Preliminary Base Plate Selection

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IN SUPPLEMENT NO. 3 to the AISC Specification,[1,2] the allowable bearing stress of steel base plates on concrete was liberalized to agree with the latest design rules of the ACI Code.[3] Based on these higher allowable bearing stresses, the author has developed design aids for rapid selection of base plates. Also, a new design procedure is proposed for lightly loaded column bases.

DESIGN AIDS

Charts 1–6 are nomographs that can facilitate the preliminary selection of steel base plates. Charts 1–3 are developed for bearing on 3,000 psi concrete, Charts 4–6 are for bearing on 4,000 psi concrete.

Development of the Charts—Supplement No. 3 to the AISC Specification limits the bearing pressure on a concrete support, in ksi, to:

$$F_p = 0.35f_c'\sqrt{A_2/A_1} \leq 0.7f_c' \qquad (1)$$

where

f_c' = specified compressive strength of concrete, ksi
A_1 = bearing area, in.^{2}
A_2 = area of concrete, in.^{2}

Since $F_p = P/A_1$, where P is the load in kips, Eq. (1) can be rewritten as

$$A_1 = \frac{P^2}{(0.35f_c')^2A_2} \leq \frac{P}{0.7f_c'} \qquad (2)$$

Figure 1 illustrates the construction of the nomographs in Charts 1–6. Each chart has two quadrants, with bearing area A_1 as the common vertical axis. The horizontal axes are concrete area A_2 in the first quadrant and base plate width B in the second quadrant.

In the first quadrant, curve $A_1 = A_2$ (minimum bearing pressure, i.e., bearing on the full area of concrete support, $F_p = 0.35f_c'$) and curve $A_1 = A_2/4$ (maximum allowable bearing pressure, $F_p = 0.7f_c'$) are plotted as upper and lower limits. Then, for a given value of f_c' and various values of P, Eq. (2) is plotted between limits (see line 1–2, Fig. 1); the limiting value of Eq. (2), $A_1 = P/0.7f_c'$, is plotted as line 2–3.

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In the second quadrant of each Chart, the equation $N = A_1/B$, where N is the depth and B is the width of base plate, is plotted for various values of N, including $N = B$ $(= \sqrt{A_1})$.

Example 1

Given: Select the preliminary size of base plate for a W12×106 column supporting a load of 560 kips, bearing on a 28-in. x 28-in. pier, f_c' = 3,000 psi.

Solution:
$A_2 = 28 \times 28 = 784$ in.^{2}

From Chart 2:
1. In first quadrant, enter chart at $A_2 = 784$ in.^{2}
2. Proceed vertically to $P = 560$ kips.
3. Draw a line from the origin through point 2, to find that the allowable bearing pressure is F_p = 1.54 ksi.
4. From point 2, proceed horizontally to A_1 = 365 in.^{2}
5. Continue horizontally to $N = 20$ in.
6. Proceed vertically to $B = 18.4$ in.

Try 19-in. x 20-in. plate.

To complete the design, proceed as per AISC Manual,[4] p. 3-95.

LIGHTLY LOADED BASE PLATES

A lightly loaded base plate shall, for the purpose of this paper, be defined as one wherein the required area A_1 is approximately equal to (or even less than) the column flange width times the depth. In this case the design procedure on p. 3-95 of the AISC Manual may lead to erroneous results. The Manual procedure assumes that the critical section is a cantilever of length m or n, whereas the critical section is most likely to fall between the flanges.

In Fig. 2 the critical stress may exist within the plate ABCD with end conditions as shown and uniform loading. There are plate solutions to this problem such as by Timoshenko and Woinowsky-Krieger.[5] However, the author does not feel that this type of solution applies to base plates, as it ignores the flexibility of the plate and subsequent redistribution of bearing stresses.

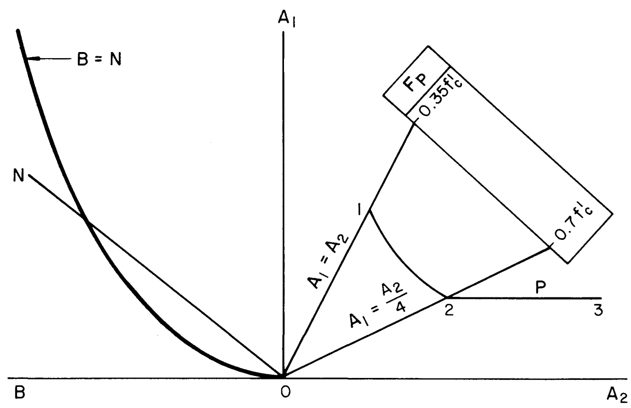


Figure 1

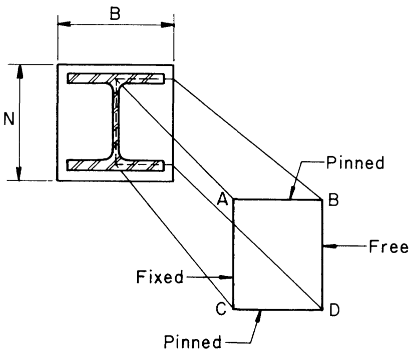


Figure 2

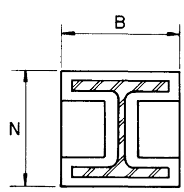


Figure 3

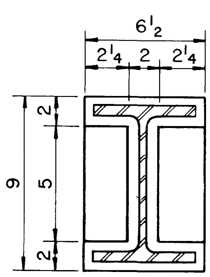


Figure 4

The proposed solution method assumes that a portion of the base plate is not stressed (shaded portion of Fig. 3) and the base plate is designed as an H-shaped strip under the column. The assumed width of the strip is purely a matter of engineering judgment depending on column size, overhang, bearing stress, etc. Although the author feels that bending in the plate will govern, plate shear can be checked, as in Example 2.

Example 2

Given: Select a base plate for a W8×20 column supporting a load of 75 kips on a 3-ft x 3-ft footing, $f_c' = 3{,}000$ psi.

Solution:

$A_2 = 3 \times 3 \times 144 = 1{,}296$ in.²

From Chart 1:

1. $A_2 = 1{,}296$ in.² > values in Chart; $\therefore$ enter Chart at $P \doteq 75$ kips.
2. Proceed horizontally to $A_1 = 36$ in.²

For W8×20:

$b_f d = 5.268 \times 8.14 = 42$ in.² $> A_1 = 36$ in.²

Try 6½ x 9 plate (see Fig. 4):

$A_1 = 9 \times 6\frac{1}{2} - 2(2\frac{1}{4} \times 5)$

$= 36$ in.² ($f_p = 75/36 = 2.08 < 2.1$ ksi **o.k.**)

Bending:

$$M = \frac{2.08\,(1)^2}{2} = 1.04 \text{ kip-in.}$$

$$t = \sqrt{\frac{6M}{bF_b}} = \sqrt{\frac{6 \times 1.04}{1 \times 27}} = 0.48 \text{ in.}$$

Shear:

$V = 2.08/2 = 1.04$ kips/in. (each side)

$$t = \frac{1.04}{14.5 \times 1} = 0.07 \text{ in. } \therefore \text{ bending governs}$$

Use: PL ½ x 6½ x 0 ft-9 in.

REFERENCES

1. Supplement No. 3 to the Specification for the Design, Fabrication & Erection of Structural Steel for Buildings *American Institute of Steel Construction, New York, N. Y., June 12, 1974.*
2. Specification for the Design, Fabrication & Erection of Structural Steel for Buildings, *American Institute of Steel Construction, New York, N. Y., Feb. 12, 1969.*
3. Building Code Requirements for Reinforced Concrete (ACI 318-71), *American Concrete Institute, Detroit, Mich., 1971.*
4. Manual of Steel Construction, 7th Edition, *American Institute of Steel Construction, New York, N. Y., 1970.*
5. *Timoshenko, S. and S. Woinowsky-Krieger* Theory of Plates and Shells, 2nd Ed., *McGraw-Hill Book Company, New York, N. Y., 1959, pp. 208–211.*

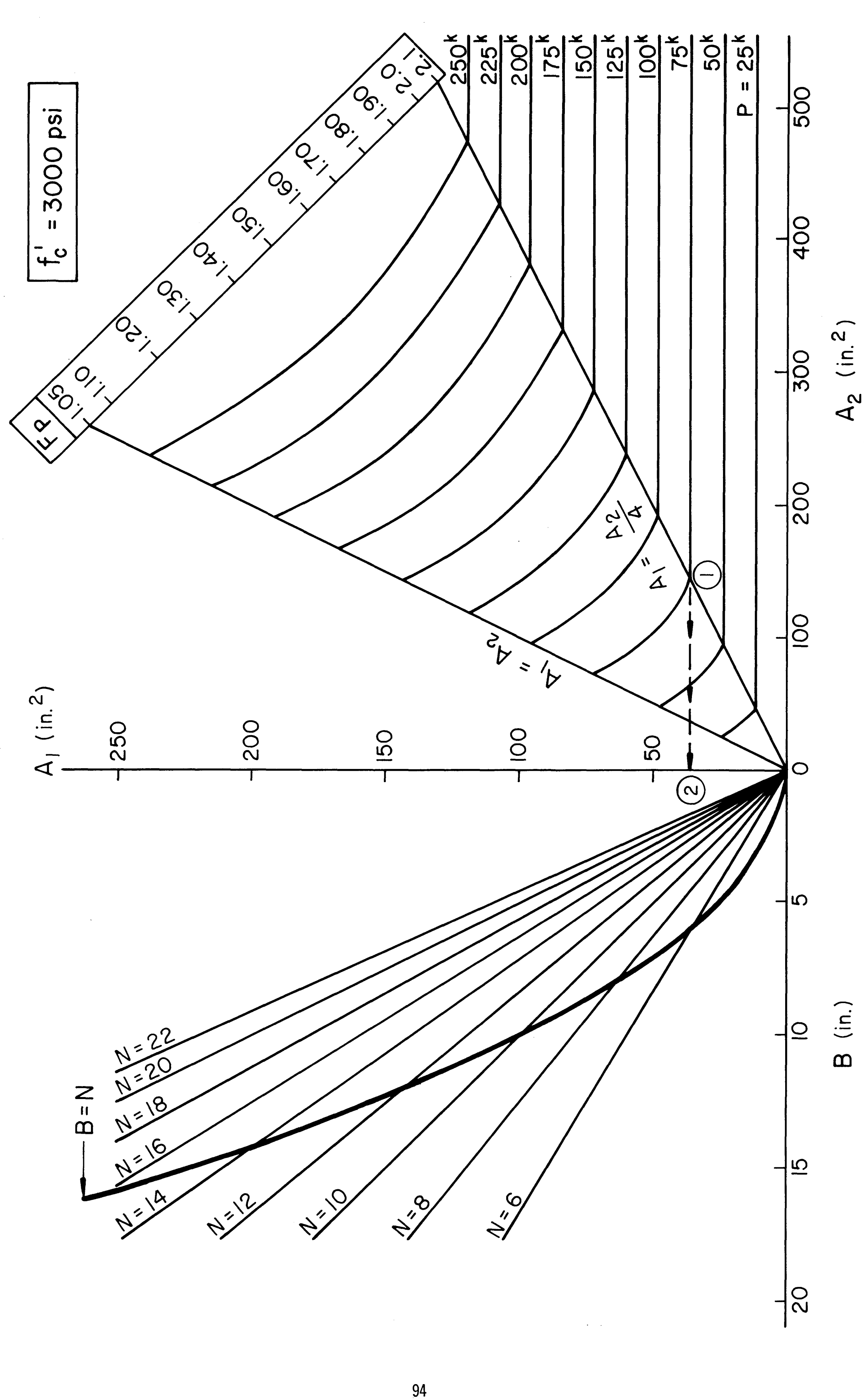
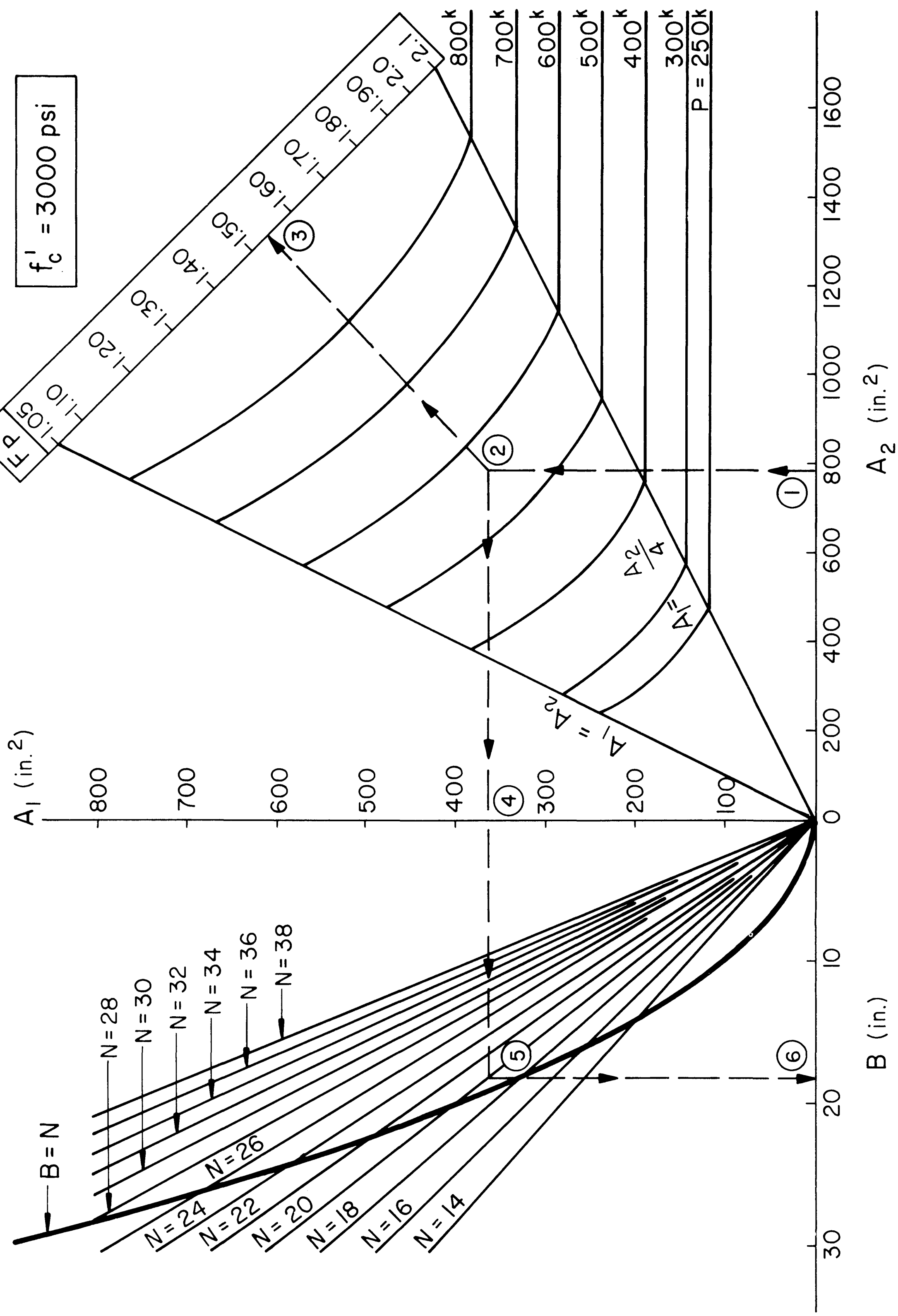

f'c = 3000 psi
FP
1.05
1.10
1.20
1.30
1.40
1.50
1.60
1.70
1.80
1.90
2.0
2.1
250k
225k
200k
175k
150k
125k
100k
75k
50k
P = 25k
A1 = A2
A1 = A2²/4
1
2
A1 (in.²)
250
200
150
100
50
0
100
200
300
400
500
A2 (in.²)
5
10
15
20
B (in.)
B = N
N = 22
N = 20
N = 18
N = 16
N = 14
N = 12
N = 10
N = 8
N = 6

Chart 7



f'_c = 3000 psi
F.P.
1.05
1.10
1.20
1.30
1.40
1.50
1.60
1.70
1.80
1.90
2.0
2.1
800k
700k
600k
500k
400k
300k
P = 250k
A₁ = A₂
A₁ = A₂/4
A₂ (in.²)
A₁ (in.²)
B (in.)
B = N
N = 14
N = 16
N = 18
N = 20
N = 22
N = 24
N = 26
N = 28
N = 30
N = 32
N = 34
N = 36
N = 38

Chart 2

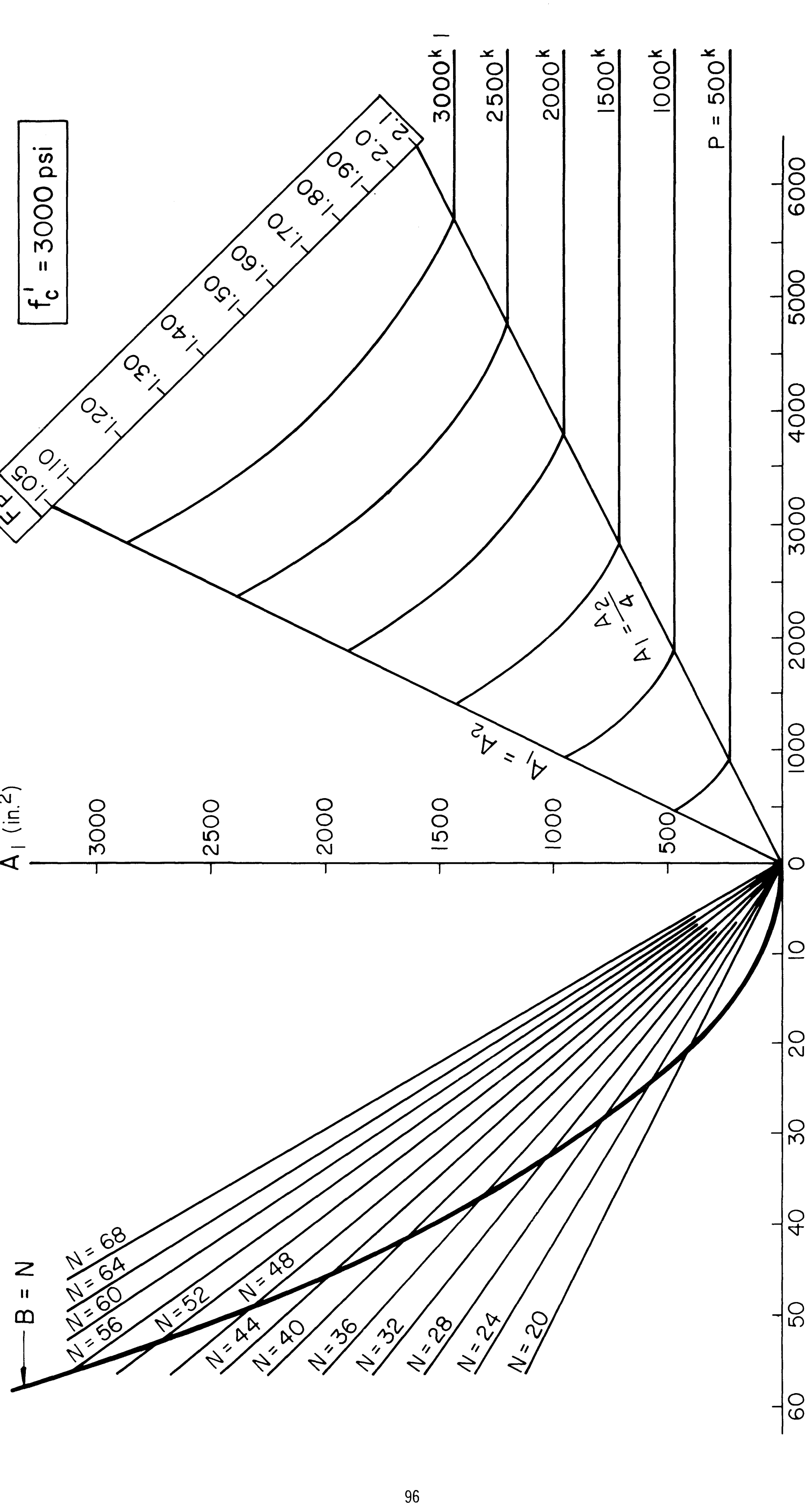
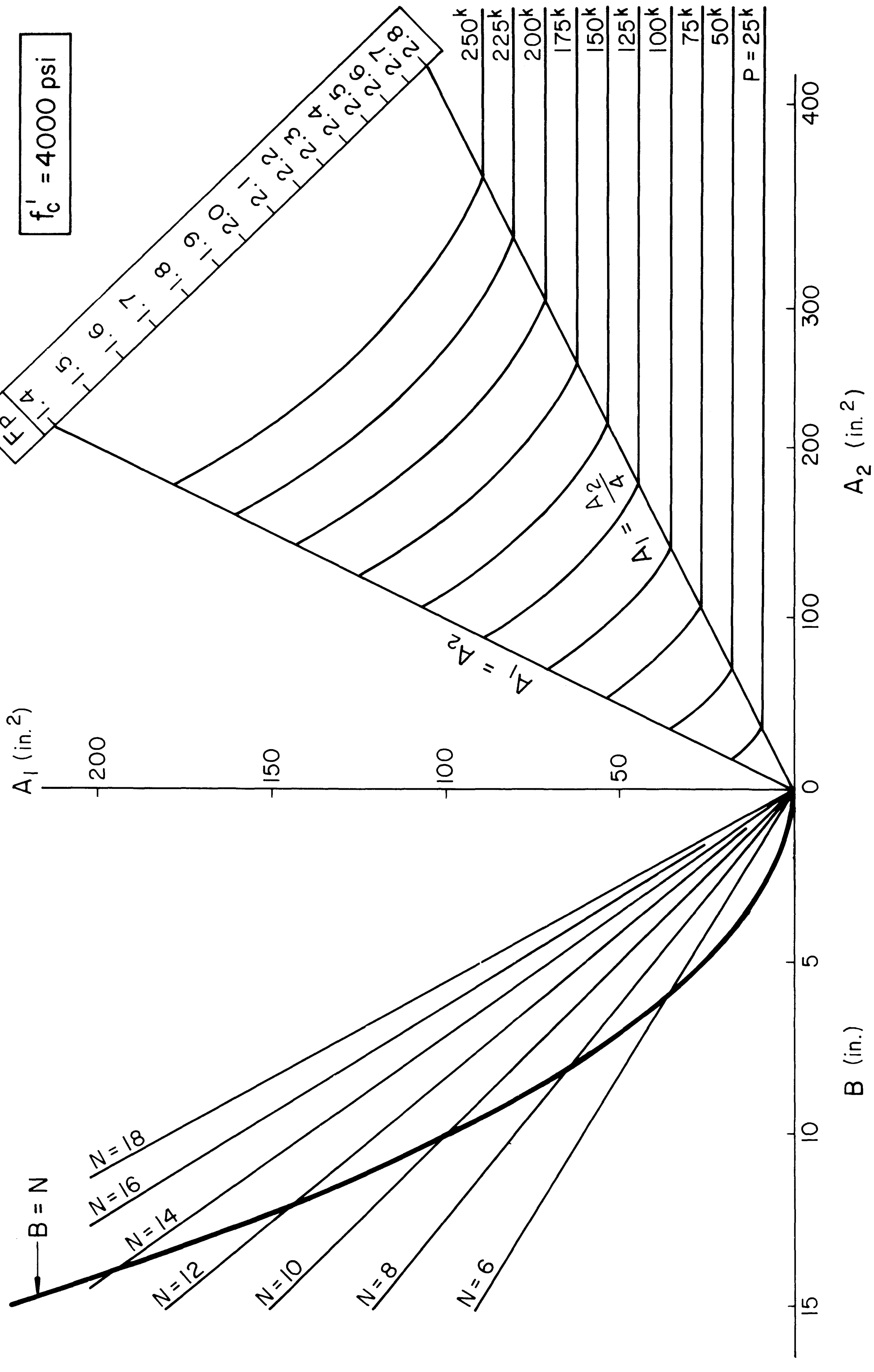
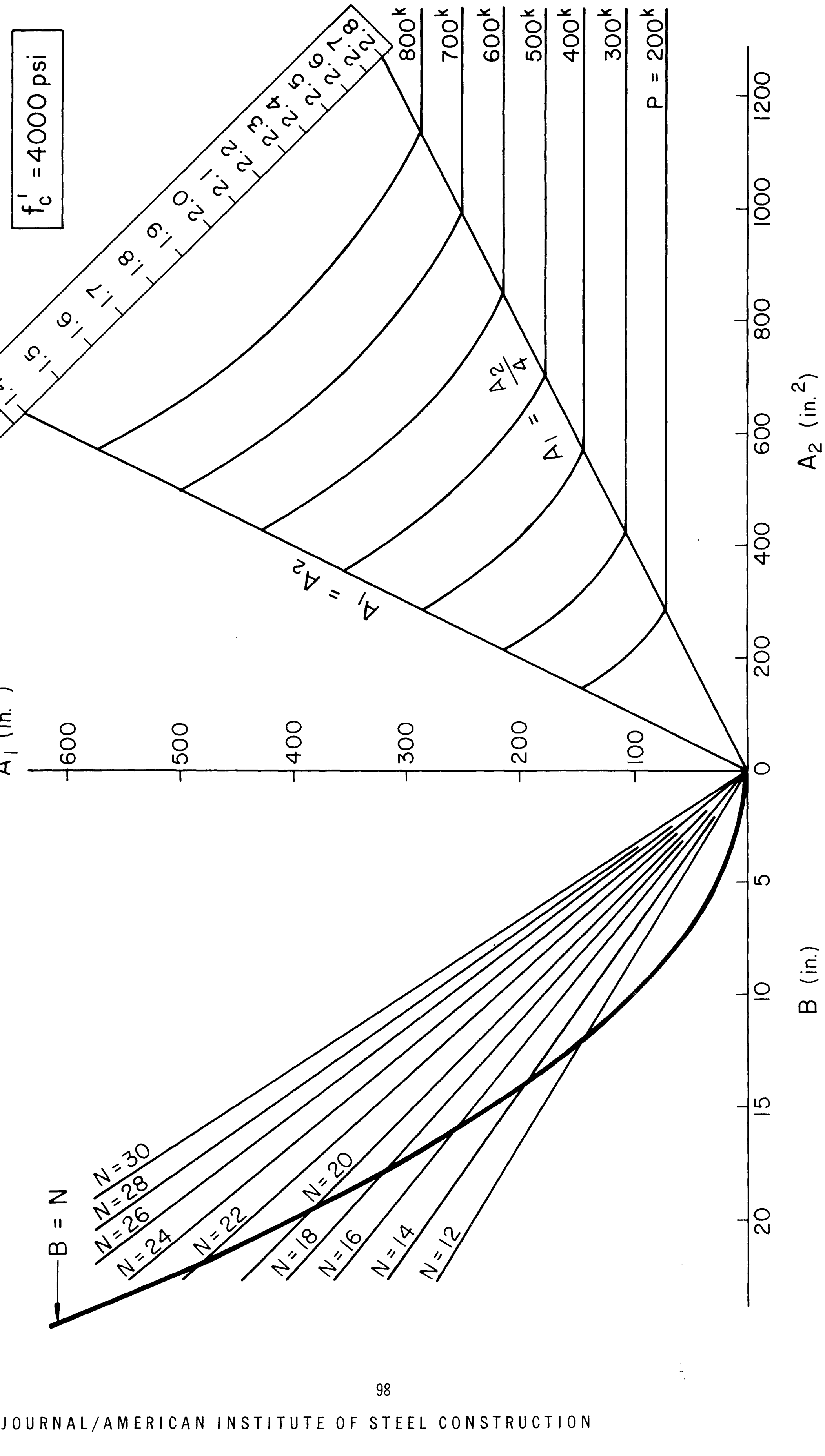

f'c = 3000 psi
Fp
1.05
1.10
1.20
1.30
1.40
1.50
1.60
1.70
1.80
1.90
2.0
2.1
3000k
2500k
2000k
1500k
1000k
P = 500k
A1 (in.2)
A1 = A2
A1 = A2/4
A2 (in.2)
B (in.)
B = N
N = 68
N = 64
N = 60
N = 56
N = 52
N = 48
N = 44
N = 40
N = 36
N = 32
N = 28
N = 24
N = 20

Chart 3



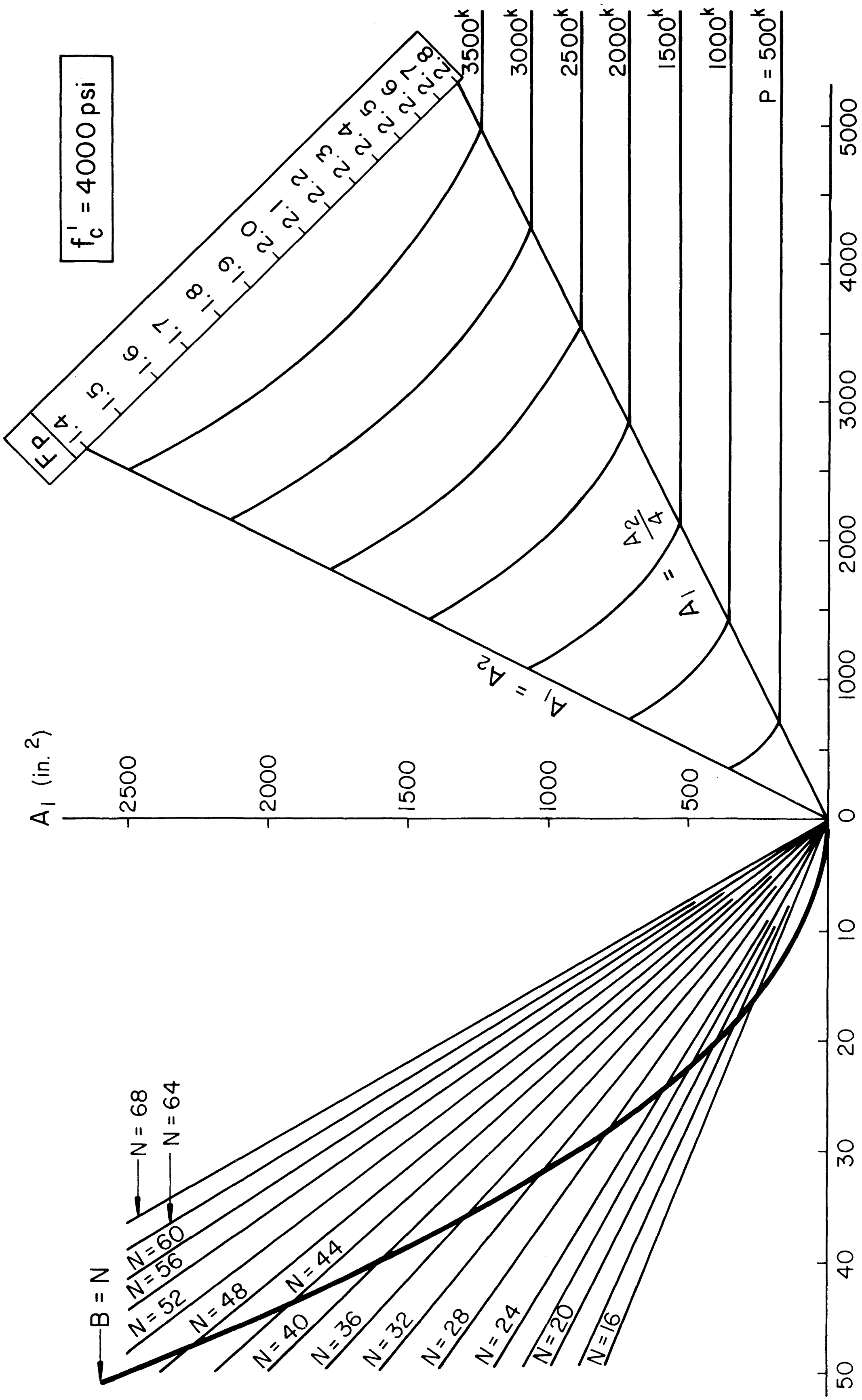
f'c = 4000 psi
A1 (in.2)
200
150
100
50
0
A2 (in.2)
100
200
300
400
B (in.)
5
10
15
B = N
N = 18
N = 16
N = 14
N = 12
N = 10
N = 8
N = 6
A1 = A2
A1 = A2²/4
P = 25k
50k
75k
100k
125k
150k
175k
200k
225k
250k
FP
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8

Chart 4



f'_c = 4000 psi
F_p
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
800k
700k
600k
500k
400k
300k
P = 200k
$A_1 = A_2$
$A_1 = \frac{A_2}{4}$
A_1 (in.^{2})
100
200
300
400
500
600
A_2 (in.^{2})
0
200
400
600
800
1000
1200
B (in.)
5
10
15
20
B = N
N=30
N=28
N=26
N=24
N=22
N=20
N=18
N=16
N=14
N=12

Chart 5



f'c = 4000 psi
FP
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
3500k
3000k
2500k
2000k
1500k
1000k
P = 500k
A1 = A2
A1 = A2/4
A1 (in.2)
2500
2000
1500
1000
500
0
1000
2000
3000
4000
5000
A2 (in.2)
10
20
30
40
50
B (in.)
B = N
N = 68
N = 64
N = 60
N = 56
N = 52
N = 48
N = 44
N = 40
N = 36
N = 32
N = 28
N = 24
N = 20
N = 16

Chart 6