Unique Application of Epoxy Repair Gel to Eliminate Draft-Tube Surface Wear and Cavitation Potentially Improving Turbine Power Generation Efficiency

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PROJECT DESCRIPTION

• Grand Coulee Dam, Western Washington state
• Largest hydroelectric dam in Western Hemisphere
• Turbine Unit #23 – current contract (3 Turbines)
• Complete refurbishment of Powerhouse #3 – a three-year project in total (GC - Andritz-Hydro)
• Draft tube repairs / resurfacing – added to general scope of turbine refurbishment
Grand Coulee Dam
Pacific Northwest, Washington
Cross-Section Sketch

Grand Coulee Dam
Third Powerhouse Cross Section

Application of Epoxy Gel to 6400 SF, floors, walls and ceiling of draft tube

Draft Tube
Site Specific Challenges

• 230 feet down for access to draft tube
• Access only by lift/basket hoist for all tools, materials, manpower
• 55 degree °F work environment
• No solvents allowed (for cleaning tools, potential automated application equipment)
• Confined space safety requirements
• Concrete walls under extreme water pressure - tried to inject water stop, hydraulic cements, other polyurethane products
• Some areas were left unrepaired / coated as a result of steady leaks
Bureau of Reclamation
Product Evaluation Criterion

• Good Bond Strength – *especially* to damp surfaces
• Minimal surface prep requirements
• Good compressive & tensile strengths
• Smoothness / good flow characteristics
• Extensive testing and evaluations conducted of over 50 products
• Conclusions led to an Epoxy Gel and a single cementitious option
  – Cementitious – thickness issue as application was only a “skim-coat” – average ½” thickness
  – May require application of a mesh base
EPOXY GEL
KEY PHYSICAL CHARACTERISTICS

• Tensile Strength: 1810 psi
• Shore Hardness: 80
• Tensile Elongation: 10%
• Compressive Strength: 6170 psi
• Bond Strength (properly prepared concrete): >1000 psi
• No priming required – single step application
• EPOXY GEL MC - @55°F – 60 minutes working time, 48 hours full cure
Interesting Access Challenges
Field Conditions

- Extremely deep wear/erosion from abrasion on entire concrete surface
  - ½” to ¾” deep linear wear lines, over entire 6400 SF surface, 40” x 40’ x (4) surfaces
  - Holes, severe surface wear
  - Dirt and debris deeply impregnated in surface
- Potential cavitation from draft tube outflow
  - Back-pressure on water flow exiting from turbine
- Poor flow characteristics due to cavitation
  - Hazen-Williams friction factor
Initial Site Inspection
Concrete Surface Restoration

• Surface Preparation Options
  – Acid Etching – Not allowed!
    • Environmental concerns for outflow to river
    • Confined space considerations
  – Shot Blasting
    • Difficult equipment, sand + solid waste generated
  – Diamond Grinding
    • Sparks, safety, confined space rules, “Hot Work”
  – High Pressure Washing – Chosen Method
    • Minimum 4000 psi
    • Relatively easy method
    • Little to no waste, only water and some solids
    • Convenient / lower skill level
    • Tested with pull test apparatus to confirm
High Pressure Water Blasting
Final Surface Preparation Prior to Application of Epoxy Gel

• Air lance – used to blow out remaining “liquid water”, dampness is OK.
• Temperature control – not an issue, a steady 55°F / product selection took into account
• Additional need to water-plug leaks from cracks and fissures in concrete walls –
  – Polyurethane resin – not 100% effective
Bond Strength Characteristics

• Medium Cure (MC) Epoxy – initial cure time 14-16 hours at 55°F / full cure after 48 hours
• Achieves maximum bond strength after 48 hours
• Bare, prepped concrete typically fails at 360-480 psi
• EPOXY GEL – failed at 460 psi, sheered at concrete NOT epoxy interface
Failure Mode Pull Testing Devices (Elcometer™)
Pull Tests on Prepared Bare Concrete

Header
Andritz Hydro  Draft Tube Adhesion Test: Concrete Only  Test Date: 12/16/13

Three (3) 50mm dia. test dollies were placed in the following areas:

1.) North Wall
2.) North Pier
3.) South Pier

Summary

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Pull Tests on Prepared Bare Concrete

Average Bond = 407 psi
Table of Bond Strength Testing
Epoxy Gel over Prepped Concrete

Average Bond = 464 psi (concrete failed)
TEST DOLLIES
Small Batches – Most Efficient Hand Power Tool Batch Mixed
Potential Automated Application Equipment
Main Water Gate to Columbia River
40’ x 40’
Application of Epoxy Gel
Application of Epoxy Gel
Man-lift Access Application
Draft Tube Completed
Completed Application
Other Applications of Epoxy Gel

- Any location where concrete has bug holes, excessive wear, cleanable surface desired
- Any thickness is possible – 100% solids, not solvent or air- cured, NO odor
- Berms, containment curbs
- Filler prior to application of top coats
- Cove base fabrication
- Overhead repairs, bridge underpasses
- Dam spillway surfaces
Colorado CDOT Bridge Repair
UPPER STILLWATER DAM
Dairy Facility - Indoor Concrete Block Repair
Dairy Facility – Outdoor Concrete Block Repair
Dairy Facility – Outdoor Concrete Block Repair
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Dairy Facility – Outdoor Concrete Block Repair

Elcometer™ Pull Test
Concrete Failure @ 380 psi
Bond Strength of Epoxy Gel
Was Adequate – Note Concrete Present on Surface
Conclusions

• Coating concrete surface of Draft Tube with Epoxy Gel - wear prevention is greatly improved by the presence of an epoxy repair compound

• Potentially and intuitively, with better friction flow characteristics, the generator output should be improved.....very difficult to quantify since so many other factors also improved-
  – Bearings, windings, major equipment overhaul etc.

• BOR confident in the outcome - proceeding with second unit this month and third in 2017-18

• Brief Video of Installation

• Questions?
THANK YOU!

• For more information, Please contact:

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