



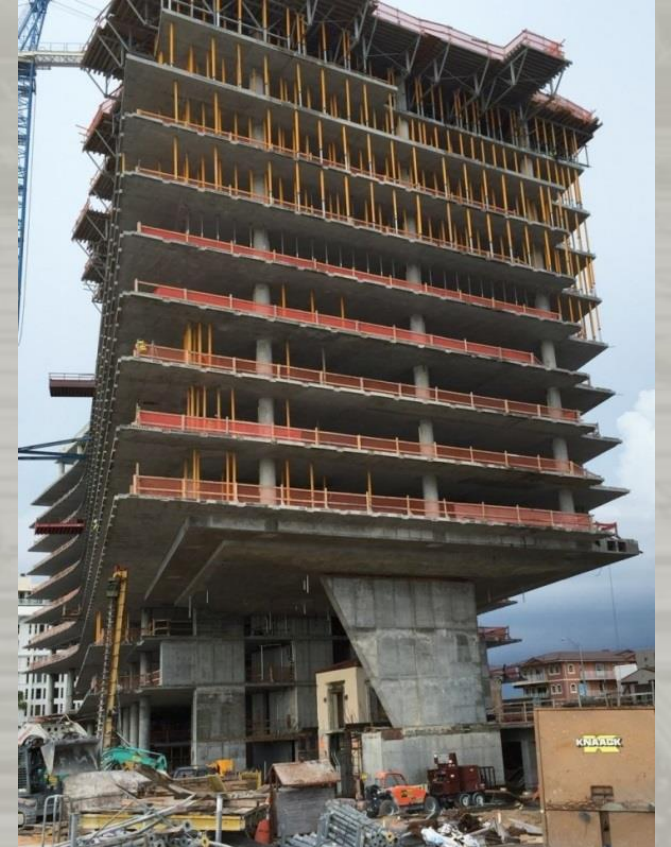
Post-Tensioning Repairs Rules for Success

Don Kline, P.E.



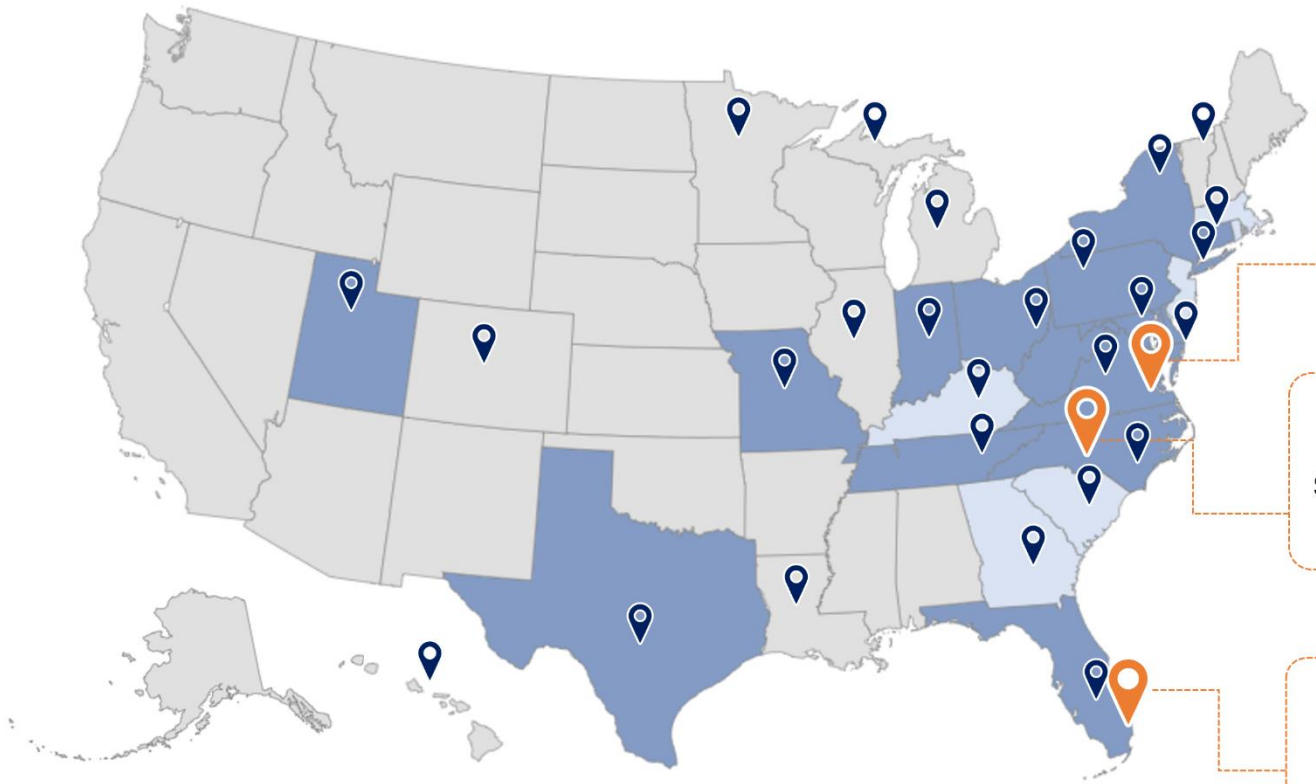
Take-Aways

- Gain knowledge of evolution of PT systems over the last 60 years
- Understand the root causes of PT issues in buildings
- Rules for successful PT repair projects



WE ARE INNOVATORS IN STRUCTURAL ENGINEERING, ANALYSIS AND DESIGN.

Post-Tensioning Experts / Offices in 3 States / Completed over 3000 jobs in 26 states, the Caribbean, and the UAE



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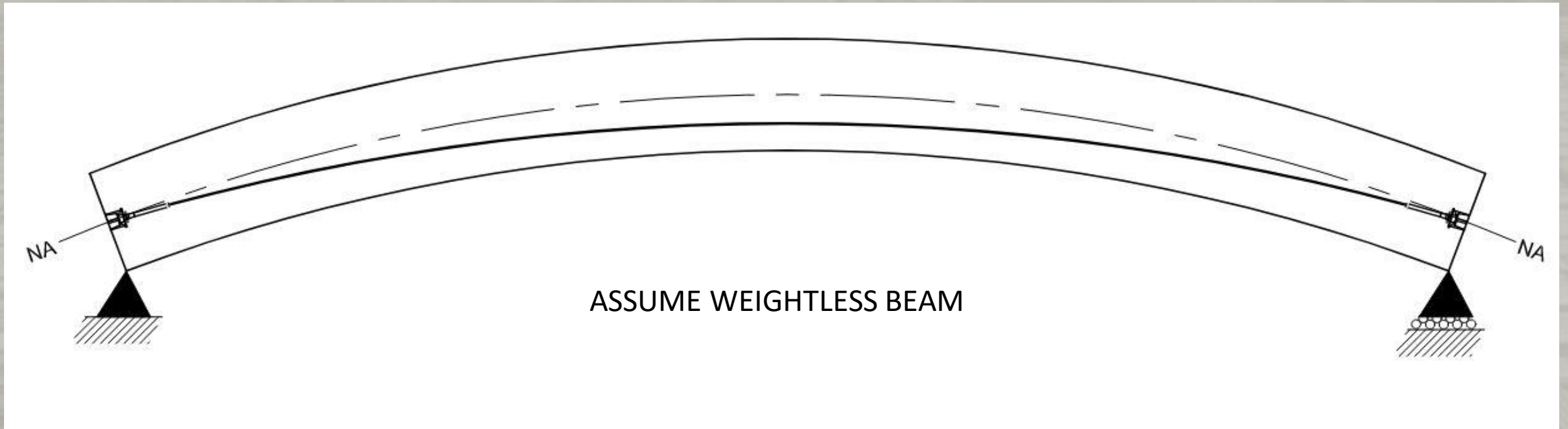
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- Kline's Regional Offices
- Kline's Projects
- Professional Registration
- Professional Registration in process

Pop Quiz



NO CHANGE



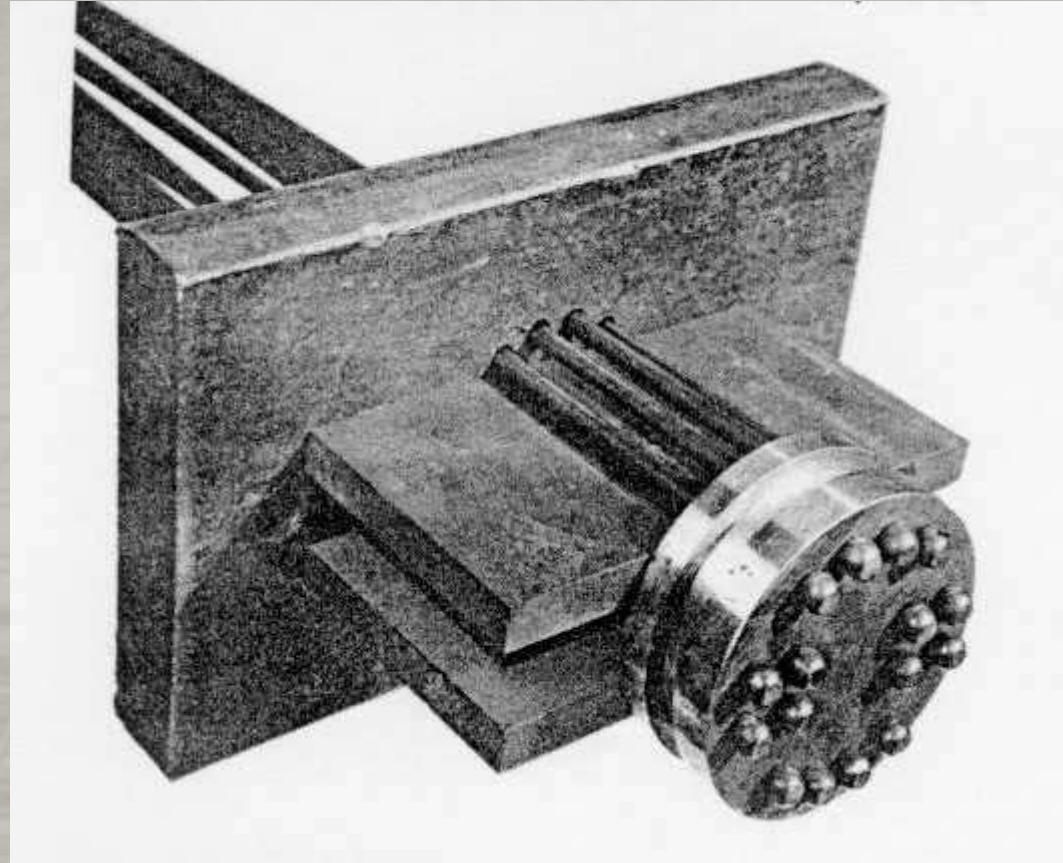
Topics

- Evolution of PT systems over the last 60 years
- Root causes of PT problems in buildings
- Rules for successful PT repair projects



Buttonhead Wire

- Used in 1950's & 1960's
- Unbonded or Bonded
- Paper wrapped
- Individual
1/4" dia. wires



Buttonhead Wire

Issues:

- Constructability
- Safety
- Shop fabricate exact lengths
- Exposed wires
- Corrosion

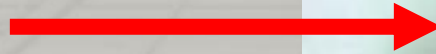


Types of Prestressing Tendons

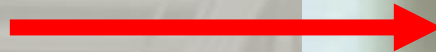
Bare Strand



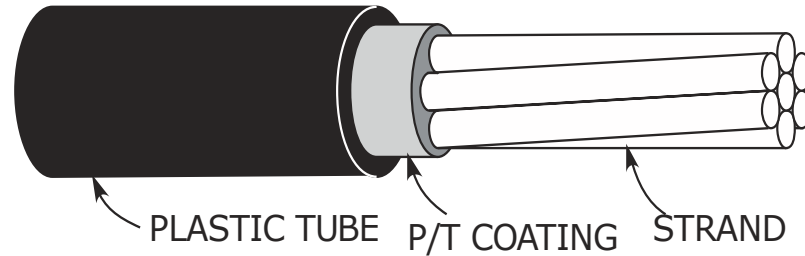
Monostrand



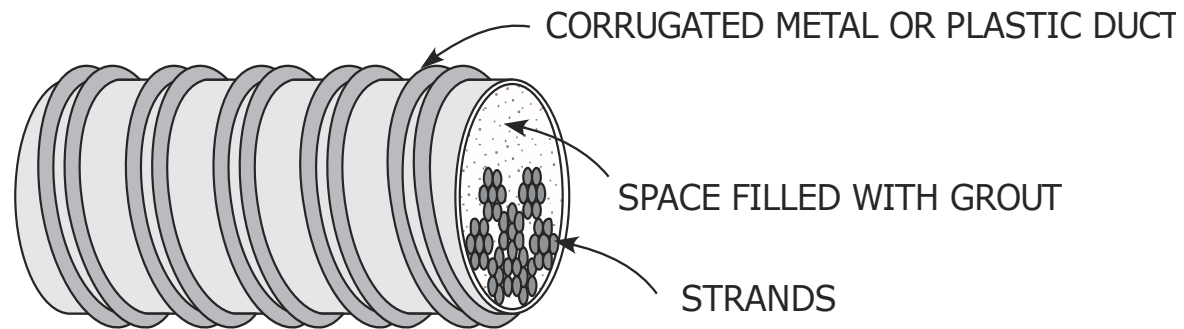
Multistrand



Bonded vs. Unbonded PT



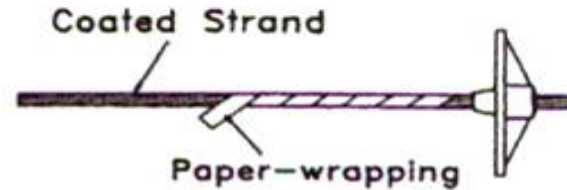
(a) PLASTIC SHEATH FILLED WITH GREASE CONTAINING UNBONDED MONOSTRAND



(b) CORRUGATED SHEATH WITH GROUTED STRANDS

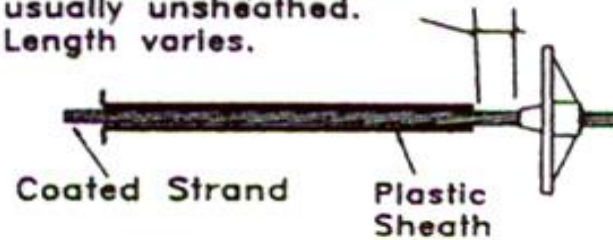
Unbonded Tendon - Protection

Paper-wrapped
1955-1975+

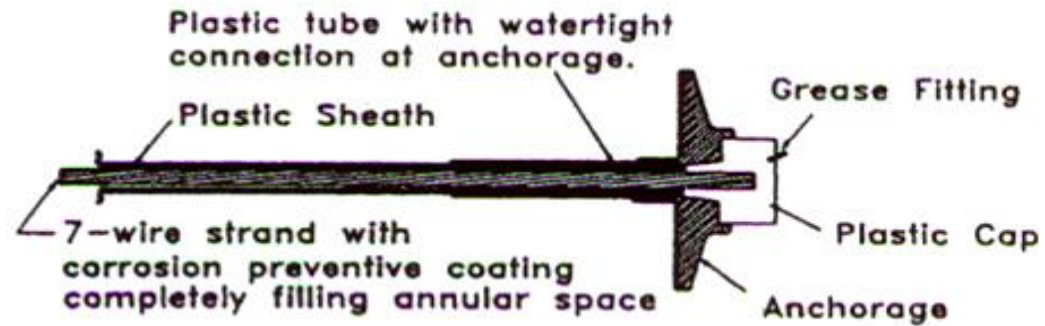


This portion of strand
usually unsheathed.
Length varies.

Plastic Sheath
1960-Present



1985 PTI
Recommended
System



Encapsulated Tendons

Photo Courtesy of General Technologies, Inc.



Prestressing Materials

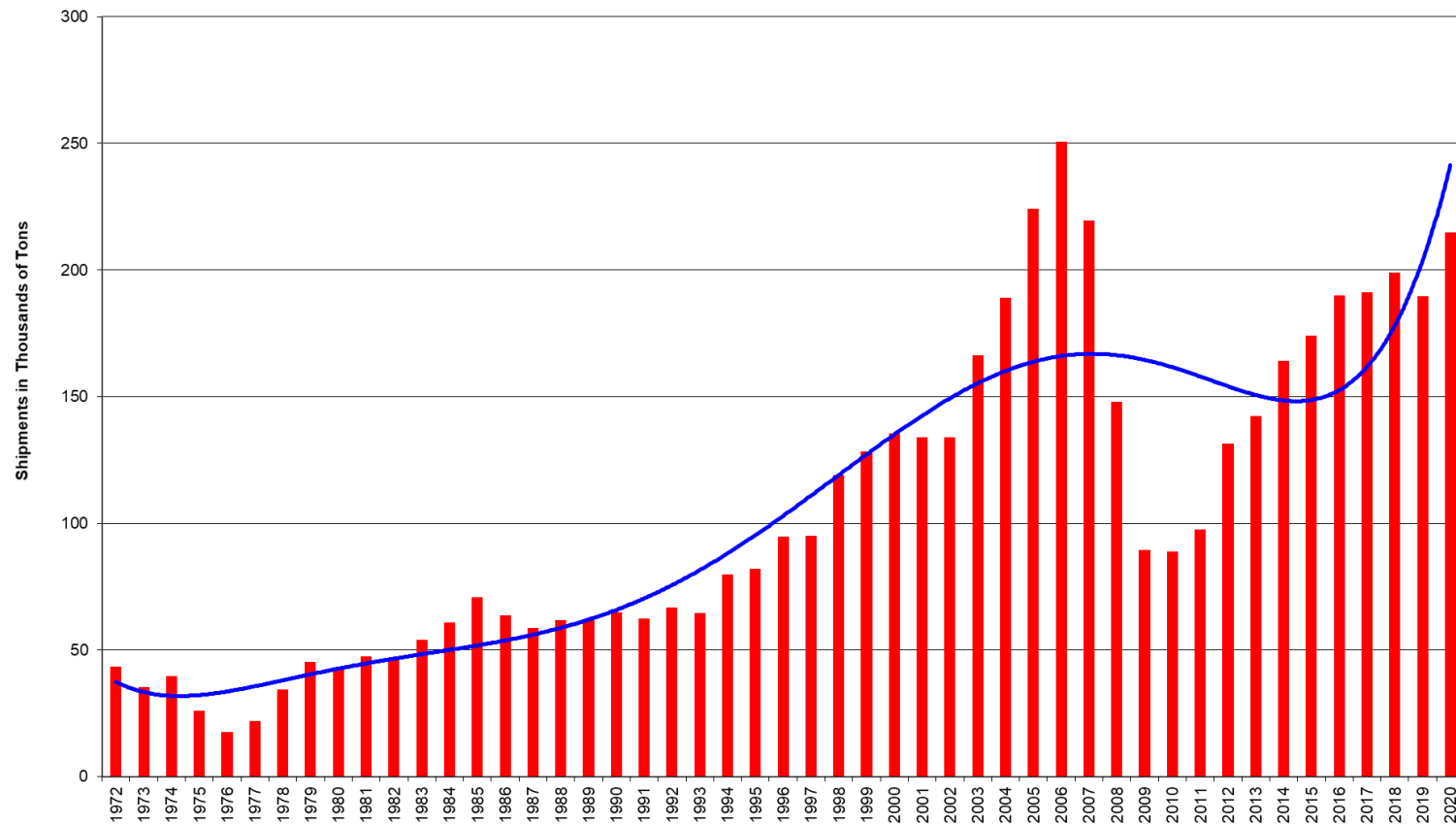
- Material
 - PT Bars
 - Stress Relieved (Before 1985)
 - Low Relaxation (After 1985)
- Strength
 - 150 ksi
 - 270 ksi
 - 270 ksi
- Final Effective
 - 90 ksi
 - 24.8 kips for ½” Dia.
 - 27 kips for ½” Dia.



PT Industry Over 50 Years

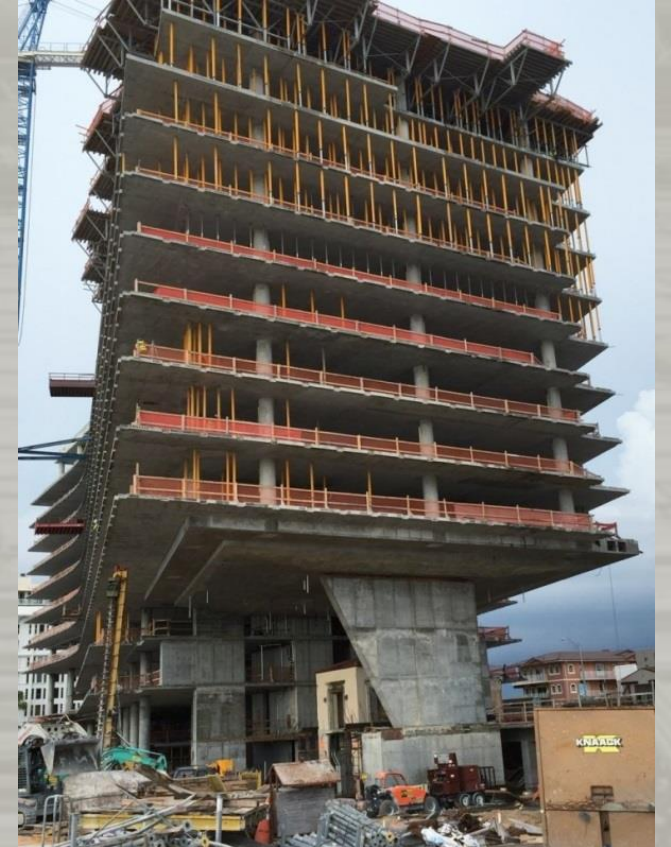
North American Post-Tensioning Shipments

Summary for the years: 1972 to 2020

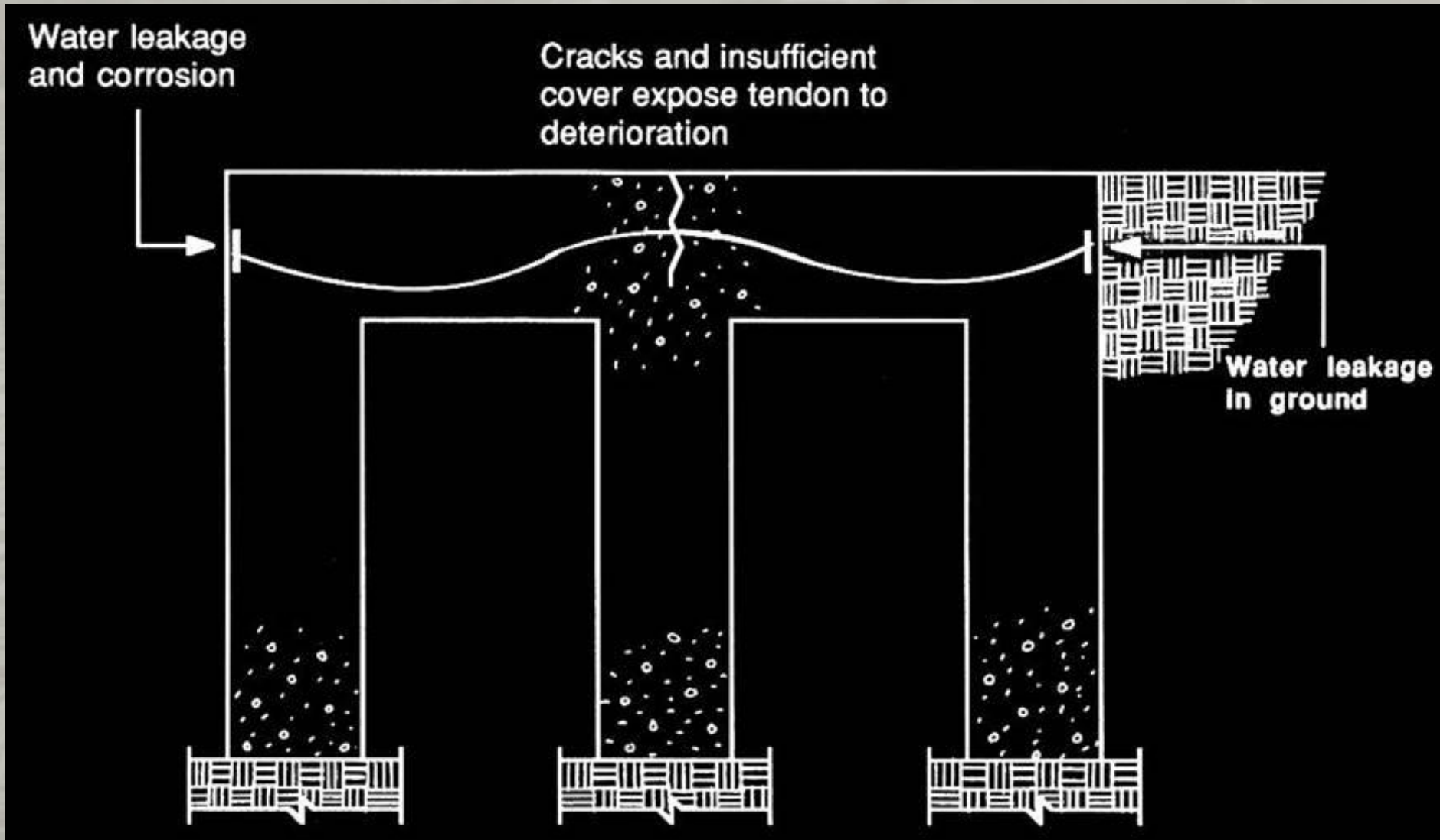


Topics

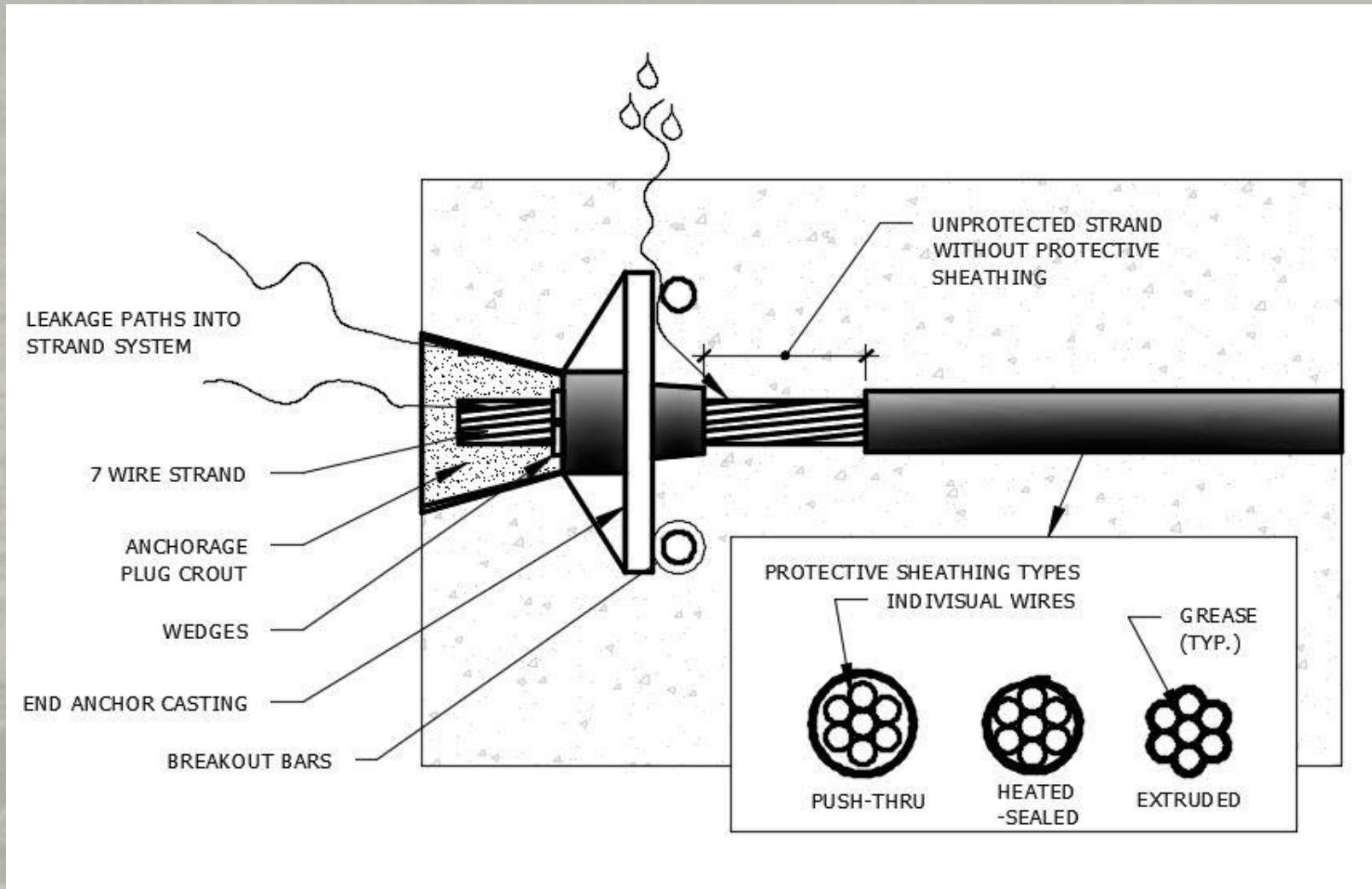
- Evolution of PT systems over the last 60 years
- Root causes of PT problems in buildings
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Causes of PT Tendon Failure



Monostrand Deterioration



Causes of PT Tendon Failure

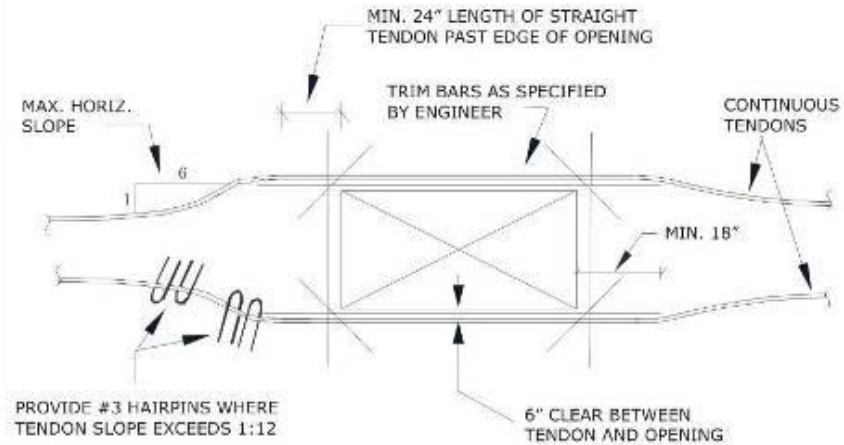


Causes of PT Tendon Failure

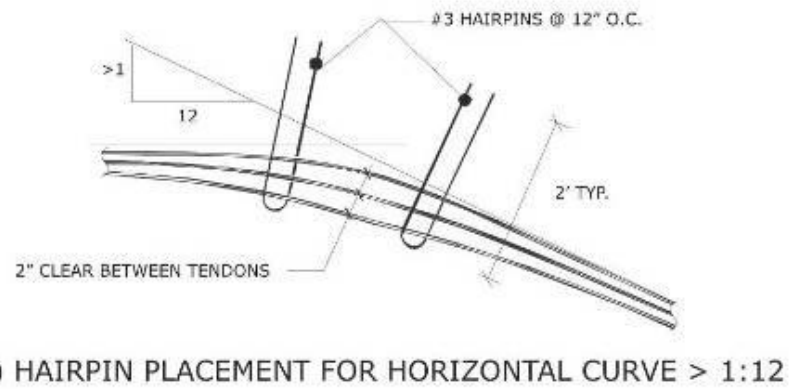
- Restraint Cracks Through Slab



Causes of PT Tendon Failure



a) PLAN VIEW AT OPENINGS



b) HAIRPIN PLACEMENT FOR HORIZONTAL CURVE > 1:12



Causes of PT Tendon Failure

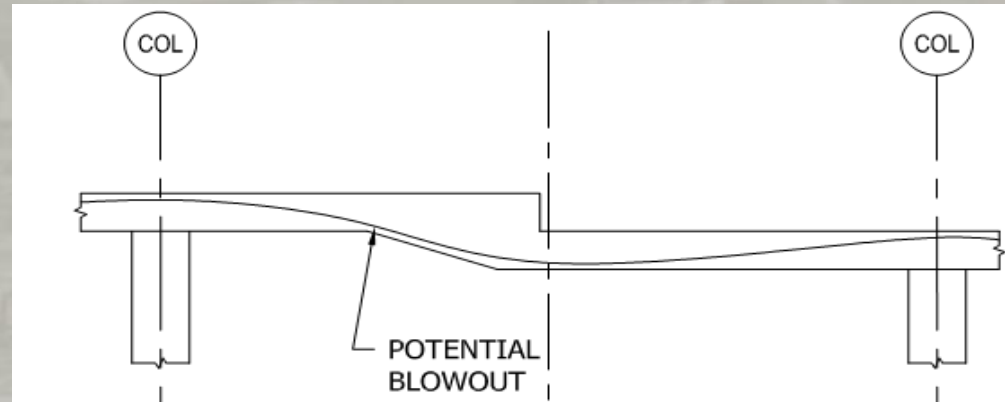


Details at Openings

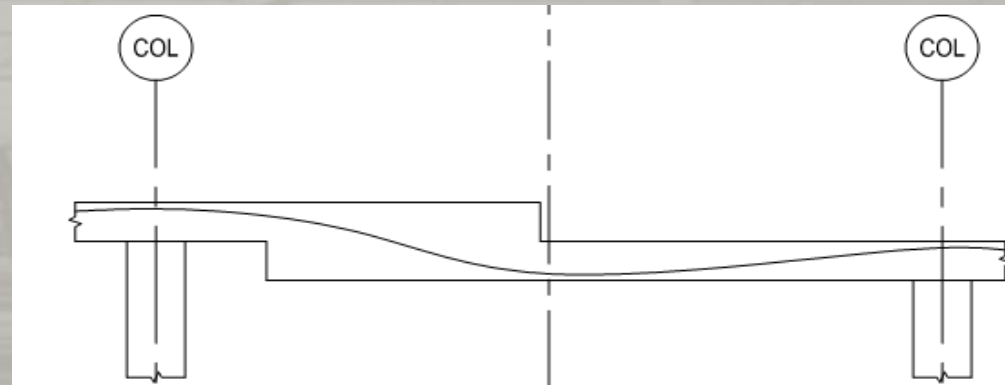


Sweeping tendons at low point

Slab Folds



Poor Detail



Preferable Detail

Slab Folds

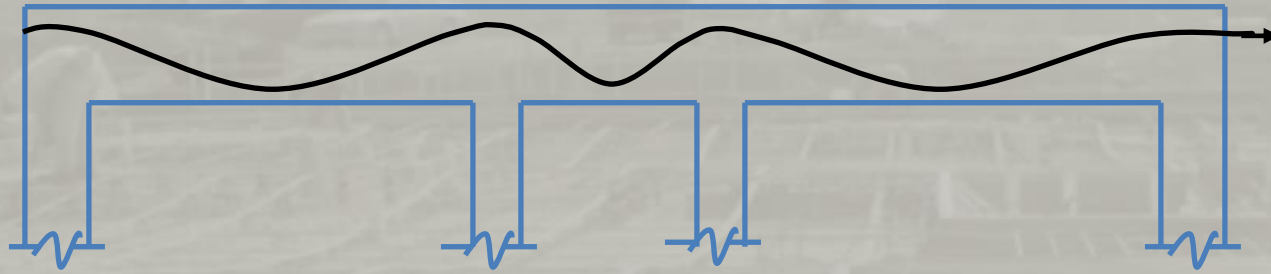


Blowout at slab fold

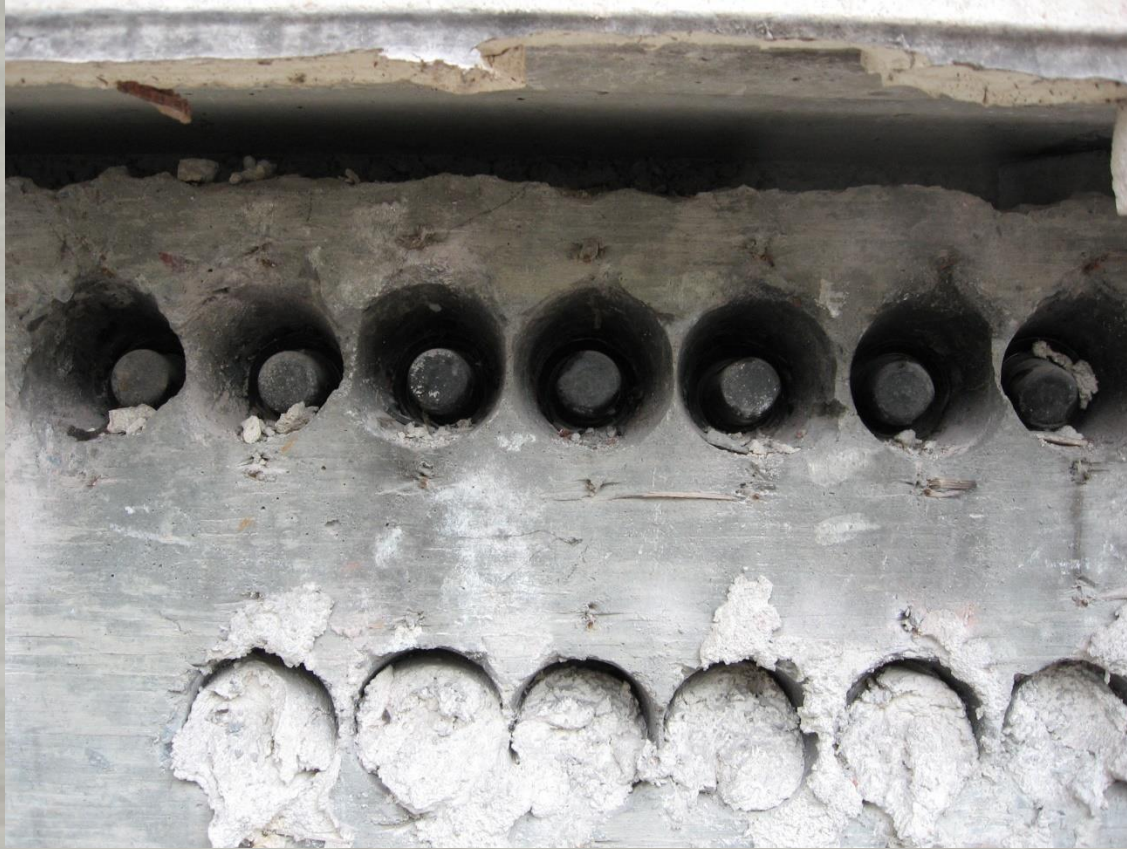
Anchorage Blowouts



Overbalancing



Tendon Finishing Problems



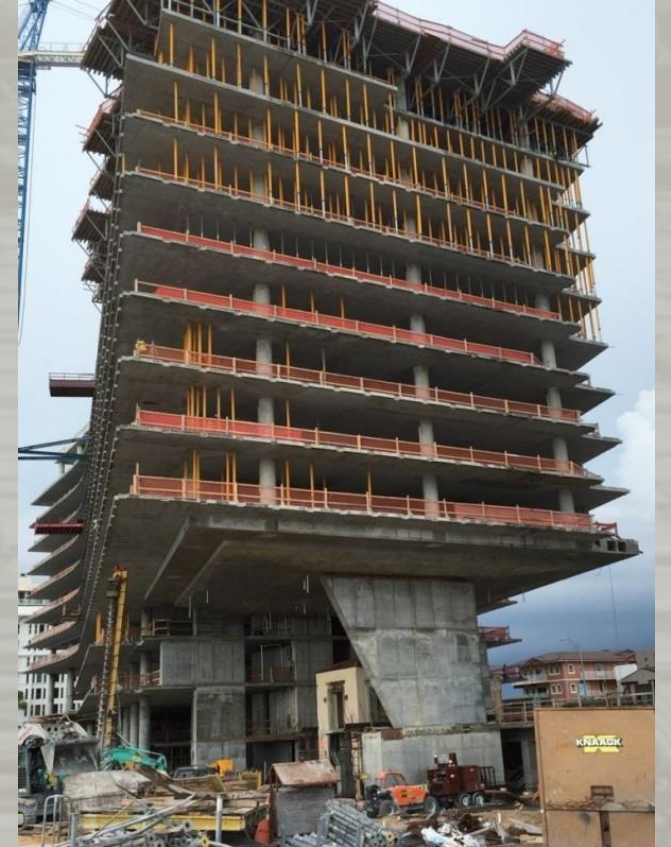
The Plumber Did It

Core Drilled Through
Tendon



Topics

- Evolution of PT systems over the last 60 years
- Root causes of PT problems in buildings
- Rules for successful PT repair projects



Rules for Successful PT Repair Projects

- Evaluate the Structure
- Develop Repair Strategy
 - Abandon
 - Repair
 - Replace
 - Apply External PT
- Plan for Safety to the Public
- Protect and Monitor

Evaluate the Structure

- Visual/Non-Destructive Testing



Visual/Non-Destructive Testing



Visual/Non-Destructive Testing

- Corroded/Failed Tendons



- Standing Water



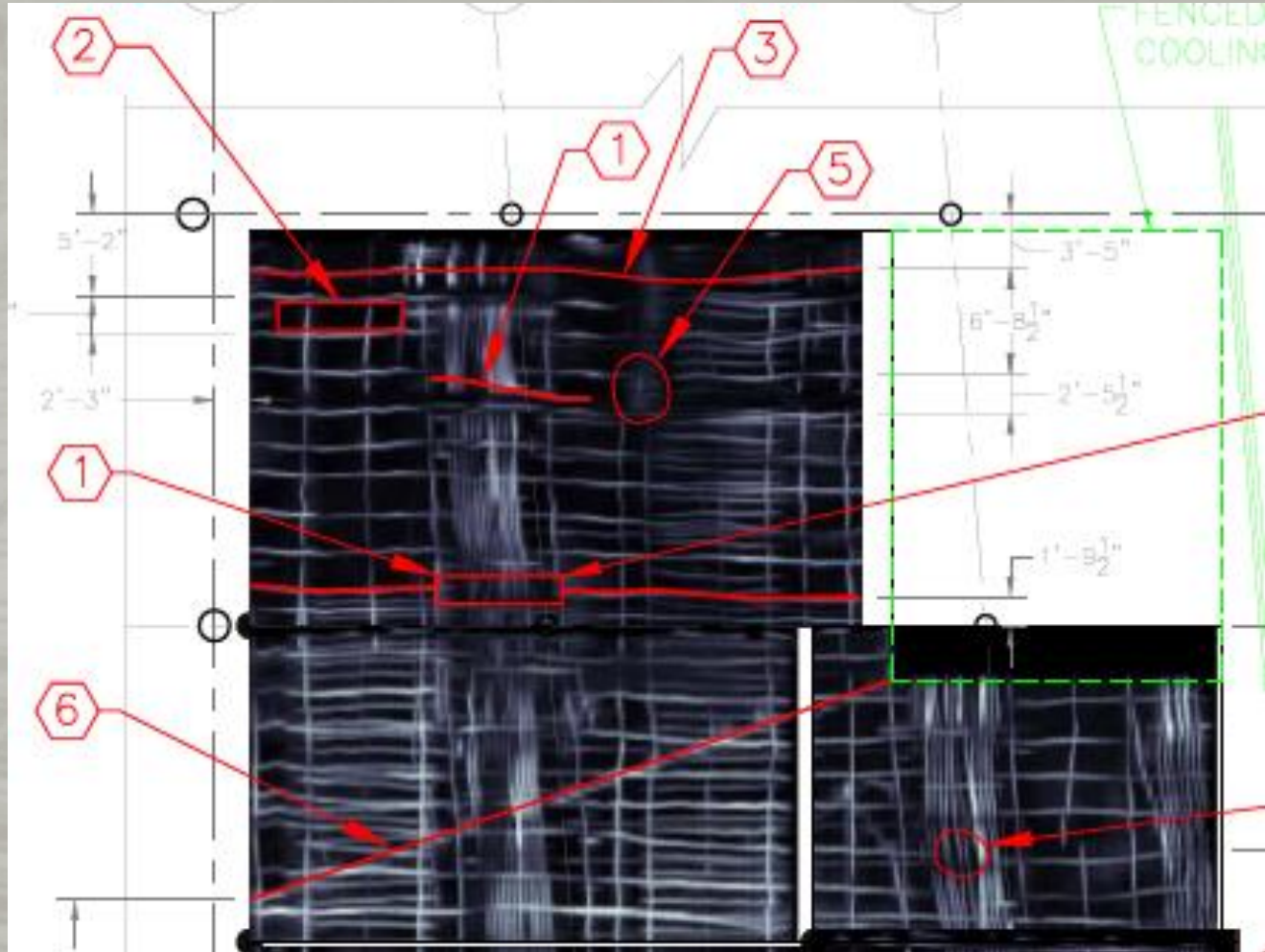
Visual/Non-Destructive Testing

- Tendon Pop-Outs
- Restraint Cracks Through Slab



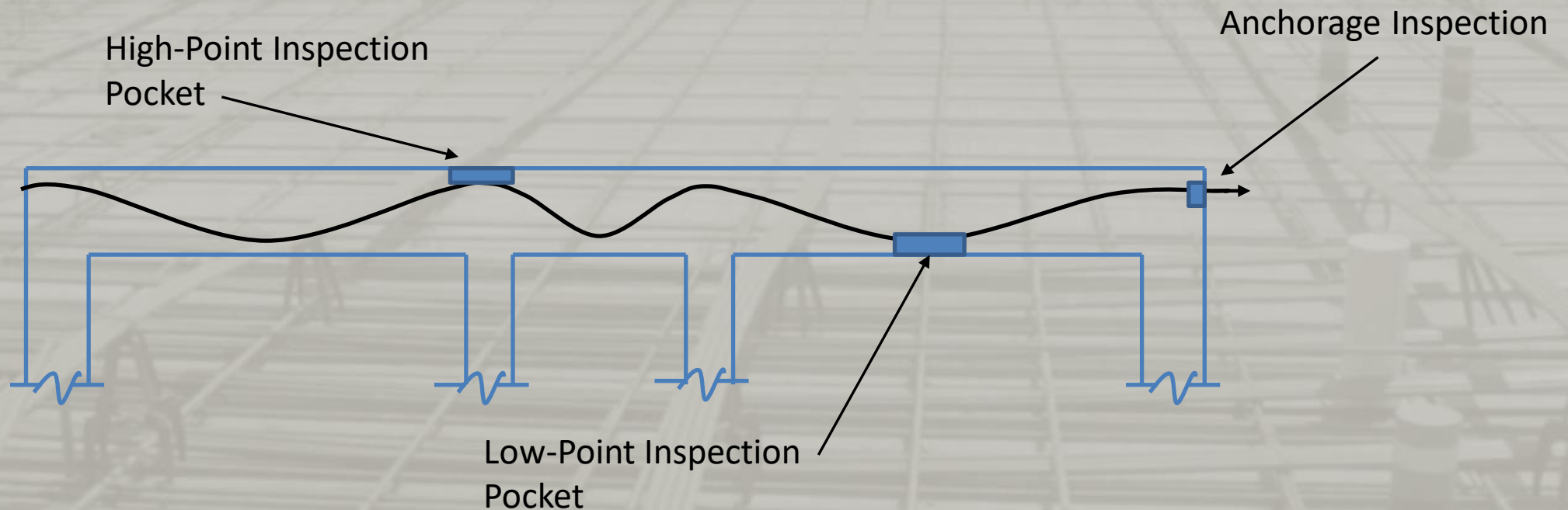
Visual/Non-Destructive Testing

- GPR/X-Ray to Determine As-Built Design
- Review As-Built Drawings

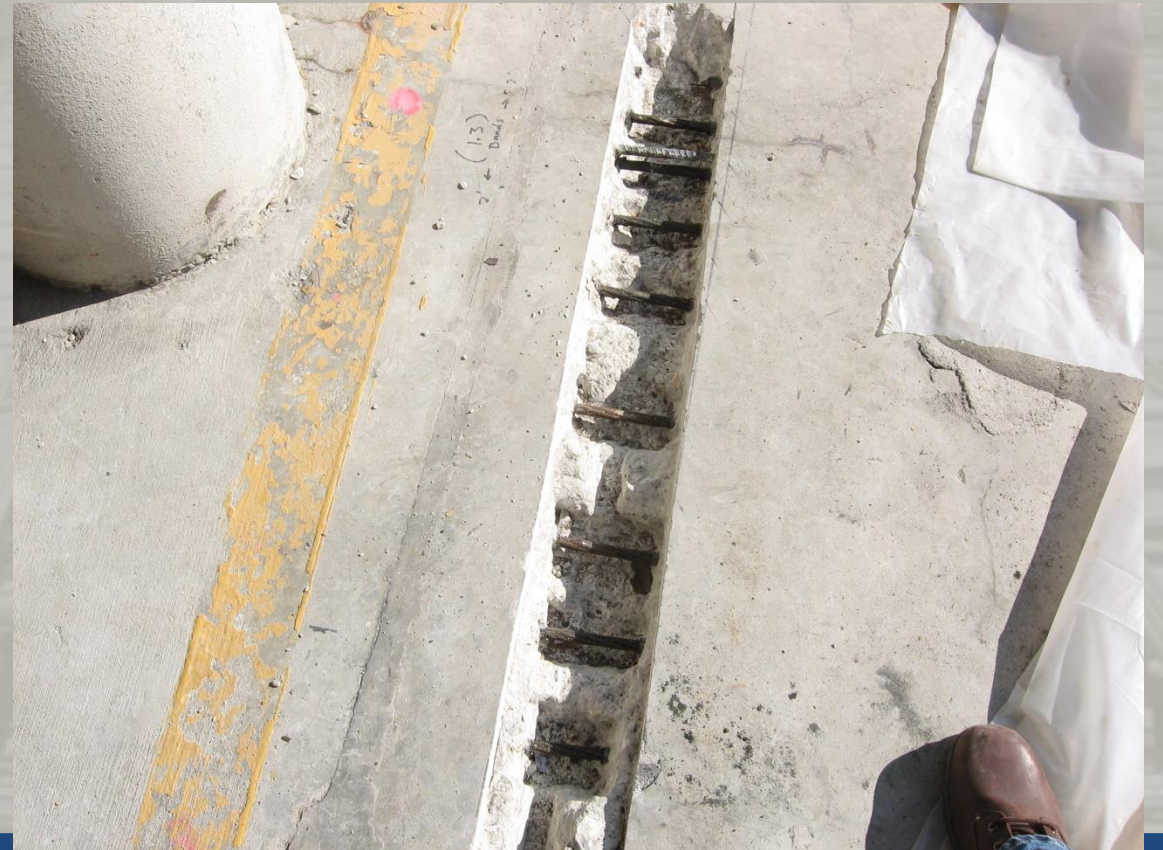


Exploratory Sampling

- Open Inspection Pockets
- Statistical Sampling – Initially inspect 5%. Increase sample size if warranted.



Exploratory Sampling



Exploratory Sampling



Exploratory Sampling



Exploratory Sampling



Exploratory Sampling



Exploratory Sampling



Tendon Finishing Issues



Tendon Finishing Problems



Tendon Finishing Problems



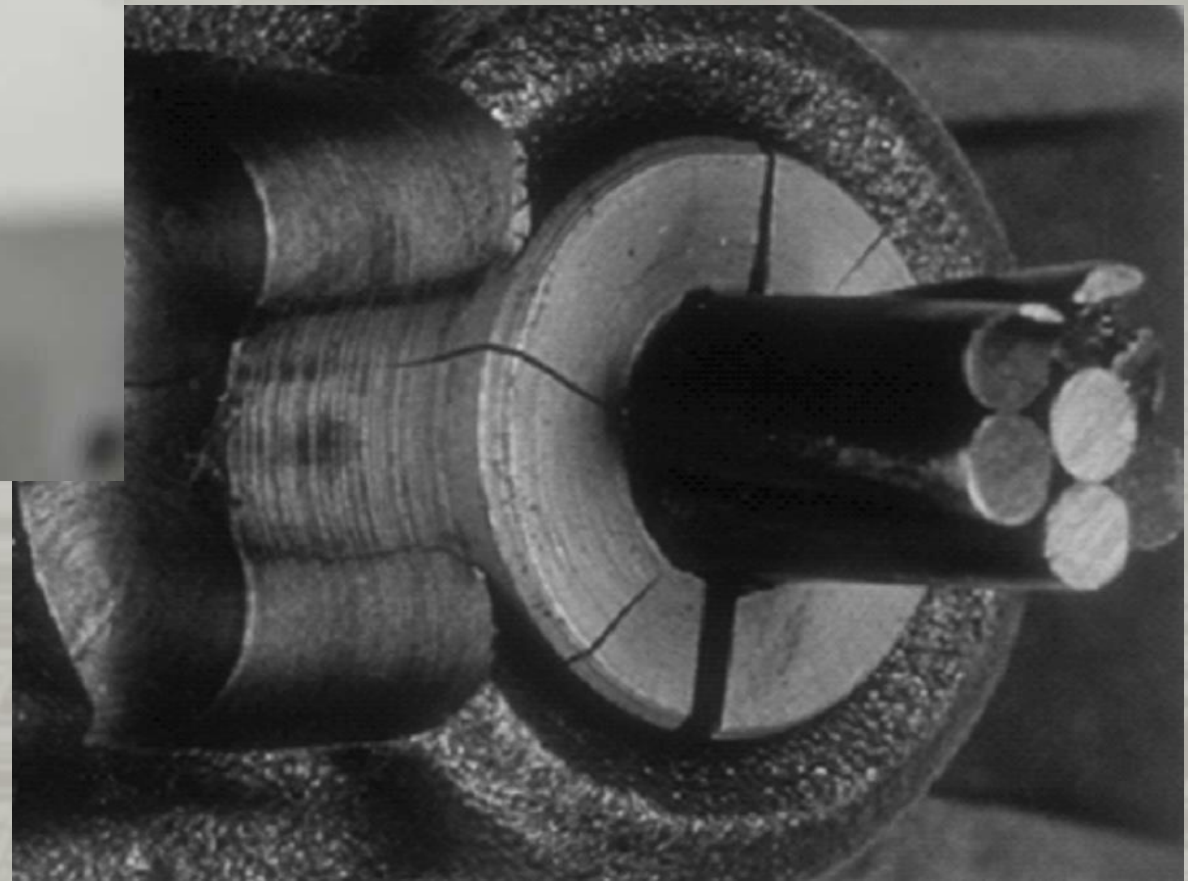
Tendon Finishing Problems



Tendon Finishing Problems



CRACKED WEDGES – Not a Problem

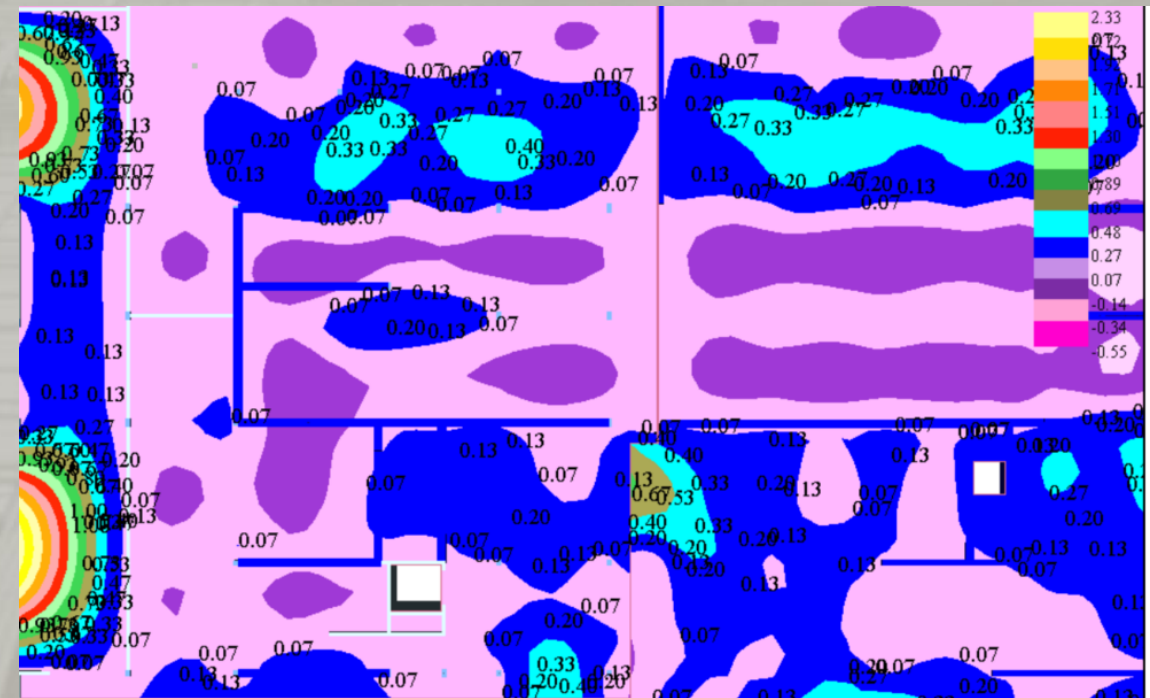


Tendon Finishing

- Cut tendon tail to proper length to accommodate end cap ($\frac{1}{2}$ - 1 in.)
- Install end cap and ensure it is seated
- Surface preparation: free from PT coating, grease, form release agent, dirt, loose concrete, etc.
- High quality chloride-free low-shrink repair grout
- Proper mixing and application

Structural Analysis

- Analyze the PT structural element to inform your repair strategy
 - Is Shoring Required
 - Abandon
 - Repair
 - Replace
 - Apply External PT



Shore to Ensure Safety to Workers and Public

- Shoring may or may not be required.

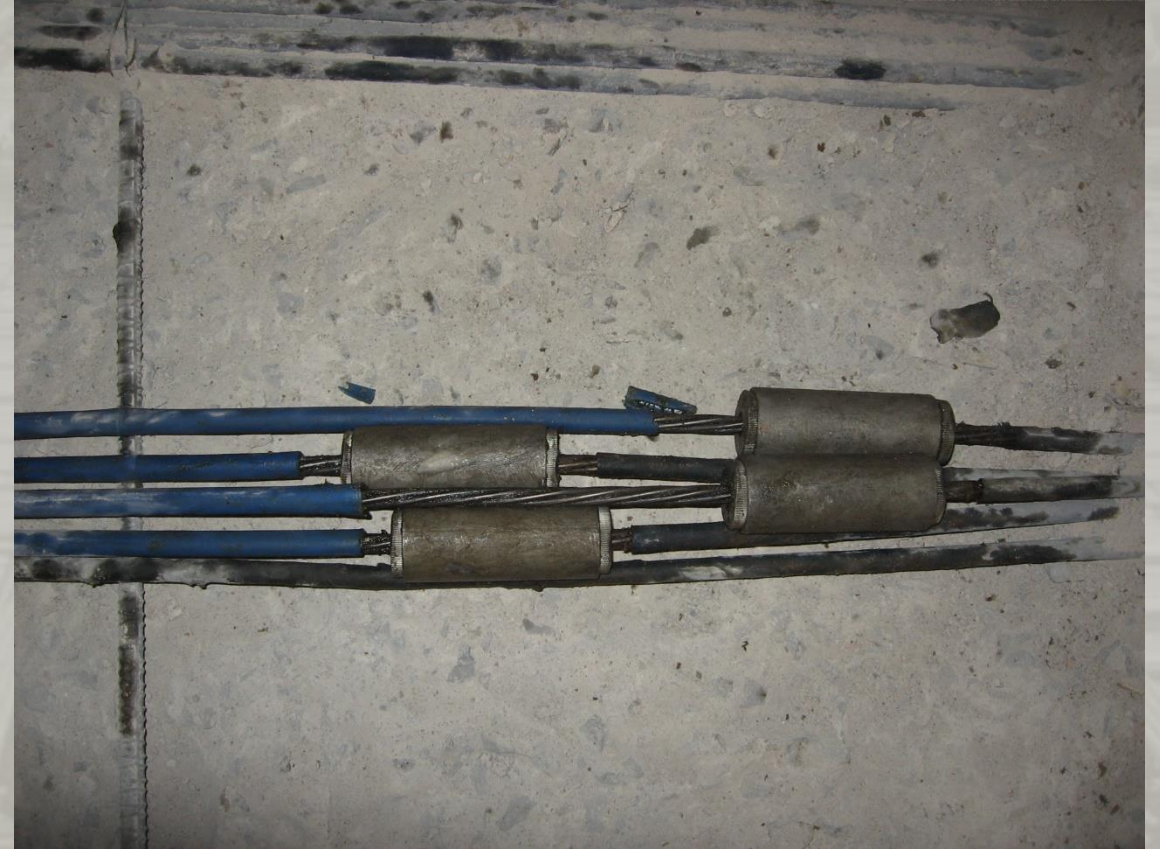


Splice Repairs

Center Stressing Anchor (Lok Coupler)



Internal Splice (Splice Chuck)



Anchorage Repairs



Detensioning and Stressing Safety

- Consider the public when detensioning and restressing



De-Tensioning



Buttonhead Y-Splice Stressing



Buttonhead Wire / Monostrand Repair



External Post-Tensioning



External Post-Tensioning



Waterproofing and Protection Strategies

- Waterproofing Membranes
 - Liquid Urethane
 - Hot Applied Modified Asphalt
 - Sheet Membranes



Waterproofing and Protection Strategies

- Sacrificial Anode Cathodic Protection
- Impressed Current Cathodic Protection




PTI Field Personnel Certification

- Level 1&2 Unbonded PT Repair Workshop
- May 5&6 at The Westin BWI

PTI/ICRI Documents

Guide for Evaluation and Repair of Unbonded Post-Tensioned Concrete Structures


PTI DC80.3-12/ICRI 320.6



pti POST-TENSIONING INSTITUTE®
ICRI INTERNATIONAL CONCRETE REPAIR INSTITUTE

PTI DC80.4-18


Guide Specification for Unbonded Post-Tensioning Repair



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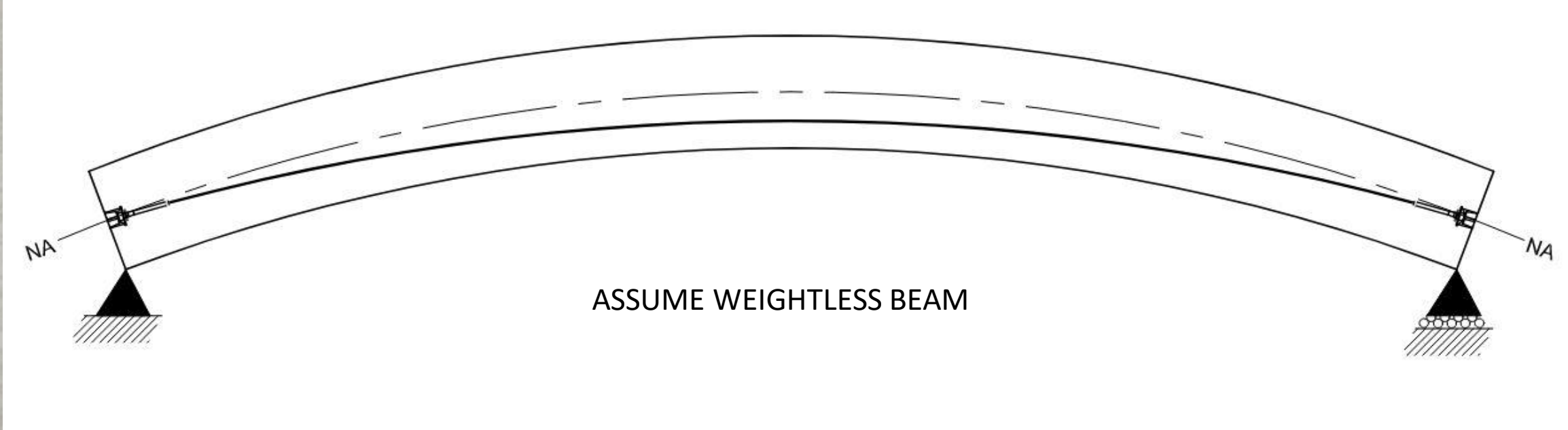
PTI DC80.2-10


Guide for Creating Openings and Penetrations in Existing Slabs with Unbonded Post-Tensioning



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Pop Quiz





Thank You!
Questions ?



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