Helical Design Theory and Applications

By

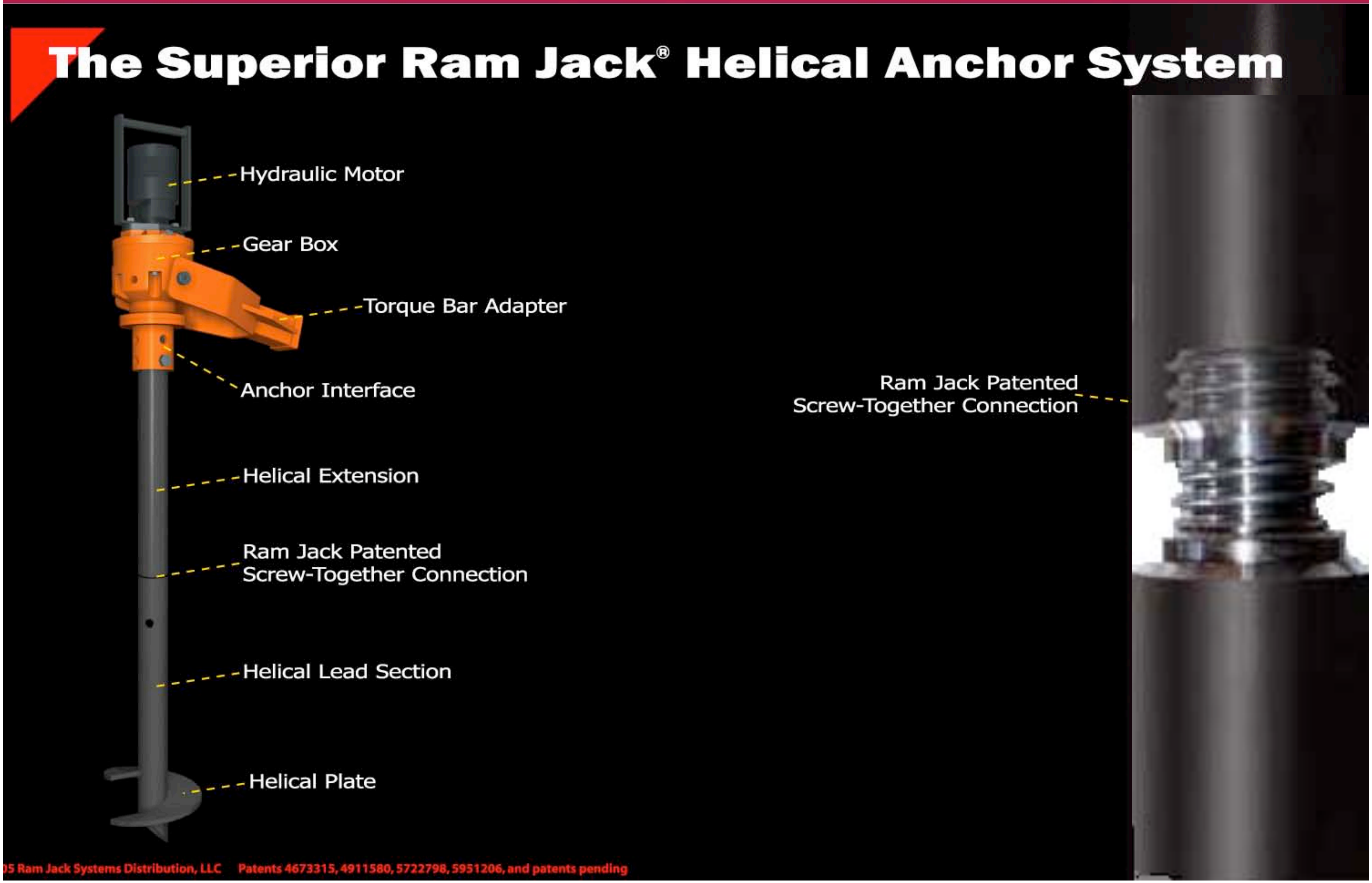
Darin Willis, P.E.

Solution Systems

Ram Jack utilizes two unique underpinning & anchoring systems

- Hydraulically driven piles (pressed)
- Helical piles (torqued)

Helical Pier / Anchor System



Helical Pier / Anchor System

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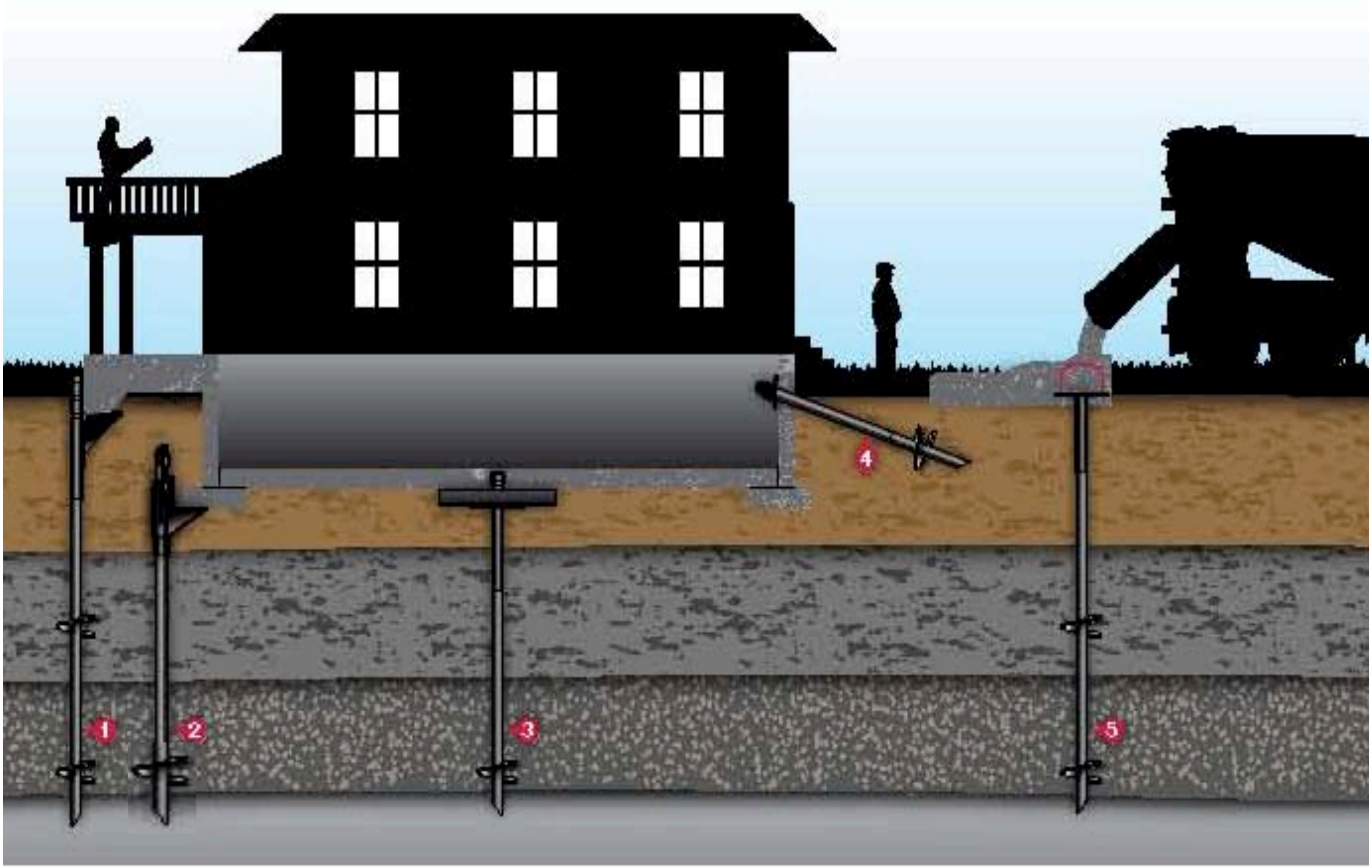

Helical Applications

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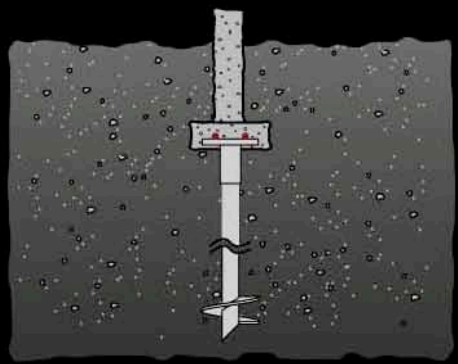
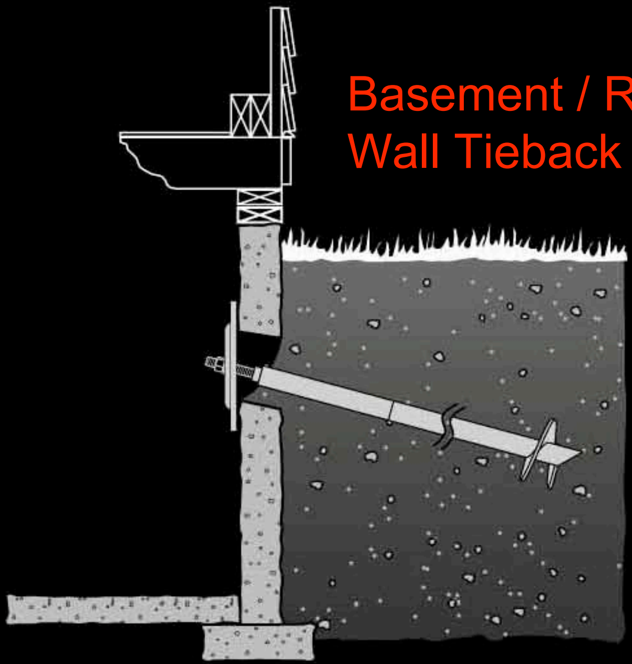
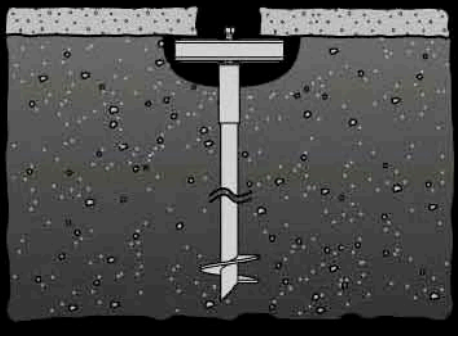
New Construction



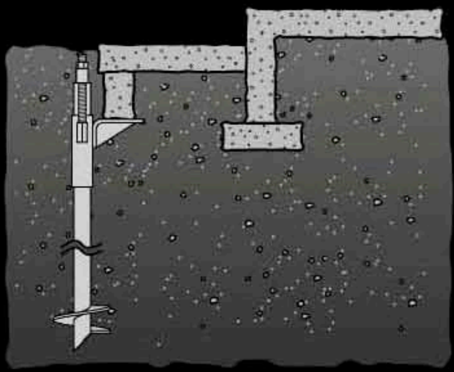
Basement / Retaining Wall Tieback



Slab Pier



Remedial Underpinning



Helical Slab Pile Installation

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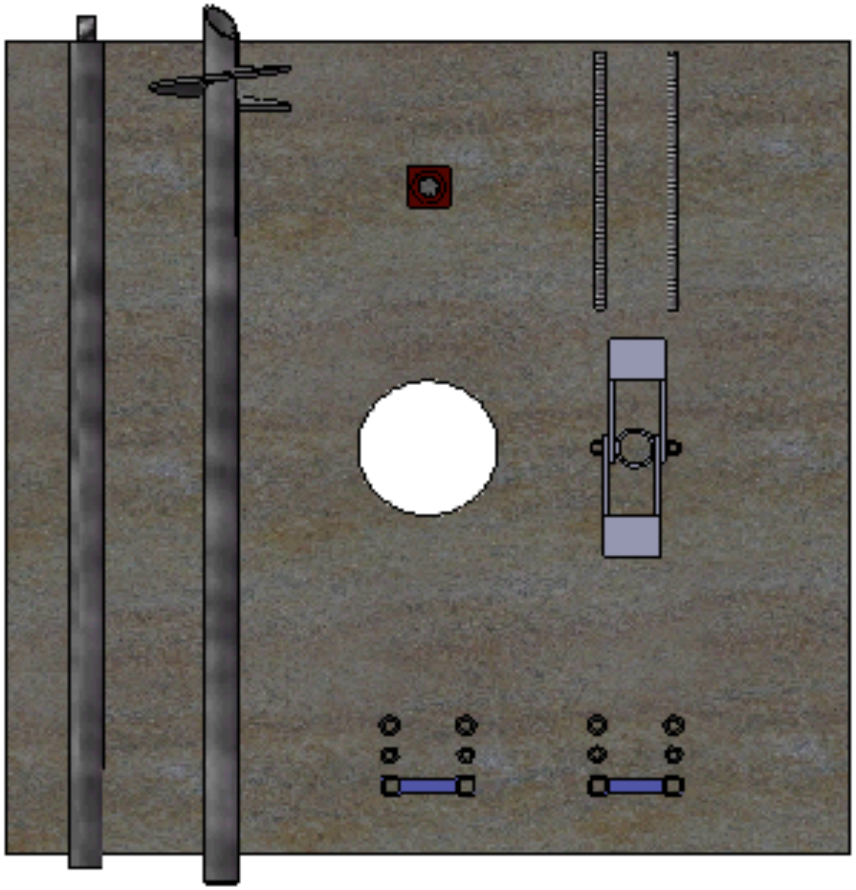

Additional Helix Applications

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- ✓Boardwalks
- ✓Pedestrian Bridges
- ✓Tower / Guy Anchors
- ✓Light Poles
- ✓Sign Supports
- ✓Pipelines
- ✓Beach Front Properties
- ✓Bulkheads

… Endless Applications …

Ram Jack's thermoplastic coating powder prevent rust & zinc from leaching into the ground water. Making it ideal for environmentally sensitive areas.

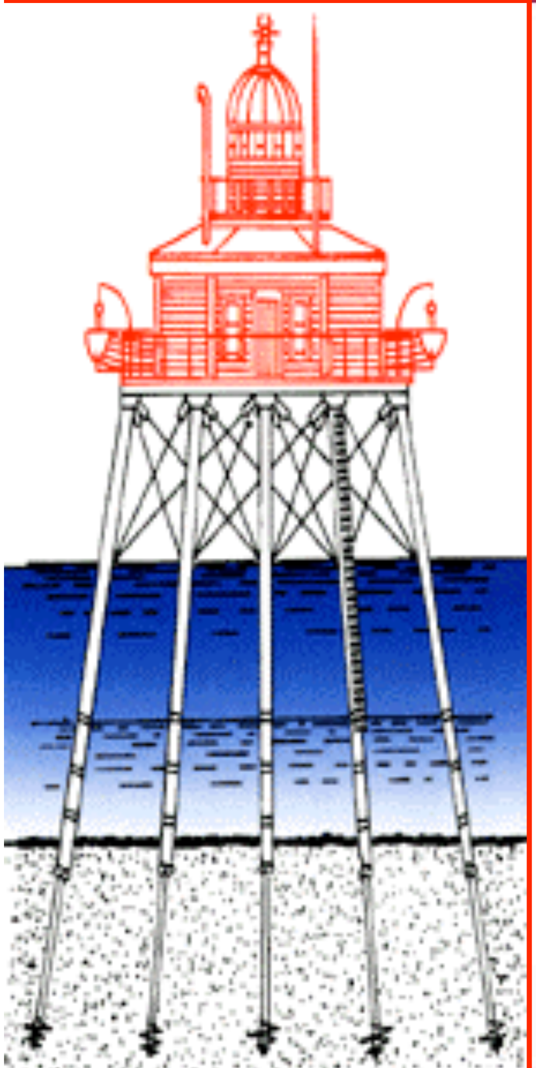
Helical Pile / Anchor System

RAM JACK FOUNDATION SOLUTIONS

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

Helix Historical Perspective



- 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

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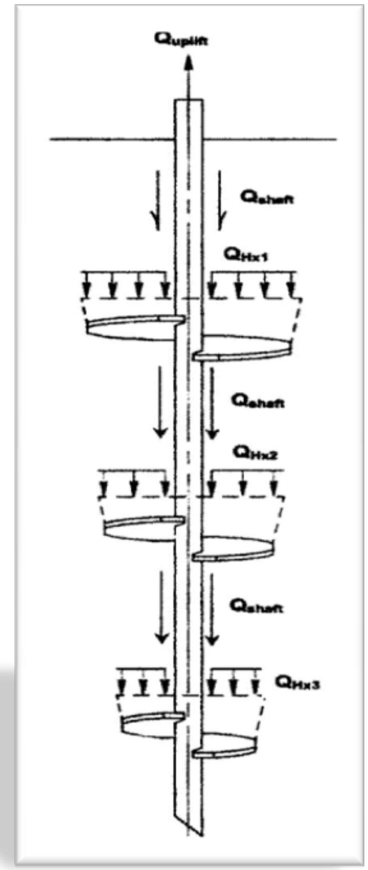
- Total capacity is the sum of the bearing resistance of each helix
- Capacity due to friction along shaft is generally assumed negligible and normally omitted



*Terzaghi Bearing Equation

$$Q_u = A_h q_u = \sum A_h (cN_c + q_v N_q)$$

A_h = helix plate area
c = soil cohesion
q_v = overburden stress
N_c & N_v = Meyerhof bearing factors

Torque Correlation Method

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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

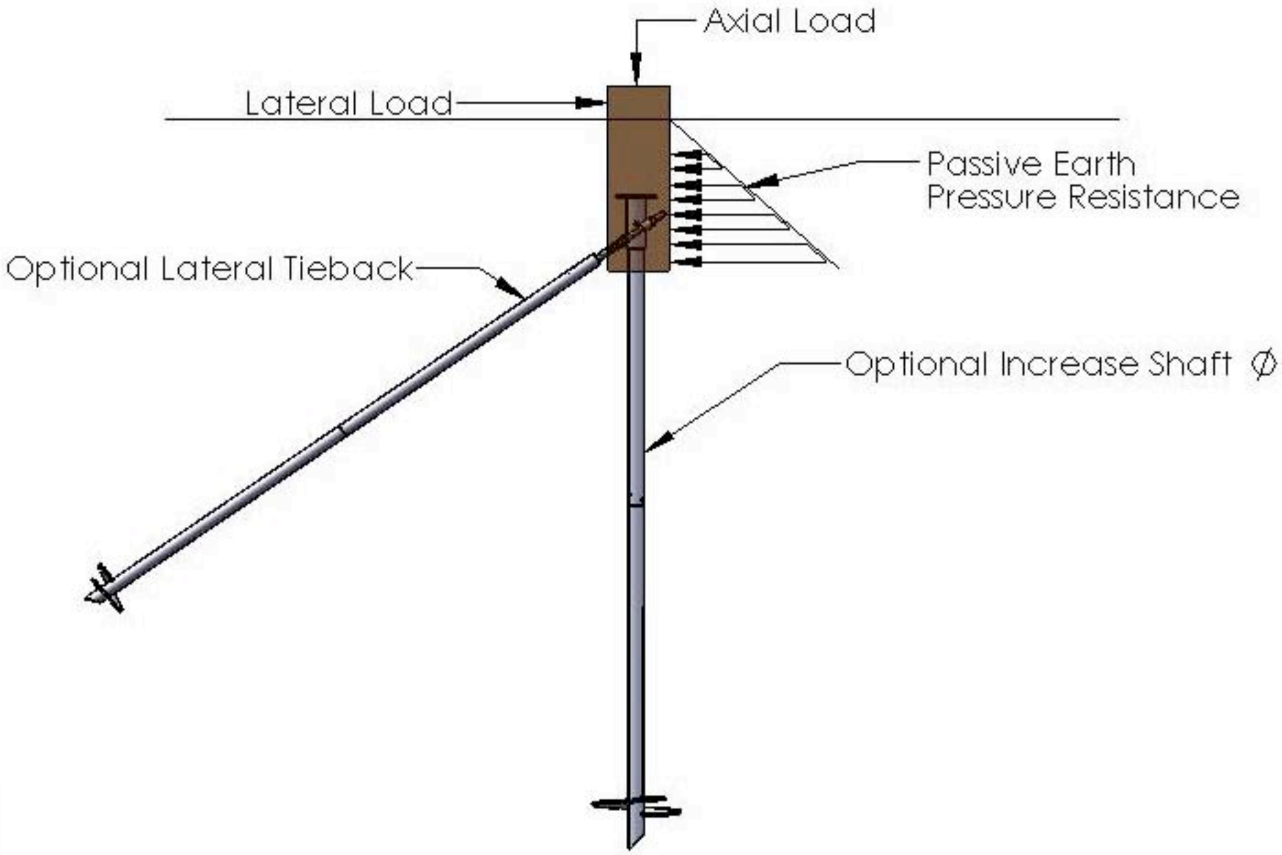
Can Test Tension or Compression

Achieving Engineered Results

Basic Considerations

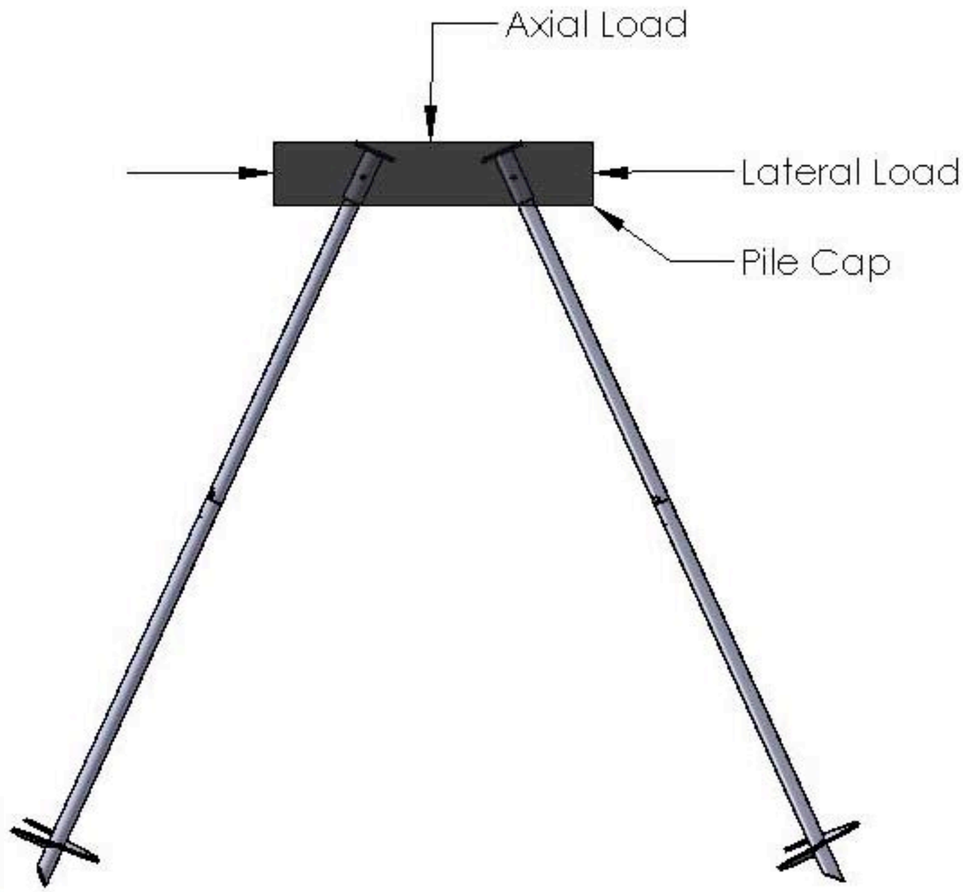
- Wind
- Seismic ground motion
- Soil (creep or slope failure)
- Hydrostatic

Resisting Elements



Lateral Loads

Battered Piers



Pier Spacing

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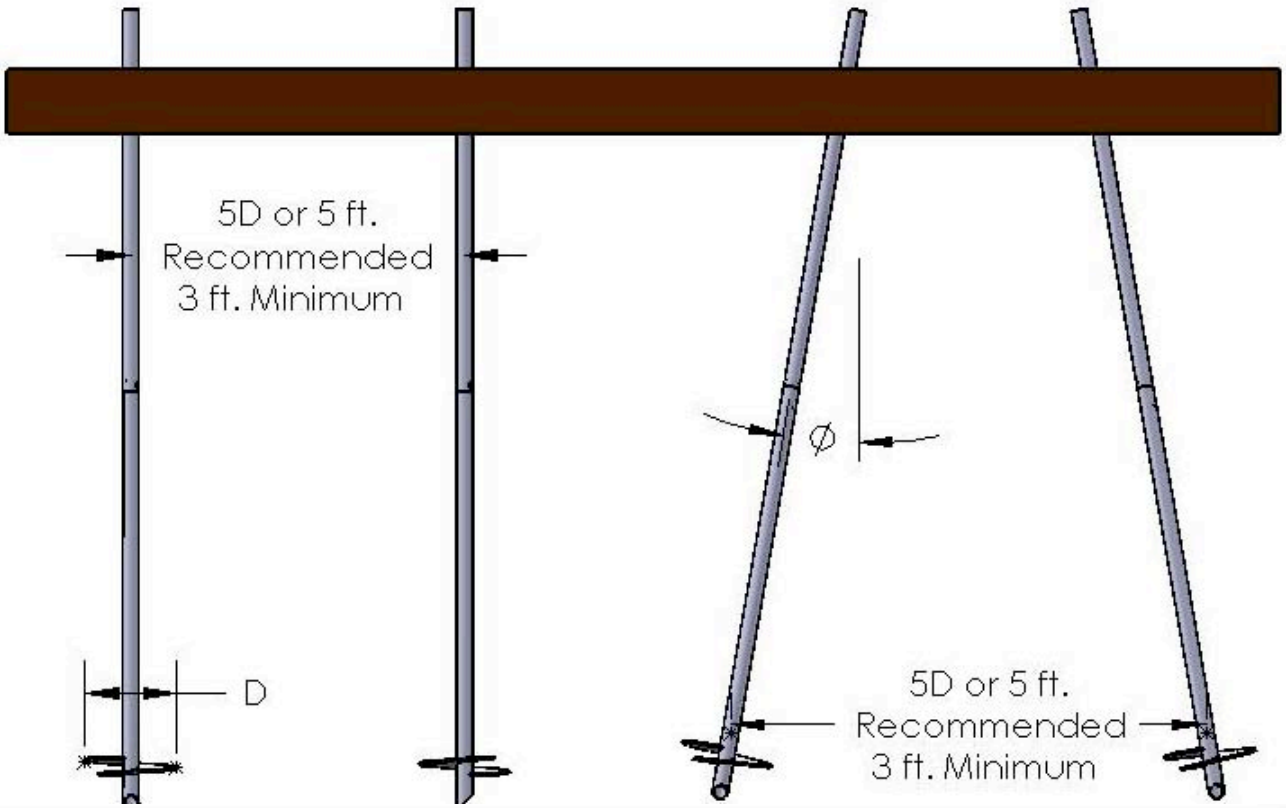
Group Effect

- 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.

Group Effect



Shaft Strength Perimeters

International Building Code (IBC)

- Braced piers or piles (Section 1808.2.5)
- Unbraced piers or piles (Section 1808.2.9.2)

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

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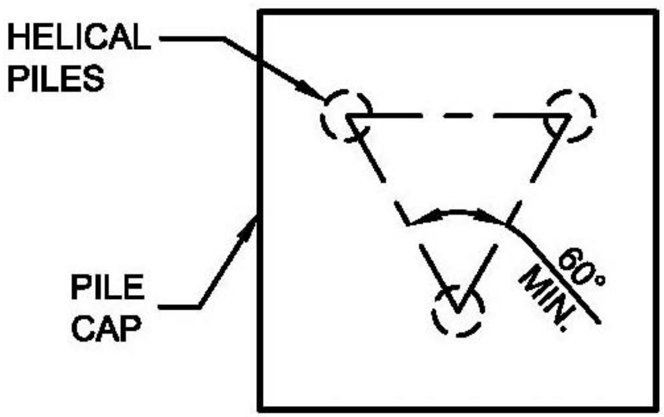
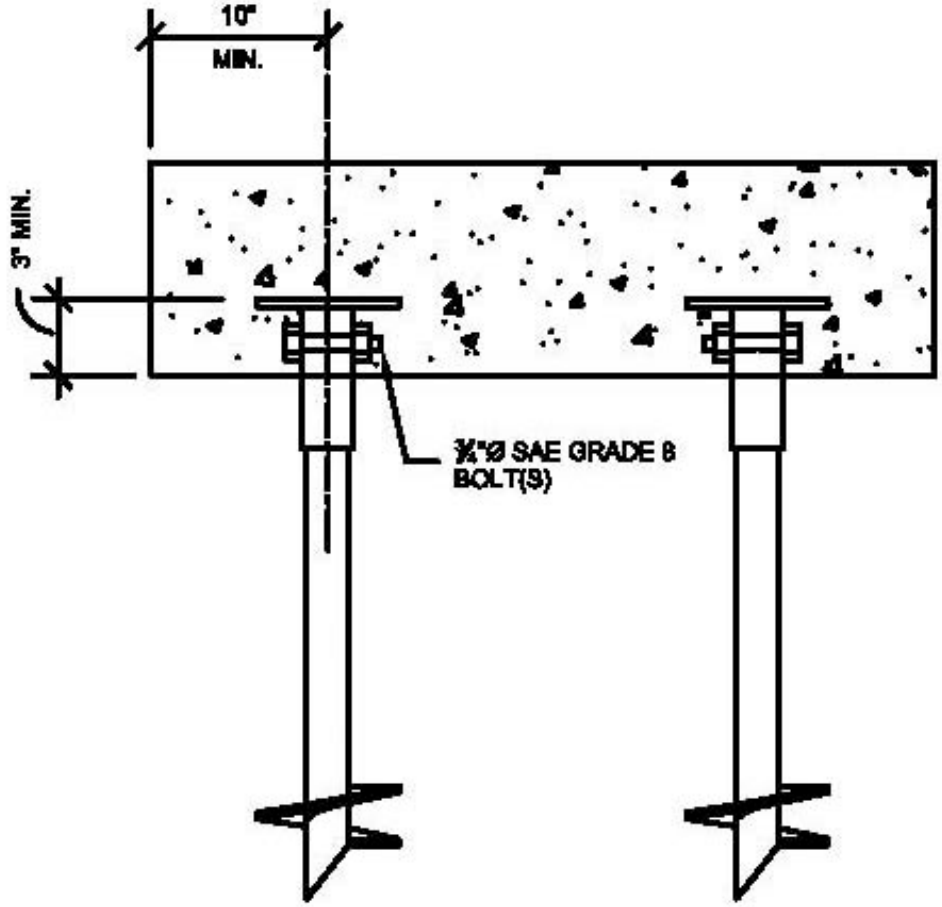


PLAN VIEW



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 ($N \geq 5$). 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

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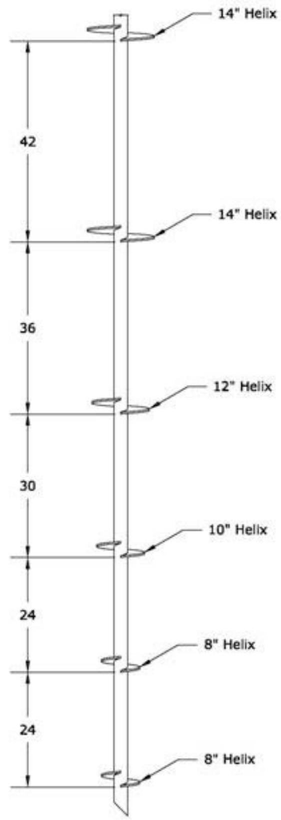
Foundation Solutions™

- 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



Configuration Aid

Ram Jack Standard Helix Configurations

Shaft Diameter	Shaft Length		
	2'-0	5'-0	7'-0
2 3/8"		8"	8"-10"
		10"	
2 7/8"	10"	10"	8"-10"
		12"	10"-12"
		10"-12"	10"-12"-14"
3 1/2"			12"-14"
			10"-12"-14"

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

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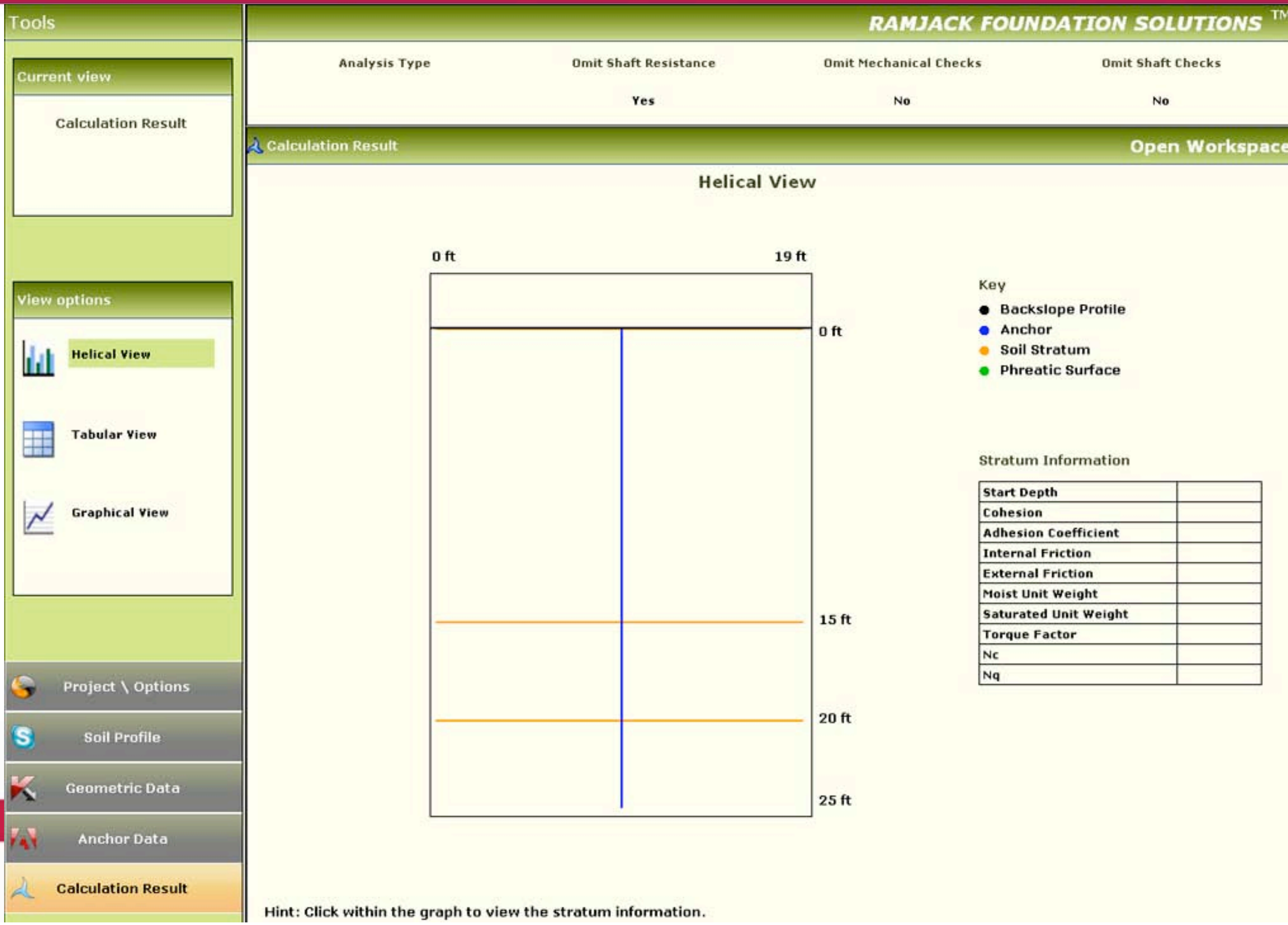

Tabular Results- Example

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Tools

Current view

Calculation Result

View options

Helical View

Tabular View

Graphical View

Project \ Options

Soil Profile

Geometric Data

Anchor Data

Calculation Result

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Analysis Type	Omit Shaft Resistance	Omit Mechanical Checks	Omit Shaft Checks
Compression Anchor	Yes	No	No

Calculation Result

Open Workspace

Tabular View

Job Type	Lead Shaft OD (inches)	Extension Shaft OD (inches)	Lead Shaft Size (ft)	Helix Configuration (inches) Format: Dia1*Thick1 - Dia2*Thick2 ..
New Construction Pier	2.875	2.875	7	10*3/8 - 12*3/8 - 14*1/2

Embedment (ft)	Ultimate* Anchor Capacity (lbs)	Torsional Resistance (lb ft)
8	21798	2383
9	22024	2408
10	22250	2433
11	22477	2458
12	22703	2483
13	24056	2509
14	25409	2534
15	28428	2559
16	31452	3085
17	33348	3110
18	39804	3876
19	44595	3902
20	52723	3928
21	60855	**5979**
22	64433	**6006**
23	72625	**7514**
24	77487	**7542**
25	**80400**	**7570**

Display Tension

Display Compression

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 (ASD) or resistance factor (LRFD) 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.

Additional Tools

www.ramjack.com

Excess to:

- Design software
- Drawings
  - AutoCAD
  - PDF
- Specifications
- Product Catalog

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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 - Foundation Repair System

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Ram Jack Engineers Resource Center

Downloads

- **Design Software**
  - Ramjack 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

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

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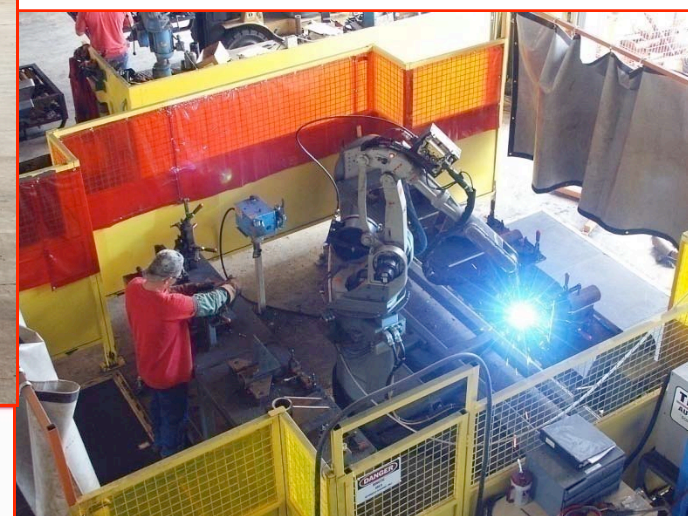
State of the Art Manufacturing Plant

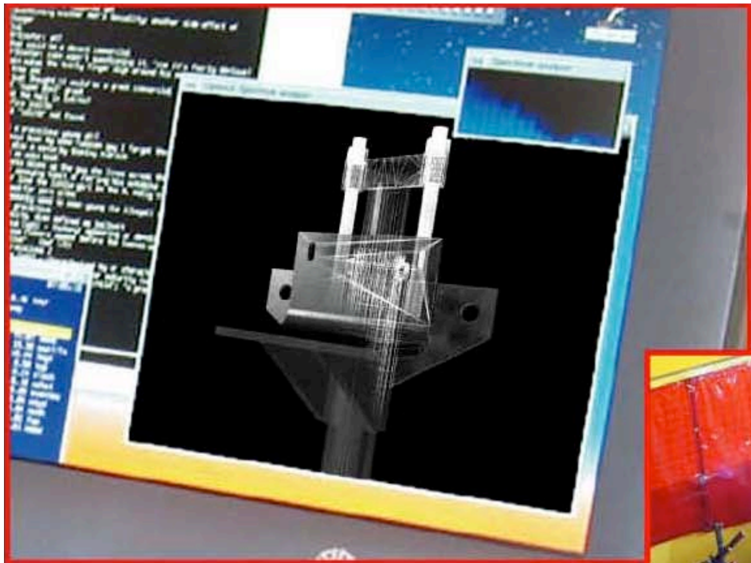
Computer controlled plasma cutting tables

All products powder coated

Robotic welding

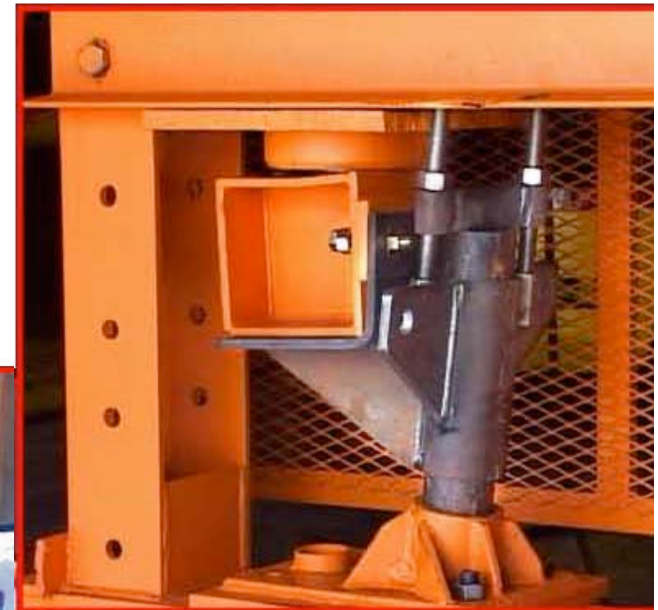


Research and Development



Product Development

State of the Art Manufacturing



Product Testing

Interesting Jobs

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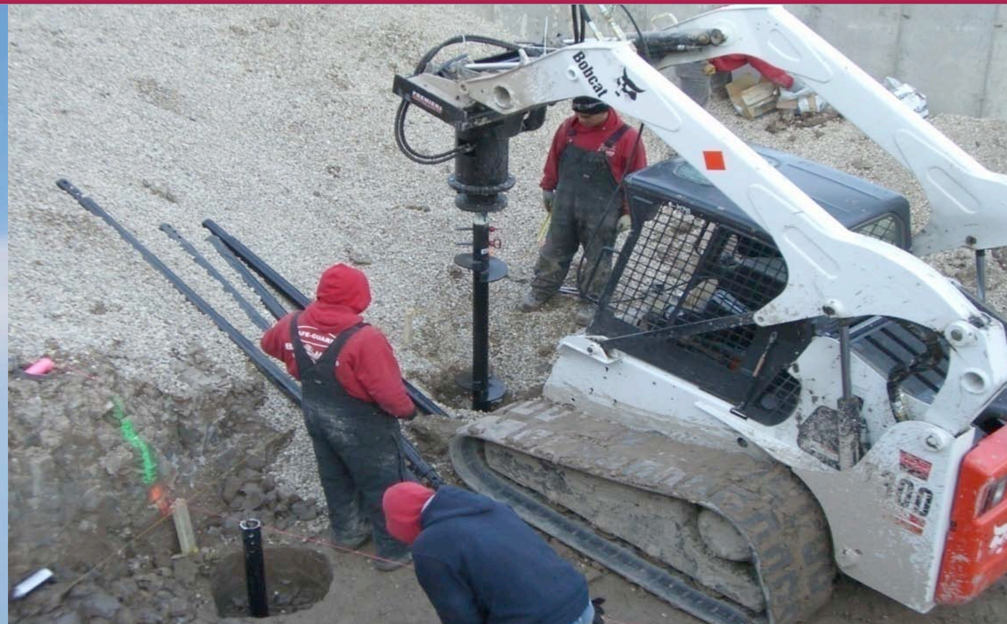

Vineyard Church
Columbus, Ohio

- 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.

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Union County Vo-Tech
Scotch Plains, New Jersey

RAM JACK FOUNDATION SOLUTIONS

- New cafeteria addition
- Required 13'-0 excavation adjacent to existing bldg
- Loads
  - Column : 25 to 45 kips
  - Wall : 1.8 kips/ft

Repair Design

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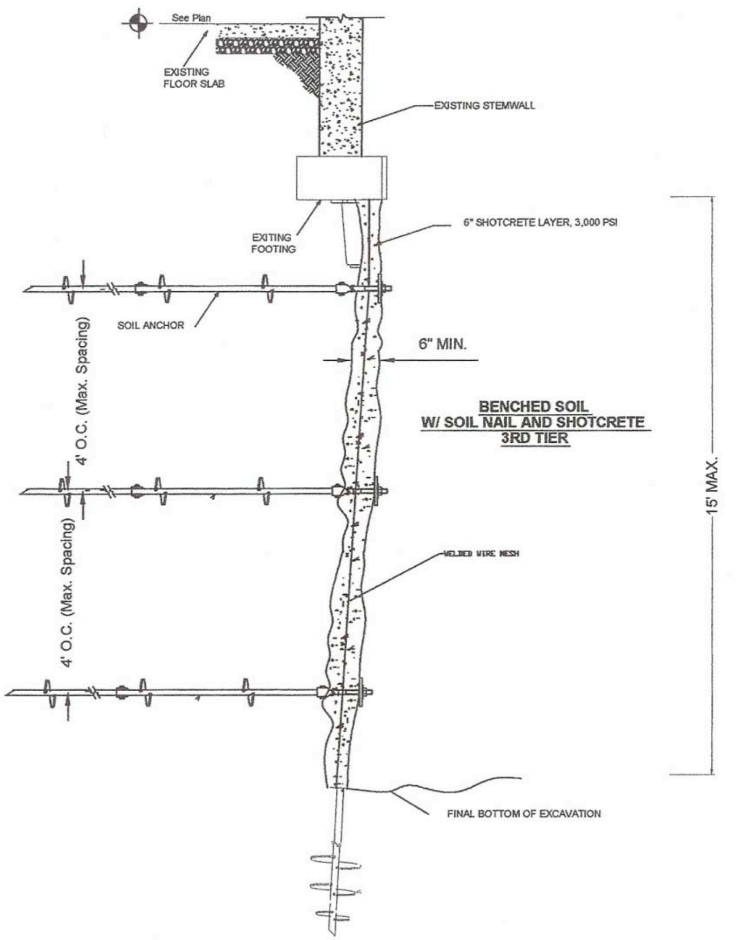

- The original design was modified replacing the underpinning piers with driven piers
- Driven piers were 2 7/8” dia. driven through a 16’-0 long 3 ½” dia. guide sleeve that would extend beyond the 13’-0 excavation
- Piers were driven approx. 40’-0

Union County Vo-Tech

Scotch Plains, New Jersey

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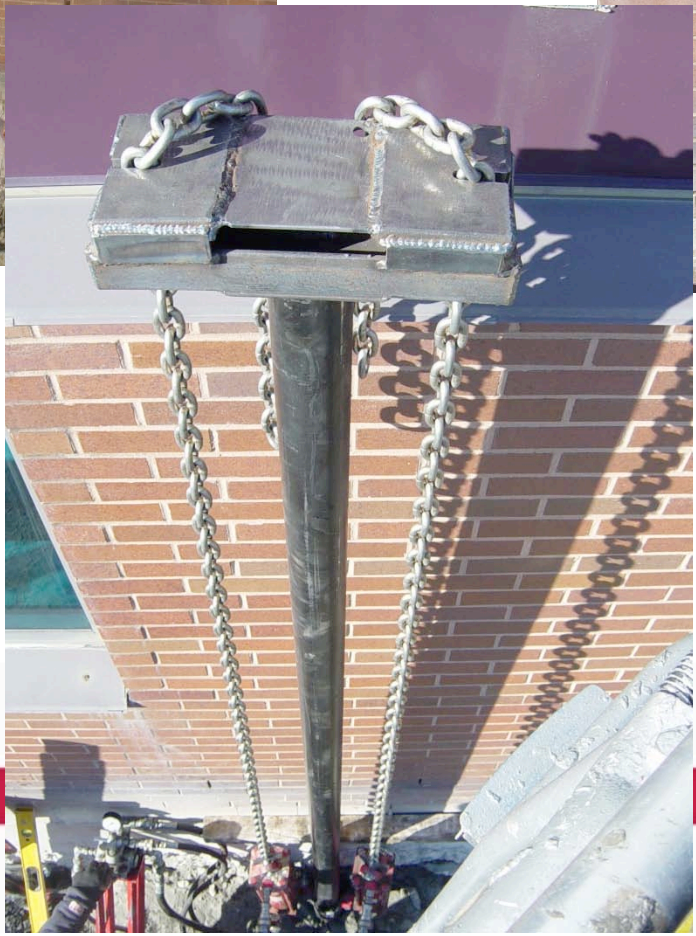

Single 16’0 guide sleeve installation

Union County Vo-Tech
Scotch Plains, New Jersey

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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

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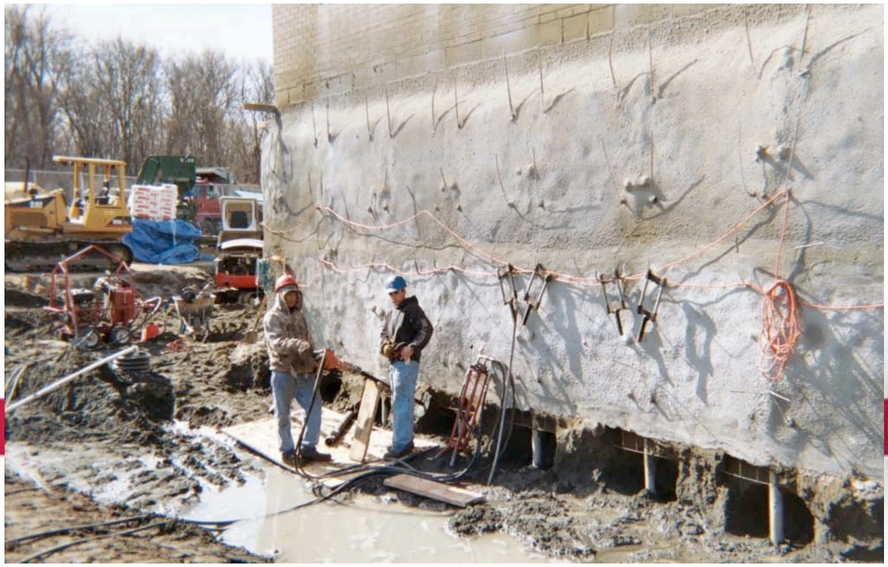
A reinforced 6” thick shotcrete wall was installed at each excavation layer



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Scotch Plains, New Jersey

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Completion of underpinning and basement wall

Oak Steel Supply
Chicago Ridge, IL

- 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

Oak Steel Supply
Chicago Ridge, IL

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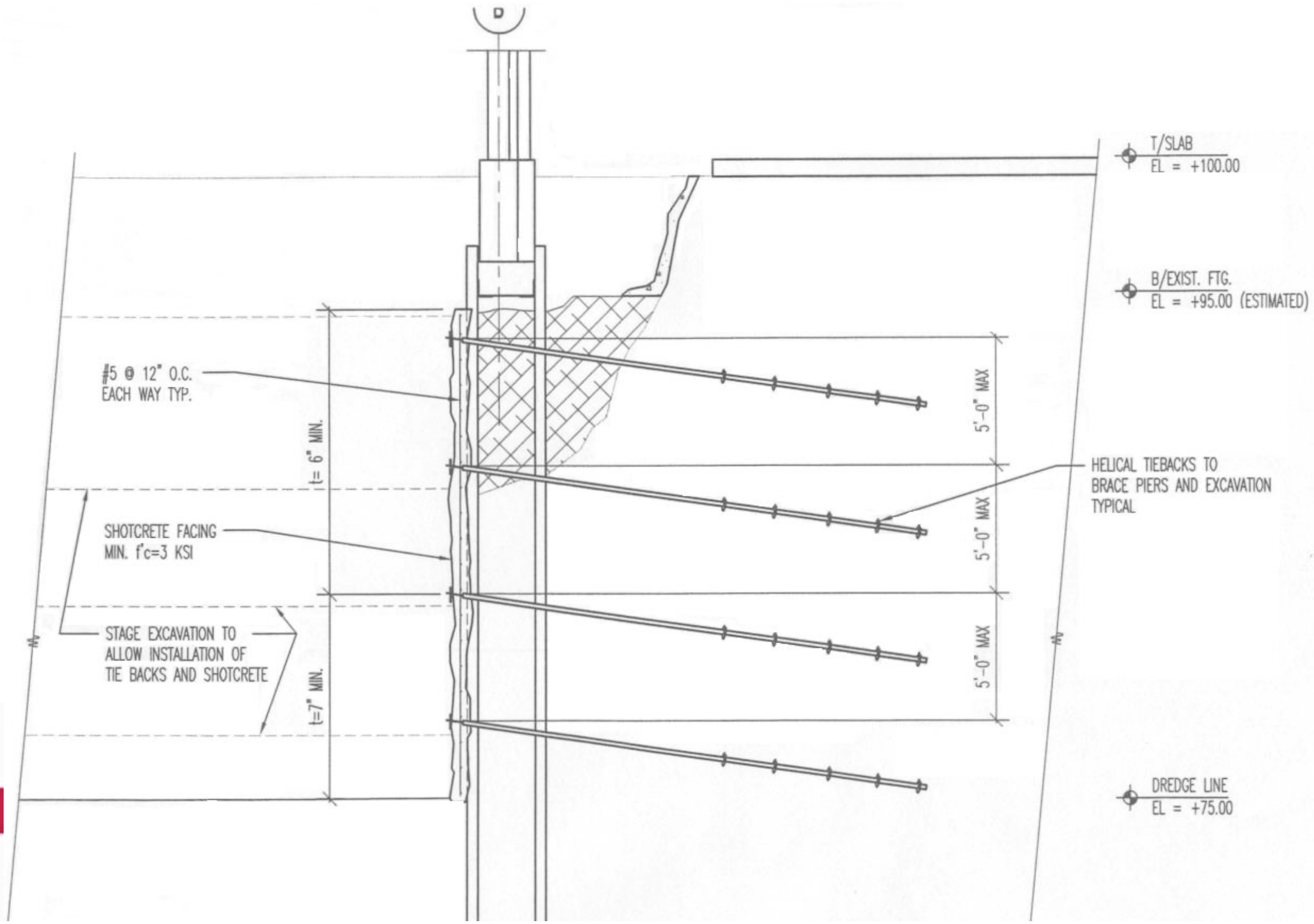
The Plan



Oak Steel Supply
Chicago Ridge, IL

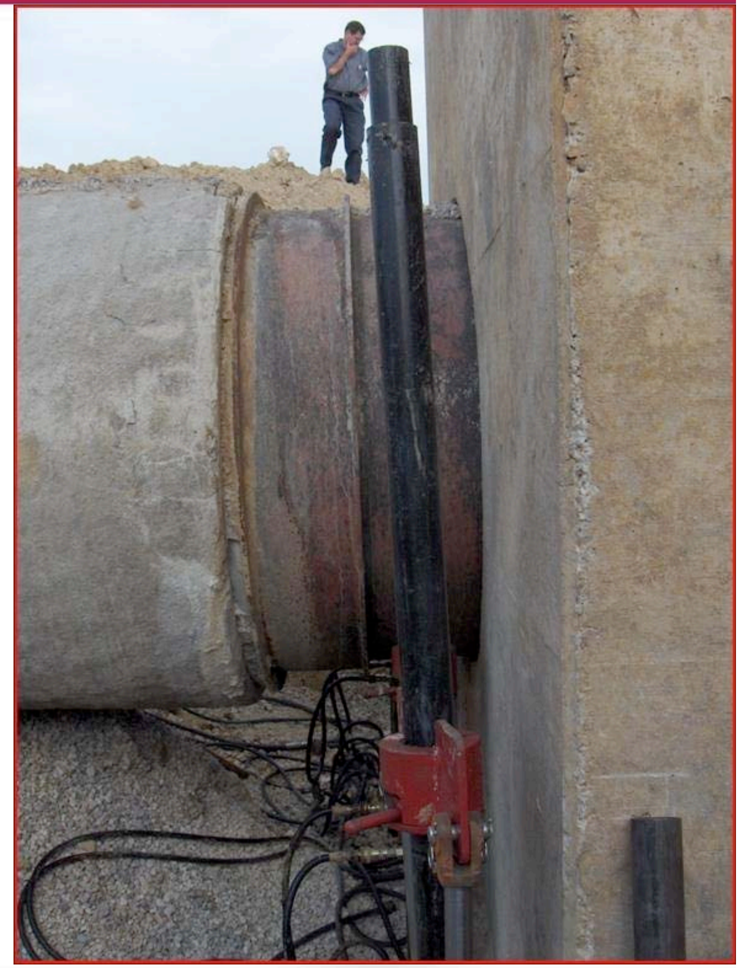
- Steel beam was install beneath grade beam.
- Excavation was performed in 5'-0 stages as tiebacks and shotcrete wall was installed.
- Constant dewatering was required due to high water table.

Oak Steel Supply
Chicago Ridge, IL

- (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 ¾”
- (27) 3 ½” diameter driven piers were required



North Texas Municipal Water District

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- Ram Jack was the only reliable system that could work within the tight quarters
- Piers were driven an average of 39’-0

North Texas Municipal Water District

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- Full elevation recovery was achieved

The End.

Questions?