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# Load Transfer Mechanism of Small-Diameter Grouted Anchors

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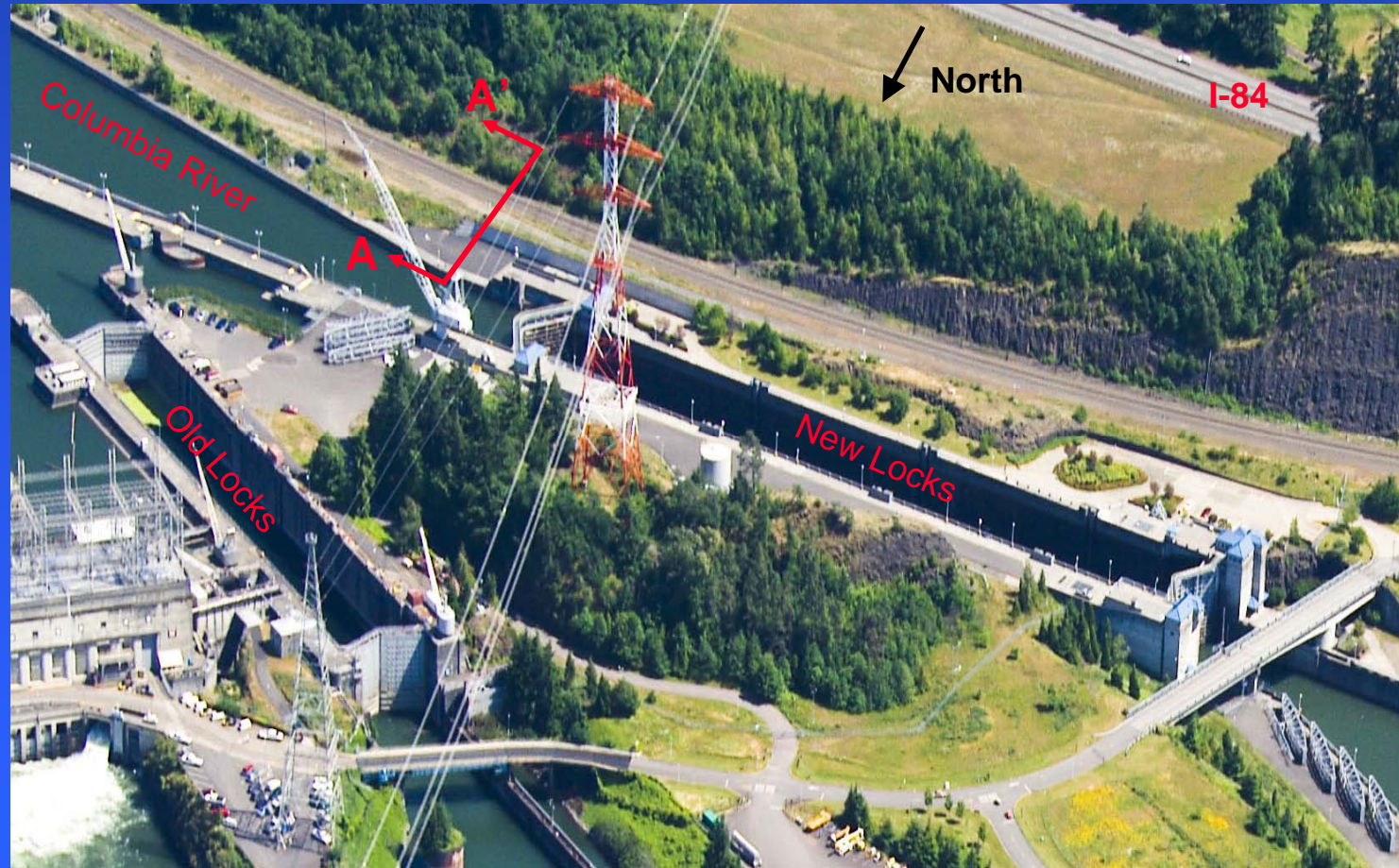
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# Problem Statement

- Is single stage grouting OK for 200% tests for small diameter anchors??
  - Is tendon bond zone = anchor bond zone for small dia. anchors??
  - What does the literature say??
  - Is there instrumentation for large & small dia. TBs
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# Project Summary

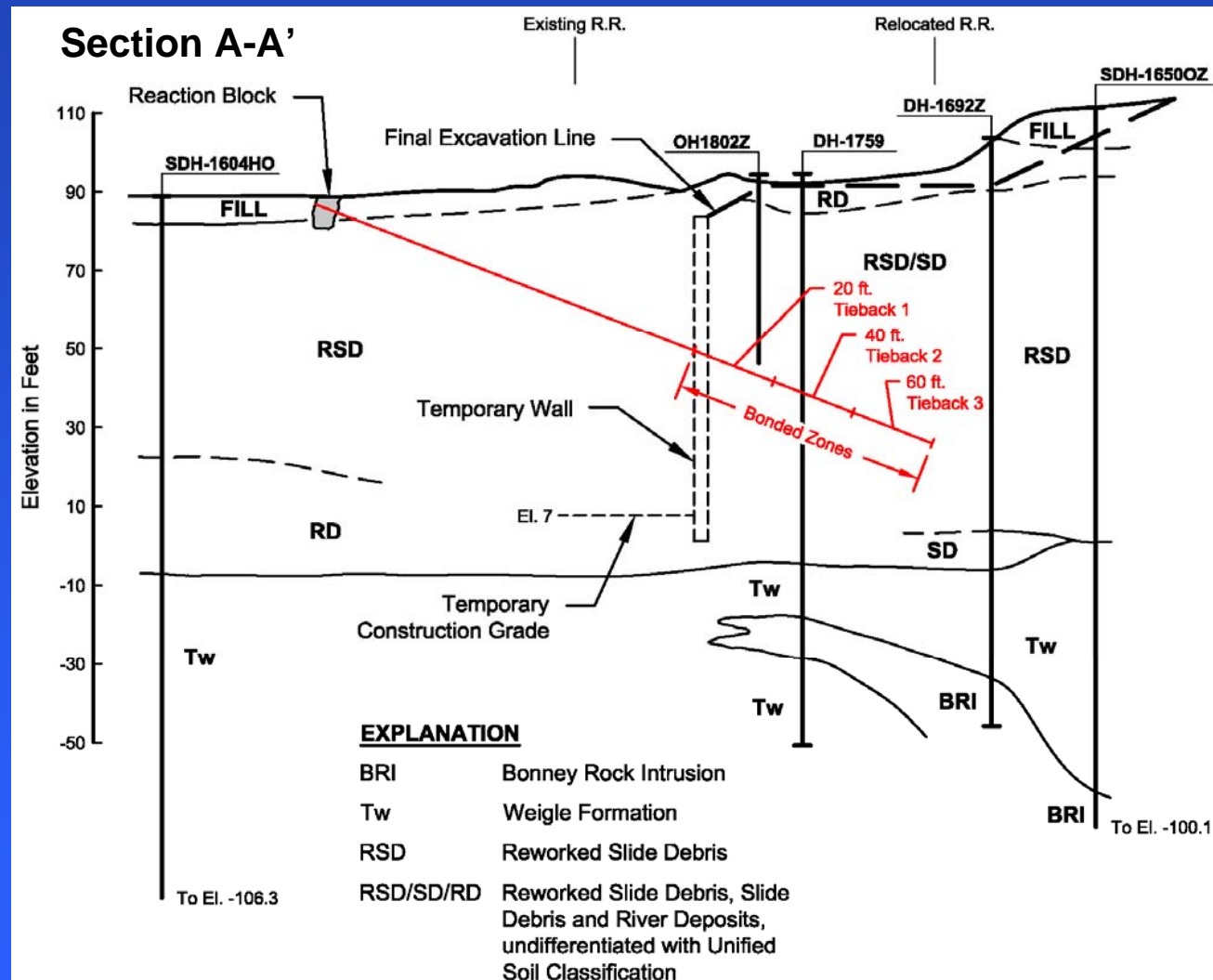
- All info. after L.R. Squier Associates 1986b):
  - ▶ SOW



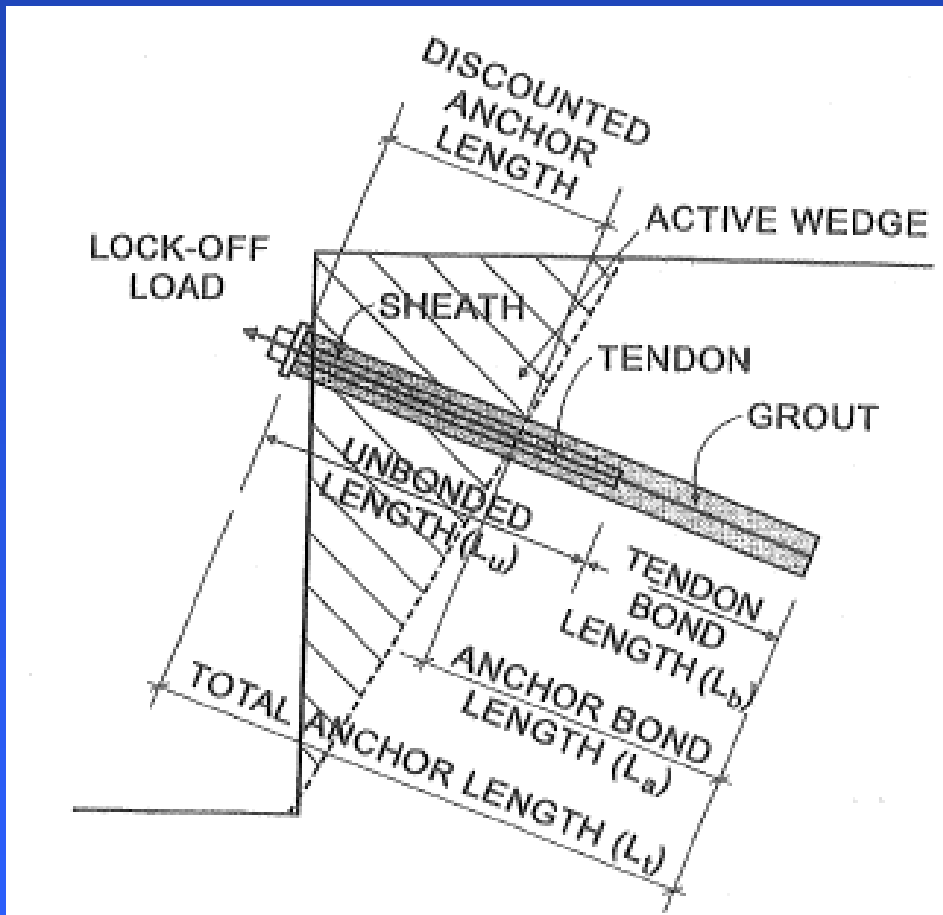
# Subsurface Conditions

Reworked Slide Debris (RSD) = heterogeneous mix of silt to large boulder sized material formed by erosion and reworking of slide debris by the Columbia River

- ▶ SB = Slide Blocks/rocks ranging in size from tens to hundreds of feet
- ▶ SD = Slide Debris is unconsolidated chaotic mix of rock-fragments to large boulders in a clay-rich matrix of decomposed rock



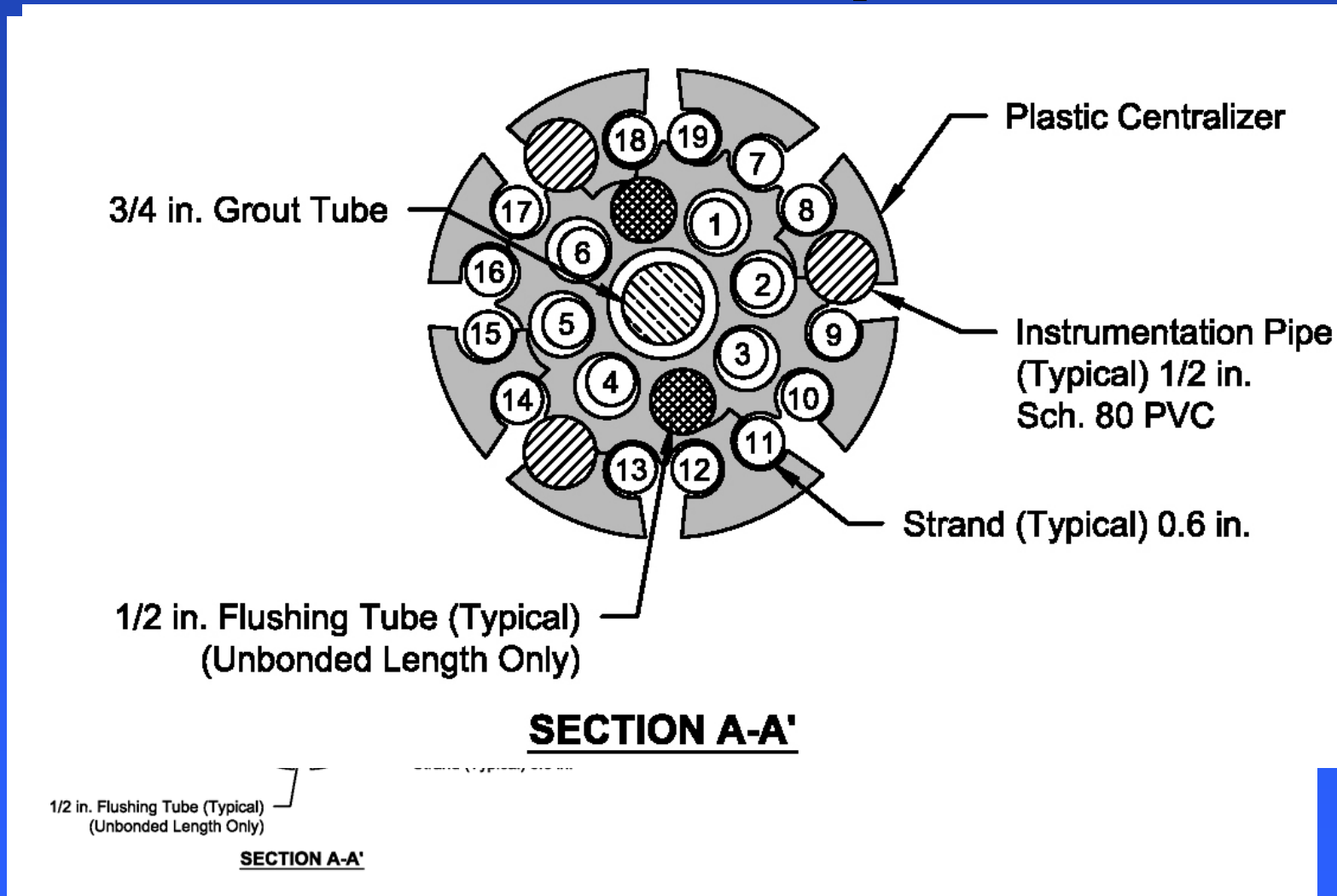
# Anchor Components



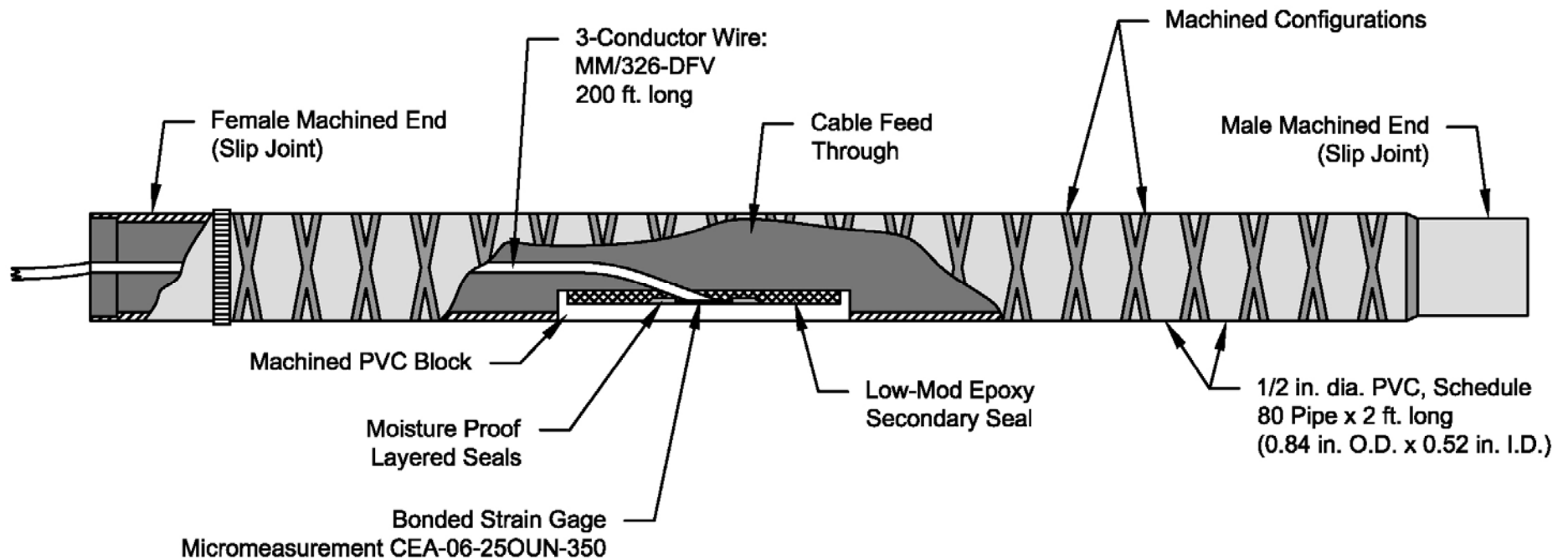
- Anchor Bond Zone = length that grout adheres to soil and results in load transfer (can be above tendon bond zone)
- Tendon Bond zone = length that bar/tendons are bonded to grout and transfer load (tendon/bar not isolated from grout with bond break [e.g. sealed sheath or greased tendon/bar])

# Anchor Installation & Components

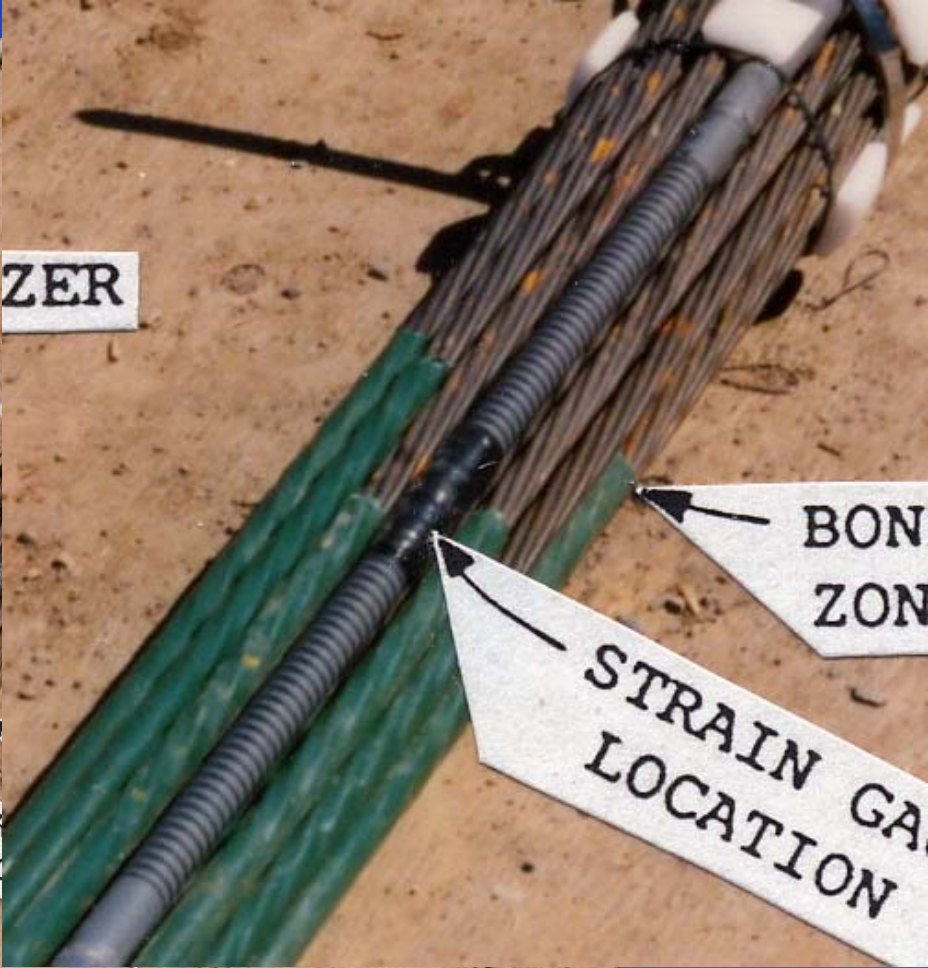
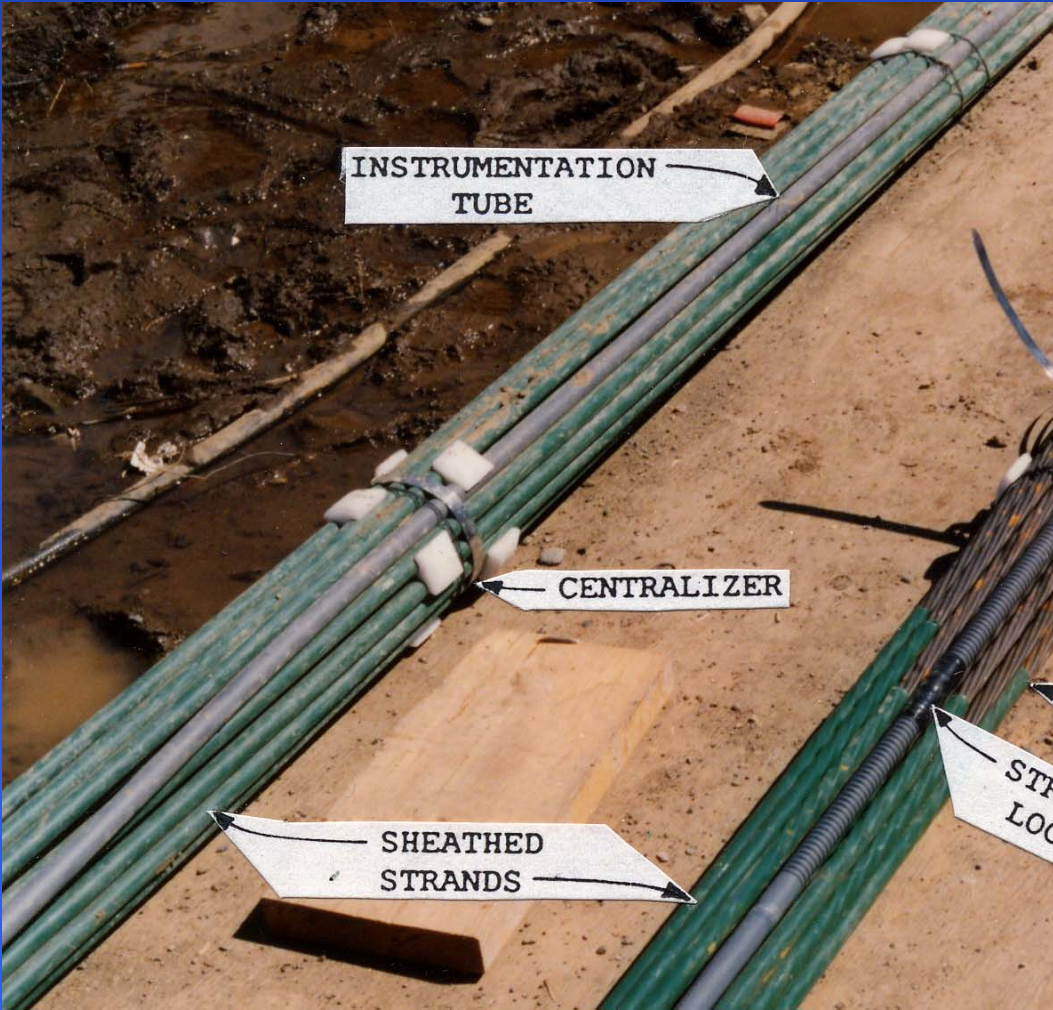
- ODEX rotary percussion drilling
- Compressed air and drill foam as drill fluid
- Gravity tremie grouted (surface gage & avg. static pressures <60 psi)
- Anchor section components



# Instrumentation



# Instrumentation



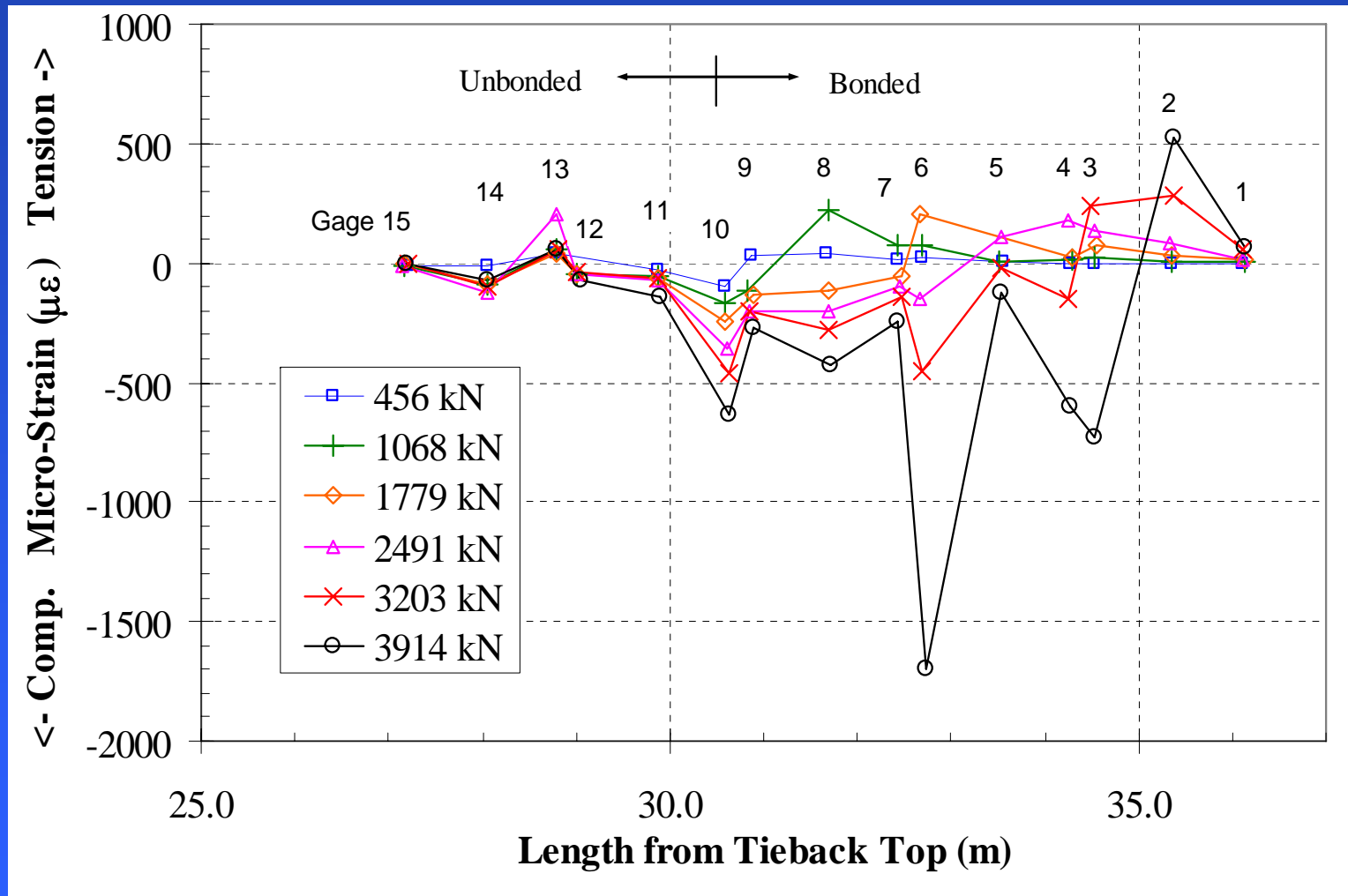
# Load Test Result Summary

				A		B	(A/B)
TB No.	Max. Test Load (kN) [kip]	Installed Bond Length (m) [ft]	Avg. Load Transfer Length <sup>b</sup> (m) [ft]	Avg. Ultimate Adhesion (kPa) [psi]	Avg. Ultimate Adhesion (klf)	Approx. Grout-Soil Interface Friction <sup>c</sup> (kPa) [psi]	Ratio of Ultimate Adhesion to Soil Friction
1	3914 <sup>d</sup> [880]	6.1 [20]	7.5 [25]	891 [129]	36	135 [20]	<b>6.6</b>
2	3647 <sup>e</sup> [820]	12.2 [40]	7.6 [25]	813 [118]	33	159 [23]	<b>5.1</b>
3	3914 <sup>d</sup> [880]	18.3 [60]	7.2 [24]	929 [135]	37	186 [27]	<b>5.0</b>

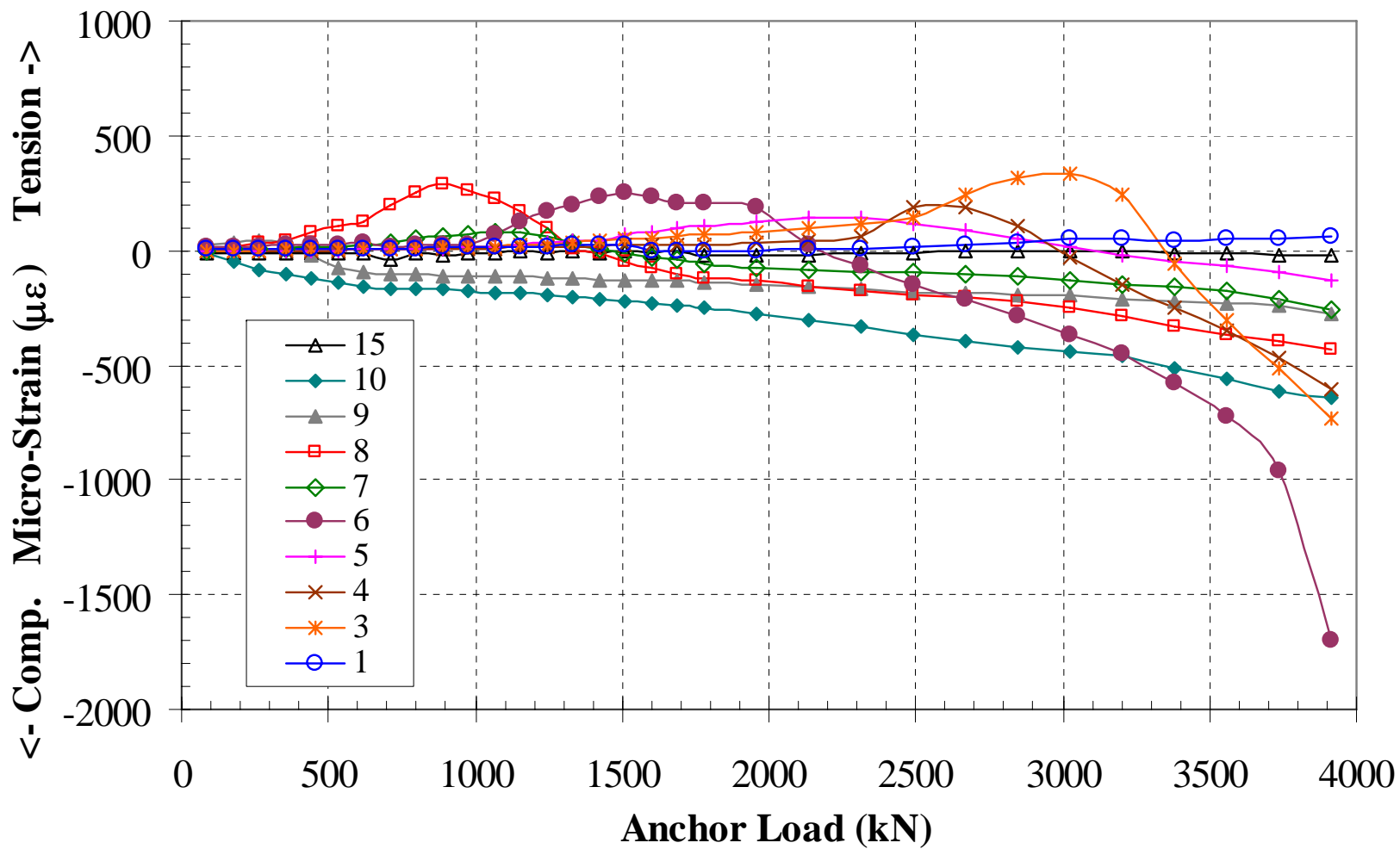
Notes:

- Adapted from L.R. Squier Associates 1986b.
- Determined from strain gage data, where measured, including unbounded and bonded lengths.
- Based on mass concrete on silty or clayey gravel interface friction of 0.5 x vertical effective stress assuming average soil unit weight of 19.6 kN/m<sup>3</sup> (125 pcf).
- Tested to maximum capacity of tendon (i.e., 0.8 guaranteed ultimate tensile strength [GUTS]), but ultimate load of soil grout interface was not reached.
- Two strands damaged during instillation were not loaded (i.e., maximum test load reduced).

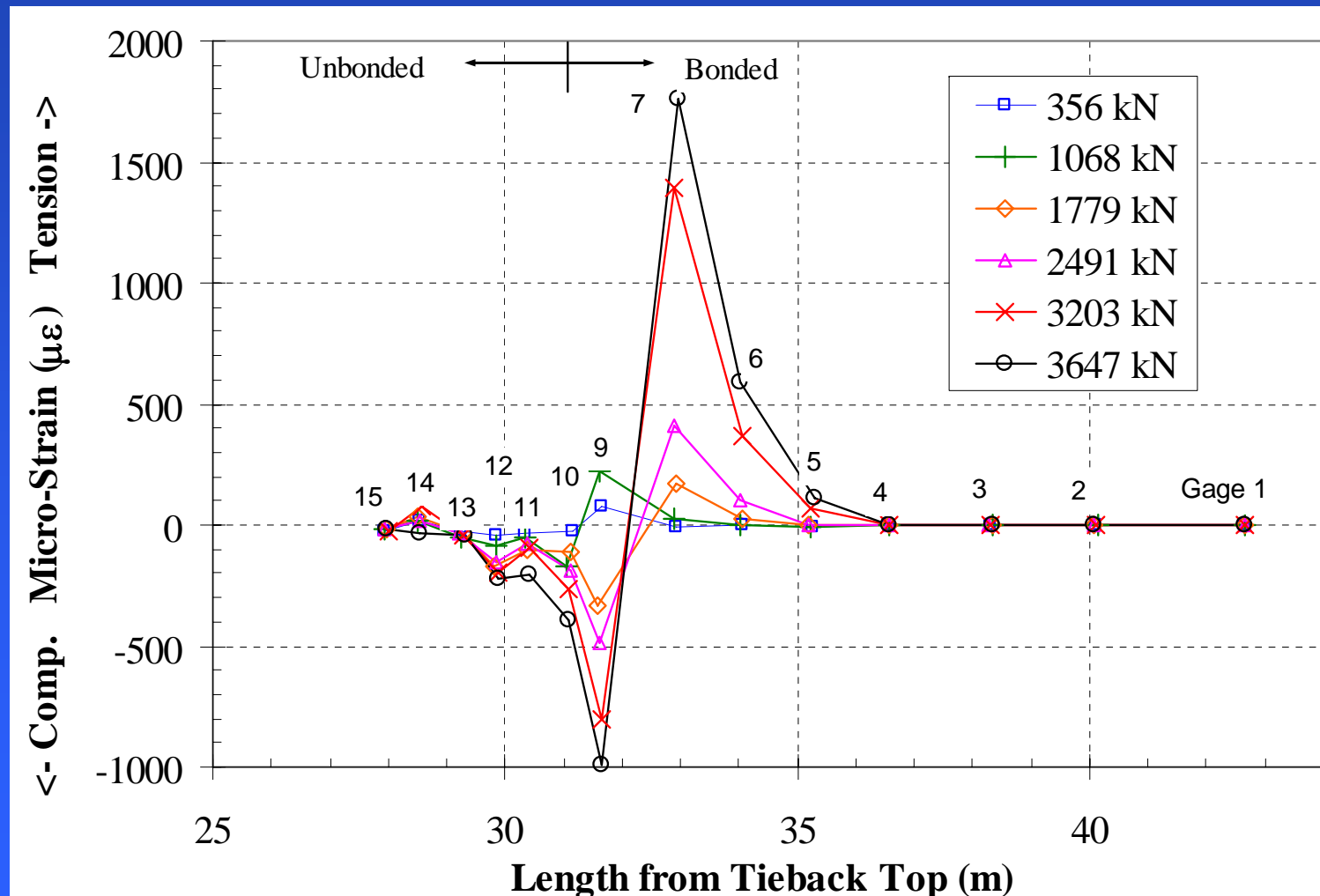
# Strain - Location Data - Tieback 1



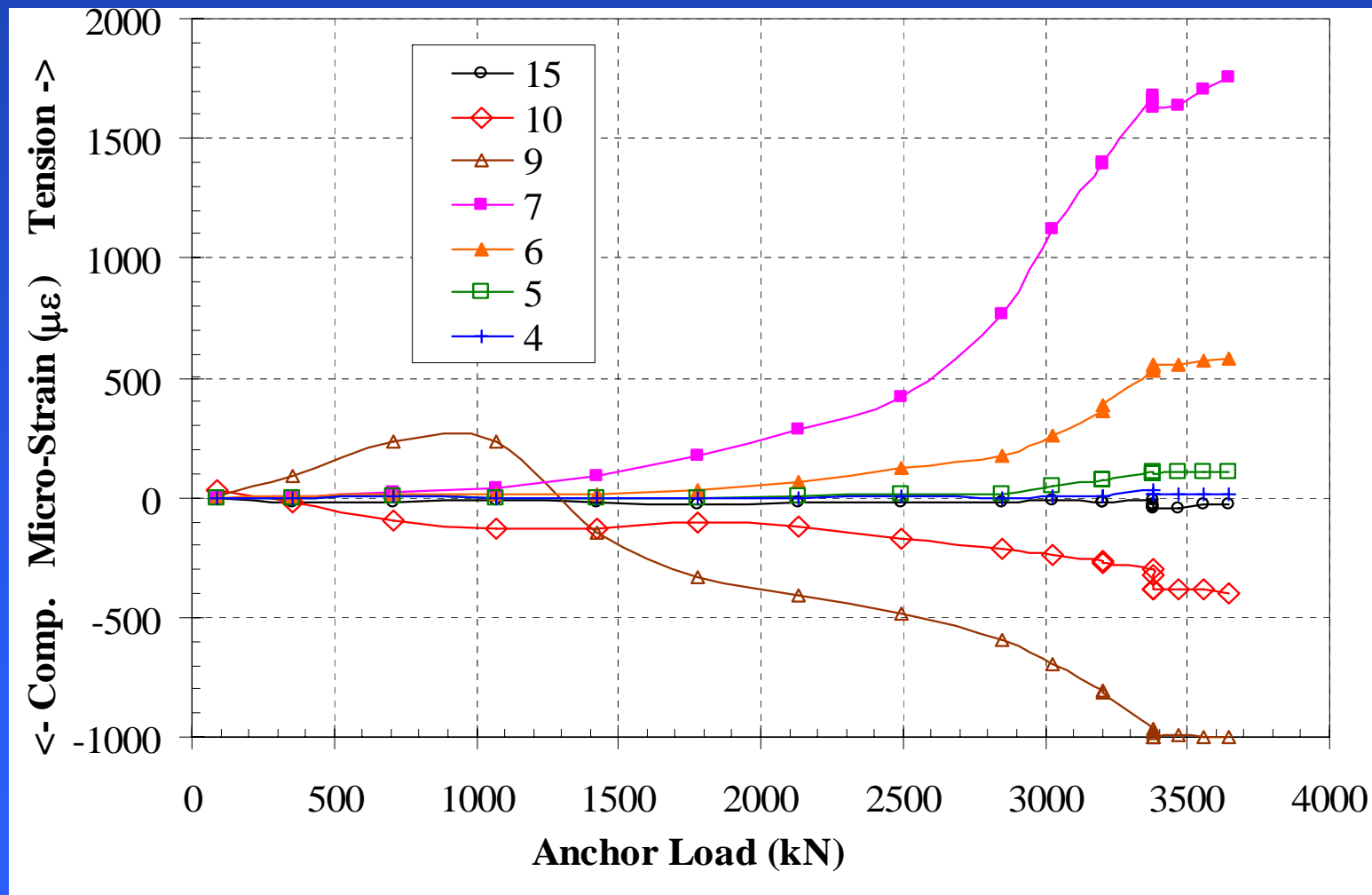
# Strain - Load Data - Tieback 1



# Strain - Location Data - Tieback 2

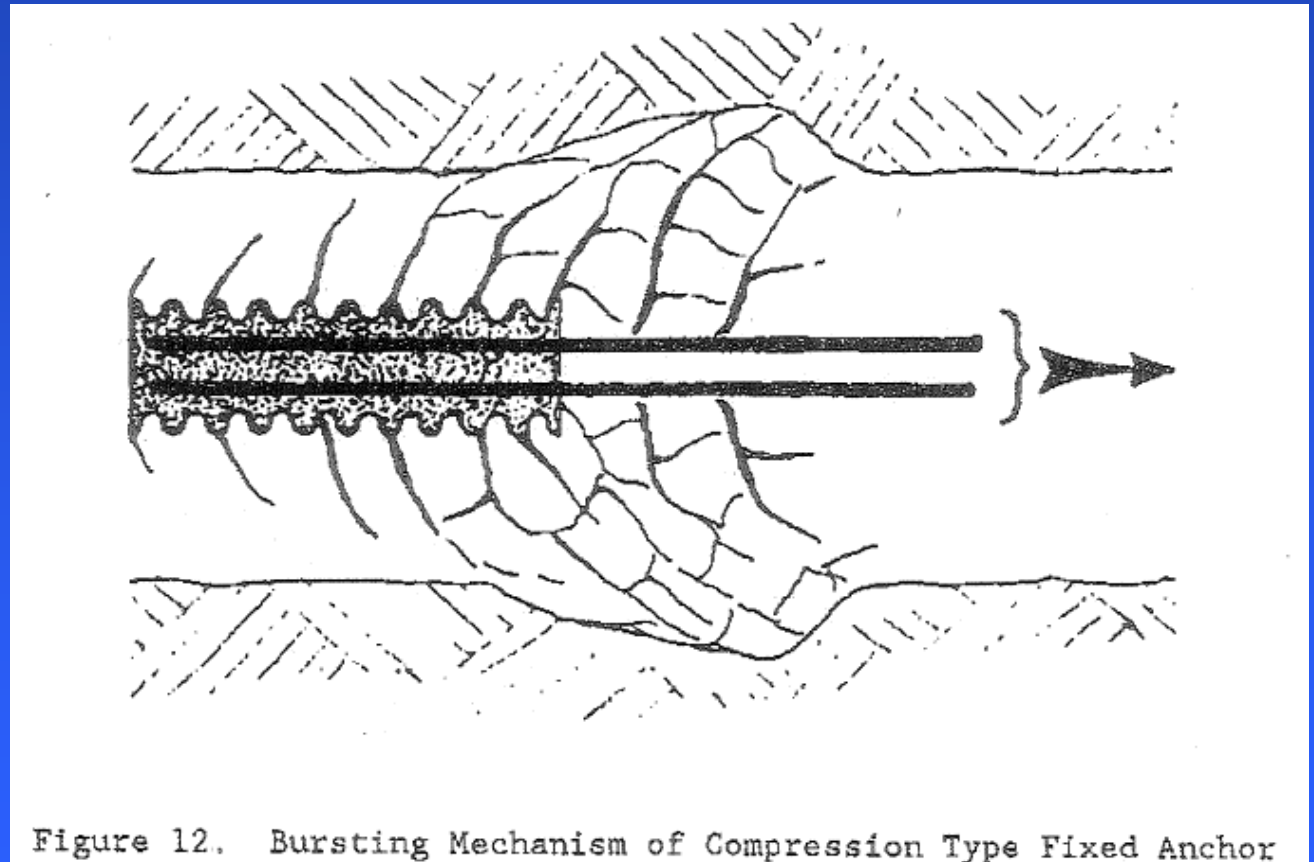


# Strain - Load Data - Tieback 2



# High Adhesion Mechanism

- High radial stresses increase grout soil adhesion due to restrained dilation (wedge action: Wernick 1978 and, Schlosser 1990, Shields et al. 1978, grout bursting Littlejohn 1990 )
- Conditions that may cause this:
  - ▶ Soil densification due to grouting
  - ▶ Formation of dense filter cake in grout at borehole wall as water is pushed out



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# Conclusions

1. Anchors carry load in both compression and tension.
  2. Compression at top of the bonded length causes the grout body to expand radially (restrained dilation), increasing the grout-soil adhesion of the anchor above values typically calculated by traditional soil mechanics.
  3. A small amount of compression occurs in the 5 ft. grouted zone above the top of the bonded length.
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# Thank You

## Acknowledgements:

- Owner: Army Corp of Engineers
  - Anchor Installation Contractor: David Weatherby and Ron Chapman of Schnabel Foundation Company
  - Hart Crowser, Geometron, Shannon & Wilson
  - Data Reduction and Compilation: Matt Veenstra of Hart Crowser
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