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Advanced Pile Encapsulation

Solutions for the Repair and Protection of Underwater Structures

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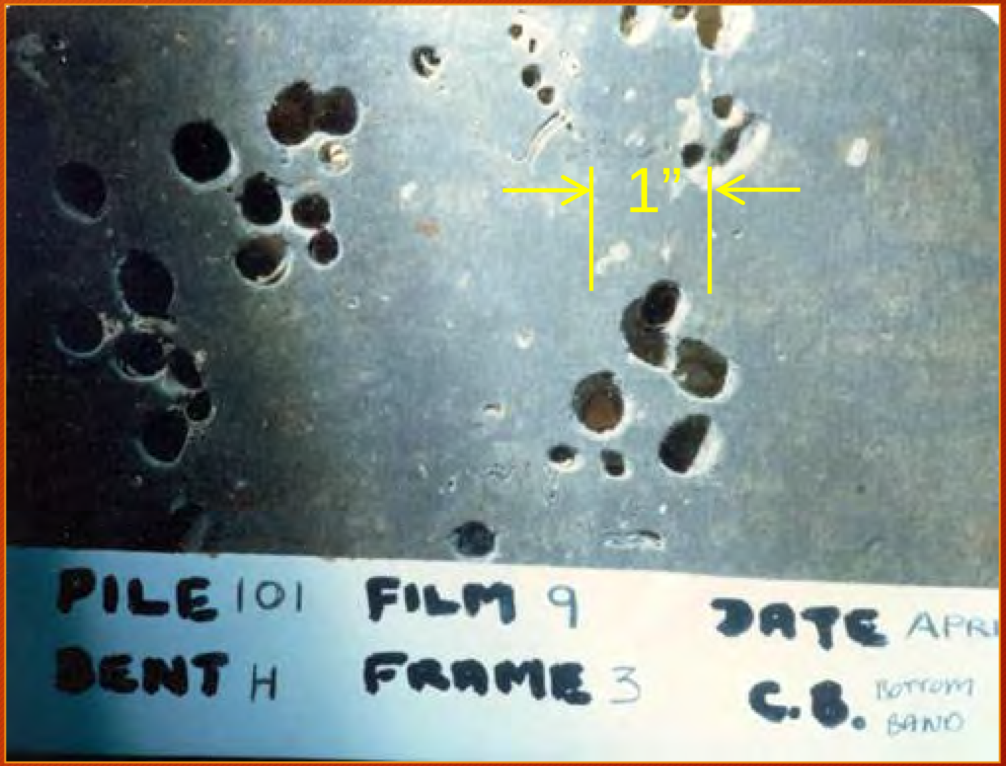
BASF
We create chemistry

LPG Trestle, Ju’Aymah, Saudi Arabia

- Trestle constructed in 1980
- Precast concrete cylinder piles

LPG Trestle, Ju’Aymah, Saudi Arabia

- Routine inspection in 1983 (3 years after construction) revealed severe marine borer attack
- 616 piles affected



LPG Trestle, Ju’Aymah, Saudi Arabia

- The owner required that the repair method…
- Would eradicate the existing borers
- Would repair the damage done by the borers
- Would not be susceptible to future borer attack
- Would stay in place and continue to provide protection for 20+ years without any maintenance

LPG Trestle, Ju'Aymah, Saudi Arabia

- The 616 piles were encapsulated using the advanced pile encapsulation technique in 1984

Repairing Marine Structures

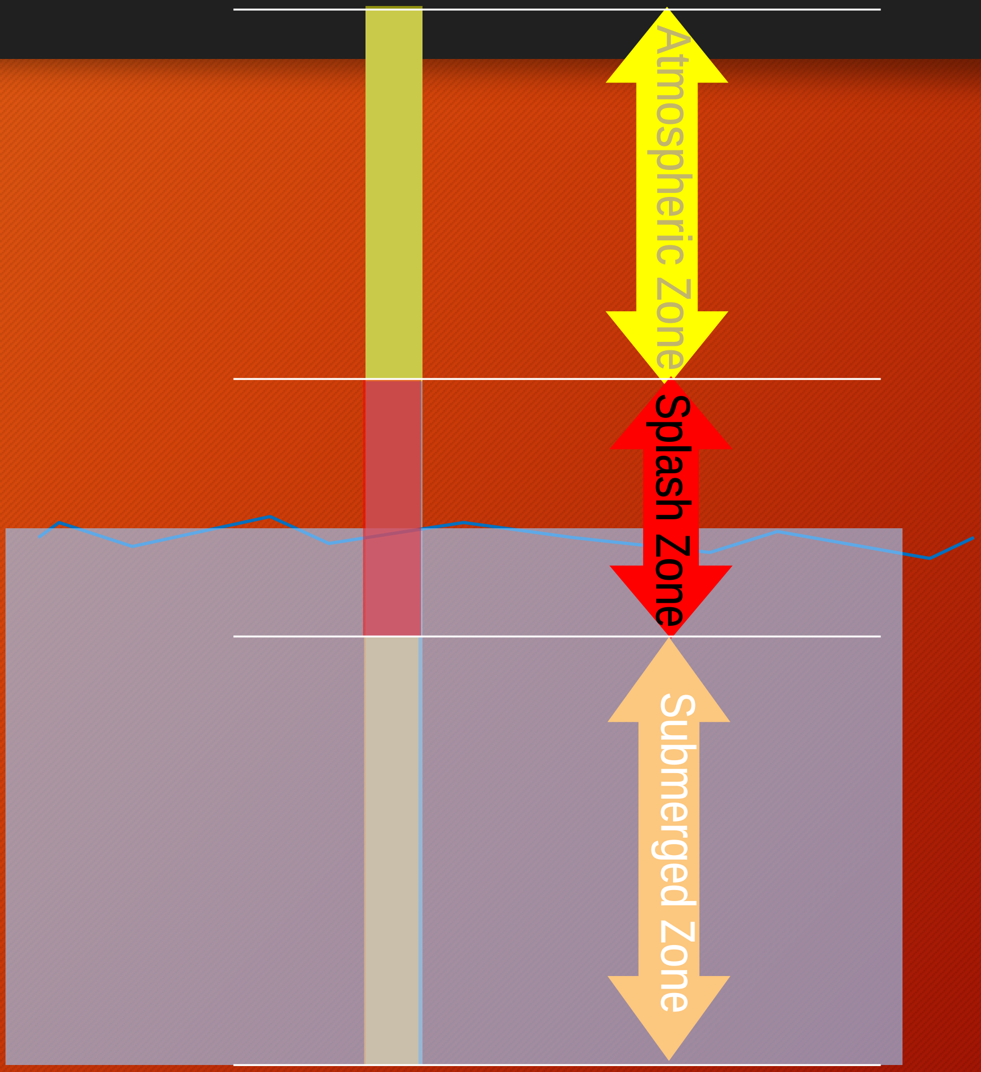
- Marine Structures
  - Submerged Piles
  - Submerged Piers
  - Seawalls
  - Dams / raceways
  - Offshore Platform Supports

The Need for Repair and Protection

- Marine Environment
  - Highly Corrosive Environment
  - Susceptible to Rot
  - Attack from Marine Organisms
  - Damage from Scour and Abrasion

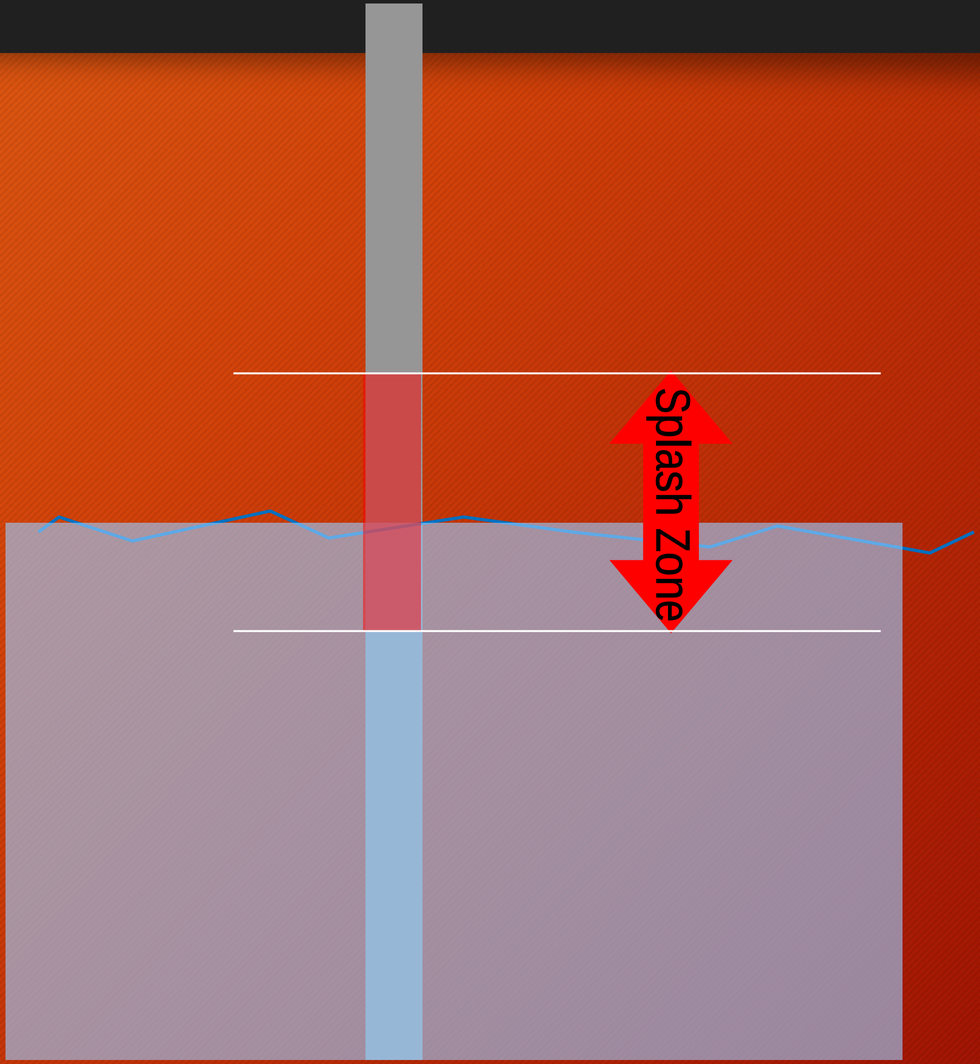
Repairs to Marine Structures

- Repair Zones
  - Atmospheric Zone
  - Splash Zone
  - Submerged Zone



Repairs to Marine Structures

- Splash Zone
  - Wetting & Drying Cycles
  - Available Oxygen
  - Heavy Wear & Abrasion

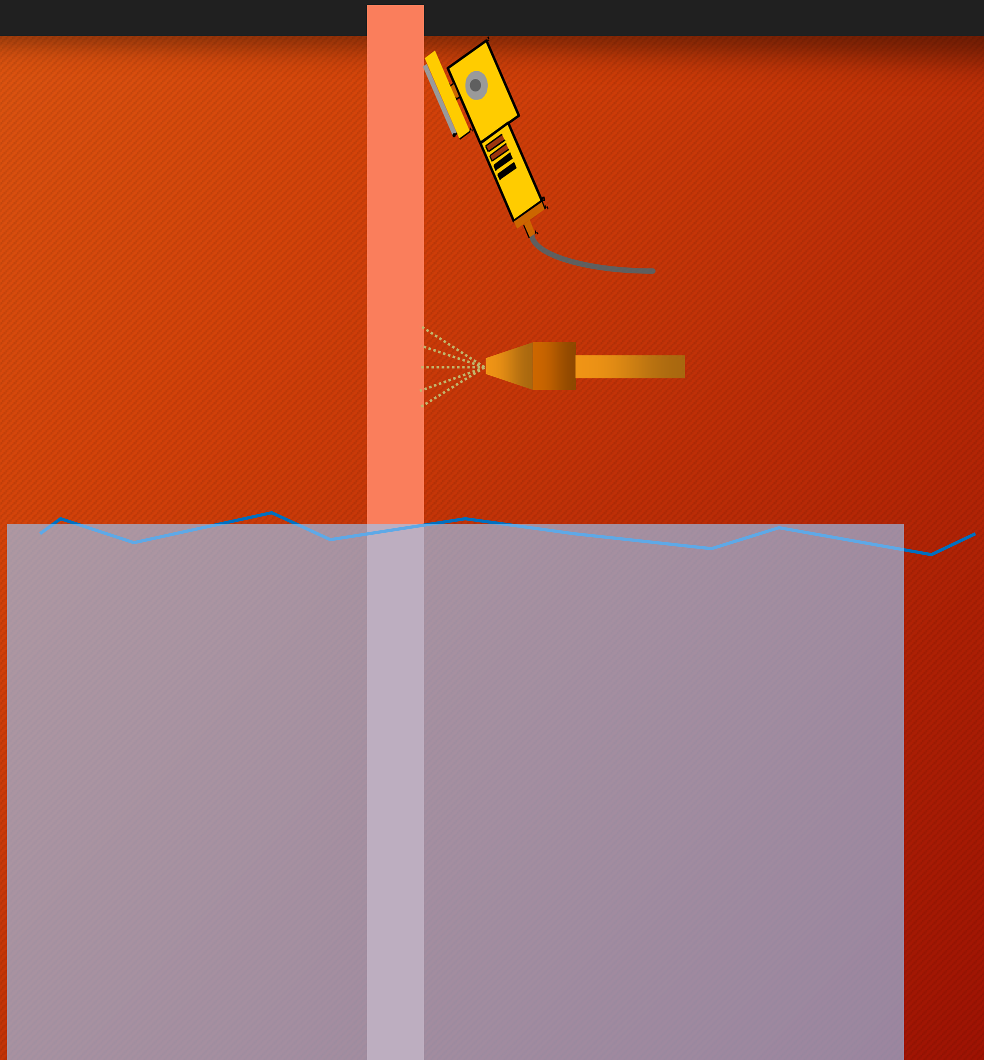


Repairs to Marine Structures

- Repair Challenges
  - Durability of Materials for Repair / Protection
  - Adequate Performance of Materials for Repair / Protection
  - Proper Placement of Materials for Repair / Protection

The Encapsulation Process

- <u>Step 1</u>
  - Surface preparation
  - Remove marine growth
  - Clean rust and scale
  - Profile substrate



The Encapsulation Process

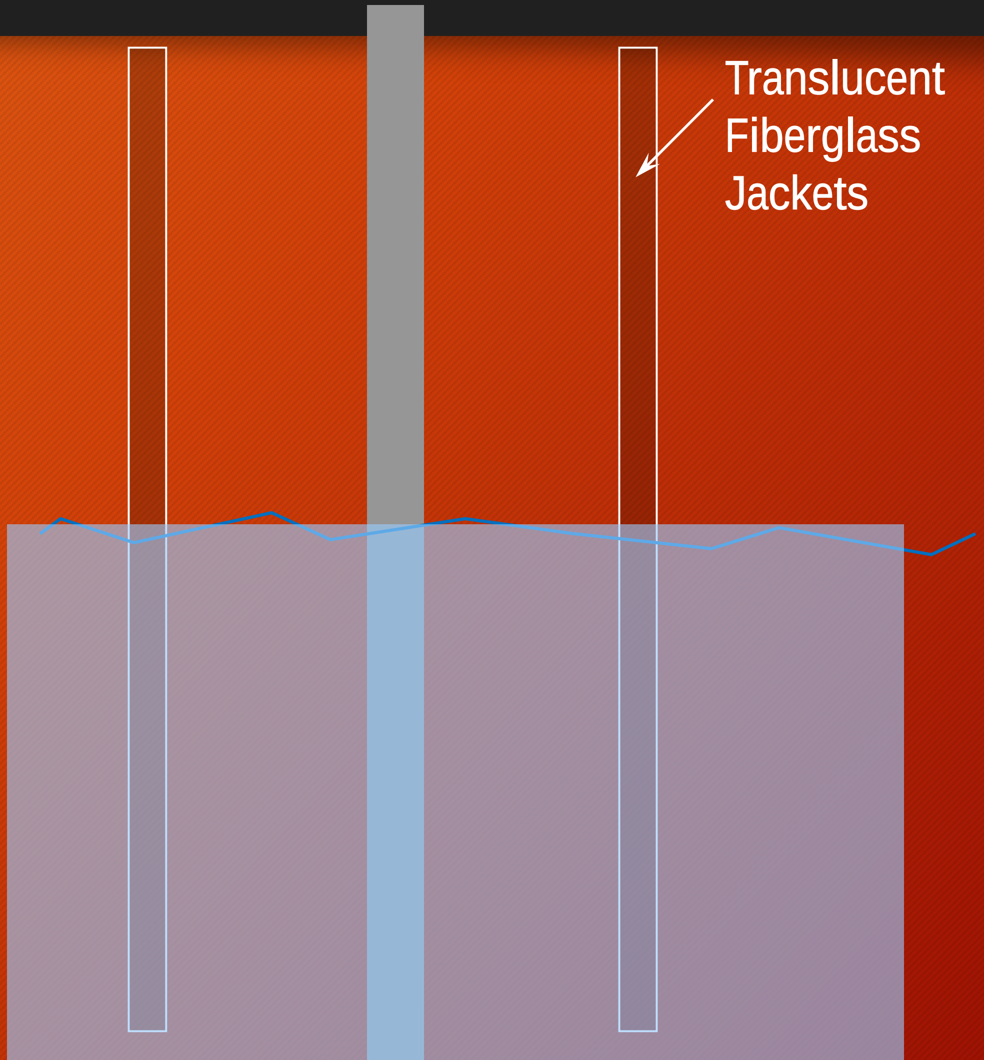
- <u>Step 1</u>
  - Sandblasting
  - Pneumatic Rotary Grinder

The Encapsulation Process

- Step 1
  - Sandblasting
  - Pneumatic Rotary Grinder

The Encapsulation Process

- Step 2
  - Fiberglass Jackets Placed Around Structure
  - Leaving 3/8” to 1/2” Annulus between Jacket and Structure
  - Seams are sealed with epoxy



Purpose Designed FRP Jackets

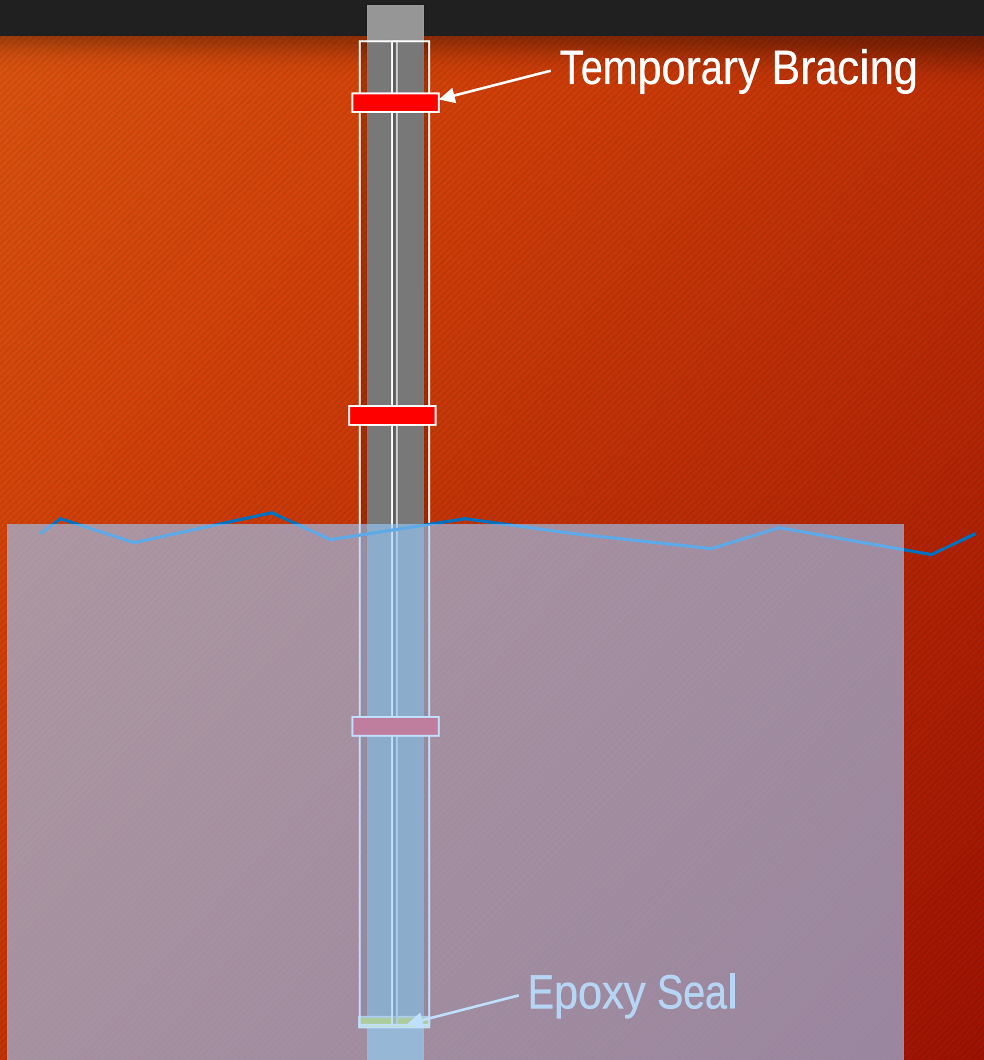
- <u>Step 2</u>
  - Appropriately sized FRP Jackets Delivered to Site
  - Polymer Stand-offs
  - Seam adhesive applied on deck

Purpose Designed FRP Jackets

- Step 2
  - Jackets set in place around pile

The Encapsulation Process

- <u>Step 3</u>
  - Seams are riveted in place
  - Temporary bracing is installed
  - Bottom of Jacket is sealed w/ epoxy coated backer rod

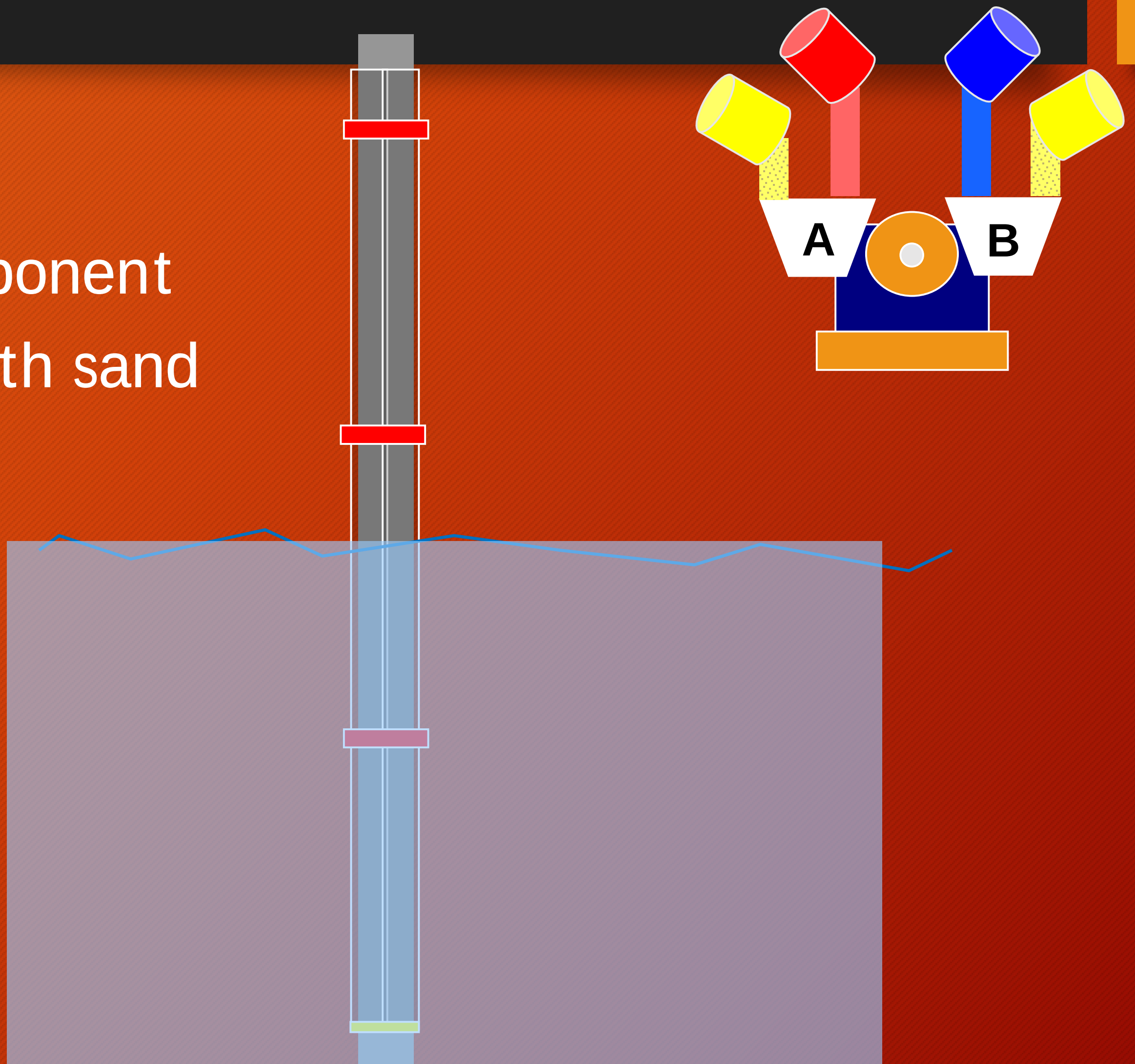


Encapsulation Purpose Designed FRP Jackets

- Step 3
  - Temporary bracing installed

The Encapsulation Process

- <u>Step 4</u>
- Each component of a two-component marine grade epoxy is mixed with sand

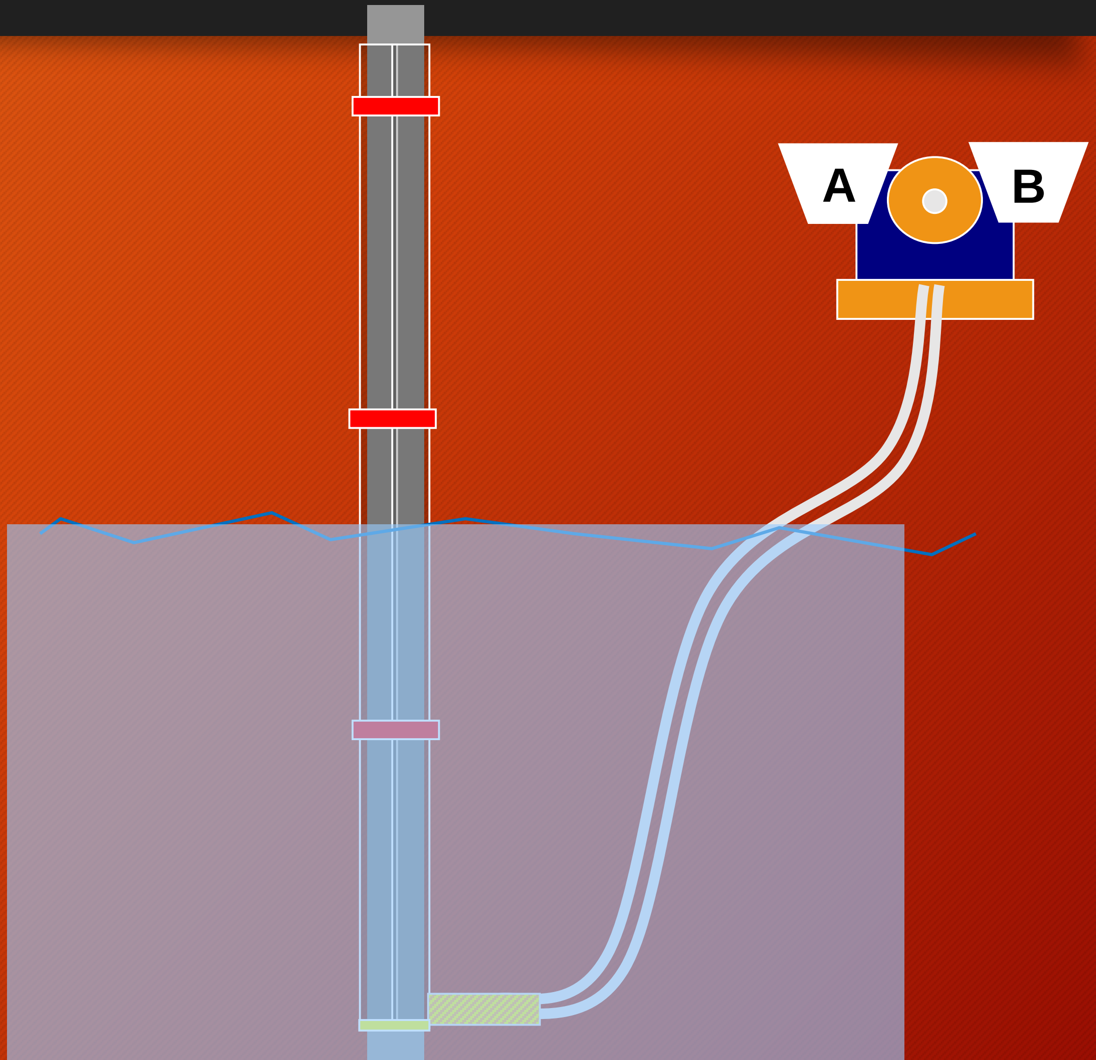


Epoxy Grout Infill Properly Placed

- Step 4
  - Plural component grout plant
  - Part A & Part B mixed with sand in each hopper

The APE Process

- <u>Step 5</u>
  - Grout plant is attached to injection port in fiberglass jacket
  - Dual-umbilical hose w/ static mixer at injection site



Epoxy Grout Infill Properly Placed

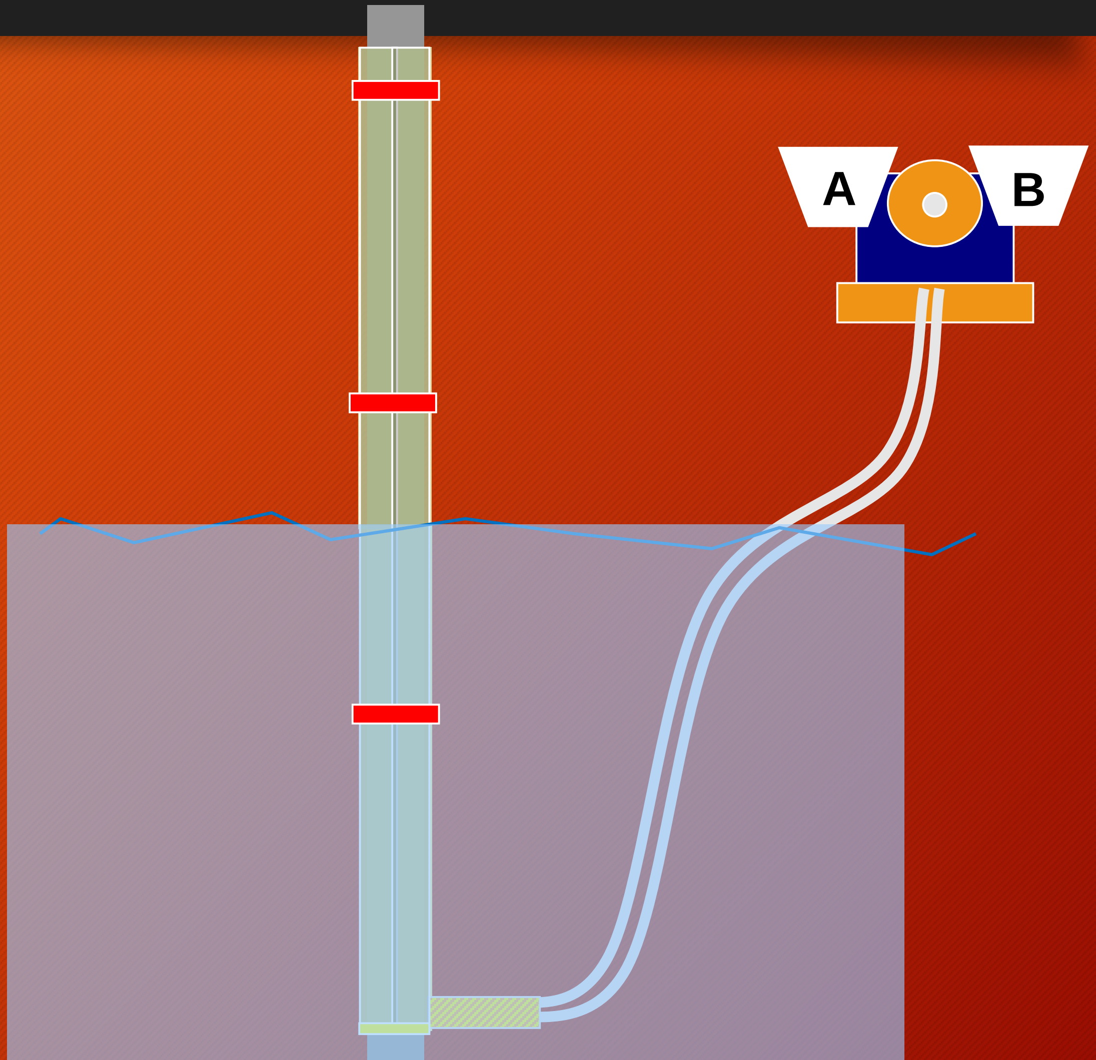
- <u>Step 5</u>
  - Downstream mixer

Epoxy Grout Infill Properly Placed

- Step 5
  - Fluid sand-filled epoxy grout is dispensed out of the mixer

The Encapsulation Process

- <u>Step 6</u>
  - Epoxy grout is pumped into annulus
  - Water in the annulus is displaced and expunged out of the top of the jacket



Epoxy Grout Infill Properly Placed

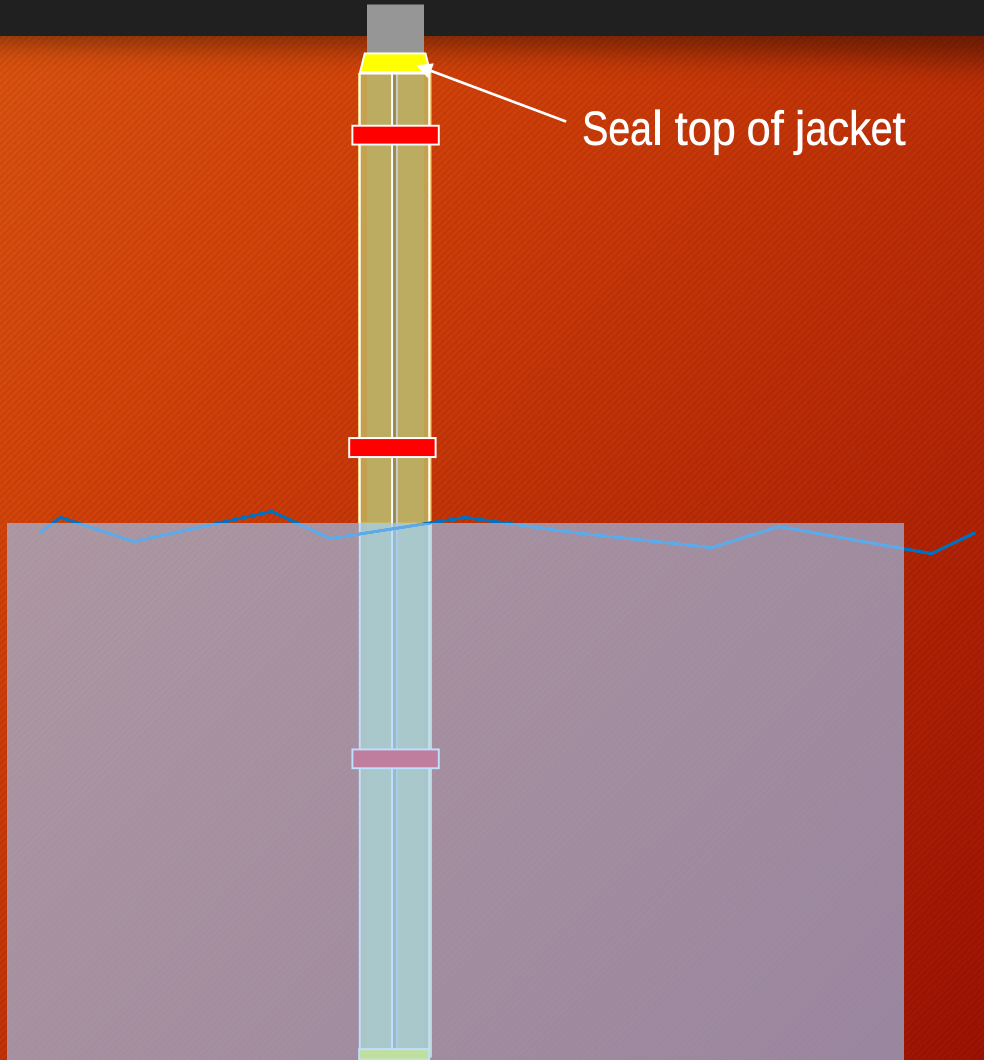
- Step 6
- Grout is pumped into the annulus
- Water is displaced above grout
- Grout progress is monitored

Epoxy Grout Infill Properly Placed

- <u>Step 6</u>
- Water is expunged out of the top of the jacket

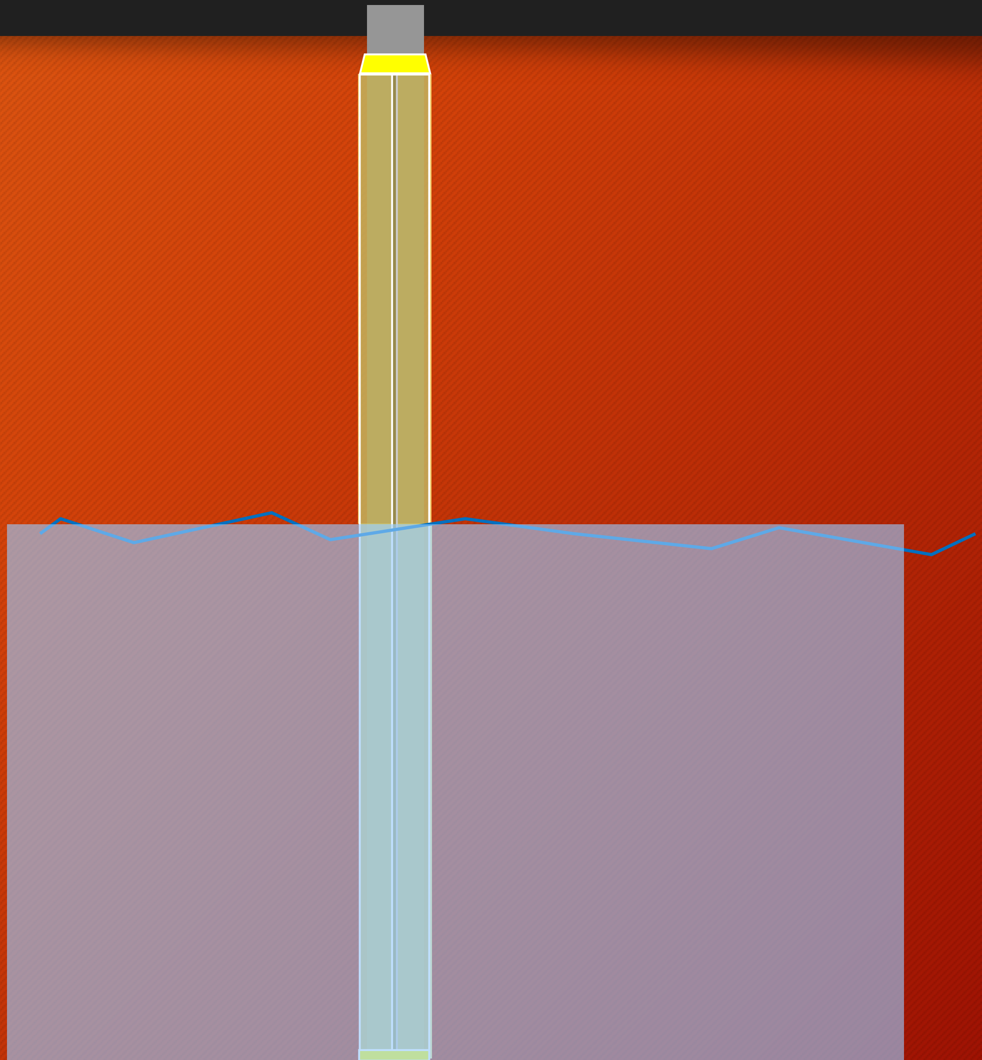
The Encapsulation Process

- Step 7
- Top of jacket is sealed with epoxy
- Bracing is removed



The Encapsulation Process

- Encapsulation is complete!



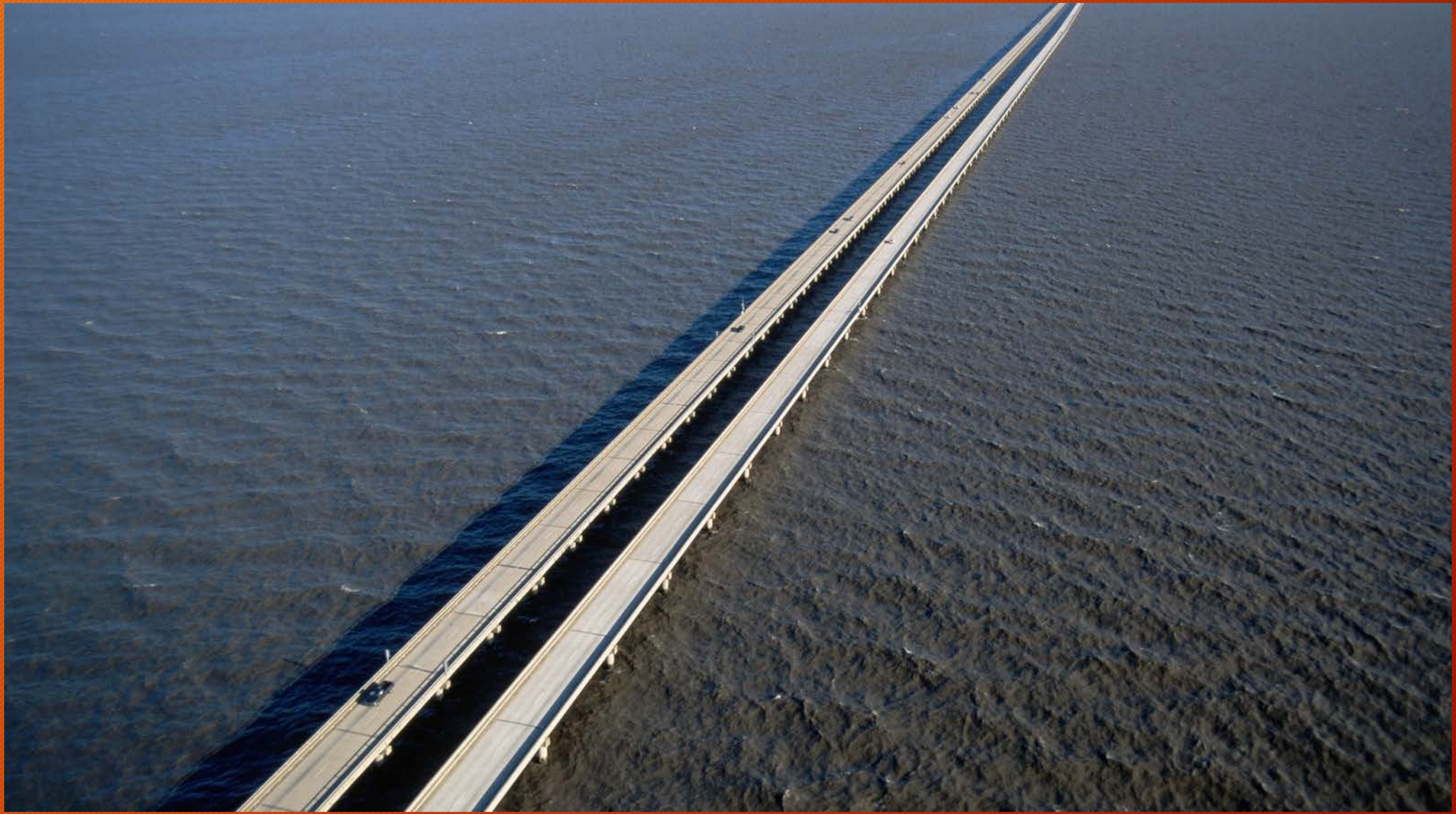
Complete Encapsulation

- FRP Jacket
- Epoxy Grout Infill
- Complete Coverage of Grout
- Well Bonded to the Pile

Complete Encapsulation

- Epoxy Grout is pumped under pressure
- Grout penetrates into cracks and voids in the substrate

Lake Pontchartrain Causeway, New Orleans, Louisiana



Lake Pontchartrain Causeway, New Orleans, Louisiana

- Pile Encapsulation
  - Started in 1988 – still ongoing
  - 26 mile long bridge
  - 54” diameter concrete cylinder piles

Lake Pontchartrain Causeway, New Orleans, Louisiana

- Pile Encapsulation
  - Encapsulations soon after completion in 1989

Lake Pontchartrain Causeway, New Orleans, Louisiana

Pile Encapsulation

- Encapsulations in 2002

Lake Pontchartrain Causeway, New Orleans, Louisiana

- Core sample

Lake Pontchartrain Causeway, New Orleans, Louisiana

- Bond testing 13-year old encapsulations

Rappahannock River Bridge, Tappahannock, Virginia

Rappahannock River Bridge, Tappahannock, Virginia

- 1993
- RC Piers Showing Corrosion and Spalling
- Encapsulations all Above Water

Rappahannock River Bridge, Tappahannock, Virginia

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- RC Piers Showing Corrosion and Spalling
- Encapsulations all Above Water

Rappahannock River Bridge, Tappahannock, Virginia

- Jackets placed over spalled areas
- No patching was done

Rappahannock River Bridge, Tappahannock, Virginia

- Completed Encapsulation

BG&E Facility, Baltimore, Maryland

- Badly deteriorated H-Piles

BG&E Facility, Baltimore, Maryland

- Encapsulate 44 “H” Piles
- Completed in 1993

BG&E Facility, Baltimore, Maryland

- Corroded steel section replaced with new structural steel
- Steel channels bolted and spliced onto existing piles

BG&E Facility, Baltimore, Maryland

- Jackets sized to H-Pile Profile

BG&E Facility, Baltimore, Maryland

- Encapsulations in place

Warren Road Bridge, Baltimore, Maryland

Warren Road Bridge, Baltimore, Maryland

Deteriorated piers

- Large concrete pier

Warren Road Bridge, Baltimore, Maryland

Pier Encapsulation:

- Large concrete pier
- Jacket Fabrication

Warren Road Bridge, Baltimore, Maryland

Pier Encapsulation:

- Large concrete pier

Des Joachims Hydroelectric Dam
Deep River, Ontario, Canada

- Tailrace Structure
  - Sits on the Ottawa River between Ontario and Quebec
  - 200-km Upstream from Ottawa, ON
  - 8 power generation units

Challenges

- Tailrace Structure
  - Structure built in 1940's
  - Damage to tailrace from scour and abrasion

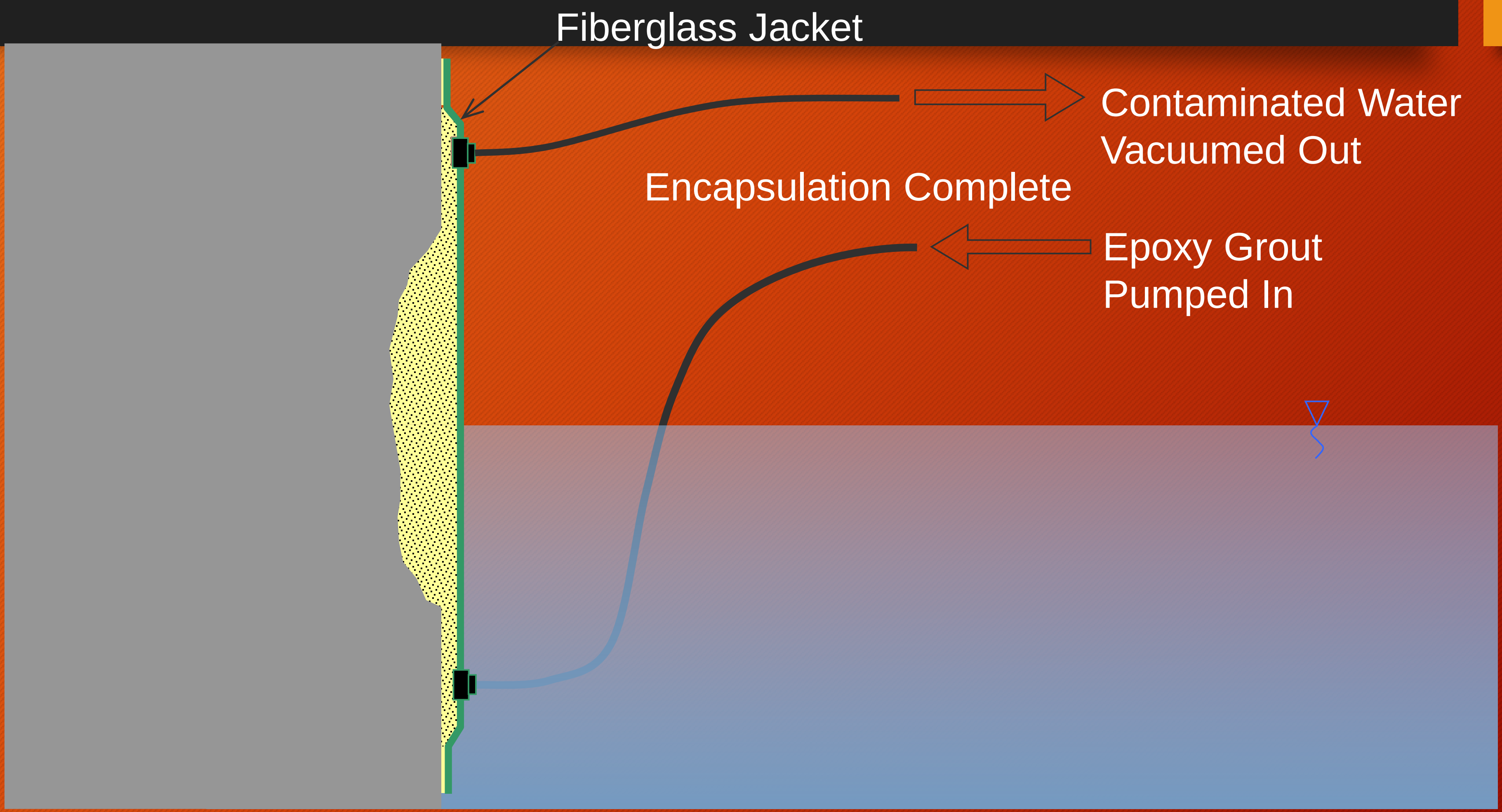
Challenges

- Damage to Piers
  - Loss of section
  - 12” to 18” of section loss in some instances
  - Reinforcing steel exposed

Challenges

- Repair Procedure
  - Restore loss of section
  - Protect against future abrasion damage
  - Protect the downstream ecosystem
  - Minimize dam shutdown time to less than 10-days

Concept


Fiberglass Jacket
Contaminated Water
Vacuumed Out
Encapsulation Complete
Epoxy Grout
Pumped In

Implementation

- FRP Panels
  - Face of peirs encapsulated using FRP panels
  - Thicker than usual panels (1/4”) were used due to severity of scour and abrasion
  - Panels hoisted into place

Implementation

- Panels Installed
  - Panels are anchored into the face of the wall at appx 12"o.c. EW
  - Stiffeners are placed to resist grouting pressure

Implementation

- Grouting Operation
  - Grout pumped into annular space
  - Expunged water and excess grout reclaimed by vacuum pumps installed on upper ports
  - Contaminated water disposed of separately to minimize environmental impact

Des Joachims Hydroelectic Dam
Deep River, Ontario, Canada

- Encapsulation in Place
  - Completed without dewatering
  - Only 7-days of shutdown time for the generators

Testing

- Core Samples
  - Excellent bond to backwall
  - Good grout consolidation
  - No cracking in grout from exotherm

Conclusion

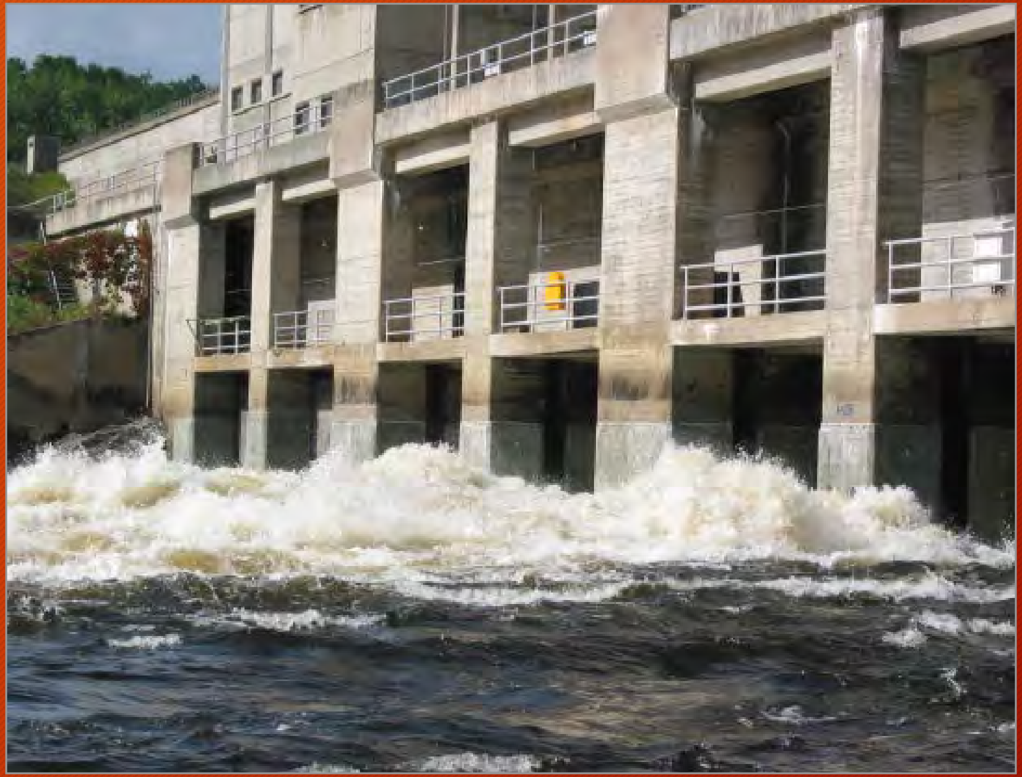
- Before…

Conclusion

- ...and After

Des Joachims Hydroelectric Dam
Deep River, Ontario, Canada

- …and In Service



Gandy Bridge
Tampa Bay, FL USA

Gandy Bridge
Tampa Bay, FL USA

Gandy Bridge
Tampa Bay, FL USA

2010

- Condition Survey
- First Encapsulated in 1987

LPG Trestle, Ju’Aymah, Saudi Arabia

32 years later…

The repair and protection via Advanced Pile Encapsulation remains in place and continues to provided protection without any maintenance

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