HELICAL ANCHORS & FOUNDATIONS

Presented by: Josh Lindberg
Helical Concepts, Inc.
Distributor
CHANCE Civil Construction
Presentation Preview

- Historical Perspective
- Product Overview
- Determination of Capacity
- Applications
- Installation Methods and Equipment
Historical Perspective

- 1st Recorded use of a Screw Pile was by Alexander Mitchell in 1836 for Moorings and was then applied by Mitchell to Maplin Sands Lighthouse in England in 1838.

- In 1843, the 1st Screw Pile Light House in the U.S. was Constructed by Capt. William H. Swift at Black Rock Harbor in Connecticut. Swift used Mitchell Screw Pile Technology.

- In the 1840’s and ’50’s, More Than 100 Screw Pile Foundation Light Houses were Constructed Along the East Coast, the Florida Coast and the Gulf of Mexico.
Manual Installation

Limited Applications
Mitchell Lighthouse at Hooper’s Strait, Maryland

Extracted Cast Iron Screw Pile, \( \approx 30'' \) Diameter
Mitchell Screw Pile 1835
A. B. Chance

Historically an Anchor Company

Since 1912
Centralia, MO - 1912
Never Creep Anchor
Early Anchor Pull Test with Office Staff
CHANCE® Civil Construction Products

- Atlas Resistance® Piers
- CHANCE® Helical Anchors
- CHANCE® Helical Piles
APPLICATIONS

- Guy Anchors & Foundations for Towers
- Helical Piles for New Construction
- Underpinning - Residential / Commercial
- Tiebacks for Excavation Bracing
- Soil Screws for Earth Retention
- Slope Stabilization
- Seismic Retro-fit
- Tie-Downs
BUILDING CODE EVALUATION REPORTS

- ICC-ES Legacy Report - 9504B
- ICC-ES Legacy Report - 94-27
- ICC-ES Legacy Report - ER5110
- ICC-ES Acceptance Criteria for Helical Foundation Systems and Devices
What is a helical pier?

A device used to attach or support a load at or near the surface of the earth.

Consists of Three Parts:

- **Termination:** Transfers applied load to the shaft
  (Repair Brackets, Guy Adapters, Shackles, etc.)

- **Shaft, or Rod:** Transfers load to bearing element
  (Square Shaft or Round Pipe)

- **Bearing Element:** Transfers applied load to soil
  (Helix or Starter Section for Resistance Pier)
Square Shaft
Helical Piers

Lead Section
Helical Extension
Extension
Importance of Helix Shape
Side View of True Helix Form

Helix formed by matching metal die so that soil disturbance is minimized.
Standard Helix Diameters

- 6-inch
- 8-inch
- 10-inch
- 12-inch
- 14-inch
- 16-inch
There are two rows of numbers and letters stamped on the shaft.

**Lead Section Example:**
(stamped under drilled hole)
- C403
- N382

**Extension Example:**
(stamped on one side)
- C403
(stamped at 90° to first side)
- N382

<table>
<thead>
<tr>
<th>Material Code</th>
<th>Product</th>
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<tbody>
<tr>
<td>C4</td>
<td>TT64</td>
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<tr>
<td>C6</td>
<td>TT76</td>
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<tr>
<td></td>
<td>SS5, SS150, SS175, SS200, SS225</td>
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CHANCE is ISO 9001 Certified

Anchor Type
Date of Manufacture
Steel Supplier Heat Run
CHANCE® Helical Anchor Shaft Torsion & Tension Ratings

SS125
4,000 ft-lb
60 kip

SS1375
5,500 ft-lb
75 kip

SS5
5,500 ft-lb
70 kip

SS150
7,000 ft-lb
70 kip

SS175
11,000 ft-lb
100 kip

SS200
16,000 ft-lb
150 kip

SS225
23,000 ft-lb
200 kip
Square Shaft Couplings
Square Shaft Tension Terminations

- Thimbleye Adapter
- Twineye Adapter
- Tripleye Adapter
- Oval Eye Adapter
- Threaded Adapter
- Chain Shackle
- Tripleye Chain Shackle
Round Shaft Sizes

RS2875.165
4,500 ft-lb
50 kip

RS2875.203
5,500 ft-lb
60 kip

RS2875.262
7,500 ft-lb
100 kip

RS3500.300
13,000 ft-lb
120 kip

RS4500.337
23,000 ft-lb
140 kip
Helical Pipe Shaft Couplings
SS to Pipe Shaft

1-1/2 SS to 2-7/8 Pipe
1-3/4 SS to HS (3.5 O.D. x 0.300 Wall)
2 SS to HS
2-1/4 to 4.5 O.D (Atlas)
8” Pipe Shaft to 2” Square Shaft with 3 Helixes
21’ - 8” Pipe Shaft

7’ - SS200 2” Sq. Shaft with Three Helices
Large Diameter Pipe Piles
Large Diameter Pipe Piles

Box Coupling

Lead Section
Remedial Repair Bracket Terminations

[Diagram of bracket terminations]
Determining Capacity
Helical Anchor/Foundation In soil

Soil Borings/Calculations
Torque Correlation
Load Test
Bearing Capacity Equation

$$Q_h = A_h (N_c \ c + q \ N_q) \leq Q_s$$

where:
- $Q_h$ = individual helix bearing capacity
- $A_h$ = projected helix area
- $c$ = cohesion
- $q$ = effective overburden pressure
- $N_q$ = bearing capacity factor
- $Q_s$ = limit determined by strength of helix
Plate Bearing Capacity Model

\[ Q_{ULT} = \sum Q_H \]

- Shaft Friction = 0
- \( H1 = 5D \) (minimum)
- Helix Spacing = 3D

SOIL SURFACE

HELIx SPACING > 3-4 DIAMETER
Engineering software for the way you work.

HeliCAP®
Helical Capacity Design Software

Theoretical Bearing Capacity Based on Soil Strength
Available from A. B. Chance Civil Construction Web Site - www.abchance.com
HeliCAP cannot account for all design parameters required to select the most efficient anchor. This option is only a guide. For more accurate information, contact your local distributor/dealer.
INSTALLATION TORQUE CORRELATION TO CAPACITY
The Torque Required to Install a Helical Pile or Anchor is Empirically Related to Its Ultimate Capacity.

\[ Q_{ult} = K_t T \]

- **Where:**
  - \( Q_{ult} = \) Ultimate Capacity \([\text{lb (kN)}]\)
  - \( K_t = \) Empirical Torque Factor \([\text{ft-1 (m-1)}]\)
    - “Default” Value = 10 (33) for Type “SS”
    - “Default” Value = 8 (26) for 2-7/8” Pipe Shaft
    - “Default” Value = 7 (23) for 3-1/2” Pipe Shaft
  - \( T = \) Installation Torque, \([\text{ft-lb (kN-m)}]\)
RELIABILITY OF TORQUE/CAPACITY MODEL

- **Uplift Capacity of Helical Anchors in Soil [Hoyt & Clemence 1989]**
  - Analyzed 91 Load Tests
  - 24 Different Test Sites
  - Sand, Silt, and Clay Soils Represented
  - Calculated Capacity Ratio \( \frac{Q_{act}}{Q_{calc}} \)
  - Three Different Load Capacity Models
    - Cylindrical Shear
    - Individual Bearing
    - Torque Correlation

- Torque Correlation Method Yields More Consistent Results than Soil Borings or Calculation

- Best Suited for On-Site Production Control and Termination Criteria
TORQUE INDICATORS

- Measuring Installation Torque
  - Shaft Twist
    - Visible Indication of Torque (Square Shaft)
  - Shear Pin Torque Limiter
    - Point-Wise Indicator
    - Simple Design, Easy to Use
  - Mechanical Dial Indicator
    - Continuous Reading Indicator
    - Never Needs Re-calibration
  - Differential Pressure Indicator
    - Continuous Reading Indicator
    - No Moving Parts
  - In-Line Hydraulic Pressure Gauge
    - Simplest, Lowest Cost, Easy to Use
    - Continuous Reading Indicator
    - Least Accurate
Acceptable Shaft Twist
Unacceptable Shaft Twist
Torque Indicators

Shear Pin Torque Limiter
Dial Torque Indicator
Differential Pressure Indicator
LOAD TESTING TO VERIFY CAPACITY
Compression Load Test Set-Up

- Reaction Anchor
- Load Beam
- Spreader Beam
- Hydraulic Jack
Sample Load-Deflection Curve of Compression Test

DESIGN LOAD = $\frac{P_{\text{ULT}}}{2}$

0.08 times the Diameter

MECHANICAL RATING OF SCREW PILE/ANCHOR

LOAD +

DEFLECTION +

UNLOAD
Corrosion

- Consideration for Permanent Structures
- “… The data indicate that undisturbed soils are so deficient in oxygen at levels a few feet below ground line or below the water table zone, that steel pilings are not appreciably affected by corrosion, regardless of the soil types or the soil properties.” – from National Bureau of Standards Monograph 127 by Romanoff
- Screw Anchor Components are Hot Dip Galvanized per ASTM A153 or A123.
  - Galvanizing will add between 5% and 20% to the life of the anchor.
- Metal Loss Rates in Disturbed Soils Based on Field Tests Conducted by National Bureau of Standards.
  - CHANCE Bulletin 01-9204 contains metal loss rate data.
- Nillson Resistivity Meters Available from Atlas Systems
Installation Equipment

Torque Motors
3,500 ft-lb
6,000 ft-lb
12,000 ft-lb
20,000 ft-lb
… OR, FAR AWAY!
PORTABLE INSTALLATION FOR TIGHT ACCESS
Applications
Tension Anchors
Helical Tiebacks

H-Pile soldier beams with sheet pile or timber lagging (stiff structural facing)

Waler

Design depends on passive resistance of soil at toe.

Assumed Failure Surface

5' min.

High Capacity Tensioned Anchor

45+ø/2

1.2 to 2.0H (typ.)

Tieback Wall
SOIL SCREW Retention Wall System

Key Components:
- Concrete Drainage Swale
- Shotcrete
- Welded Wire Mesh
- Screw Anchor
- Drainage Medium
- Weep hole
- Finish Grade
- Drain Gate
SOIL NAIL Installation Sequence

Step 1 - Excavate top bench.

Step 2 - Install upper tier of soil screws.

Step 3 - Install drainage strips, reinforcing steel and anchor plates, and apply initial shotcrete layer.

Step 4 - Continue steps 1 through 3 to bottom of wall.

Step 5 - Apply final wall facing.
Soil Screw® Retention Wall System
Guy Anchors for Telecommm Towers
Pipeline Buoyancy Control
Synthetic Band System
Helical New Construction - Vertical and Diagonal for Hillside Application
Compression Anchors

- Residential/Commercial Underpinning
- New Construction
- Helical Pulldown Micro Piles
- Large Capacity Pipe Piles
HELICAL PIER Foundation Systems
Remedial Repair
New Construction Bracket

C150 0458 for 1 ½” Square Shaft 40,000 lb design load
C150 0459 for 1 ¾” Square Shaft 60,000 lb design load
New Construction - Slabs and Foundations

Helical Piles Supporting Structural Slab

Access Limitations on Industrial Site
Boardwalk
Walkways for Wetlands
HELICAL PULLDOWN® Micropile
Maximum side resistance (friction) is mobilized after downward displacement of from 0.5 to greater than 3 percent of the shaft (grout column) diameter, with a mean of approximately 2 percent [Reese, Wright (1977)].

This side resistance or friction continues almost equal to the ultimate value during further settlement. No significant difference is found between cohesive and cohesionless soil except that further strain in clay sometimes results in a decrease in shaft resistance to a residual value. In contrast, the point (end bearing) resistance develops slowly with increasing load and does not reach a maximum until settlements have reached on the order of 10 percent of the diameter of the base (largest helix) [Terzaghi, Peck (1948)].
Design Advantages

Buckling Resistance
- Soft/Loose soils overlying competent bearing strata

Mobilization of Skin Friction
- Total capacity a function of skin friction and end bearing

Additional Corrosion Protection
- Microsil grouts
- Optional casing

Enhanced Load/Deflection Response
- Increases shaft stiffness
- Stiffens load/deflection response
TOTAL CAPACITY

\[ Q_t = Q_h + Q_f \]

where:

- \( Q_t \) = Ultimate Static Resistance of the Screw Pile

**End-Bearing Pile**

- Majority of Capacity Developed in End-Bearing

**Friction Pile**

- Majority of Capacity Developed in Skin Friction

**Composite Pile**

- Significant Capacity in Both End-Bearing and Skin Friction
GENERAL FRICTION CAPACITY
EQUATION

\[ Q_f = \sum [\pi D \ f_s \ \Delta L_f] \]

where:

- \( D \) = Diameter of Grouted Pile Column
- \( f_s \) = Sum of Friction and Adhesion between Soil and Pile (force/area)
- \( \Delta L_f \) = Incremental pile length over which \( \pi D \) and \( f_s \) are taken as constant
New Construction – HPM
Tasker Homes
Philadelphia, PA
554 Residential Units
18 City Blocks
44 Acre Site
Grade Beam & Helical Pier Detail

3645 Helical Piers Installed
Design Load: 40 Ton (80 Ton Ultimate)
Preproduction Load Tests: 8
Depth: 15 to 60 feet
Production: 20 to 60 Piers/Day/Machine
Soil: Urban Fill underlain by Sand & Gravel
Typical Plan View
Residential Dwelling Unit

20 Feet (6 m)

36 Feet (11 m)
Incorporate Tolerance for Installation Location

- ± 3 inches Within Tolerance (3631 Places or 99.6 %)
- ± 3 to 9 inches Out of Tolerance (14 Places or 0.4 %)
- > 9 inches Out of Tolerance (0 Places)
HELICAL PULLDOWN® Micropile
Structural Slab Upgrade