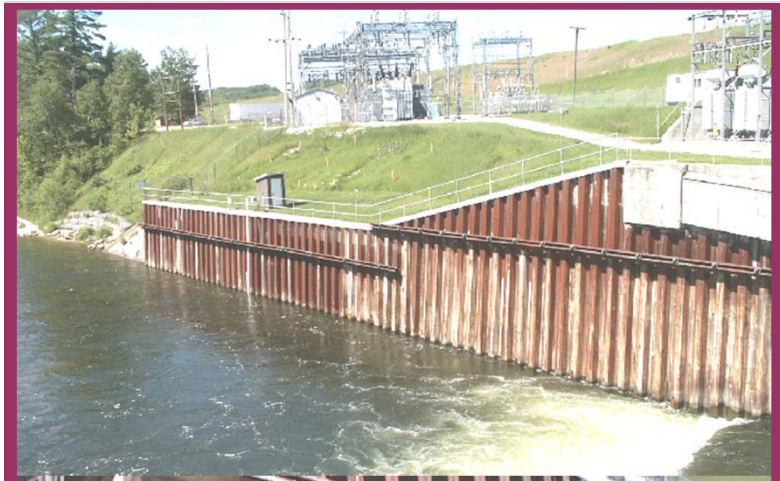
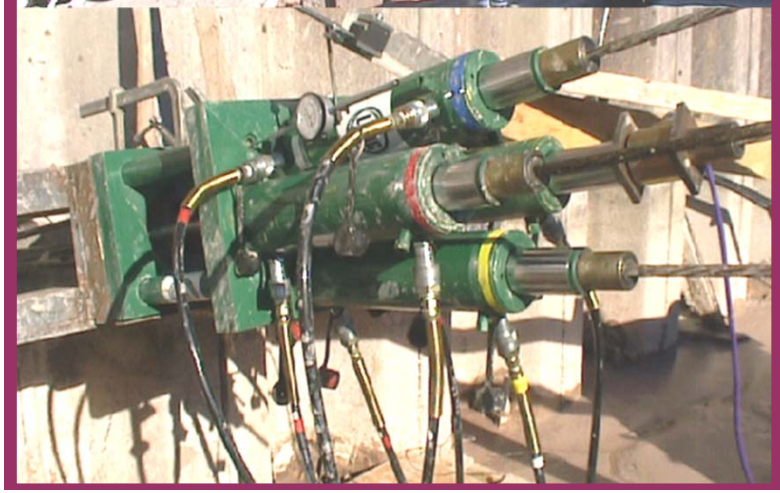




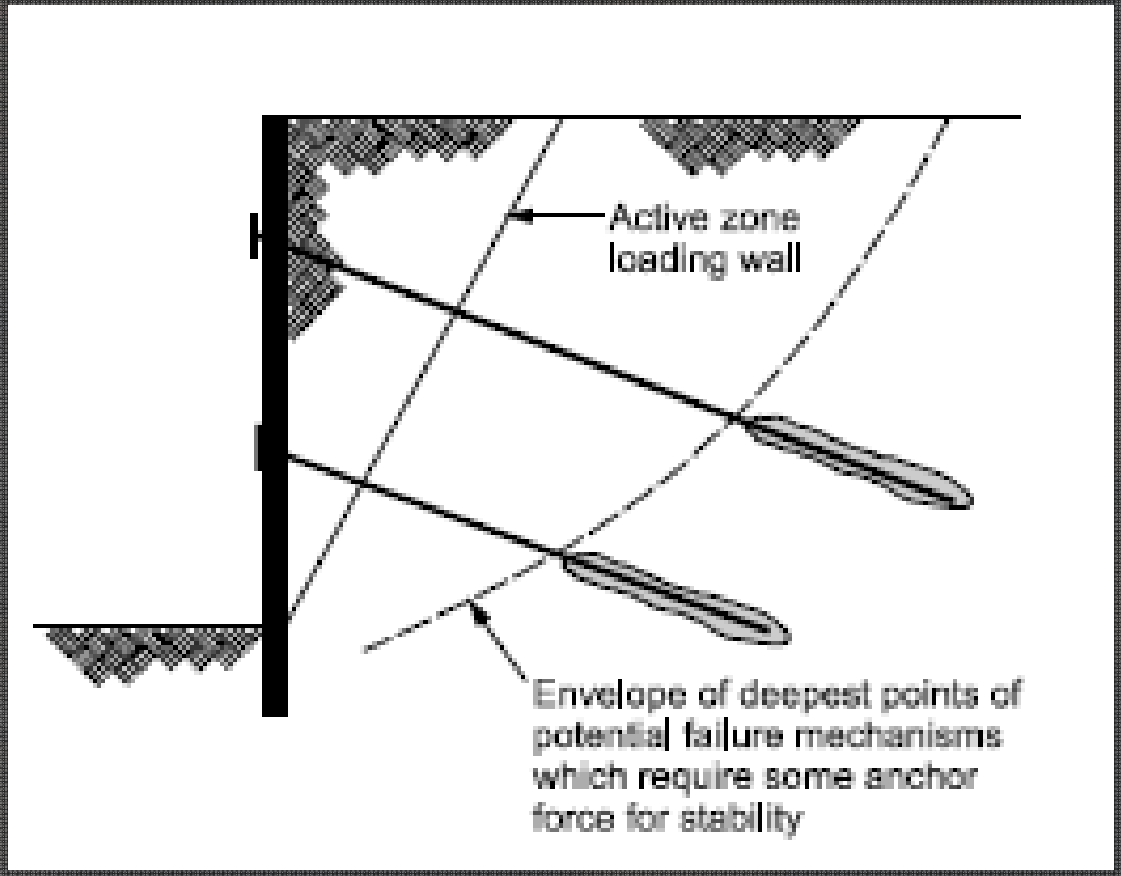
Load-Distributed Ground Anchors

Andrew Baxter, PE, PG
Schnabel Engineering

POST-TENSIONING INSTITUTE ®
Stressing the Stronger Concrete Solution

Traditional Ground Anchor

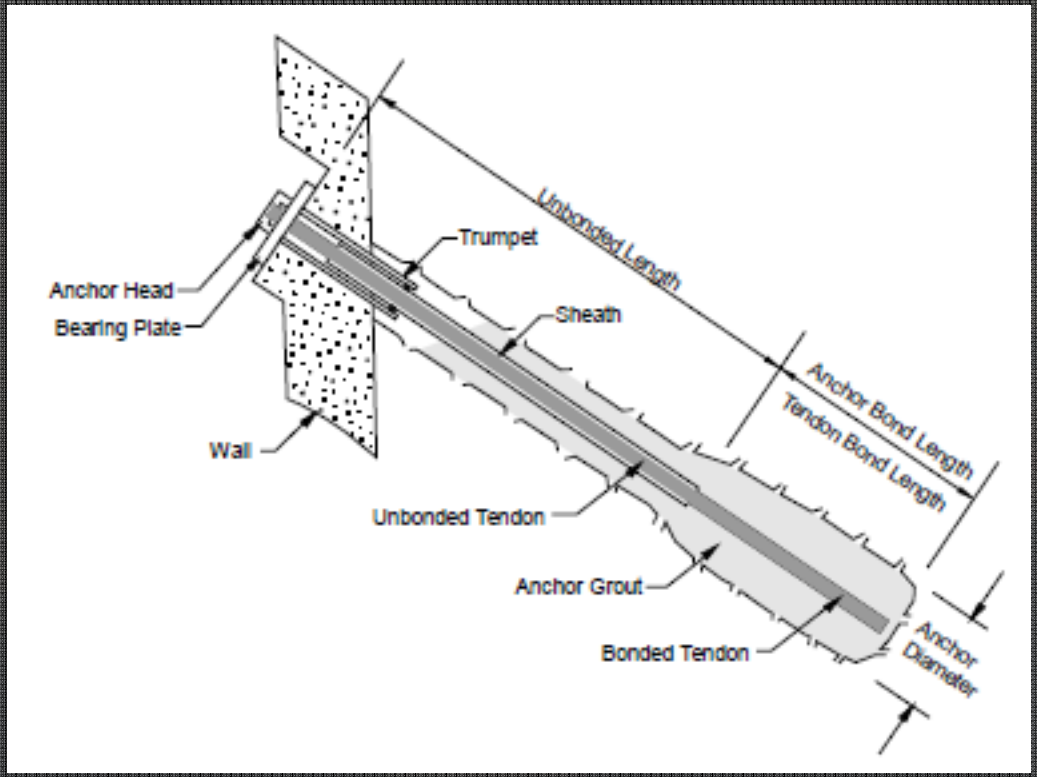
- Pre-Stressed Anchors or Tiebacks



From FHWA GEC No.4

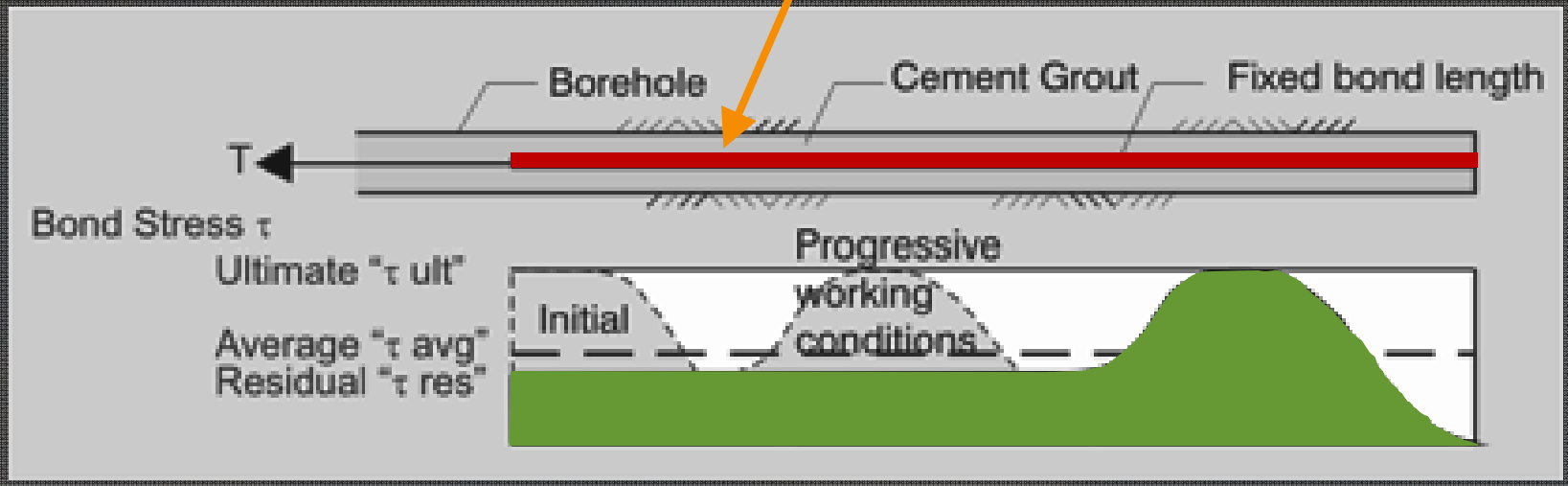
Traditional Ground Anchor

- Components of Traditional Ground Anchor



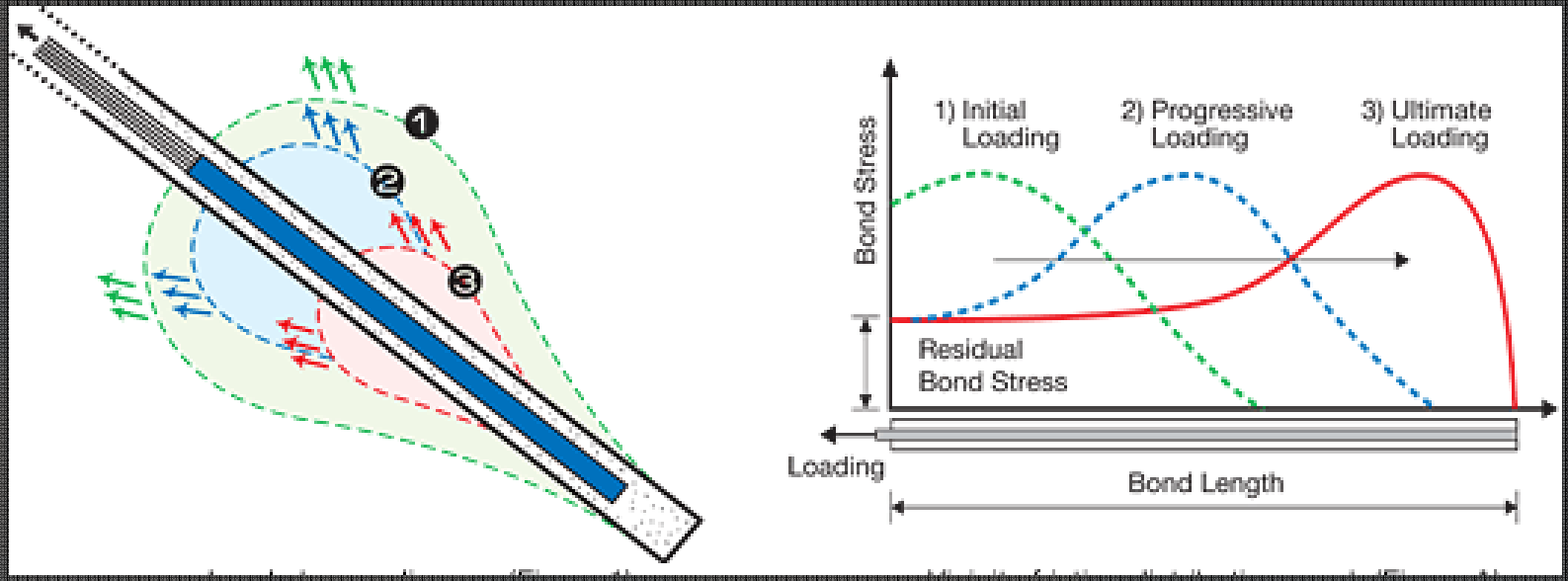
From FHWA GEC No.4

Traditional Fixed Length Ground Anchor



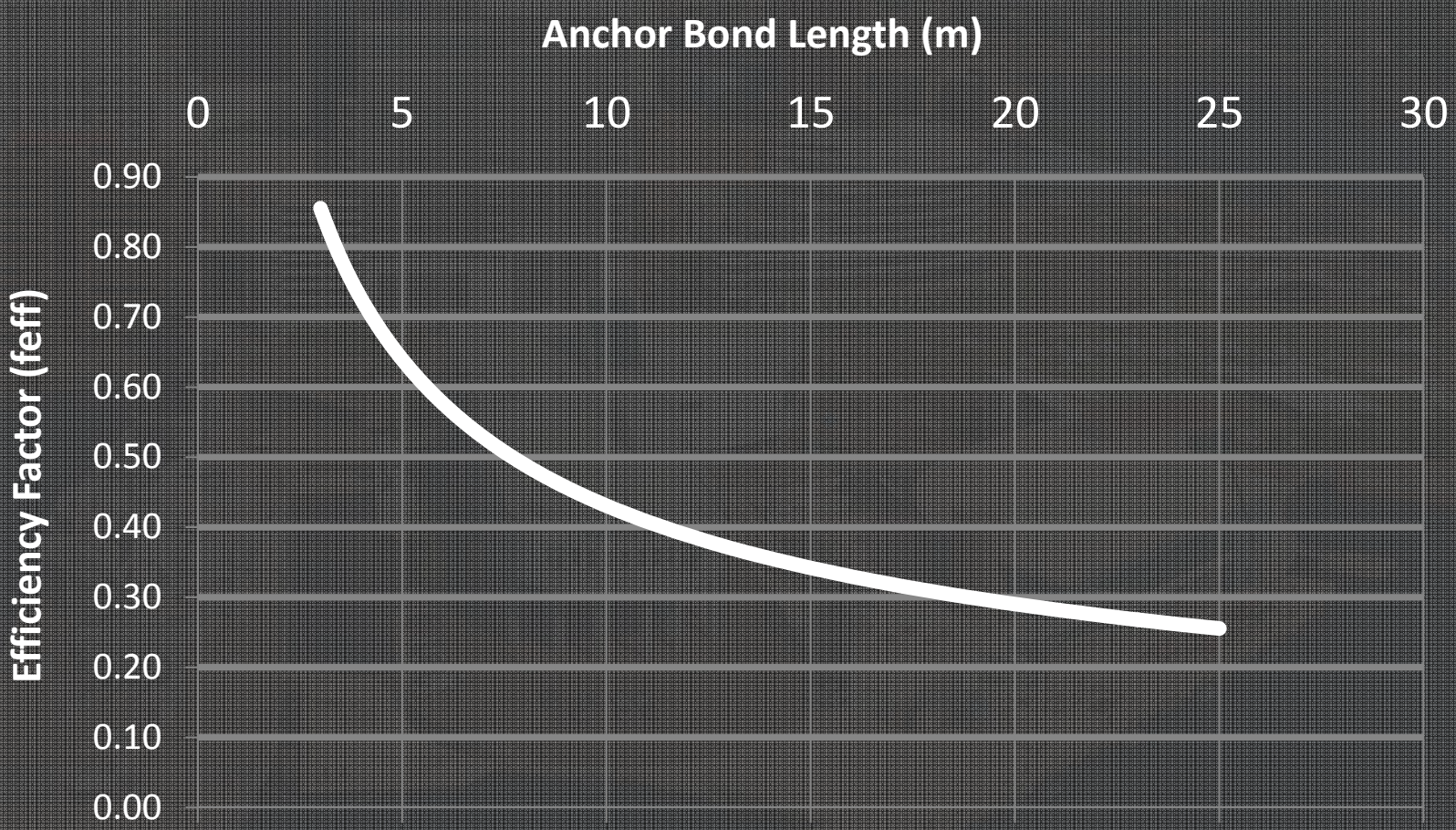
Traditional Ground Anchor

- Load Transfer of Traditional Tiebacks



Courtesy of SAMWOO

Efficiency of Ground Anchor Bond Zones

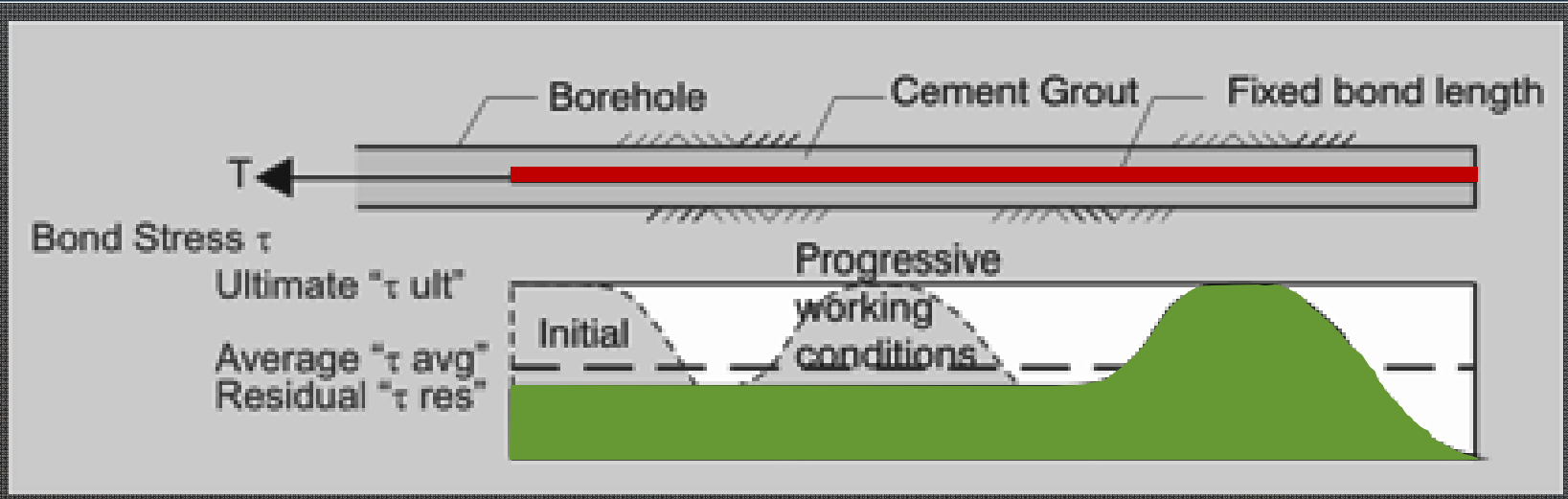


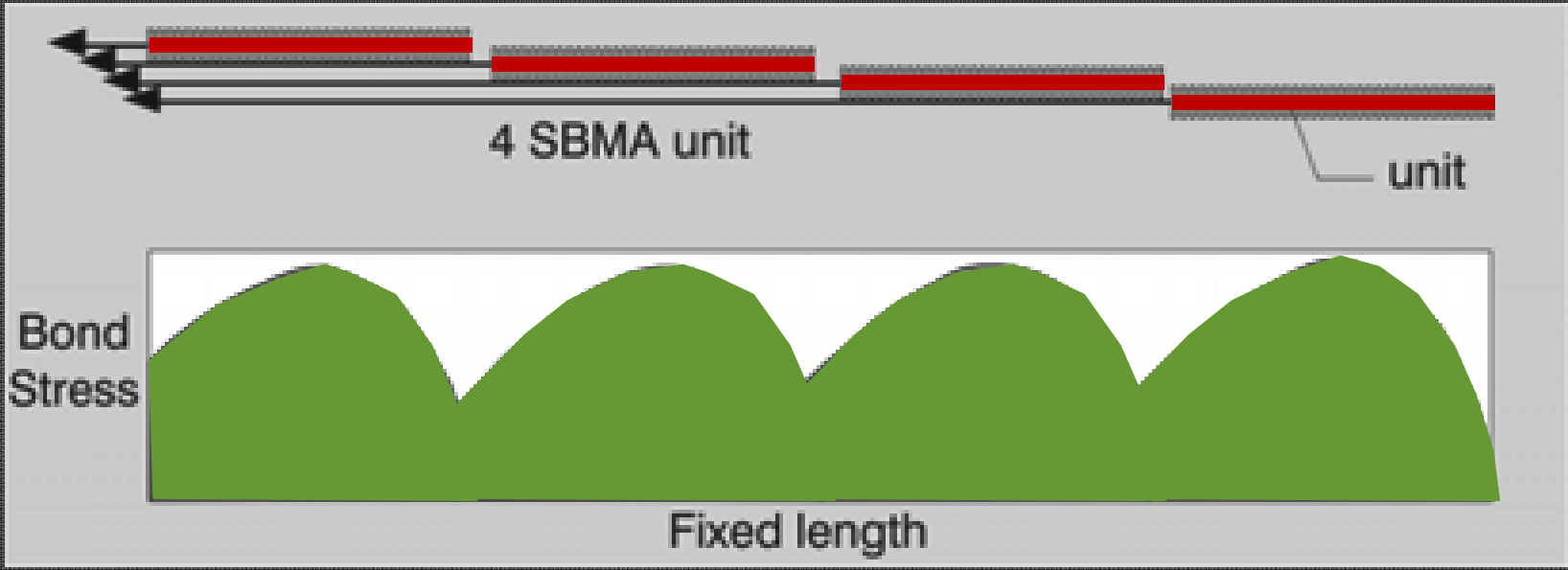
Barley, 1995

Efficiency of Ground Anchor Bond Zones

- Function of:
  - Strain softening behavior of the soil
  - Stiffness of soil and anchor
  - Fixed length of the bond zone

$$f_{eff} = 1.6 * \left(\frac{L_{fix}}{L_0}\right)^{-0.57}$$

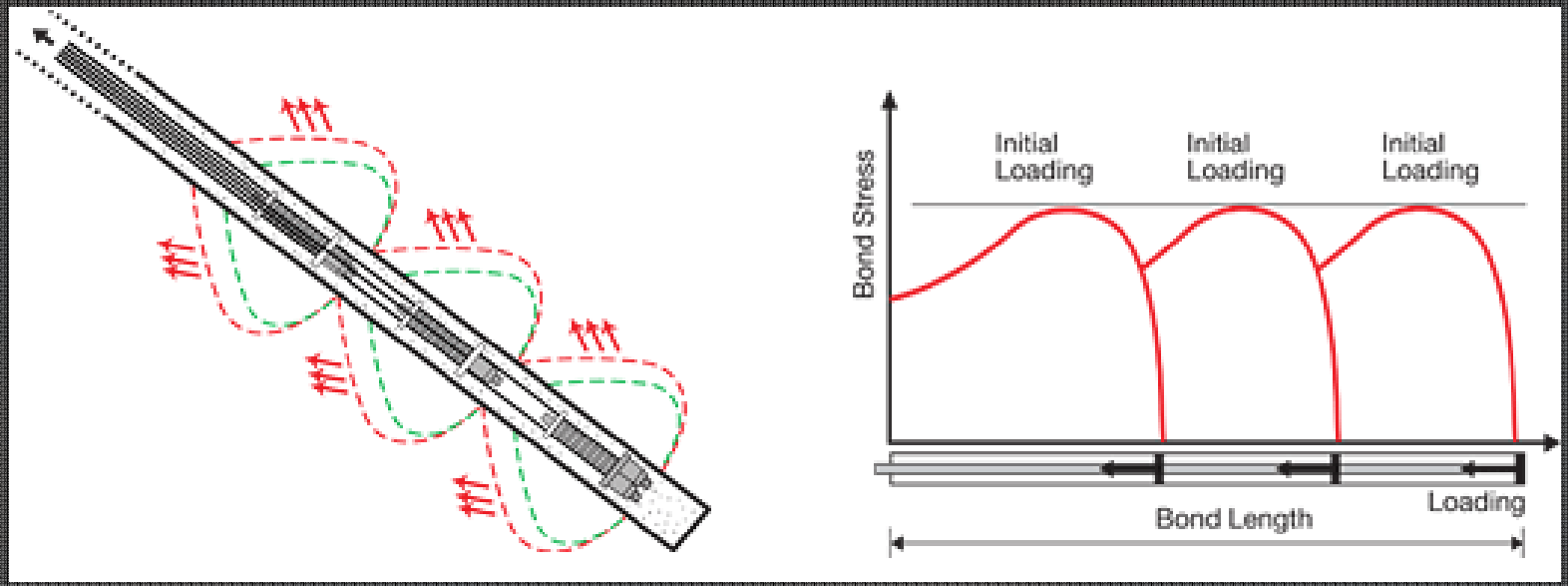




POST-TENSIONING INSTITUTE ®
Stressing the Stronger Concrete Solution

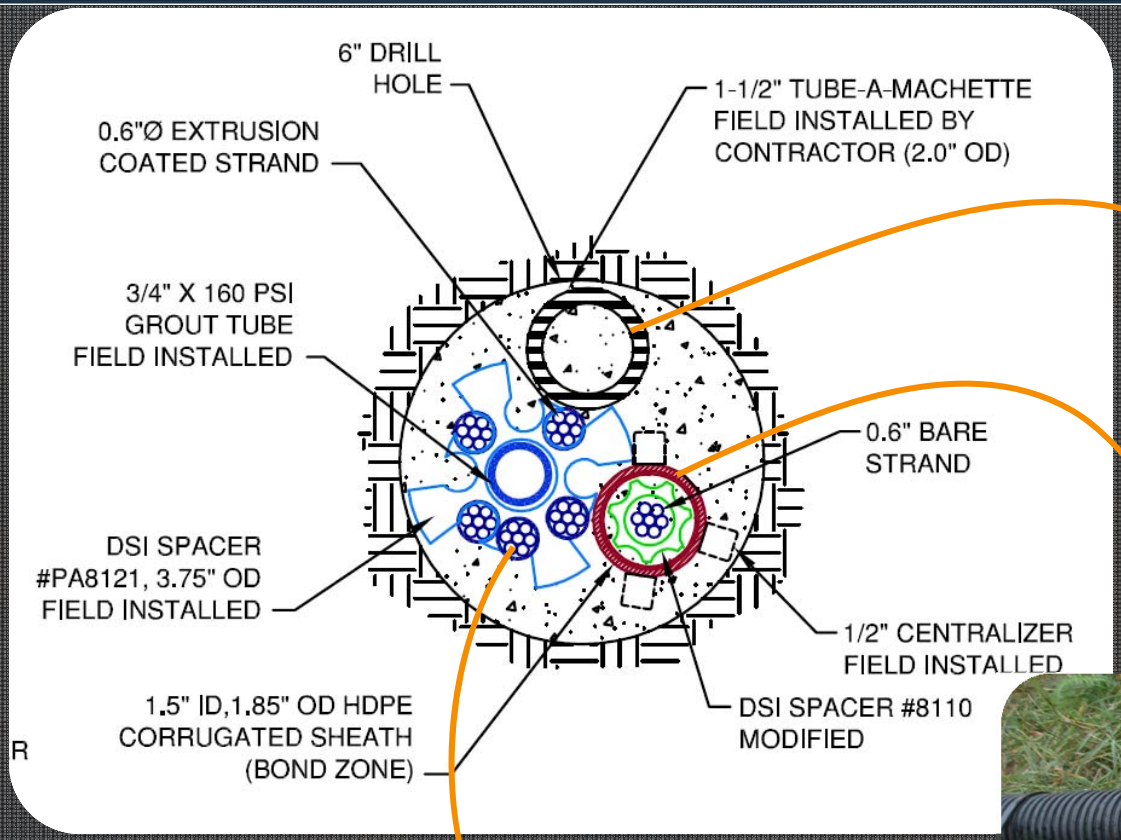
Traditional Tiebacks Vs. LDA

- Load Transfer of LDCAs



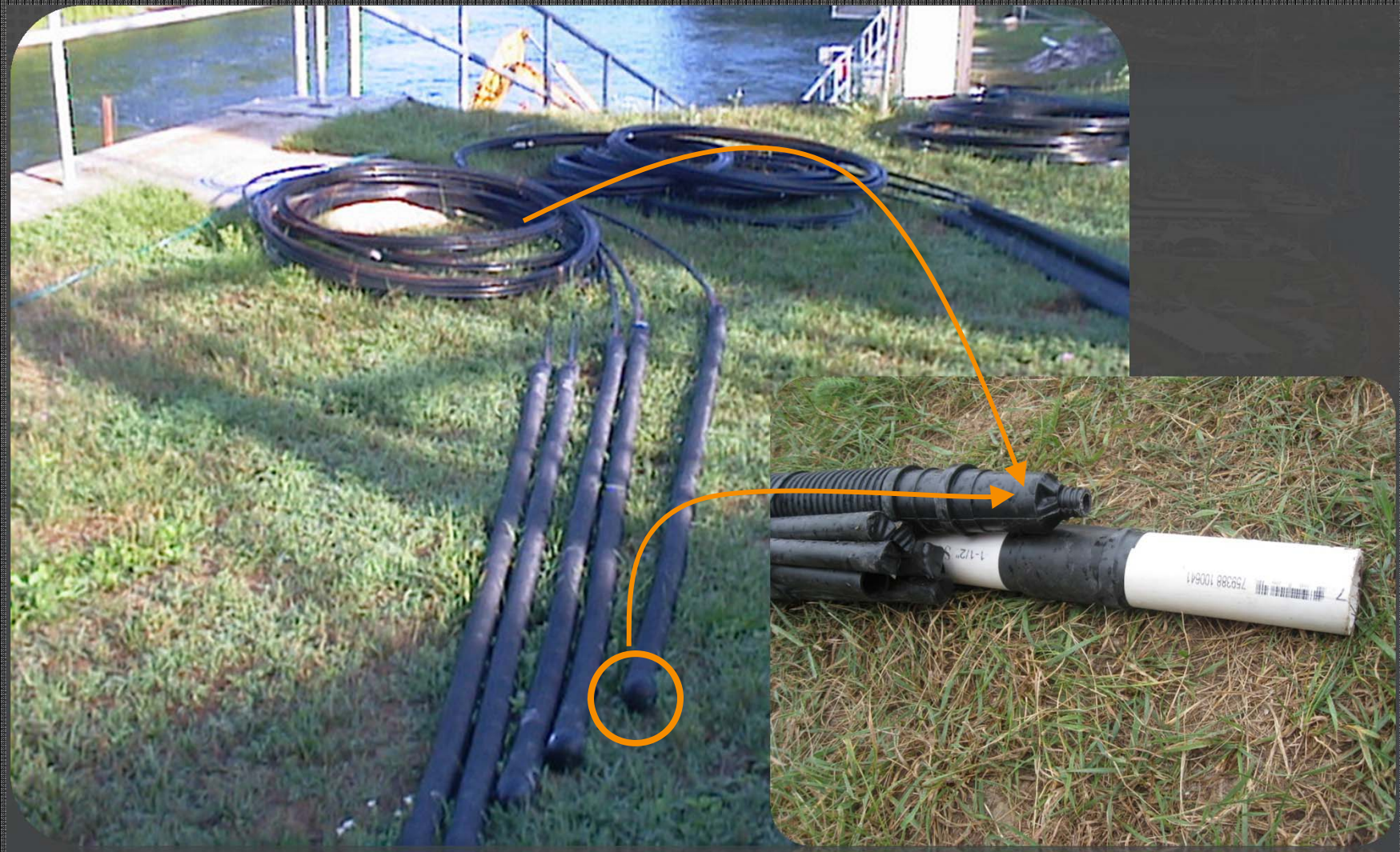
Courtesy of SAMWOO

Anchor Configuration



Courtesy DSI

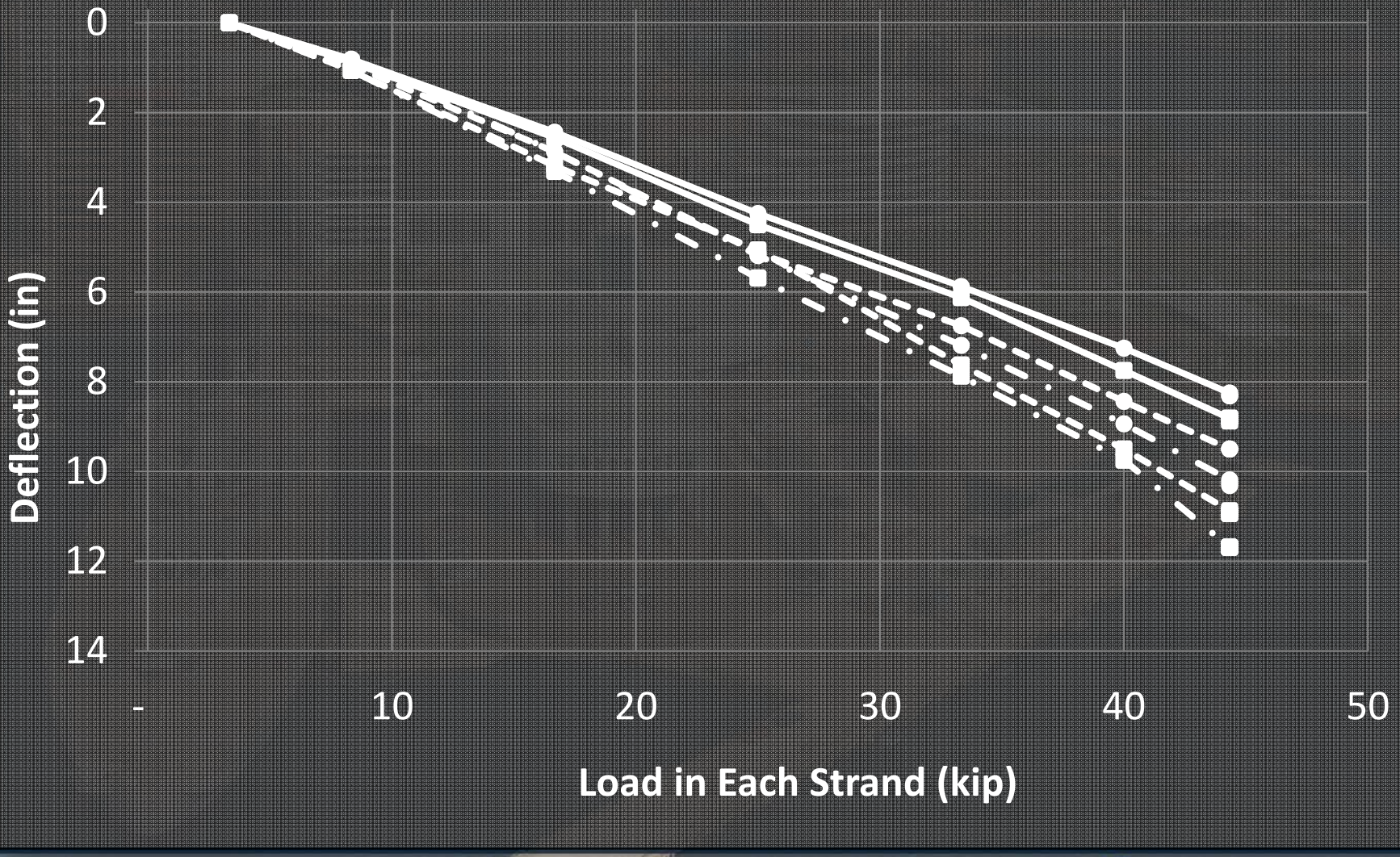
Anchor Configuration



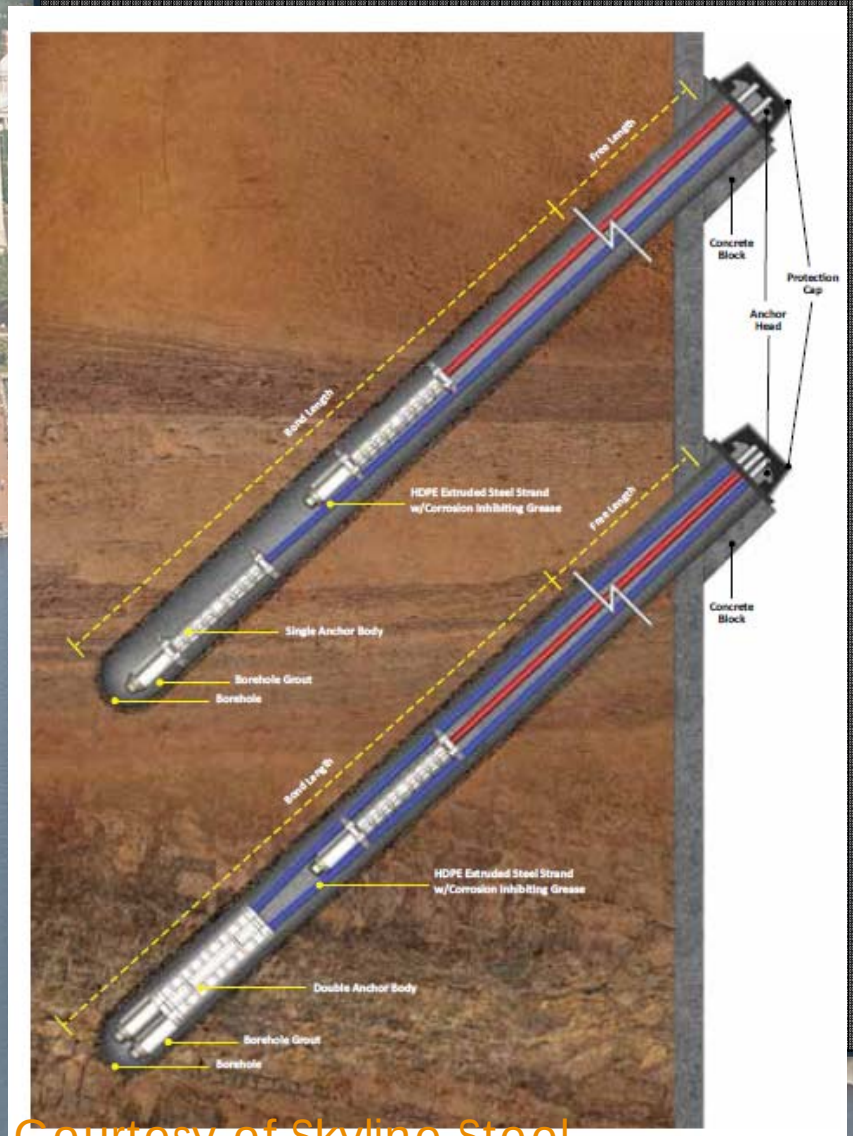
Installation Method

Load Testing Hydraulic Jack System

Load Test (80% MUTS of 270 KSI Strand)



Traditional Tiebacks Vs. LDCA



Courtesy of Skyline Steel

- Components of LDCAs

Traditional Tiebacks Vs. LDCA

- **Types of LDCAs**

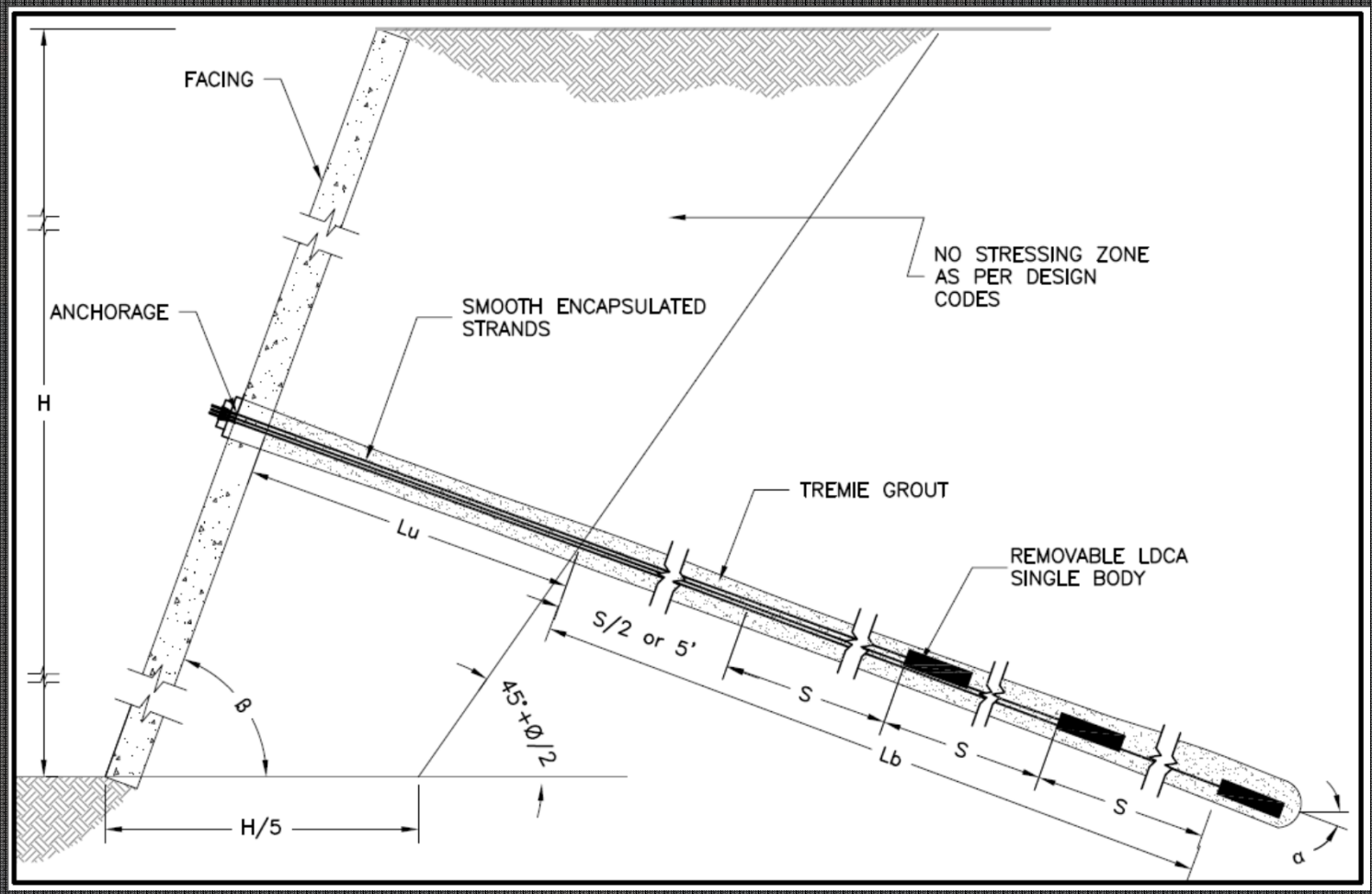
Single Strand Body

Double Strand Body

Triple Strand Body

Courtesy of SAMWOO

Design, Installation and Testing Recommendations



Research Program

- Installation Procedure

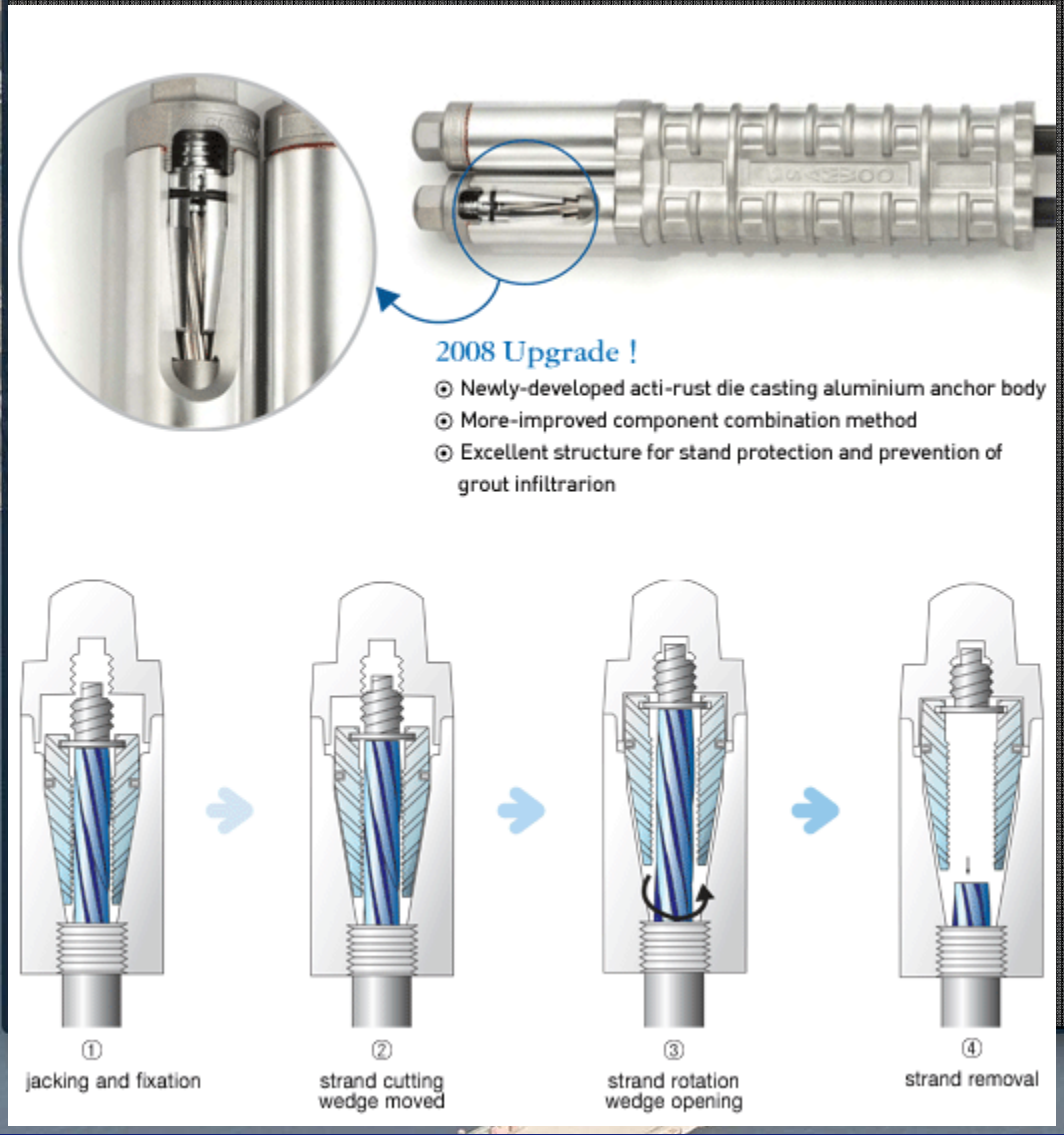
Research Program

- Test Site

LD Compression Ground Anchors

- Testing Procedures and Equipment

Traditional Tiebacks Vs. LDCA



- Temporary and Removable

Courtesy of SAMWOO

Research Program

- Two Stages
  - Stage 1, to familiarize with the anchors, installation procedures, and testing procedures
    - Reston Station, VA
    - Tysons Corner, VA
  - Stage 2, Large Scale Testing at Auburn University, Spring Villa Geotechnical Test Site

Research Program

- Stage 1
  - Evaluate the use Different drilling methods
  - Evaluate tendon installation procedures
  - Evaluate Post-Grouting
  - Evaluate use of conventional center hole jack

Research Program

- Stage 2 aimed at developing design criteria:
  - Using a standard installation procedure
  - Using a standard testing procedure
  - Compare the performance of removable LDCAs with equivalent traditional tiebacks
    - Evaluate the effects of the grout mix strength
    - Evaluate the effects of body spacing
    - Evaluate and determine the extent of the bond length

Research Program

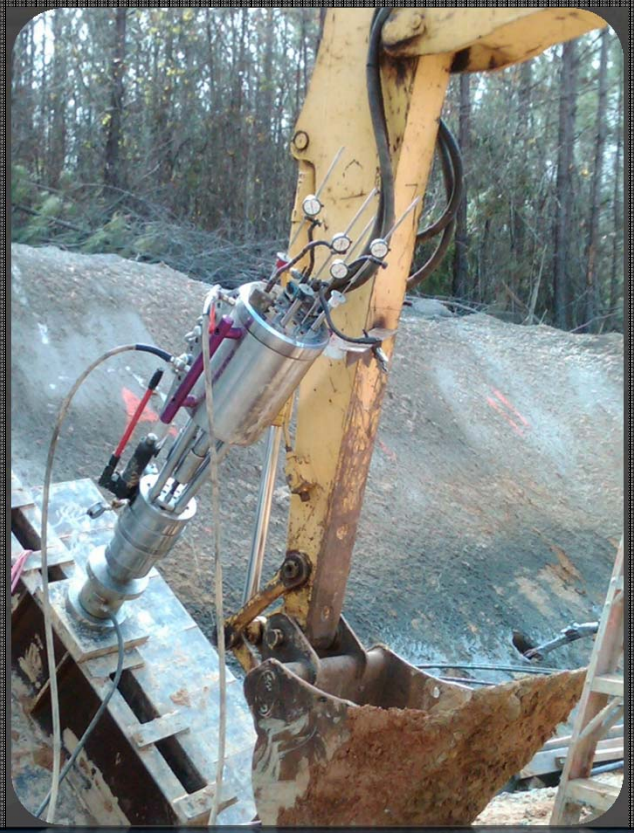
Tie #	Type	#0.6"ϕ Strands	Borehole Diameter (inches)	Grout W/C	Grouting Method	LDCA Body Type	Lu (ft)	S (ft)	Lb (ft)
1	LDCA	3	7	0.45	Tremie	Single	15	6	19
2	LDCA	3	7	0.45	Tremie	Single	15	9	28
3	LDCA	3	7	0.45	Tremie	Single	15	6	19
4	LDCA	3	7	0.45	Tremie	Single	15	9	28
5	LDCA	3	7	0.60	Tremie	Single	15	6	19
6	LDCA	3	7	0.60	Tremie	Single	15	9	28
7	LDCA	2	7	0.45	Tremie	Double	15	6	7
a	LCTA	3	7	0.45	Tremie	NA	15	NA	18
b	LCTA	3	7	0.45	Tremie	NA	15	NA	27
c	LCTA	3	7	0.60	Tremie	NA	15	NA	18
d	LCTA	3	7	0.60	Tremie	NA	15	NA	27
e	LCTA	3	7	0.60	Post- grouted	NA	15	NA	10
f	LCTA	3	7	0.60	Post- grouted	NA	15	NA	10

Research Program

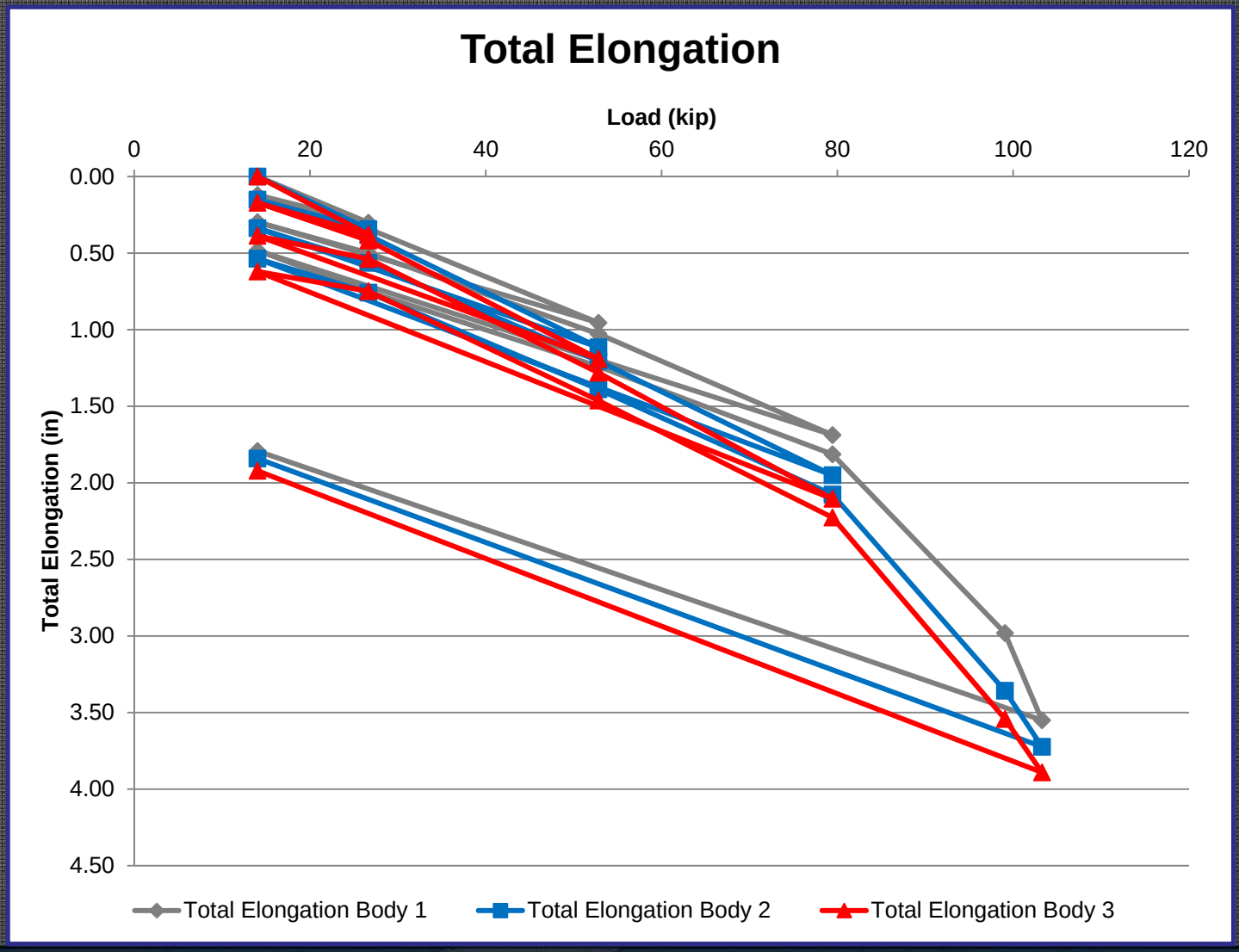
- Instrumentation

Research Program

- Testing Procedure



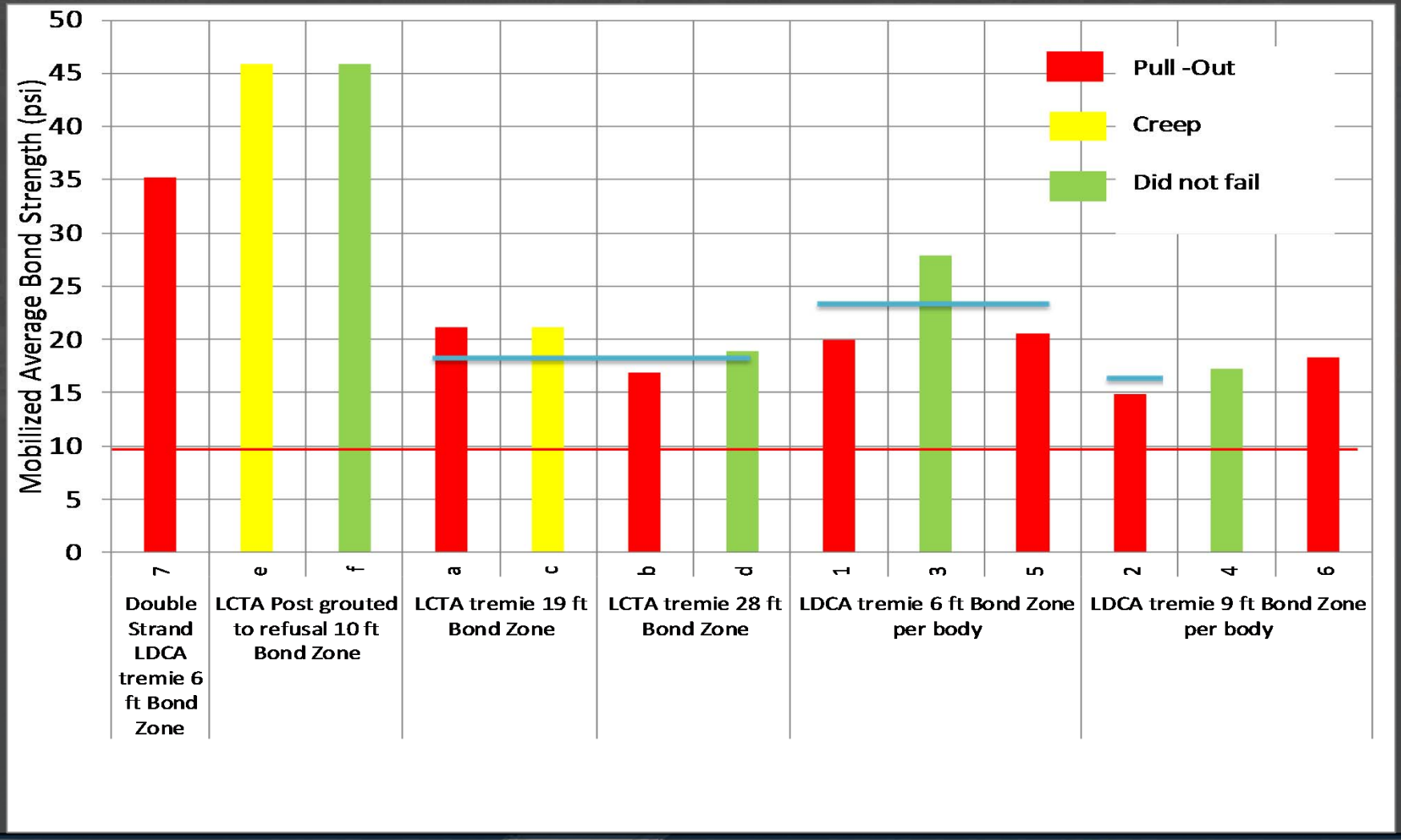
Testing Results



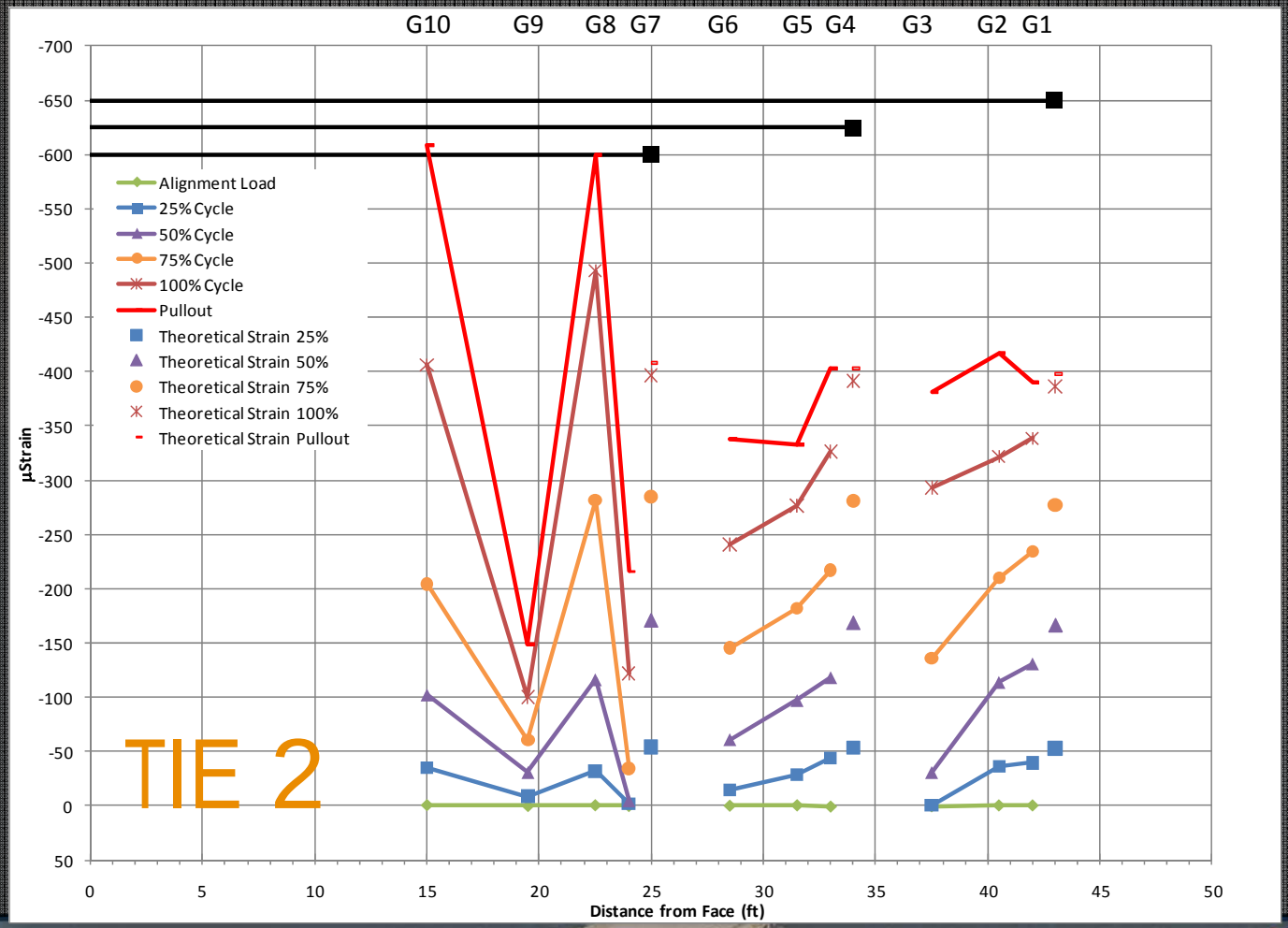
Research Program

Tie #	Design Load (kip)	Max. Test Load (kip)	Maximum Elongation (inches)	Elastic Elongation (inches)	Residual Elongation (inches)	Failure Mode	Average Mobilized Bond Strength(	
							psi	kip/ft
1	105	100	4.73	2.39	2.34	Pull-out	19.9	5.3
2	105	110	6.75	2.73	4.02	Pull-out	14.9	3.9
3	105	140	3.89	3.23	0.66	Strand Wire Broke	27.9	7.4
4	105	127	4.63	3.73	0.90	Strand Wire Broke	17.2	4.5
5	105	103	3.89	1.97	1.92	Pull-out	20.5	5.4
6	105	135	4.97	3.93	1.04	Pull-out	18.3	4.8
7	70	65	3.50	1.68	1.82	Pull-out	35.2	9.3
a	105	106	3.67	1.50	2.17	Pull-out	21.1	5.6
b	105	125	4.16	1.82	2.34	Pull-out	16.9	4.5
c	105	106	3.59	1.65	1.94	Pull-out	21.1	5.6
d	105	140	3.70	NA	NA	Passed	18.9	5.0
e	105	121	2.53	1.40	1.13	Creep	45.9	12.1
f	105	121	2.44	1.51	0.93	Passed	45.9	12.1

Research Program

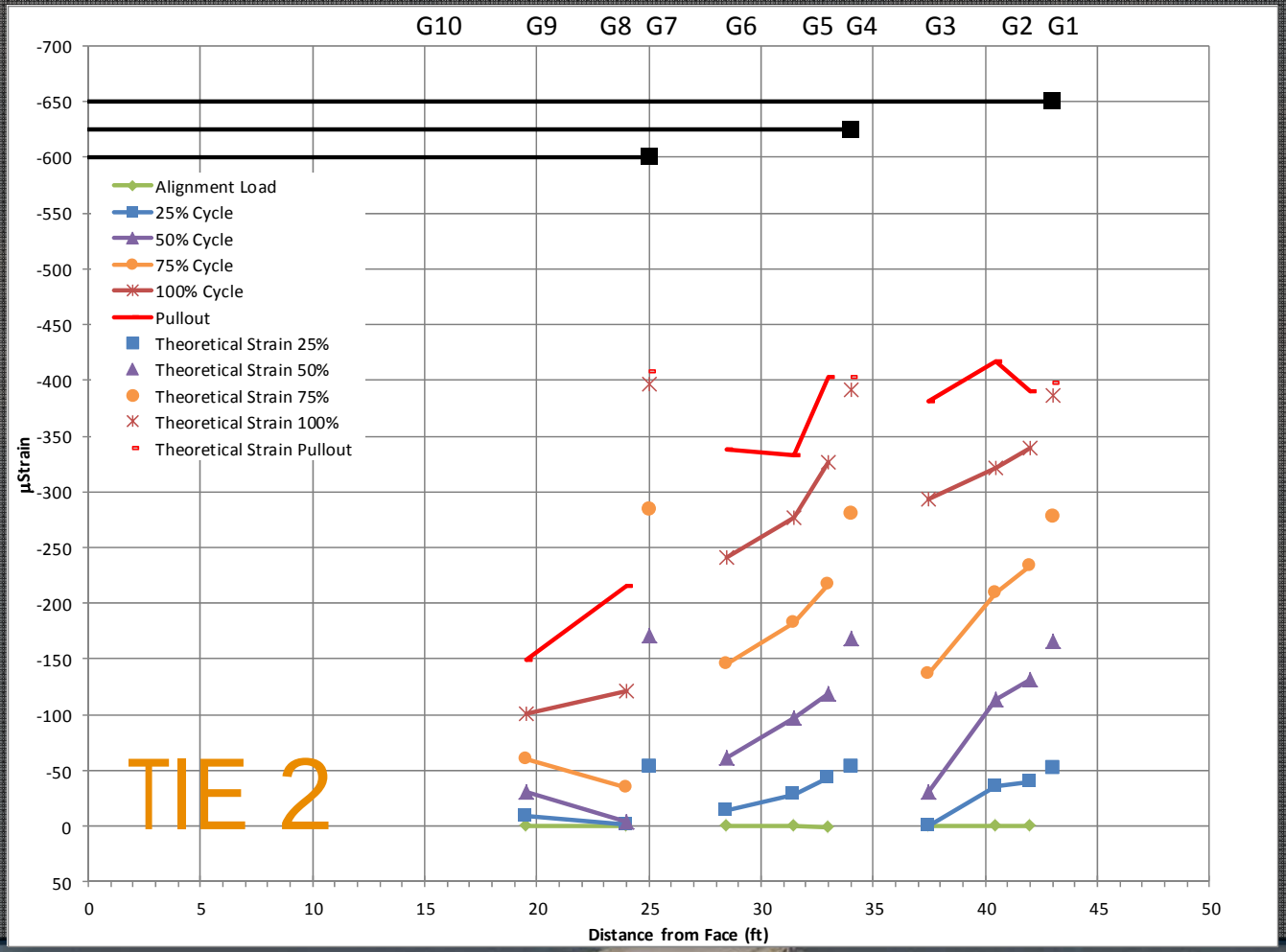


Research Program



- Load Transfer

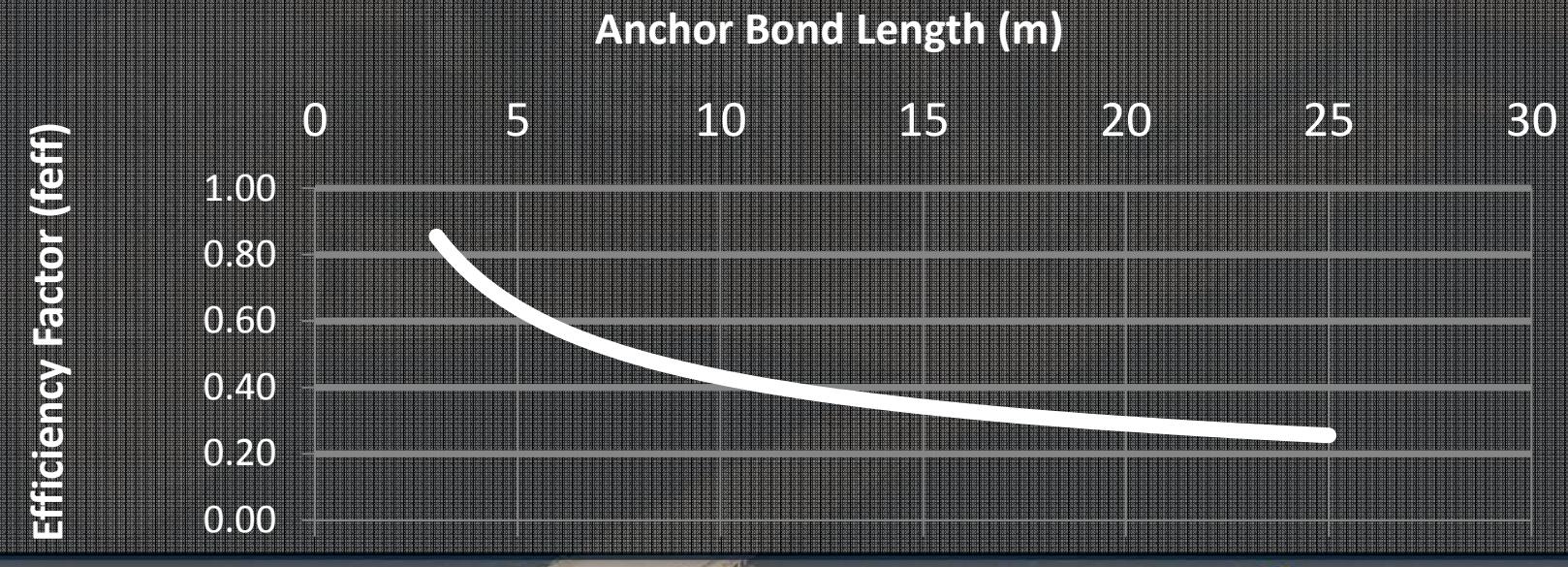
Research Program



- Load Transfer

Conclusions

- General Conclusions
  - LDA verses traditional anchors can provide significantly higher capacities in soft ground formations.
  - LD Compression Anchors with short spacing have comparable capacity values with LD Tension Anchors



Questions?

Andrew Baxter, PE, PG
Schnabel Engineering