mark V
  - Tyfo® SCH-11UP
  - Tyfo® UC Strips
- Epoxies
  - Tyfo® S Epoxy
  - Tyfo® SW1S Epoxy
  - Tyfo® S-T Epoxy
  - Thickened Tyfo® S and Tyfo® S-T Epoxies

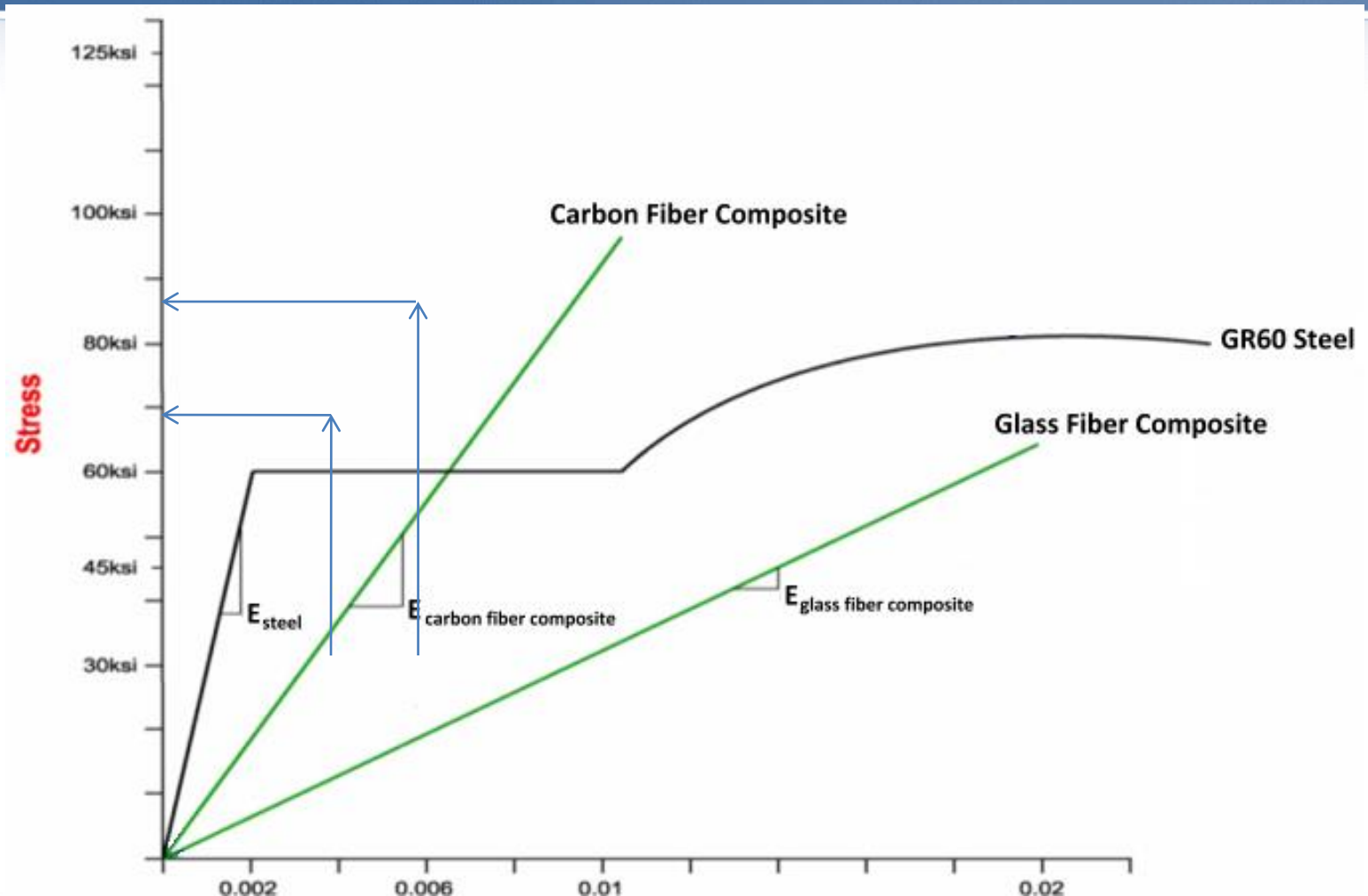
Tyfo® SCH-41

Tyfo® SCH-Mark V

Carbon Fiber Reinforced Polymer (CFRP): Properties are based on the fiber and durability is based on the polymer



Stress-Strain Behavior Illustrates Critical Design Principals



Typical CFRP Design Approach

- Consider degradation level of host pipe
- Stand-alone (fully structural design) versus composite design (with inner core)
- Use Load resistance factor design/AWWA C305 (LRFD)

Circumferential Design

Limit State	Loads
CFRP Rupture (2)	1-Internal pressure 2-Internal pres. + External Loads
Buckling	External loads: Groundwater + Vacuum
Debonding	Empty pipe under

Longitudinal Design

Limit State	Loads
CFRP Rupture	Internal pressure (Thrust, Poisson) + Temperature
Debonding	Internal pressure (Thrust, Poisson) + Temperature
Buckling	Temperature

FRP Codes-Reports-Design Guidelines

Code/ Report	Code Title	Date
AWWA C305	CFRP Renewal and Strengthening of PCCP	Dec-18
AWWA C304-04	Prestressed Concrete Pressure Pipe, Steel Cylinder Type	Dec-07
AWWA M11	Steel Water Pipe - A Guide for Design and Installation	Jul-04
ASME PCC-2	Repair of Pressure Equipment and Piping	Apr-11
ASME B31.1	Power Piping (ASME Code for Pressure Piping, B31)	Jun-12

Uses of FRP Rehabilitation Systems

- Structural rehabilitation
  - Segmental repairs
  - Full length repairs
  - Fully structural rehabilitation
  - Single criteria requirement – pressure, transient, broken back, joint rehab
- Joint rehabilitation
  - Leak remediation
  - Structural strengthening
- Reinforced coating application
  - Durable coating
  - Nominal strength

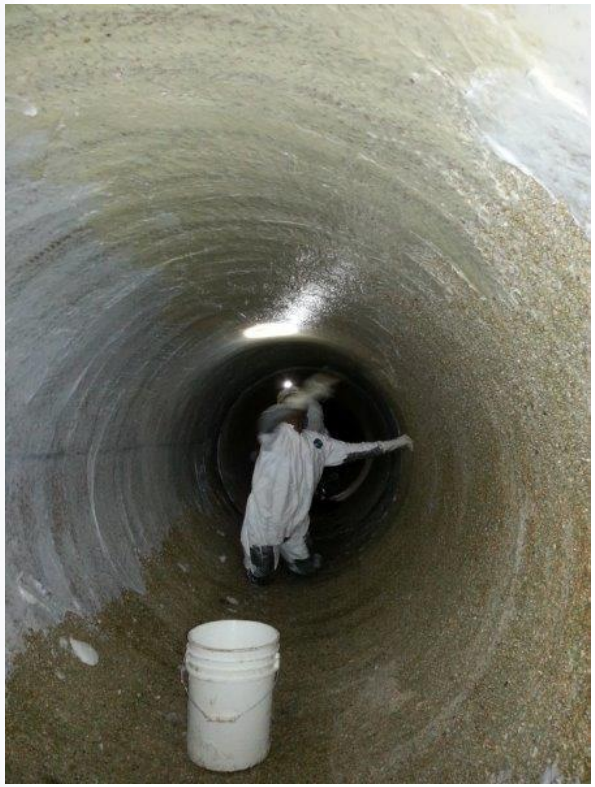
FRP Installation Method
STEP 1: SURFACE PREPARATION

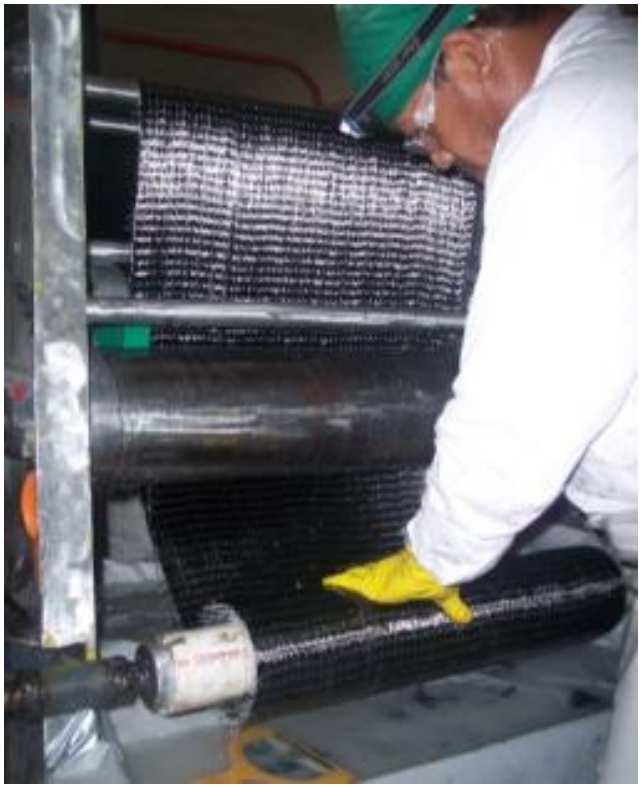
Sand Blasting Equipment

Finished Surface - Concrete

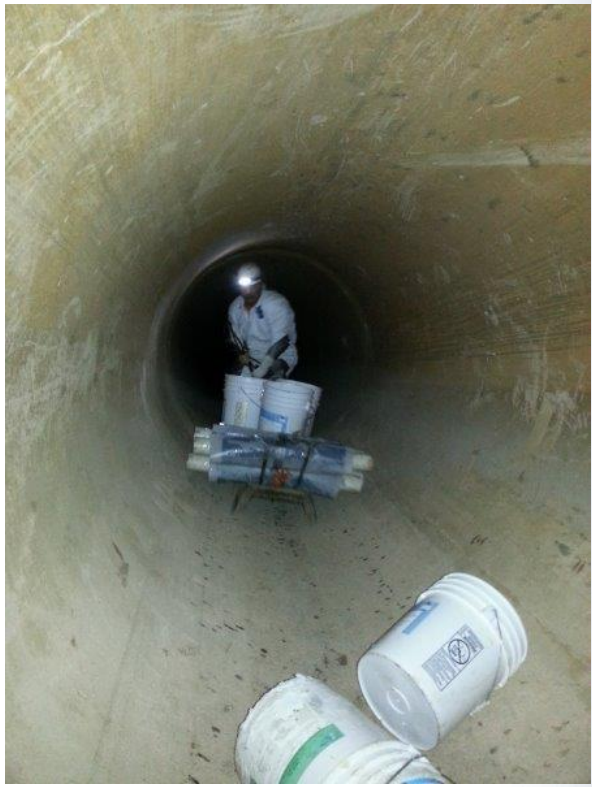
FRP Installation Method
STEP 2: PRIMER / SATURATION

Surface Primer





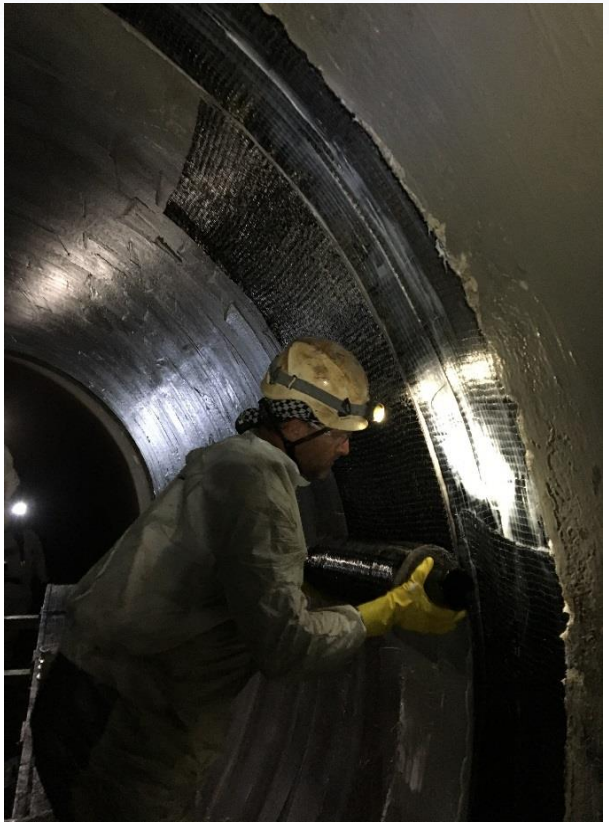
Material Transport



CFRP Impregnation

Installation Method
STEP 3: FRP SYSTEM INSTALLATION

Circumferential layer



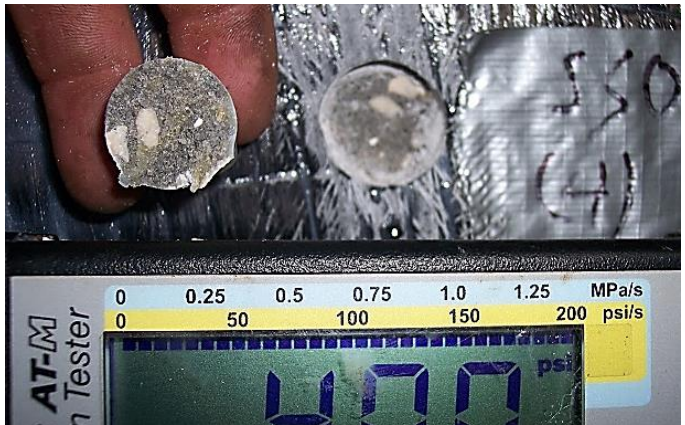
Circumferential layer installation

QA/QC Process

- Continuous Inspection conducted by Quality Control Specialist (QCS)
- Selected QA/QC steps documented
  - CFRP material manufactured by an ISO 9001:2015 certified company
  - Verify installation is in accordance with drawings and specifications
  - Condition of host pipe
  - Control of air flow, temperature, and humidity
  - Surface preparation
  - Adhesion tests
  - Material saturation
  - Application (details, timing)
  - Termination details
  - Preparation of witness panels
  - Post-installation inspection
  - Curing (85% cure before service)

In-Situ Quality Control Testing
ASTM D4541 – Adhesion Testing

- Minimum (3) 2 ft x 2 ft panels on adjacent non-repair pipes
- Prepared and tested by Installer (ASTM D4541)
- Witnessed by Inspector
- >200 psi required for at least 3 tests per panel
- Failure mode may affect design approach!



Testing of Witness Panels after Construction

- Prepared by the Installer, witnessed by the Inspector, tested by the Independent Testing Agency
- Three panels or one panel per day per work shift, whichever is greater
- One layer of CFRP
- Preparation of panels spread throughout construction

Case Study – Zoar Levee
Unique Project Requirements

- 36” reinforced concrete box culvert rehabilitation
- Operated by US Army Corps of Engineers
- The box culvert structure is critical for dam safety
- Box culver joints were cracked and damaged due to service conditions
- The FRP composite wrap was designed to prevent soil erosion behind the culvert and to maintain dam integrity
- The FRP wrap was used in conjunction with concrete repairs
- The FRP wrap supported watertight requirements and nominal strength requirements

Case Study – Zoar Levee
Ventilation and Dehumidification

Case Study – Zoar Levee
Unique Project Requirements

- Background and E-verify checks
- USACE safety practices
- Confined space entry plan and rescue team
- Cleaning and jetting of culvert
- Pre and Post CCTV
- Ventilation
- Surface preparation
- Inspection and QC testing (ASTM D3039 and D4541)
- Materials contain 0% VOC
- 22 joints repaired

Case Study – Zoar Levee
Unique Project Challenges

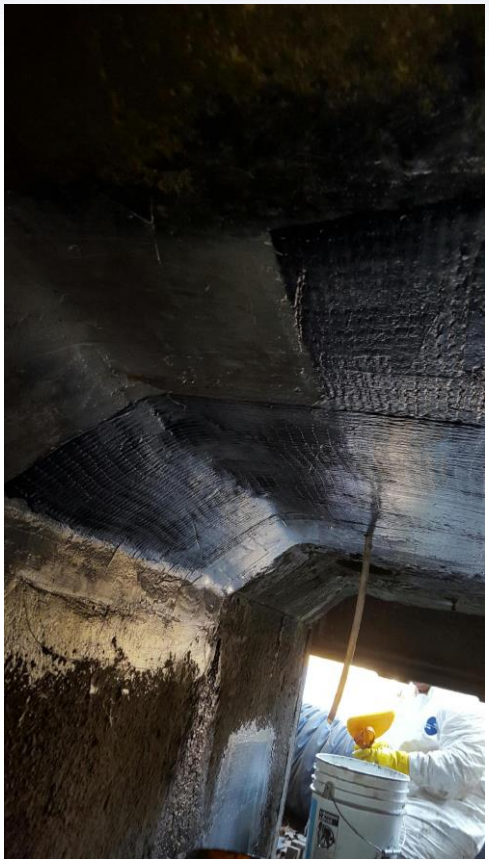
- Small site setup footprint
- No truck access was allowed on the levee walls and hence a CIPP crew was not allowed to enter the site
- Hydraulic capacity requirement prevented the loss of cross sectional area
- CIPP liners would reduce the culvert hydraulic capacity
- The USACE required a repair method to prevent sink holes at the dam structure

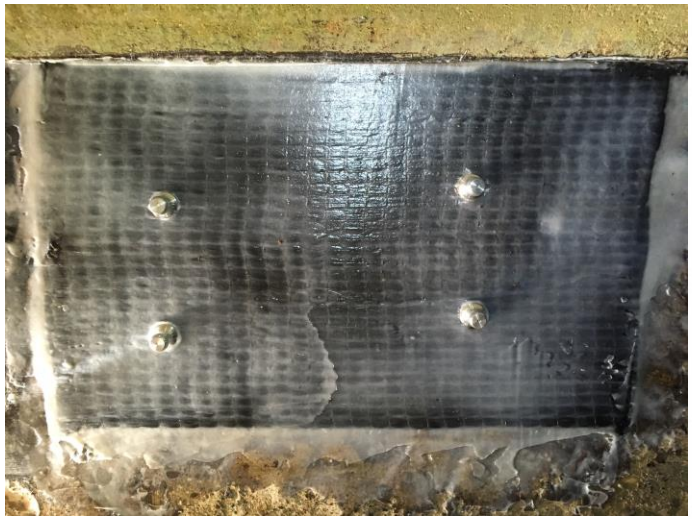
Case Study – Zoar Levee Concrete Repairs

Case Study – Zoar Levee
Installed FRP Composite System

CFRP joint repair

Case Study – Zoar Levee
FRP Material Inspection





Conclusions

- Unique box culvert structure was successfully rehabilitated with FRP materials
- Joint rehabilitation or spot repairs for pipes or box culverts can be cost effectively rehabilitated with FRP materials
- The concrete repairs and FRP materials effectively provide the leak prevention and nominal strengthening required by project
- The project team was able to support all required safety, quality control, logistics and structural criteria
- The project team delivered the project on time and on budget

Thank you!

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