Rapid Selection of W Columns (AASHO Method of Design)

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IN DESIGN of a column subjected to combined axial load and bending about one axis, use of the AASHO formula in Appendix C of the AASHO Specifications for the allowable column stress is tedious and time-consuming.

Rapid selection of the required column size for given forces can be made with the aid of curves presented here. Curves are developed for A36 steel, but can be used for A588 and other higher strength steels.

BASIC EQUATIONS

From Appendix C of AASHO Specifications:

$$f_s = \frac{f_y/\eta}{1 + (0.25 + e''_x c/r^2)\, B \text{ Cosec. } \phi} \qquad \text{Eq. (A)}$$

$$\frac{L}{r} = \text{Cos}^{-1}\alpha \left[\frac{E(1 + 0.25 + e''_x c/r^2)}{f_y}\right]^{1/2} \qquad \text{Eq. (B)}$$

$$f_s = \frac{f_y/\eta}{(1 + 0.25 + e''_x c/r^2)} \qquad \text{Eq. (C)}$$

The meaning of the different symbols is the same as given in Appendix C, except as defined below:

e''_x = Eccentricity of applied load at end of column having the greater computed moment M_g, in.
= M_g/P

P = Axial compressive load, kips

Curves are developed using Eq. (C) for a number of wide flange (W) sections.

LIMITATIONS OF CURVES

Curves presented here can be used for the design of a column where the following conditions are applicable:

(a) Eq. (C) governs the design; i.e., the value of actual L/r is assumed to be less than or equal to the value given by Eq. (B).

(b) Allowable stress value obtained by ignoring moments and considering P load as concentric load, and using L/r about an axis perpendicular to the plane of bending, is assumed to be greater than that given by Eq. (C).

(c) Bending of the column is about the major axis.

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USE OF CURVES

(a) *For A36 Steel:*

Enter the curves with known values of P and $e''_x (= M_g/P)$.

(b) *For Higher Strength Steels:*

(1) Calculate value of given eccentricity ($e''_x = M_g/P$).

(2) Calculate equivalent value of axial load P.

$$P' = (P \times 20 \times \eta)/f_y$$

For A588 steel (F_y = 50 ksi), $P' = 0.73P$

(3) Enter the curves with values of e''_x and P'.

The curve which falls towards the right and above the point of intersection of P (or P') and e''_x represents the required size of the column.

ILLUSTRATIVE EXAMPLES

Example 1

Given: P = 195 kips
M_g = 3900 in.-kips (bending about major axis)
A36 steel

Solution:

Assume W14 section required.

$$e''_x = M_g/P = 3900/195 = 20.0 \text{ in.}$$

From Fig. 2 (for P = 195 kips and e''_x = 20 in.):

W14×167 satisfies

Example 2

Given: P = 411 kips
M_g = 2466 in.-kips (bending about major axis)
A588 Steel (F_y = 50 ksi)

Solution:

Assume W12 section required.

$$e''_x = M_g/P = 2466/411 = 6.0 \text{ in.}$$

For A588 steel (F_y = 50 ksi):

$$P' = 0.73P = 0.73 \times 411 \approx 300 \text{ kips}$$

Enter Fig. 3 with P' = 300 kips and e''_x = 6 in.

W12×133 satisfies

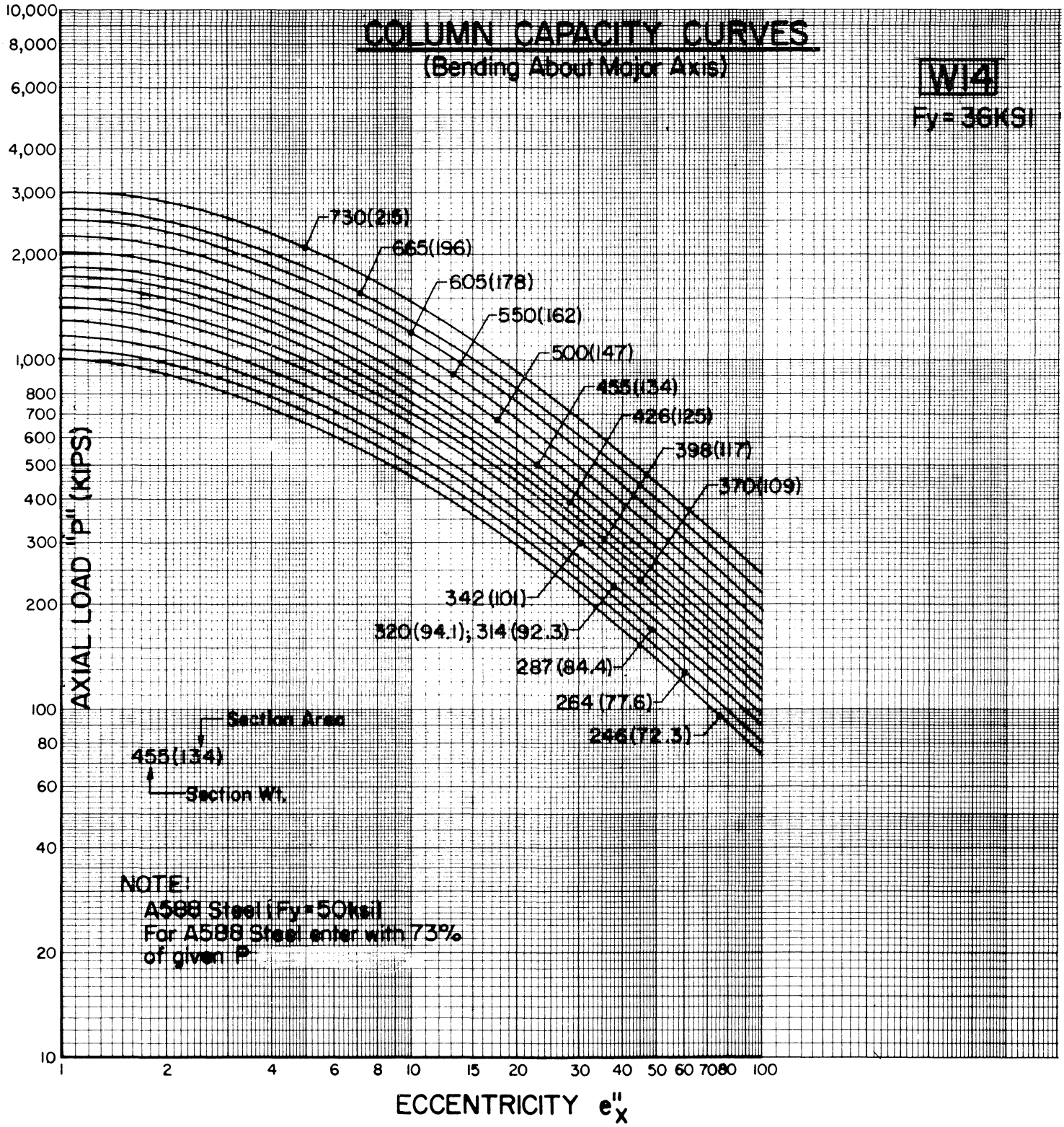
COLUMN CAPACITY CURVES
(Bending About Major Axis)
W14
Fy = 36KSI
730(215)
665(196)
605(178)
550(162)
500(147)
455(134)
426(125)
398(117)
370(109)
342(101)
320(94.1); 314(92.3)
287(84.4)
264(77.6)
246(72.3)
AXIAL LOAD "P" (KIPS)
ECCENTRICITY e''_x
Section Area
455(134)
Section Wt.
NOTE:
A588 Steel (Fy = 50ksi)
For A588 Steel enter with 73%
of given P
10,000
8,000
6,000
4,000
3,000
2,000
1,000
800
700
600
500
400
300
200
100
80
60
40
20
10
1
2
4
6
8
10
15
20
30
40
50
60
70
80
100

Figure 1

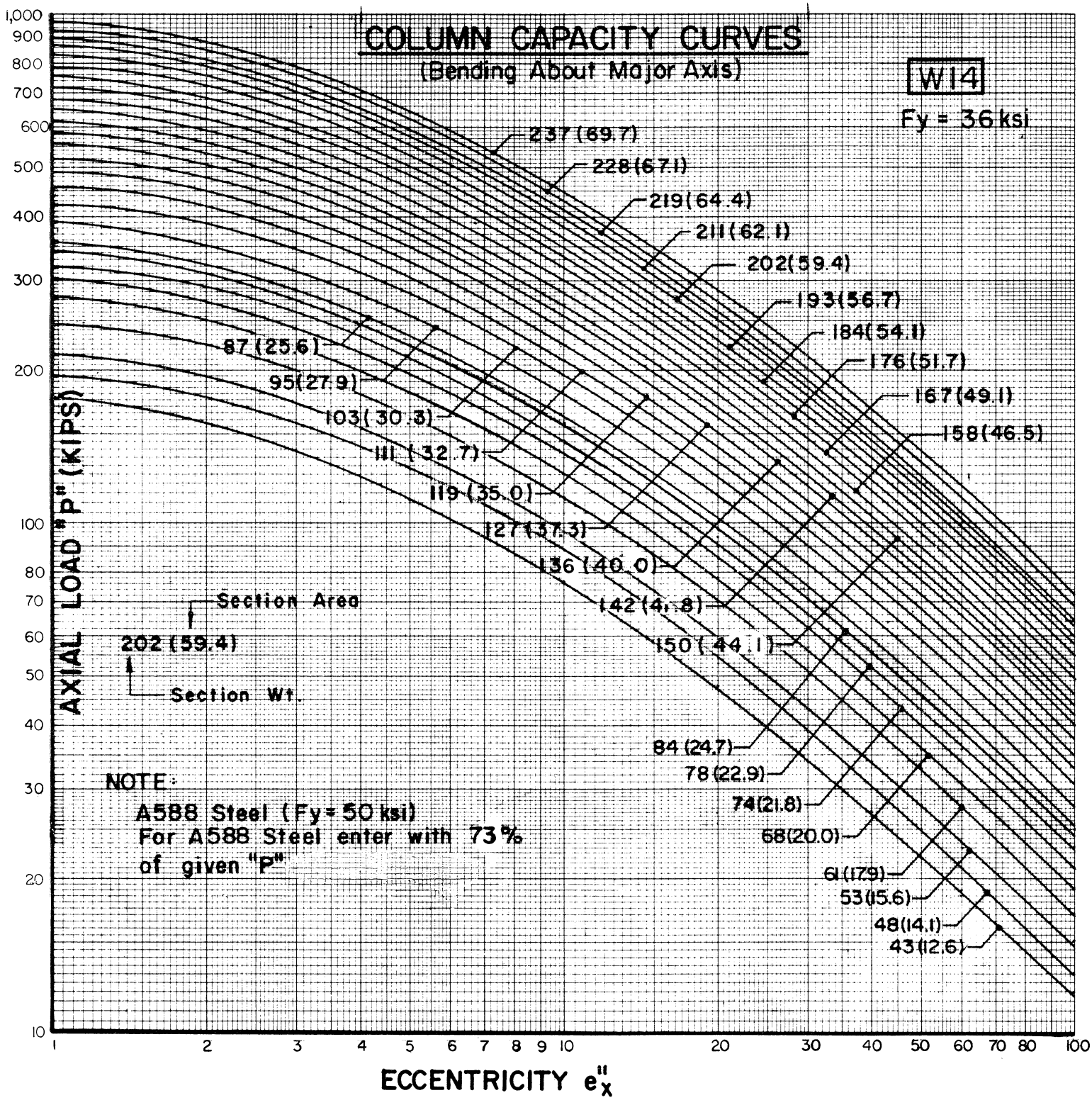
COLUMN CAPACITY CURVES
(Bending About Major Axis)
W14
Fy = 36 ksi
237 (69.7)
228 (67.1)
219 (64.4)
211 (62.1)
202 (59.4)
193 (56.7)
184 (54.1)
176 (51.7)
167 (49.1)
158 (46.5)
87 (25.6)
95 (27.9)
103 (30.3)
111 (32.7)
119 (35.0)
127 (37.3)
136 (40.0)
142 (41.8)
150 (44.1)
84 (24.7)
78 (22.9)
74 (21.8)
68 (20.0)
61 (17.9)
53 (15.6)
48 (14.1)
43 (12.6)
Section Area
202 (59.4)
Section Wt.
NOTE:
A588 Steel (Fy = 50 ksi)
For A588 Steel enter with 73%
of given "P"
AXIAL LOAD "P" (KIPS)
ECCENTRICITY e"x
1,000
900
800
700
600
500
400
300
200
100
80
70
60
50
40
30
20
10
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70
80
100

Figure 2

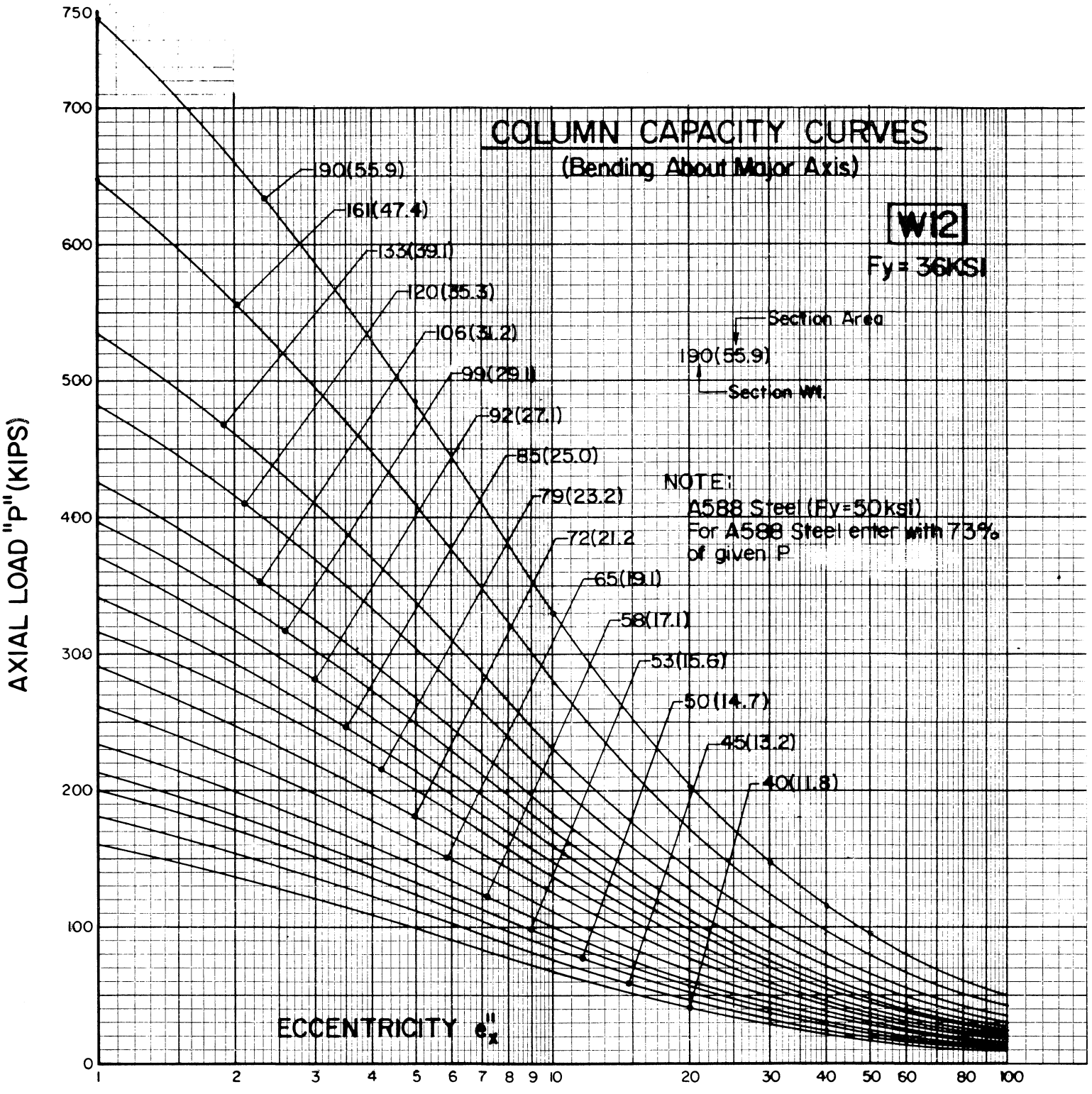
COLUMN CAPACITY CURVES
(Bending About Major Axis)
W12
Fy = 36KSI
AXIAL LOAD "P" (KIPS)
ECCENTRICITY e_x''
Section Area
190(55.9)
Section Wt.
190(55.9)
161(47.4)
133(39.1)
120(35.3)
106(31.2)
99(29.1)
92(27.1)
85(25.0)
79(23.2)
72(21.2
65(19.1)
58(17.1)
53(15.6)
50(14.7)
45(13.2)
40(11.8)
NOTE:
A588 Steel (Fy=50ksi)
For A588 Steel enter with 73%
of given P
750
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
80
100

Figure 3

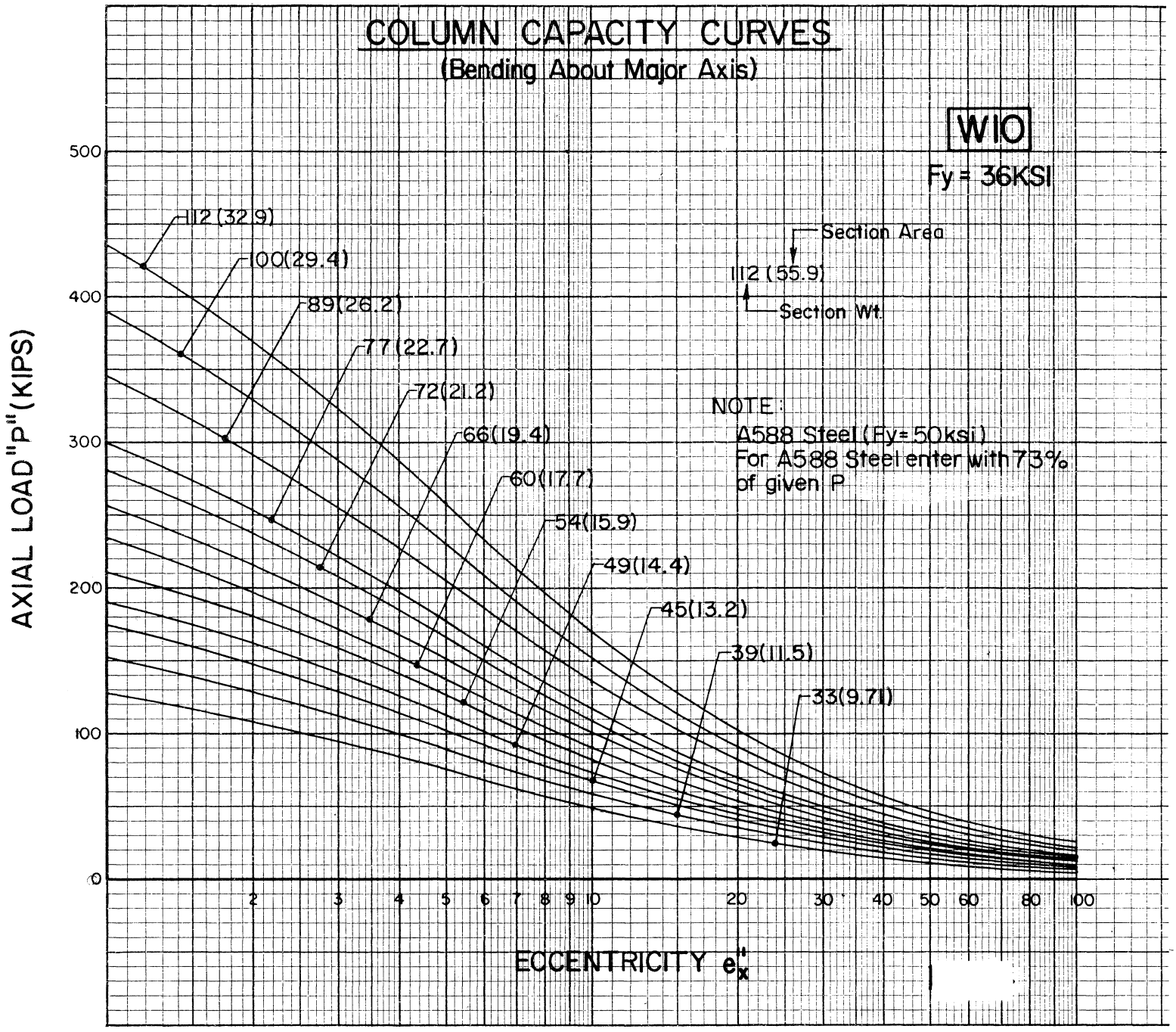
COLUMN CAPACITY CURVES
(Bending About Major Axis)
W10
Fy = 36KSI
112 (32.9)
100(29.4)
89(26.2)
77 (22.7)
72(21.2)
66(19.4)
60(17.7)
54(15.9)
49(14.4)
45(13.2)
39(11.5)
33(9.71)
Section Area
112 (55.9)
Section Wt.
NOTE:
A588 Steel (Fy = 50ksi)
For A588 Steel enter with 73%
of given P
AXIAL LOAD "P" (KIPS)
500
400
300
200
100
0
2
3
4
5
6
7
8
9
10
20
30
40
50
60
80
100
ECCENTRICITY e_x''

Figure 4

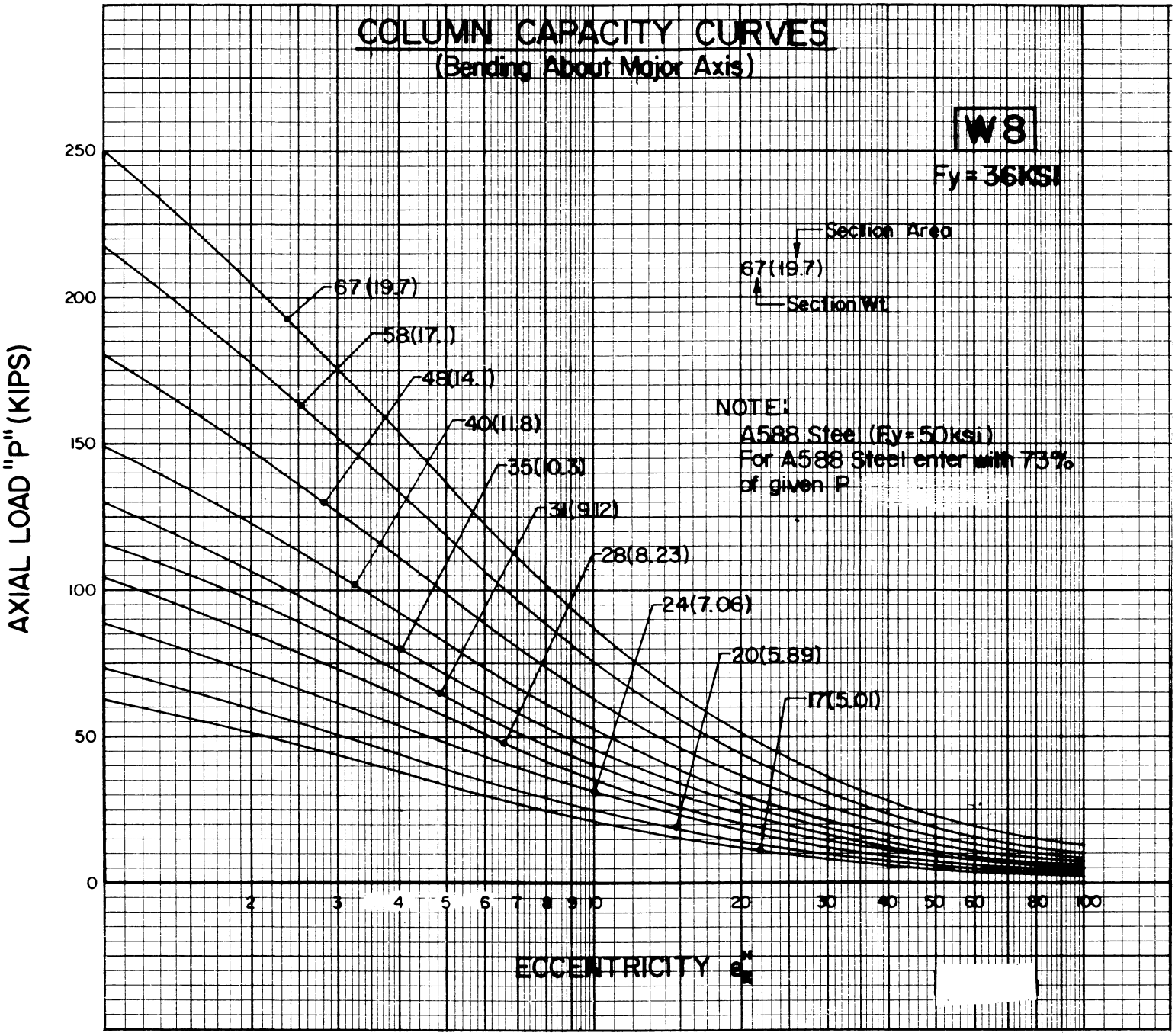
COLUMN CAPACITY CURVES
(Bending About Major Axis)
W8
Fy = 36KSI
Section Area
67(19.7)
Section Wt
67(19.7)
58(17.)
48(14.1)
40(11.8)
35(10.3)
31(9.12)
28(8.23)
24(7.06)
20(5.89)
17(5.01)
NOTE:
A588 Steel (Fy=50ksi)
For A588 Steel enter with 73%
of given P
AXIAL LOAD "P" (KIPS)
ECCENTRICITY e_x^x
250
200
150
100
50
0
2
3
4
5
6
7
8
9
10
20
30
40
50
60
80
100

Figure 5