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ICRI 2022 Spring Convention

Repair of Architectural Terra Cotta

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ICRI CONCRETE REPAIR
Restore | Repurpose | Renew


Repaired Terra Cotta Figure
Royal Theatre
Victoria, BC
Not A Repair
(Crazed Glaze)
Repair
Not A Repair
(Crazed Glaze)
Repair
Not A Repair
(Crazed Glaze)
THE BEST REPAIRS
ARE HARD TO FIND

Things We Should Know About Terra Cotta

- Manufactured Clay Masonry
  - High Temperature Firing
- Composite Material
  - May or May Not be Glazed
    - Slip Glaze vs. Vitreous Glaze
  - Vitreous Glaze Is Of A Different Composition Than Clay Body or “Bisque”
  - Near Zero Permeability When Glaze Is Intact
- Low Coefficient of Thermal Expansion
  - Expands & Contracts Less Than Other Materials As Temperature Changes
  - Complicates Repair &/or Replacement
- “Grows” Over Time

Polychrome Glaze
90 West Street, NYC
1910

Unglazed or Slip Glaze
700 Broadway, NYC
1891

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Common Causes of Terra Cotta Failure

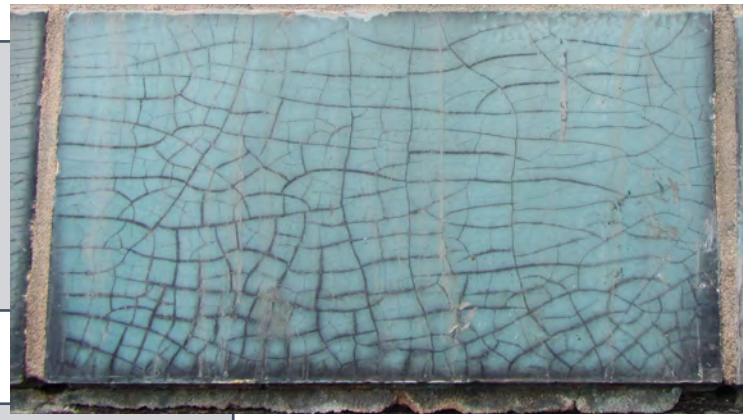
Material Issues

- Growth Over Time
- Poor Original Glaze Fit

Assembly & Exposure Issues

- Poor Detailing
- Poor Maintenance
- Moisture Entrapment
- Steel Corrosion
- Structural Movement

Glaze Crazing



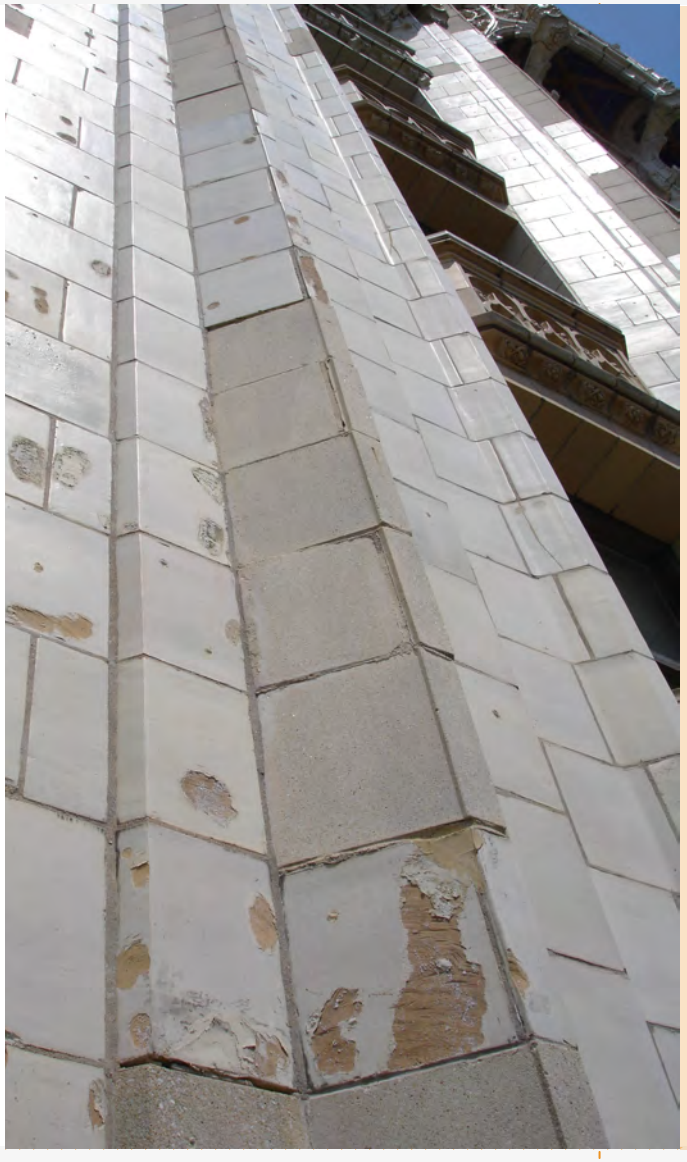
Displacement

Glaze Spalling

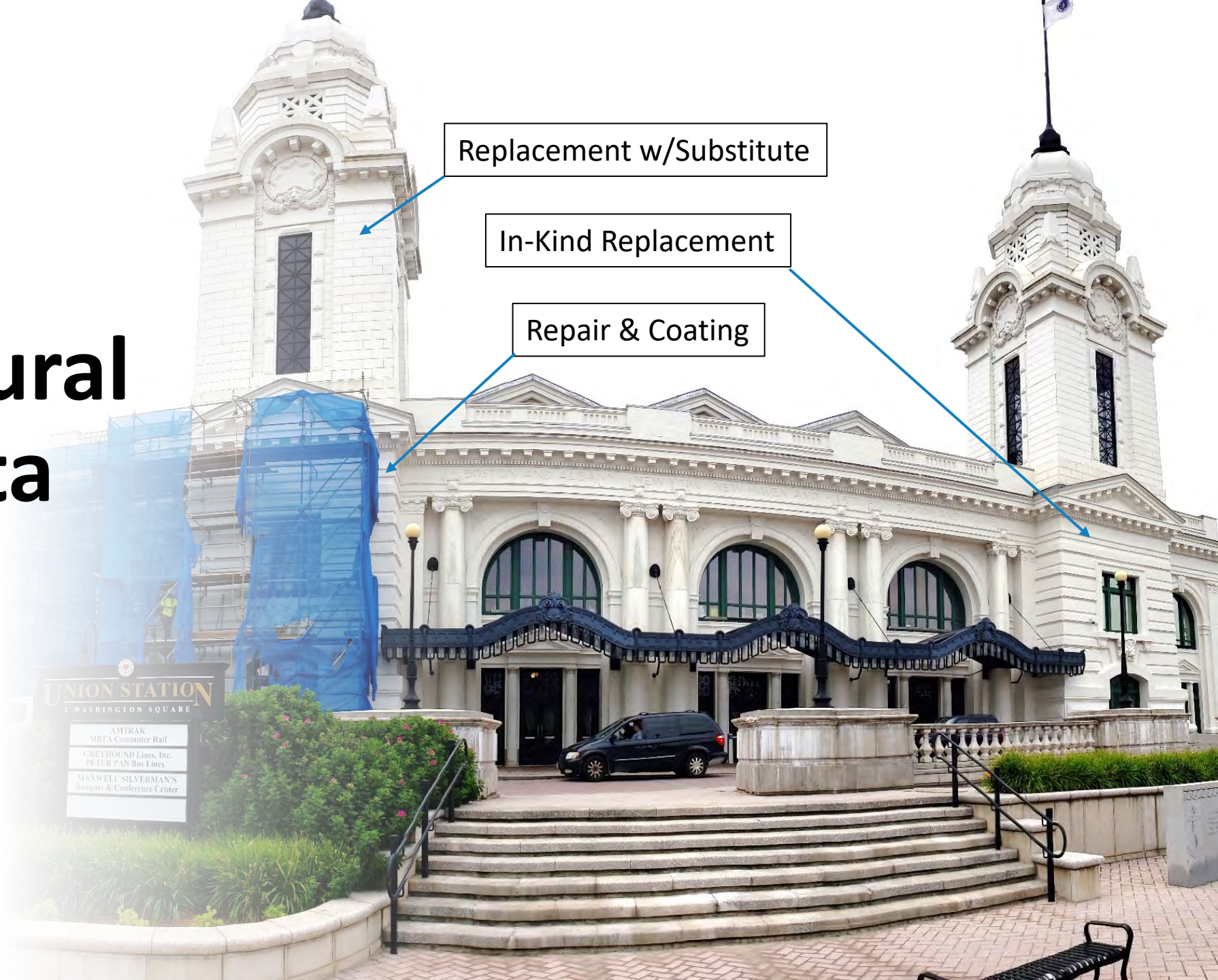
Joint Failure

Approaches to Intervention

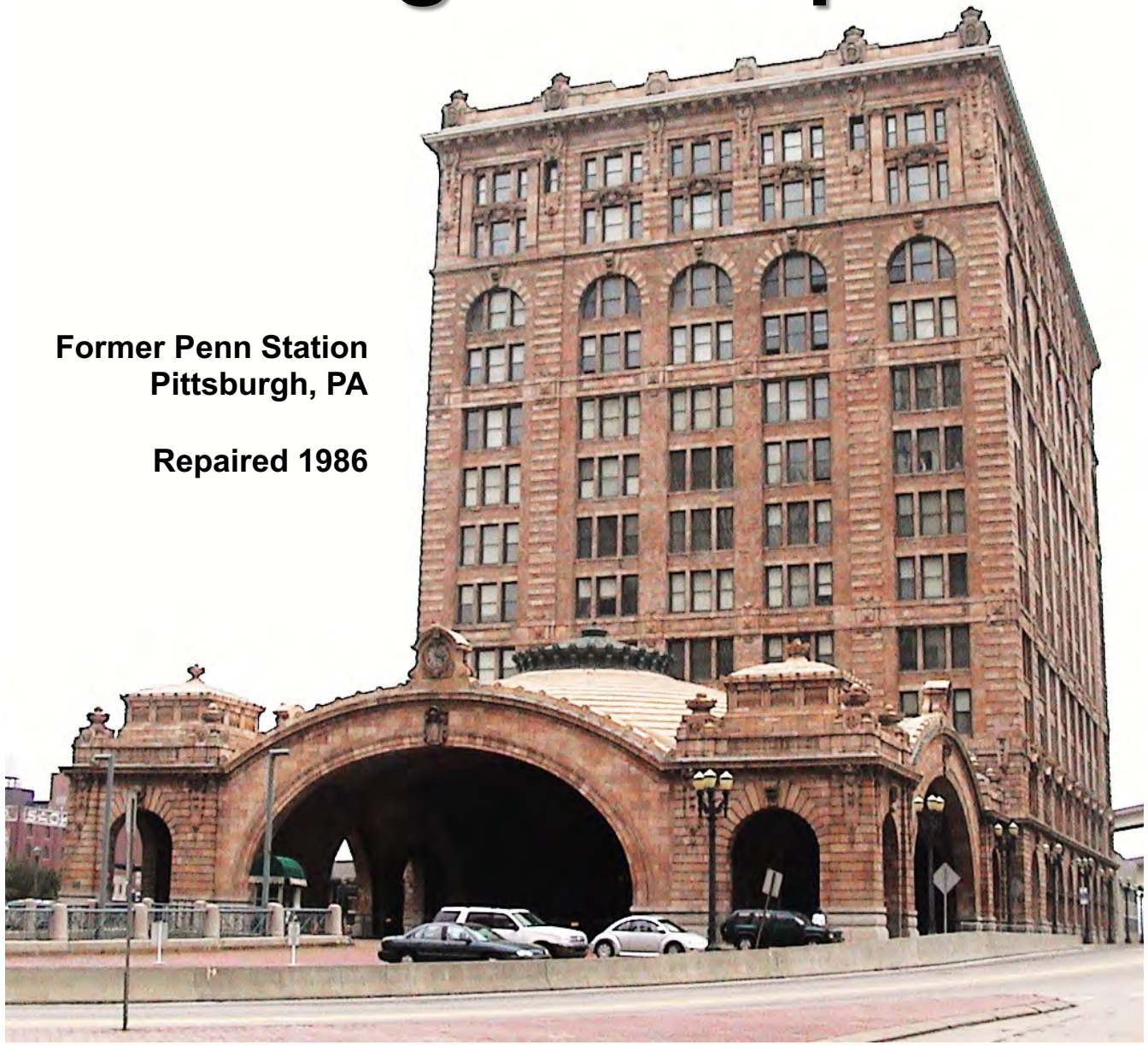
- Preservation/Stabilization
- Restoration
  - Repair, Protection, Maintenance
  - Retention of Historic Fabric
  - Limited Unit Replacement
- Reconstruction
  - Disassembly
  - Replace Unsalvageable Units
  - Necessary If Structural Steel Needs Replacement



Repair of Architectural Terra Cotta



How Long Can Repairs Last?



Former Penn Station
Pittsburgh, PA

Repaired 1986

30+ Years Later

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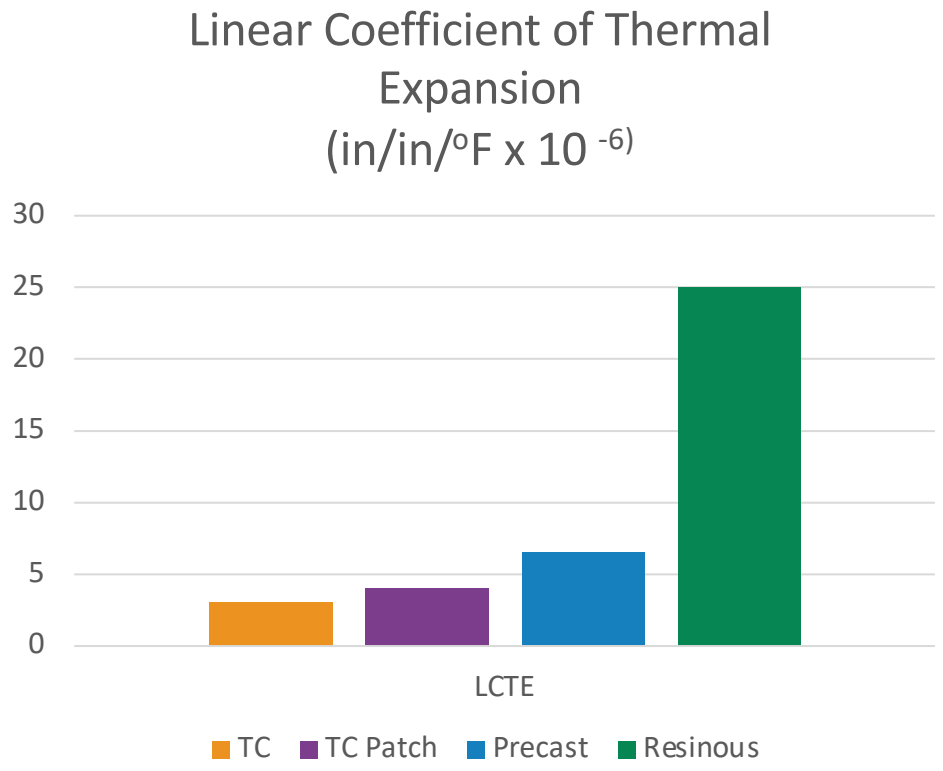
Repairs to Withstand the Test of Time…

- For Repairs To Last:
  - Underlying Causes of Deterioration Must Be Comprehensively Addressed
  - Must Use Good Practices and Workmanship
  - Must Use Compatible, Durable Materials

Terra Cotta Repair Challenges

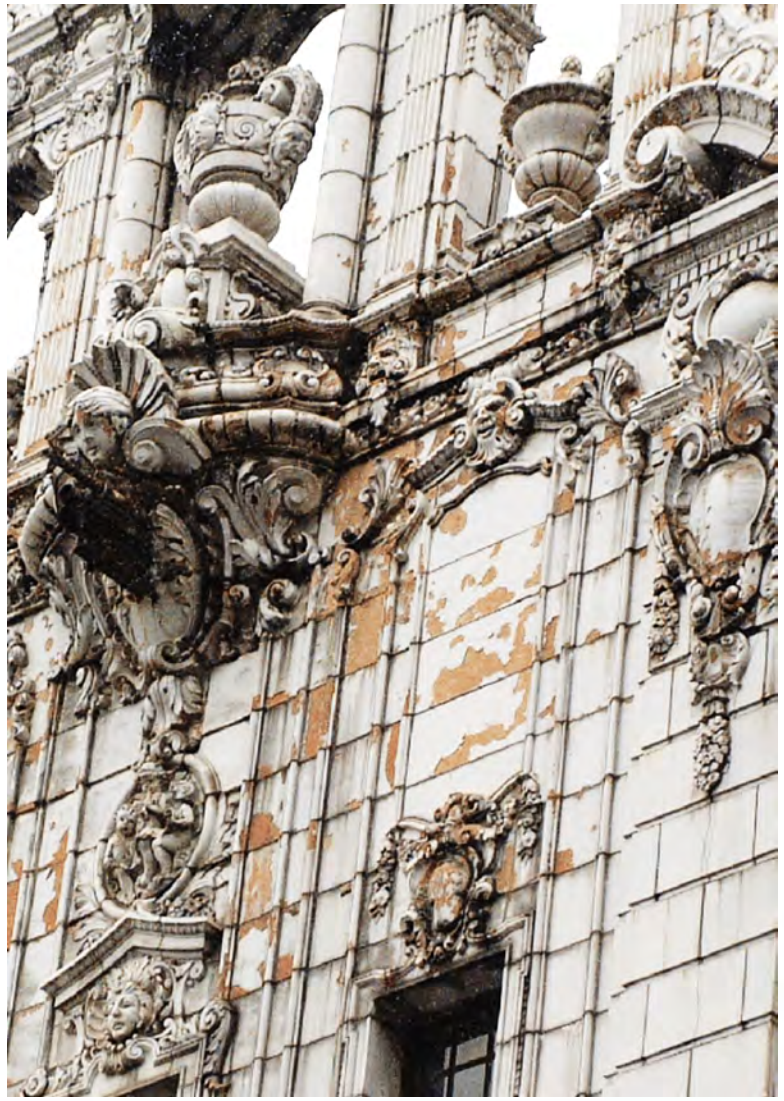
- Thermal Incompatibility of Most Repair Systems



Failed Epoxy-Based Resurfacing Mortar

Terra Cotta Repair Challenges

- Thin-Section Glaze Spalls are Most Common
  - Nominally 1/16”
- Most Repair Systems Perform Poorly in Thin Sections
- Repair Systems Designed for this Specific Application Have Proven Durable and Effective



Terra Cotta Repair Challenges

- Damaged TC Assemblies Tend to be Wet
- Most Repair Systems Perform Poorly in Applications to Wet Masonry
  - Dynamic Moisture Hinders Repair Applications
    - Recent Research Supports Use of Moisture-Insensitive Barrier Primer
- Few Projects Allow Time for Drying
  - Drying Can Take Many Years

Biological Growth in Wet Bisque Beneath Spalling Glaze

Repair System Options

- Very Small Number of Commercial Systems Designed Specifically for Terra Cotta Repair
- Proprietary Formulations
  - Typically Cement-Based
  - Latex-Modified vs. Unmodified
- Multi-Step Repairs
  - Thin Patch (<1/4”)
  - Deep Patch (>1/4”)
  - Coatings to Match Glaze

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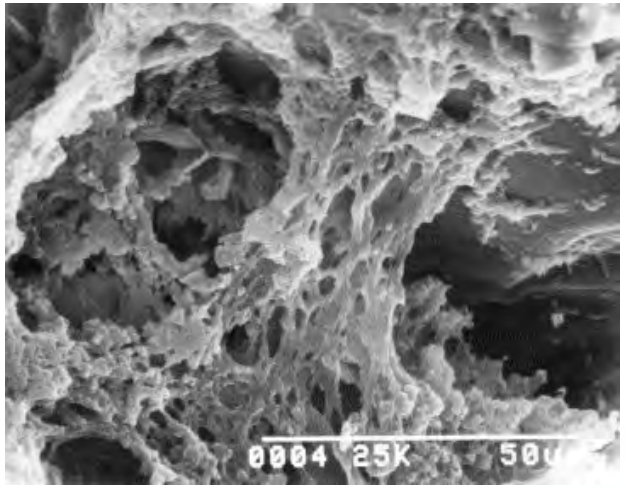
Latex-Modified Cement Technology

Why Do We Use It?

- Increases Adhesion
  - Typically 2x – 4x Higher
- Improves Flexibility
  - Typically 2x – 3x Flexural Strength
  - Lower Modulus of Elasticity
- Lowers Shrinkage
  - Up to 70% Reduction
  - Eliminates Shrinkage Cracking
- Reduces Curing Requirements
  - 0 – 24 hrs (max.)
    Wet Curing
- Does Not Impair Permeability
  - NOTE: TC with Intact Glaze is Impermeable

**MICROPHOTOGRAPH:
PORTLAND CEMENT IN EARLY
STAGE OF HYDRATION**



**MICROPHOTOGRAPH:
LATEX MODIFIED MORTAR AFTER ACID DIGESTION**

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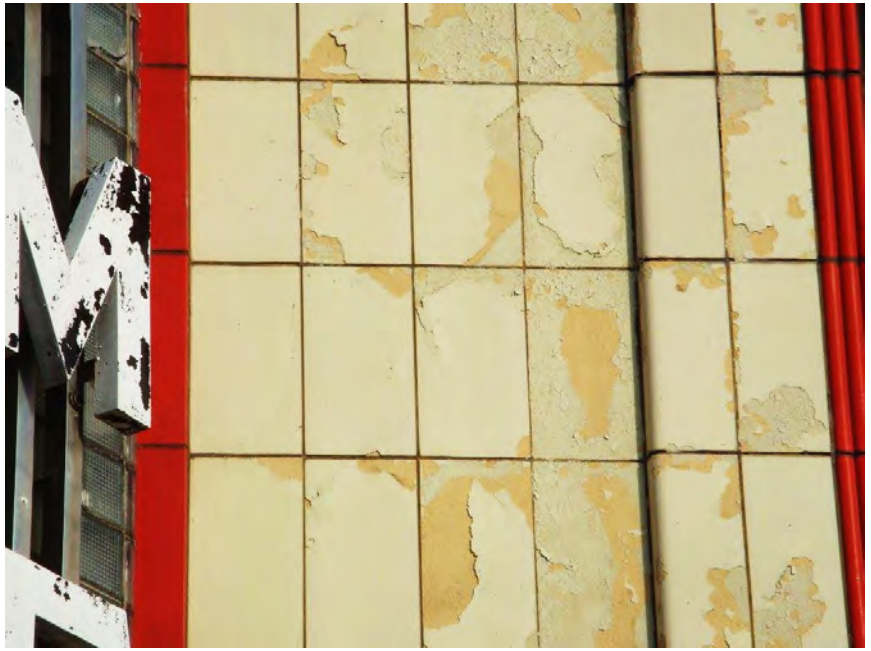

Glaze Spall Repair: Thin Patching

- Do You Really Have To Cut Out ½" of Sound Terra Cotta Bisque?
  - Causing More Damage Than Original Problem
- Thin Section Patches May Be Used at 1/4" or Less

Skip Thin Glaze Spall Repair?

Coating Over Glaze Spalls Without Patching

- You *Can* Just Coat the Bisque, But it Looks Like _____....

Thin Patch

Custom Multi-Step Glaze-Matched Coating System

Large & Deep Repairs

- With Low-Shrinkage Repair Material, There Is No Limit to Patch Size
- Example: Terra Cotta Bracket Repairs at 230 Park Avenue, NYC
  - Cast In Place Patches Up to 1000 lbs./14” Thick

230 Park Avenue: 2010

30 OF THE 32 BRACKETS WERE FAILING, REQUIRING REPLACEMENT

230 Park Avenue: Repair

- 14” Thick Castings Poured in Terra Cotta Patching Compound After Anchor Installation
- Individual Castings Weighed Up to 1000 lbs.
- Repair Cost <5% of Replacement Cost

230 Park Avenue: After

Ten years later...

Terra Cotta Replacement

- In-Kind, New TC Units
  - 3 Current Manufacturers
- Substitute Materials
  - Precast Concrete
  - GFRC
  - FRP
  - Limestone
  - Proprietary, Cementitious
  - Proprietary, Resinous

In-Kind Replacement

- PRO's
  - Maximum Compatibilty
  - Historically Accurate
  - Highly Durable
  - Fireproof
  - No Joint or Anchoring Redesign
- CON's
  - Costly
  - Long Lead Times

Precast Concrete

- PRO's
  - Low Cost
  - Rapid Production
- CON's:
  - Poor Weathering
  - Thermal Expansion Mismatch
  - High Density
  - Potential Steel Corrosion
  - Anchoring Redesign

Woolworth Building
New York

GFRC

- PRO's
  - Lightweight
  - Moderate Cost
  - Rapid Production
  - Good Initial Esthetics
- CON's
  - Thermal Expansion Mismatch
  - Requires Redesigned Anchoring & Joints
  - May Tend to Weather Poorly

Nordstrom Flagship Store
Seattle

Resinous - Proprietary

- PRO's
  - Rapid Production
  - Good Initial Esthetics
- CON's
  - Large Thermal Mismatch
    - Requires Joint Redesign & Sealants
  - Mortar & Sealant Bonding Issues
  - Potential Fire Issues
  - Some Systems Demonstrate Poor Long-Term Esthetics

Resinous Castings

FRP Replacement

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Cementitious - Proprietary

US COURTHOUSE & POST OFFICE
HONOLULU, HI 2003

- While Some Units Could Be Patched, Many Shattered
- Replacements Cast On Site Using Custom Terra Cotta Repair Mortar

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COMPLETED CASTINGS

Cementitious - Proprietary

- PRO's
  - Hollow, Lightweight Units
  - Excellent Thermal Compatibility
  - Drop-In, One-for-One Replacement
    - No Anchoring Changes
    - No Joint Redesign or Sealants
    - Partial-Depth Replacement Possible
  - Rapid Production
  - No Mortar/Sealant Bonding Issues
  - Castings Are Non-Combustible
  - Easily Repairable if Needed
- CON's
  - It's Not Terra Cotta
  - Glazes Matched with Durable Coatings
    - Eventual Maintenance

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Glaze Replication Challenges

- Bond to Existing Glaze
- Broad Range of Glaze Colors
- Complex Finishes
- “Depth” of Vitreous Glazes
- Durability

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GLAZE MATCHING 1: Polyurethane

- Waterborne Aliphatic Polyurethane
- Thin Film
- Can Be Clear, Translucent or Opaque
- Can Be Gloss, Satin or Flat
- Depth: Clear Coats Over Color Coats
- Detail: Can Layer & Sponge-Apply Multiple Colors

New York State Education Building
Albany, NY

POLYURETHANE GLAZE COATING

GLAZE MATCHING 2: Acrylic

Lucas Theater, Savannah, GA

- Matte Finish
- High Permeabilty
- Crack Bridging & Weather-Proofing
- Opaque
- Surface Tolerant
- Can Also Use As Base Coat for PolyurethaneTop Coat

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ACRYLIC GLAZE COATING

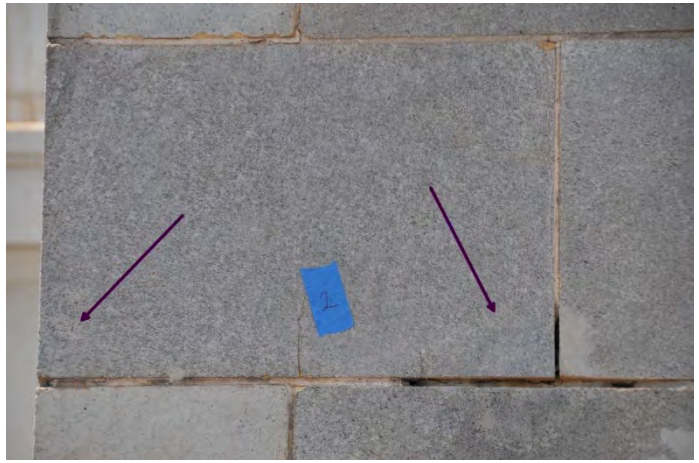
- Matte Finish Glaze Coating
- Requires No Primer
- Good Detail Retention
- Durable

Omni William Penn Hotel
Pittsburgh, PA

California State Library

California State Library

California State Library



CUSTOM SPECKLE COATING
OVER CUSTOM GREY COATING

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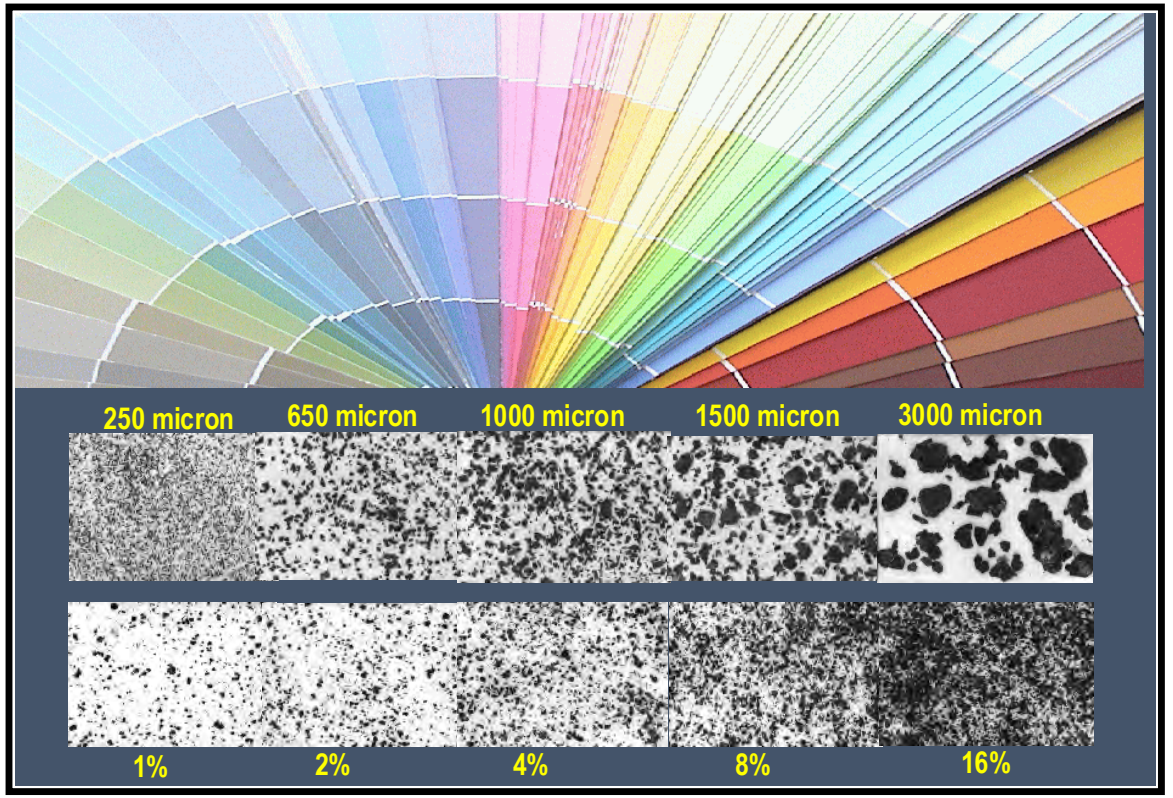
SPECKLE REPRODUCTION

- Color Flakes Suspended in Clear Binder
- May Be Controlled for Size, Concentration & Color



Wet Terra Cotta Building Challenges

Union Station
Worcester, MA
1997

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DRYING PLAN 1998

1. STABILIZE
    a. New Roof
    b. Parapet Flashings & Joints
    c. Seal Openings
    d. New Heating System
2. Install Test Areas
3. STOP!

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DRYING PLAN 1999

1. BREATHE!
    a. **Open All Joints**
    b. **Scale Loose Glaze**
    c. **Drill 10,000 Holes**
    d. **Apply Permeable Primer**
2. STOP & TEST

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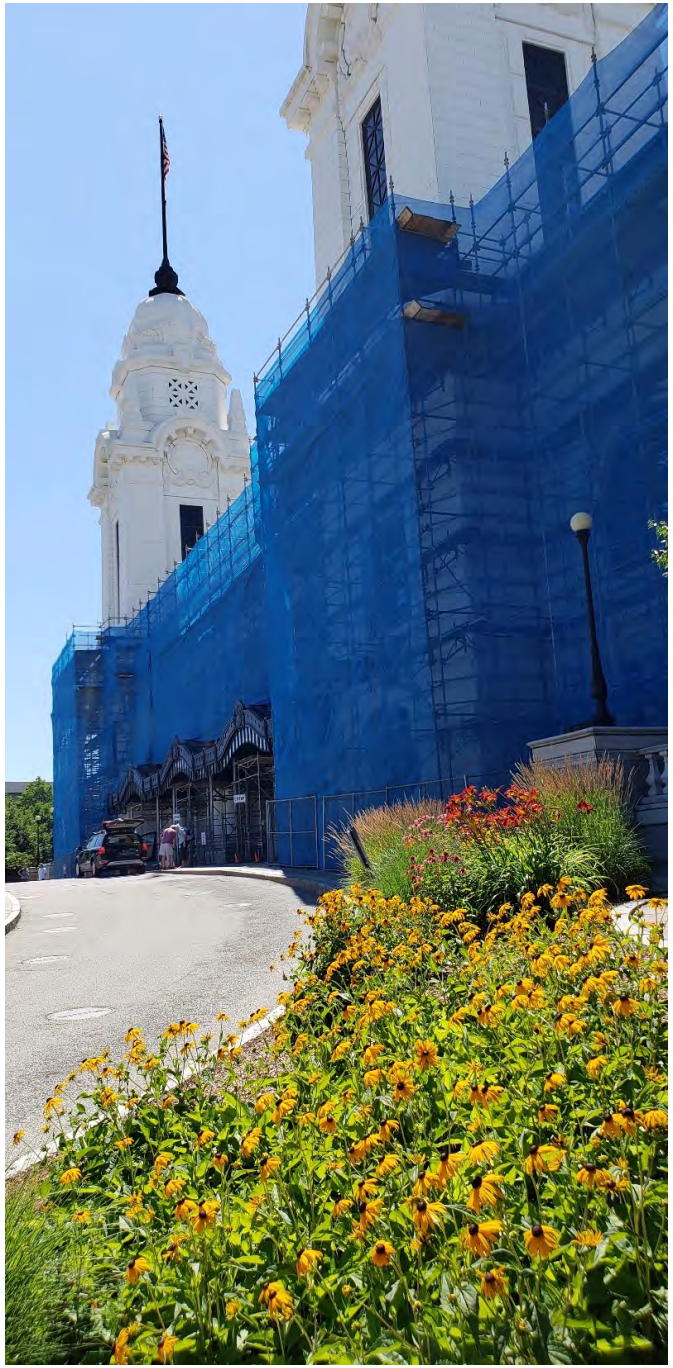
BREATHABLE COATING TEST AREA
ON SATURATED WATER TABLE

- Multi-Disciplinary Restoration Team
- Comprehensive Specs and Mock-Ups
- Carefully Planned Work Sequence
  - Envelope Stabilization Prior to TC Repair
  - Carefully Implemented Drying Plan
  - TIME!
- 5-Year Follow-Up/Touch-Up



2019


UNION STATION
2 WASHINGTON SQUARE
AMTRAK
MBTA Commuter Rail
GREYHOUND Lines, Inc.
PETER PAN Bus Lines
MAXWELL SILVERMAN'S
Banquet & Conference Center

Ritz Carlton Hotel
San Francisco, CA

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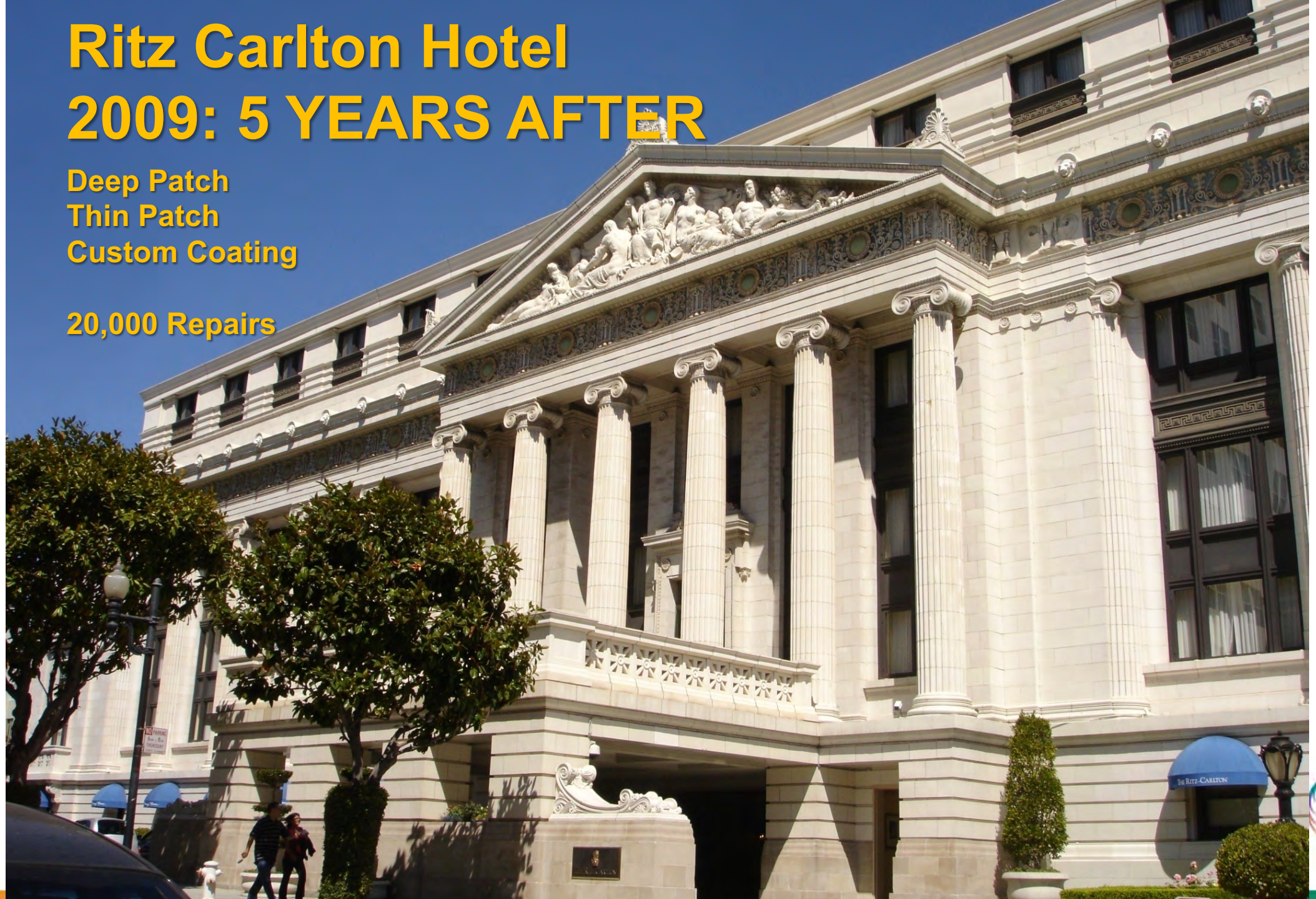
2003

2005
AFTER REPAIR

Ritz Carlton Hotel
2009: 5 YEARS AFTER

Deep Patch
Thin Patch
Custom Coating

20,000 Repairs



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ALL BLOCKS HEAVILY
REPAIRED WITH
THIN PATCH & COATED
WITH 4 SHADES OF
POLYURETHANE

2020

VENTURA CITY HALL
VENTURA, CA

ICRI
CONCRETE REPAIR


2004 1 6

VENTURA CITY HALL

2004

ICRI
CONCRETE REPAIR


VENTURA CITY HALL
2004
2004 6 17

VENTURA CITY HALL
2009: 5 YEARS AFTER

THIN REPAIRS
POLYURETHANE GLAZE
10,000 REPAIRED UNITS

ICRI
CONCRETE REPAIR

VENTURA CITY HALL

ICRI
CONCRETE REPAIR

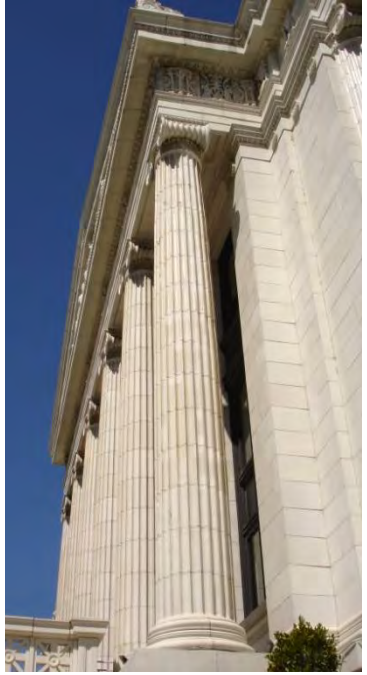
VENTURA CITY HALL

2005


VENTURA CITY HALL
2009

Wet TC Buildings

- Follow-Up
  - **Wet Buildings May Take Years To Stabilize**
- Sequence of Work is Critical
  - **Stabilization**
  - **Drying**
  - **Time!**
  - **Finishes**
- Plan For Ongoing Maintenance



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John Fidler Preservation Technology Inc.
Worcester Redevelopment Authority
Kronenberger & Sons Restoration
Nault Architects
Hawaiian Dredging
Pullman Services
Works In Stone, Inc.
Con-Spec Associates, Inc./CastCotta

Questions?

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