

CONCRETE REPAIR IN AGGRESSIVE ENVIRONMENTS

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Whether you are:

New to Concrete Restoration and Repair
or a Seasoned Veteran,

There are Basic Elements Involved in Understanding
The causes of and
Repair methods used

When Concrete Subjected to Use in an Aggressive
Environment **DETERIORATES**

OVERVIEW –

WHY DOES CONCRETE DETERIORATE?

- Concrete Structures in Wastewater Environments Deteriorate Over Time Due to:
 - Wetting/Drying Cycles
 - Freeze/Thaw Cycles
 - Abrasion
 - Chloride Intrusion
 - Chemical Attack
 - Stress Caused by Loading and Unloading of Concrete Tanks
- Concrete Structures in Water/Wastewater Industry
 - Under Constant Attack
 - Beyond Designed Life Expectancy

OVERVIEW – WHAT TYPES OF STRUCTURES?

- Concrete Water/Wastewater Structures Include:
 - Clarifiers
 - Sludge Thickener Tanks
 - Filtration Structures
 - Sludge Digesters
 - Aeration Tanks
 - Outfalls
 - Wastewater Support Structures
 - Water Treatment Tanks
 - Concrete Buildings Exposed to By-Products

ASSESSMENT OF CONCRETE

- Factors Used to Determine Repair Method:
 - Type of Deterioration (Spalls, Cracks, Abrasion, Chemical Attack, etc.)
 - Size and Depth of Area to be Repaired or Restored
 - Treatment of Exposed Reinforcing Steel
 - Location of Deteriorated Area
 - Temperature or Climatic Conditions
 - Accessibility
 - Type of Material Best Suited for the Repair or Restoration

GETTING STARTED:

- Determine Surface Preparation Method through Assessment of Concrete's Condition:
- References to Consider:
 - SSPC SP 13/NACE No. 6 Surface Preparation of Concrete
 - ICRI Technical Guideline No. 310.2

SURFACE PREPARATION OF CONCRETE

- Determine Extent of Area To Be Repaired
 - Visual Assessment is Often Not Enough!
 - Going Below the Surface By Chipping or Sounding Concrete Often Leads to Discovery of Additional Factors Which Help Define the Overall Project



SURFACE PREPARATION METHODS

- Hand-chipping
- Electric, air or hydraulic powered chippers
- Hydrodemolition
- Coring
- Concrete Planer
- Concrete Sawing



Routing out cracks in concrete

KEYS TO SUCCESSFUL SURFACE PREPARATION

- Once Perimeter is Determined, Saw Cut to Define Area
- Remove All Deteriorated Concrete, Dust and Debris
- The Fewer Corners, The Better-
 - Lowers Chance of Cracking after Repair is Complete
- If Future Movement Seems Likely After Repair,
 - Use Joint Sealant around Repair

EXPOSED REINFORCING STEEL

- SSPC Surface Preparation Standards
 - SSPC-SP 1 Solvent Cleaning
 - SSPC-SP 2 Hand Tool Cleaning
 - SSPC-SP 3 Power Tool Cleaning
 - SSPC-SP 6 Commercial Blast Cleaning
 - SSPC-SP 11-87T Power Tool Cleaning to Bare Metal
- Selection Depends on Job Site Factors

TREATING REINFORCING STEEL

- Common Steel Primers
 - Non-Immersion Application
 - One-Component, Pre-Mixed Liquid Organic Zinc
 - Sacrificial Protection Against Steel Corrosion
 - SSPC PS No. 20, Type II Organic Zinc Primer
 - **FX-406 Organic Zinc Rich Primer**
 - Immersion Application
 - Two-Component Epoxy Organic Rich Primer
 - Barrier and Sacrificial Protection Against Steel Corrosion
 - SSPC PS No. 20, Type II Organic Zinc Primer
 - **FX-408 Epoxy Organic Zinc Rich Primer**

PRIMING REINFORCING STEEL



FX-408 Zinc Rich Epoxy Primer is Applied to Existing Steel.
Some existing steel may be beyond repair, requiring replacement

COMMON TYPES OF REPAIRS AND SELECTION OF REPAIR MATERIALS

- Cracks
- Small Spalls
- Large Spalls
- Partial or Full Depth Horizontal Repairs
- Concrete Resurfacing

CRACK REPAIR

- Determine Cause of Cracking, Typically Job of Engineer
 - Movement or Settlement of Structure?
 - Thermal Expansion or Contraction?
 - Loading and Unloading of Structure as Part of Frequent Use?
 - Absence of Adequate Expansion Joints?
 - Erosion of Ground Supporting Structure?

Can be a Combination of Many Above Factors!
- Once Cause is Determined, Repair Plan Can be Made

CRACK REPAIR

- Epoxy Pressure Injection Options:
 - Hand Held Caulking Gun with Dual Cartridge Epoxy Units
 - Low Pressure Epoxy Injection Machine
 - Plural Component Automatic Metering Pressure Injection Machine
- Method Depends on:
 - Size and Amount of Cracks
 - Location of Cracks
 - Accessibility to Area
 - Contractor's Capabilities
 - Time Restraints



CRACK REPAIR MATERIALS

TWO STEP PROCESS

- Epoxy Sealer
 - Used to Adhere the Surface Mounted Ports
 - Used to Seal Crack Openings Between Ports
 - **FX-763 Low Modulus Hydro-Ester Trowel Grade Epoxy**
- Epoxy Resin
 - Used to Pump into Cracks
 - Cold Weather Applications: 32°-50°F - **FX-741 Hydro-Ester® Epoxy**
 - Applications Above 50°F - **FX-751 LV Hydro-Ester® Epoxy**

CRACK REPAIR MATERIALS

- **Moving Cracks Require New or Additional Expansion Joints:**
 - Must be Sealed with a Flexible Joint Sealant material
 - Fox Product Specifically for Use in Water/Waste Water
 - Has High Polysulfide Polymer Content
 - Provides Resistance to:
 - Many Chemicals and Bioactivity
 - Shrinkage
 - Aging
 - Thermal Stress
 - Effects of Outdoor Exposure Including UV and Weather
 - Provides Durable, Elastomeric, Weather Tight Seal
 - Retains Flexibility Even With Substrate Movement
 - **FX-572 Self Leveling Polysulfide Joint Sealant**
 - **FX-573 Non- Sag Polysulfide Joint Sealant**

SPALL REPAIR

- Definition: Area Deteriorated by Elements or Force
- Surface Preparation Remains the Same!
- Considerations for Selecting Repair Material:
 - In Water/Wastewater Repair and Restoration Projects
 - Down Time is a Major Factor in Material Selection
 - Materials Must be Rapid Setting
 - Materials Must Be Able to Receive Top Coat Systems Within Hours of Placement
- Typically use Bonding Agent and Repair Mortar

BONDING AGENTS

Four Different Bonding Methods:

- Dampen Concrete
 - Prevent Moisture Loss from Repair Mortar
 - Reduce the potential for shrinkage cracks
- Cementitious (Scrub Coat)
 - Promote Bonding of Repair Mortar to Substrate
 - Minimal Bond Strength
- Latex
 - Higher Bond Strength between Repair Mortar and Substrate
- Epoxy
 - Greater Bond Strength between Repair Mortar and Substrate

BONDING AGENTS

- Use With Rapid Setting Repair Mortars
 - Epoxy Bonding Agent
 - Ultimate Bond Strength Between Existing Concrete and New Repair Mortar
 - **FX-752 Hydro-Ester® All Purpose Bonding Agent**
 - Latex Bonding Agent
 - For Thin Applications – when repair depth is $\frac{1}{4}$ " max
 - Doesn't Bleed Through Thin Material
 - **FX-Bond Crete**



SPALL REPAIR – SMALL

- Defined as Areas < 10 Sq. Ft. x 4” Deep
- Overhead/Vertical Surfaces -Common Method of Repair:
 - Hand Patching/Troweling.
 - Fiber Reinforced Rapid Curing Polymer Modified Cement with a Migratory Corrosion Inhibitor.
 - **FX-263 Rapid Hardening Trowelable Mortar**
 - Single Component
 - Add Water to Activate
 - Rapid Setting



SPALL REPAIR – LARGE

- Areas Range From Hundreds to Thousands of Square Feet
- Considerations for Material Selection
 - Fast Return to Service
 - Weather Conditions At Time of Placement
 - Application Technique (Hand Applied or Spray Applied)
 - Thickness of Repair Areas
 - Type of Coating or Membrane System to be Applied Over Repair Material
 - Amount of Curing Time Before Top Coat/Membrane System Will Be Applied
 - If No Top Coat Will Be Applied, What Kind of Exposure Will There Be?

SPALL REPAIR – LARGE

- **Common Methods of Repair:**
 - **Hand Applied:**
 - Long Pot Life and Working Time – 30-45 Minutes
 - Vertical/Overhead Repair Areas, Less Than 3 Inches Thick
 - Polymer Modified Fiber Reinforced Cement Mortar with a Migratory Corrosion Inhibitor and Silica Fume
 - **FX-262 Repair Mortar**
 - **Spray Applied:**
 - Surface Can Be Troweled or Floated to Create Desired Finish
 - Different Coating Systems Require Different Finishes for Adhesion/Aesthetic Purposes
 - **FX-262 Repair Mortar**

LARGE SPALL AGGREGATE EXPOSED



Overview

Before

After

FX-262 Repair Mortar – Spray Applied

SEWAGE MANHOLE APPLICATION



Before And After Application of FX-262
Ready for Top Coat Application

SPALL REPAIR – LARGE

■ Special Situations:

- Repair Material Exposed to High Levels of Hydrogen Sulfide
- No Top Coat Needed
- Calcium Aluminate Repair Mortar
- Hand or Sprayed Applied In Lifts Up To 2”
- **FX-293 Calcium Aluminate Repair Mortar**



Sewage Manhole Application:

**After Application of FX-293
No Top Coat to be Applied**

PARTIAL OR FULL DEPTH HORIZONTAL REPAIRS

- **Defined As:**
 - Partial Depth Repairs:
 - From 2" deep to 50% of Thickness of Slab
 - Full Depth Repairs:
 - Full Thickness/Total Replacement of Slab
- **Prior to and After Repair, Additional Work May Be Required:**
 - Replace / Add Reinforcing Steel
 - Special Formwork
 - Cribbing / Shoring Structure Being Repaired
 - Curing of the Repair Materials

PARTIAL OR FULL DEPTH HORIZONTAL REPAIRS

- Pre-Bagged Cementitious Repair Materials Incorporating:
 - Admixtures To Achieve 12-24 Hour High Early Strengths
 - Air Entrainment for Resistance to Freeze/Thaw Cycles
 - Fibers
 - Extender Materials – Pea Gravel/Stone
 - Inhibits Alkali Silica Reaction
- **FX-32 Concrete Mix AE Air Entrained Concrete with Corrosion Inhibitor**
 - Longer Cure Time Required than other products reviewed
 - Use with **FX-752 Epoxy Bonding Agents**

ACI Standards for Curing Should be Followed

Based on Temperature at Placement

- Wet Curing, Curing Compounds,
- In Cold Weather – Heat Blankets/Protection from Cold

CONCRETE RESURFACERS

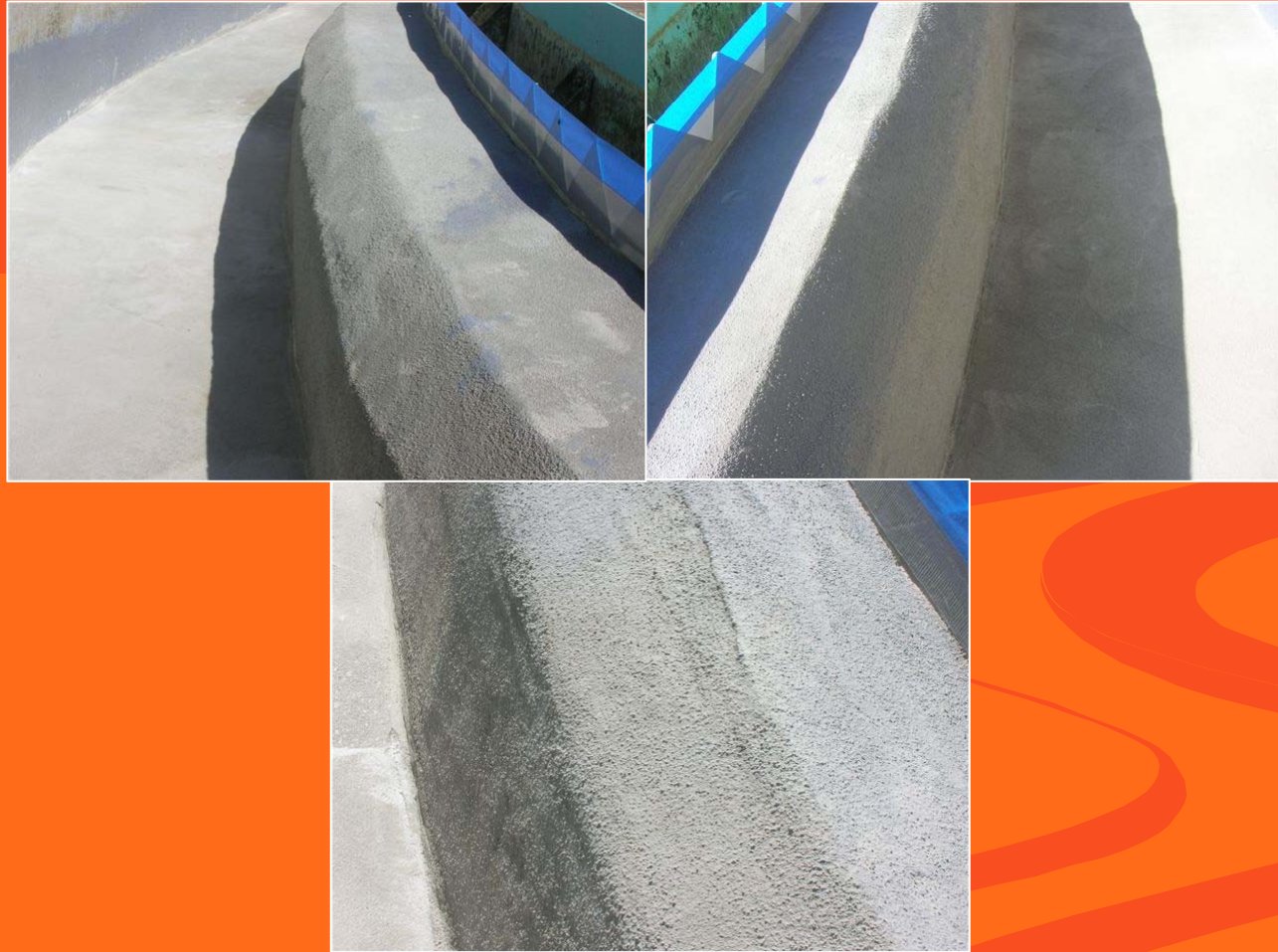
- Are Used When Surface Preparation Such As:
 - Sandblasting
 - Water Blasting
 - Grinding
 - Scarifying
- Reveals the Following Situations:
 - Bug Holes
 - Tire Wire Holes
 - Form Marks
 - Honey Combs
 - Other Voids in Surface
- Product Selection:
 - **FX-472 Epoxy Resurfacer Trowel Grade**
 - **FX-262 Repair Mortar**

REPAIR OF EXISTING CLARIFIER



Erosion of Concrete, Resulting in Exposed Aggregate

REPAIR OF EXISTING CLARIFIER



FX-262 Repair Mortar

Applied as a Parge Coat $\frac{1}{4}$ " to $\frac{1}{2}$ " Thick

REPAIR OF EXISTING CLARIFIER



FX-472 Resurfacer to Fill in Bug Holes

THANK YOU

- Any questions?
- To Receive the Paper:
“Concrete Repair in Aggressive Environments”
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