Rehabilitation of Raw Water Conduit and Pedestrian Tunnel

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Presentation Outline

- Introduction
- Background
- Investigation
- Findings / Evaluations
- Repairs
- Challenges
- Questions
PROJECT AREA:
East and West Raw Water Conduits and Tunnel
Project Background (from Owner’s Report)

- Visible cracks in walls and ceiling in Chemical Building
- Water leakage through cracks
- Other areas not visible without dewatering system
Raw Water Conduits

- Constructed in mid 1950s
- Dual Raw Water Conduits
  - 7 feet diameter
  - 7 feet square under Chemical Building
- Design Components
  - Cast-in-place Concrete
  - Reinforced Concrete Pipe
  - Steel-Plate Pipe
- Chlorination chamber
- Venturi Meters
Details of As-Designed Conduits

SECTION "A"

SECTION "B"

SECTION "C"
Site Access

- Permit required confined space
- Only 2 access points
  - Chemical Building
  - Low Lift Building
- Hazards
  - Chlorine
  - 36-inch bypass line
  - Venturi
Site Limitations

- Only 1 conduit out of service at a time
- Repairs during low demand (winter months)
- Uninterrupted Plant Operation
- NSF 61 – Drinking Water Standard
INVESTIGATION
Investigation

Panoramo Camera Inspection

• 360° Digital recording
• pan / tilt and zoom by reviewer
• Measurement of features
Investigation

• Manned Entry
• Physical Measurements
• Concrete Cores
• Condition Assessment
• Sounding of Concrete
Investigation

Geophysical Survey

• Identify potential voids
• Comparison with historical soil information
Soundings

• No Delamination Observed

Concrete Cores

• Compressive Strength 7300 psi
• Tensile strength of Steel 60 ksi
Condition Assessment

- Fairly Good Condition
- Offset joints at Low Lift Bldg.
- Defects mainly in Chemical Bldg.
- Grout missing at some joints
- Visible Cracks and Fractures
Condition Assessment

- 1 Gushing & 1 Running leak
- Dripping & weeping leaks
- Previously sealed fractures were reopened and leaking
- Rubber seals sound but distressed – bars placed to hold in place
Petrographic Analysis

- **W/C ratio** – 0.33 to 0.35 for CIP, 0.35 to 0.37 for steel plate pipe

- No air entrainment

- Water –soluble chloride 0.03 to 0.04 % (well within ACI range)

- Cement paste friable, soft and degraded at surface

- Carbonation to 5/16-inch at surface
Carbonation Process

$\text{CO}_2$ in air or water

$\text{Ca(OH)}_2$ converts to $\text{CaCO}_3$
Other cement compounds decomposed

Hardened concrete

* $\text{CaCO}_3$ dissolves in cold water – softens surface
** on dry surface $\text{CaCO}_3$ hardens and shrinkage may result
Structural Evaluation

- Conduits Structurally sound
- Cracking due to thermal movement
- Continued infiltration will impact durability
Sinkhole Evaluation

- Sinkhole developed near Low Lift Bldg. after returning East Conduit to service
- Owner re-drained East Conduit, replaced plug on drain line
- Owner filled sinkhole at surface
- NTH revisited site, performed supplemental GPR survey
Ground Penetrating Radar

- Several anomalies detected
- Sloping reflectors and soil pocket
- No indication of voids
- Anomalies match construction features shown on plans
Supplemental GPR

Line 1

GPR Line Adjacent to Sinkhole, Lines Indicate Limits of Observed Sinkhole Effects

Line 2

GPR Line Above Sinkhole (Surface Feature), Arrow Indicates Small Depression Observed at Ground Surface

Line 3

GPR Line Adjacent to Sinkhole, Anomaly Barely Discernable
Raw Water Conduit at Low Lift Building – area of sinkhole
• Fractures in wall
• Bowing of concrete
• Delamination in floor near Chemical Bld.
• Leak in Wall at Chemical Bld.
REPAIRS
Surface Preparation is KEY
Surface Preparation

1. Seal Leaks
2. Repair joints
3. Remove softened / carbonated layer
4. Repair fractures and cracks
   - Rout and seal with urethane
   - Inject with epoxy
5. Coat interior with Crystalline Waterproofing
6. Replace rubber seals
7. Repeat for opposite Conduit

8. Repair Pedestrian Tunnel
   - Install new wall section
   - Grout fractures/cracks
   - Repair spalls/delaminations
Working in cold weather
Limited Site Access
Reinforcement on inside of Pedestrian Tunnel without effecting conduits
Working around conduits
Original rubber not available
Cold water under pressure (35°F)
Interpretation from Owner’s Representative