STRUCTURAL RESILIENCY

Ryders Lane Pump Station

Ryan Benoit, Project Engineer, PE

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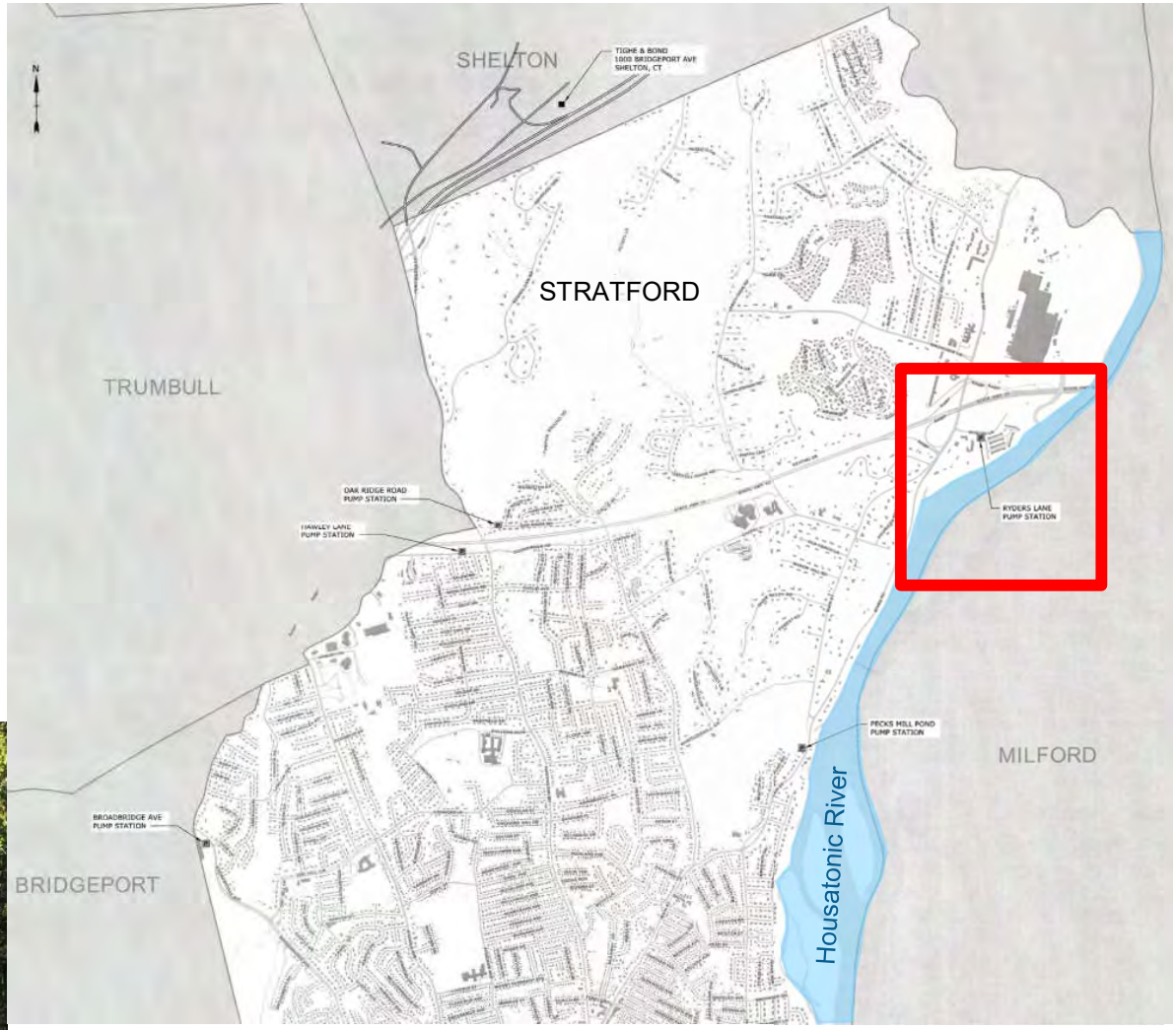
OUTLINE

- Overview of Pump Station
- Construction Site
- Design Requirements
- Structural Resiliency Upgrades
- Quiz
- Q & A

OVERVIEW OF PROJECT

- **Summary**
  - Age, flow, pump capacity, equipment
- **Cost**
  - Construction Contract: $3.5 million
- **Current Status**
  - 75% complete of the pump station



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CONSTRUCTION SITE LOCATION – RYDERS LANE

CONSTRUCTION SITE

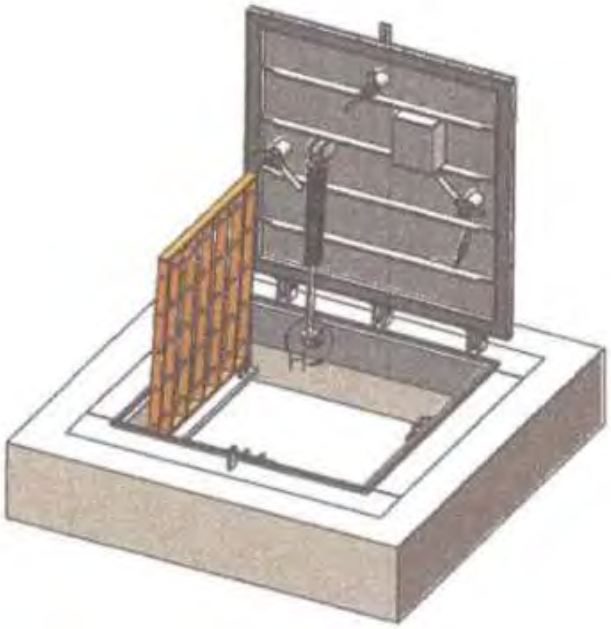
- TR-16 design guidelines for flood level above 100-year flood plus 3 feet
- Excessive flood buoyancy loads
- Retrofit structural upgrades

DESIGN REQUIREMENTS – PUMPING STATIONS

- **TR-16 Guidelines**
  - Design capacity:
    - Handle peak wastewater flows
  - Site layout:
    - All equipment accessible at all times
  - Flood Protection:
    - Protected from the 100-year flood plus 3 feet elevation
    - Fully operational during a 25-year flood
  - Environmental Considerations:
    - Sensitivity to environmental conditions
  - Energy Considerations:
    - Minimize energy consumption

DESIGN REQUIREMENTS – PUMPING STATIONS

- **TR-16 Structural Design**
  - Earthquake Loads and Uplift Forces
  - Wet and drywells completely separated
  - Equipment Removal
  - Concrete Substructure
  - Access



STRUCTURAL UPGRADES TO RYDERS LANE

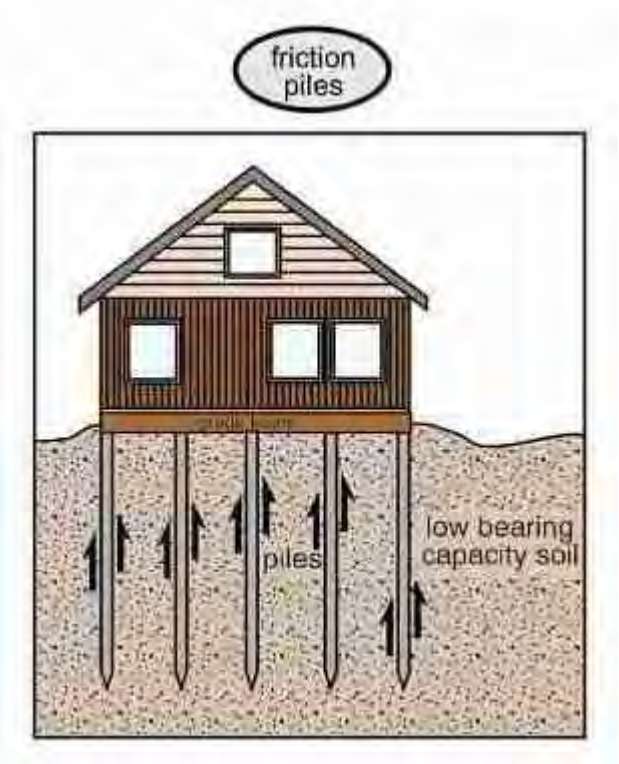
1. **Micropiles**
   - Exterior on pumping station foundation walls, below grade
2. **Carbon Fiber Wall Reinforcement**
   - Interior application on foundation walls
3. **New Concrete Pilaster Columns**
   - Interior of pumping station building
4. **Existing Concrete Repairs**
   - Epoxy crack injection repairs
   - Spalled concrete repairs

BUOYANCY DESIGN CONSIDERATIONS

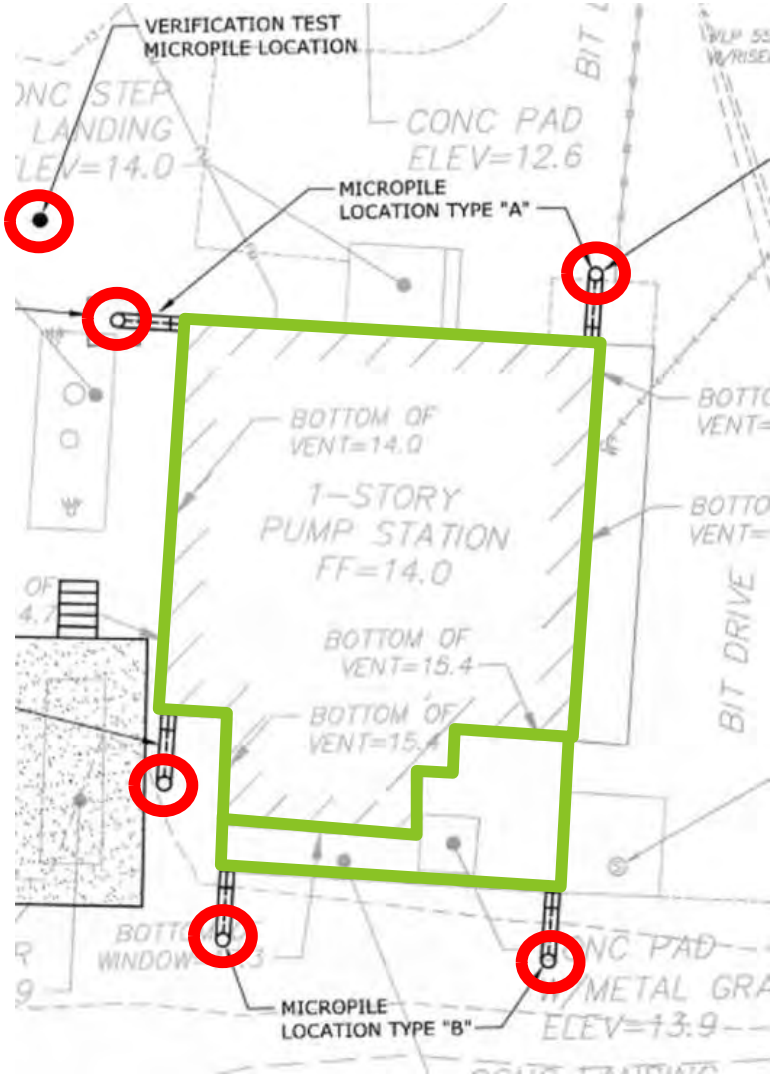
- **Situation:**
  - Large uplift (buoyancy) forces
- **Design Consideration #1:**
  - Increase the weight of the structure
  - Solution: 6 feet of additional concrete in the basement
    - Not feasible
- **Design Consideration #2:**
  - Increase resistance to uplift
  - Solution: Add micropiles to resist movement

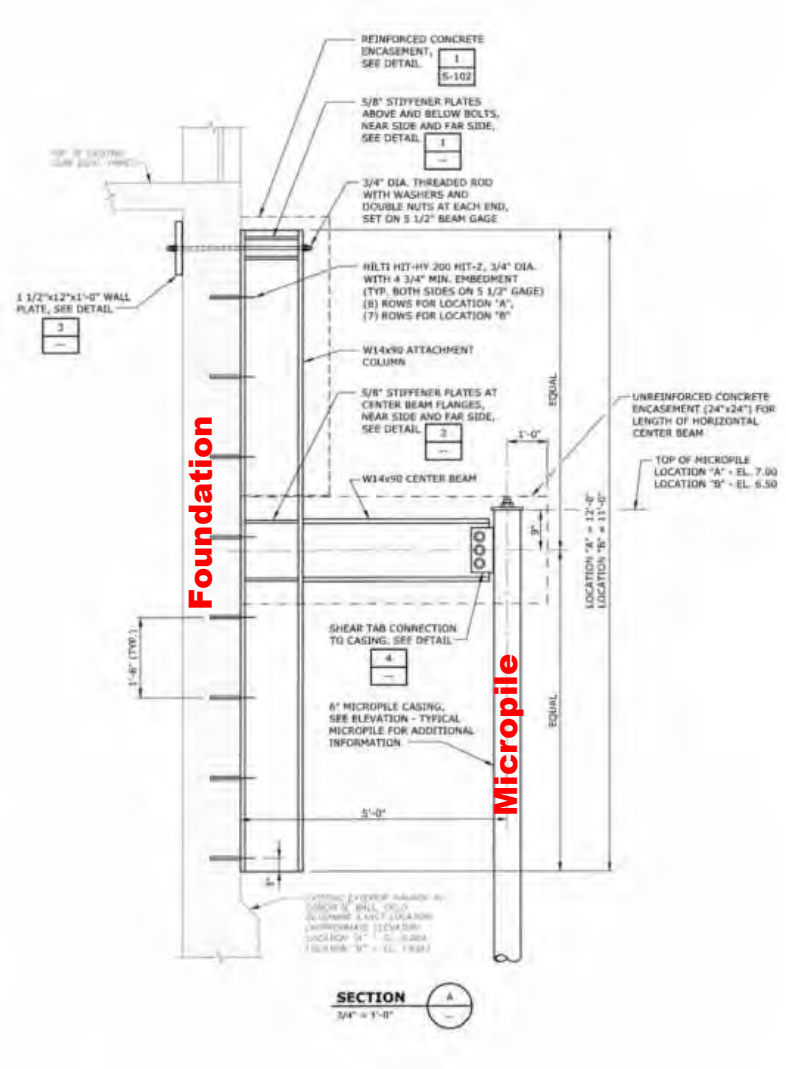
FRICTION PILE FOUNDATION (MICROPILES)

- Type of foundation support
- Frictional resistance force between pile surface and adjacent soil
- Pile length determined based on soil conditions



STRUCTURAL DETAILS – DRAWINGS





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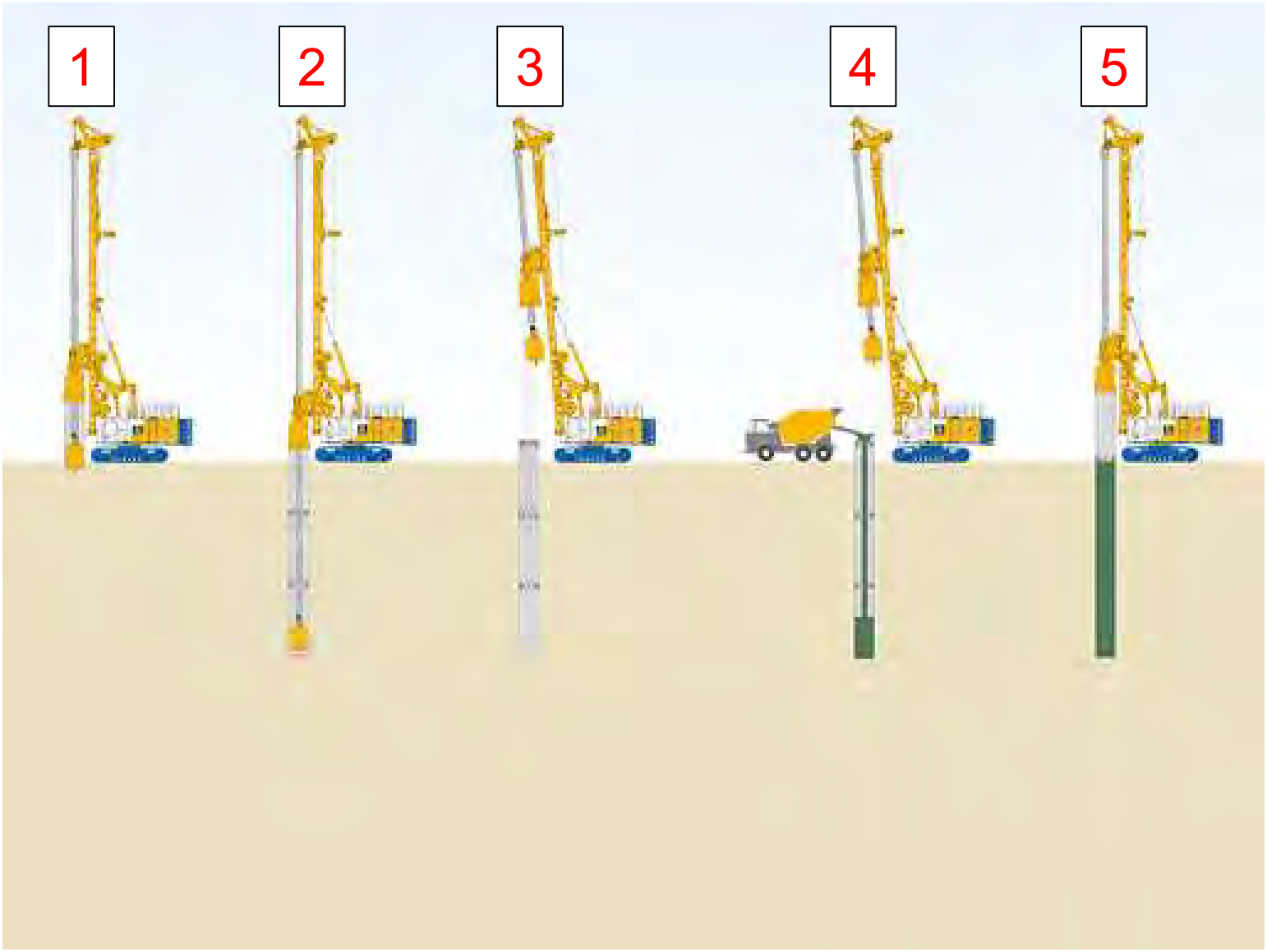
EQUIPMENT – DRILL RIG & GROUT MIXER

INSTALLATION PROCESS



DRILLING, GROUTING, AND REINFORCING

MICROPILE TESTING

CONNECTION TO BUILDING FOUNDATION

CONNECTION TO BUILDING FOUNDATION CONT

CONNECTION TO BUILDING FOUNDATION CONT

CONCRETE TESTING

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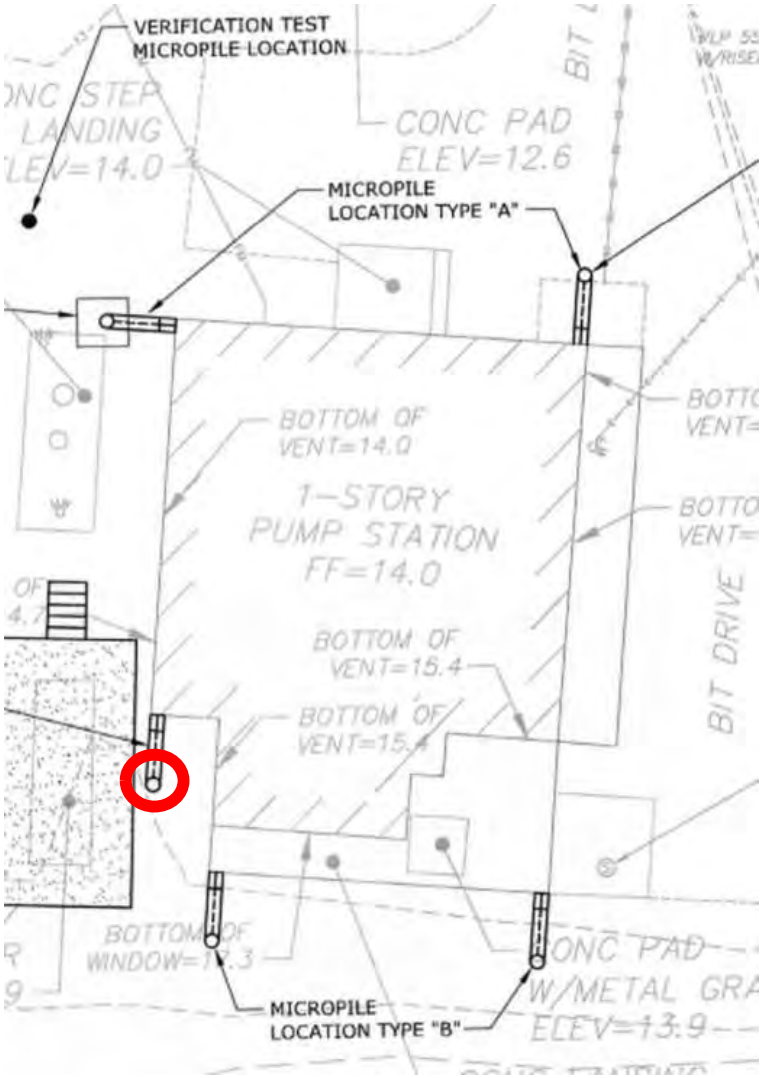
UNKNOWN ASSUMED DEWATERING CASING



UNKNOWN ASSUMED DEWATERING CASING

COST OF MICROPILES

- **Drilling 6 Micropiles (5 Building & 1 Test):**
  - $325,000
    - Includes drilling, steel casing, grouting, steel reinforcing, and testing
- **5 Steel Connections to Building:**
  - $45,000
    - Includes steel, installation, and welding
- **Concrete Encasement of 5 Connections:**
  - $20,000
    - Includes concrete, forming, pouring, and rebar
- **Total:**
  - $390,000
- **Cost per Micropile:**
  - About $65,000 per Micropile

FLOOD LOAD DESIGN CONSIDERATIONS

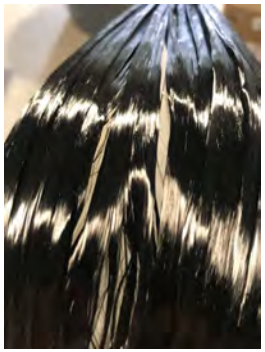
- **Situation:**
  - Inadequate existing wall strength
- **Design Consideration #1:**
  - Increase existing wall thickness
  - Solution: New concrete cast on outside of walls
    - Impractical
- **Design Consideration #2:**
  - Increase strength of existing walls
  - Solution: Apply carbon fiber wall reinforcement to interior of walls

CARBON FIBER WALL REINFORCEMENT

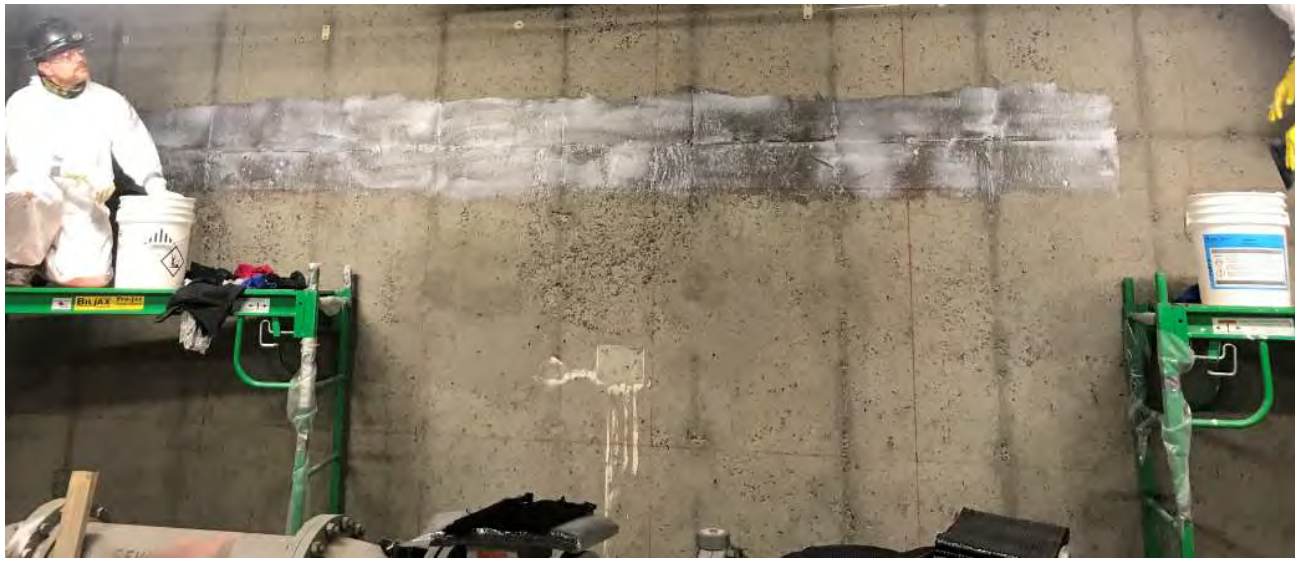
- **Typical Applications**
  - Bridges
  - Pipelines
  - Vertical Applications
- **Dry Tensile Strength**
  - 620,000 psi
- **Epoxy Tens. Strength**
  - 10,500 psi
- **Composite Strength**
  - 121,000 psi

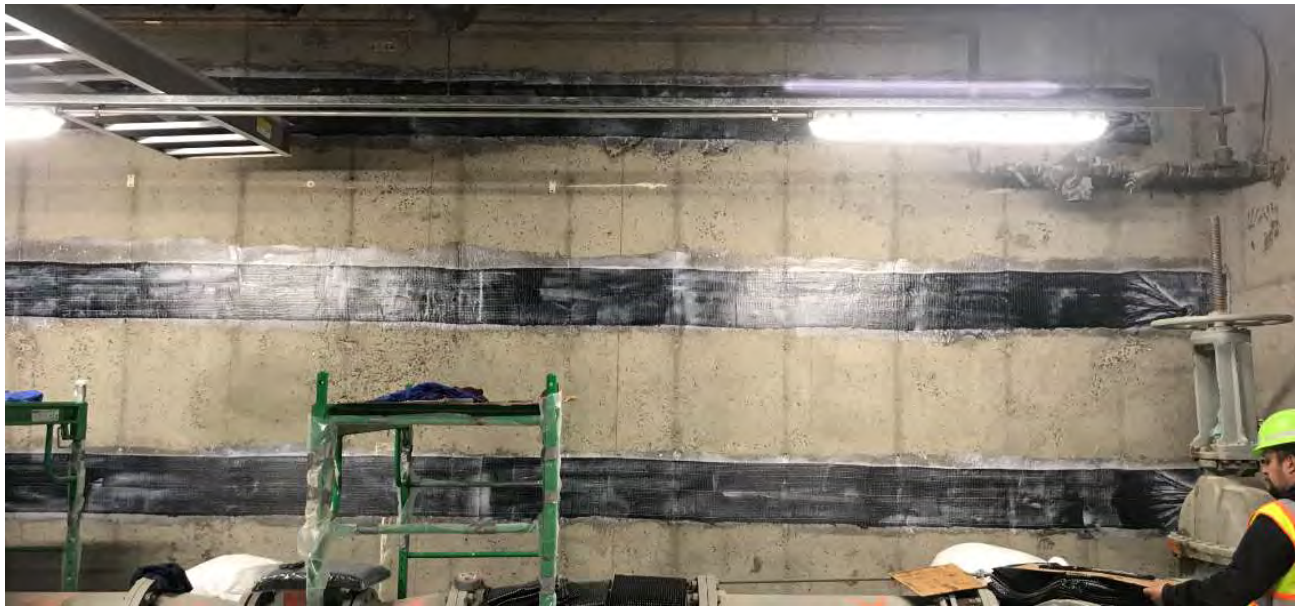
MATERIALS

- Carbon Fiber Strips and Anchors
- Epoxy Application

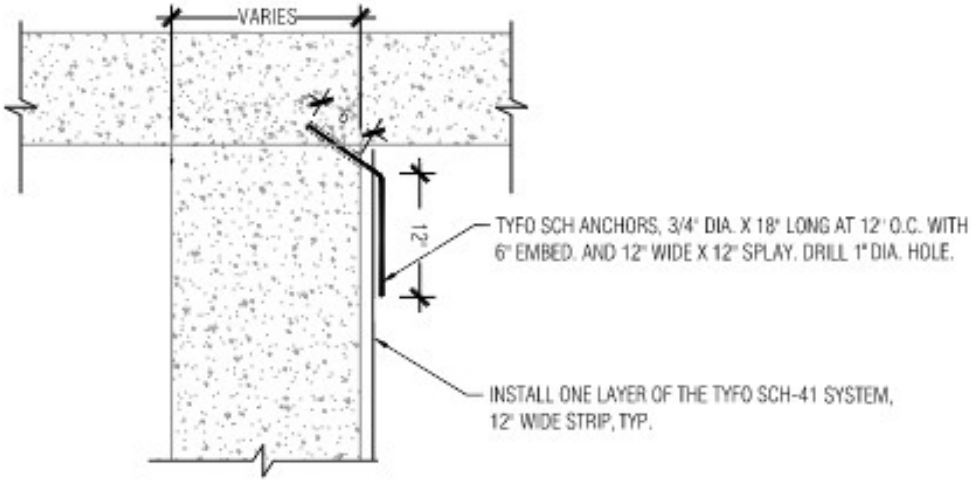


INSTALLATION PROCESS





INSTALLATION PROCESS CONT.



Detail
N.T.S.

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ADHESION PULL TEST

- **Installer performs adhesion pull tests on carbon fiber wall reinforcement system to confirm proper adhesion (400 psi)**
  - All adhesion tests to date have passed at > 560 psi

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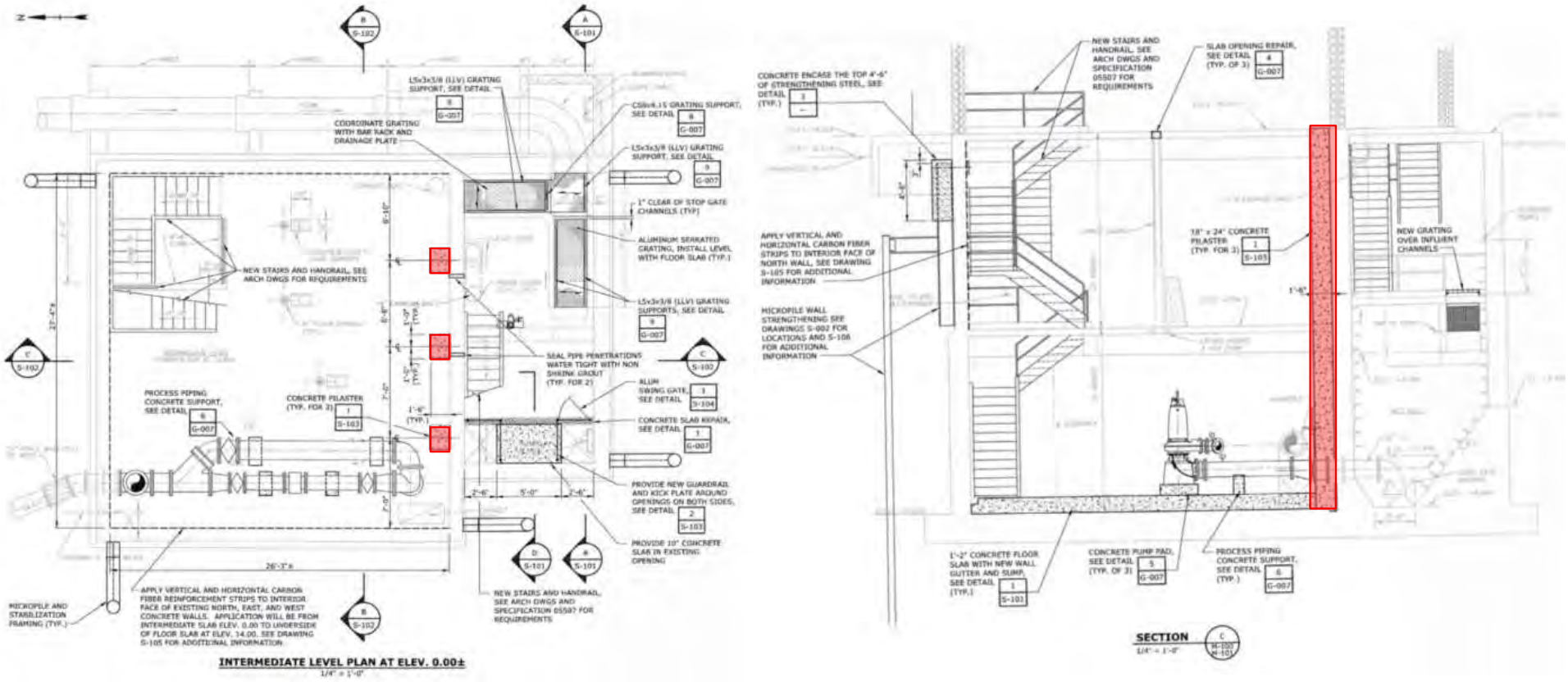
COST – RYDERS LANE PS

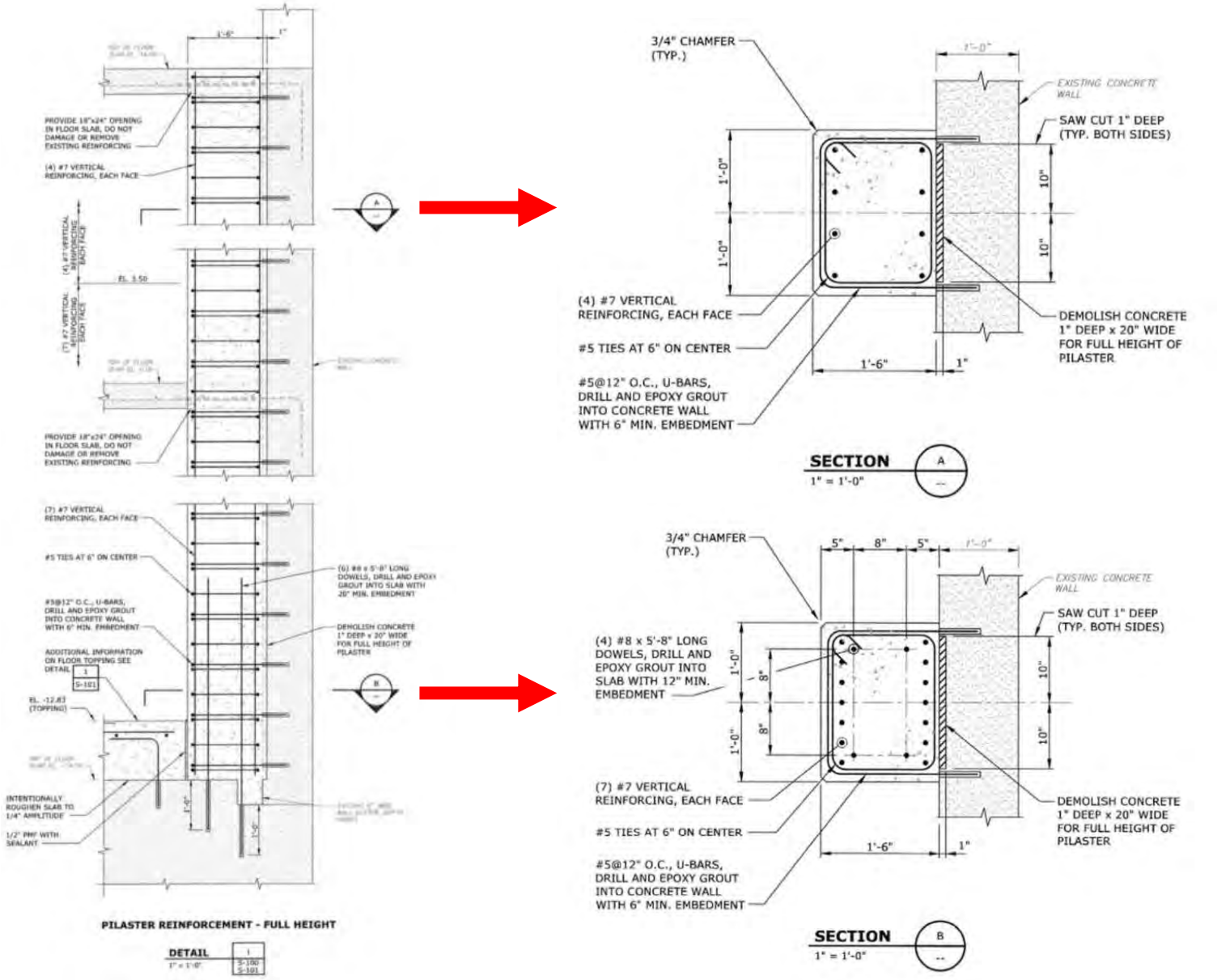
- **Carbon Fiber Wall Reinforcement:**
  - $80,000
- **Surface Area Reinforced:**
  - Approximately 1,100 SF
- **Cost per SF**
  - Approximately $72 per SF*
    - Variables:
      - How much is needed
      - Wall preparation

CONCRETE PILASTER COLUMNS

- Additional structural components required
- Reinforced concrete pilaster columns were constructed



CONCRETE PILASTER COLUMNS - REBAR



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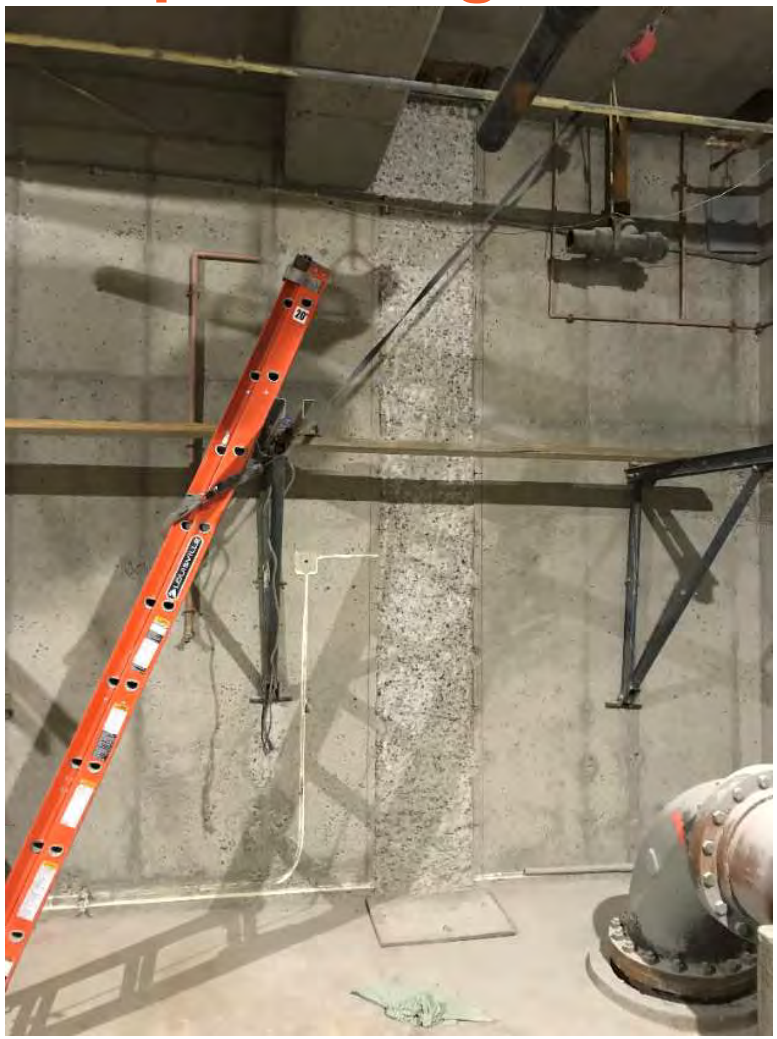
PILASTER COLUMNS INSTALLATION

- Prep existing walls



- Demolish existing floor slabs without damaging rebar

PILASTER COLUMNS INSTALLATION CONT

- Drill and epoxy rebar into existing wall and floor

- Install rebar

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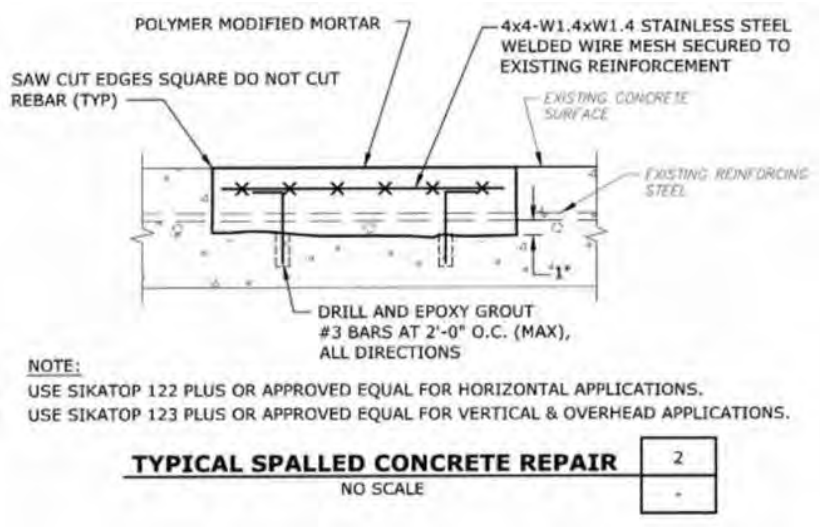
PILASTER COLUMNS INSTALLATION CONT

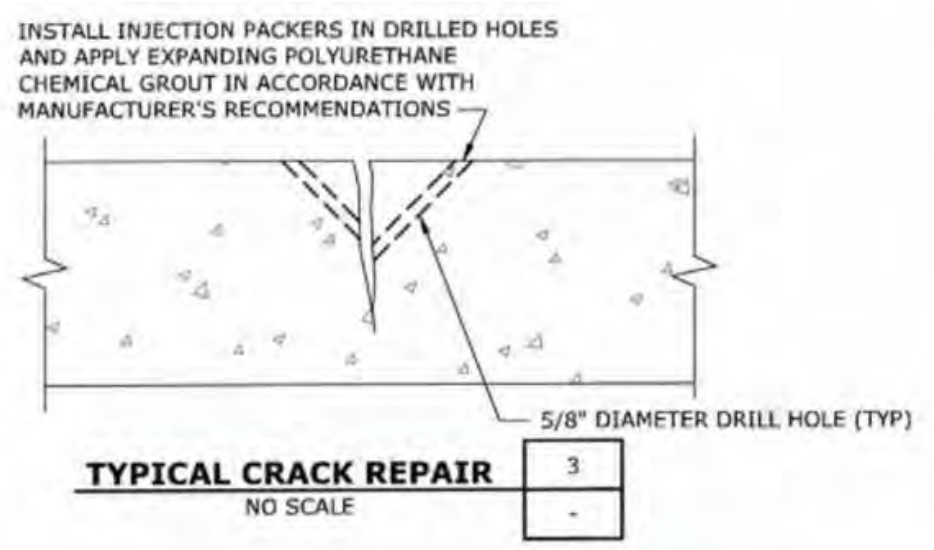
PILASTER COLUMNS INSTALLATION CONT

PILASTER COLUMNS FINAL PRODUCT

EXISTING CONCRETE REPAIRS

- **Spalled Concrete Repair**
- **Concrete Crack Repair**





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SPALLED CONCRETE

SPALLED CONCRETE REPAIR

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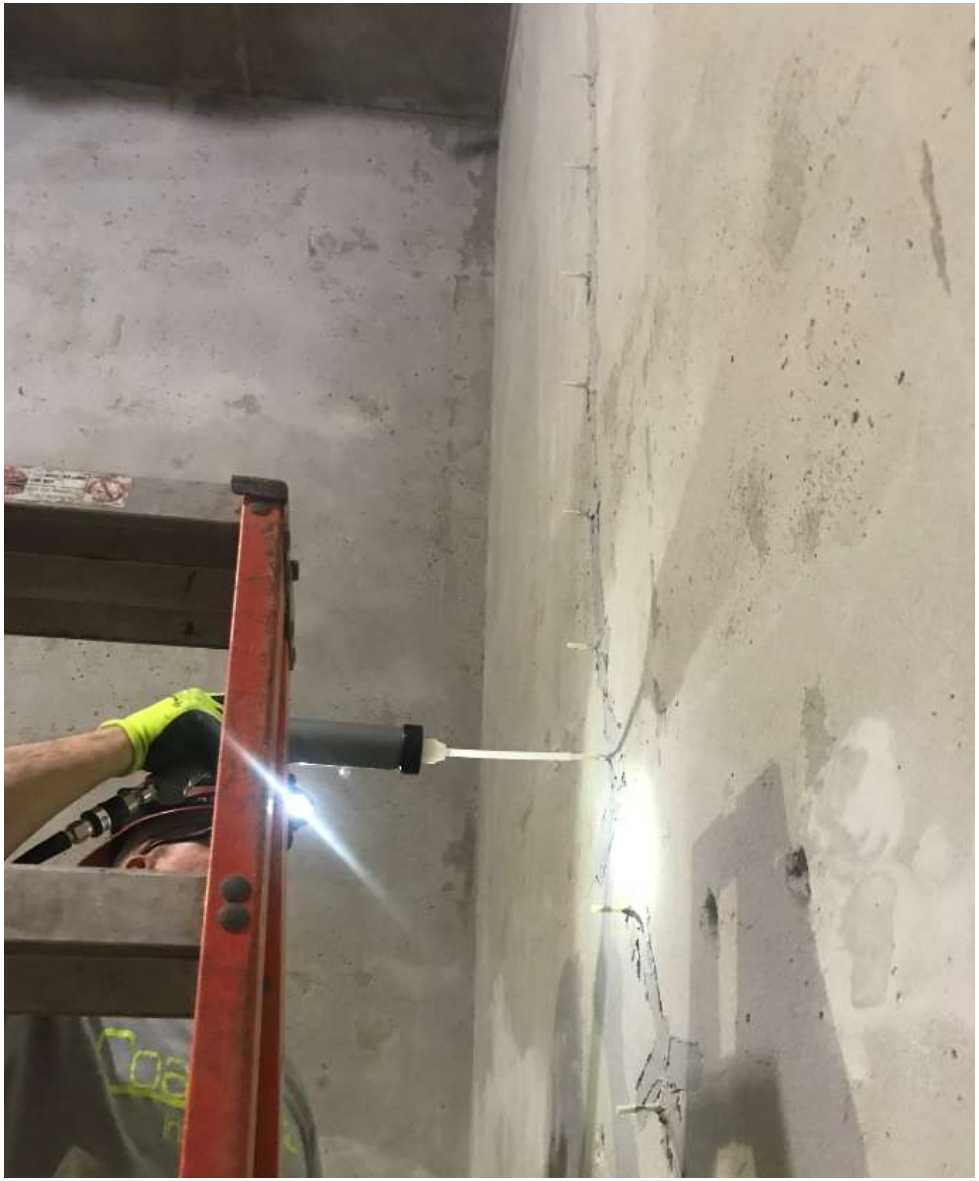
CRACK IN EXISTING CONCRETE

PREPPING FOR EPOXY INJECTION

EPOXY INJECTION



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CONCRETE CRACK REPAIR

QUIZ

- **Question #1:**
  - Per TR-16 design guidelines, all equipment and entrances/openings should be protected from the 50-year flood elevation.
    - True / False
      - 100-year flood plus 3 feet elevation
- **Question #2:**
  - To date, all adhesion pull tests on the carbon fiber wall reinforcement system have passed for this project.
    - True / False

QUESTIONS?

- **Thank you to the Town of Stratford & Jon Popoli**
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