SIMPSON GUMPERTZ & HEGER

Engineering of Structures and Building Enclosures

Specialized Surface Preparation and Repair of Historic Stadiums with Freeze-Thaw Damage

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18 April 2012


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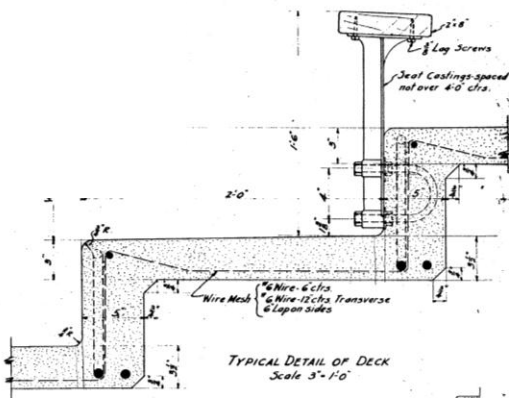
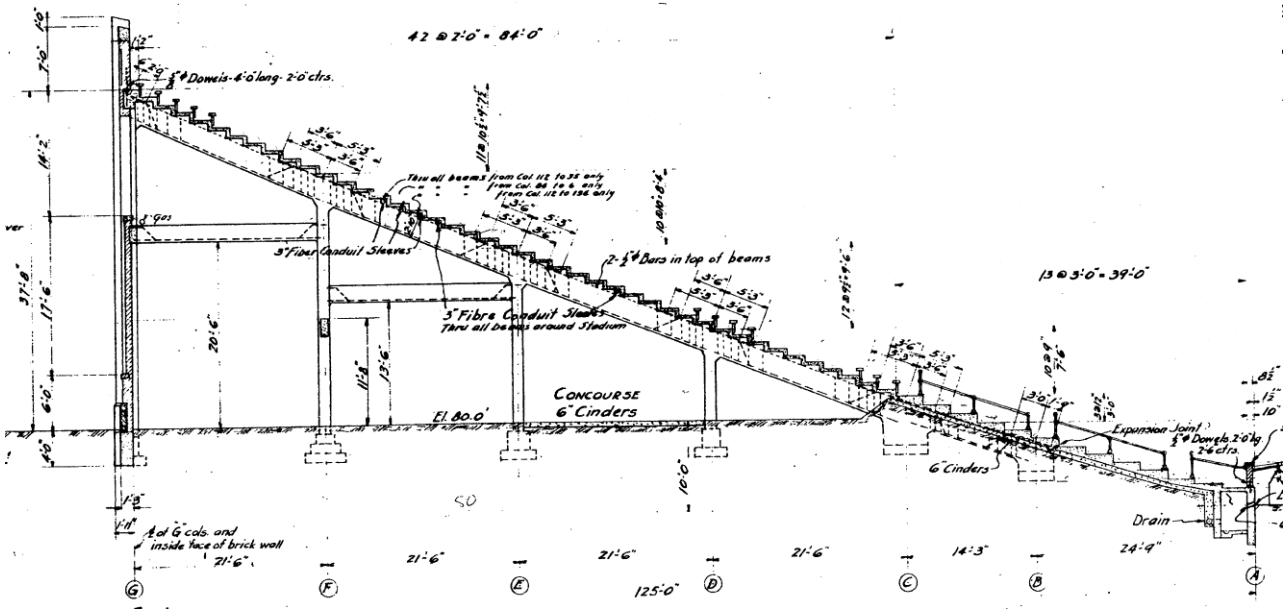
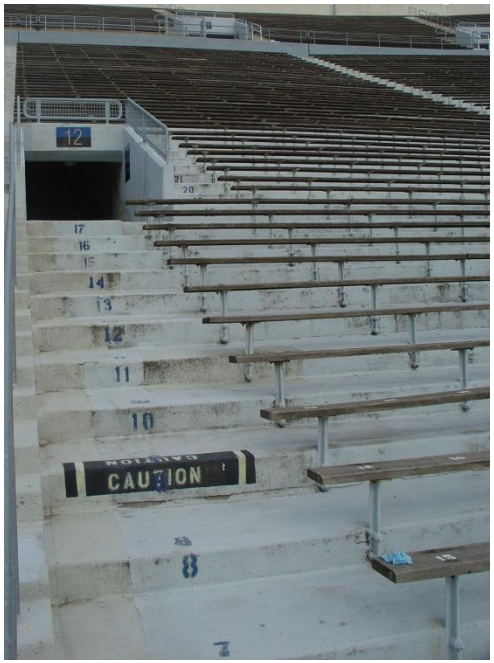
Description of Structure

- Cast-in-place concrete Stadia
  - Raker beams
  - Seat slabs and riser beams
  - Usually have elastomeric coating on topside







Typical Damage At Stadia…

- Corrosion
- Failed joints
- Condensation
- Organic growth
- **Freeze-Thaw Deterioration**

Freeze-Thaw Deterioration

- Occurs when water gets into the concrete and freezes.
- Ice formation is expansive, so it creates tensile stresses in the concrete.
- It is a progressive failure, starting at the surface and working its way into the concrete.
- Modern concretes use air entrainment, but those only came into widespread use in the 1950's, well after most cast-in-place stadia were built.

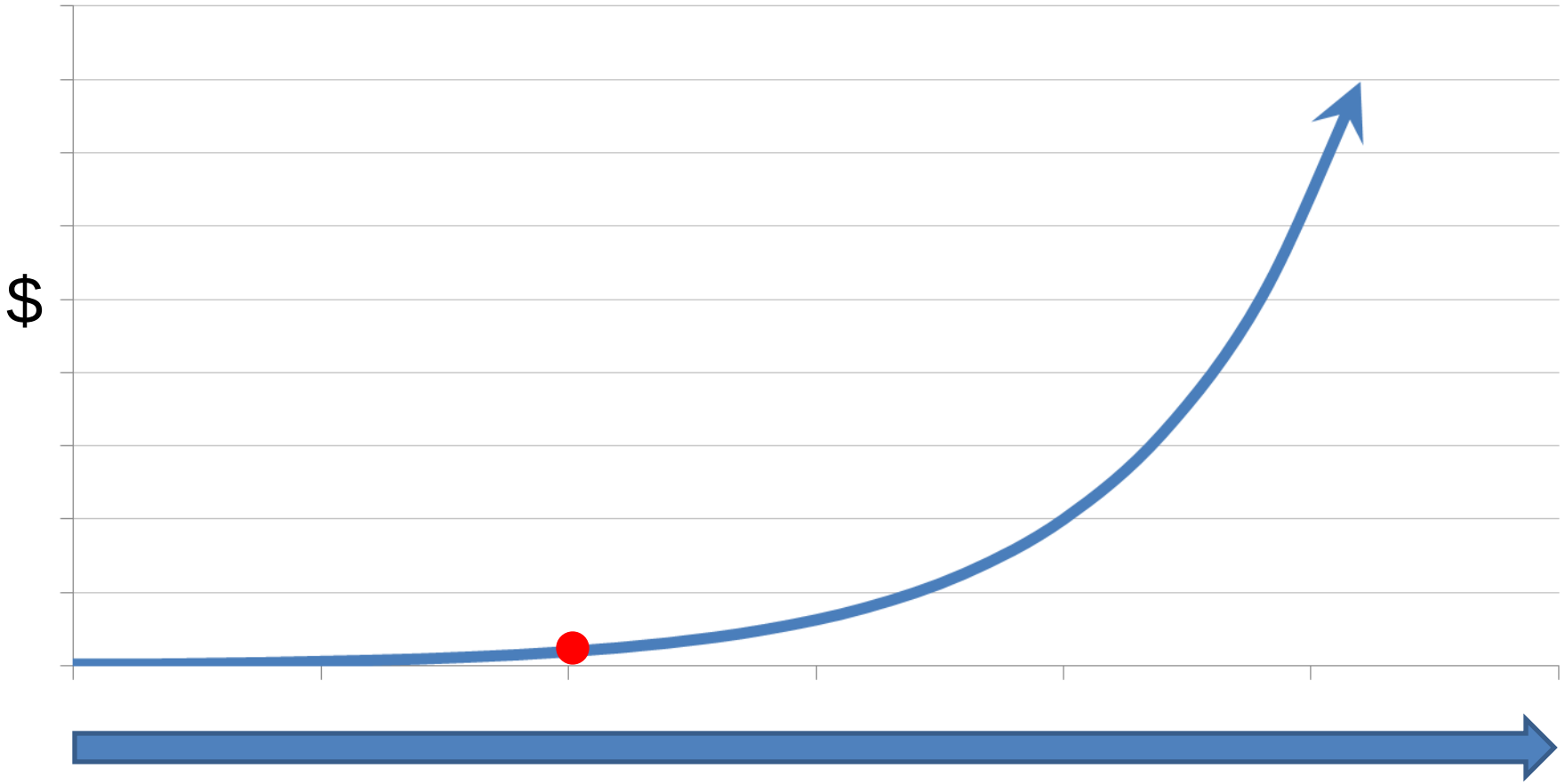
Freeze/Thaw Repair Is Complicated By…

- Damage is widespread, and often concealed
- Variability in damage
- Cracking that is interconnected
- Fragility of concrete in direction parallel to exposed face
- Exposed nature of the concrete in use
- Requirement to prevent trapping moisture

Owner Concerns

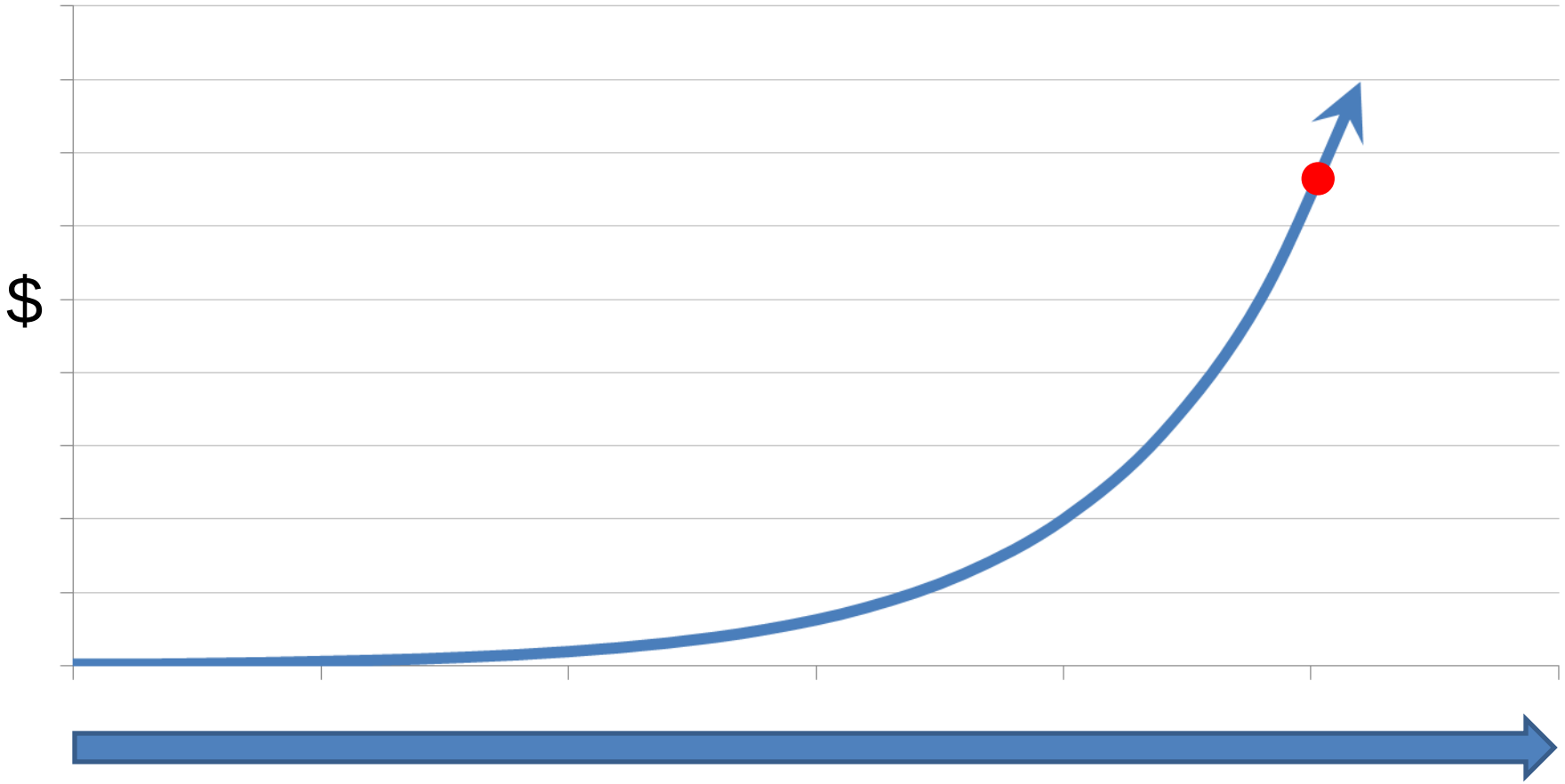
- How will the repaired stadium look?
  - “Like new” would essentially require complete demolition
  - Is the level of damage possible to repair?
- Conventional techniques may be inadequate
  - Special construction methods
  - Additional oversight of repair demolition and surface preparation
  - Close collaboration between all parties

Owner Concerns & Costs



Repair Approach: “Coat and Pray”

Owner Concerns & Costs



Repair Approach: “Blow and Go”

Owner Concerns & Costs

Repair Approaches: “TLC”

Solution Is Found In…

- Communicating Motivations and Expectations
  - Extended service life
  - Stadium isn't going to be "like new"
  - Variable appearance
- Sharing Common Goals of:
  - Performing minimum number of repairs,
  - On-site inspection to get reliable repairs,
  - Predicting quantities of repair is challenging and will require NDT and condition survey
- Staying Flexible
  - Special procedures may be required, particularly in demolition
  - Particular conditions may require special detailing in the field

IMPLEMENTING THE REPAIRS

Implementing the Repairs…

- Coating Removal
- Concrete Repairs
- Testing and Inspection of Concrete Repairs
- Waterproofing Preparation & Installation

Coating Removal

Coating Removal

- Hydrodemolition: the superior method of coating removal
  - "Mower" with rotating head for bulk removal
  - "Lance" for removing remainder
  - High-pressure: 35,000 psi
  - Removes coating and unsound concrete near surface

Coating Removal

Coating Removal – Mower

- Video of Hydro Mower

Coating Removal – Mower

Coating Removal – Lance

- Remove coating from vertical surfaces and edges of treads/risers

Coating Removal – Lance

- Video of Hydro Lance

Coating Removal – Identifying Deterioration

Concrete Repairs – Condition Inspection

- Next goal is to determine extent & depth of repairs
- Implement conventional condition inspection
- Identify extents of deterioration:
  - Chain drag on horizontal surfaces
  - Hammer sounding on vertical surfaces

Concrete Repairs – Condition Inspection

Concrete Repairs – Partial vs. Full Depth

- Next goal is to determine depth of repairs
- Choice of demolition method:
  - Hydrodemolition
    - No microcracking
    - Fully prepares concrete and reinforcing surfaces
    - Slower rate of removal; typically higher cost/sq ft
  - Electric Chipping Hammers
    - Induces microcracking
    - Additional surface preparation usually required (sand blast)
    - Can result in lower bond strengths
    - Owner often prefers this method due to schedule

Concrete Repairs – Best Practices

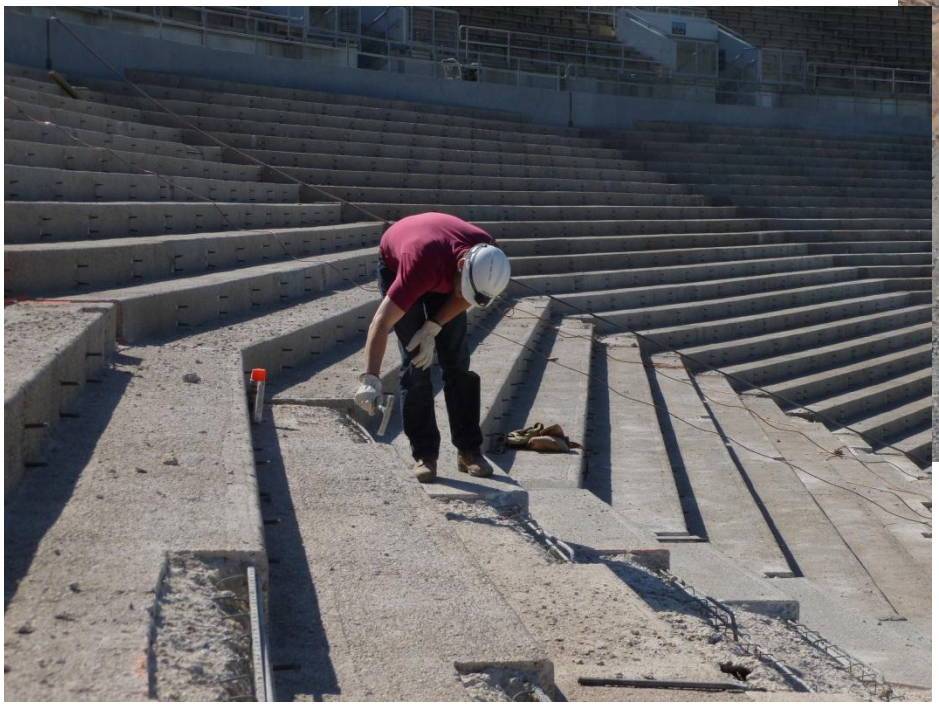
- Electric Chipping Hammer Demolition:
  - Saw-cut the perimeter of repair BEFORE removing all loose and unsound concrete.
  - Minimize bruising and microcracking of good concrete by removing concrete in thin lifts; inspect surface after each lift
  - Require Engineer approval of each repair
  - “Growth” of repair extents: vibrating reinforcing steel and adjacent sound concrete
- Determination of partial-depth vs. full-depth is made on a case-by-case basis

Concrete Repairs – Partial-Depth Nosing

Concrete Repairs – Partial-Depth Tread

Concrete Repairs – Full-Depth Demolition

- Inspect full-depth repair edges to determine if additional demolition is needed



Concrete Repairs – Repair Mortar Placement

Testing Partial-Depth Repairs

- Sounding repairs (hammer)
- Direct-Tension Pull-Tests
  - Measure average bond stress
  - Failure to be minimum 150 psi or within substrate
  - Require frequent tests initially in project to verify demolition method is providing adequate bond

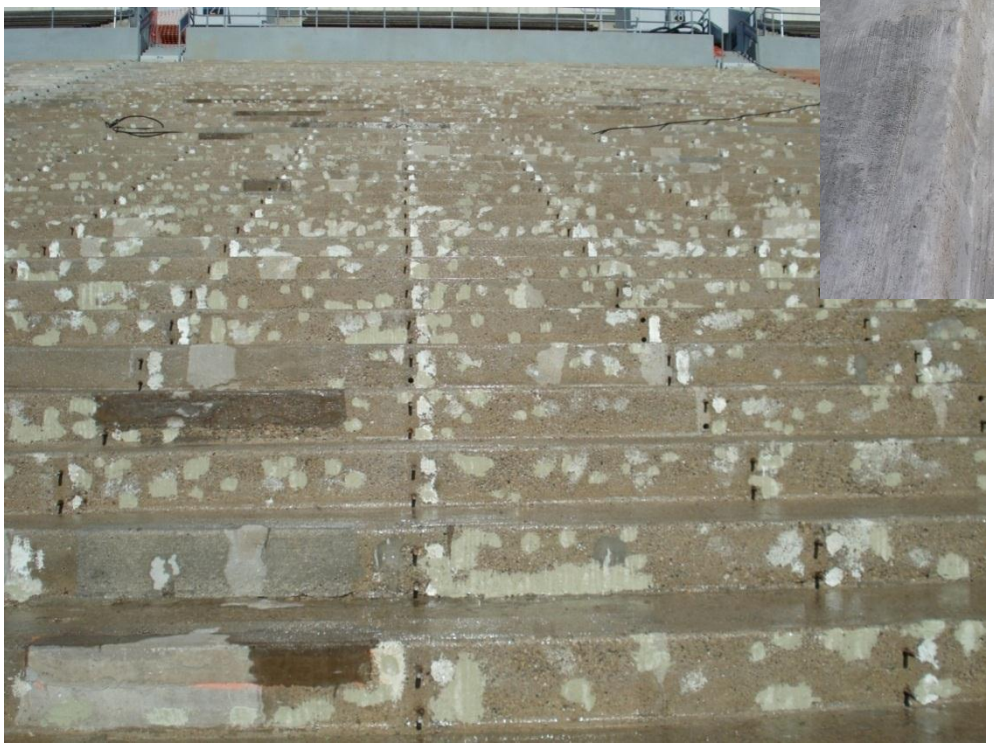
Waterproofing Preparation

- Alternatives for waterproofing preparation:
  - Cementitious parge coat (continuous)
  - Installing localized epoxy products at pits, grooves, or voids

Parge Coat

Epoxy Mortar

Waterproofing Preparation

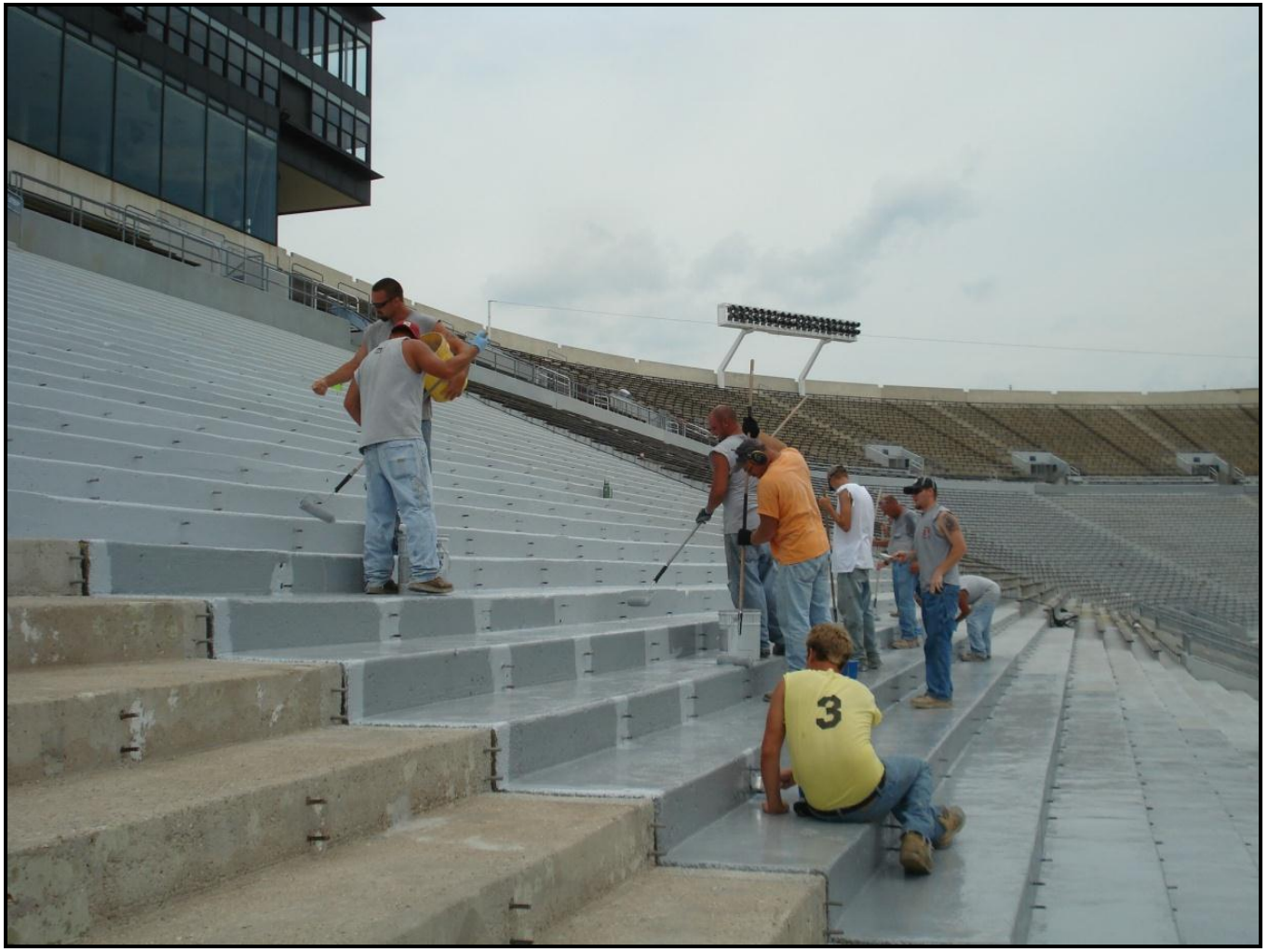


Waterproofing Installation

- Choose a robust waterproofing system
  - Sand-filled urethane base coat
  - Conduct mock-up to confirm amount of sand relative to surface irregularity

Waterproofing Installation – Sand-Filled Urethane Base Coat

Waterproofing Installation – Intermediate Coat



Waterproofing System – Finished Appearance

Summary

- Stadium work can be very interesting and rewarding,
- They present challenges to conventional thinking
  - Can they be “like new?”, Can marginal concrete remain?, When do we stop?
- Successful projects require careful alignment of goals and expectations of all parties,
- Careful and proper preparation is key,
- Use selective hydrodemolition as a screening tool,
- Close cooperation and inspection is required.

Questions?