EVALUATING POST-TENSIONED ANCHORS IN DAMS: FACTORS FOR RISK ASSESSMENT

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Presentation Outline

1. History of Prestressed Anchor Usage in North American Dams
2. Causes of Load Loss During Service
3. Evolution of Corrosion Protection Concepts
4. Causes of Corrosion in Anchors
5. Challenges in Evaluating Current Anchor Performance
6. Recommendations for Preliminary Risk Assessment
7. Related Studies

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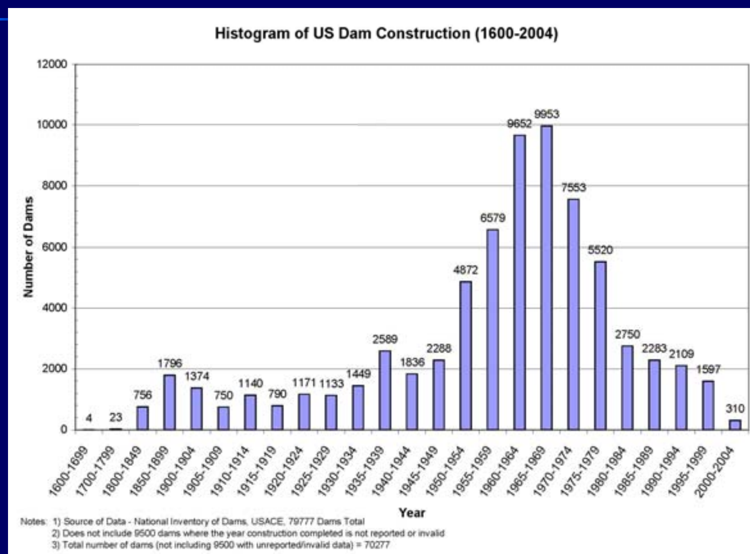
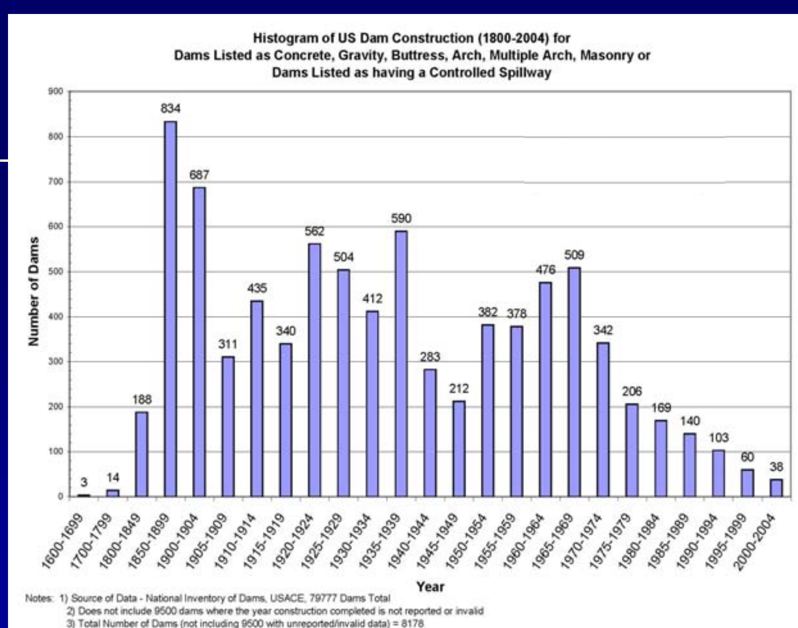
1. History of Prestressed Anchor Usage in North American Dams

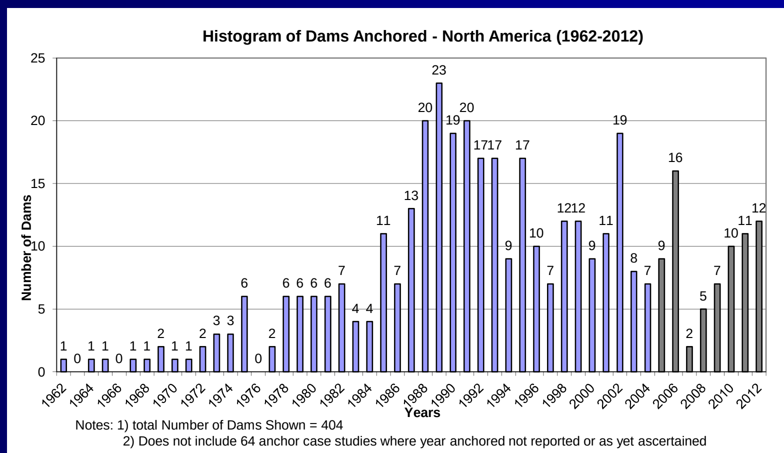
Task 3 of National Research Project on Anchors for Dams (2005-2007)





Update (2005-2012 Projects)

- 55 Additional technical papers (big boost from 2007 Institution of Civil Engineers Conference, London). Average is around 5 per year.
- 72 new case histories with 60% in U.S. 12 Projects featured anchoring for the second or third time.



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2. Causes of Anchor Load Loss with Time

- Lock-off loss/inaccuracy in applying LOL
- Progressive seating of wedges (especially epoxy-coated strand)
- Relaxation/creep of tendon steel
- Creep of rock mass / rock-grout bond

All these are minor or completely manageable

- Corrosion – inducing loss of steel section and/or destruction of top anchorage

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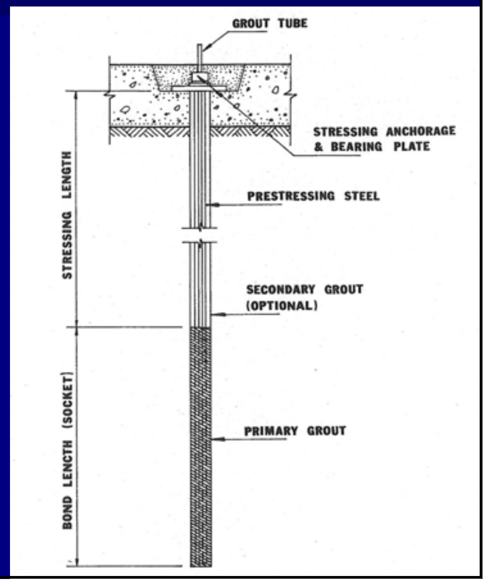
3. Evolution of Corrosion Protection Concepts

Rock Anchor Components (PCI, 1974).
(Note the lack of protection to the steel other than grout placed in 2 stages.)



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1960s – 1970s
Bare Strand/Wire Throughout

- Tendon proposed/selected by Contractor/PT Supplier (wire, strand, bar)
- Grout conceived to be the only protection: 2 stages essential
- Fully bonded, and so no long-term load monitoring capability

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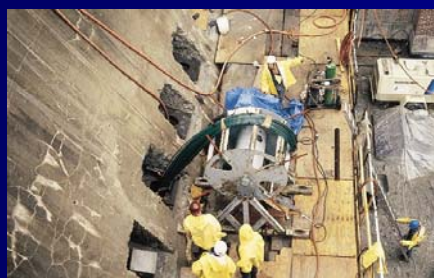
1970s – 1980s

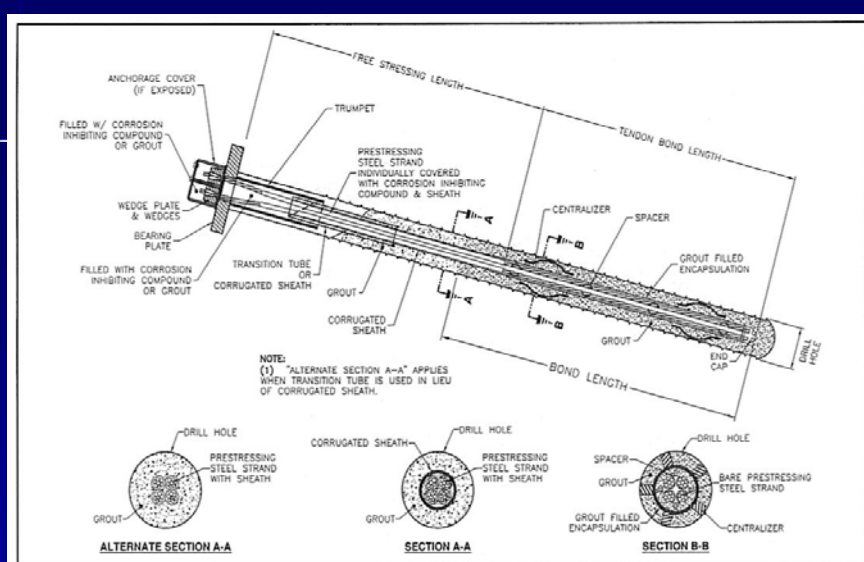
Greased and sheathed free lengths, bare strand on bond length



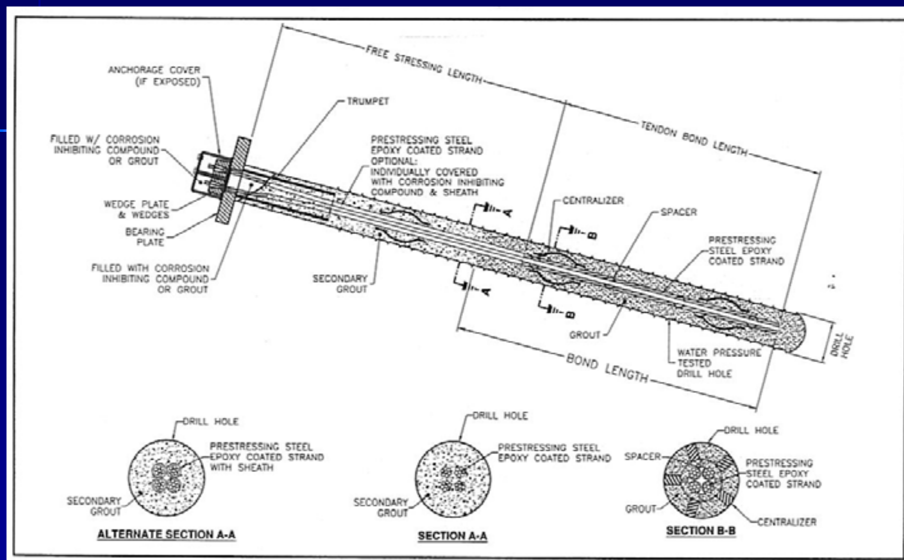
1980s Onwards

Corrugated Sheathing on Bond Length (1980s)
Extending to Full Length Protection by 1990s

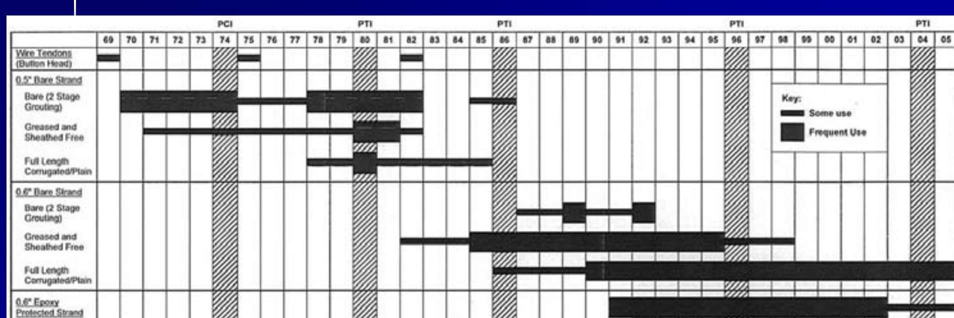
Greased and sheathed protection on individual strands, permitting single stage grouting



Class I Protection – Encapsulated Strand Anchor
(PTI, 2004)



Class I Protection – Epoxy-Coated Strand Anchor
(PTI, 2004)



Note: From 1996 onwards, the term "Class I Protection" superseded the old "Double Corrosion Protection"

4. Causes of Corrosion Failure of Anchors*

- **Design**
  - Inadequate corrosion protection specified (head to distal end)
  - Acceptance of “windows” in corrugated sheathing
  - Nose cone inadequacy
  - Reliance on grout alone
- **Construction**
  - Inadequate pregrouting/redrilling, esp. in artesian conditions
  - Damage to corrugated/epoxy protection during installation
  - Poor grout and grouting practices (including 2 stage grouting)
  - Inadequate protection to anchor head after lock-off

* Note: Ground water may not need to be “aggressive”: it just needs to be in contact with the steel, be mobile, and have access to oxygen.

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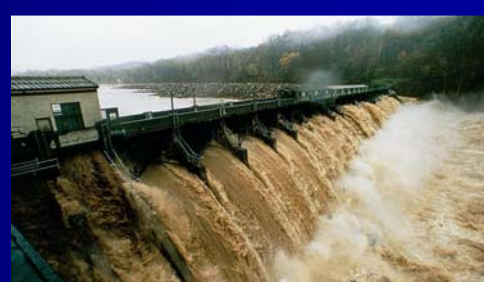
5. Challenges to Evaluating the Status of Existing Anchors

- Physical access to head
- “Concreting in” of head
- Cropping of strands/old “button heads”
- Fully bonded free length
- No load cells/strain gages
- Inaccurate/unreliable initial lock-off data



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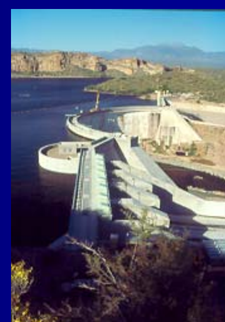
6. Recommendations for Risk Assessment by Owners

1. Conduct anchor system design review to judge if anchor forces theoretically meet current needs and are consistent with PFMAs
2. Conduct review of historical records to isolate projects potentially at risk as a result of design deficiencies and/or construction problems, especially those with anchors installed pre-1996
3. Site evaluation to judge ambient service condition pose risk
4. Investigate feasibility of conducting in-situ assessments
   - Head condition
   - Residual load (load cells, lift-off)
   - Evidence of tendon distress
5. Conduct the in-situ assessments!



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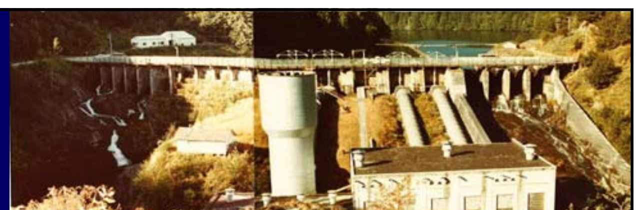
7. Related Studies



1. Assessment of multi-wire button head tendons for Australia and New Zealand Dams
2. CEATI Forensics Study
   - Elwha Dam Decommissioning
   - Identifying additional sites
     1. John Hollis Bankhead – 16 anchors 1965
     2. Industry input requested

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CEATI Forensics Study

48 anchors - 1980, 1985, 1986

8. What's Next

1. Re-mining and refreshing of National Research Program files - Presentation of Update to National Research Program, Session 5C
2. Develop assessment tools, including event tree for understanding, analyzing and communicating dam safety risk and for supporting decision making related to existing PT anchor systems

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Questions?

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