Post-Tensioning System Evaluation
Hwy 400 Northbound Bridge over Hwy 407

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Post-Tensioning Grout Problems

- Voids
  - Incomplete filling of ducts or grout leakage prior to hardening
  - Typically, caused by grout bleed where excess water floats to the top of the grout resulting in a pocket of water or a void if the water later evaporates.

- Chloride Contaminated Grout
  - Exposure to chlorides in the environment
  - Chloride contamination of the grout

Post-Tensioning Grout Problems

- Variations in Grout Properties
  - Grout is intended to provide a uniform, protective environment around post-tensioning strands
  - Variations in grout properties create variations in corrosion potentials which can initiate and sustain corrosion.
  - Excess water used with prepackaged grouts can result in segregation and the creation of a layer of porous and / or soft grout with a different chemical composition compared to good quality grout
Mostly corrosion of tendons within the anchor limits
Most prevalent on external tendons

- Severe corrosion was present inside the anchors

• Constructed in 1990
• 4 span post-tensioned rectangular box girder; 203.6 m long
Evaluation Process

- Visual and delamination survey
- Ground penetrating radar
- Sonic/ultrasonic impact-echo testing on tendons
- Openings to verify echo results and collect samples
- 8 dust samples for chlorides
- 1 sample for petrography
- 11 samples for carbonation
- Inspect 1 stressing head
- 2 air tests along PT tendons

Visual and Delamination Survey

- Narrow cracking along post-tensioning particularly in exterior girder
- Localized delaminations not associated with post-tensioning
- Minor to severe honeycombing
- Large areas of parging
- Localized abrasions
Locating PT tendons

- Locate tendons with ground penetrating radar
- Determine the average depth of concrete covering the PT tendon

Impact-Echo Testing

- Check for voids in grouted ducts

Sampling

- Cut openings to verify findings and collect samples
Chloride Testing

- 0.2% by weight of cement (ACI)
- 0.031% by weight of concrete
- 1.2 lb Cl-/yd3 of concrete (0.71 kg/m3)
- These code guidelines are rather simplistic
- Different concrete conditions have different thresholds: wet or dry concrete, pre-stressed, etc.
- In reality corrosion activity is progressive and based on the Chloride / Hydroxyl Ratio (Cl-/OH-)

Chloride Limit for New Construction (ACI 222R)

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<tr>
<td>Test Method</td>
<td>ASTM C121</td>
<td>ASTM C121</td>
<td>Soxhlet</td>
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<tr>
<td>Pre-stressed</td>
<td>0.08</td>
<td>0.06</td>
<td>0.04</td>
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<tr>
<td>Reinforced</td>
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<tr>
<td>Dry</td>
<td>0.20</td>
<td>0.15</td>
<td>0.15% by weight</td>
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Carbonation Testing

- Mainly to determine amount of carbonation
- Can also be used to determine some types of chemical contamination
- 1% phenolphthalein in alcohol or 50/50 mixture of distilled water and alcohol
- Generally perceived to indicate pH of > 9.5
**Petrographic Examination**

- Good quality
- No inherent defects
- Water-cement ratio 0.35 to 0.45
- Well-hydrated
- Abundant Calcium Hydroxide
- 2-3% air content

**Air Flow Test**

- Testing for voids along tendons
- Interstitial spaces in tendons seldom filled with grout and often contain air voids where water and chlorides can collect
- Tendons tested did not show any sign of air flow

**Questions**

- Thanks to:
  - Vector Corrosion Technologies
  - NDT Corporation
  - Petro Laboratories Inc.
  - CTL Group