Post-Tensioning Corrosion Evaluation and Mitigation

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Abstract

Corrosion of post-tensioned tendons can lead to wire/tendon break and possible bridge collapse is a serious problem for bridge owners.

Water bleeding and grout segregation from portland cement grout and improper grout installation have created pockets of voids and water/moisture in many bridges. Water or sufficient moisture presence and/or corrosive ion concentration has caused corrosion in the tendons. Formulated, prepackaged grout has been an important advancement, however, soft grout pockets have been found , resulting in significant tendon corrosion in many bridges.

PT corrosion evaluation (CE) correlating the moisture level to the corrosion condition of the tendon, tendon drying to remove water/moisture and injecting corrosion-resistant materials has been employed in unbonded post-tensioned structure for more than twenty years. These technologies have successfully mitigated tendon corrosion and reduced the wire/strand breakage rate significantly.

These technologies are finding their way into applications in post-tensioned bridges. CE helps to evaluate corrosion environments and corrosion risks of the post-tensioned tendons, and tendon drying and corrosion-inhibiting material impregnation can improve the environment for the tendon and mitigate corrosion.

Embedded zinc sacrificial anodes have been included in patch repairs of steel reinforced concrete structural elements as well was prestressed concrete bridge suffering from corrosion since the mid-nineties. Unlike impressed current cathodic protection (ICCP) system which may cause prestressed steel hydrogen embrittlement, sacrificial anodes are safe to use in post-tensioned structures.

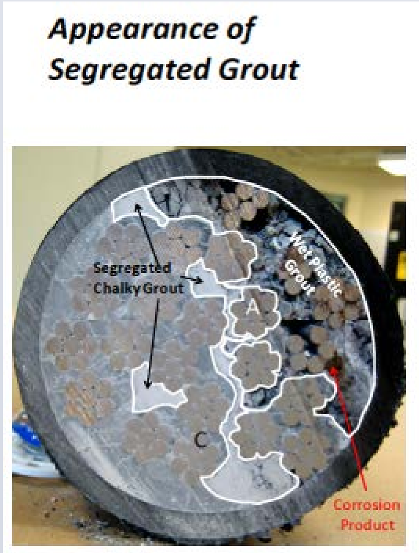
This poster/paper presents the causes of post-tensioning corrosion and the resulting corrosion damages, then introduces different evaluation techniques and corrosion mitigation systems to improve the durability of the post-tensioned bridges.

Keywords: post-tension corrosion evaluation, cathodic protection, corrosion, post-tension impregnation, embedded anodes, post-tensioned tendon, and tendon drying.

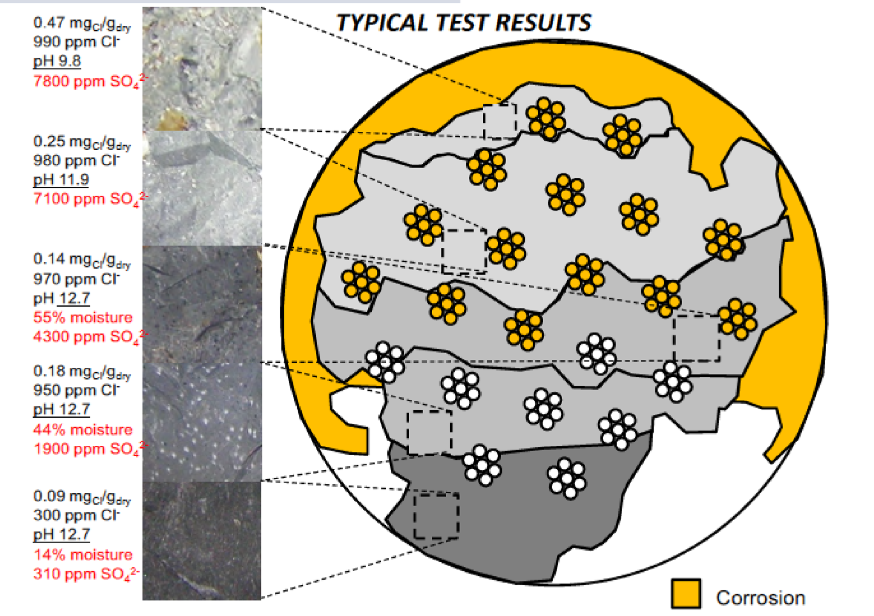
Causes of Post-Tensioning Corrosion

- Voids and moisture between strands and between wires
- Water bleeding from grout
- Grout Segregation
- Water penetration from anchorage pocket, joints, cracks
- Water penetration due to floods
- Chloride -contaminated grout
- Soft grout and high corrosive ion concentration
- Dissimilar grouts in the same tendon

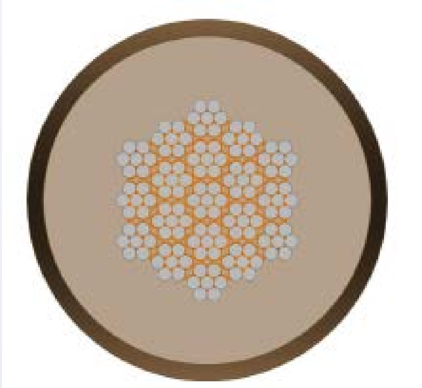
Wick-induced bleed test by American Segmental Bridge Institute in April 2012 showing portland cement grout with about 4% bleeding after 24 hours of grouting operation.



Grout Segregation test by Florida Department of Transportation

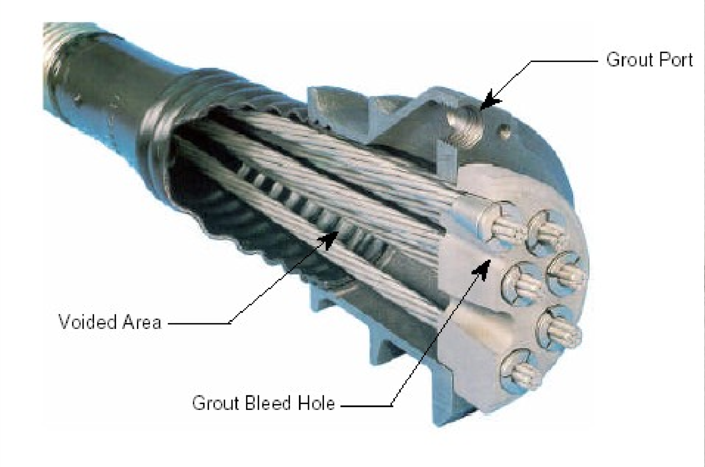


Post-Tensioning Corrosion Damage



Inner wire corrosion due to the presence of voids and moisture

Wire corrosion from inside-out caused by water penetration, resulting in wire break and concrete spalling



Corrosion of Tendon at Anchor (2000) from Florida Department of Transportation. Most tendon corrosion is within anchorage zone

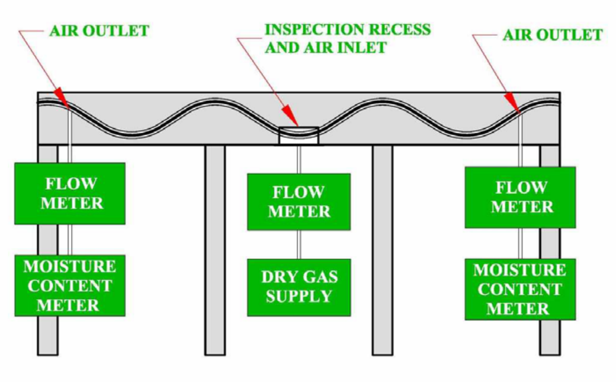
Cable corrosion and breaks due to dissimilar grouts caused by re-grouting

Post-Tensioning Evaluation

- Visual inspection / test pits
- PT Corrosion Evaluation by moisture testing
- Chloride analysis of PT grout
- PH and chemical testing
- Petrographic analysis
- Scanning Electron Microscopy examination
- Cable Break Detection

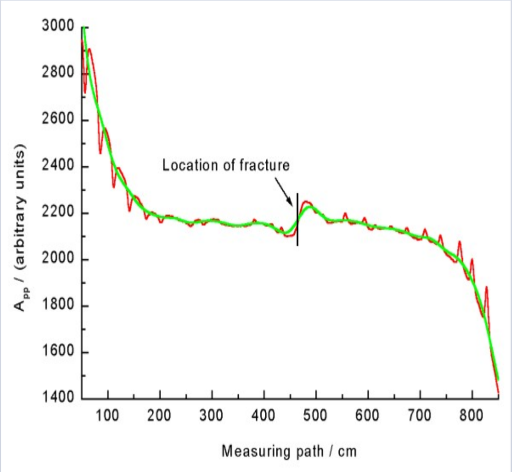
Make exploratory opening to inspect the conditions of the grout and wires

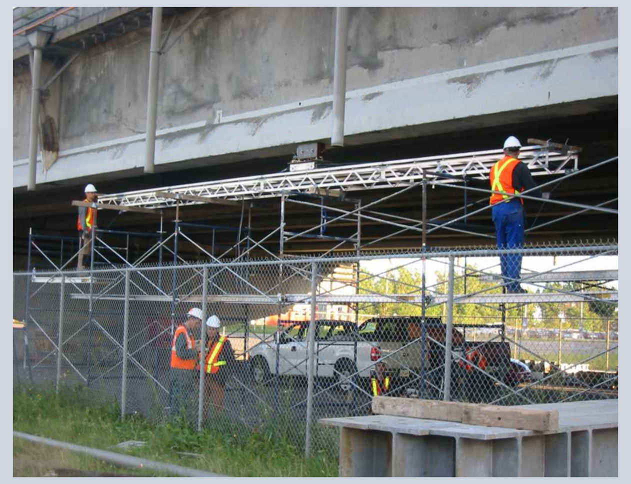
Take grout samples for lab tests White and chalky grouts, grout pores are common



Corrosion Evaluation by Moisture Testing:

- Use the exploratory openings and anchorage pocket to pump dry gas into the tendon to evaluate the moisture contents and its corrosion risk.
- Cable with moisture content greater 0.7% is a WET cable with high corrosion risk.
- Cable with moisture content less 0.3% is DRY cable with low corrosion risk.

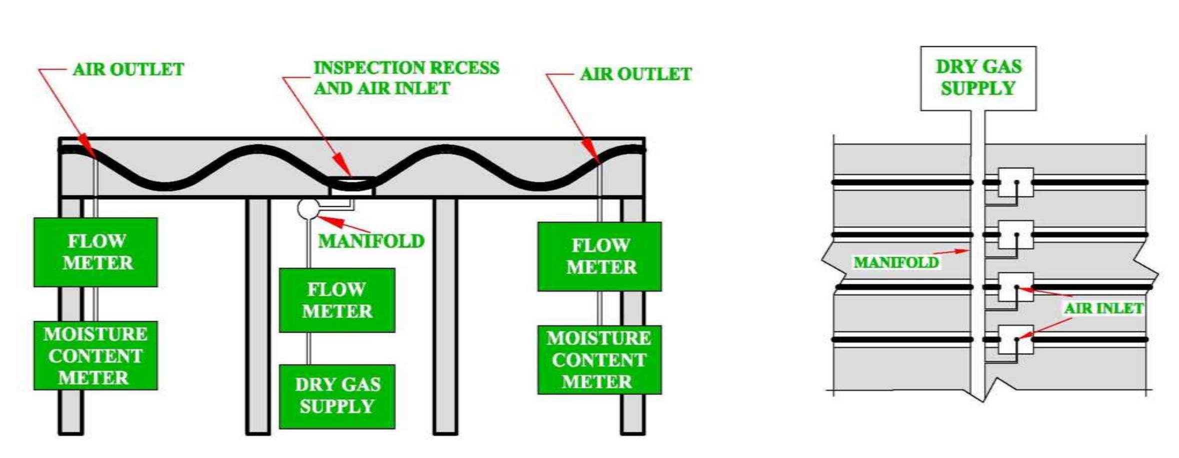




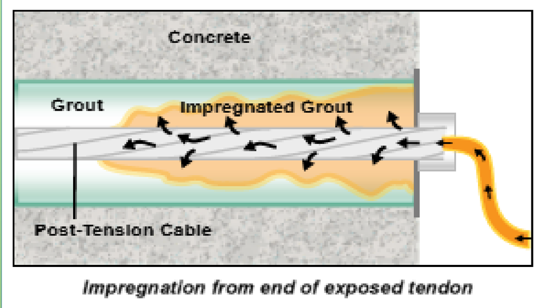
Conduct Remnant Magnetism testing to identify strand/wire fractures or breaks

Post-Tensioning Corrosion Mitigation

- Cable drying
- Cable impregnation
- Galvanic protection
- Cable cleaning
- Re-grouting



Dry the wet tendons/grout to remove the water/moisture from the tendons and the grout.



Impregnate the tendon/grout to fill the interstitial space between wires/strands and also the grout Pores to control corrosion