



VTRC

**Virginia Transportation
Research Council**



Lessons from Post-tensioned Grouting Problems

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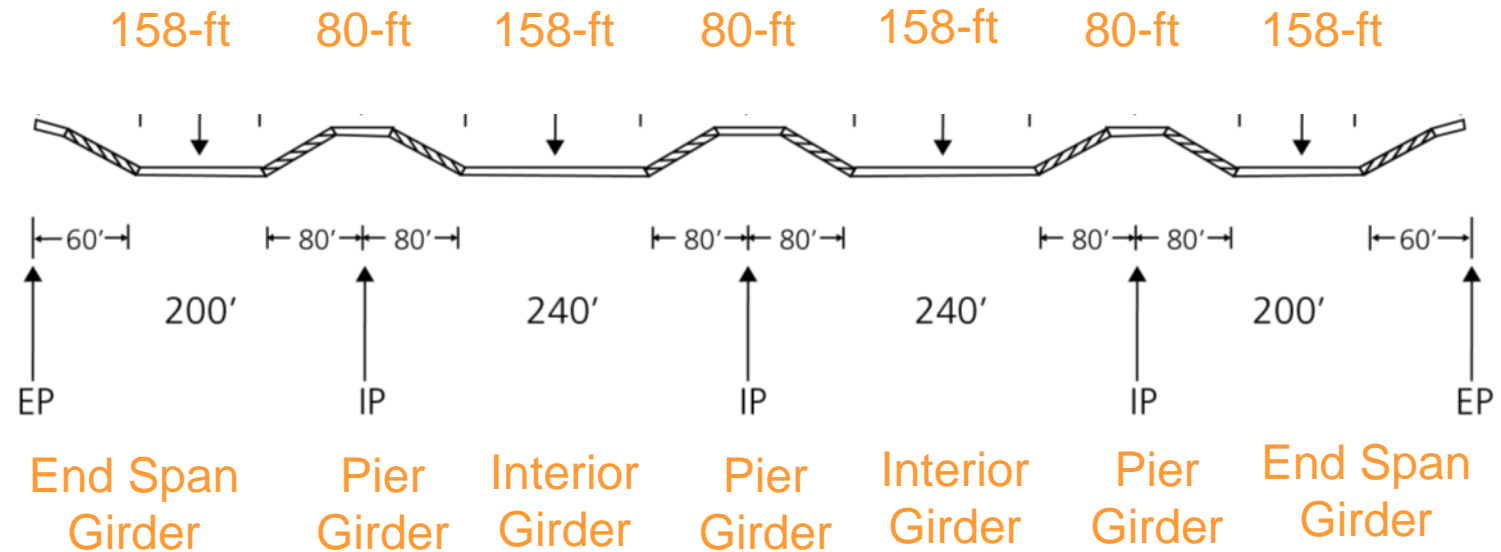
March 26, 2024

Lord Delaware and Eltham Bridges

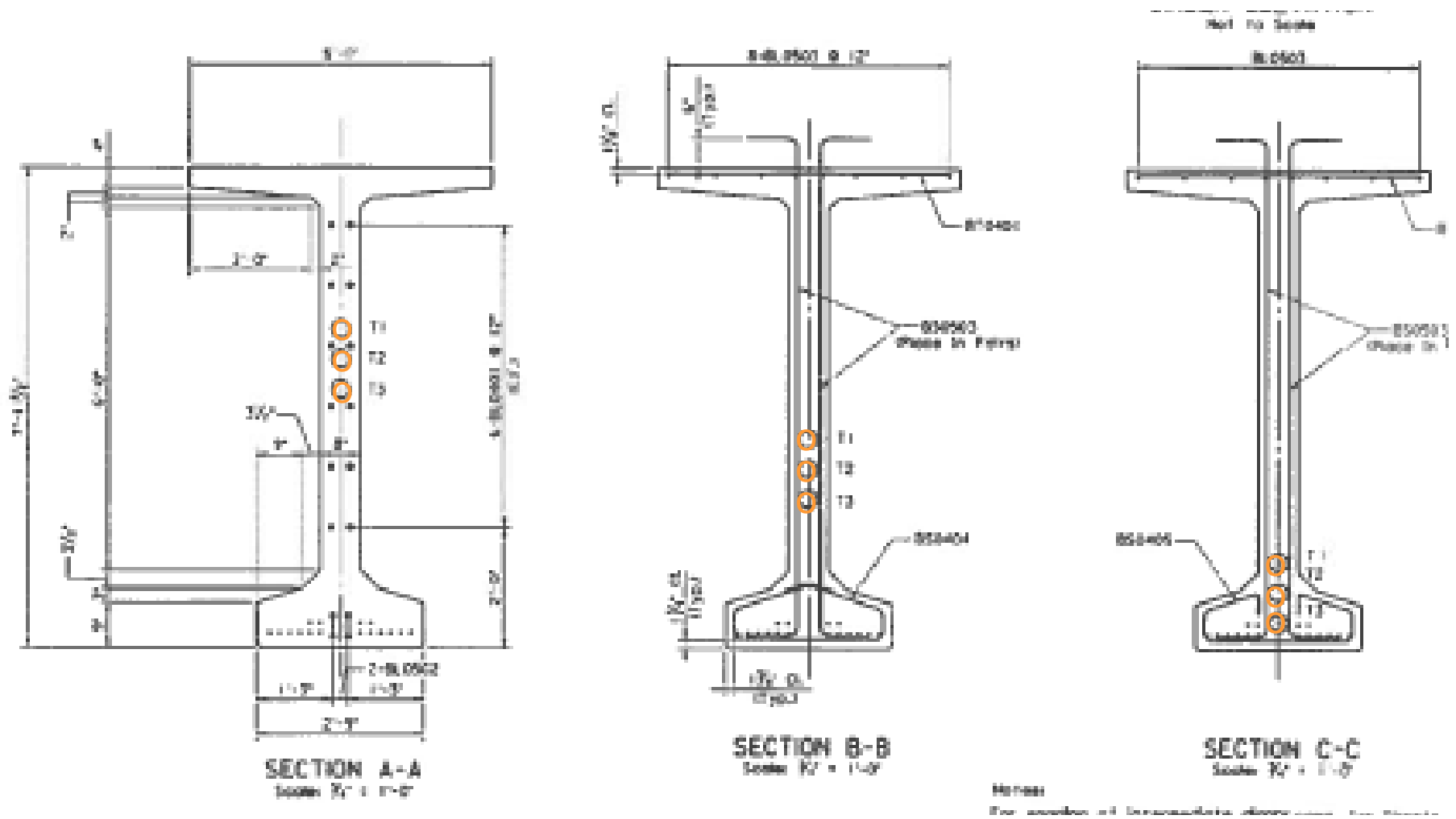


Post-tensioning Profile

Two sets of seven 4-span continuous post tensioned girders 880-ft long in each bridge (14 miles of PT duct)



Girder Sections Showing PT Ducts



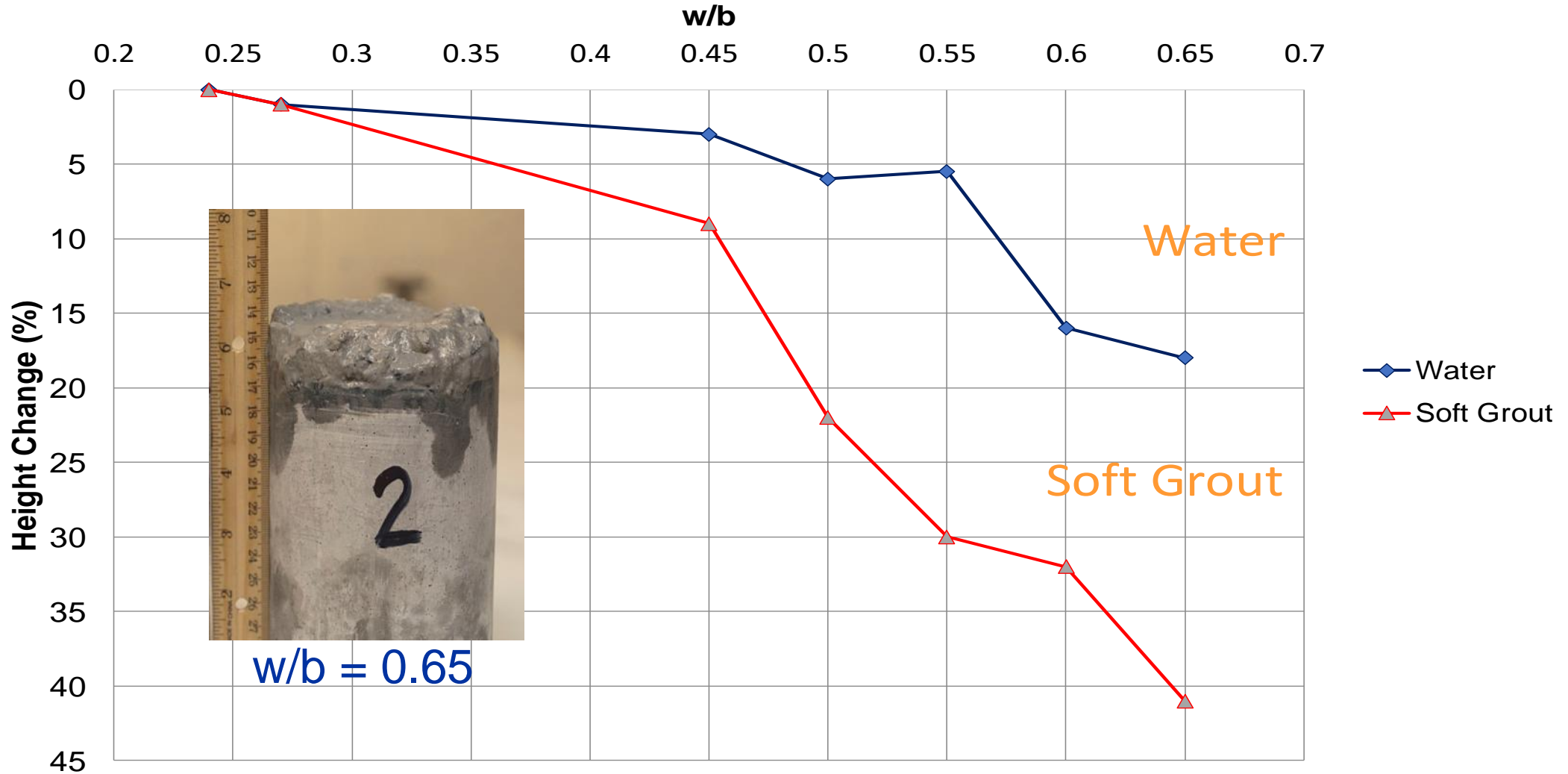
Spall in Web Adjacent to Tendon Duct



Cracks & Water Leaks at Closure Pour Joints



Height Changes from 4x8-in cylinders



Michael's Initial Hypothesis from Experience

- A. Tendon grout may contain excess water, possibly more than twice the recommended amount of water.**
- B. Concrete spalled likely because the water in the duct expanded after being subjected to freezing conditions.**
- C. Tendon grout segregated in the duct with solid grout settling near the bottom PT profile, soft grout rising to the intermediate level sections and water and voids likely at the top profile over and near the piers.**

B. Simple Concrete Freeze Test



6x12 cylinder with
lightweight
concrete

3.5" conduit filled
with
water

Frozen overnight

Field Investigation

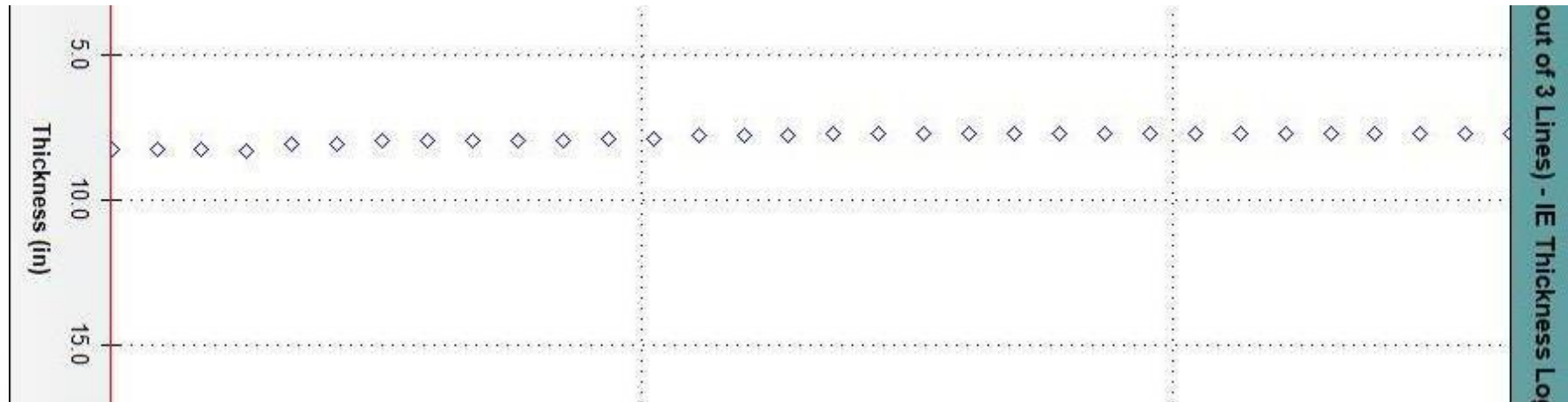
- **Eltham Bridge**
 - 54 cross-sections
 - Data from girders all seven girders

- **Lord Delaware Bridge**
 - 26 cross-sections
 - Data from one girder

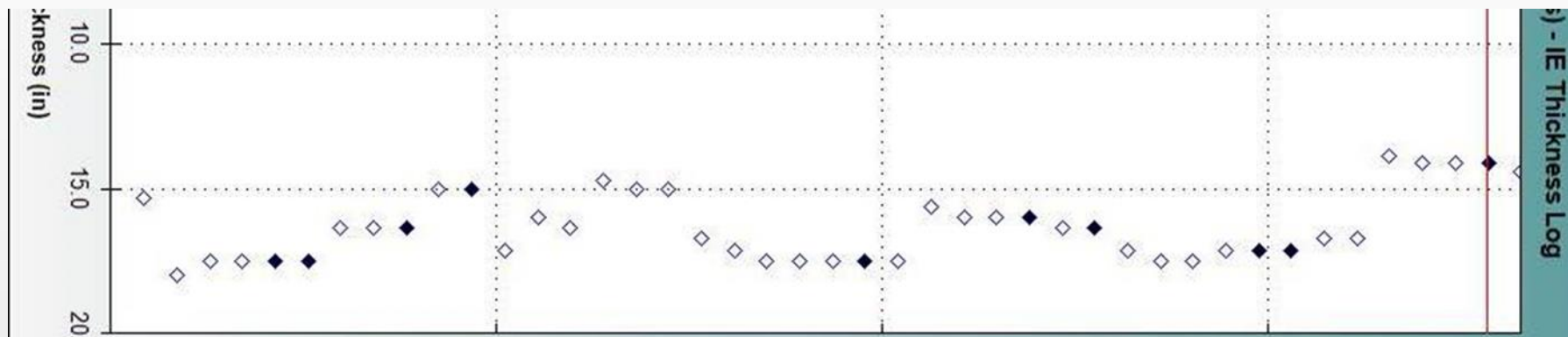
- **41 samples were collected through drilling into tendon ducts. Determined chlorides, sulfates and pH.**

Impact Echo Scans

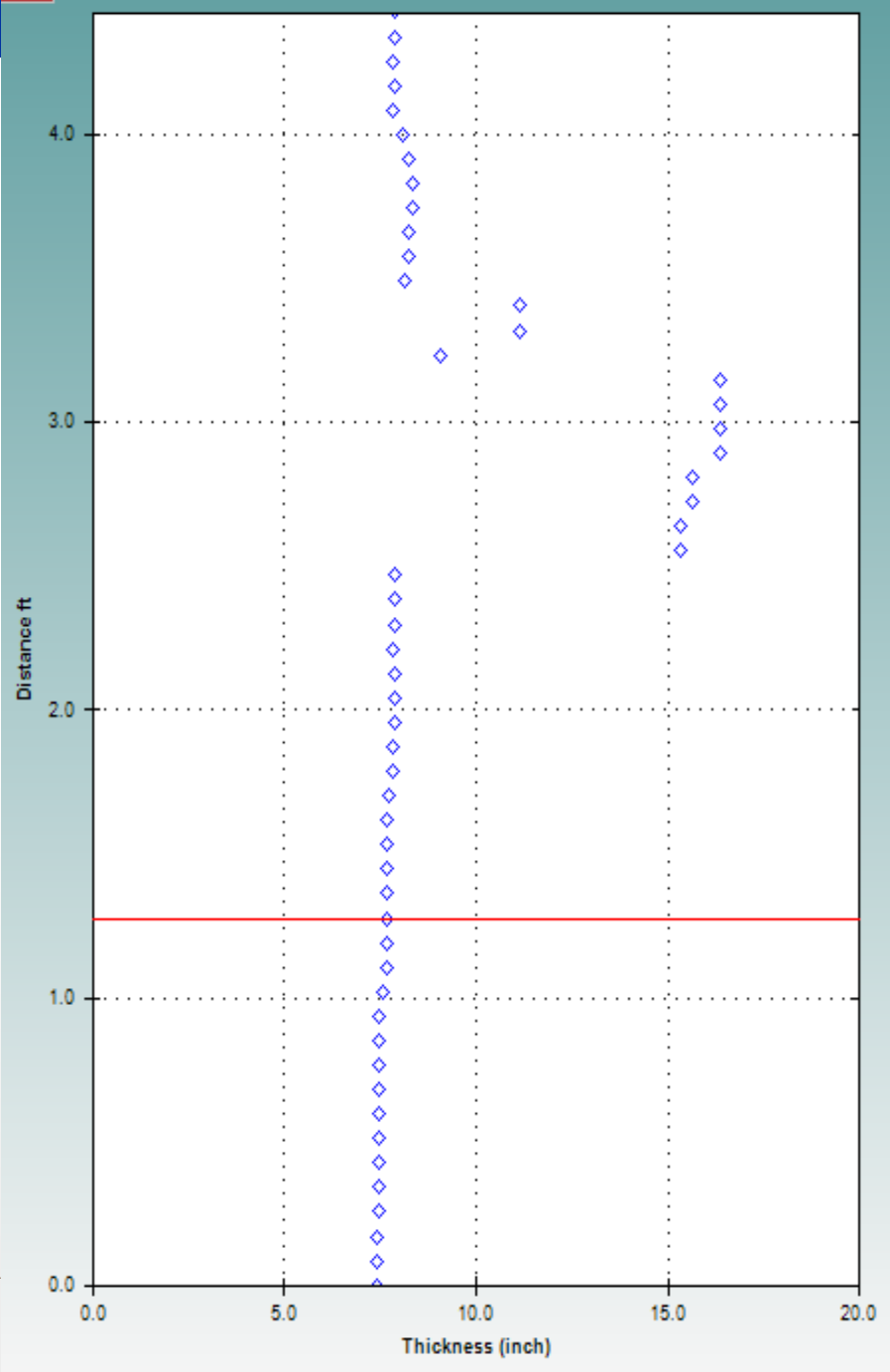
Indicating Hard Grout



Indicating Water, Soft Grout or Void

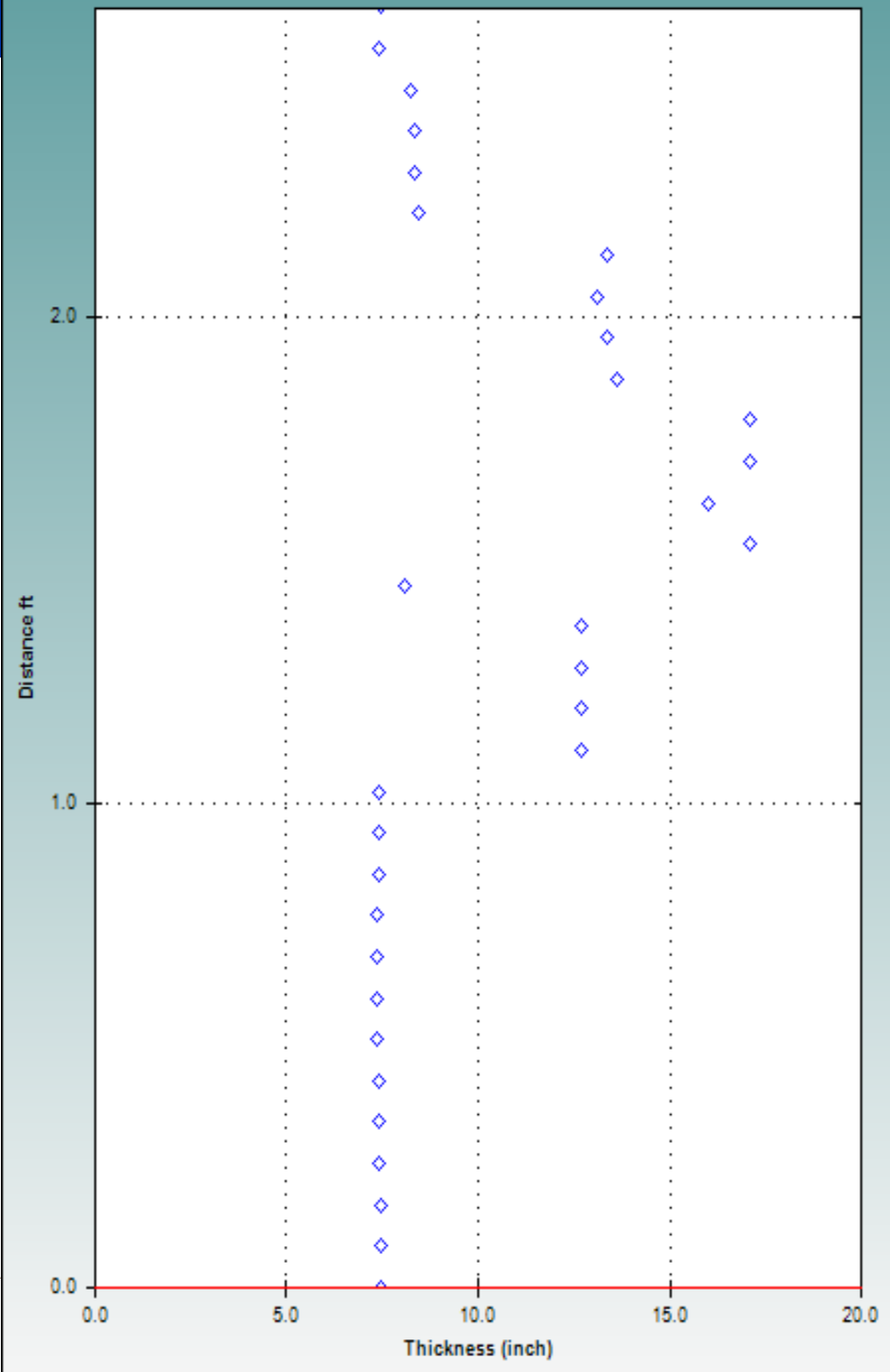






After air compression
45 ft. from Pier



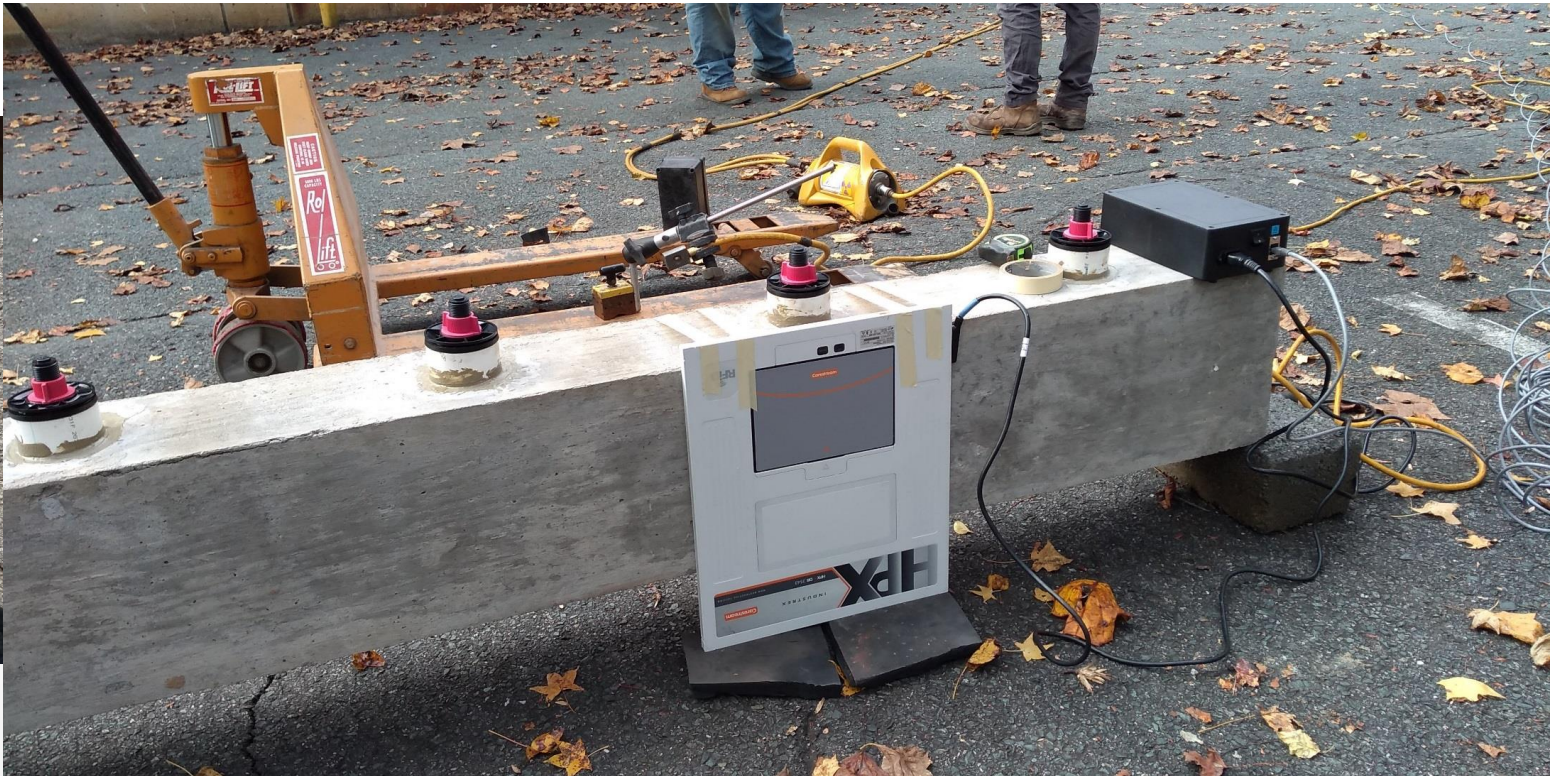


After air compression
35 ft. from Pier



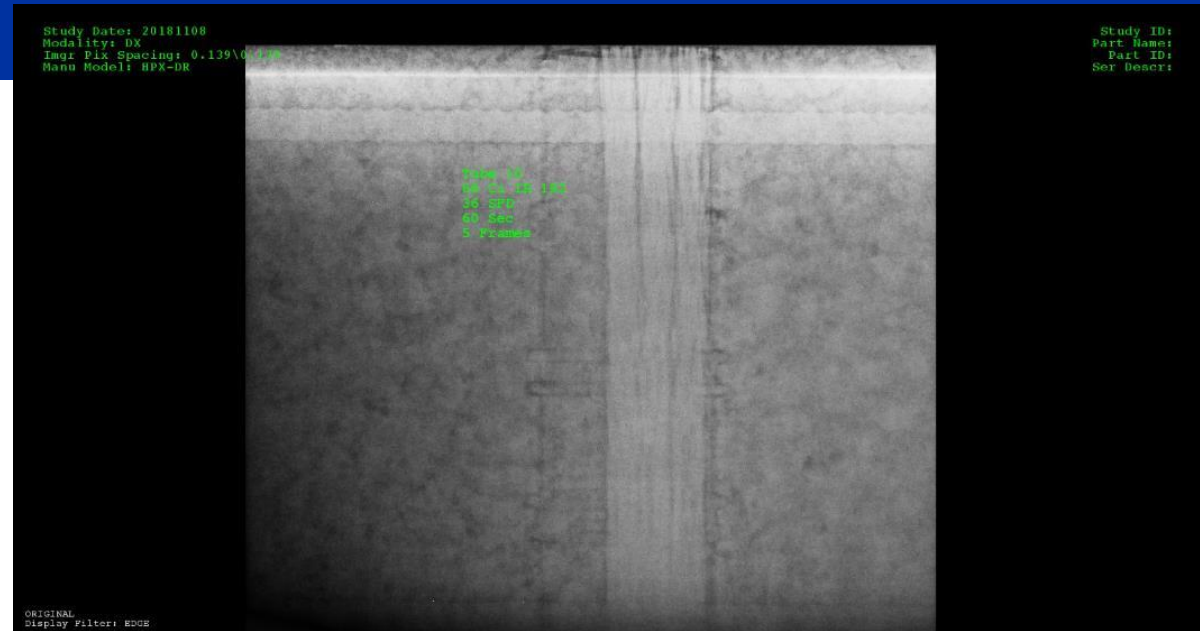
Non-Intuitive Lessons Along the Way

- **Some interior girders had no cracks on the surface, but the ducts contained a lot of water indicating different temperature exposure.**
- **Lord Delaware Bridge appeared more predictable compared to Eltham Bridge**
- **Water in the ducts are probably from construction, because most air compression tests did not result in a leakage**

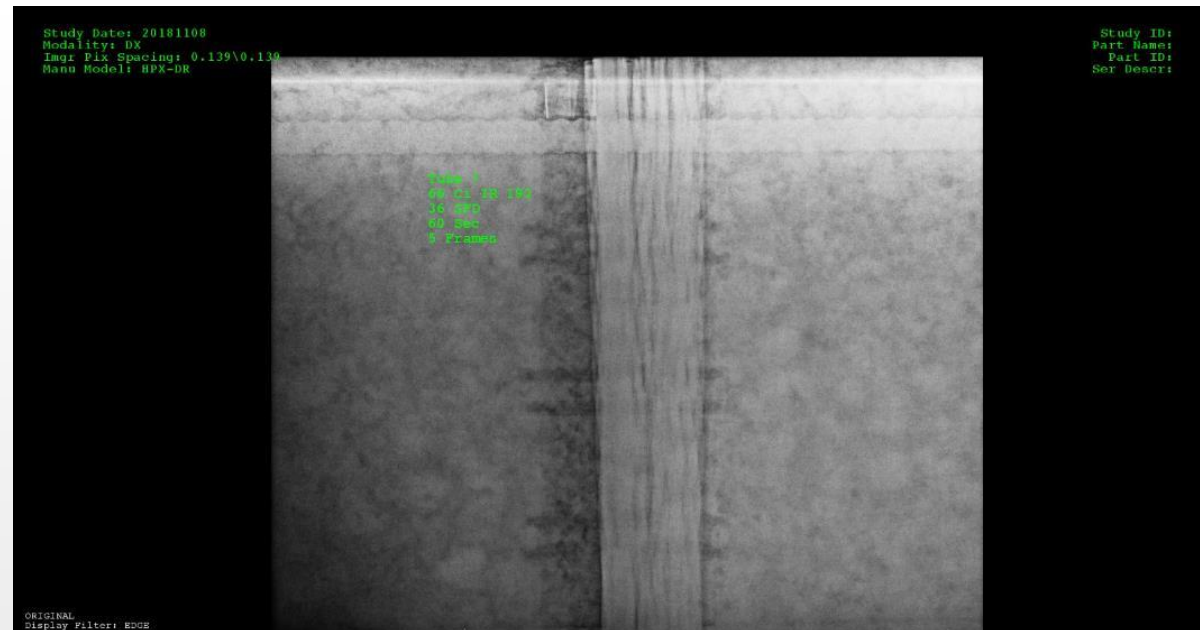


Digital Gammagraphy of Plastic Duct

Solid Grout

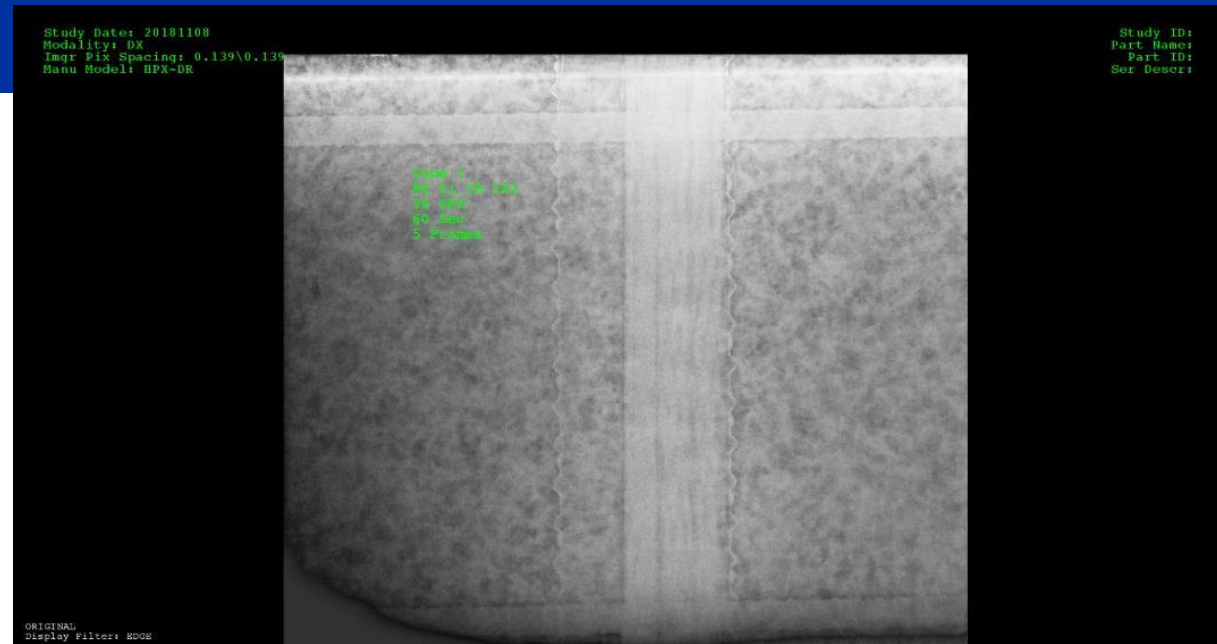


Empty Duct

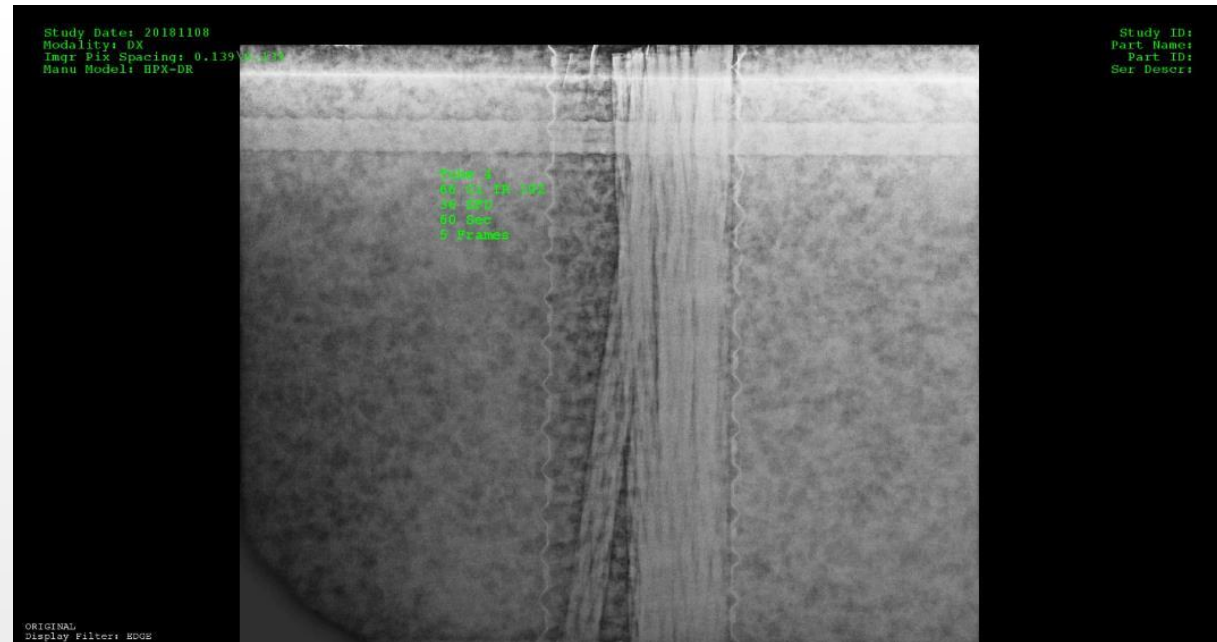


Digital Gammagraphy of Metallic Duct

Solid Grout



Empty Duct



Magnetic Flux for External Ducts



Takeaway #1 - Importance of Preparation & Verification

- **Field evaluations are naturally triple-blinded.**
- **Recently, two separate instances of field evaluations using traditional NDE:**
 - an extensive consultant evaluation of PT tendon locations only matched 60% ground truth
 - Another small investigation had 50% match with the ground-truth
- **With Magnetic Flux, two consultants attempted their system on Michael's mockups:**
 - one consultant matched 100% of artificial defects, while another matched 60%.

Takeaway #2
Common
sensible
approach &
“Do not
harm”



Takeaway #3 Learning by Doing





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