Helical Piers & Tieback Anchors

Applications and Design Considerations

Rocky Mountain
STEEL FOUNDATIONS

Presented by: Ian Romain, P.E.

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Why Helicals?

- Quick Installation (Time)
- No Spoils, Immediate Loading
- Known & Verified Holding Capacity
- Water Table/Contaminants does not adversely affect installation
- Reliable & Uniform System/Design - ISO 9001
- Manageable Segmented System/Limited Access
- Building Code (IBC) Compliance
- Quality Manufacturing since **1912**

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ISO 9001 - Material Certification

CERTIFICATE OF REGISTRATION

This is to certify that

Hubbell Power Systems, Inc.

Centralia Operations

210 North Allen Street, Centralia, Missouri 65240 USA

operates a

Quality Management System

which complies with the requirements of

ISO 9001:2008

for the following scope of registration

The Quality Management System as it applies to design, manufacture and sale of medium voltage class switching and protective equipment, linemen's tools and safety equipment, specialty anchoring products and poleline construction materials for use in the utility, telecommunications, industrial and contractor markets worldwide.

Certificate No:	CERT-0033876	Original Certification Date:	July 1, 1992
File No:	001136	Current Certification Date:	October 22, 2009
Issue Date:	October 7, 2009	Certificate Expiry Date:	October 21, 2012

Chris Jouppi
President,
QMI-SAI Canada Limited

Alex Ezrakhovich
General Manager,
SAI Global Certification Services Pty Ltd

Certified System

ANAB ACCREDITED

ISO 9001

Registered by:
SAI Global Certification Services Pty Ltd, 286 Sussex Street, Sydney NSW 2000 Australia with QMI-SAI Canada Limited, 20 Carlson Court, Suite 100, Toronto, Ontario M9W 7K6 Canada (SAI GLOBAL). This registration is subject to the SAI Global Terms and Conditions for Certification. While all due care and skill was exercised in carrying out this assessment, SAI Global accepts responsibility only for proven negligence. This certificate remains the property of SAI Global and must be returned to them upon request.
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Historical Perspective

- **1836** – First Recorded Screw Pile was by Alexander Mitchell for Moorings.
- **1838** – Alexander Mitchell – Maplin Sands Lighthouse, England
- **1851** – Bridgeport Harbor Light House, Connecticut
- **1840's-1850's** – More than 100 Light Houses constructed along East Coast & Gulf of Mexico

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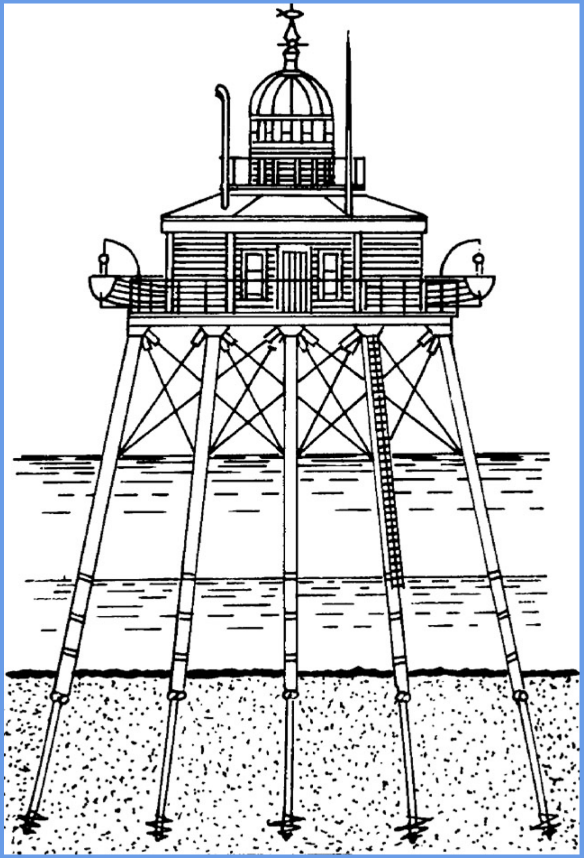
Alexander Mitchell (1780-1868)

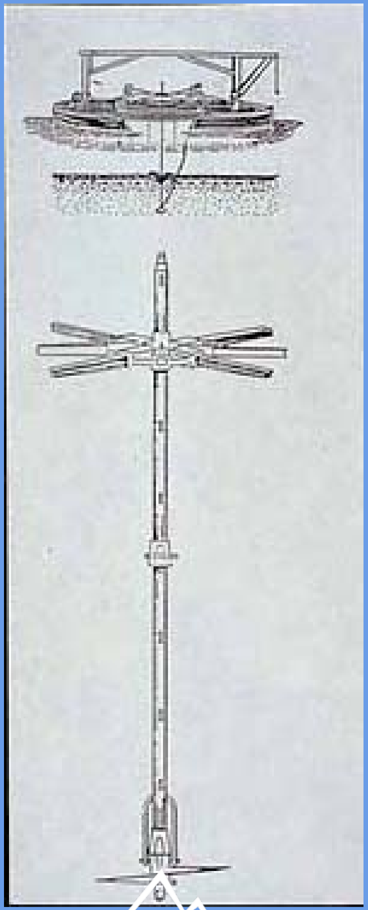
"Mitchell's Patented Screw-Pile"

- U.K. Patent No. 6446 – **1833** (renewed 1847)
- U.S. Patent No. 3986 - April 1, **1845**

Mitchell's Screw Pile - 1836



Maplin Sands Lighthouse - 1838



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Rocky Mountain Steel Foundations

Historical Perspective

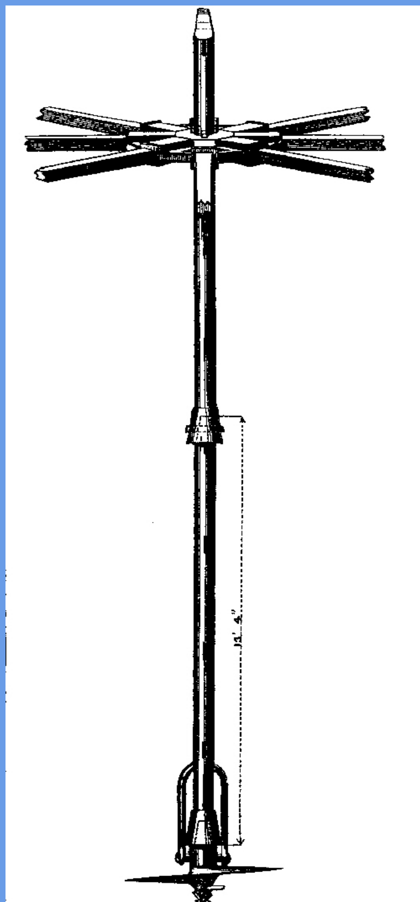

Fig. 6.

"A screw pile turned by 8 capstan bars 20 feet long, each manned by four or five men, with a screw 4 feet in diameter passed in less than two hours through a stratum of sand and clay more than 20 feet thick…"

Proceedings of the Institution of Civil Engineers 1877

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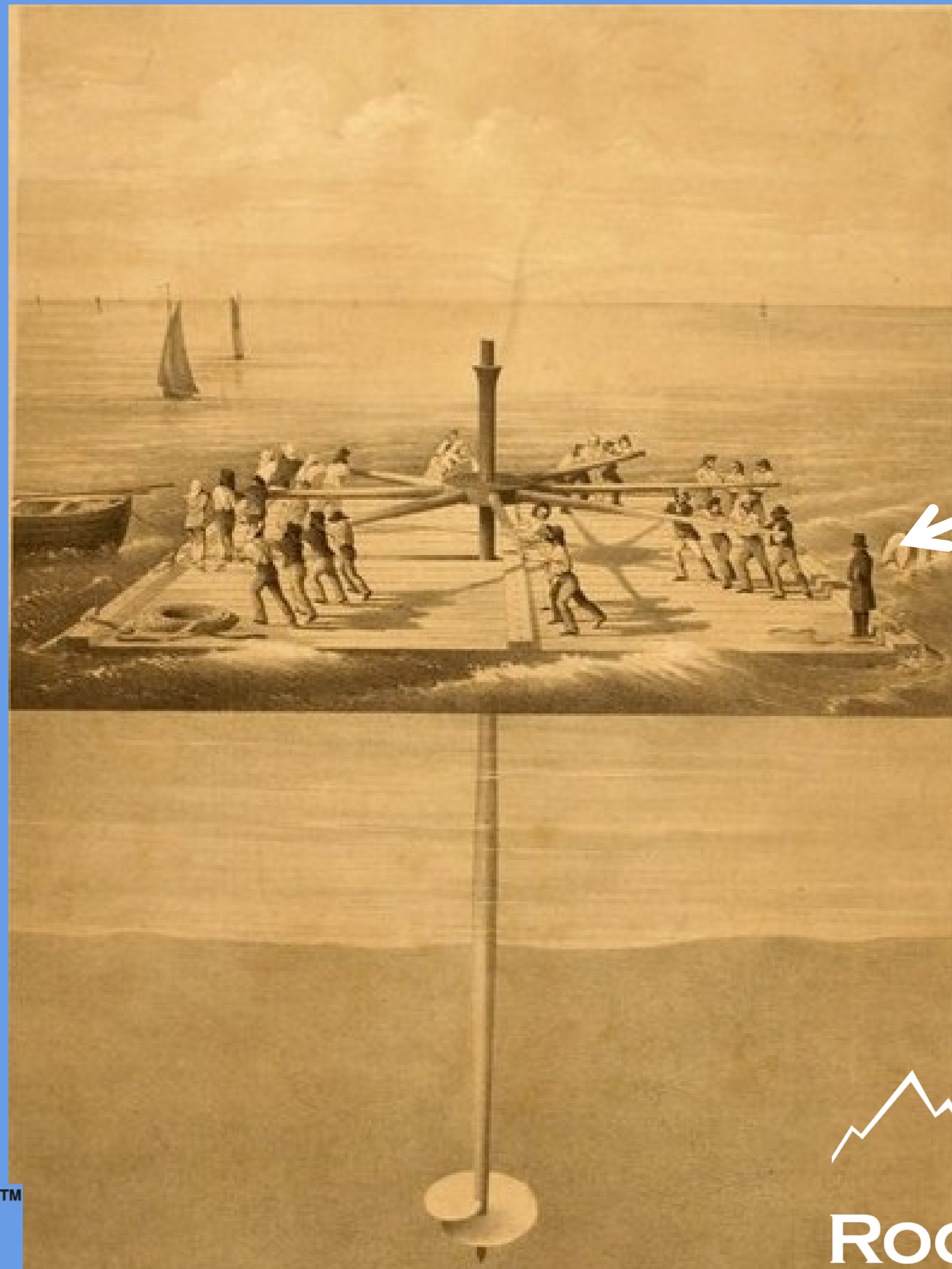

Engineer?

Pleasure Piers in Southern England

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Brighton Piers - 2007

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U.S. History

Black Rock Harbor, Connecticut (1843)

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Albert Bishop Chance

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1912 – Disastrous ice storm hit Centralia, MO, Knocking down Telephone Poles – A new anchorage system was needed…

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A New Anchorage system for the Telephone Poles was needed…

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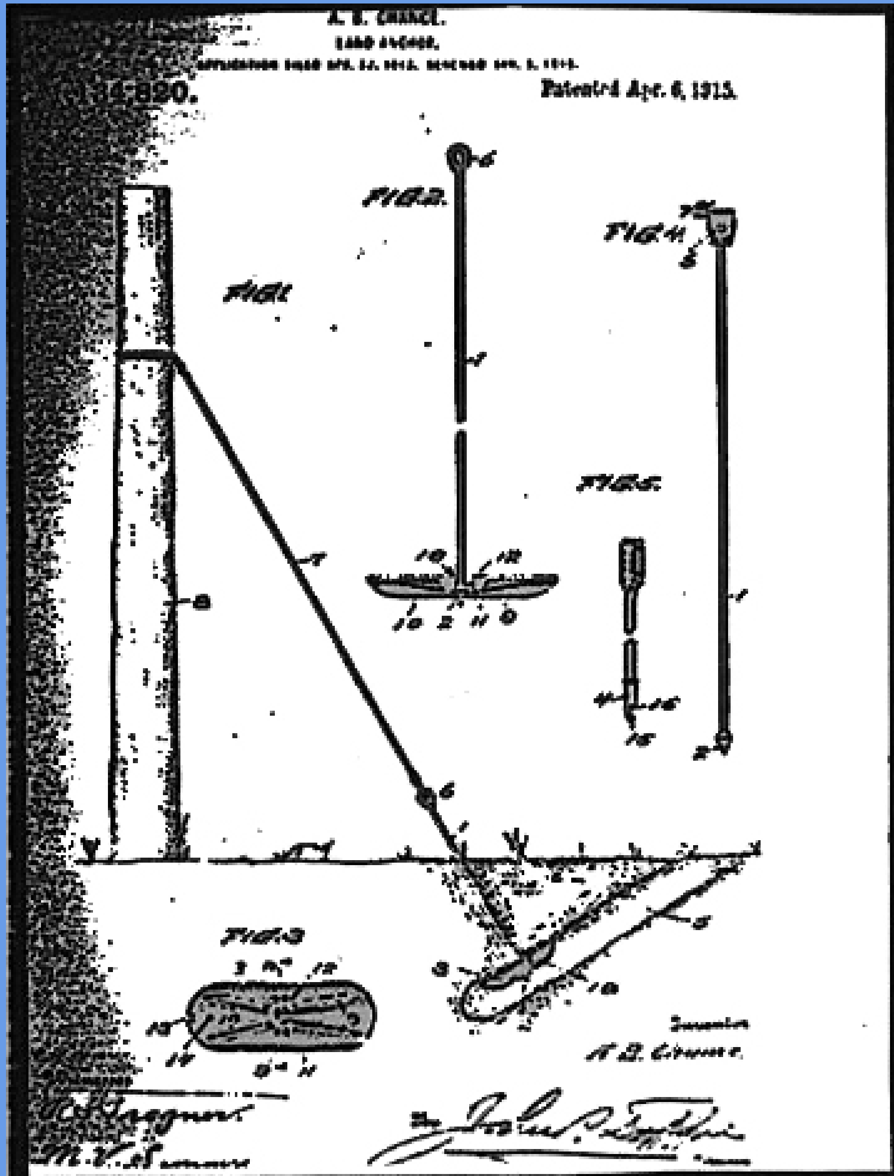

“Never-Creep” Anchor
Invented **1912**

Copy of Original Patent

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“Never-Creep”
Returned in **1970**

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AB Chance Now!!!

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Basic Soil Mechanics

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Effective Stresses

- Terzaghi's Law of Effective Stress

$$\bar{\sigma} = \sigma - u$$

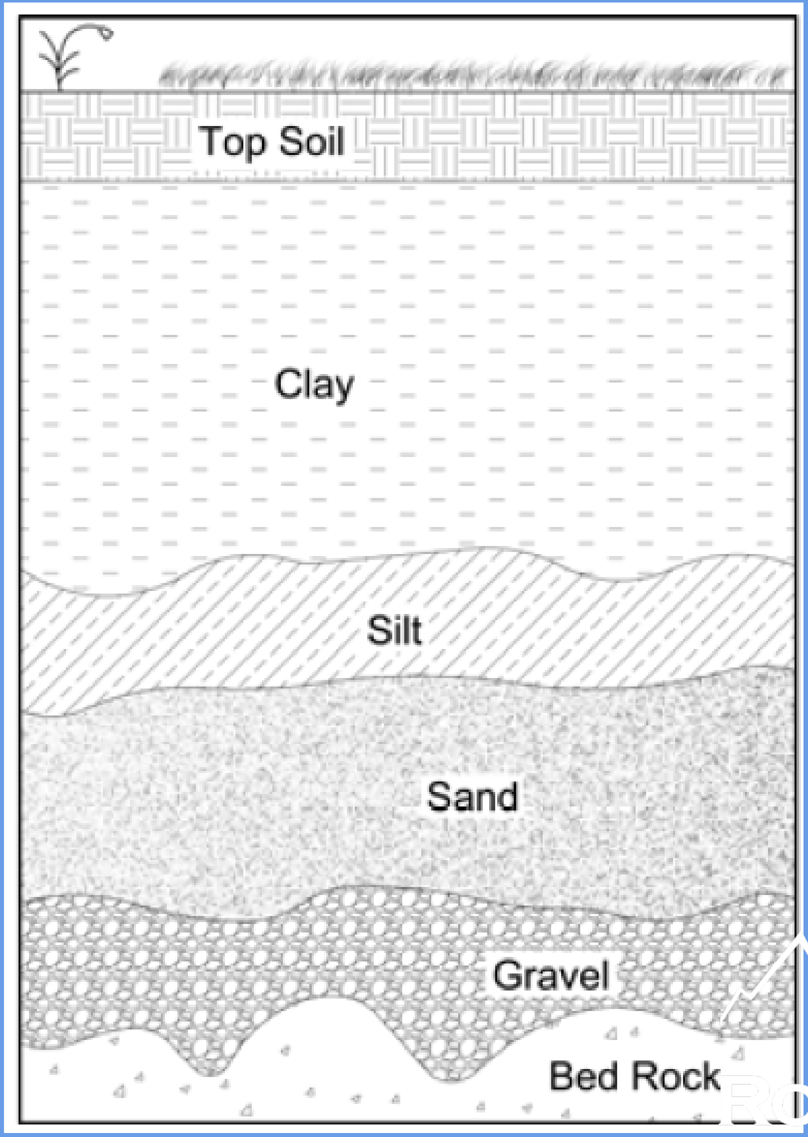
$\bar{\sigma}$ (or σ') is "effective stress" in the soil

σ is the "total" or applied stress

u is the pore pressure

EFFECTIVE STRESSES GOVERN SOIL BEHAVIOR

Typical Soil Profile



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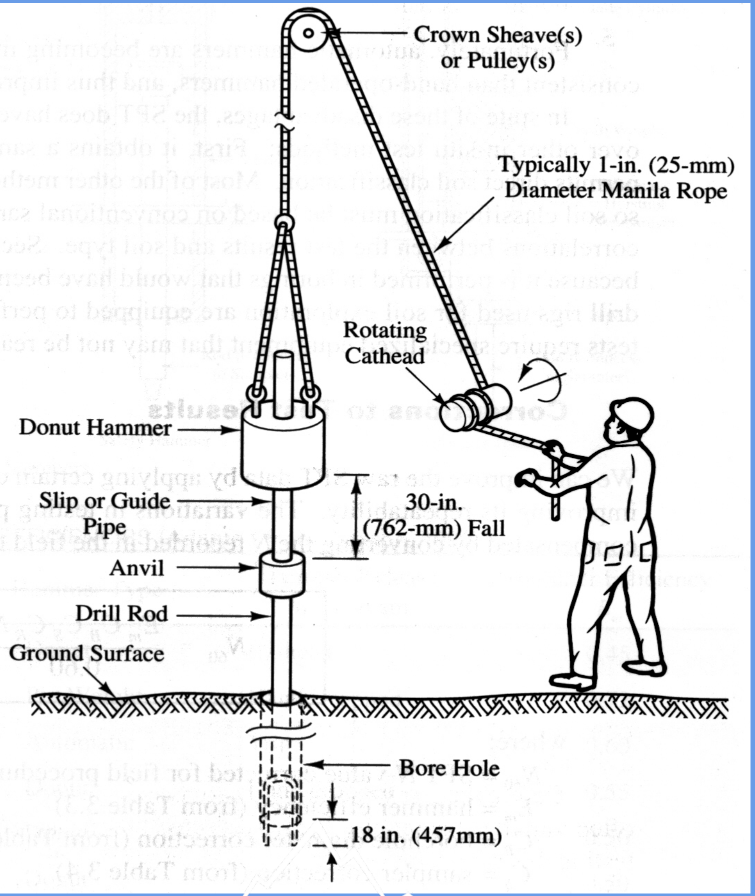
Standard Penetration Test (SPT)

- SPT "N-value" is number of blows of special hammer required to penetrate standard sampler 12 inches
  - 140-lb hammer
  - 30-inch drop
  - Penetrate total distance of 18-inches, measure the number of blows required for each 6-inch increment
  - Compute "N-value" by summing number of blows for last 12-inches of penetration



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Consistency of Cohesive (Clay) Soils

Consistency	Consolidation History	Blows/ft N_{70}	Comments
Very Soft	Normally Consolidated	0-2	Runs through fingers when squeezed
Soft	Normally Consolidated	3-4	Very easy to form into a ball
Medium	Normally Consolidated	5-8	Can be formed into a ball
Stiff	NC to OCR 2-3	9-15	Can make thumbprint w/ strong pressure
Very Stiff	Over Consolidated	16-30	Can scratch with thumbnail
Hard	Highly Over Consolidated	>30	Cannot be deformed by hand

Relative Density of Granular (Sand & Gravel) vs. N-Values

Relative Density	N-Values	Friction Angle
Very Loose	0-4	<28°
Loose	4-9	28° - 30°
Medium Dense	10-29	31° - 35.5 °
Dense	30-49	36° - 41°
Very Dense	50-80	41° - 50°
Extremely Dense	>80	?

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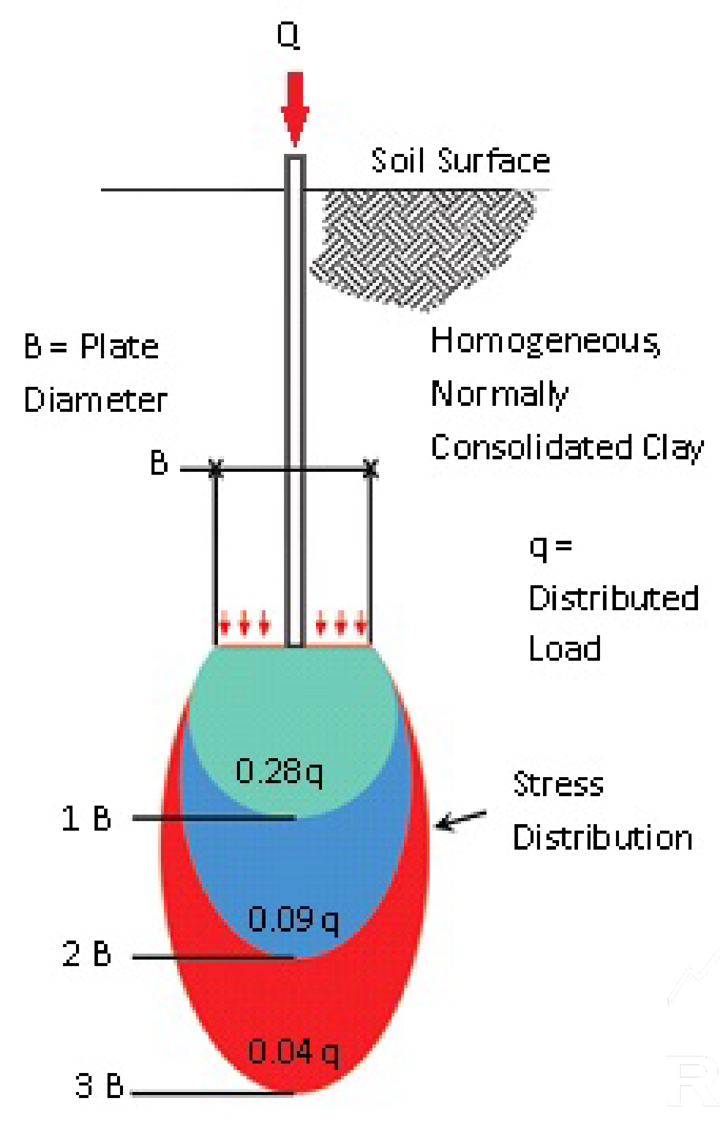
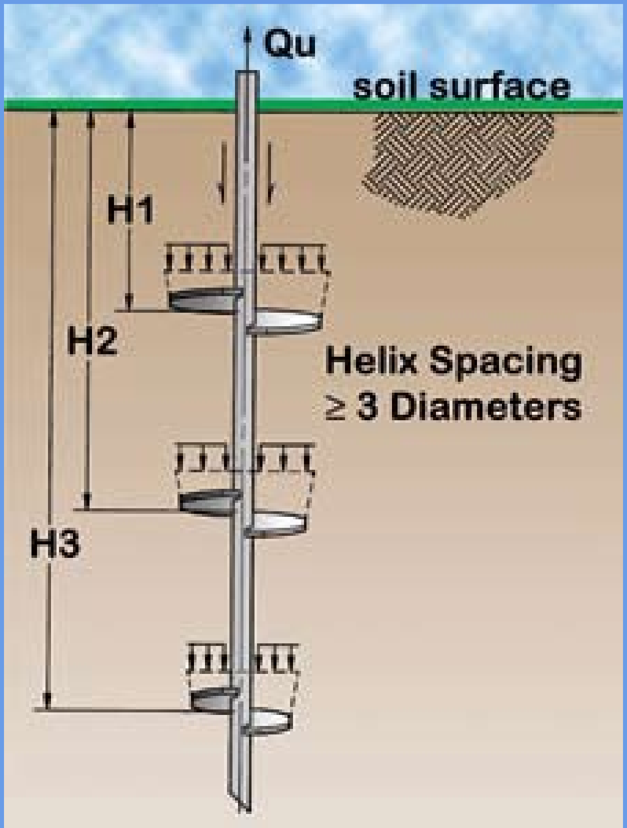
Soil Stress Distribution

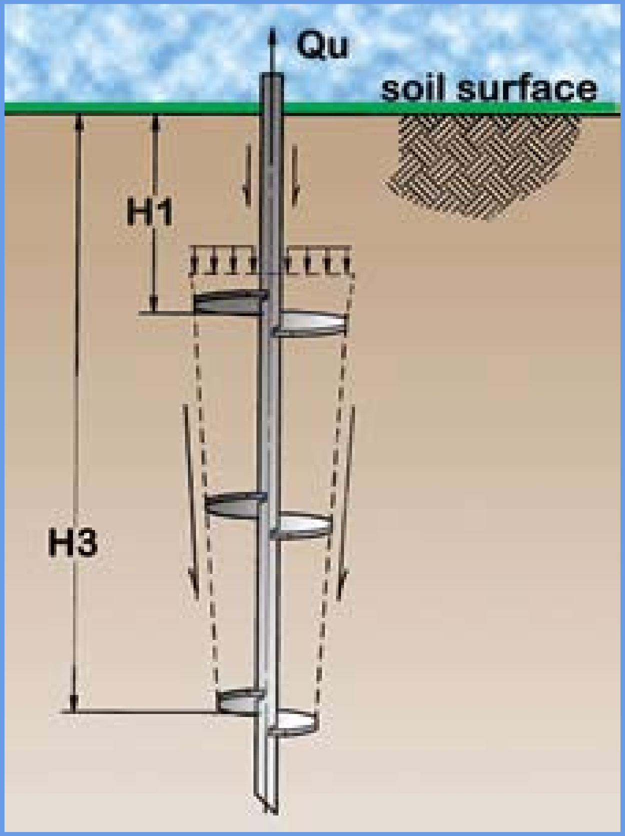


Boussinesq Equation
(circa 1885)

Inter-Helix Spacing



Bearing Capacity Theory



Cylindrical Shear Theory

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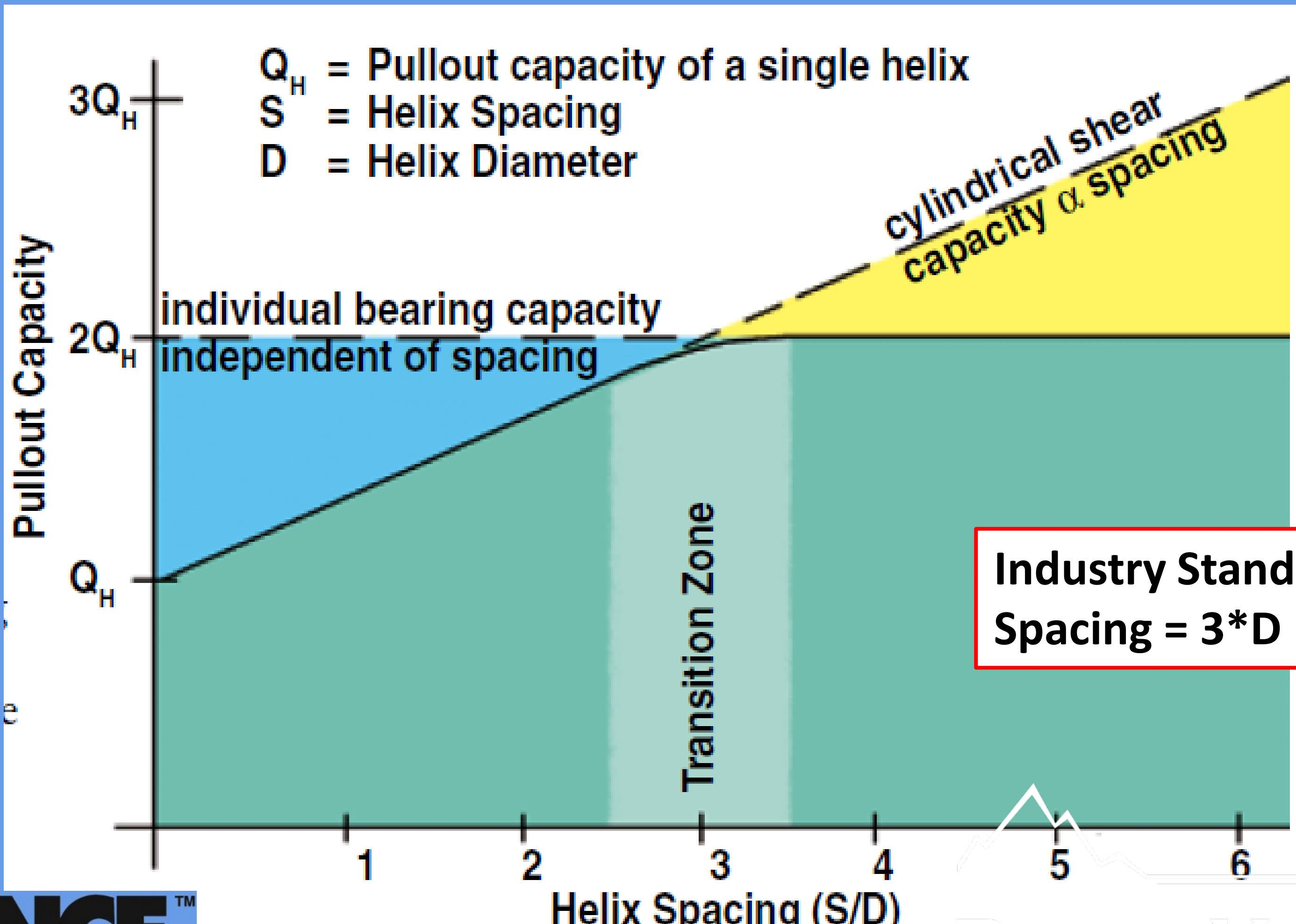
Inter-Helix Spacing



Industry Standard Spacing = 3*D

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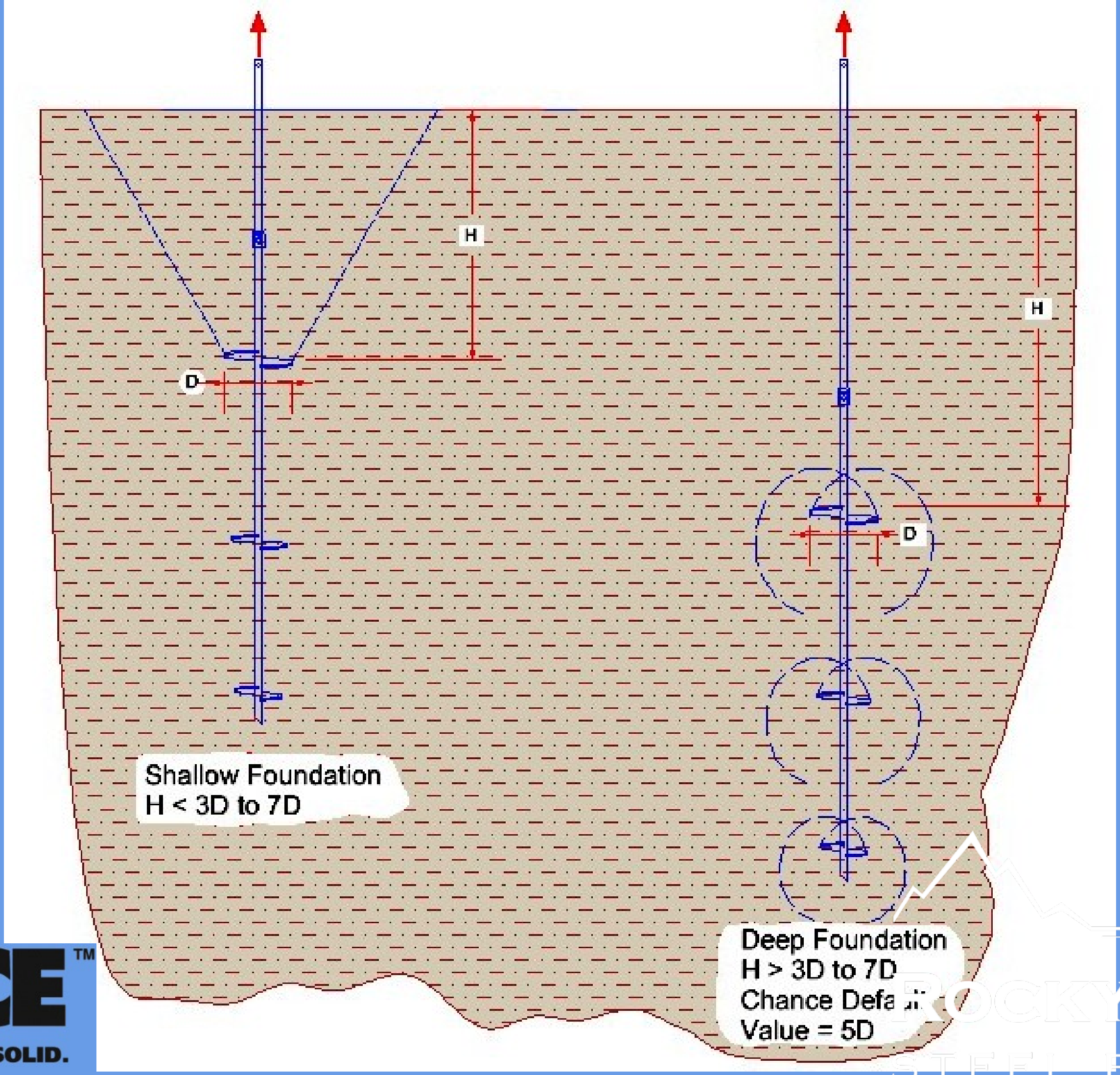
Shallow vs. Deep Anchors/Piles



"H" in reference to Upper Most Helix

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Soil Capacity – Individual Bearing Method

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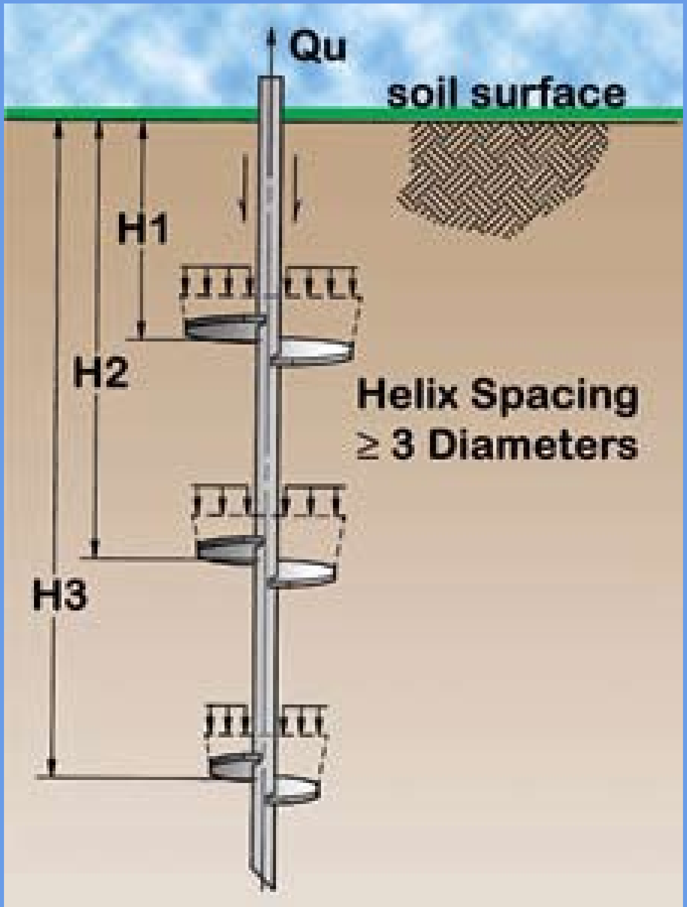
Plate Bearing Capacity Model



- Total Capacity Equal to Sum of Individual Helix Bearing Capacities
- Model valid for both tension and compression
- Helix Spacing ≥ 3*D
- Min Depth: H1 ≥ 5*D (or Frost Depth)
- Capacity due to Friction along Shaft = Zero

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Individual Bearing (Chance) Method

General Bearing Capacity Equation:

$$Q_{ult} = A(CN_C + qN_q + \frac{1}{2}\gamma BN_\gamma)$$

where:

- A = Area of footing
- C = Cohesion
- q = Overburden Pressure (γD) (D= Depth of footing below groundline)
- γ= Unit weight of Soil
- B = Width of Footing
- N_c, N_q, N_γ = Bearing Capacity Factors

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Individual Bearing (Chance) Method

"Individual Bearing Plate" Method:

$$Q_{ult} = \Sigma Q_h$$

Where:

$$Q_h = A_h(N_c C + \gamma D N_q) \leq Q_s$$

$$Q_h = A_h(9C + \gamma D N_q) \leq Q_s$$

Cohesion

Friction

where:

- A_h = Projected Area of Helix
- N_c = 9 for ratio of top helix depth to helix dia. >5
- D = Depth of Helix Plate below Groundline
- N_q= Bearing Capacity Factor for Sand
- Q_s = Upper Mechanical Limit determined by Helix Strength

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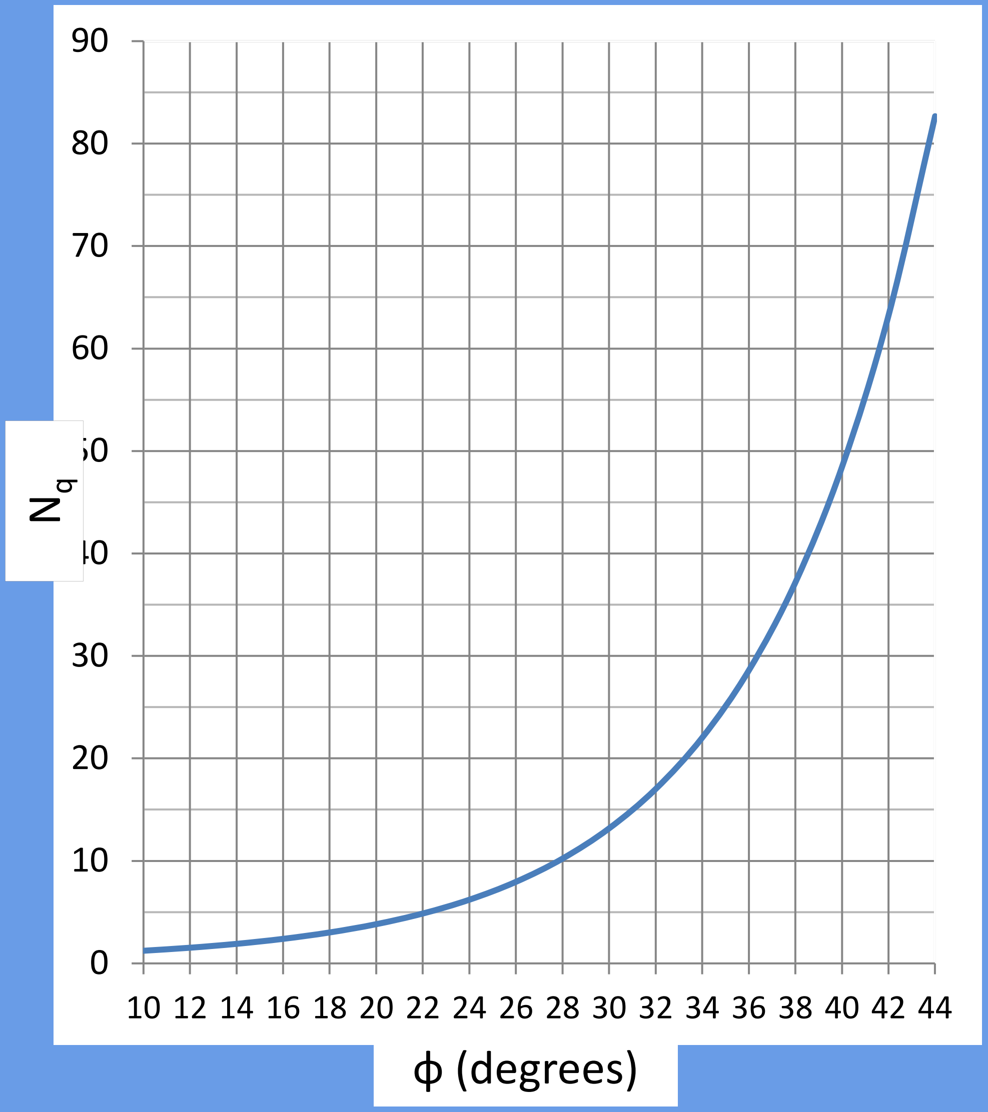
Empirical Values for Internal Friction

- $\phi = 0.28 * N + 27.4$
  - Examples:
    - $N=6$, $\phi=29°$
    - $N=15$, $\phi=31°$
    - $N=27$, $\phi=35°$

    N = Blow Count Value per ASTM D 1586 (SPT)

Above based on Bowles 1st Edition Foundation Analysis and Design. Similar to Eq. by Teng And Associates: $\phi=N/4+28.5$

Bearing Capacity Factor Curve



- N_q vs. ϕ
- Cohesionless Soils
- Adapted from G.G. Meyerhoff Factors for Driven Piles in his paper: Bearing Capacity and Settlement of Pile Foundations, 1976
- Equation:

  Nq=0.5 (12*ϕ)^(ϕ/54)

Empirical Estimates for Cohesion

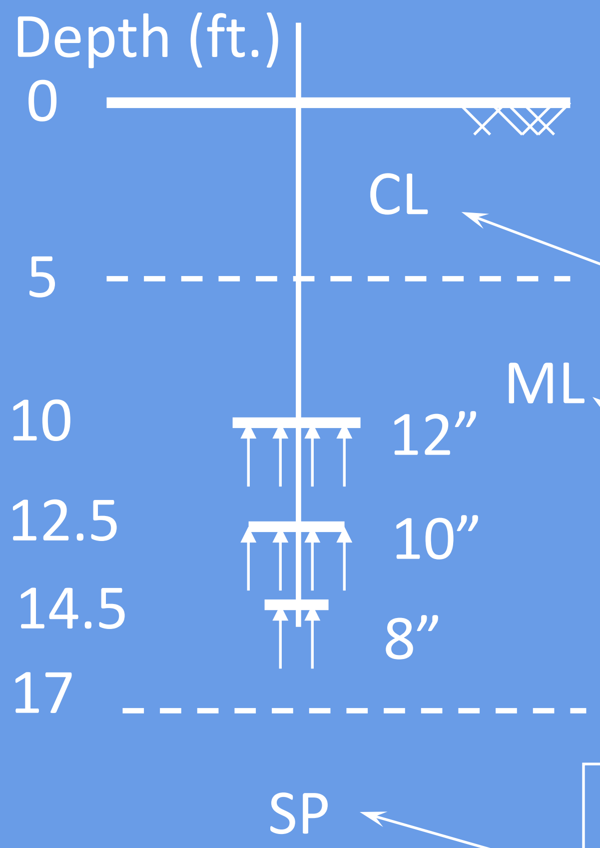
- C(ksf) = N/8 or 0.125*N
- Or C (kPa) = 6*N
  - Examples:
    - N = 8, C = 1 ksf (48 kPa)
    - N = 10, C = 1.25 ksf (60 kPa)
    - N = 3, C = 0.38 ksf (18 kPa)
- N = Blow Count Value per ASTM D 1586 (SPT)
- Cohesion estimate ranges: 0.1N – 0.2N (ksf) [5N to 10N (kPa)]

UNITS!!

Sample Helical Pile Calculation 1

Helix Configuration: 8”-10”-12”

$$Q_u = \Sigma A_i(N_c C_i + q_i N_q)$$



$C = 1500$ psf (0.73 kg/cm^2)
$\gamma = 115$ pcf ($1{,}842$ kg/m^3)
$\phi = 0°$

$C = 200$ psf (0.097 kg/cm^2)
$\gamma = 110$ pcf ($1{,}762$ kg/m^3)
$\phi = 26°$ $N_q=8$

$C = 0$
$\gamma = 120$ pcf ($1{,}922$ kg/m^3)
$\phi = 34°$

Sample Helical Pile Calculation 1 cont.

Cohesion

Friction

Qu =

$$\frac{\pi(8in)^2}{4}*\left[\frac{1ft^2}{144in^2}\right]*\left[9*200psf+\left(5ft*115pcf+9.5ft*110pcf\right)*8\right]$$

$$+\frac{\pi(10in)^2}{4}*\left[\frac{1ft^2}{144in^2}\right]*\left[9*200psf+\left(5ft*115pcf+7.5ft*110pcf\right)*8\right]$$

$$+\frac{\pi(12in)^2}{4}*\left[\frac{1ft^2}{144in^2}\right]*\left[9*200psf+\left(5ft*115pcf+5ft*110pcf\right)*8\right]$$

=5,152 + 7,090 + 8,482 = <u>20,725 lb</u>

8”

10”

12”

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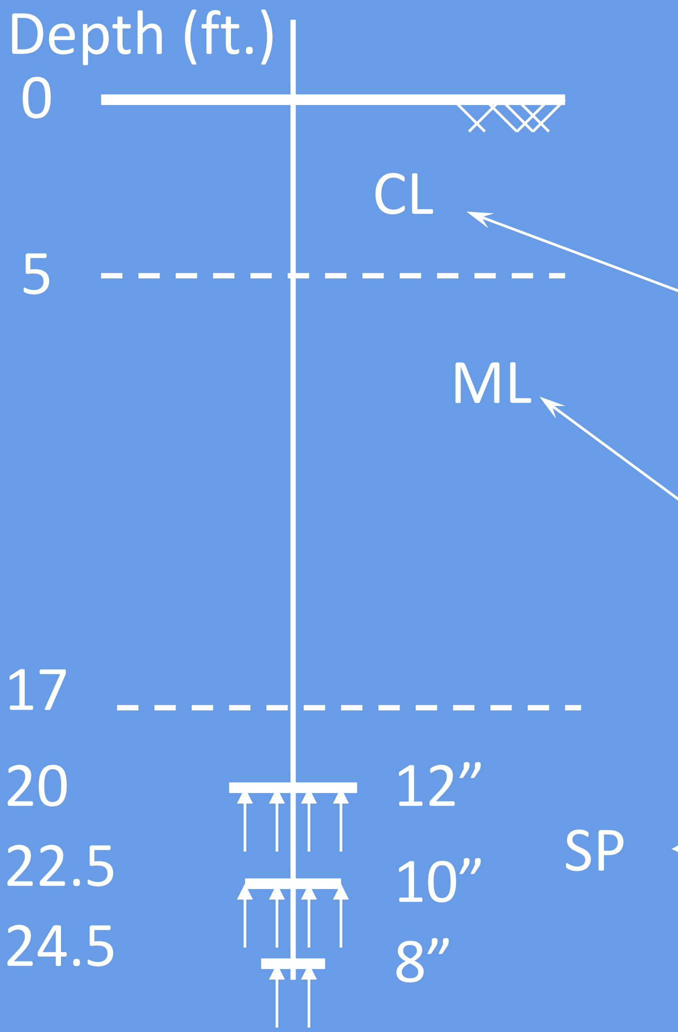
Sample Helical Pile Calculation 2



Helix Configuration: 8"-10"-12"

$$Q_u = \Sigma A_i(N_c C_i + q_i N_q)$$

0

Friction Only

$C = 1500$ psf (0.73 kg/cm^2)
$\gamma = 115$ pcf ($1{,}842$ kg/m^3)
$\phi = 0°$

$C = 200$ psf (0.097 kg/cm^2)
$\gamma = 110$ pcf ($1{,}762$ kg/m^3)
$\phi = 26°$

$C = 0$
$\gamma = 120$ pcf ($1{,}922$ kg/m^3)
$\phi = 34°$

$N_q=22$

Sample Helical Pile Calculation 2 cont.

No Cohesion

Friction Only

Qu =

$$\frac{\pi(8in)^2}{4}*\left[\frac{1ft^2}{144in^2}\right]*[(5ft*115pcf+12ft*110pcf+7.5ft*120pcf)*22]$$

$$+\frac{\pi(10in)^2}{4}*\left[\frac{1ft^2}{144in^2}\right]*[(5ft*115pcf+12ft*110pcf+5.5ft*120pcf)*22]$$

$$+\frac{\pi(12in)^2}{4}*\left[\frac{1ft^2}{144in^2}\right]*[(5ft*115pcf+12ft*110pcf+3ft*120pcf)*22]$$

=21,464 + 30,658 + 38,964 = <u>91,086 lb</u>

8”

10”

12”

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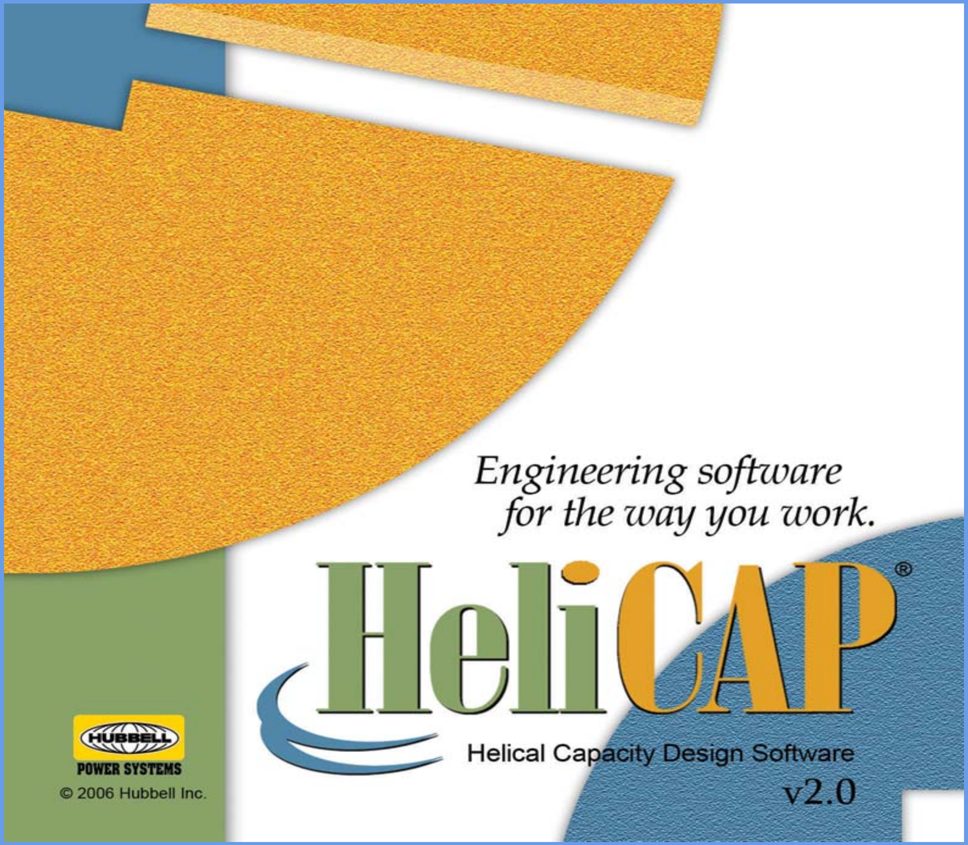
HeliCAP® v2.0 Helical Capacity Design Software



- Microsoft Windows Based Bearing, Uplift, and Friction Capacity Software
- 4 Types of Helical Applications: Compression, Tension, Tiebacks, and Soil Screws
- Within those applications can also calculate friction capacity of a grout column or steel pipe shaft.
- Based on soil and anchor/pile inputs the program returns theoretical capacities and installation torque.

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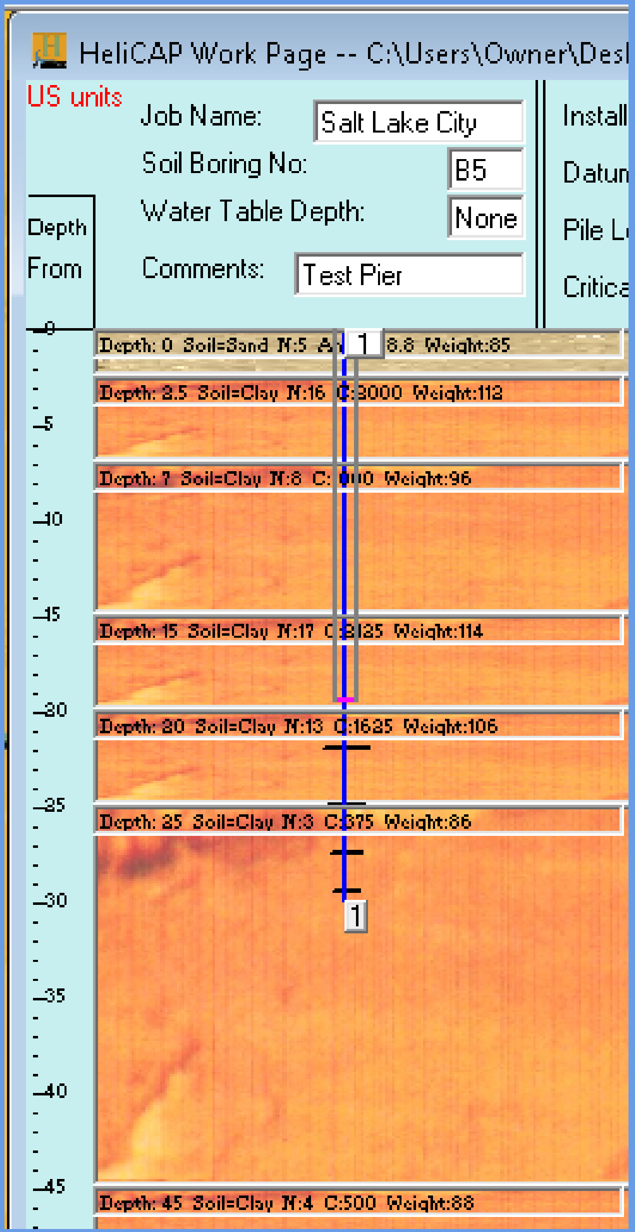
Theoretical Capacity - HeliCAP

- Input Soil Data
- Select Helical Configuration
- Enter Pier Depth
- Analyze with both End Bearing and Friction contributions



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Theoretical Capacity – HeliCAP 3.0

- www.hpsapps.com/helicap

Job Number : 10 **Job Name** : Sturgis WRRF

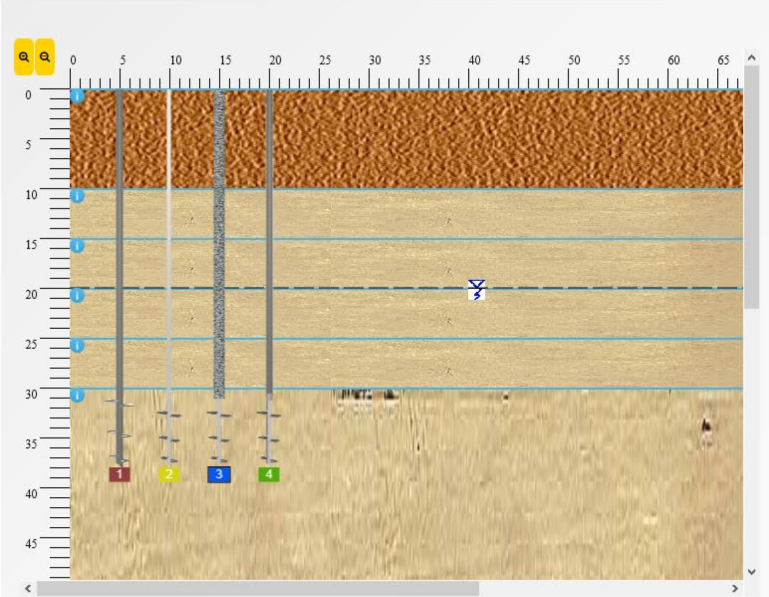
Table 4 values | SB-4

Application Mode: Compression

Display Depth: 75

Grid Lines: OFF

SAVE | CALCULATE | PRINT



Water Table Depth (ft): 20

Hammer Efficiency: Safety Hammer (60%)

Critical Depth (ft): None

No Load Zone Depth Below Groundline (ft): None

SOIL PROFILE

	Depth (ft)	Soil Type	N	N_{60}	Cohesion (psf)	Angle of Internal Friction (degrees)	In Situ Unit Weight (pcf)	Clay Bearing Capacity Factor (N_c)	Sand Bearing Capacity Factor (N_q)	Bond Value (psf)
1	0	Clay Fill (1)	12	12	1500	0	104	9	0	
2	10	Sand	5	5	0	28.8	85	0	11.29	
3	15	Sand	7	7	0	29.3	95	0	12.03	
4	20	Sand	2	2	0	27.9	70	0	10.07	
5	25	Sand	20	20	0	33	110	0	19.33	
6	30	Sand	30	30	0	35.8	120	0	27.83	
7										

Profile | Series | Table | Capacity Graph | Torque Graph

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Installation Methodology

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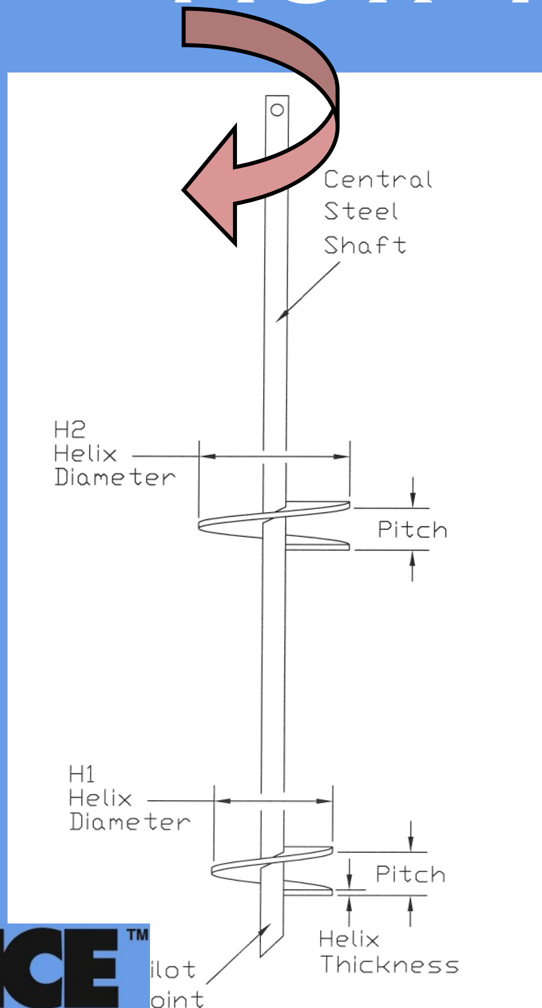
Helical Piles & Anchors – How They Work



- **Low Soil Displacement Foundation Element Specifically Designed to Minimize Disturbance During Installation**
- **Consists of One or More Helix Plates Attached to a Central Steel Shaft**
- **Rotated, or "Screwed" into Soil Much Like a Wood Screw Driven into a Piece of Wood**

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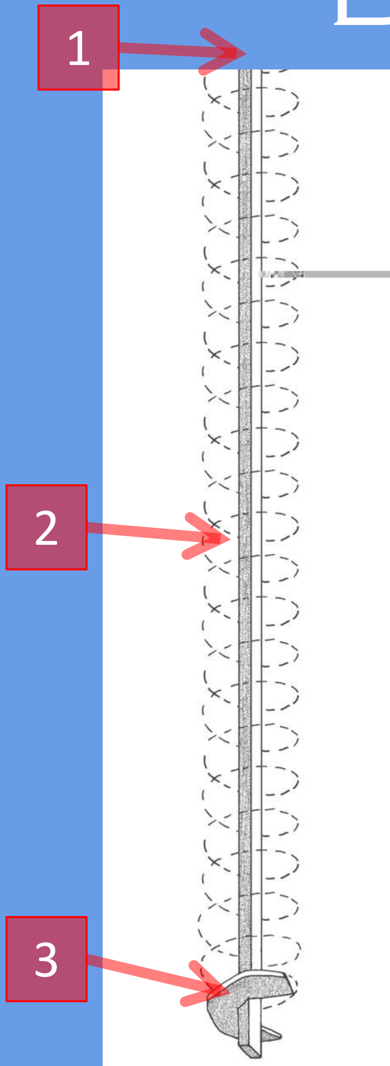
Rocky Mountain Steel Foundations

Basic Components



- 3 Helix – Serves Two-Fold Purpose
  - Installation
    - Ramped Spiral
    - Uniform Pitch
    - Provides Downward Force or Thrust
  - Bearing Element
- 2 Central Steel Shaft
  - Transmits Installation Torque & Axial Force
  - Slender Size & Shape to Reduce Friction
- 1 Termination
  - Pile Cap
  - Threaded Stud
  - Bolted Plate
  - Bracket

4

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ROCKY MOUNTAIN STEEL FOUNDATIONS

ESR 2794

- Evaluation Report performed by ICC
- Per AC 358
- Compliance with 2006, 2009, 2012 IBC
- Evaluates Caps, Brackets, Shafts, Couplings, Helices
- ASD and LRFD Design Methods
- Capacity = Lowest of P1, P2, P3, P4 (Soils)

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IBC Building Code

1810.3.1.5 Helical piles.

Helical piles shall be designed and manufactured in accordance with accepted engineering practice to resist all stresses induced by installation into the ground and service loads.

1810.3.3.1.9 Helical piles.

The allowable axial design load, P_a, of helical piles shall be determined as follows:

$$P_a = 0.5\,P_u \qquad \text{(Equation 18-4)}$$

where P_u is the least value of:

1. Sum of the areas of the helical bearing plates times the ultimate bearing capacity of the soil or rock comprising the bearing stratum.
2. Ultimate capacity determined from well-documented correlations with installation torque.
3. Ultimate capacity determined from load tests.
4. Ultimate axial capacity of pile shaft.
5. Ultimate axial capacity of pile shaft couplings.
6. Sum of the ultimate axial capacity of helical bearing plates affixed to pile.

IBC Building Code

TABLE 1810.3.2.6
ALLOWABLE STRESSES FOR MATERIALS USED IN DEEP FOUNDATION ELEMENTS

MATERIAL TYPE AND CONDITION	MAXIMUM ALLOWABLE STRESS[a]
1. Concrete or grout in compression[b]	
Cast-in-place with a permanent casing in accordance with Section 1810.3.2.7	$0.4\ f'_c$
Cast-in-place in a pipe, tube, other permanent casing or rock	$0.33\ f'_c$
Cast-in-place without a permanent casing	$0.3\ f'_c$
Precast nonprestressed	$0.33\ f'_c$
Precast prestressed	$0.33\ f'_c - 0.27\ f_{pc}$
2. Nonprestressed reinforcement in compression	$0.4\ f_y \leq 30{,}000$ psi
3. Steel in compression	
Cores within concrete-filled pipes or tubes	$0.5\ F_y \leq 32{,}000$ psi
Pipes, tubes or H-piles, where justified in accordance with Section 1810.3.2.8	$0.5\ F_y \leq 32{,}000$ psi
Pipes or tubes for micropiles	$0.4\ F_y \leq 32{,}000$ psi
Other pipes, tubes or H-piles	$0.35\ F_y \leq 16{,}000$ psi
Helical piles	$0.6\ F_y \leq 0.5\ F_u$
4. Nonprestressed reinforcement in tension	$0.6\ f_y$
Within micropiles	
Other conditions	$0.5\ f_y \leq 24{,}000$ psi
5. Steel in tension	
Pipes, tubes or H-piles, where justified in accordance with Section 1810.3.2.8	$0.5\ F_y \leq 32{,}000$ psi
Other pipes, tubes or H-piles	$0.35\ F_y \leq 16{,}000$ psi
Helical piles	$0.6\ F_y \leq 0.5\ F_u$
6. Timber	In accordance with the ANSI/AWC NDS

a. f'_c is the specified compressive strength of the concrete or grout; f_{pc} is the compressive stress on the gross concrete section due to effective prestress forces only; f_y is the specified yield strength of reinforcement; F_y is the specified minimum yield stress of steel; F_u is the specified minimum tensile stress of structural steel.

b. The stresses specified apply to the gross cross-sectional area within the concrete surface. Where a temporary or permanent casing is used, the inside face of the casing shall be considered the concrete surface.

Installation Energy

- Energy to Pier = Energy Required to Penetrate the Soil, plus the Energy Loss to Friction
- Provided by the Machine – Consists of Two Parts
  - Rotational Energy - Supplied by Torque Motor
    - Rotation and Incline Plane of Helix Provides Downward Thrust
    - AKA Installation Torque
  - Downward Force (Crowd) – Supplied by Machine

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ROCKY MOUNTAIN
STEEL FOUNDATIONS

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ROCKY MOUNTAIN
STEEL FOUNDATIONS

Installation Torque vs. Ultimate Capacity

The Torque Required to Install a Helical Pile or Anchor is Empirically Related to It's Ultimate Capacity

- $Q_{ult} = K_t * T$
  - Where:
    - Q_{ult} = Ultimate Capacity [lb]
    - T = Installation Torque [ft*lb]
    - K_t = Empirical Torque Factor [ft^{-1}]
      - "Default" Value = 10 for Type "SS"
      - "Default" Value = 9 for 2-7/8 "RS"
      - "Default" Value = 7 for 3-1/2" "RS"
      - "Default" Value = 6-7 for 4-1/2" "RS"

Torque = Capacity

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ROCKY MOUNTAIN STEEL FOUNDATIONS

Torque - Advantages

- Provides Excellent Field Control of Installation
- Monitors Soil Conditions
- <u>Torque is a Direct measure of Soil Shear Strength</u>
- Predicts Holding Capacity of the Soil
- Helical Piles/Anchors can be Installed to Specified Torque

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ROCKY MOUNTAIN STEEL FOUNDATIONS

Factor of Safety

- Select an Appropriate Factor of Safety (FS) to Apply to the *Ultimate Capacity* of the helical Anchor/Pile to Develop the required Design, or *Working Capacity* per Anchor/Foundation

- In general, Chance Civil Construction Recommends a Minimum FS of Two (2)

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ROCKY MOUNTAIN STEEL FOUNDATIONS

Inspection
what to look for:

- Helices – True Helix – Not “Duck Billed”
- Hot-Dip Galvanized
- Installation Log (torque monitoring)
- Bracket or Cap (Rated for the load)
- Product Series (Carry the load – Max ratings)
- Required Axial Load (Torque)

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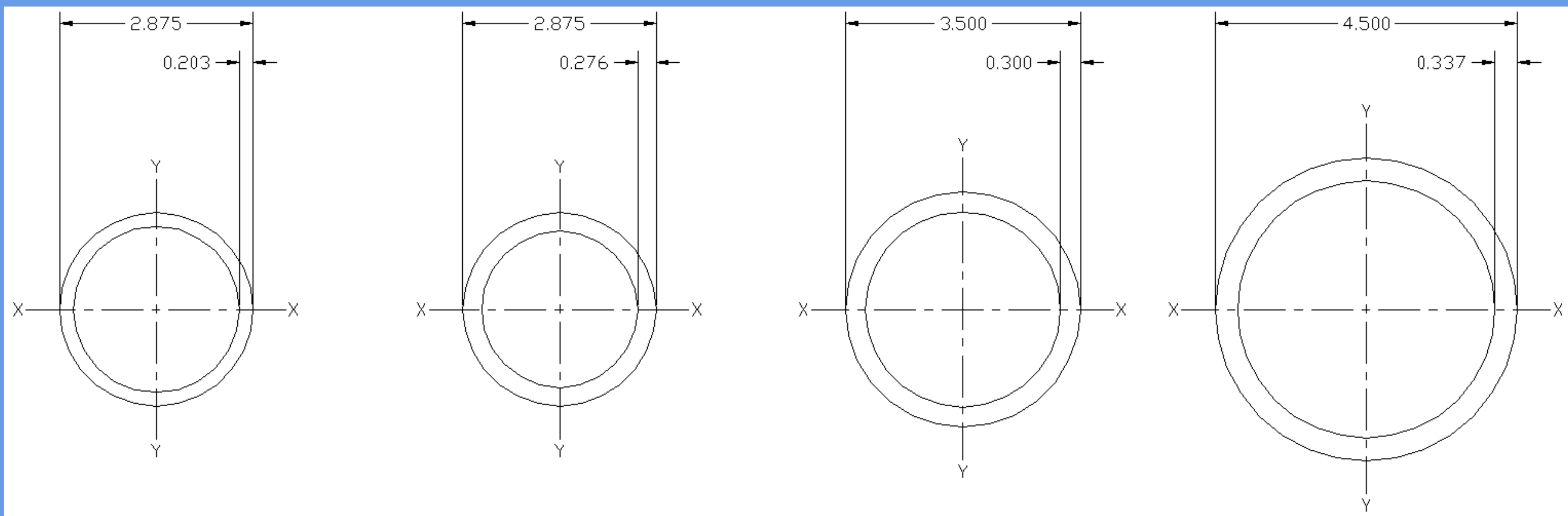
ROCKY MOUNTAIN STEEL FOUNDATIONS

Round Shafts
Torsion and Tension Ratings



RS2875.203
5,500 ft-lb
60 kip (T)
49.5 kip (C)

RS2875.276
8,000 ft-lb
90 kip (T)
72 kip (C)

RS3500.300
13,000 ft-lb
120 kip (T)
91 kip (C)

RS4500.337
23,000 ft-lb
140 kip (T)
138 kip (C)

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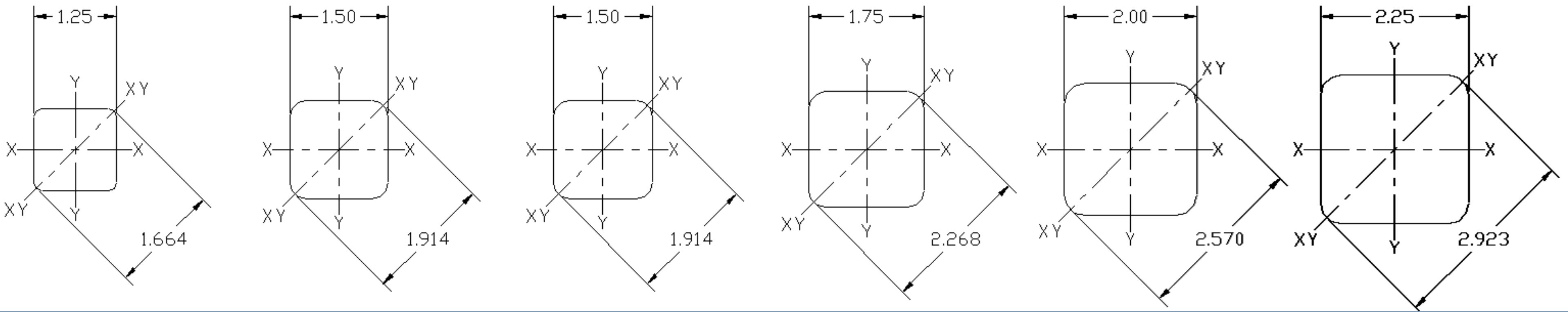
Rocky Mountain
Steel Foundations

Square Shafts
Torsion and Tension Ratings



SS125
4,000 ft-lb
60 kip (T)
40 kip (C)

SS5
5,700 ft-lb
70 kip (T)
57 kip (C)

SS150
7,000 ft-lb
70 kip (T)
70 kip (C)

SS175
10,500 ft-lb
100 kip (T)
105 kip (C)

SS200
16,000 ft-lb
150 kip (T)
150 kip (C)

SS225
23,000 ft-lb
200 kip (T)
200 kip (C)

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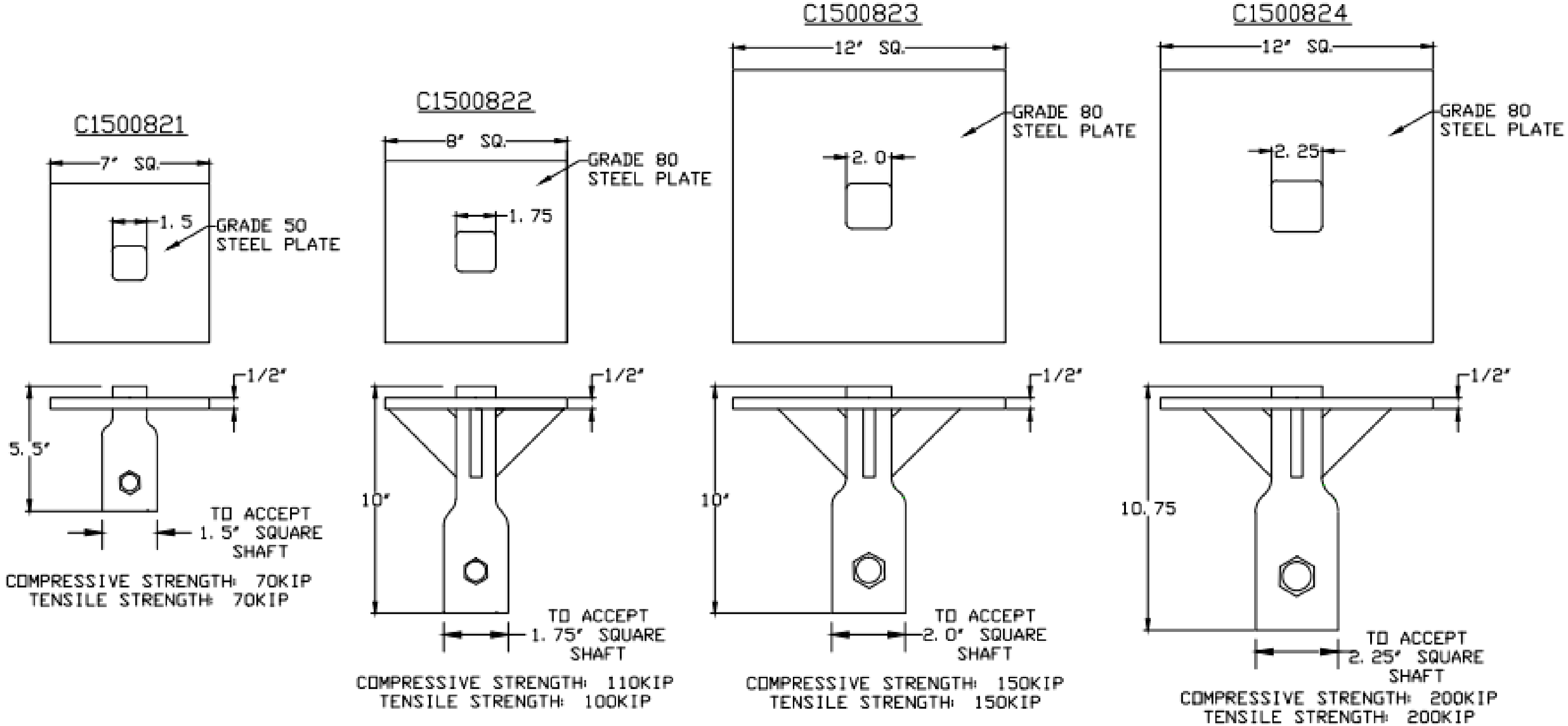
ROCKY MOUNTAIN
STEEL FOUNDATIONS

COMPRESSION/TENSION NEW CONSTRUCTION PILE CAPS



=NOTES=

1. FINISH: STANDARD CATALOG NUMBER IS MILL FINISH STEEL.
   TO ORDER GALVANIZED FINISH ADD 'G' TO STANDARD CATALOG NUMBER.
2. MATERIAL SPECIFICATIONS:
   PLATE: HOT ROLLED STEEL PLATE PER ASTM A572 GRD. 50.
   OR HOT ROLLED STEEL PLATE PER ASTM A656 GRD. 80.
   SOCKET: ROUND CORNER SQUARE STEEL BAR PER TT-76
   BOLT: 3/4" HEX HEAD BOLTS PER ASTM A325 TYPE 1.
   7/8", 1-1/8", AND 1-1/4" HEX HEAD BOLTS PER ASTM A193.

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TOLERANCE CHART

HUBBELL® POWER SYSTEMS

TITLE COMPRESSION/TENSION NEW CONSTRUCTION PILE CAP

SIZE	DWG NO.	CAT / PART / ASSY NO.	REV
SB	SA1500821	SEE DRAWING	C

DO NOT SCALE THIS DRAWING	DRN BY TLW	DATE 8/12/11	SHEET 1 OF 1

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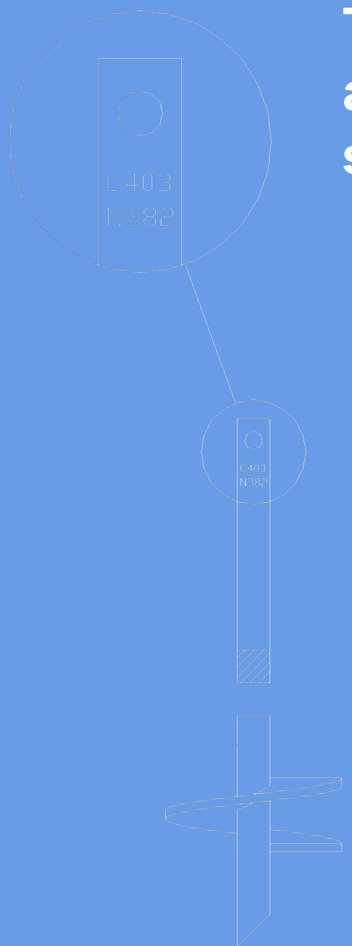
ROCKY MOUNTAIN STEEL FOUNDATIONS

Square Shaft – Material Identification

There are two rows of numbers and letters stamped on the shaft.



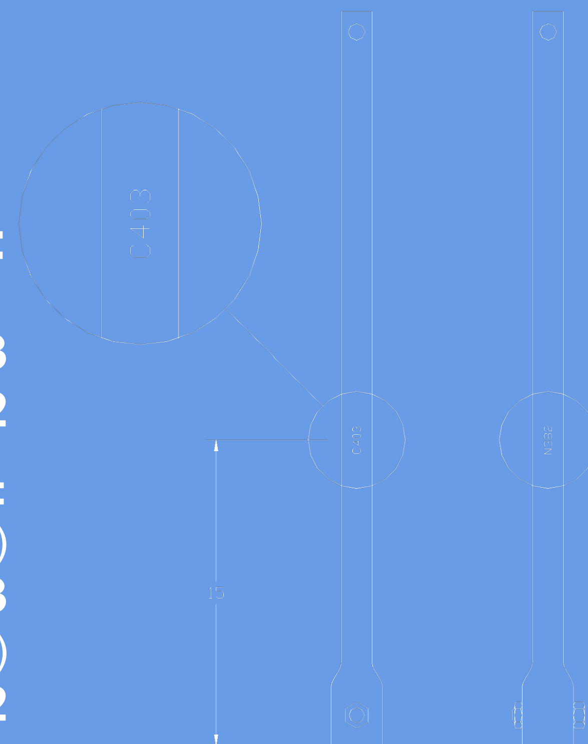
Lead Sections

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

Extension Example:
(stamped on one side)
C403
(stamped at 90º to first side)
N382

C608
- C6 — Material
- 08 — Year

N382
- N — Steel Supplier
- 382 — Heat Number



Extensions

Material Code		Product
C4	TT64	SS5
C6	TT76	SS150, SS175 SS200, SS225

ISO 9001 - Material Certification

CERTIFICATE OF REGISTRATION

This is to certify that

Hubbell Power Systems, Inc.
Centralia Operations
210 North Allen Street, Centralia, Missouri 65240 USA

operates a

Quality Management System

which complies with the requirements of

ISO 9001:2008

for the following scope of registration

The Quality Management System as it applies to design, manufacture and sale of medium voltage class switching and protective equipment, linemen's tools and safety equipment, specialty anchoring products and poleline construction materials for use in the utility, telecommunications, industrial and contractor markets worldwide.

Certificate No:	CERT-0033876	Original Certification Date:	July 1, 1992
File No:	001136	Current Certification Date:	October 22, 2009
Issue Date:	October 7, 2009	Certificate Expiry Date:	October 21, 2012

Chris Jouppi
President,
QMI-SAI Canada Limited

Alex Ezrakhovich
General Manager,
SAI Global Certification Services Pty Ltd

Certified System
ISO 9001

ANAB ACCREDITED

Registered by:
SAI Global Certification Services Pty Ltd, 286 Sussex Street, Sydney NSW 2000 Australia with QMI-SAI Canada Limited, 20 Carlson Court, Suite 100, Toronto, Ontario M9W 7K6 Canada (SAI GLOBAL). This registration is subject to the SAI Global Terms and Conditions for Certification. While all due care and skill was exercised in carrying out this assessment, SAI Global accepts responsibility only for proven negligence. This certificate remains the property of SAI Global and must be returned to them upon request.
To verify that this certificate is current, please refer to the SAI Global On-Line Certification Register: www.qmi-saiglobal.com/qmi_companies/

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ROCKY MOUNTAIN
STEEL FOUNDATIONS

Standard Helices Diameters

6-inch
8-inch
10-inch
12-inch
14-inch
16-inch

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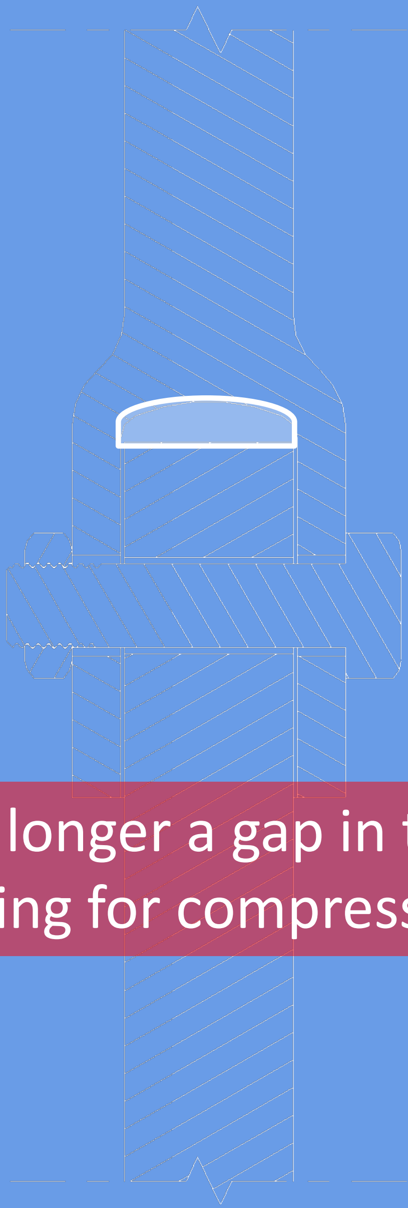
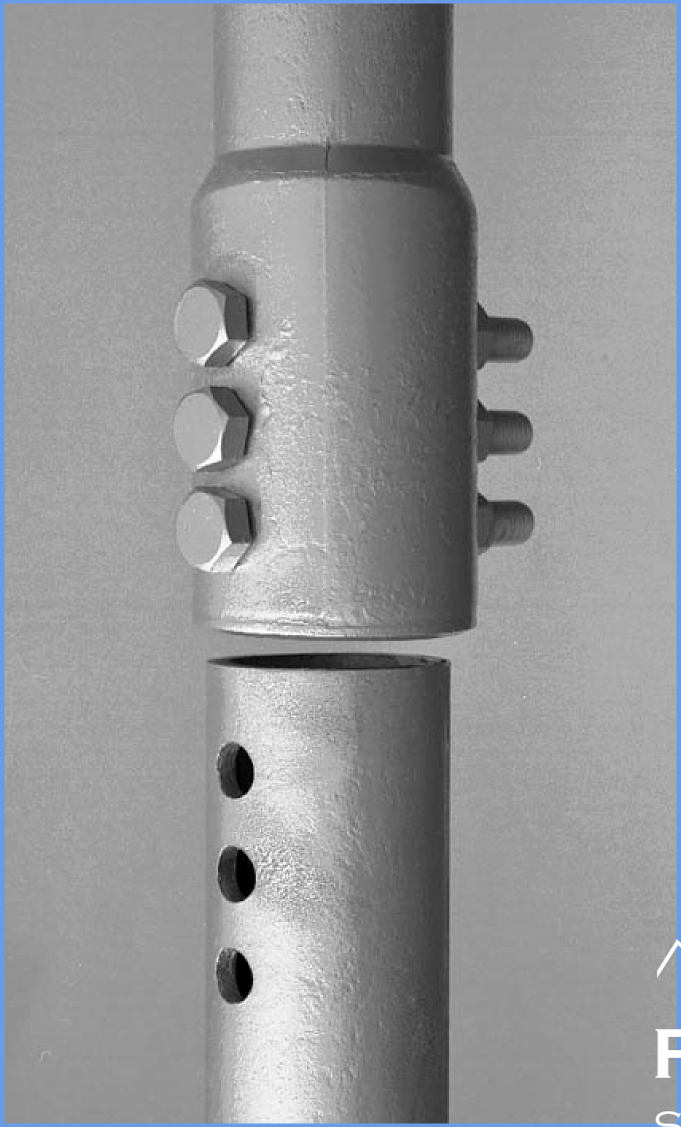
ROCKY MOUNTAIN
STEEL FOUNDATIONS

Square Shaft Coupling



There is no longer a gap in the coupling – Direct bearing for compressive loads

Round Shaft Coupling



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STEEL FOUNDATIONS

Torque Indicators

Shear Pin Torque Limiter

Wireless Electronic Torque Monitor

Differential Pressure Indicator

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ROCKY MOUNTAIN
STEEL FOUNDATIONS

Installation Equipment

Torque Motors

3,500 ft-lb

6,000 ft-lb

12,000 ft-lb

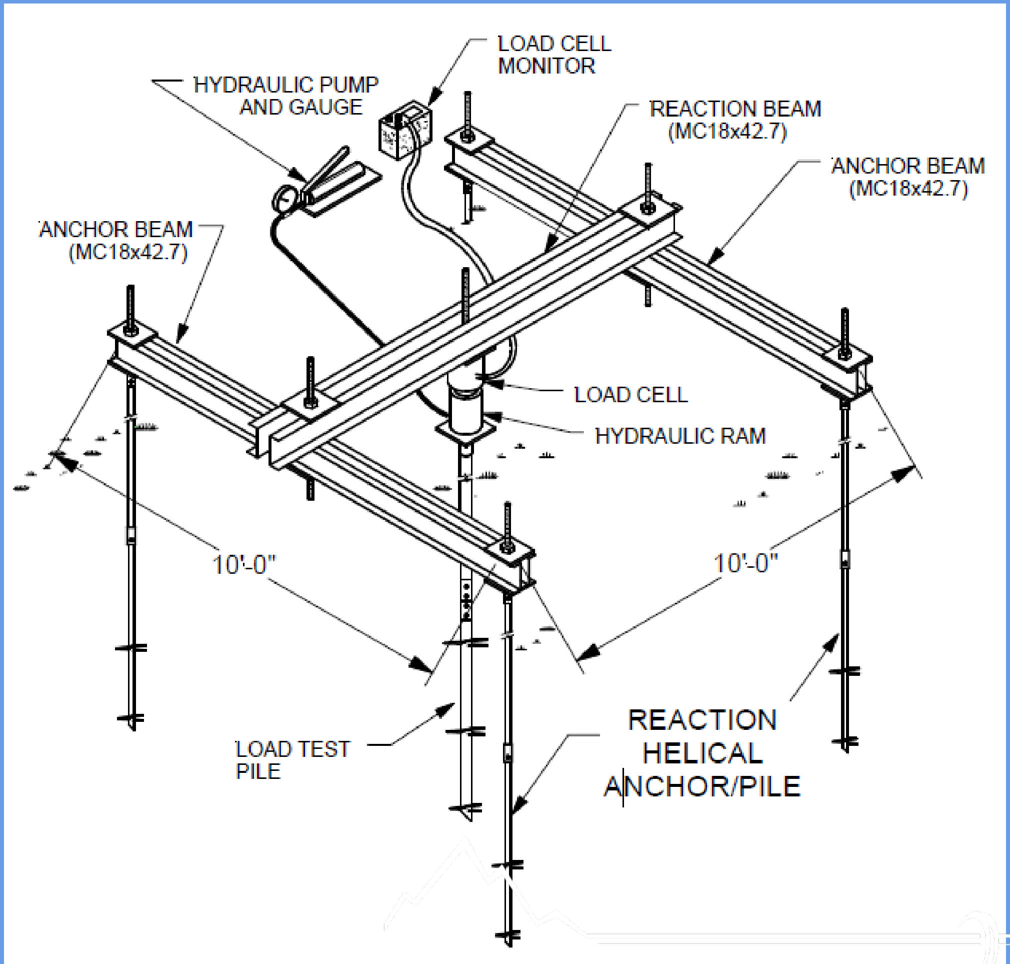
20,000 ft-lb

ROCKY MOUNTAIN

STEEL FOUNDATIONS

Load Test Procedure

- Hydraulic Pump (with Calibration) loaded in 500 psi increments
- Hold Load for 2.5 minutes
- Measure Deflection



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Compression Load Test

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STEEL FOUNDATIONS

Table 1: Steps for Pre-Production Load Testing:

Load Step	Hold Time (Minutes)
AL	2.5
0.20 DL	2.5
0.40 DL	2.5
0.50 DL	2.5
0.20 DL	1.0
AL	1.0
0.40 DL	1.0
0.60 DL	2.5
0.80 DL	2.5
1.00 DL	2.5
0.50 DL	1.0
0.20 DL	1.0
AL	1.0
0.50 DL	1.0
1.00 DL	1.0
1.20 DL	2.5
1.40 DL	2.5
1.60 DL	2.5
1.80 DL	2.5
2.00 DL	10

Sample Load/Disp Curve

Tension Test - HP 2 - SS175 8/10 Double x 28' - T = 9,200 ft*lb
Performed 8/6/2019

DL 100 ton jack power pump

18000	LOAD	PSI	GuageA	Guage B	hold	load (kip)	Δ A	Δ B	Δ Ave
0.5	9000	535	0.618	0.700	1.0	9.00	0.000	0.000	0.000
1	18000	975	0.624	0.708	2.5	18.00	0.006	0.008	**0.007**
1.2	21600	1151	0.625	0.710	2.5	21.60	0.007	0.010	0.009
1.4	25200	1327	0.628	0.716	2.5	25.20	0.010	0.016	0.013
1.6	28800	1503	0.631	0.72	2.5	28.80	0.013	0.020	0.017
1.8	32400	1679	0.642	0.736	2.5	32.40	0.024	0.036	0.030
2	36000	1855	0.671	0.799	10.0	36.00	0.053	0.099	**0.076**
1.5	27000	1415	0.666	0.792	1.0	27.00	0.048	0.092	0.070
1	18000	975	0.664	0.792	1.0	18.00	0.046	0.092	0.069
0.5	9000	535	0.662	0.786	1.0	9.00	0.044	0.086	0.065
0.1	1800	183	0.649	0.766	1.0	1.80	0.031	0.066	0.049

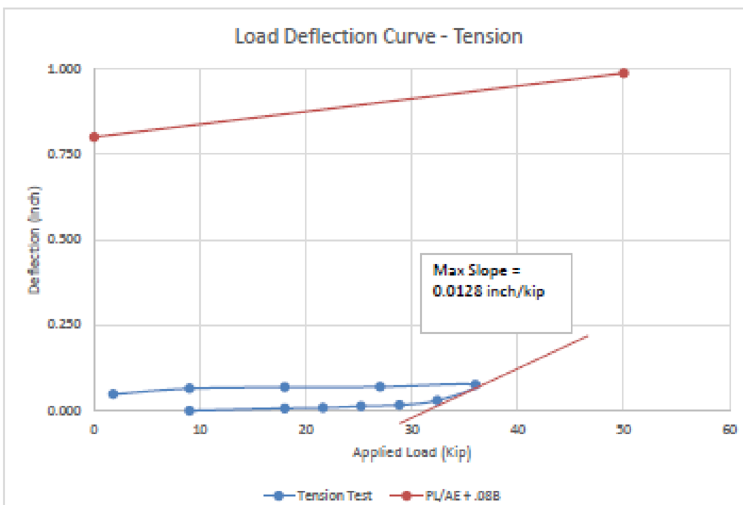
Elastic

B=	10	in
L=	28	ft
A=	3.1	in^2

.08B + PL/AE

Load	PL/AE
0	0.8
50	0.987

max slope = 0.0128 inch/kip <0.05 GOOD!
1.8 to 2.0



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Tension Test – Tieback Anchor

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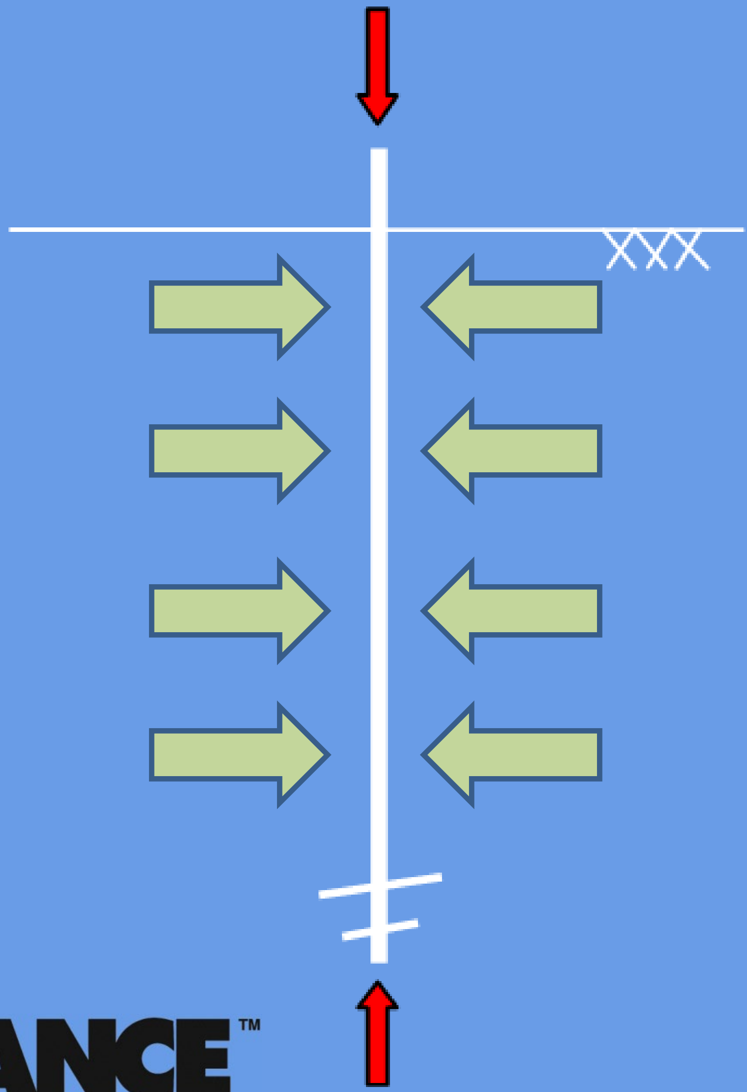
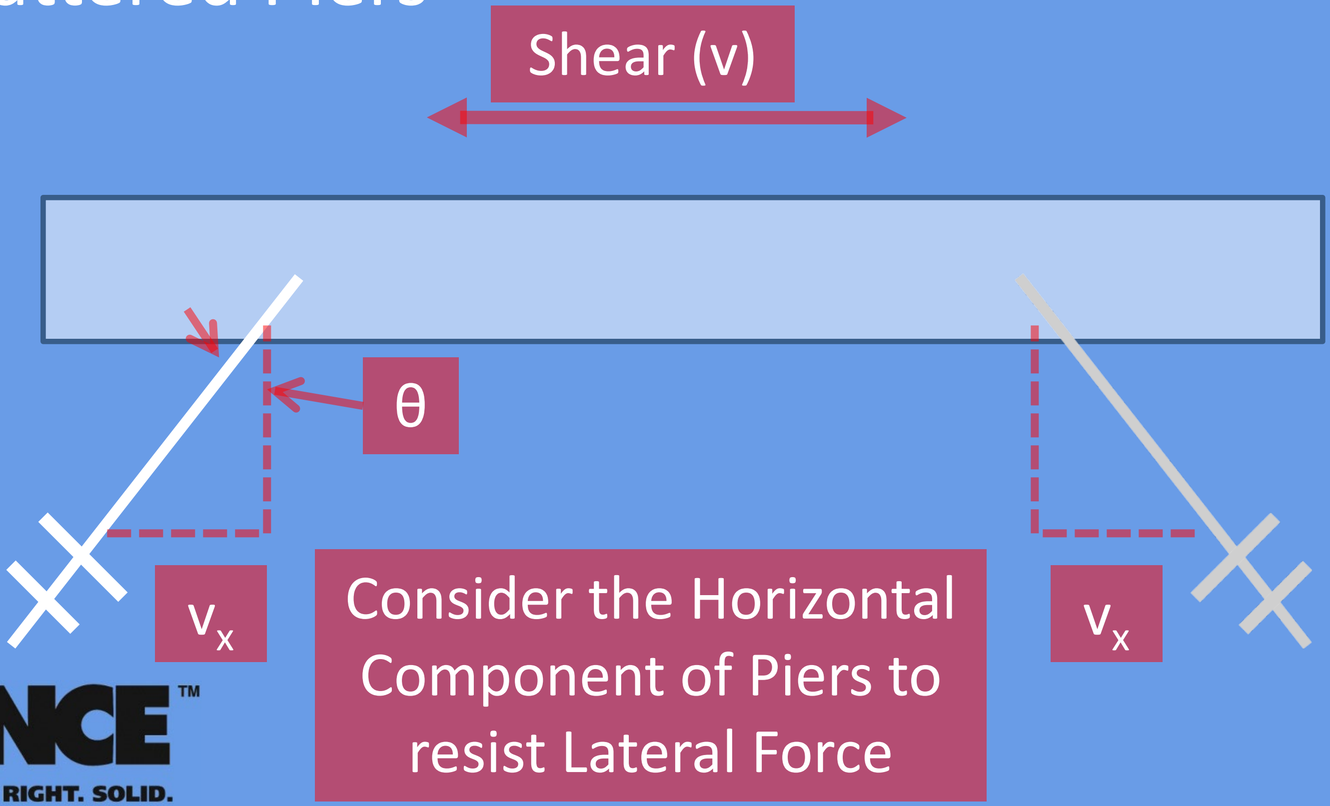
Shaft Buckling



- Research shows Elastic Buckling is a Practical Concern Only in the Softest Soils
  - Soil Provides Lateral support to shaft
- Practical Guideline: Soil with SPT Blow count of **4 or less**
  - Very soft & soft clays
  - Very loose sands
- Helical Pulldown® Micropile
- Pipe Sleeve

Lateral Loads

- Passive Earth Pressure
- Skin Friction (Grade Beam to Soil)
- Battered Piers



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Corrosive Environments

- Soil Type
  - Fine grained clay and silts
  - Organics
  - Contaminants
  - Disturbed vs. Undisturbed
- Moisture Content
  - Corrosion potential increases with an increase in moisture content
  - Saturated soils with little or no oxygen have reduced corrosion potential
- pH
  - Neutral soils with pH~7 have lower corrosion potential
- Resistivity
  - Used to determine corrosion potential
  - Low resistivity means higher corrosion potential

3 Levels of Corrosion Protection

- Sacrificial Anodes (Magnesium or Zinc bags)
- Hot dipped galvanizing or other coatings
- Sacrificial loss of Steel (may vary based on region or engineer preference)

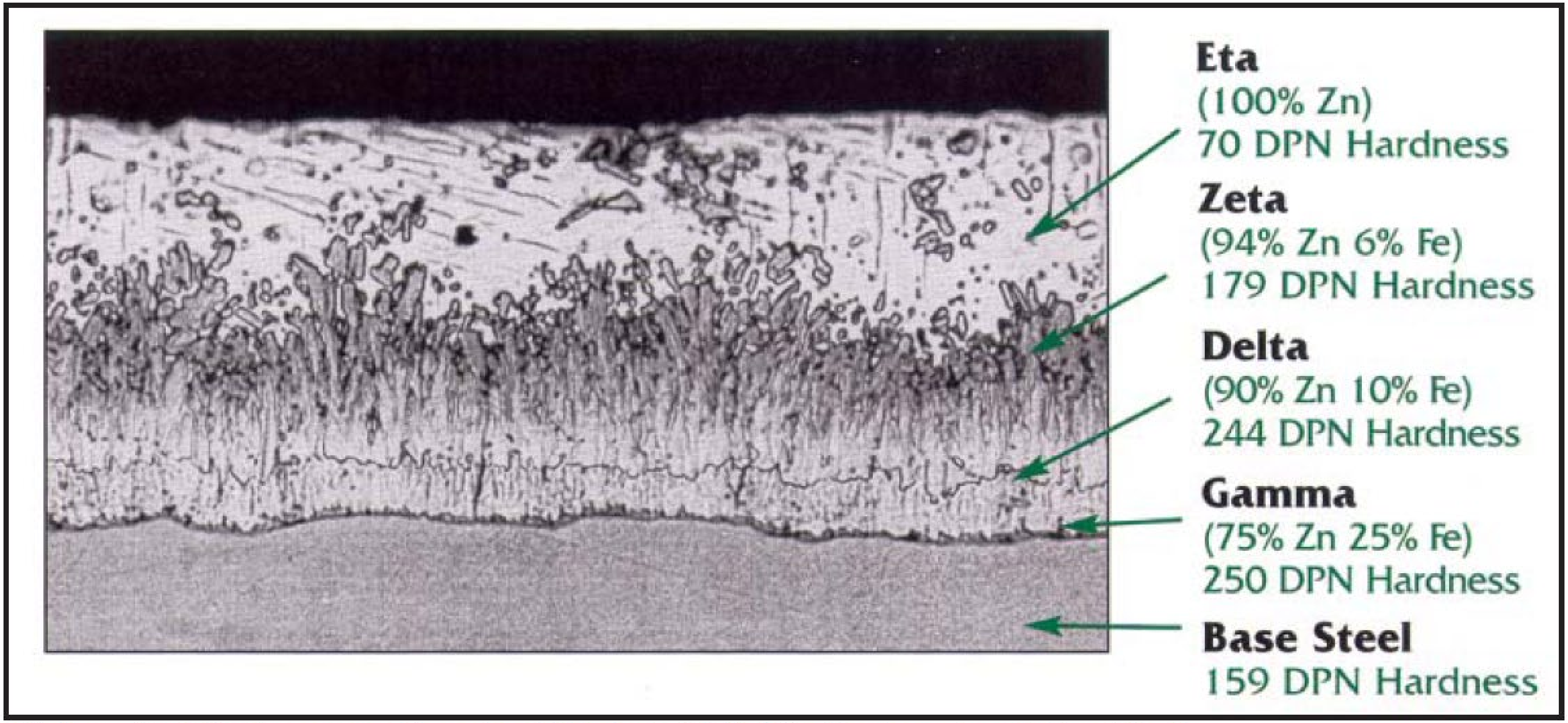

Figure 6: Photomicrograph of Batch Hot-Dip Galvanized Coating

American Galvanizers Association
www.galvanizeit.org

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Why Chance Helicals?

- Quick Installation (Time)
- No Spoils, Immediate Loading
- Known & Verified Holding Capacity
- Water Table/Contaminants does not adversely affect installation
- Reliable & Uniform System/Design - ISO 9001
- Manageable Segmented System/Limited Access
- Building Code (IBC) Compliance
- Quality Manufacturing since **1912**

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ROCKY MOUNTAIN STEEL FOUNDATIONS

Foundation Underpinning

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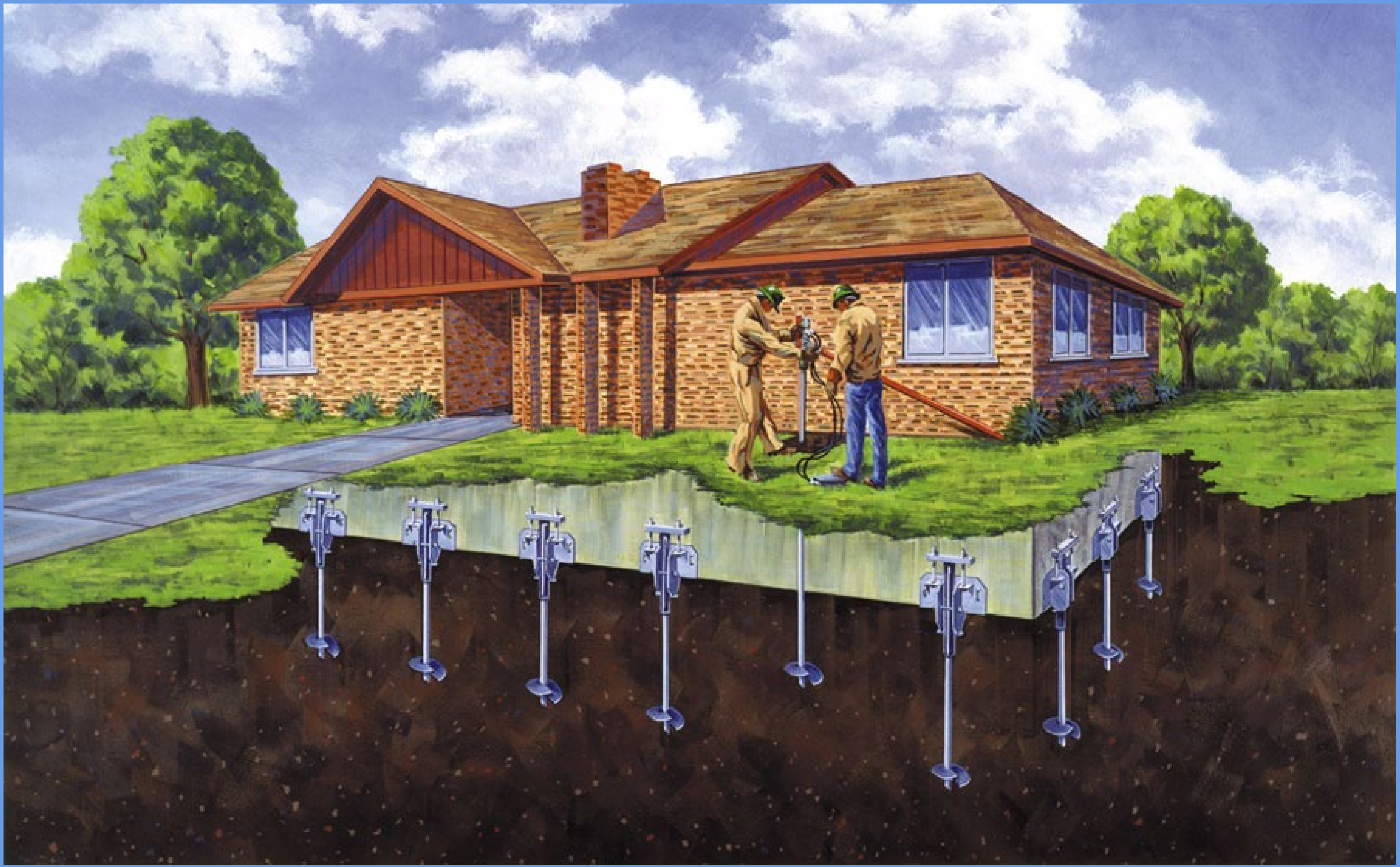

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Applications

- Stabilization
  - Prevent Further Movement
- Lifting
  - 4” or more

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Underpin

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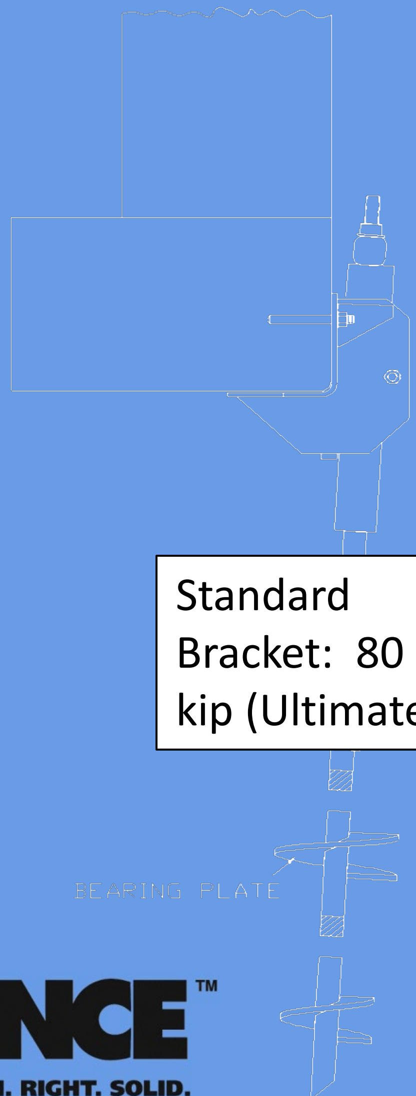
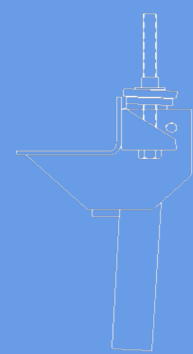
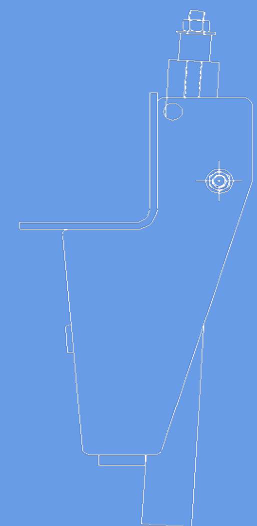
Brackets



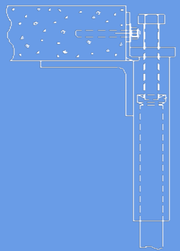
Standard Bracket: 80 kip (Ultimate)



Low Profile Bracket: 30 kip (Ultimate)



Heavy Duty Bracket: 120 kip (Ultimate)



Porch Bracket: 10 kip (Ultimate)

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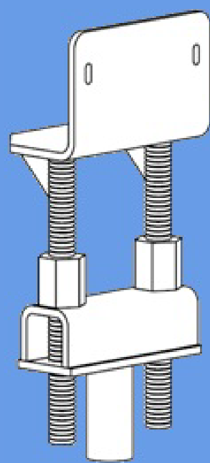
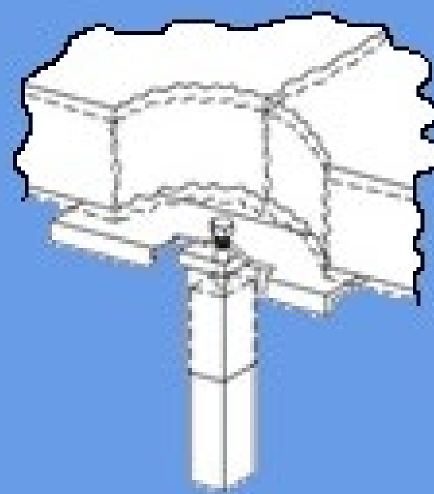
ROCKY MOUNTAIN STEEL FOUNDATIONS

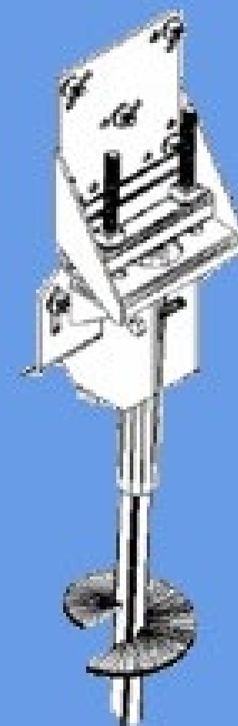
Brackets Cont.



Direct Jack (DJ) Bracket: 100 kip (Ultimate)



Slab Bracket: 10 kip (Ultimate)



Uplift Bracket: 15 kip (Ultimate)

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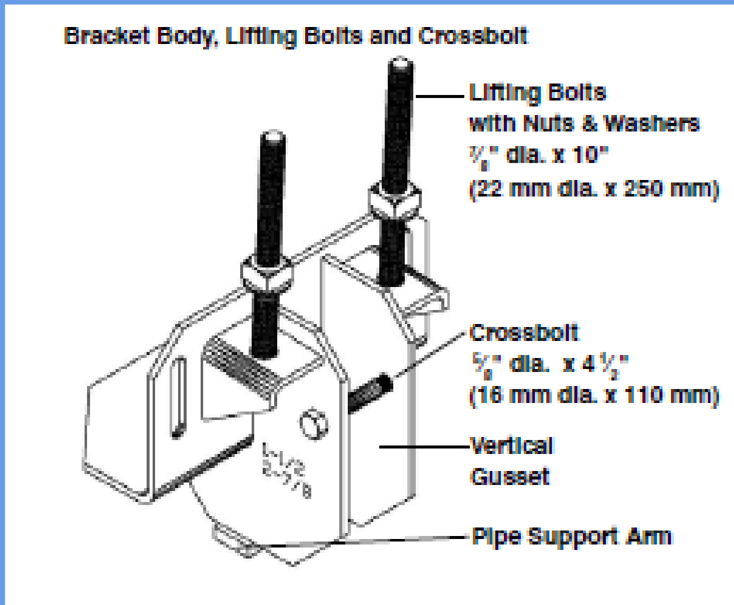
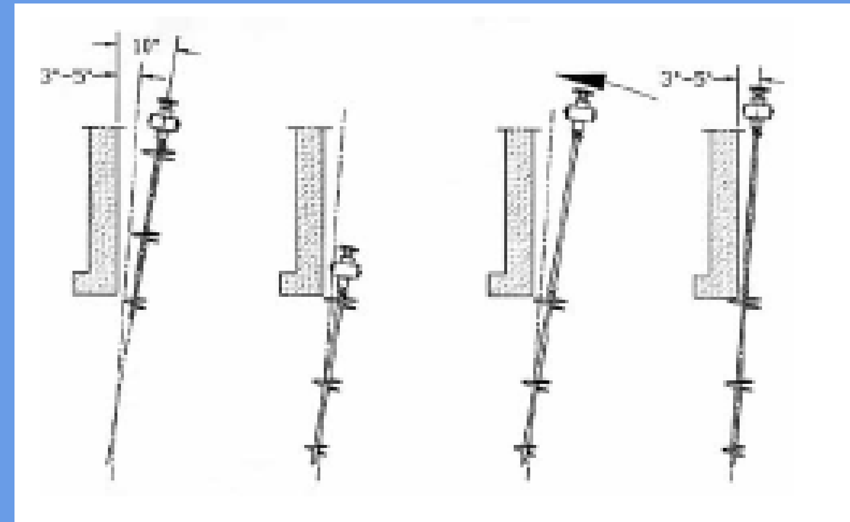
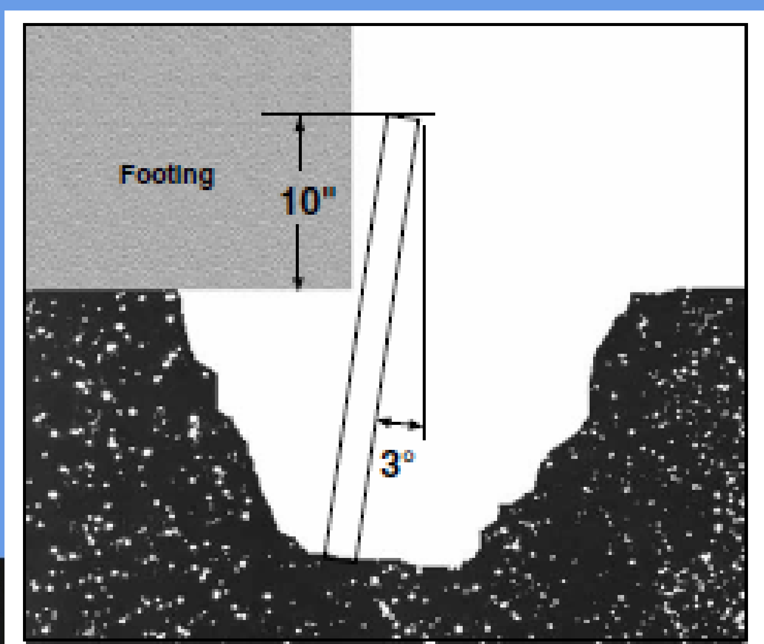
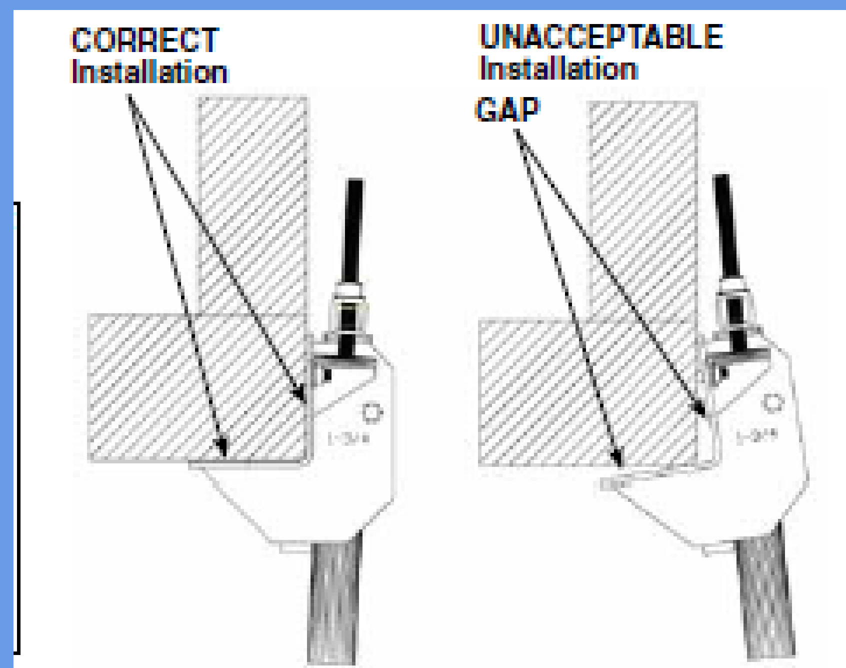
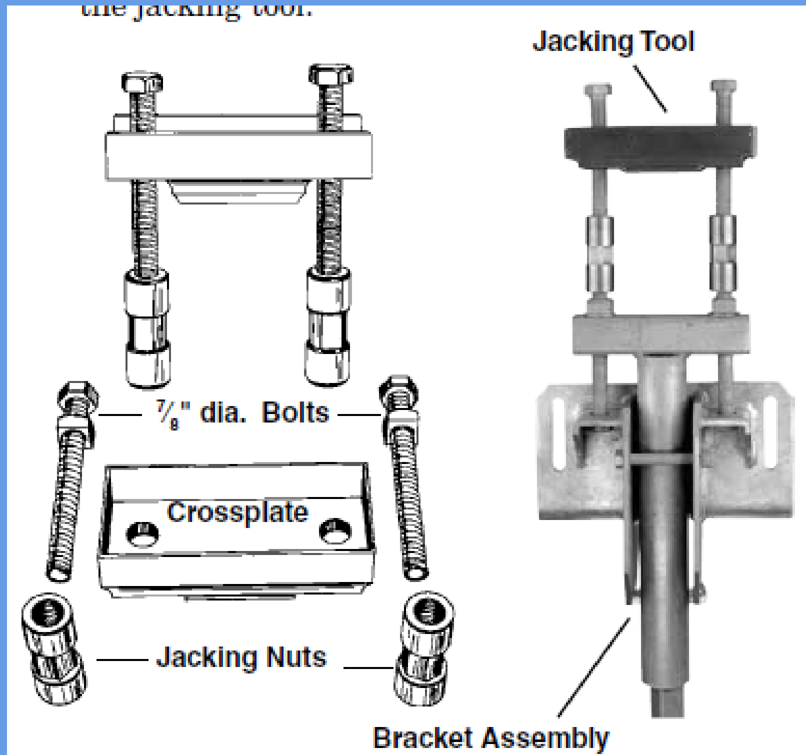
Rocky Mountain STEEL FOUNDATIONS

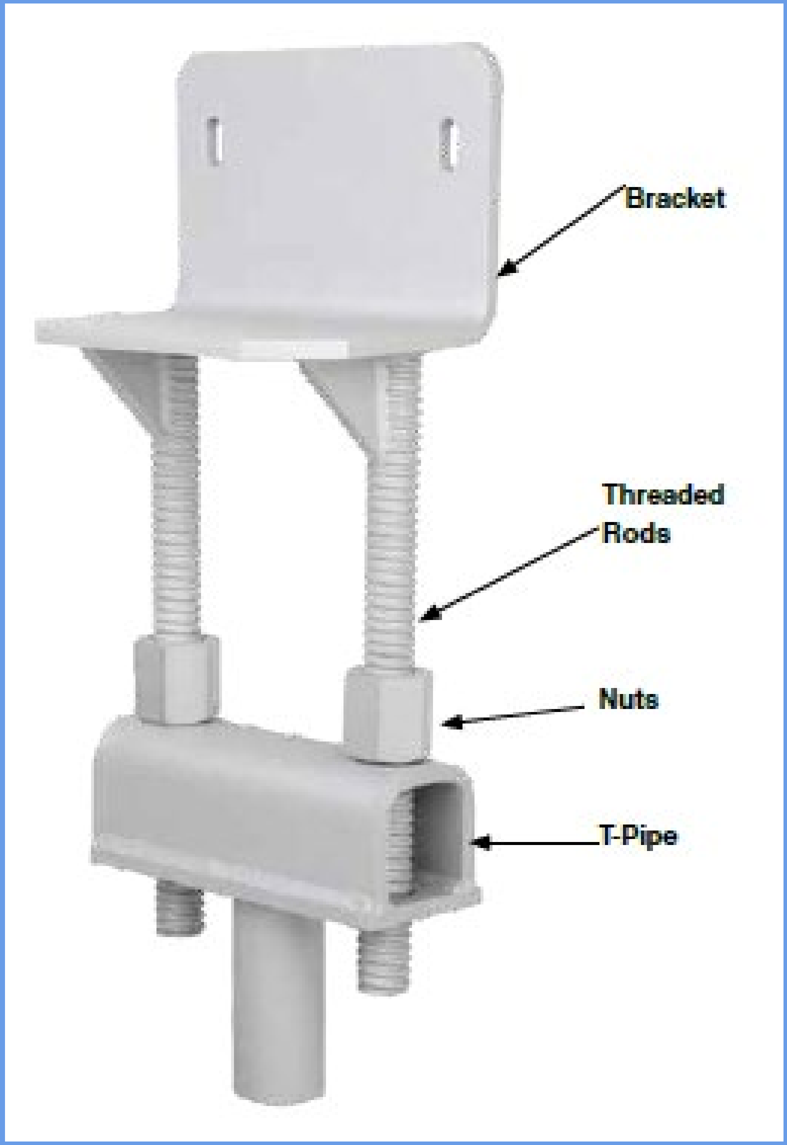

Bracket Body, Lifting Bolts and Crossbolt
Lifting Bolts
with Nuts & Washers
7/8" dia. x 10"
(22 mm dia. x 250 mm)
Crossbolt
5/8" dia. x 4 1/2"
(16 mm dia. x 110 mm)
Vertical
Gusset
Pipe Support Arm

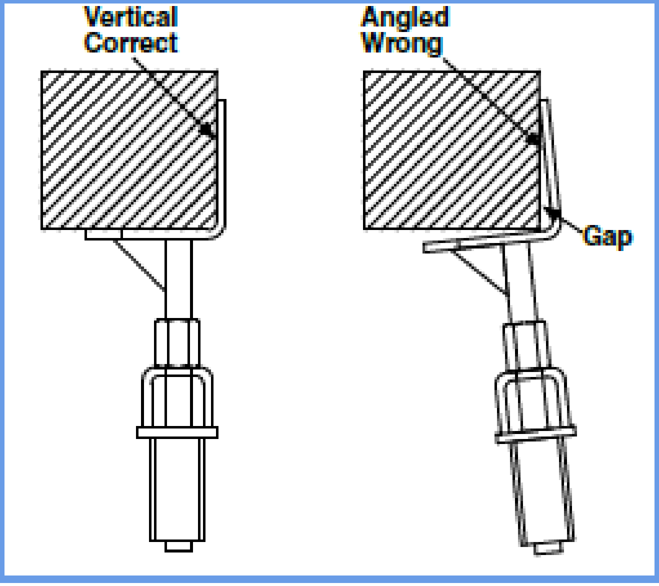


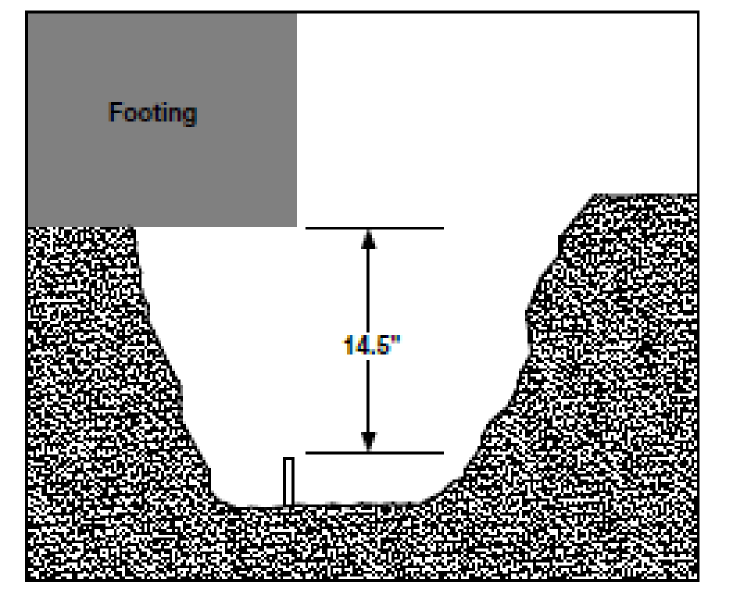

Footing
10"
3°


CORRECT
Installation
UNACCEPTABLE
Installation
GAP


Jacking Tool
⅞" dia. Bolts
Crossplate
Jacking Nuts
Bracket Assembly







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STEEL FOUNDATIONS

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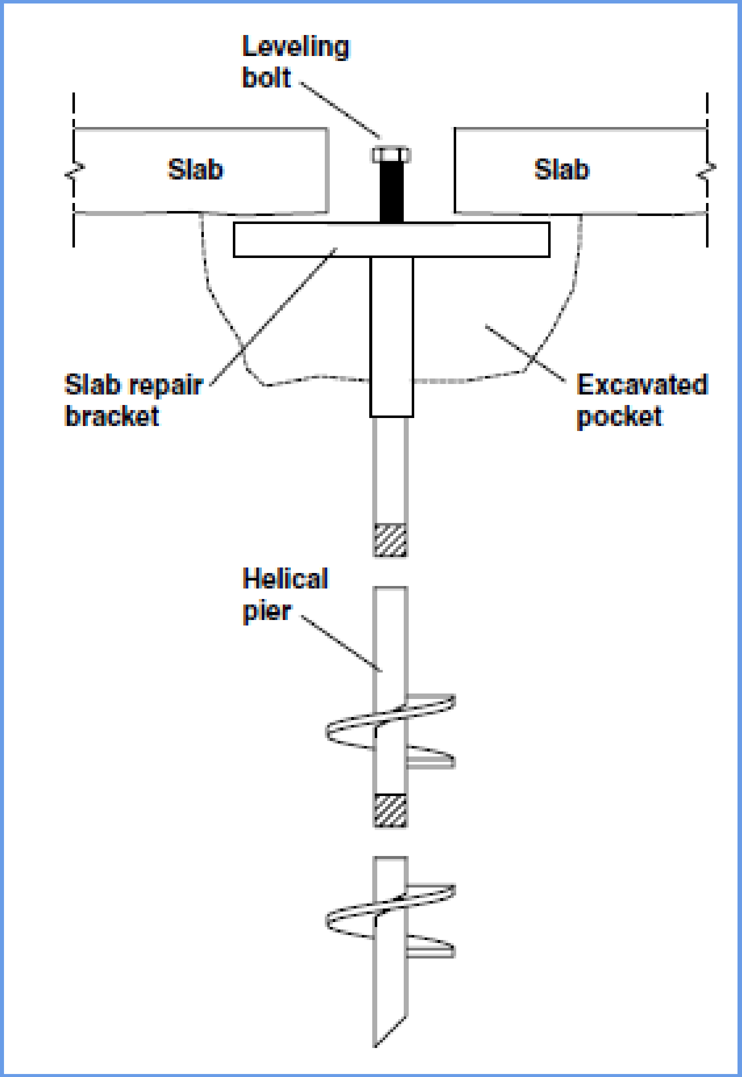
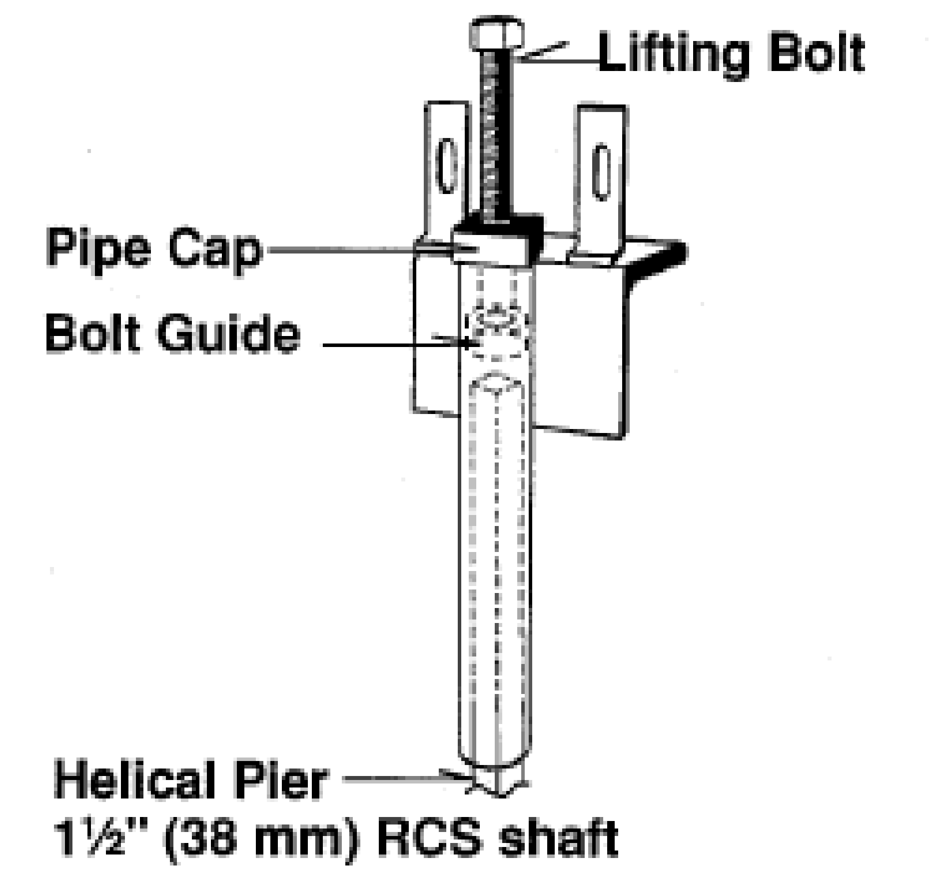
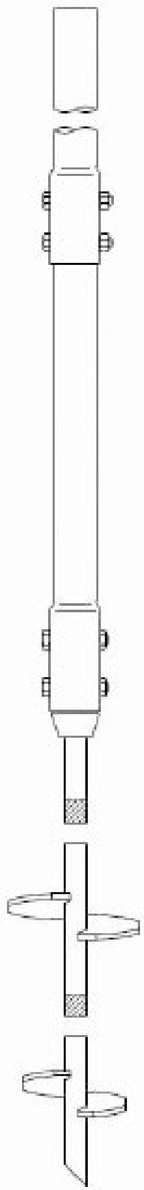

Leveling bolt
Slab
Slab
Slab repair bracket
Excavated pocket
Helical pier


Lifting Bolt
Pipe Cap
Bolt Guide
Helical Pier
1½" (38 mm) RCS shaft



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New Construction

Rocky Mountain

Steel Foundations

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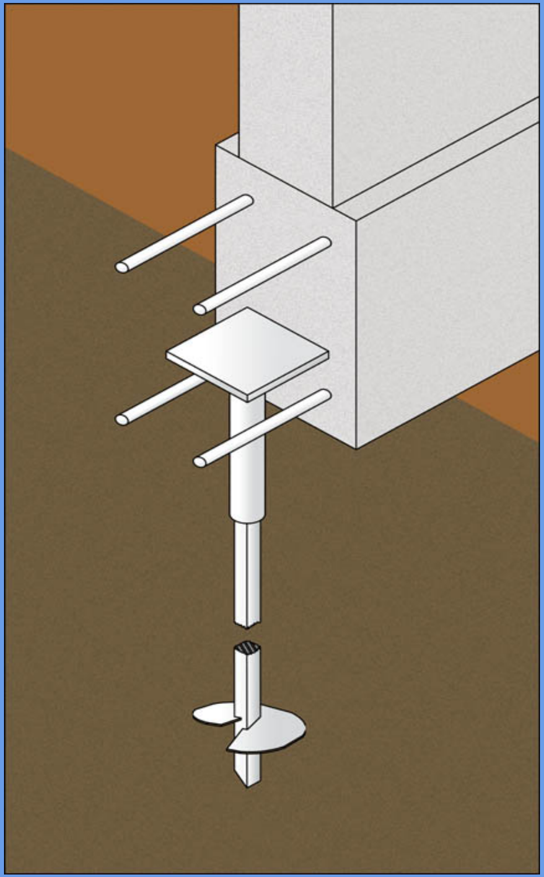

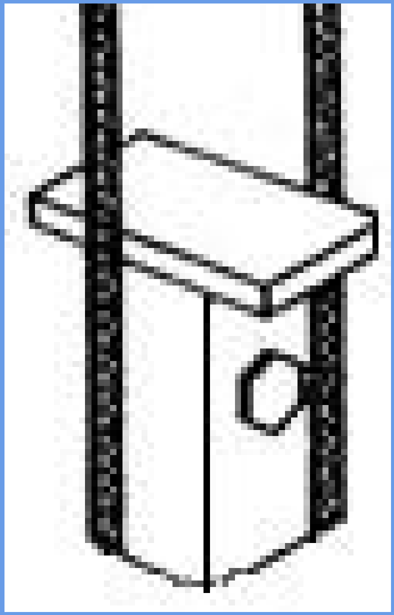

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Helical Pulldown® Micropile

Rocky Mountain
Steel Foundations

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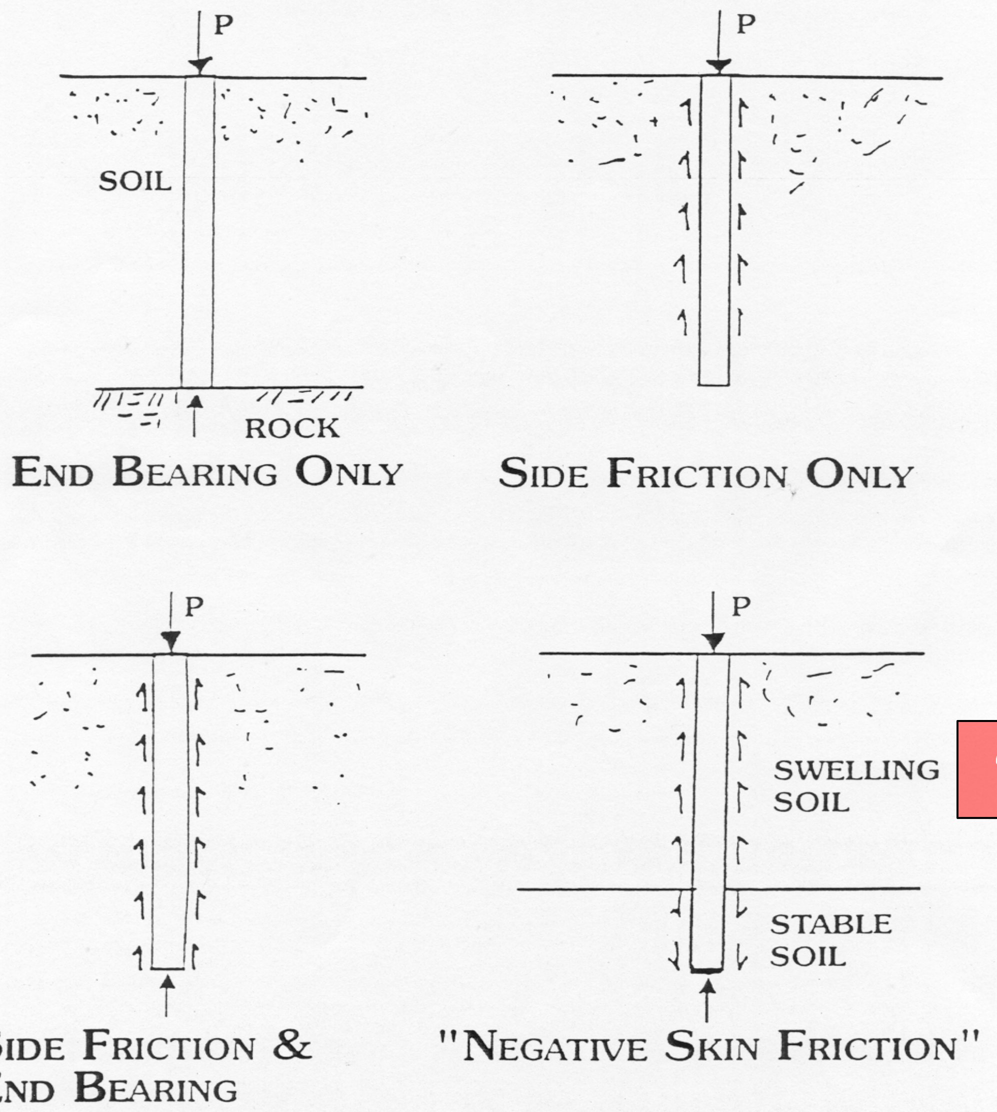
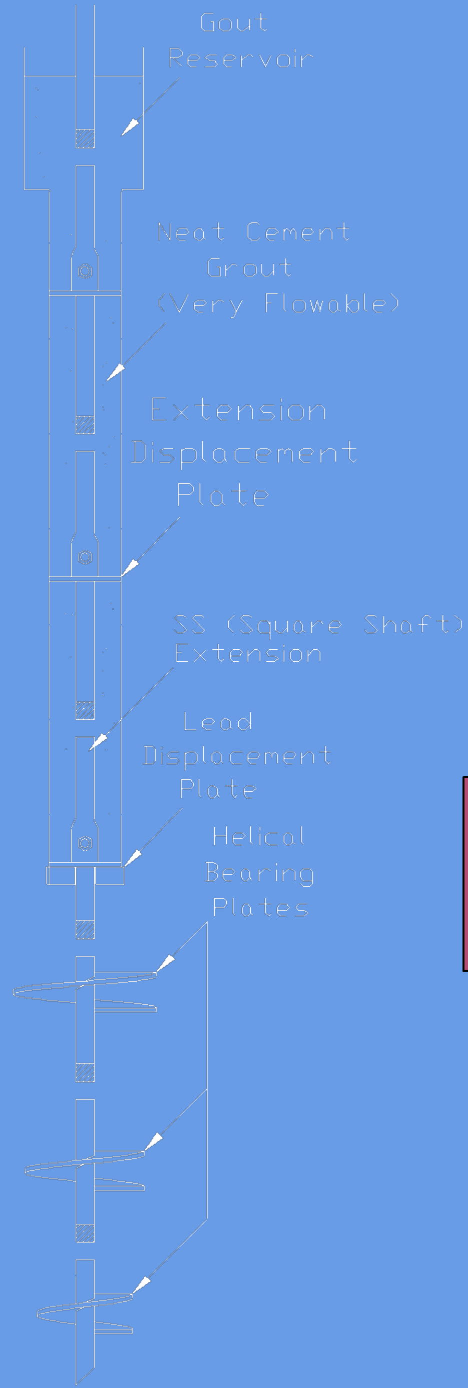
LOAD TRANSFER MECHANISMS
(Compression Loading)



"Active Zone"



Extension Displacement Plate

Lead Displacement Plate

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STEEL FOUNDATIONS

Installing Shaft Extension

Grout “Pulled Down”

Grout Column in Clay

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Grout Column in Sand

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Helical Pulldown® Micropile - Summary

- Increased Capacities (Skin Friction)
- Adjustable grout column diameters
- PVC or Steel Casing (@ any depth if Req'd)
- Video on Website, Facebook, & YouTube

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Rocky Mountain Steel Foundations

Tiebacks and Soil Screws®

Rocky Mountain
STEEL FOUNDATIONS

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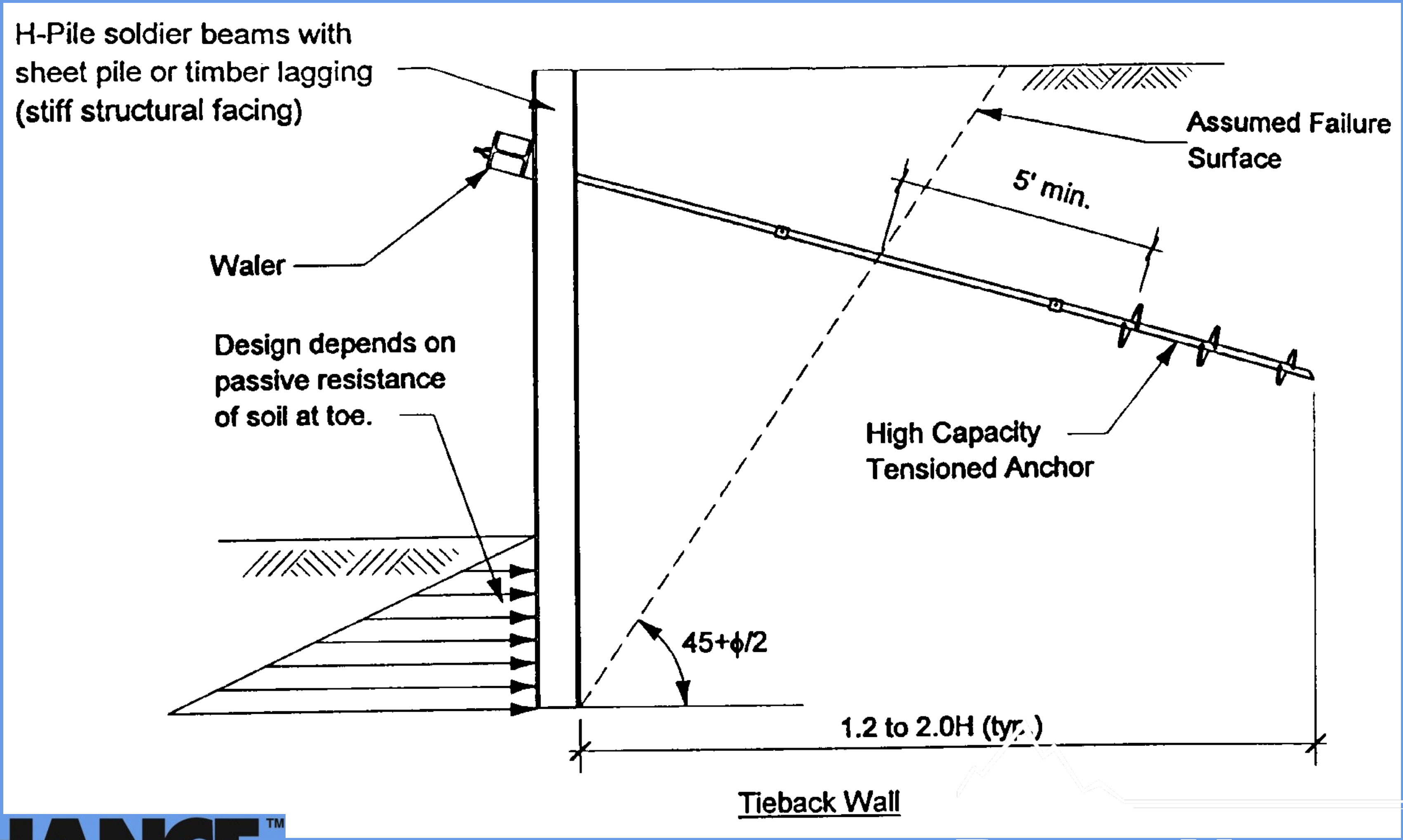
Tieback Typical Section



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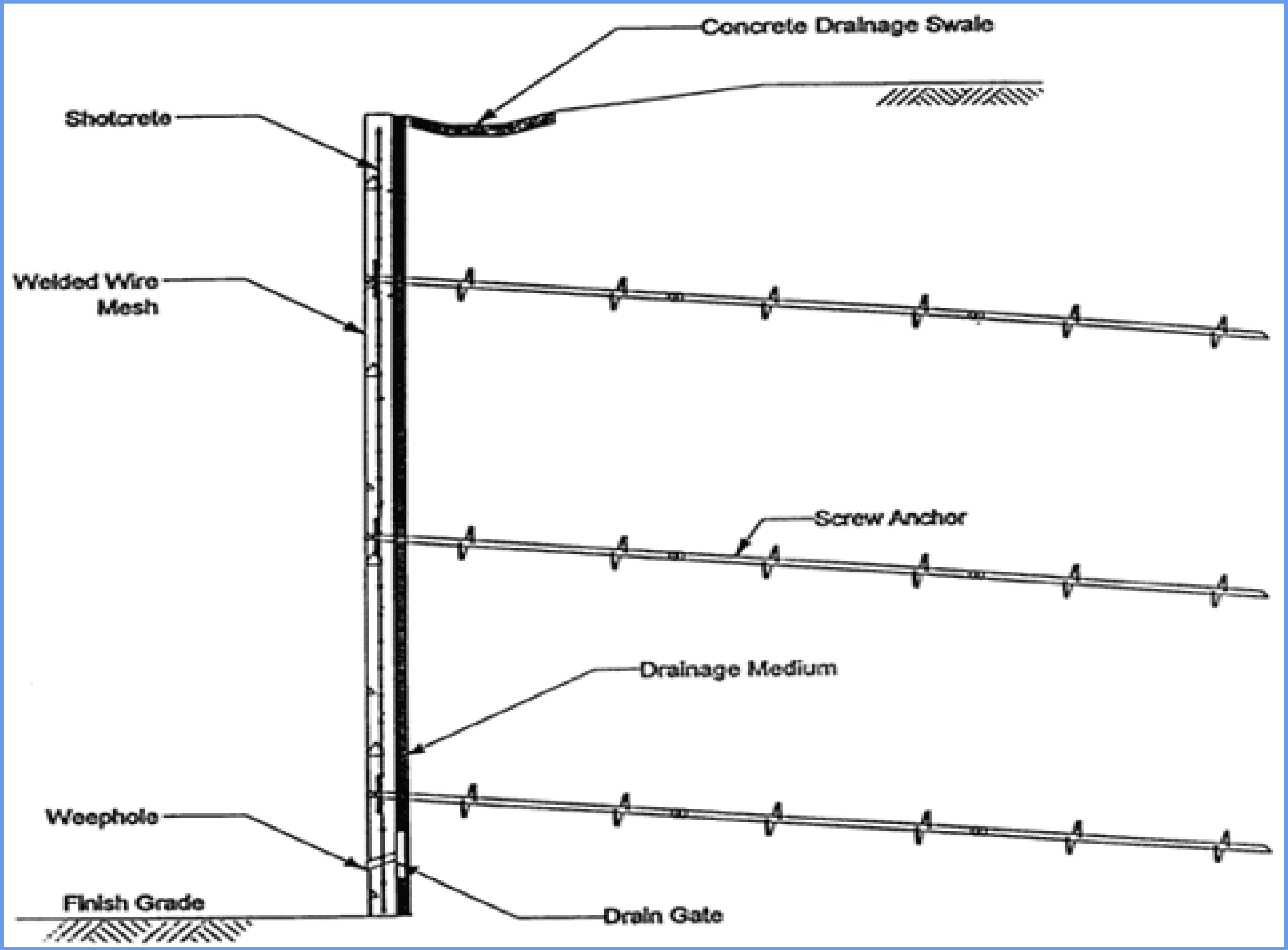
Soil Screw® Typical Section



Soil Screw® Installation Sequence

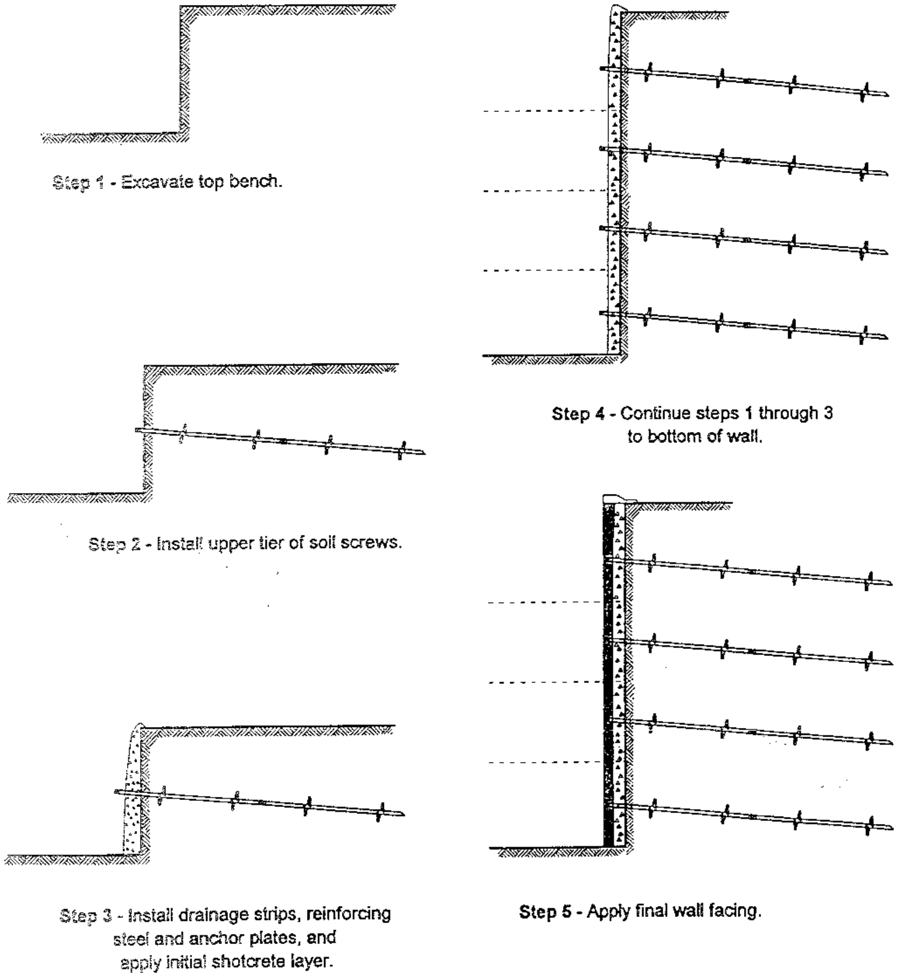
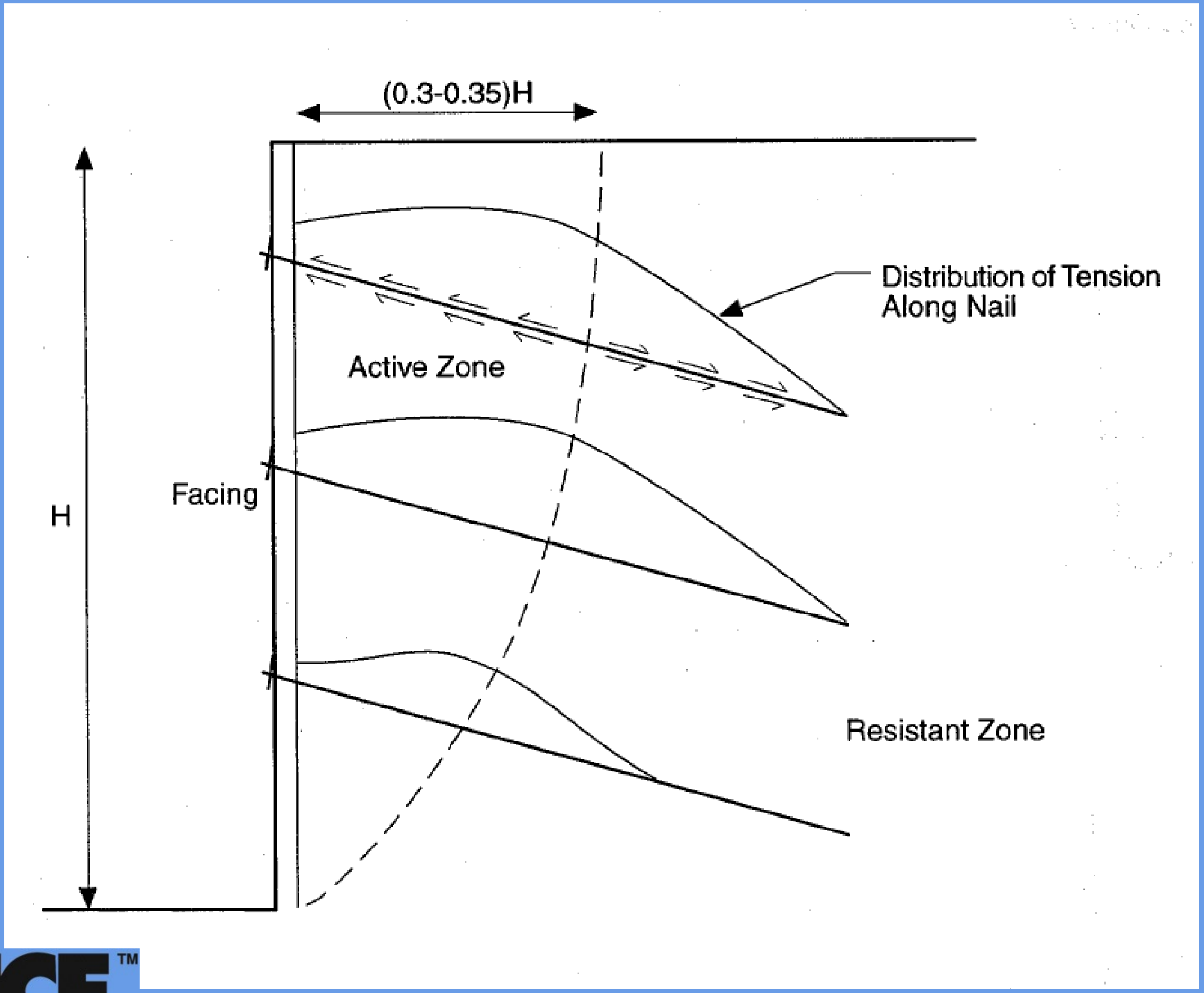
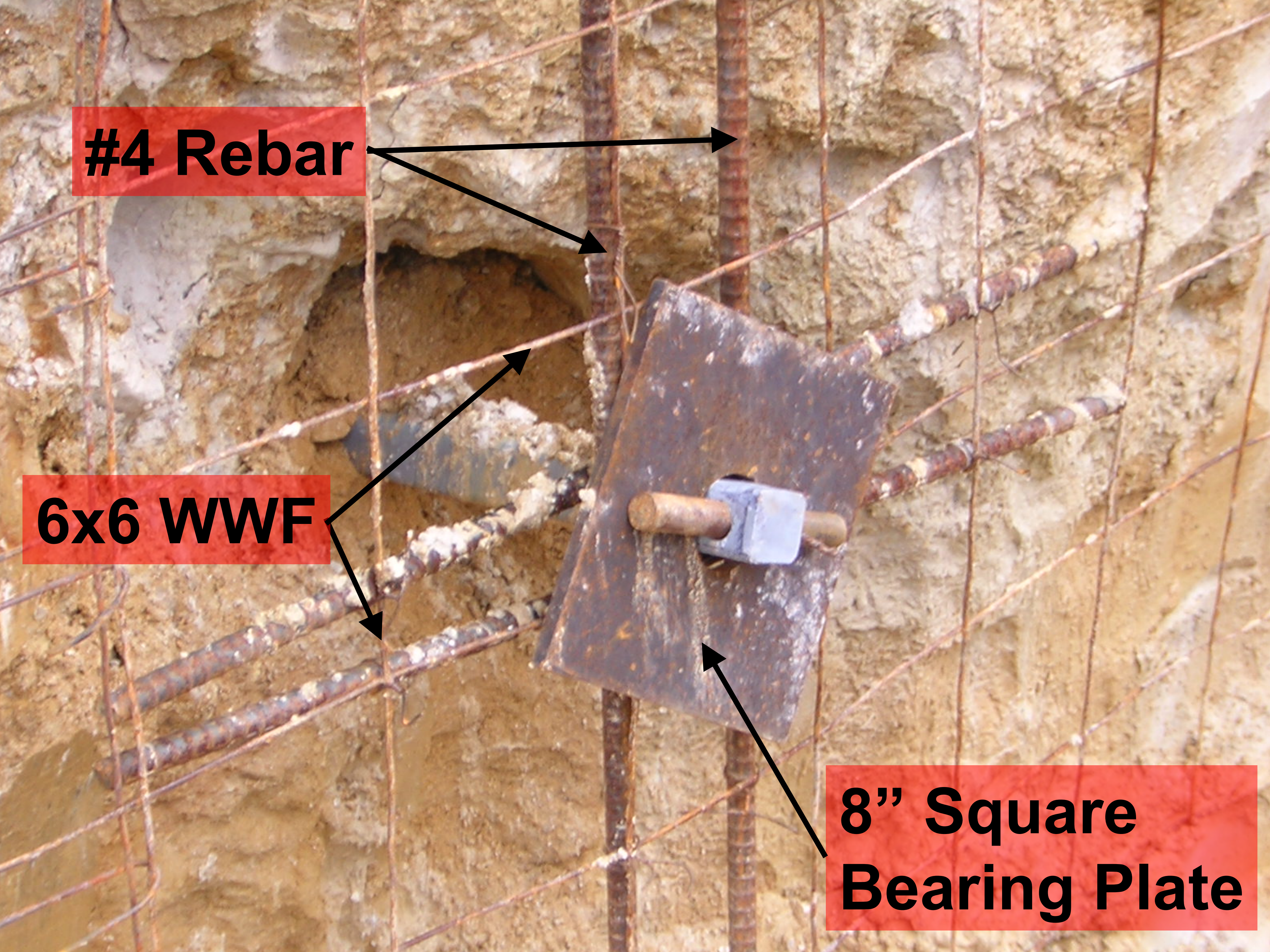


Figure 1.2.1 SOIL SCREW™ Retention Wall System Installation Sequence.

- Soil Screws are installed in "top down construction"
- Typical excavation depths of 3 to 5 ft are used in each step
- Steel reinforcement, bearing plates, drainage medium and shotcrete is applied at each cut
- Typical wall thickness are 4 inches for temporary to 6 inches for permanent
- References for design:
- FHWA0-IF-03-017 - Geotechnical Engineering Circular No. 7 – Soil Nail Walls
- FHWA-SA-96-069R – Manual for Design and Construction Monitoring of Soil Nail Walls

Soil Screw® Tensile Load




#4 Rebar
6x6 WWF
8” Square
Bearing Plate

Space – At A Premium!
Helical Soil Nails – The Solution.

First Row of *Helical* Soil Nails Installed Including Special Designed Head Assembly

Specially Designed Soil Nail Head Assembly Installed

Apply the Second Application of Shotcrete:

Second Layer of Shotcrete Applied - Project Complete!

Contact Information

- Ian Romain, P.E.
  - Phone: 406-756-7437
  - Cell: 406-579-6076
  - Email: ian@rockymtnsteel.com

ROCKY MOUNTAIN

STEEL FOUNDATIONS

Case Histories

Rocky Mountain
Steel Foundations

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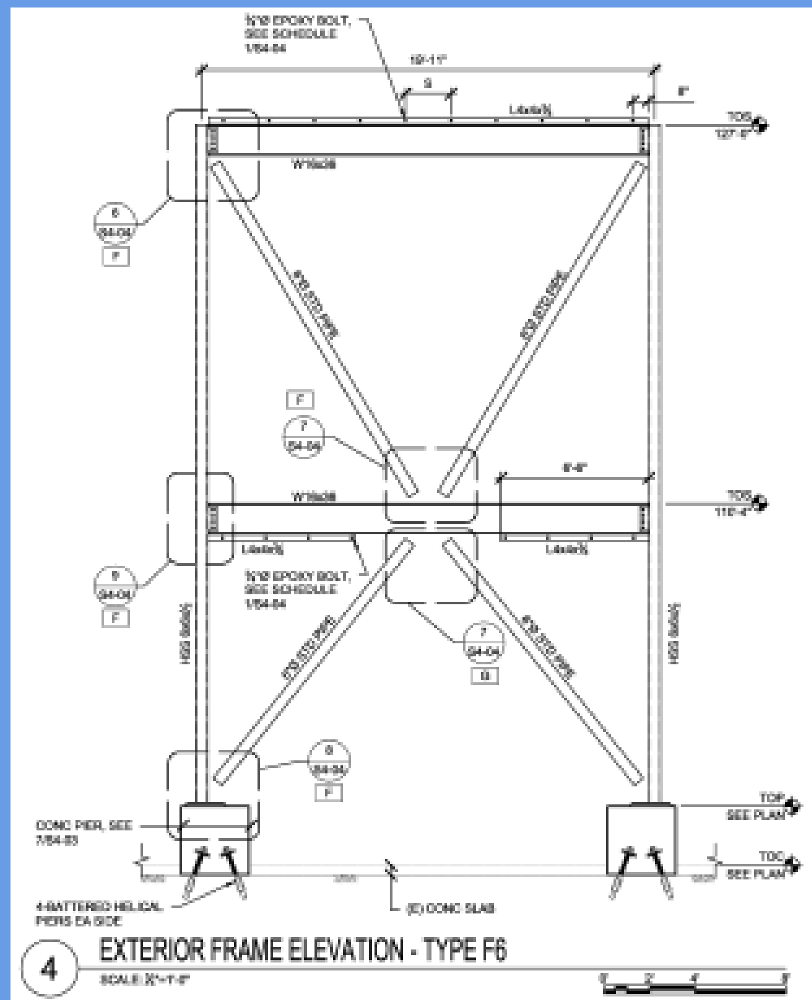
MSU – Cheever/Howard/Haynes Seismic Retrofit



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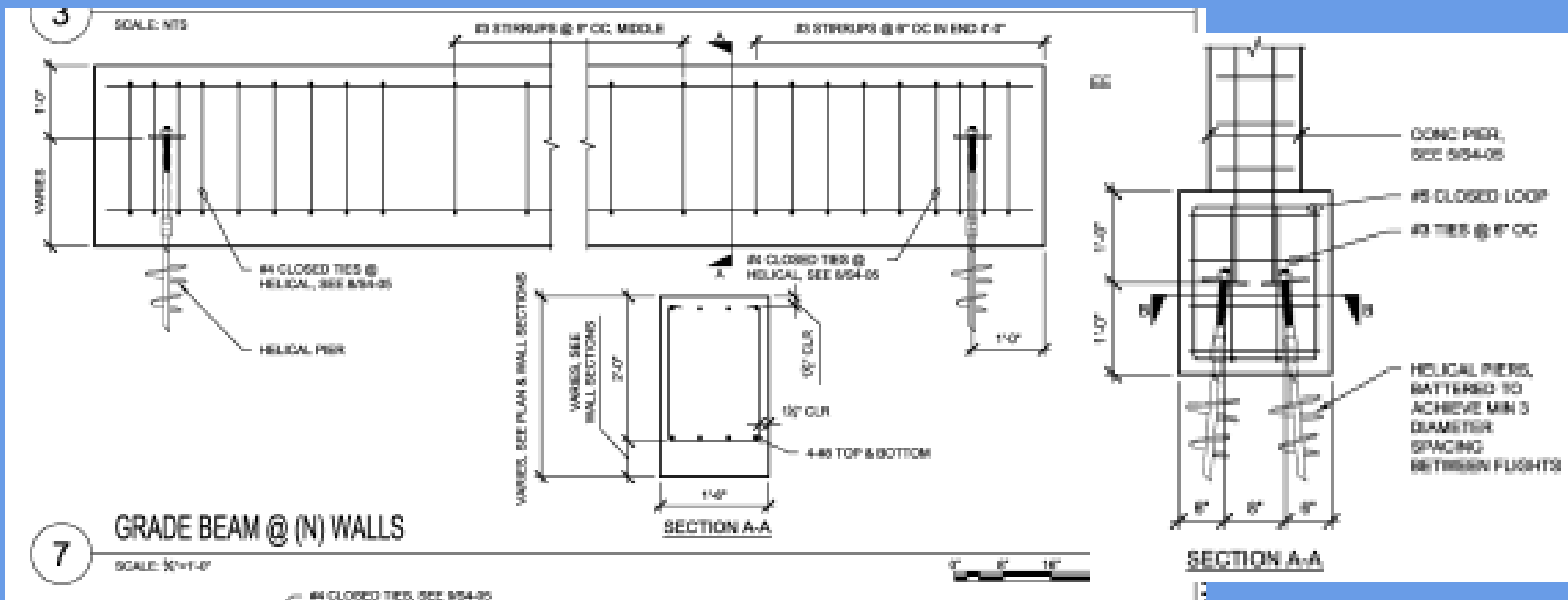
MSU – Cheever/Howard/Haynes Seismic Retrofit



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STEEL FOUNDATIONS

Touchet – Water Tank

- New 30’ Dia – 120,000 gallon Tank
- Original Design = 12” Driven Pile
- Use 37 ea SS150 Piers
  - 25 vertical
  - 9 battered (40 degree)

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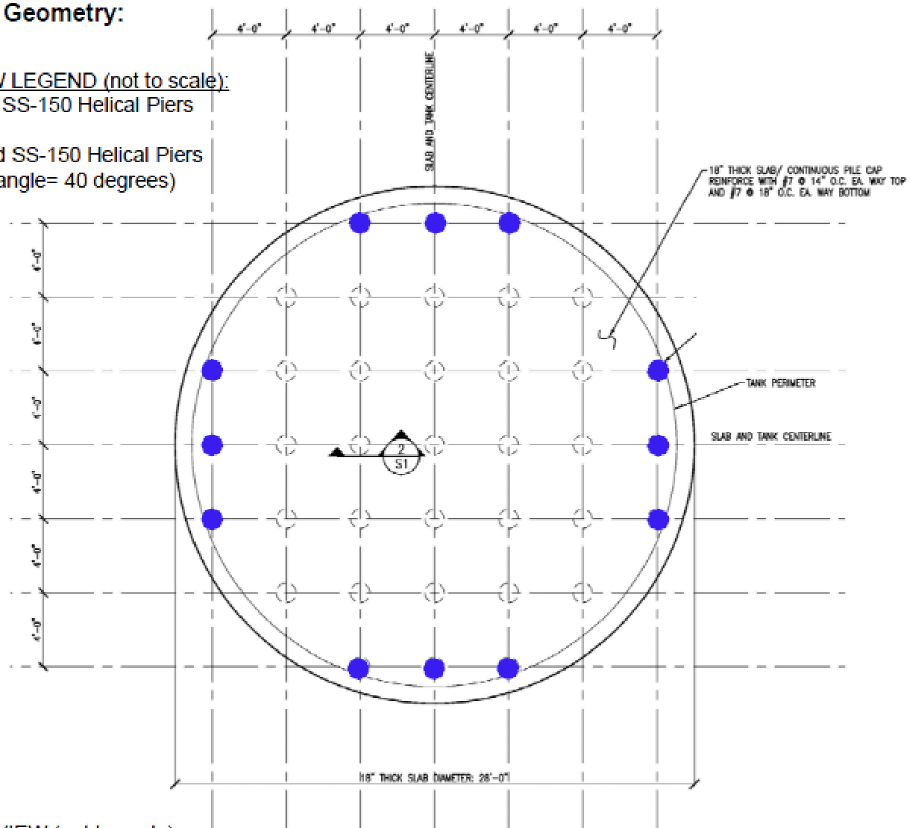
Geotechnical Calculations - Helical Pier Support for Water Tank Foundation

Problem Geometry:

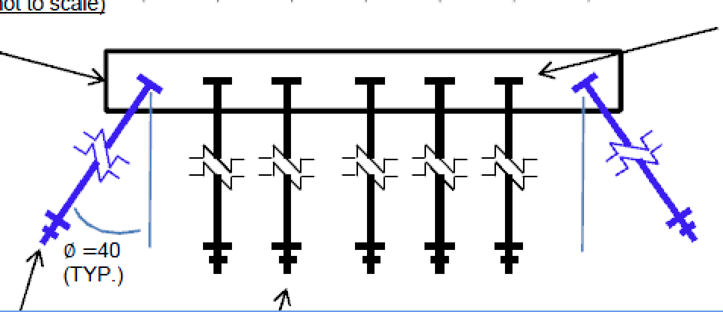
PLAN VIEW LEGEND (not to scale):

○ Vertical SS-150 Helical Piers

● Battered SS-150 Helical Piers (Batter angle= 40 degrees)



PROFILE VIEW (not to scale)



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STEEL FOUNDATIONS

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STEEL FOUNDATIONS

Butte WWTP

- Existing Concrete Tank
- Helical Piers Used for Buoyancy Control
- Procedure:
  – Core Concrete Slab
  – Install Piers – SS5 (8”/8”) x 15’
  – Tension Test
  – Pour New “Cap”

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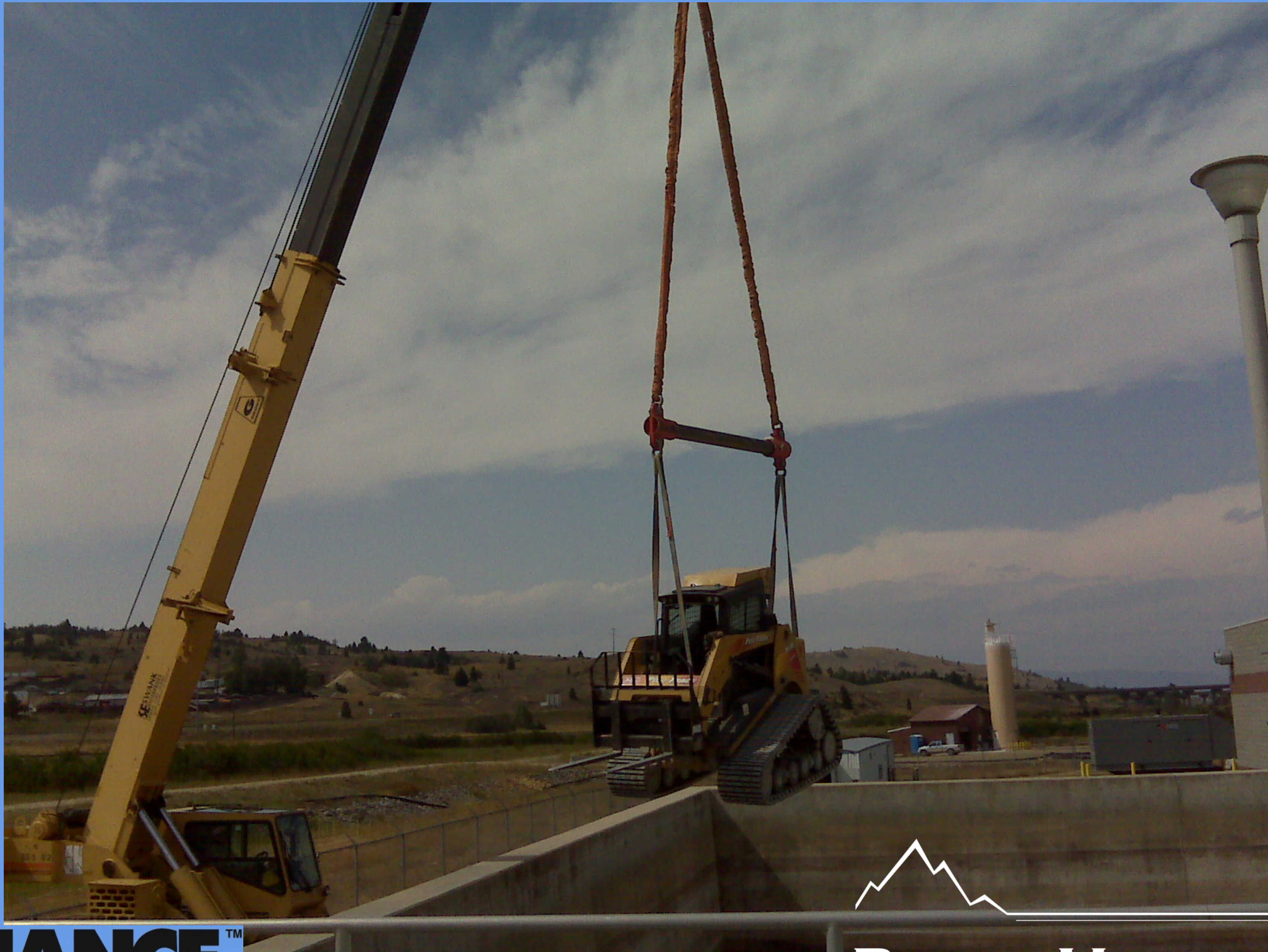
ROCKY MOUNTAIN STEEL FOUNDATIONS



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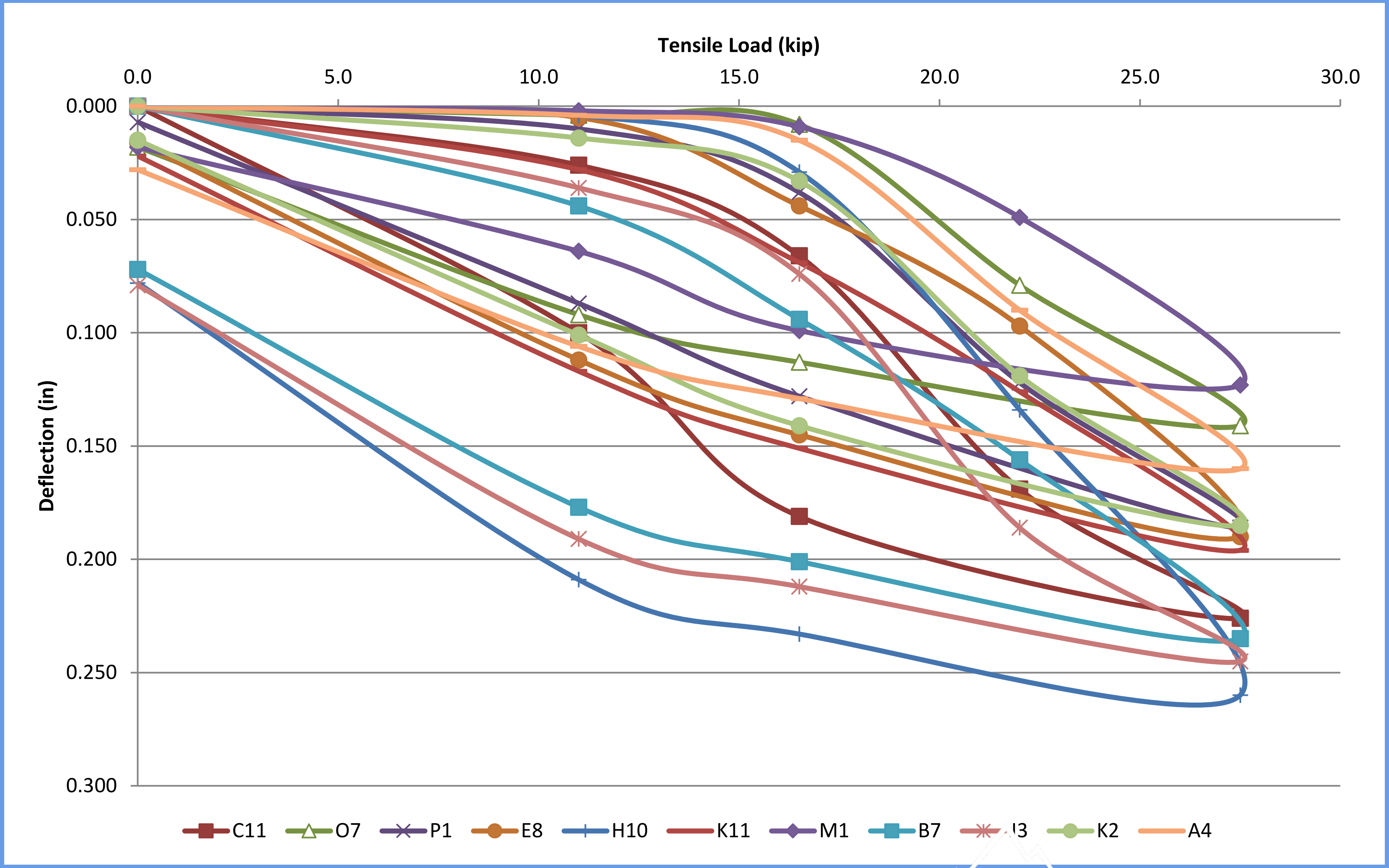

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STEEL FOUNDATIONS

Flathead Lake Villas
Bigfork, MT

- New Construction
- SS200 with 8" Grout Column
- 8"/10"/12" x42' (35' of Grout Column)
- PVA Fibermesh in Grout
- Liquefaction Concerns

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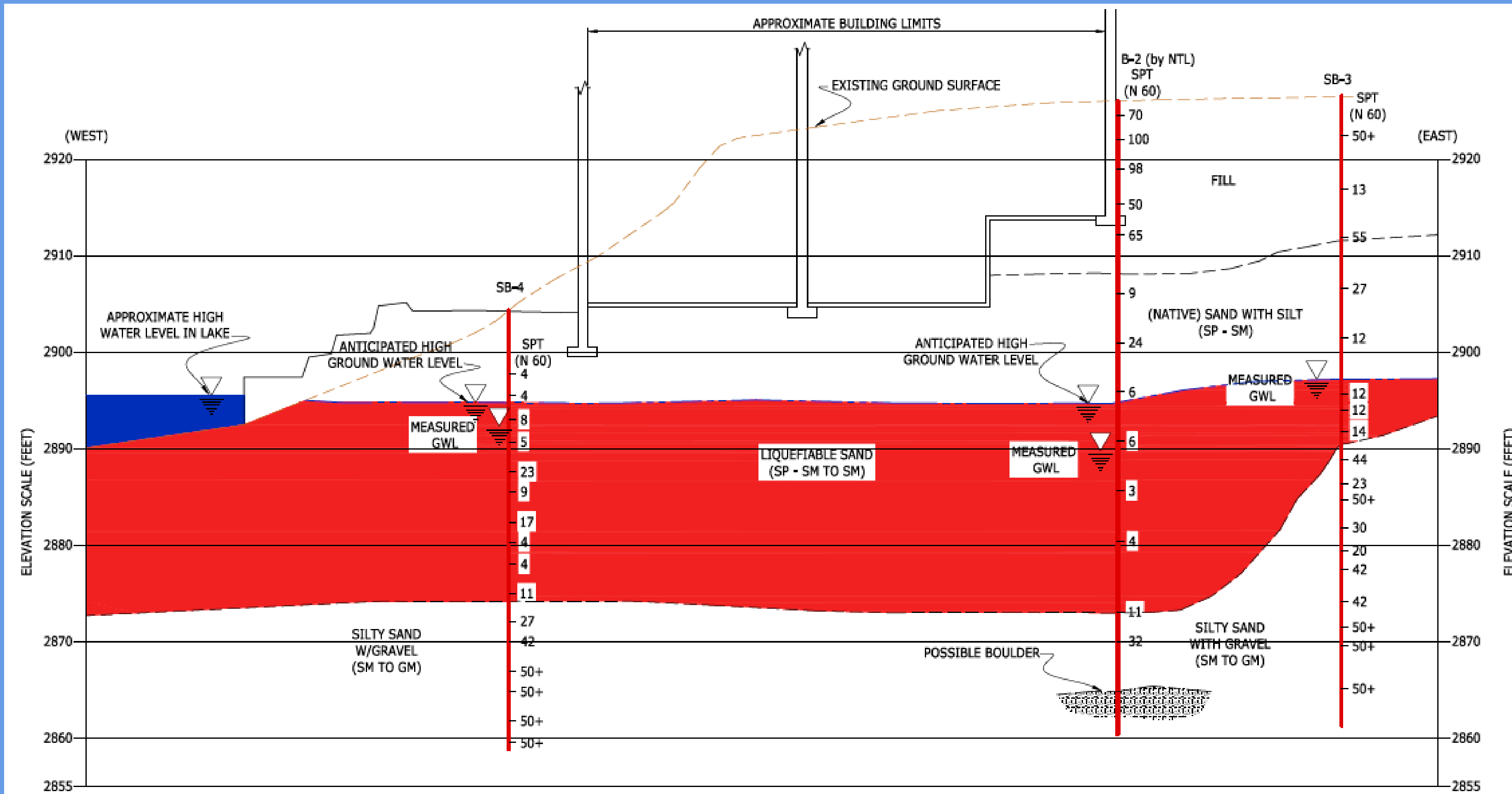
STEEL FOUNDATIONS



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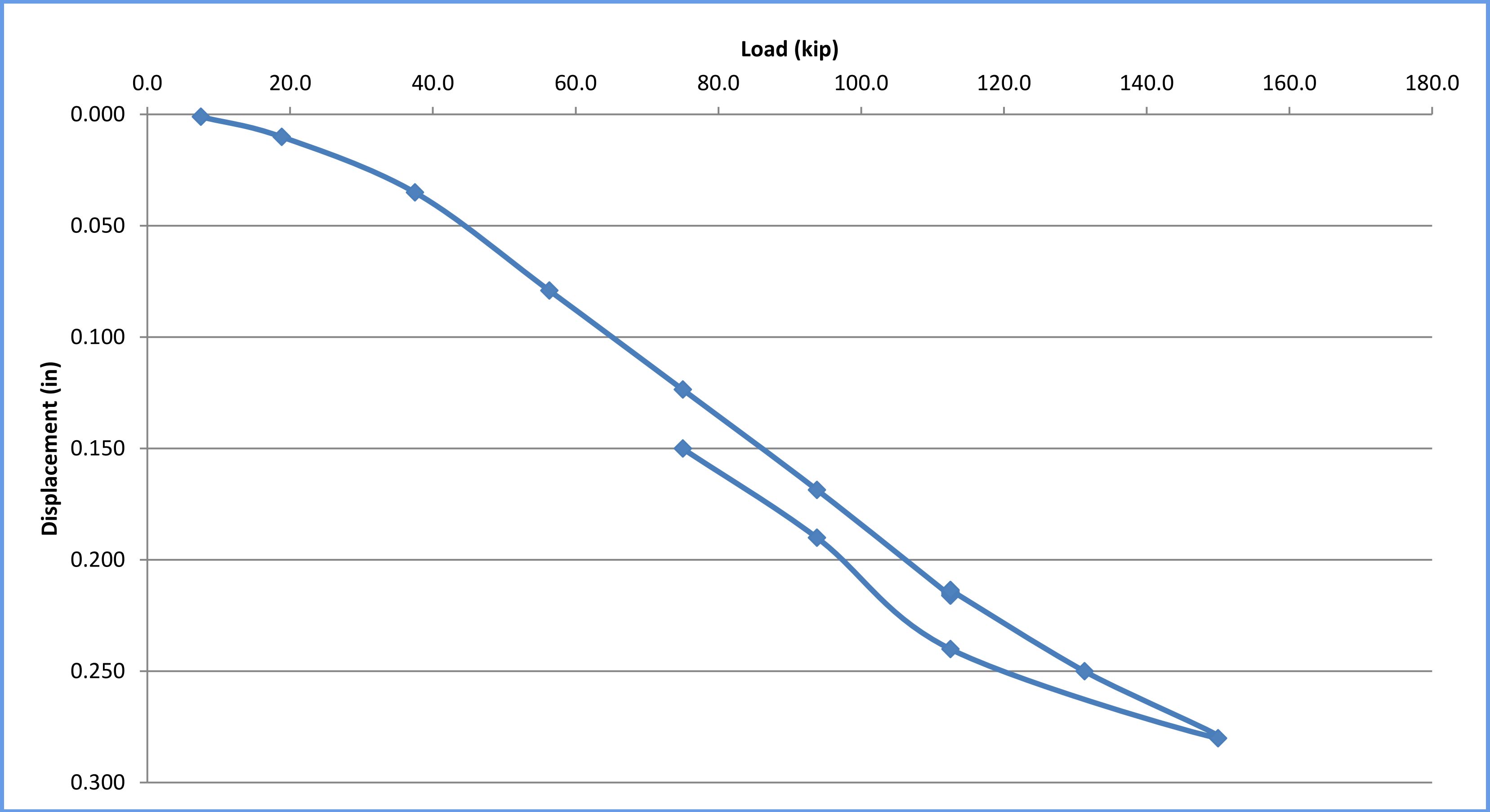
STEEL FOUNDATIONS



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ROCKY MOUNTAIN STEEL FOUNDATIONS

Bobcat Stadium Scoreboard
Bozeman, MT

- Limited Footprint
- New 36' x 39' Scoreboard
- 8 – SS175 anchors
- 50 kip working/ 100 kip ultimate
- Piers installed in 1 day

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STEEL FOUNDATIONS

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Central Wyoming College
Riverton, WY

- Health Sciences Center
- 53 each SS5 (Plain)
- 255 each SS175 (Plain & Grouted)
- Varying Depths 10’ to 70’
  – “Swimming Pool”

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Helical Pier Load Test Results

Project Information

Project Name:	CWC Health and Science Center
Job Number:	5241.26173.01

Pier Information

Pier Number/Location:	B.5-12.4	Install Date:	6/4/2012
Pier Type:	2 helices, 10-8, extensions 1x3.5', 8x7', grouted	Test Date:	6/7/2012
Design Load:	160 kips		
Tension/Compression:	Compression		
Installation Length:	63'		
Installation Torque:	160 kips		
Notes:	Dial gauge reading - 1 revolution equals 1/10 of an inch		

Load Test Observations

General Loading

Load Cell Pressure (psi)	Load Increment	Hold Time (min.)	Reading 1	Reading 2	Deflection 1 (tenth of inch)	Deflection 2 (tenth of inch)
415	AL	1	10.21	8.24	0	0
834	0.2 DL	2.5	8.9	7.19	-1.31	-1.05
1667	0.4 DL	2.5	8.29	6.72	-1.92	-1.52
2501	0.6 DL	2.5	7.11	5.56	-3.1	-2.68
3335	0.8 DL	2.5	6.72	5.19	-3.49	-3.05
4169	1.0 DL	2.5	6.14	4.57	-4.07	-3.67
5003	1.2 DL	2.5	5.63	4.03	-4.58	-4.21
5838	1.4 DL	2.5	5.1	3.44	-5.11	-4.8
6671	1.6 DL	2.5	4.45	2.75	-5.76	-5.49
7505	1.8 DL	2.5	4.05	2.37	-6.16	-5.87
8340	2.0 DL	10	3.25	1.95	-6.96	-6.29
6254	1.5 DL	1	3.4	2.12	-6.81	-6.12
4169	1.0 DL	1	4	2.74	-6.21	-5.5
2084	0.5 DL	1	4.86	3.64	-5.35	-4.6
415	AL	5	5.95	4.49	-4.26	-3.75

Last Load Increment

Time (min)	Reading 1	Reading 2	Deflection 1 (tenth of inch)	Deflection 2 (tenth of inch)
1	3.28	1.95	-6.93	-6.29
2	3.28	1.95	-6.93	-6.29
3	3.28	1.95	-6.93	-6.29
4	3.28	1.95	-6.93	-6.29
5	3.28	1.95	-6.93	-6.29
10	3.28	1.95	-6.93	-6.29

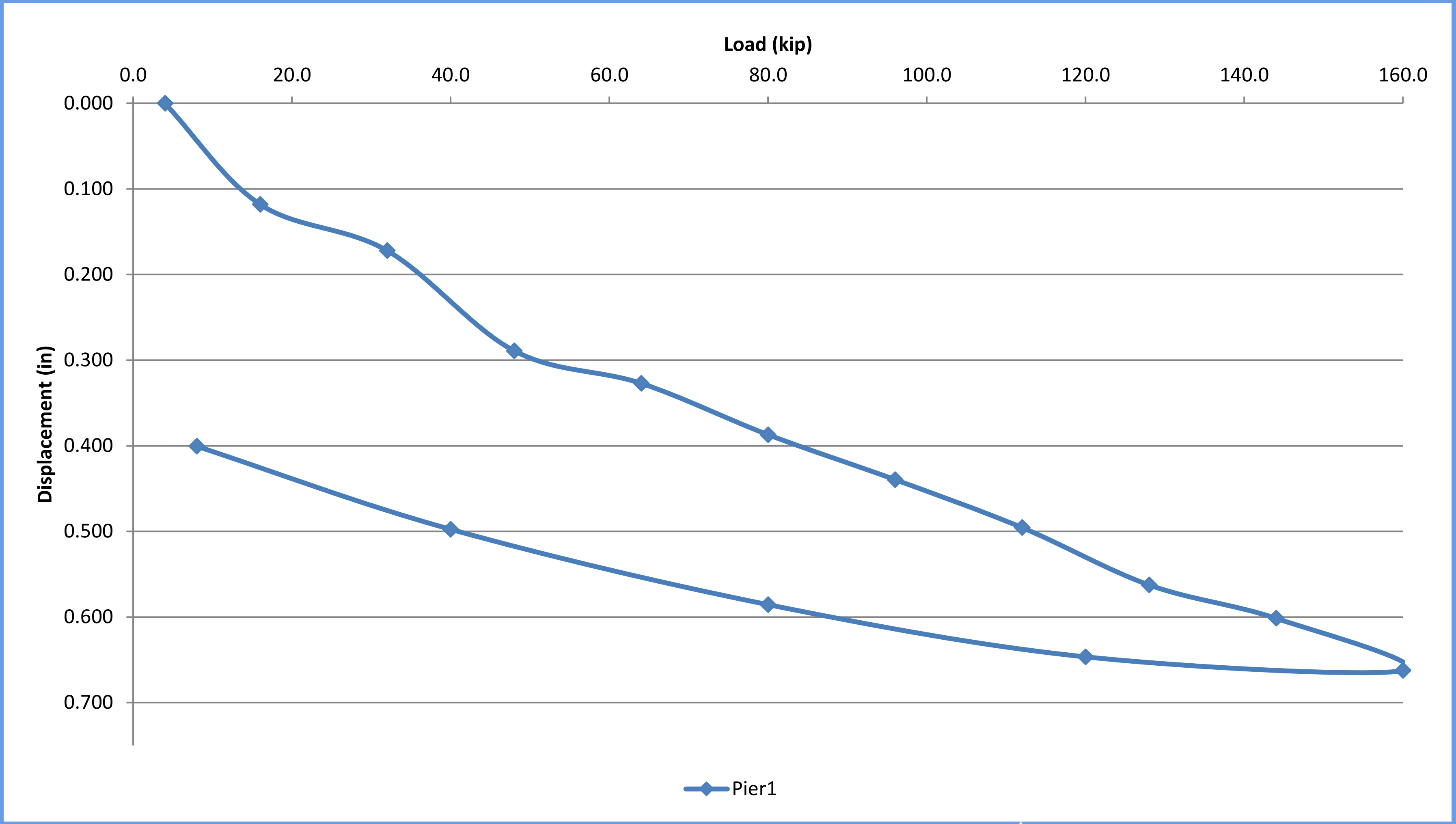
Net Deflection at Design Load	-0.407	inches
Net Deflection at 2xDL	-0.696	inches

*The above observations were made by DOWL HKM. All test procedures were completed by Montana Helical Pier personnel based on shop drawing submittals. The structural Engineer of Record should review all results and determine if measured deflections are acceptable. Calibration of hydraulic ram was not observed.

Observed By: Jessica Klein, EIT

Reviewed By: Kasey D. Jones, Ph.D., P.E.

DOWL HKM
945 Lincoln Street
Lander, Wyoming 82520
307-332-3285



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STEEL FOUNDATIONS

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TownPump Expansion Helena, MT

- Existing Crawlspace
- Add Basement
- Underpin Existing
- 2 shotcrete layers

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Other Projects

- Montana State University – Seismic Upgrades
  - Cheever, Howard, Haynes Halls
- Washington State University
  - Scoreboard, CUB, Stadium Upgrades
  - Tiebacks (Utility – ¼” max Deflection)
- Oil/Gas Projects (E. Montana, N. Dakota)
  - Eliminate Concrete, Load Immediately

Other Projects

- Cell On Wheels (COW)
- Tilt Up Panels
- Gas/Utility (No Concrete)

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Gas/Utility

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