Prestressed Piling

Prestressed concrete piling are vital elements in the foundations of buildings, bridges and marine structures throughout the world. They vary in size from 10 in. (254 mm) square piles used in building foundations to the 66 in. (1676 mm) diameter cylinder piles used in marine structures and bridges. Many areas of North America have poor soil conditions requiring pile foundations for even relatively light structures. In such areas, prestressed concrete piling have come to be the usual method of construction, having been proven the logical choice of materials where permanence, durability and economy must be considered. Heavy marine structures often rely on prestressed concrete piling driven through deep water or through deep layers of unsuitable material for their support. Prestressed concrete piling can be designed to safely support these heavy loads as well as lateral loads caused by wind, waves and earthquakes. In marine environments these piles can resist corrosion caused by salt water and by thousands of cycles of wetting and drying.\(^1\)

The following pages contain the specifications and service load interaction diagrams for the majority of the standard pile sizes for Heldenfels Enterprises, Inc. This information is to be used to assist engineers in the design of their projects. This manual is not intended to replace the necessity of a profession engineered design.

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\(^1\) Recommended Practice for Design, Manufacture and Installation of Prestressed Concrete Piling, PCI Committee on Prestressed Concrete Piling, Mar-Apr 1993
12"x12" Pile
Type A

1" Chamfer
(typ. as shown)

1'-0"

1'-0"

2½"

2½"

7"

7"

2½"

Spiral Hooping

Concrete
Normal Weight = 150 pcf
28-Day Strength, f_c = 6000 psi
Release Strength, f_{ci} = 4000 psi

Prestressing Strand
Quantity = 4
½"Ø, 270 ksi Lolax
Pulled to 31.0 kips each (75%)
Precast/Prestressed Piling: Service Load Interaction Diagram

**Service Load Interaction Diagram**

**Pile Size** = 12" x 12"

- **Concrete Normal Weight** = 6000 psi
- **Concrete Normal Weight** = 4000 psi
- **Prestressing Strand Type** = 270 ksi, Lolax
- **Prestressing Strand Size** = 1/2" (std.)
- **Prestressing Strand Qty.** = 4
- **Prestressing Strand Area** = 0.153 in²
- **Pull** = 75%

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Heldenfels Enterprises, Inc.

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5700 IH 35 South, San Marcos, TX 78666, phone, 512.396.2376, www.heldenfels.com
Design Criteria
1) Service Load Design.
2) Allowable Compressive Stress = 0.45f′c for SUSTAINED LOADS.
3) Allowable Tension Stress = 0 for SUSTAINED LOADS.
4) For TEMPORARY LOADS, Allowable Compressive Stress = 0.60f′c.
5) For TEMPORARY LOADS, Allowable Tension Stress = 0.
6) Assume a sustained compression service load equal to: 100 kips.
7) Use PCI method for estimating prestress losses.
8) Bending is about principle axes AND only one axis at a time.
9) Slenderness is not considered.
10) Ultimate capacity must be checked to ensure the required factor of safety is achieved in accordance with ACI 318.

Design Input
Section Size:
\[ h = 12 \text{ inches} \]
\[ b = 12 \text{ inches} \]

Section Area (accounting for chamfers, radii, etc.):
\[ A_g = 142 \text{ square inches} \]

Prestressing Strand:
\[ \text{Type} = 270 \text{ ksi, Lolax} \]
\[ \text{Size} = 1/2" \text{ (std.)} \]
\[ \text{Qty.} = 4 \]
\[ \text{Area} = 0.153 \text{ square inches per strand} \]
\[ \text{Pull} = 75\% \text{ (initial)} \]

Concrete:
\[ \text{wc} = 145 \text{ pcf (concrete weight)} \]
\[ f′c = 6000 \text{ psi (28-day Concrete Compressive Strength)} \]
\[ f′ci = 4000 \text{ psi (Required Concrete Release Strength)} \]
\[ Ec = 4,463,151 \text{ psi (concrete modulus of elasticity at 28-days)} \]
\[ Eci = 3,644,147 \text{ psi (concrete modulus of elasticity at transfer of prestress)} \]
12"x12" Pile
Type B

1" Chamfer
(typ. as shown)

Spiral Hooping

2½"
3½"
3½"
2½"

Concrete
Normal Weight = 150 pcf
28-Day Strength, f'c = 7000 psi
Release Strength, f'ci = 4000 psi

Prestressing Strand
Quantity = 8
½"Ø, 270 ksi Lolax
Pulled to 31.0 kips each (75%)
Precast/Prestressed Piling: Design Criteria and Input

Design Criteria
1) Service Load Design.
2) Allowable Compressive Stress = 0.45$f'_c$ for SUSTAINED LOADS.
3) Allowable Tension Stress = 0 for SUSTAINED LOADS.
4) For TEMPORARY LOADS, Allowable Compressive Stress = 0.60$f'_c$.
5) For TEMPORARY LOADS, Allowable Tension Stress = 0.
6) Assume a sustained compression service load equal to: 150 kips.
7) Use PCI method for estimating prestress losses.
8) Bending is about principle axes AND only one axis at a time.
9) Slenderness is not considered.
10) Ultimate capacity must be checked to ensure the required factor of safety is achieved in accordance with ACI 318.

Design Input
Section Size:
- $h$ = 12 inches
- $b$ = 12 inches

Section Area (accounting for chamfers, radii, etc.):
- $A_g$ = 142 square inches

Prestressing Strand:
- Type = 270 ksi, Lolax
- Size = 1/2" (std.)
- Qty. = 8
- Area = 0.153 square inches per strand
- Pull = 75% (initial)

Concrete:
- $w_c$ = 145 pcf (concrete weight)
- $f'_c$ = 7000 psi (28-day Concrete Compressive Strength)
- $f'_c$ = 4000 psi (Required Concrete Release Strength)
- $E_c$ = 4,820,754 psi (concrete modulus of elasticity at 28-days)
- $E_{ci}$ = 3,644,147 psi (concrete modulus of elasticity at transfer of prestress)
Pile Size = **12" x 12"**

- **Concrete**
  - Normal Weight: 7000 psi
  - 4000 psi

- **Prestressing Strand**
  - Type = 270 ksi, Lolax
  - Size = 1/2" (std.)
  - Qty. = 8
  - Area = 0.153 in²
  - Pull = 75%

---

**DATE** 6/9/2010

**BY** cK Structural

**SHEET** 12x12B

Heldenfels Enterprises, Inc.
14"x14" Pile
Type A

Concrete
Normal Weight = 150 pcf
28-Day Strength, f'c = 6000 psi
Release Strength, fci = 4000 psi

Prestressing Strand
Quantity = 4
½"Ø, 270 ksi Loralx
Pulled to 31.0 kips each (75%)
Precast/Prestressed Piling: Design Criteria and Input

Design Criteria
1) Service Load Design.
2) Allowable Compressive Stress = 0.45f_c for SUSTAINED LOADS.
3) Allowable Tension Stress = 0 for SUSTAINED LOADS.
4) For TEMPORARY LOADS, Allowable Compressive Stress = 0.60f_c.
5) For TEMPORARY LOADS, Allowable Tension Stress = 0.
6) Assume a sustained compression service load equal to: 150 kips.
7) Use PCI method for estimating prestress losses.
8) Bending is about principle axes AND only one axis at a time.
9) Slenderness is not considered.
10) Ultimate capacity must be checked to ensure the required factor of safety is achieved in accordance with ACI 318.

Design Input
Section Size:
- h = 14 inches
- b = 14 inches

Section Area (accounting for chamfers, radii, etc.):
- A_g = 194 square inches

Prestressing Strand:
- Type = 270 ksi, Lolax
- Size = 1/2" (std.)
- Qty. = 4
- Area = 0.153 square inches per strand
- Pull = 75% (initial)

Concrete:
- wc = 145 pcf (concrete weight)
- f'c = 6000 psi (28-day Concrete Compressive Strength)
- f'ci = 4000 psi (Required Concrete Release Strength)
- Ec = 4,463,151 psi (concrete modulus of elasticity at 28-days)
- Eci = 3,644,147 psi (concrete modulus of elasticity at transfer of prestress)
Precast/Prestressed Piling: Service Load Interaction Diagram

Pile Size = 14" x 14"

Concrete
Normal Weight = 6000 psi
Normal Weight = 4000 psi

Prestressing Strand
Type = 270 ksi, Lolax
Size = 1/2" (std.)
Qty. = 4
Area = 0.153 in²
Pull = 75%

Service Load Interaction Diagram

DATE 6/9/2010
BY cK Structural SHEET 14x14A

Heldenfels Enterprises, Inc.

Engineering Department 14"x14" Pile, Type A

5700 IH 35 South, San Marcos, TX 78666, phone, 512.396.2376, www.heldenfels.com
14"x14" Piling
Type B

1" Chamfer
(typ. as shown)

Concrete
Normal Weight = 150 pcf
28-Day Strength, $f'c$ = 7000 psi
Release Strength, $f'ci$ = 4000 psi

Prestressing Strand
Quantity = 8
$rac{1}{2}$"Ø 270 ksi Lofax
Pulled to 31.0 kips each (75%)
Design Criteria
1) Service Load Design.
2) Allowable Compressive Stress = 0.45f'_c for SUSTAINED LOADS.
3) Allowable Tension Stress = 0 for SUSTAINED LOADS.
4) For TEMPORARY LOADS, Allowable Compressive Stress = 0.60f'_c.
5) For TEMPORARY LOADS, Allowable Tension Stress = 0.
6) Assume a sustained compression service load equal to: 250 kips.
7) Use PCI method for estimating prestress losses.
8) Bending is about principle axes AND only one axis at a time.
9) Slenderness is not considered.
10) Ultimate capacity must be checked to ensure the required factor of safety is achieved in accordance with ACI 318.

Design Input
Section Size:
\[ h = 14 \text{ inches} \]
\[ b = 14 \text{ inches} \]

Section Area (accounting for chamfers, radii, etc.):
\[ A_g = 194 \text{ square inches} \]

Prestressing Strand:
Type = \( 270 \) ksi, Lolax
Size = \( 1/2" \) (std.)
Qty. = 8
Area = 0.153 square inches per strand
Pull = 75% (initial)

Concrete:
\[ w_c = 145 \text{ pcf (concrete weight)} \]
\[ f'_c = 7000 \text{ psi (28-day Concrete Compressive Strength)} \]
\[ f'c_i = 4000 \text{ psi (Required Concrete Release Strength)} \]
\[ E_c = 4,820,754 \text{ psi (concrete modulus of elasticity at 28-days)} \]
\[ E_{ci} = 3,644,147 \text{ psi (concrete modulus of elasticity at transfer of prestress)} \]
Precast/Prestressed Piling: Service Load Interaction Diagram

**Pile Size = 14" x 14"**

Concrete Normal Weight 7000 psi

Prestressing Strand Type = 270 ksi, Lolax

Size = 1/2" (std.)

Qty. = 8

Area = 0.153 in²

Pull = 75%

**Service Load Interaction Diagram**

**DATE** 6/9/2010

**BY** cK Structural

**SHEET** 14x14B

5700 IH 35 South, San Marcos, TX 78666, phone, 512.396.2376, www.heldenfels.com
16"x16" Piling
Type A

1" Chamfer
(typ. as shown)

Concrete
Normal Weight = 150 pcf
28-Day Strength, f_c = 5000 psi
Release Strength, f'c1 = 4000 psi

Prestressing Strand
Quantity = 8
1/2", 270 ksi Lollax
Pulled to 31.0 kips each (75%)
Design Criteria
1) Service Load Design.
2) Allowable Compressive Stress = 0.45f'_c for SUSTAINED LOADS.
3) Allowable Tension Stress = 0 for SUSTAINED LOADS.
4) For TEMPORARY LOADS, Allowable Compressive Stress = 0.60f'_c.
5) For TEMPORARY LOADS, Allowable Tension Stress = 0.
6) Assume a sustained compression service load equal to: 250 kips.
7) Use PCI method for estimating prestress losses.
8) Bending is about principle axes AND only one axis at a time.
9) Slenderness is not considered.
10) Ultimate capacity must be checked to ensure the required factor of safety is achieved in accordance with ACI 318.

Design Input
Section Size:
\[ h = 16 \text{ inches} \]
\[ b = 16 \text{ inches} \]

Section Area (accounting for chamfers, radii, etc.):
\[ A_g = 254 \text{ square inches} \]

Prestressing Strand:
\[ \text{Type} = 270 \text{ ksi, Lolax} \]
\[ \text{Size} = 1/2" \text{ (std.)} \]
\[ \text{Qty.} = 8 \]
\[ \text{Area} = 0.153 \text{ square inches per strand} \]
\[ \text{Pull} = 75\% \text{ (initial)} \]

Concrete:
\[ \text{wc} = 145 \text{ pcf (concrete weight)} \]
\[ f'_c = 5000 \text{ psi (28-day Concrete Compressive Strength)} \]
\[ f'_ci = 4000 \text{ psi (Required Concrete Release Strength)} \]
\[ E_c = 4,074,281 \text{ psi (concrete modulus of elasticity at 28-days)} \]
\[ E_{ci} = 3,644,147 \text{ psi (concrete modulus of elasticity at transfer of prestress)} \]
Precast/Prestressed Piling: Service Load Interaction Diagram

Pile Size = 16" x 16"
Concrete: Normal Weight 5000 psi, 4000 psi
Prestressing Strand: Type = 270 ksi, Lolax
Size = 1/2" (std.)
Qty. = 8
Area = 0.153 in²
Pull = 75%

Service Axial Load (kips) vs. Service Bending Moment (kip*feet)

DATE: 2/12/2010
BY: cK Structural
SHEET: 16x16A
Design Criteria
1) Service Load Design.
2) Allowable Compressive Stress = 0.45f'_c for SUSTAINED LOADS.
3) Allowable Tension Stress = 0 for SUSTAINED LOADS.
4) For TEMPORARY LOADS, Allowable Compressive Stress = 0.60f'_c.
5) For TEMPORARY LOADS, Allowable Tension Stress = 0.
6) Assume a sustained compression service load equal to: 400 kips.
7) Use PCI method for estimating prestress losses.
8) Bending is about principle axes AND only one axis at a time.
9) Slenderness is not considered.
10) Ultimate capacity must be checked to ensure the required factor of safety is achieved in accordance with ACI 318.

Design Input
Section Size:
\[ \begin{align*}
&h = 16 \text{ inches} \\
&b = 16 \text{ inches}
\end{align*} \]

Section Area (accounting for chamfers, radii, etc.):
\[ A_g = 254 \text{ square inches} \]

Prestressing Strand:
\[ \begin{align*}
&\text{Type} = 270 \text{ ksi, Lolax} \\
&\text{Size} = 1/2'' \text{ (std.)} \\
&\text{Qty.} = 12 \\
&\text{Area} = 0.153 \text{ square inches per strand} \\
&\text{Pull} = 75\% \text{ (initial)}
\end{align*} \]

Concrete:
\[ \begin{align*}
&\text{wc} = 145 \text{ pcf (concrete weight)} \\
&f'_c = 7000 \text{ psi (28-day Concrete Compressive Strength)} \\
&f'_ci = 4000 \text{ psi (Required Concrete Release Strength)} \\
&E_c = 4,820,754 \text{ psi (concrete modulus of elasticity at 28-days)} \\
&E_{ci} = 3,644,147 \text{ psi (concrete modulus of elasticity at transfer of prestress)}
\end{align*} \]
Precast/Prestressed Piling: Service Load Interaction Diagram

**Service Load Interaction Diagram**

**Pile Size = 16" x 16"**

- **Concrete**: Normal Weight
- **Prestressing Strand**: Type = 270 ksi, Lolax
- **Size**: 1/2" (std.)
- **Qty.**: 12
- **Area**: 0.153 in²
- **Pull**: 75%

**DATE**
2/12/2010

**BY**
cK Structural

**SHEET**
16x16B

Heldenfels Enterprises, Inc.
Engineering Department
16"x16" Pile, Type B

5700 IH 35 South, San Marcos, TX 78666, phone, 512.396.2376, www.heldenfels.com
16"x16" Pile
Type B

1" Chamfer
(typ. as shown)

1'4"

2½"
4" 3" 4"

2½"

Spiral Hooping

Concrete
Normal Weight = 150 pcf
28-Day Strength, f'c = 7000 psi
Release Strength, f'ci = 4000 psi

Prestressing Strand
Quantity = 12
½" Ø, 270 ksi Lolax
Pulled to 31.0 kips each (75%)
18"x18" Piling
Type A

1" Chamfer
(typ. as shown)

1'-6"

2½"
6½"
2½"
2½"
6½"
4"
4"
5"
2½"

Concrete
Normal Weight = 150 pcf
28-Day Strength, f_c = 5000 psi
Release Strength, f_ci = 4000 psi

Prestressing Strand
Quantity = 10
½" Ø, 270 ksi Lolax
Pulled to 31.0 kips each (75%)
Design Criteria
1) Service Load Design.
2) Allowable Compressive Stress = 0.45f'c for SUSTAINED LOADS.
3) Allowable Tension Stress = 0 for SUSTAINED LOADS.
4) For TEMPORARY LOADS, Allowable Compressive Stress = 0.60f'c.
5) For TEMPORARY LOADS, Allowable Tension Stress = 0.
6) Assume a sustained compression service load equal to: 400 kips.
7) Use PCI method for estimating prestress losses.
8) Bending is about principle axes AND only one axis at a time.
9) Slenderness is not considered.
10) Ultimate capacity must be checked to ensure the required factor of safety is achieved in accordance with ACI 318.

Design Input
Section Size:

- h = 18 inches
- b = 18 inches

Section Area (accounting for chamfers, radii, etc.):
- Ag = 332 square inches

Prestressing Strand:
- Type = 270 ksi, Lolax
- Size = 1/2" (std.)
- Qty. = 10
- Area = 0.153 square inches per strand
- Pull = 75% (initial)

Concrete:
- wc = 145 pcf (concrete weight)
- f'c = 5000 psi (28-day Concrete Compressive Strength)
- f'ci = 4000 psi (Required Concrete Release Strength)
- Ec = 4,074,281 psi (concrete modulus of elasticity at 28-days)
- Eci = 3,644,147 psi (concrete modulus of elasticity at transfer of prestress)
Pile Size = 18" x 18"

Concrete
Normal Weight = 5000 psi
4000 psi

Prestressing Strand
Type = 270 ksi, Lolax
Size = 1/2" (std.)
Qty. = 10
Area = 0.153 in²
Pull = 75%

DATE: 2/12/2010

BY: cK Structural
SHEET: 18x18A

5700 IH 35 South, San Marcos, TX 78666, phone, 512.396.2376, www.heldenfels.com
18"x18" Piling
Type B

1" Chamfer
(typ. as shown)

Concrete
Normal Weight = 150 pcf
28-Day Strength, f_c = 7000 psi
Release Strength, f_ci = 4000 psi

Prestressing Strand
Quantity = 12
\( \frac{1}{2} \)\( ^\circ \), 270 ksi Lolax
Pulled to 31.0 kips each (75%)
Design Criteria
1) Service Load Design.
2) Allowable Compressive Stress = 0.45f'_c for SUSTAINED LOADS.
3) Allowable Tension Stress = 0 for SUSTAINED LOADS.
4) For TEMPORARY LOADS, Allowable Compressive Stress = 0.60f'_c.
5) For TEMPORARY LOADS, Allowable Tension Stress = 0.
6) Assume a sustained compression service load equal to: 575 kips.
7) Use PCI method for estimating prestress losses.
8) Bending is about principle axes AND only one axis at a time.
9) Slenderness is not considered.
10) Ultimate capacity must be checked to ensure the required factor of safety is achieved in accordance with ACI 318.

Design Input
Section Size:
- h = 18 inches
- b = 18 inches

Section Area (accounting for chamfers, radii, etc.):
- A_g = 332 square inches

Prestressing Strand:
- Type = 270 ksi, Lolax
- Size = 1/2" (std.)
- Qty. = 12
- Area = 0.153 square inches per strand
- Pull = 75% (initial)

Concrete:
- wc = 145 pcf (concrete weight)
- f'_c = 7000 psi (28-day Concrete Compressive Strength)
- f'_ci = 4000 psi (Required Concrete Release Strength)
- Ec = 4,820,754 psi (concrete modulus of elasticity at 28-days)
- Eci = 3,644,147 psi (concrete modulus of elasticity at transfer of prestress)
Precast/Prestressed Piling: Service Load Interaction Diagram

**Pile Size =** 18" x 18"
- **Concrete**
  - Normal Weight: 7000 psi
  - Normal Weight: 4000 psi
- **Prestressing Strand**
  - Type: 270 ksi, Lolax
  - Size: 1/2" (std.)
  - Qty.: 12
  - Area: 0.153 in²
  - Pull: 75%

**Service Load Interaction Diagram**

- **Service Axial Load (kips)**
- **Service Bending Moment (kip*feet)**

**Heldenfels Enterprises, Inc.**

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<td>cK Structural</td>
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<td>SHEET</td>
<td>18x18B</td>
</tr>
</tbody>
</table>

5700 IH 35 South, San Marcos, TX 78666, phone, 512.396.2376, www.heldenfels.com
20"x20" Pile
Type A

Concrete
Normal Weight = 150 pcf
28-Day Strength, $f_c = 6000$ psi
Release Strength, $f_{ci} = 4000$ psi

Prestressing Strand
Quantity = 16
$\frac{1}{2}\text{"}, 270$ ksi Lolax
Pulled to 31.0 kips each (75%)
Design Criteria
1) Service Load Design.
2) Allowable Compressive Stress = 0.45f'c for SUSTAINED LOADS.
3) Allowable Tension Stress = 0 for SUSTAINED LOADS.
4) For TEMPORARY LOADS, Allowable Compressive Stress = 0.60f'c.
5) For TEMPORARY LOADS, Allowable Tension Stress = 0.
6) Assume a sustained compression service load equal to: 500 kips.
7) Use PCI method for estimating prestress losses.
8) Bending is about principle axes AND only one axis at a time.
9) Slenderness is not considered.
10) Ultimate capacity must be checked to ensure the required factor of safety is achieved in accordance with ACI 318.

Design Input
Section Size:
- h = 20 inches
- b = 20 inches

Section Area (accounting for chamfers, radii, etc.):
- A_g = 398 square inches

Prestressing Strand:
- Type = 270 ksi, Lolax
- Size = 1/2" (std.)
- Qty. = 16
- Area = 0.153 square inches per strand
- Pull = 75% (initial)

Concrete:
- wc = 145 pcf (concrete weight)
- f'c = 6000 psi (28-day Concrete Compressive Strength)
- f'ci = 4000 psi (Required Concrete Release Strength)
- Ec = 4,463,151 psi (concrete modulus of elasticity at 28-days)
- Eci = 3,644,147 psi (concrete modulus of elasticity at transfer of prestress)
Precast/Prestressed Piling: Service Load Interaction Diagram

Pile Size = 20" x 20"

Concrete
Normal Weight = 6000 psi
Normal Weight = 4000 psi

Prestressing Strand
Type = 270 ksi, Lolax
Size = 1/2" (std.)
Qty. = 16
Area = 0.153 in²
Pull = 75%

Service Load Interaction Diagram

Heldenfels Enterprises, Inc.
Engineering Department
20"x20" Pile, Type A

DATE: 2/12/2010
BY: cK Structural
SHEET: 20x20A

5700 IH 35 South, San Marcos, TX 78666, phone 512.396.2376, www.heldenfels.com
20"x20" Piling
Type B

1" Chamfer
(typ. as shown)

Spiral Hooping

Concrete
Normal Weight = 150 pcf
28-Day Strength, fc = 8000 psi
Release Strength, fci = 4500 psi

Prestressing Strand
Quantity = 16
1/2"Ø, 270 ksi Lolax
Pulled to 31.0 kips each (75%)
Design Criteria

1) Service Load Design.
2) Allowable Compressive Stress = 0.45f'_c for SUSTAINED LOADS.
3) Allowable Tension Stress = 0 for SUSTAINED LOADS.
4) For TEMPORARY LOADS, Allowable Compressive Stress = 0.60f'_c.
5) For TEMPORARY LOADS, Allowable Tension Stress = 0.
6) Assume a sustained compression service load equal to: 800 kips.
7) Use PCI method for estimating prestress losses.
8) Bending is about principle axes AND only one axis at a time.
9) Slenderness is not considered.
10) Ultimate capacity must be checked to ensure the required factor of safety is achieved in accordance with ACI 318.

Design Input

Section Size:

- h = 20 inches
- b = 20 inches

Section Area (accounting for chamfers, radii, etc.):

- A_g = 398 square inches

Prestressing Strand:

- Type = 270 ksi, Lolax
- Size = 1/2" (std.)
- Qty. = 16
- Area = 0.153 square inches per strand
- Pull = 75% (initial)

Concrete:

- wc = 145 pcf (concrete weight)
- f'_c = 8000 psi (28-day Concrete Compressive Strength)
- f'_{ci} = 4500 psi (Required Concrete Release Strength)
- E_c = 5,153,603 psi (concrete modulus of elasticity at 28-days)
- E_{ci} = 3,865,202 psi (concrete modulus of elasticity at transfer of prestress)
Precast/Prestressed Piling: Service Load Interaction Diagram

Service Load Interaction Diagram

Pile Size = 20" x 20"

Concrete
Normal Weight 8000 psi
4500 psi

Prestressing Strand
Type = 270 ksi, Lolax
Size = 1/2" (std.)
Qty. = 16
Area = 0.153 in²
Pull = 75%

Date: 2/12/2010

Heldenfels Enterprises, Inc.
Engineering Department
20'x20' Pile, Type B

SUSTAINED + TEMPORARY LOADS

5% Eccentricity

(0.33f_c - 0.27fp_c)Ag

SUSTAINED LOADS

SERVICE BENDING MOMENT (kip * feet)

Service Axial Load (kips)

Service Bending Moment (kip*feet)
24"x24" Piling
Type A

1" Chamfer (typ. as shown)

Spiral Hooping

2½"
4"
4"
3"
4"
4"
2½" Strand

Concrete
Normal Weight = 150 pcf
28-Day Strength, $f_c = 6000$ psi
Release Strength, $f_{ci} = 4000$ psi

Prestressing Strand
Quantity = 20
1½"Ø, 270 ksi Lolax
Pulled to 31.0 kips each (75%)
Design Criteria
1) Service Load Design.
2) Allowable Compressive Stress = 0.45f'c for SUSTAINED LOADS.
3) Allowable Tension Stress = 0 for SUSTAINED LOADS.
4) For TEMPORARY LOADS, Allowable Compressive Stress = 0.60f'c.
5) For TEMPORARY LOADS, Allowable Tension Stress = 0.
6) Assume a sustained compression service load equal to: 800 kips.
7) Use PCI method for estimating prestress losses.
8) Bending is about principle axes AND only one axis at a time.
9) Slenderness is not considered.
10) Ultimate capacity must be checked to ensure the required factor of safety is achieved in accordance with ACI 318.

Design Input
Section Size:
\[ h = 24 \text{ inches} \]
\[ b = 24 \text{ inches} \]

Section Area (accounting for chamfers, radii, etc.):
\[ A_g = 574 \text{ square inches} \]

Prestressing Strand:
\[ \text{Type} = 270 \text{ ksi, Lolax} \]
\[ \text{Size} = 1/2" \text{ (std.)} \]
\[ \text{Qty.} = 20 \]
\[ \text{Area} = 0.153 \text{ square inches per strand} \]
\[ \text{Pull} = 75\% \text{ (initial)} \]

Concrete:
\[ \text{wc} = 145 \text{ pcf (concrete weight)} \]
\[ \text{f'c} = 6000 \text{ psi (28-day Concrete Compressive Strength)} \]
\[ \text{f'ci} = 4000 \text{ psi (Required Concrete Release Strength)} \]
\[ \text{Ec} = 4,463,151 \text{ psi (concrete modulus of elasticity at 28-days)} \]
\[ \text{Eci} = 3,644,147 \text{ psi (concrete modulus of elasticity at transfer of prestress)} \]
Precast/Prestressed Piling: Service Load Interaction Diagram

**Service Load Interaction Diagram**

Pile Size = 24" x 24"

Concrete
Normal Weight 6000 psi
4000 psi

Prestressing Strand
Type = 270 ksi, Lolax
Size = 1/2" (std.)
Qty. = 20
Area = 0.153 in²
Pull = 75%

Heldenfels Enterprises, Inc.

Engineering Department 24"x24" Pile, Type A

5700 IH 35 South, San Marcos, TX 78666, phone, 512.396.2376, www.heldenfels.com
24"x24" Pile
Type B

1" Chamfer (typ. as shown)

Concrete
Normal Weight = 150 pcf
28-Day Strength, f_c = 8000 psi
Release Strength, f_c' = 4500 psi

Prestressing Strand
Quantity = 20
\( \frac{3}{8} \)" Ø, 270 ksi Lolax
Pulled to 31.0 kips each (75%)
Precast/Prestressed Piling: Design Criteria and Input

Design Criteria
1) Service Load Design.
2) Allowable Compressive Stress = 0.45f'\_c for SUSTAINED LOADS.
3) Allowable Tension Stress = 0 for SUSTAINED LOADS.
4) For TEMPORARY LOADS, Allowable Compressive Stress = 0.60f'\_c.
5) For TEMPORARY LOADS, Allowable Tension Stress = 0.
6) Assume a sustained compression service load equal to: 1200 kips.
7) Use PCI method for estimating prestress losses.
8) Bending is about principle axes AND only one axis at a time.
9) Slenderness is not considered.
10) Ultimate capacity must be checked to ensure the required factor of safety is achieved in accordance with ACI 318.

Design Input
Section Size:
- h = 24 inches
- b = 24 inches

Section Area (accounting for chamfers, radii, etc.):
- A\_g = 574 square inches

Prestressing Strand:
- Type = 270 ksi, Lolax
- Size = 1/2" (std.)
- Qty. = 20
- Area = 0.153 square inches per strand
- Pull = 75% (initial)

Concrete:
- wc = 145 pcf (concrete weight)
- f'c = 8000 psi (28-day Concrete Compressive Strength)
- f'ci = 4500 psi (Required Concrete Release Strength)
- Ec = 5,153,603 psi (concrete modulus of elasticity at 28-days)
- Eci = 3,865,202 psi (concrete modulus of elasticity at transfer of prestress)
Precast/Prestressed Piling: Service Load Interaction Diagram

Service Load Interaction Diagram

Pile Size = 24" x 24"

Concrete
Normal Weight 8000 psi
4500 psi

Prestressing Strand
Type = 270 ksi, Lolax
Size = 1/2" (std.)
Qty. = 20
Area = 0.153 in²
Pull = 75%

Heldenfels Enterprises, Inc.
Engineering Department 24"x24" Pile, Type B

DATE 2/12/2010
BY cK Structural

5700 IH 35 South, San Marcos, TX 78666, phone, 512.396.2376, www.heldenfels.com
Pile Connection Detail
(Side-View Thru Pile and Foundation)

- Cast-in-Place (C.I.P.) Concrete Foundation
- Top of C.I.P. Foundation
- Sawcut top of pile as required to attain proper elevation
- Top of Pile Elevation
- As Required By E.O.R.
- Btm. of C.I.P. Foundation
- Precast/Prestressed Pile
- Provide Min. Hook Length (By E.O.R.)
- Provide Min. Ld Distance (By E.O.R.)
- Rebar as required by Engineer-of-Record (E.O.R.)
- Install Grout - at rebar - (By Others)
- 2"Ø (or as req.) Corrugated Sleeve
  *Oversize length as req.
- Fill Bottom of Sleeves - below rebar - with Sand (By Others)

*HEI provides oversize sleeve lengths such that the top of pile can be sawcut to the proper elevation and enough sleeve length remains to adequately anchor the grouted rebar. The General Contractor, E.O.R., and HEI will coordinate this sleeve length prior to beginning pile production.
Design Criteria
1) Service Load Design.
2) Allowable Compressive Stress = 0.45$f'_c$ for SUSTAINED LOADS.
3) Allowable Tension Stress = 0 for SUSTAINED LOADS.
4) For TEMPORARY LOADS, Allowable Compressive Stress = 0.60$f'_c$.
5) For TEMPORARY LOADS, Allowable Tension Stress = 0.
6) Assume a sustained compression service load equal to: 250 kips.
7) Use PCI method for estimating prestress losses.
8) Bending is about principle axes AND only one axis at a time.
9) Slenderness is not considered.
10) Ultimate capacity must be checked to ensure the required factor of safety is achieved in accordance with ACI 318.

Design Input
Section Size:
- $h = 16$ inches
- $b = 16$ inches

Section Area (accounting for chamfers, radii, etc.):
$A_g = 254$ square inches

Prestressing Strand:
- Type = 270 ksi, Lolax
- Size = 1/2" (std.)
- Qty. = 8
- Area = 0.153 square inches per strand
- Pull = 75% (initial)

Concrete:
- $w_c = 145$ pcf (concrete weight)
- $f'c = 5000$ psi (28-day Concrete Compressive Strength)
- $f'ci = 4000$ psi (Required Concrete Release Strength)
- $Ec = 4,074,281$ psi (concrete modulus of elasticity at 28-days)
- $Eci = 3,644,147$ psi (concrete modulus of elasticity at transfer of prestress)
Sample Calculations

Precast/Prestressed Piling: Points for Service Load Interaction Diagram - Sustained Loads

Effective Force in Strand, $F_{\text{eff}}$

$$F_{\text{eff}} = 24,729 \text{ lbs}$$

Effective Prestress in Pile, $\sigma_{\text{eff}}$

$$f_{\text{pc}} = 779 \text{ psi}$$

Point 1 - Upper Boundary (Compression Only, No Bending $\rightarrow M_1 = 0$)

$$P_1/A + M_1/S + f_{\text{pc}} = 0.45f'_{c}$$

\[
\begin{align*}
A &= \frac{254}{\text{square inches}} \\
M_1 &= 0 \\
S &= \frac{683}{\text{inches}^3}
\end{align*}
\]

$$P_1 = 373,666 \text{ lbs}$$

Point 2 - Compression with Minimum Eccentricity (5%)

$$P_2/A + M_2/S + f_{\text{pc}} = 0.45f'_{c}$$

$$e_{\text{min}} = 0.80 \text{ (minimum eccentricity)}$$

$$M_2 = 0.80 P \text{ lb*inches}$$

$$P_2 = 287,955 \text{ lbs}$$

$$M_2 = 19.2 \text{ kip*feet}$$

Point 3 - Crossover From Compression to Tension Controls

Part A: $P_3/A + M_3/S + f_{\text{pc}} = 0.45f'_{c}$

Part B: $P_3/A - M_3/S + f_{\text{pc}} = 0 \text{ OR } P_3 = A[(M/S) - f_{\text{pc}}]$

Rewrite Part A: $A[(M_3/S) - f_{\text{pc}}]/A + M_3/S + f_{\text{pc}} = 0.45f'_{c}$

Solve for $M_3$:

$$M_3 = 768,000 \text{ kip*inches}$$

$$M_3 = 64.0 \text{ kip*feet}$$

Solve for $P_3$:

$$P_3 = A[(M_3/S) - f_{\text{pc}}]$$

$$P_3 = 87,916 \text{ lbs}$$

Point 4 - Tension Controls and $M = 0$

$$P_4/A - 0/S + f_{\text{pc}} = 0$$

$$P_4 = -197,834 \text{ lbs}$$
Sample Calculations

Precast/Prestressed Piling: Points for Service Load Interaction Diagram - Sustained + Temporary Loads

Effective Force in Strand, $F_{\text{eff}}$

$$F_{\text{eff}} = 24,729 \text{ lbs}$$

Effective Prestress in Pile, $\sigma_{\text{eff}}$

$$\sigma_{\text{eff}} = 779 \text{ psi}$$

Point 1 - Upper Boundary (Compression Only, No Bending)

$$P_1/A + M_1/S + f_{pc} = 0.60f'_c$$

- $A = 254 \text{ square inches}$
- $M_1 = 0$
- $S = 683 \text{ inches}^3$

$$P_1 = 564,166 \text{ lbs}$$

Point 2 - Compression with Minimum Eccentricity (5%)

$$P_2/A + M_2/S + f_{pc} = 0.60f'_c$$

- $e_{\text{min}} = 0.80$ (minimum eccentricity)
- $M_2 = 0.80 P$ lb*inches

$$P_2 = 434,758 \text{ lbs}$$
$$M_2 = 29.0 \text{ kip*feet}$$

Point 3 - Crossover From Compression to Tension Controls

- **Part A:** $P_3/A + M_3/S + f_{pc} = 0.60f'_c$
- **Part B:** $P_3/A - M_3/S + f_{pc} = 0 \quad \text{OR} \quad P_3 = A[(M/S) - f_{pc}]$

Rewrite Part A: $A[(M_3/S) - f_{pc}]/A + M_3/S + f_{pc} = 0.60f'_c$

Solve for $M_3$:

$$M_3 = 1,024,000 \text{ kip*inches}$$
$$M_3 = 85.3 \text{ kip*feet}$$

Solve for $P_3$:

$$P_3 = A[(M_3/S) - f_{pc}]$$
$$P_3 = 183,166 \text{ lbs}$$

Point 4 - Tension Controls and $M = 0$

$$P_4/A - 0/S + f_{pc} = 0$$
$$P_4 = -197,834 \text{ lbs}$$
### Sample Calculations

#### Precast/Prestressed Piling: Points for Service Load Interaction Diagram

<table>
<thead>
<tr>
<th>Points - Sustained Loads</th>
<th>Points - Sustained + Temp. Loads</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P&lt;sub&gt;1&lt;/sub&gt;</strong> = 373,666 lbs</td>
<td><strong>P&lt;sub&gt;1&lt;/sub&gt;</strong> = 564,166 lbs</td>
</tr>
<tr>
<td><strong>M&lt;sub&gt;1&lt;/sub&gt;</strong> = 0.0 kip*feet</td>
<td><strong>M&lt;sub&gt;1&lt;/sub&gt;</strong> = 0.0 kip*feet</td>
</tr>
<tr>
<td><strong>P&lt;sub&gt;2&lt;/sub&gt;</strong> = 287,955 lbs</td>
<td><strong>P&lt;sub&gt;2&lt;/sub&gt;</strong> = 434,758 lbs</td>
</tr>
<tr>
<td><strong>M&lt;sub&gt;2&lt;/sub&gt;</strong> = 19.2 kip*feet</td>
<td><strong>M&lt;sub&gt;2&lt;/sub&gt;</strong> = 29.0 kip*feet</td>
</tr>
<tr>
<td><strong>P&lt;sub&gt;3&lt;/sub&gt;</strong> = 87,916 lbs</td>
<td><strong>P&lt;sub&gt;3&lt;/sub&gt;</strong> = 183,166 lbs</td>
</tr>
<tr>
<td><strong>M&lt;sub&gt;3&lt;/sub&gt;</strong> = 64.0 kip*feet</td>
<td><strong>M&lt;sub&gt;3&lt;/sub&gt;</strong> = 85.3 kip*feet</td>
</tr>
<tr>
<td><strong>P&lt;sub&gt;4&lt;/sub&gt;</strong> = -197,834 lbs</td>
<td><strong>P&lt;sub&gt;4&lt;/sub&gt;</strong> = -197,834 lbs</td>
</tr>
<tr>
<td><strong>M&lt;sub&gt;4&lt;/sub&gt;</strong> = 0.0 kip*feet</td>
<td><strong>M&lt;sub&gt;4&lt;/sub&gt;</strong> = 0.0 kip*feet</td>
</tr>
</tbody>
</table>

#### Standard Building Code Equation for Maximum Axial Load

\[
P_{\text{max}} = (0.33f'c - 0.27f_{pc})A_g
\]

\[
P_{\text{max}} = 365,685 \text{ lbs}
\]
Precast/Prestressed Piling: Service Load Interaction Diagram

**Pile Size = 16" x 16"

Concrete Normal Weight
5000 psi
4000 psi

Prestressing Strand Type = 270 ksi, Lolax
Size = 1/2" (std.)
Qty. = 8
Area = 0.153 in²
Pull = 75%

---

**Sample Calculations**

`Heldenfels Enterprises, Inc.`

Engineering Department

`16"x16" Pile, Type A`

`STANDARD PILING`

`DATE 2/12/2010`

`BY cK Structural SHEET 16x16A`

5700 IH 35 South, San Marcos, TX 78666, phone, 512.396.2376, www.heldenfels.com`
Prestress Losses
TL = ES + CR + SH + RE
PCI Eq. 4.7.3.1

TL = Total Losses (psi)
ES = Elastic Shortening (psi)
CR = Creep of Concrete (psi)
SH = Shrinkage of Concrete (psi)
RE = Relaxation of Tendons (psi)

Elastic Shortening (ES)
ES = K_{es}E_{ps}f_{cir} / E_{ci}
PCI Eq. 4.7.3.2

K_{es} = 1.0 for pretensioned members
E_{ps} = 28,500,000 psi
E_{ci} = 3,644,147 psi

f_{cir} = K_{cir}[P_{i}/A_{g} + P_{i}*(e^{2}/I_{g})] - M_{g}*(e/I_{g}) (PCI Eq. 4.7.3.3)
K_{cir} = 0.9 for pretensioned members
P_{i} = 247,860 lbs
A_{g} = 254 square inches
e = 0 inches
I_{g} = 5,461 inches^{4}
M_{g} = 0 kip*inches
f_{cir} = 878 psi

ES = 6,869 psi

Creep of Concrete (CR)
CR = K_{cr}(E_{ps}/E_{c})(f_{cir} + f_{cds})
PCI Eq. 4.7.3.4

K_{cr} = 2.0 Normal Weight Concrete
E_{c} = 4,074,281 psi

f_{cds} = P_{d}/A_{g} + M_{sd}(e)/I_{g} (PCI Eq. 4.7.3.5)
M_{sd} = 0 kip*inches
f_{cds} = 984 psi

CR = 26,057 psi

Shrinkage of Concrete (SH)
SH = (8.2 x 10^{-6})K_{sh}E_{ps}(1 - 0.06V/S)(100 - R.H.)
PCI Eq. 4.7.3.6

K_{sh} = 1.0 for pretensioned members
V/S = 4.00 inches
R.H. = 75 % (PCI Fig. 3.10.12)

SH = 4,440 psi
Sample Calculations

Precast/Prestressed Piling: Prestress Loss Calculations

Prestress Losses (continued)

Relaxation of Tendons (RE)

\[ \text{RE} = (K_{re} - J(SH + CR + ES))C \]

\[ K_{re} = 5,000 \quad \text{for 270 ksi, Lolax Strand} \]

PCI Eq. 4.7.3.7

\[ J = 0.040 \quad \text{for 270 ksi, Lolax Strand} \]

PCI Table 4.7.3.1

\[ \frac{f_{pl}}{f_{pu}} = 0.75 \]

\[ C = 1.00 \]

See Table Below

\[ \text{RE} = 3,505 \quad \text{psi} \]

<table>
<thead>
<tr>
<th>( \frac{f_{pl}}{f_{pu}} )</th>
<th>C-Value</th>
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<tbody>
<tr>
<td>0.80</td>
<td>1.28</td>
</tr>
<tr>
<td>0.79</td>
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<tr>
<td>0.78</td>
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<td>0.74</td>
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<tr>
<td>0.71</td>
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<tr>
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<td>0.37</td>
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<tr>
<td>0.60</td>
<td>0.33</td>
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</table>

Total Losses, TL

\[ \text{TL} = 40,871 \quad \text{psi} \]

Heldenfels Enterprises, Inc.

<table>
<thead>
<tr>
<th>Engineering Department</th>
<th>STANDARD PILING</th>
<th>16&quot;x16&quot; Pile, Type A</th>
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<th>2/12/2010</th>
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<td></td>
<td></td>
<td></td>
<td>BY</td>
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<td></td>
<td>SHEET</td>
<td>16x16A_07</td>
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</table>

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