Concrete Repair

A Restorative Approach

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Today’s Focus

• **Condition Inspections:**
  Early Identification of conditions for preventative maintenance

• **Testing:**
  Field Evaluation Techniques

• **Concrete Crack Repair Processes**

• **Case Studies and Applications**
Condition Inspections

- Visual and cursory non-destructive assessment
- Ratings identify conditions on sliding scale – notes are provided by the inspectors to detail conditions quantified in rating numbers
- Actions delayed for conditions until major rehabilitation or replacement work is required

= $$$$$$$$
In-Depth Inspection

Used for identified critical elements/conditions for planning or design

Usually too late for cost-effective preventative maintenance
Early Detection and Documentation
Typical Repairs
Typical Repairs
Causes of Cracking

Types of Cracks

Structural

- Design Load
- Overload
- Settlement of Supports
- Creep etc.
Causes of Cracking

Types of Cracks

Intrinsic

Before Hardening
- Early Frost Damage
- Plastic Settlement
- Plastic Shrinkage
- Physical
  - Long-term Drying Shrinkage
- Chemical
  - Crazing
  - Reinforcement Corrosion
  - Alkali Aggregate Reaction
  - Carbonation Shrinkage
- Thermal
  - Freeze/Thaw Spalling
  - Seasonal Temp. Cracking
  - Early Thermal Cracking

After Hardening
Loss of Support
Crazing
Plastic Shrinkage Cracking
Drying Shrinkage
Alkali-Aggregate Reaction
Thermal Cracks
Corrosion
An Ideal Formula for a Successful Repair

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Early Identification of Failure Mode
+ 
Matching Proper Repair Process & Materials
Identifying Failure Modes:
Concrete Testing

Destructive Testing
• Coring
• Petrographic Analysis
• Chloride-Ion

Non-Destructive Testing
• Audio Sounding (hammer, chain)
• Penetrating Radar
• Impact Echo
• Impulse Response
Crack Investigation: Applications for Impulse Response

- Slabs, Walls and Piers, Pavements
- Concrete Consolidation
- Cylindrical Structures (silos, chimney stacks and tanks)
- Concrete Beams
- Cladding Integrity on Buildings
Impact Echo and Impulse Response

1. Used to determine the general condition of the concrete at depths which cannot be evaluated by visual or Acoustic Impact (hammer sounding) methods.

2. Provides similar information as concrete coring methods without requiring extensive numbers of cores and patching
Impulse Response Results
Impact Echo Equipment
Impact Echo Testing Applications

Green Street Parking Garage
Impact Echo Applications

City of Ithaca Green Street Parking Garage

• Cast-in-place Post-tensioned Concrete framing
• Poorly consolidated concrete
  * Honeycombing, exposed reinforcement
• Testing of one girder, column and beam to determine depth of honeycombing
Concrete/Crack Repair Methods

- Remove and Replace
- Surface Repair
- Pressure Injection
- Vacuum Injection
Comparison Of Methods To Fill Dead End Cracks

Pressure Injection:

• Filler is resisted by water and debris which remains in the crack – repair considered partial, non-structural in nature, and treated as a temporary fix.

• Air moisture and other contaminants are ultimately sealed in crack dead ends

• Potential for additional damage from pressure
Comparison Of Methods To Fill Dead End Cracks

Vacuum Injection:

• Water, loose debris and air are removed by vacuum flushing of cracks.

• Filler is drawn to the most remote cracks by the vacuum created during the process.

• Repair becomes structural and permanent due to strength and full penetration of MMA: 6000 psi.
Vacuum Injection
Vacuum Flush
Cracked and Debonded Bridge Decks
Slabs
Vacuum Flush

Bridge Decks
Vacuum Flush and Topical Coating

LNG
Containment Dike
Vacuum Flush and Topical Coating
Watsontown Bridge
9 Span Barrel Arch Bridge
Column Repairs
3 Column Bent

- Concrete removal, Class D repairs, sealing - $117,000, 8+ weeks
- 3 Column bent – Concrete patching, Vacuum Flushing repair – $91,000, 3 weeks
- Maintenance prior to reconstruction – Vacuum Flushing - $79,000, 2 weeks
Alkali-Silicate Reaction

NYPA Microwave Tower Foundation
Microwave Pedestal Repair:

Vacuum Injection Set-up
NYPA Vacuum Injection Repair
Completed Pedestal Repair

BEFORE

AFTER
Crack Repair Applications: Masonry
Manhattan Bridge

- Fine Crack
- Med. Width Thru - Crack
- Wide & Deep Crack
Williamsburg Bridge

Vacuum Injection of interior column supports
Williamsburg Bridge

Vacuum Injection of interior column supports
Pavement experts believe that the most economical way to extend the life of concrete slabs is to rehabilitate when they are still in good condition.

Waiting generally increases costs because more expensive repair methods must be used.
Moving Forward

- Early action extends structure life
- Identify conditions for in-depth investigations
  - Biennial inspections – provide valuable information for early detection and identification
- Build program for preventative action
  - In-depth inspections of identified conditions
  - Use of non-destructive testing
  - Use of preventative maintenance to protect assets
Questions?