Load-Distributed Ground Anchors

Andrew Baxter, PE, PG
Schnabel Engineering
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

Grouted Bond Length
Traditional Ground Anchor

- Load Transfer of Traditional Tiebacks

![Diagram of load transfer process]

Courtesy of SAMWOO
Efficiency of Ground Anchor Bond Zones

Efficiency Factor ($f_{eff}$) vs. Anchor Bond Length (m)

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

\[ f_{eff} = 1.6 \times \left( \frac{L_{fix}}{L_0} \right)^{-0.57} \]
Traditional Tiebacks Vs. LDA

- Load Transfer of LDCAs

Courtesy of SAMWOO
Anchor Configuration

- 0.6" Ø Extrusion Coated Strand
- 3/4" x 160 PSI Grout Tube Field Installed
- DSI Spacer #PA6121, 3.75" OD Field Installed
- 1.5" ID, 1.85" OD HDPE Corrugated Sheath (Bond Zone)
- 1-1/2" Tube-A-Machete Field Installed by Contractor (2.0" OD)
- 0.6" Bare Strand
- 1/2" Centralizer Field Installed

Courtesy DSI
Anchor Configuration
Load Testing Hydraulic Jack System
Load Test (80% MUTS of 270 KSI Strand)
Traditional Tiebacks Vs. LDCA

- Components of LDCAs

Courtesy of Skyline Steel
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

2008 Upgrade!

- Newly-developed anti-rust die casting aluminium anchor body
- More-improved component combination method
- Excellent structure for stand protection and prevention of grout infiltration

1. Jacking and fixation
2. Strand cutting wedge moved
3. Strand rotation wedge opening
4. Strand removal

Courtesy of SAMWOO

POST-TENSIONING INSTITUTE®
Stressing the Stronger Concrete Solution
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 of different drilling methods
  - Evaluate tendon installation procedures
  - Evaluate Post-Grouting
  - Evaluate use of conventional center hole jack
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
<table>
<thead>
<tr>
<th>Tie #</th>
<th>Type</th>
<th>#0.6” φ Strands</th>
<th>Borehole Diameter (inches)</th>
<th>Grout W/C</th>
<th>Grouting Method</th>
<th>LDCA Body Type</th>
<th>Lu (ft)</th>
<th>S (ft)</th>
<th>Lb (ft)</th>
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Research Program

- Instrumentation
Research Program

- Testing Procedure
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<th>Tie #</th>
<th>Design Load (kip)</th>
<th>Max. Test Load (kip)</th>
<th>Maximum Elongation (inches)</th>
<th>Elastic Elongation (inches)</th>
<th>Residual Elongation (inches)</th>
<th>Failure Mode</th>
<th>Average Mobilized Bond Strength</th>
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Research Program

Mobilized Average Bond Strength (psi)

- Double Strand LDCA tremie 6 ft Bond Zone
- LCTA Post grouted to refusal 10 ft Bond Zone
- LCTA tremie 19 ft Bond Zone
- LCTA tremie 28 ft Bond Zone
- LDCA tremie 6 ft Bond Zone per body
- LDCA tremie 9 ft Bond Zone per body

LEGEND:
- Red: Pull-Out
- Yellow: Creep
- Green: Did not fail
Research Program

Load Transfer

-700 -650 -600 -550 -500 -450 -400 -350 -300 -250 -200 -150 -100 -50 0 50 0 5 10 15 20 25 30 35 40 45 50

μ Strain

Distance from Face (ft)

Alignment Load

25% Cycle

50% Cycle

75% Cycle

100% Cycle

Pullout

Theoretical Strain 25%

Theoretical Strain 50%

Theoretical Strain 75%

Theoretical Strain 100%

Theoretical Strain Pullout

TIE 2
Research Program

Load Transfer

Alignment Load
-600
-650
-700

Distance from Face (ft)

0 5 10 15 20 25 30 35 40 45 50

Theoretical Strain 25%
Theoretical Strain 50%
Theoretical Strain 75%
Theoretical Strain 100%
Theoretical Strain Pullout

G10 G9 G8 G7 G6 G5 G4 G3 G2 G1

25% Cycle
50% Cycle
75% Cycle
100% Cycle
Pullout

TIE 2
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.