DYWIDAG Strand Anchors Systems
Soil and Rock Anchors

Prestressed rock and soil anchors have become an important tool for the geotechnical or structural design engineer. Their safe and reliable use in both permanent and temporary applications is accepted throughout the world.

Anchors are most commonly referred to as tiebacks for installation angles of 15°-50° from horizontal or tiedowns (51°-90° installation angle).

Soil Anchors

Soil anchors are pressure grouted tendons installed in either cohesive or non-cohesive soil or loose rock. The anchors transfer forces into the ground through the prestressing steel and grout body. In the free stressing length the anchor remains free to move.

Typical Uses for Soil Anchors

- Anchoring of support structures for excavations such as sheet pile walls, soldier piles with lagging, drilled piles, slurry walls, and concrete retaining walls.
- Counteracting uplift forces in structures subjected to buoyancy and lateral loads.
- Stabilization of eccentrically loaded foundations.
- Stabilization of natural or excavated slopes.

Rock Anchors

Rock anchors are post-tensioned tendons installed in drilled holes for which at least the entire bond length is located in rock. The anchor force is transmitted to the rock by bond between the grout body and the rock. Rock anchors can remain unbonded in the free stressing length allowing the anchor to be checked and re-tensioned at any time. In such cases, adequate corrosion protection for the stressing anchorage and the free stressing length must be provided.

On the other hand, the free stressing length can also be fully grouted after the anchor has been stressed, in which case future load adjustment is no longer possible.

Typical Uses for Rock Anchors

- Resist external and uplift forces caused by wind or seismic event.
- Tie back retaining walls.
- Stabilize eccentrically located foundations, slopes, rock walls, and cuts.
- Increase the stability of dams or large bridge foundations.

Fields of Applications

- Retaining Walls
- Dam Stabilizations
- Bridges Structures
- Tower Foundations
- Foundation Uplift Anchors
- Slope Stabilizations
DYWIDAG Permanent (DCP) Strand Anchors

Key Features
- Long-lasting system for permanent use
- Variable anchor head and angle compensation designs
- Double Corrosion Protection (DCP) is achieved by protecting the strands with barrier against corrosion. It consists of a corrugated sheathing, a pipe welded to the bearing plate and a cover cap along with encasement in cement grout.

Fields of Application
- Retaining Walls
- Rock and Slope Stabilization
- Tiedown Anchors
- Excavations

![Diagram of DYWIDAG Permanent Strand Anchor]

DYWIDAG Temporary Strand Anchor

Key Features
- Temporary System for a service life of up to two years
- Variable anchor head and angle compensation designs

Fields of Application
- Excavations
- Temporary Structures

![Diagram of DYWIDAG Temporary Strand Anchor]
Anchor Capacity

Although there is no theoretical limit to the capacity of a multistrand anchor, practical considerations such as drill hole size and the availability of material handling equipment limit the size of an anchor to 91.0-6” (152 mm) dia. strands in most cases. Larger anchors can be manufactured, but the practicality and economics of their use should be thoroughly evaluated before they are incorporated into a design.

Stress Levels

DYWIDAG Strand Anchor Systems may be stressed to the allowable limits of the American Concrete Institute Code No. ACI 318. The maximum jacking stress (test load) for anchors shall not exceed 0.80 f_pu of the prestressing steel. The lock off load depends on the specific requirements of the project. Initial load transfer force at lock-off shall not exceed 0.70 f_pu.

Wedges shall always be seated at a load that is greater than 0.50 f_pu. The final (working) prestress level is dependent on:
- Application
- Installation procedure
- Stressing sequence
- Rigidity of the structural system
- Seating losses

Anchor Length

No theoretical length limit exists, however, considerations should be made to allow for practical drilling and material handling.

The unbonded length of an anchor is determined by the location of the failure plane and/or the location of competent ground capable of resisting the anchor force. A minimum unbonded length of 15 ft is recommended for strand anchors, so that load losses associated with seating of the wedges will not result in major decrease of prestress force.

The bond length of the anchor depends on:
- Capacity of the ground (ground conditions)
- Hole diameter
- Installation practices
- Drilling method
- Grouting method

Post Grouting can significantly improve the holding capacities of anchors in soil and reduce the bond length.

Literature

Publications below are useful guides for selecting and designing temporary and permanent ground anchor systems.
- Recommendations for Prestressed Rock and Soil Anchors, published by the PTI (Post-Tensioning Institute), www.post-tensioning.org
DYWIDAG Strand Anchors

DYWIDAG Strand Anchors utilize 0.6" dia. 7-wire, low relaxation 270 ksi Strand conforming to ASTM A416 (bare strand) or ASTM A882 (epoxy coated strand).

### DYWIDAG Strand Anchors Properties

<table>
<thead>
<tr>
<th>Number of Strands</th>
<th>Nominal Cross Section Area (Aps) [ea]</th>
<th>Ultimate Strength (Fpu x Aps)</th>
<th>0.80 Fpu x Aps</th>
<th>0.70 Fpu x Aps</th>
<th>0.60 Fpu x Aps</th>
<th>Nominal Weight (bare steel only)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>[in²]</td>
<td>[mm²]</td>
<td>[kips]</td>
<td>[kN]</td>
<td>[kips]</td>
<td>[kN]</td>
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<tr>
<td>1</td>
<td>0.217</td>
<td>140</td>
<td>58.6</td>
<td>261</td>
<td>46.9</td>
<td>208</td>
</tr>
<tr>
<td>2</td>
<td>0.434</td>
<td>280</td>
<td>117.2</td>
<td>521</td>
<td>93.7</td>
<td>417</td>
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<tr>
<td>4</td>
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<td>234.4</td>
<td>1,043</td>
<td>187.5</td>
<td>834</td>
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<tr>
<td>5</td>
<td>1.085</td>
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<td>293.0</td>
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<td>1.302</td>
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<td>15,901</td>
<td>2,859.7</td>
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</tbody>
</table>

Aps = Area Prestressing Steel  
Fpu = Minimum Ultimate Strength

Please consult your local sales office for systems exceeding 61 strands.

### DYWIDAG DCP Strand Anchor and Wedge Plate Dimensions

<table>
<thead>
<tr>
<th>Strand Range Inside Sheathing*</th>
<th>HDPE Corrugated Sheathing Outside Diameter</th>
<th>Trumpet Pipe Outside Diameter</th>
<th>Wedge Plate Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ea]</td>
<td>Nom. Size [in]</td>
<td>[in]</td>
<td>[mm]</td>
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<tr>
<td>1-3</td>
<td>2</td>
<td>2.44</td>
<td>62</td>
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<tr>
<td>4</td>
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<td>2.5</td>
<td>2.92</td>
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<td>7</td>
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<td>91</td>
</tr>
<tr>
<td>8-9</td>
<td>3</td>
<td>3.60</td>
<td>91</td>
</tr>
<tr>
<td>10-12</td>
<td>4</td>
<td>4.60</td>
<td>117</td>
</tr>
<tr>
<td>13-15</td>
<td>4</td>
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<td>117</td>
</tr>
<tr>
<td>16-17</td>
<td>4</td>
<td>4.60</td>
<td>117</td>
</tr>
<tr>
<td>18-19</td>
<td>5</td>
<td>5.85</td>
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<tr>
<td>20-24</td>
<td>5</td>
<td>5.85</td>
<td>149</td>
</tr>
<tr>
<td>25-27</td>
<td>6</td>
<td>6.8</td>
<td>173</td>
</tr>
</tbody>
</table>

* Based on the use of a single 0.5" ID x 0.75" OD internal grout tube. Bearing plate sizes subject to project specific requirements.

Wedge Plate  
Bearing Plate  
Trumpet Pipe O.D.  
Corrugated Sheathing O.D.
## Anchor Types and Corrosion Protection

<table>
<thead>
<tr>
<th>Temporary Anchor</th>
<th>Anchor with Single Corrosion Protection (PTI-Class II)</th>
<th>Anchor with Double Corrosion Protection (PTI-Class I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Grout Protected Bond Length</td>
<td>- Grout Protected Bond Length</td>
<td>- Grout Filled Bond Length Encapsulated</td>
</tr>
<tr>
<td>- Greased &amp; PE Extruded Unbonded Length</td>
<td>- Greased &amp; PE Extruded Unbonded Length</td>
<td>- Greased &amp; PE Extruded Unbonded Length</td>
</tr>
</tbody>
</table>

### Typical Uses

**Temporary Anchor**  
Temporary Applications with a service life of ≤ 24 Month

**Anchor with Single Corrosion Protection (PTI-Class II)**  
Anchor in known non-aggressive ground (refer to PTI Recommendations)

**Anchor with Double Corrosion Protection (PTI-Class I)**  
Permanent Application where a pre-grouted sheathing is an advantage
Anchor Types and Corrosion Protection

<table>
<thead>
<tr>
<th>Anchor with Double Corrosion Protection (PTI-Class I)</th>
<th>Anchor with Epoxy Coated Strand (PTI-Class I)</th>
<th>Anchor with Epoxy Coated Strand (PTI-Class I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Grout Filled Corrugated Sheath Full Length</td>
<td>▪ Two Stage Grouted Hole</td>
<td>▪ Greased &amp; PE Extruded Unbonded Length</td>
</tr>
<tr>
<td></td>
<td>▪ Optional: Corrugated Sheathing (not shown)</td>
<td>▪ Optional: Corrugated Sheathing</td>
</tr>
</tbody>
</table>

![Diagram of Anchor Types]

**Typical Uses**
- **All Permanent Applications**
- **Large Capacity Permanent Anchors**
- **Large Capacity Permanent Anchors**
Anchor Installation, Stressing and Monitoring Equipment

Installation Equipment

Uncoiling equipment is utilized to ensure efficient and safe installation of anchors while minimizing the risk of damage to the corrosion protection system. Various manual and motorized styles of uncoilers are available for rent to meet your project specific needs.

Stressing Equipment

DSI has a large fleet of stressing equipment that enables our customers to test and lock off anchors of any size. The stressing jacks are complemented by stressing chairs, pulling heads and hydraulic pumps for safe and efficient stressing operations.

Customized equipment has been provided for many jobs with difficult access or for high capacity anchors. Our in house engineering staff is well equipped to work with you on your job specific details and requirements.

Load Monitoring Equipment

Our DYNA Force® Elasto-Magnetic Sensor allows for short and long term monitoring of anchor loads through calibrated sensors and a Power Stress Unit (read out box) that displays loads in kips with an accuracy of +/- 1 %.

Sensors can also be utilized in the bond length of the anchor to verify its performance.

Please refer to our DYNA Force® Elasto-Magnetic Sensor brochure for further technical information.
Post Grouting of Anchors

Post Grouting of anchors can significantly improve the load carrying capacity of anchors in cohesive soils by increasing the skin friction of the anchor grout body with the soil.

The primary grout body in the bond length of the anchor is fractured by introducing additional grout through a post grout line with pressures up to 1,200 PSI [8 MPa].

Post grouting of anchors that initially failed load test acceptance criterion can improve the capacity of the anchor and result in a passing subsequent test. Anchors can be installed with a single or multiple post grout lines.

Benefits of post-grouting are illustrated in the table below. This table was developed by Dr. Helmut Ostermayer of the Technical University of Munich based on actual test results.

<table>
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<tr>
<th>Soil Type</th>
<th>Bond length (ft)</th>
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<tr>
<td>Sandy silt, medium plasticity</td>
<td>Very stiff to hard with post-grouting</td>
</tr>
<tr>
<td>Silty clay light to medium plasticity</td>
<td>Very stiff with post-grouting</td>
</tr>
<tr>
<td>Clay medium plasticity</td>
<td>Stiff without post-grouting</td>
</tr>
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</tr>
</tbody>
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Skin friction (kN/m²) vs. Bond length (ft)

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Skin friction (kN/m²) vs. Bond length (ft)
References

DYWIDAG Permanent Strand Anchors

The Elephant Trunk, Hwy 1: Stabilization of a Steep Coastline Using Permanent DYWIDAG Strand Anchors, CA, USA

Owner Caltrans (California Department of Transportation), USA +++ General Contractor John Madonna Construction Co., Inc., USA +++ Subcontractor Drill Tech Drilling & Shoring Inc., USA +++ Engineering Caltrans (California Department of Transportation), USA

DSI Unit DYWIDAG-Systems International USA Inc., BU Geotechnics, USA
DSI Scope Production, supply
DYWIDAG Products 259 Type 5-0.6" and 6-0.6" permanent DYWIDAG Strand Anchors

DYWIDAG Strand Anchors Prevent Settlements at a Large Retail Center, AL, USA

General Contractor Hayward Baker, Inc., USA +++ Engineering Burns Cooley Dennis, Inc., USA

DSI Unit DYWIDAG-Systems International USA Inc., BU Geotechnics, USA
DSI Scope Production and Supply
DYWIDAG Products 80 permanent 12-0.6" DYWIDAG Strand Anchors; 6 DYNA Force® Sensors; rental of equipment
Large Scale Use of DYWIDAG Anchors: The San Gabriel Trench in California, USA

Owner Alameda Corridor-East Construction Authority (ACE), USA +++ General Contractor Walsh Construction Co., USA +++ Subcontractor Malcolm Drilling Company, Inc., USA +++ Consulting Engineers Moffat & Nichol, Pirooz Barar & Associates, Inc. (PB&A), BMA Construction Engineers, Inc., all of them USA

DSI Unit DYWIDAG-Systems International USA Inc., BU Geotechnics, USA
DSI Scope Production and Supply
DYWIDAG Products 202 temporary, 3-6 Type 0.6” strand DYWIDAG Strand Anchors, 2,206 permanent, 4-10 Type 0.6” strand, DCP DYWIDAG Strand Anchors, 433 permanent, 26mm Ø DCP DYWIDAG Bar Anchors

DYWIDAG Strand Tendons Stabilize Challenging Pier Footings for Motorway 73 in Quebec, Canada

Owner Department of Transportation Quebec, Canada +++ General Contractor Construction Couillard Ltée., Canada +++ Subcontractor Entreprises Michel Beaupied Inc (Les), Canada +++ Architect WSP Canada Inc., Canada +++ Consulting WSP Canada Inc. and Roche ltée, Groupe-conseil, both Canada

DSI Unit DYWIDAG-Systems International Canada Ltd., Eastern Division, Canada
DSI Scope Design, production, supply, engineering services, technical support, supervision
DYWIDAG Products 80 double corrosion protected Type 27-0.6” DYWIDAG Strand Anchors
The Vancouver House Project: Impressive Architecture with DYWIDAG Systems, BC, Canada

Owner Westbank Projects Corp., Canada +++ Contractor Southwest Contracting Ltd., Canada +++ Architects BIG, USA, DIALOG and James K.M. Cheng Architects Inc., both Canada +++ Consulting Engineers GeoPacific Consultants Ltd., Canada

DSI Unit DSI Canada Civil Ltd., Canada
DSI Scope Production, supply
DYWIDAG Products 1,200 Type 3-0" and 4-0" DYWIDAG Strand Anchors, 200 R51 DYWI® Drill Hollow Bar Anchors

Expansion of Lucile Packard Children’s Hospital with DYWIDAG Systems, CA, USA

Owner DPR Construction, USA +++ Subcontractor Malcolm Drilling Company, Inc., USA +++ Architect Hammel, Green and Abrahamson, Inc., USA +++ Engineering Degenkolb Engineers, USA

DSI Unit DYWIDAG-Systems International USA Inc., BU Geotechnics, USA
DSI Scope Production, supply
DYWIDAG Products 282 temporary DYWIDAG Strand Anchors with 4 to 7 strands, 230 temporary DYWIDAG THREADBAR® Anchors, stressing and coiling equipment
DYWIDAG Tiedown Restressable Strand Anchors

Permanent DYWIDAG Strand Anchors for Changuinola Dam, Panama

Owner AES Changuinola S.A., Panama +++ General Contractor Changuinola Civil Works Joint Venture CCWJV, consisting of: E. Pihl & Son A.S. and MT Højgaard A/S, both Denmark; Alstom GmbH, Germany +++ Anchor Designer MD & G Engineers, South Africa

DSI Unit DYWIDAG-Systems International USA Inc., BU Geotechnics, USA
DSI Services Production, Supply and Technical Support
DSI Products supplied 43, restressable, double corrosion protected (DCP) 12-0.6“ DYWIDAG Strand Anchors; 48, DYNA Force® Sensors; equipment

Strengthening of Roanoke Rapids Dam Using DYWIDAG Strand Anchors and DYNA Force® Sensors, NC, USA

Owner Dominion North Carolina Power, USA +++ General Contractor Brayman Construction Corporation, USA +++ Engineers HDR/DTA, Inc., USA

DSI Unit DYWIDAG-Systems International USA Inc., BU Geotechnics, USA
DSI Scope Production and Supply
DYWIDAG Products restressable, epoxy coated 30-0.6“ DYWIDAG Strand Anchors; 15 DYNA Force® Sensors
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