Steel Column Base Plate Design

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THE DESIGN OF base plates of columns in steel frame buildings is simple but time consuming. The AISC *Manual of Steel Construction* contains tables of base plate sizes and thickness for maximum loads on columns of short lengths. However, in actual practice the column loads for various column sizes are seldom maximum as tabulated in the AISC Manual. Therefore, the size and thickness of base plate have to be calculated following the procedure given on pg. 3-95 of the AISC *Manual of Steel Construction, 7th Edition.* The writer has developed an alignment chart for the design of base plates of axially loaded columns using the AISC method.

The plate thickness t, in inches, is given by the larger value of the following:

$$t = \sqrt{\frac{3F_p m^2}{F_b}} \qquad (1)$$

or

$$t = \sqrt{\frac{3F_p n^2}{F_b}} \qquad (2)$$

where

F_p = allowable concrete bearing pressure, psi
F_b = allowable plate bending stress, psi
$m = \dfrac{(L - 0.95d)}{2}$
$n = \dfrac{(B - 0.8b)}{2}$
L = base plate length, in.
B = base plate width, in.
d = column depth, in.
b = column flange width, in.

For economical design, the dimensions of a base plate should be such that m and n are approximately equal. If base plate dimensions are so chosen that m is slightly larger than n, Eq. (1) will always control the plate thickness.

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From the AISC Specification Sect. 1.5.5:

$F_p = 0.25f'_c$ on full area of concrete support
$F_p = 0.375f'_c$ on loaded concrete area equal to one-third or less of the total concrete support area

Also, from AISC Specification Sect. 1.5.1.4.3:

$$F_b = 0.75F_y$$

where f_c and F_y are compressive strength of concrete and yield stress of steel, respectively.

Substituting the values of F_p, F_b and m in Eq. (1), the plate thickness is given as:

On full support area: $$t = \frac{(L - 0.95d)}{6}\sqrt{\frac{9f'_c}{F_y}} \qquad (3)$$

On one third or less of support area:

$$t = 1.225\,\frac{(L - 0.95d)}{6}\sqrt{\frac{9f'_c}{F_y}} \qquad (4)$$

The alignment chart is drawn for:

f'_c = 4000 psi
F_y = 36000 psi

Substituting these values in Eqs. (3) and (4):

On full support area: $$t = \frac{(L - 0.95d)}{6} \qquad (5)$$

On one-third or less of support area:

$$t = 1.225\,\frac{(L - 0.95d)}{6} \qquad (6)$$

Equations (5) and (6) are linear in L, d and t. An alignment chart, Fig. 1, is drawn for a wide range of column loads and common column sections. The base plate width B and length L are so proportioned that $(L - 0.95d)$ is always larger than $(B - 0.8b)$ and therefore controls the design thickness.

The use of the alignment chart is illustrated by the following examples:

ALIGNMENT CHART
COLUMN BASEPLATE DESIGN

Concrete Strength f'_c = 4000 psi

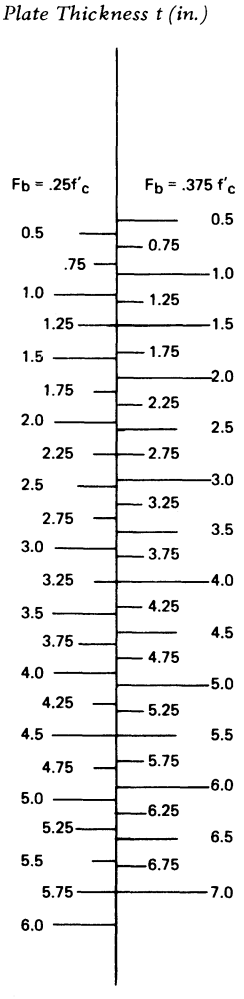
Steel Yield Stress Fy = 36,000 psi

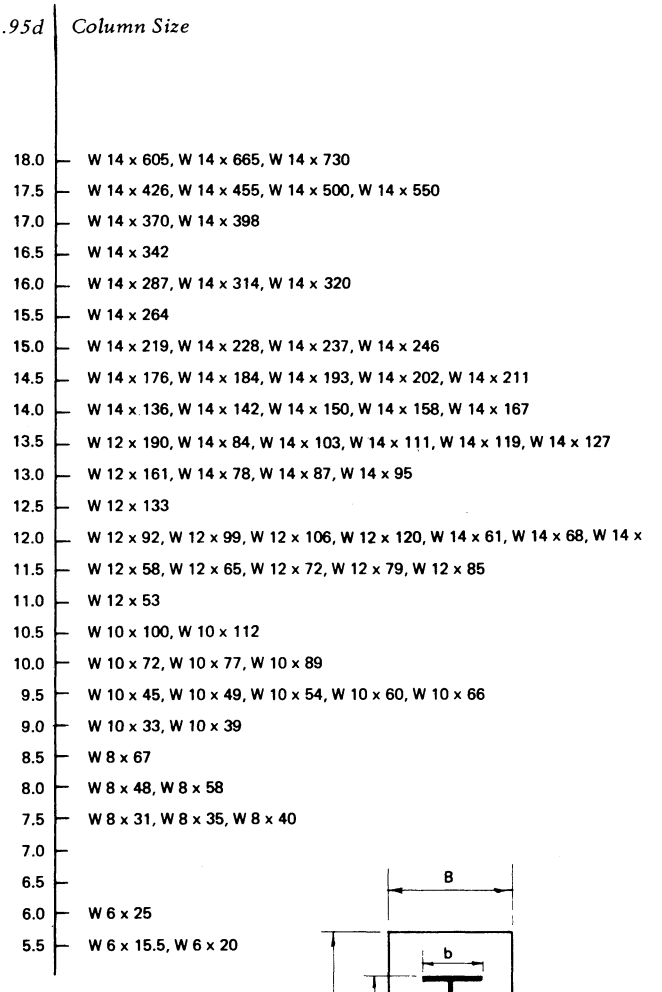
Allowable Concrete Bearing Pressure:

On full area $F_p = .25\ fc$ = 1000 psi

On one-third area or less $F_p = .375\ f'_c$ = 1500 psi

llowable aseplate ad (kips)		*Baseplate Size*	
= f'_c	F_p = $.375f'_c$	Width B (in.)	Length L (in.)
10	120	8	10
10	150	9	11
10	180	10	12
10	210	11	13
10	250	12	14
10	270	12	15
10	280	12	16
10	330	13	17
10	370	14	18
10	420	15	19
10	480	16	20
10	540	17	21
10	600	18	22
10	660	19	23
10	720	20	24
10	780	21	25
10	850	22	26
10	930	23	27
10	1000	24	28
10	1080	25	29
10	1170	26	30
10	1260	27	31
10	1350	28	32
50	1440	29	33
20	1530	30	34
80	1620	31	35
50	1730	32	36
20	1830	33	37
90	1930	34	38
60	2040	35	39
40	2160	36	40
20	2280	37	41
00	2400	38	42
80	2520	39	43
60	2640	40	44
40	2760	41	45
30	2890	42	46
20	3030	43	47
10	3170	44	48
00	3300	45	49
00	3450	46	50





1. Design Load = (DL + LL) or .75 (DL + LL + Wind Load), whichever is greater.
2. Select baseplate size from table of allowable loads.
3. Align the length (L) of plate and the column size and read plate thickness (t) for appropriate concrete bearing.

t = Baseplate Thickness

Use minimum t = ¼"

Figure 1

Example 1:

Given: Design the base plate.

Column: W14×87
Axial load = 240 kips
Concrete f_c = 4000 psi
Allowable concrete bearing $F_p = 0.25f'_c$
Steel F_y = 36000 psi
Full area of concrete support loaded.

Solution:

From the column of allowable loads on base plates, the plate dimensions are $B = 14$ in. and $L = 18$ in.

Align $L = 18$ in. and column size W14×87, and determine plate thickness t for $F_p = 0.25f'_c$, which is 1.0 in.

Base plate required is 14 x 1 x 1′-6″

The alignment chart can also be used for values of f'_c and F_y other than 4000 psi and 36000 psi, respectively, as in the following example.

Example 2:

Given:

Column W14×127
Axial load = 400 kips

Loaded area of concrete support less than one-third of total support area, i.e.:

$F_p = 0.375f'_c$
Concrete f'_c = 3000 psi
Steel F_y = 42000 psi

Solution:

The base plate dimensions can be determined using equivalent column load for concrete support of f'_c = 4000 psi and then multiplying the thickness t obtained from the alignment chart by the correction factor $\sqrt{9f'_c/F_y}$.

Equivalent load for 4000 psi concrete

$$= 400 \times \frac{4000}{3000} = 534 \text{ kips}$$

Base plate dimensions from table of allowable load for concrete bearing $F_p = 0.375f'_c$ are:

$B = 17.0$ in.
$L = 21.0$ in.

From alignment chart $t = 1.53$ in.

$$\text{Corrected thickness} = 1.53\sqrt{\frac{9 \times 3000}{42000}}$$

$$= 1.53 \text{ x } 0.8 = 1.23 \text{ in., say } 1\tfrac{1}{4} \text{ in.}$$

Hence, base plate required is 17 x 1¼ x 1′-9″.

The chart is applicable for bases with direct load only. The base plates with overturning moment or uplift due to seismic or wind load are to be specially designed.

For column sizes other than those shown on the alignment chart, the chart can still be used by proportioning the base plate length L and B such that $(L - 0.95d)$ is larger than $(B - 0.80b)$. Then align $0.95d$ of column and L to determine plate thickness t.