Helical Design Theory
and Applications

By
Darin Willis, P.E.
Ram Jack utilizes two unique underpinning & anchoring systems

- Hydraulically driven piles (pressed)
- Helical piles (torqued)
Helical Pier / Anchor System

The Superior Ram Jack® Helical Anchor System

- Hydraulic Motor
- Gear Box
- Torque Bar Adapter
- Anchor Interface
- Helical Extension
- Ram Jack Patented Screw-Together Connection
- Helical Lead Section
- Ram Jack Patented Screw-Together Connection
- Helical Plate

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Helical Applications

New Construction

Basement / Retaining Wall Tieback

Slab Pier

Remedial Underpinning
Helical Slab Pile Installation
Ram Jack’s thermoplastic coating powder prevent rust & zinc from leaching into the ground water. Making it ideal for environmentally sensitive areas.
Benefits:
✓ - 5 to 200 kip ultimate capacity range
✓ - Can be used in tension or compression
✓ - Does not require structure for reaction resistance
✓ - No drilling spoils during installation
✓ - No vibration during installation
✓ - Adaptable to almost any foundation
✓ - No welding in the field
✓ - Fast, efficient installation in any weather
1st recorded use of helical piers was by Alexander Mitchell in 1836 for Moorings and was then used by Mitchell in 1838 to support Maplin Sands Lighthouse in England.

In the 1840’s and 50’s, more than 100 helical foundation lighthouses were constructed along the East Coast, Florida Coast & the Gulf of Mexico.

Through advancements in installation equipment, geometries & research, helical foundations are now used throughout the world.
Helical Theory & Design
Design Considerations

• Pile capacity
  – Individual bearing method
  – Torque correlation
• Lateral resistance
• Spacing
• Unbraced length of pile
Individual Bearing Method

- Total capacity is the sum of the bearing resistance of each helix
- Capacity due to friction along shaft is generally assumed negligible and normally omitted

*Terzaghi Bearing Equation

\[ Q_u = A_h q_u = \sum A_h (c N_c + q_v N_q) \]

- \( A_h \) = helix plate area
- \( c \) = soil cohesion
- \( q_v \) = overburden stress
- \( N_c \) & \( N_v \) = Meyerhof bearing factors
Torque Correlation Method

The torque required to install a pier or anchor is empirically and theoretically related to ultimate capacity:

\[ Q_{ult} = K_t (T) \]

- \( T \) = torque [ft-lb]
- *\( K_t \) = helix torque factor [ft-1]
  - default value = 10 for 2 3/8” diameter
  - default value = 9 for 2 7/8” diameter
  - default value = 8 for 3 1/2” diameter
  - default value = 7 for 4 1/2” diameter

*\( K_t \) ranges from 3 to 20 – Recommended default values are listed but can only be accurately determined from a load test.
Field Testing

Pile Load Tests

Can Test Tension or Compression

Achieving Engineered Results
Lateral Loads

Basic Considerations

- Wind
- Seismic ground motion
- Soil (creep or slope failure)
- Hydrostatic
Lateral Loads

Resisting Elements

- Lateral Load
- Axial Load
- Passive Earth Pressure Resistance
- Optional Lateral Tieback
- Optional Increase Shaft Ø
Battered Piers

Axial Load

Lateral Load

Pile Cap
Pier Spacing

Group Effect

• Piers spaced to close together have to use the same soil in their zones of influence.

• Piers are recommended to be spaced 5 times the largest diameter helix or 5’-0.

• The minimum spacing should be at least 3’-0.
Pier Spacing

Group Effect

5D or 5 ft. Recommended
3 ft. Minimum

D

5D or 5 ft. Recommended
3 ft. Minimum
Shaft Strength Perimeters

International Building Code (IBC)

– Braced piers or piles (Section 1808.2.5)
– Unbraced piers or piles (Section 1808.2.9.2)
Shaft Strength Perimeters

Braced Piers or Piles

(IBC Section 1808.2.5)

1) Three or more piles connected to a rigid cap…
2) Single row of piles for one and two story homes (light construction) provided center of piles are located within the width of the foundation wall.
3) Top of piers embedded min. of 3” into cap/footing and at least 4” from edges of cap/footing.
Braced Pile Examples

PLAN VIEW

HELI CAL PILES

PILE CAP

10" MIN.

3" MIN.

3/8" SAE GRADE 8 BOLT(3)
Shaft Strength Perimeters

Unbraced Piers or Piles
	(IBC Section 1808.2.9.2)

1) Piles in air, water or in fluid soil shall be designed as columns.
2) Piles not laterally braced & driven in firm soil (N ≥ 5). Designed with 5’-0 unbraced length
3) Piles not laterally braced & driven in soft soil (N < 5). Designed with 10’-0 unbraced length
Acceptance Criteria for Helical Foundation Systems (AC 358)

- Approved June 5, 2007
- Sets industry standard
- Higher quality & reliability
- Requires extensive testing
- ESR should be completed by late 2008
Foundation Solutions™
Helical Design Software

Foundation Solutions™

- Provides easy helical design solution for:
  - Piles {underpinning, new construction & slab}
  - Anchors {tieback & guy}
- Based on “Individual Bearing Method”
- User friendly & flexible design software
- Provides design confidence
- Downloadable free to Design Engineers
Additional Benefits of Foundation Solutions™

- Allows input for various helix diameters & configurations
- Allows input on various shaft sizes based on required loading
- Capacities are based on strength of materials and soil with the lesser controlling
- Estimates both pier & anchor embedment lengths
- Provides both tabular & graphical output
Helix Sequence Reference
## Ram Jack
### Standard Helix Configurations

<table>
<thead>
<tr>
<th>Shaft Diameter</th>
<th>Shaft Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2'-0</td>
</tr>
<tr>
<td>2 3/8&quot;</td>
<td>8&quot;</td>
</tr>
<tr>
<td>2 7/8&quot;</td>
<td>10&quot;</td>
</tr>
<tr>
<td>3 1/2&quot;</td>
<td>10&quot;-12&quot;</td>
</tr>
</tbody>
</table>

**NOTE:** Standard thickness is 3/8" for 8", 10" & 12" helices and 1/2" for 14" and 16" helices. All other configurations or plate thicknesses are considered custom orders. Please allow 4 to 8 weeks for delivery of custom orders.
Helical Profile - Example

#### Helical View

**Key**
- Backslope Profile
- Anchor
- Soil Stratum
- Phreatic Surface

**Stratum Information**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Start Depth</td>
<td></td>
</tr>
<tr>
<td>Cohesion</td>
<td></td>
</tr>
<tr>
<td>Adhesion Coefficient</td>
<td></td>
</tr>
<tr>
<td>Internal Friction</td>
<td></td>
</tr>
<tr>
<td>External Friction</td>
<td></td>
</tr>
<tr>
<td>Moist Unit Weight</td>
<td></td>
</tr>
<tr>
<td>Saturated Unit Weight</td>
<td></td>
</tr>
<tr>
<td>Torque Factor</td>
<td></td>
</tr>
</tbody>
</table>

**Hint:** Click within the graph to view the stratum information.
### Tabular View

<table>
<thead>
<tr>
<th>Job Type</th>
<th>Lead Shaft OD (inches)</th>
<th>Extension Shaft OD (inches)</th>
<th>Lead Shaft Size (ft)</th>
<th>Helix Configuration (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Construction Pier</td>
<td>2.075</td>
<td>2.075</td>
<td>7</td>
<td>10*3/0 - 12*3/0 - 14*1/2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Embedment (ft)</th>
<th>Ultimate Anchor Capacity (lbs)</th>
<th>Torsional Resistance (lb-ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>21786</td>
<td>2983</td>
</tr>
<tr>
<td>9</td>
<td>22284</td>
<td>2968</td>
</tr>
<tr>
<td>10</td>
<td>22259</td>
<td>2943</td>
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<tr>
<td>11</td>
<td>22477</td>
<td>2966</td>
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<tr>
<td>12</td>
<td>22703</td>
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<tr>
<td>25</td>
<td>80460</td>
<td>7579</td>
</tr>
</tbody>
</table>

Note: Ultimate capacity is the estimated maximum load that can be applied to the anchor in a strain-controlled test. An appropriate factor of safety (ASC) or resistance factor (LATD) must be applied by the user. A factor of safety of 2.0 is commonly used, but both higher and lower values have been found appropriate for specific jobs.
Excess to:

- Design software
- Drawings
  - AutoCAD
  - PDF
- Specifications
- Product Catalog
The patented Ram Jack System has proven so effective it is now available as an authorized dealership repair system, throughout the U.S. and across the globe.
Ram Jack Engineers Resource Center

Downloads

- **Design Software**
  - Ram Jack Foundation Solutions

- **Product Drawings**
  - Helical Piles and Anchors
  - Helical Brackets and Assemblies
  - Hydraulically Driven Piles
  - Hydraulically Driven Pile Brackets

- **System Specifications**
  - Helical Piles
  - Hydraulically Driven Piles

- **Engineering Manual / Product Catalog**
  - 2008

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How to download a file:

Internet Explorer Users

Right click the file, and select "Save Target As".
Ram Jack Manufacturing Plant

Ada, OK

Ram Jack established in 1968

Currently 48 Dealers – United States, Canada, Panama & Costa Rica
Ram Jack Headquarters

State of the Art Manufacturing Plant

Computer controlled plasma cutting tables

All products powder coated

Robotic welding
Research and Development

Product Development

State of the Art Manufacturing

Product Testing
Interesting Jobs
• 221 piers required on addition
• 150 kip ultimate capacity
• Required 4 1/2” diameter shaft with a 8”-10”-12” helix configuration
• Minimum 20,500 ft-lb installation torque
Project was behind schedule due to site prep work and relocating a 24” diameter storm drain.

Ram Jack’s coordination effort was able to get the project back on track by installing 30 to 35 piers per day.
• New cafeteria addition
• Required 13’-0 excavation adjacent to existing bldg
• Loads
  – Column : 25 to 45 kips
  – Wall : 1.8 kips/ft
Repair Design

• The original design was modified replacing the underpinning piers with driven piers.

• Driven piers were 2 7/8” dia. driven through a 16’-0 long 3 ½” dia. guide sleeve that would extend beyond the 13’-0 excavation.

• Piers were driven approx. 40’-0
Single 16’0 guide sleeve installation
Three layers of pier tiebacks were installed to provide lateral bracing.

Once a layer of tiebacks were installed the site was excavated 5’-0
Union County Vo-Tech
Scotch Plains, New Jersey

A reinforced 6” thick shotcrete wall was installed at each excavation layer.
Union County Vo-Tech
Scotch Plains, New Jersey

Completion of underpinning and basement wall
• Installing 25’-0 deep pit adjacent to building column
• Column load 133 kips
• Water table 12’-0 below finished floor
• Pit collapsed on original contractor undermining the building column
• Steel beam was install beneath grade beam.
• Excavation was performed in 5’-0 stages as tiebacks and shotcrete wall was installed.
• Constant dewatering was required due to high water table.
• (6) 2 7/8” diameter piles installed to 60 kips
• 30’-0 guide sleeves were used
• Owner’s concrete pit and permanent dewatering system was installed
North Texas Municipal Water District

- A 65” water main break undermined a 120 ton metering box
- The metering box had settled 4 $\frac{3}{4}$”
- (27) 3 ½” diameter driven piers were required
North Texas Municipal Water District

- Ram Jack was the only reliable system that could work within the tight quarters
- Piers were driven an average of 39'-0
• Full elevation recovery was achieved
The End.

Questions?