Rapid Selection of Column Base Plates

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OVER THE PAST several years there have been a number of articles published proposing design aids for the rapid selection of column base plates. Although the design calculations as presented in the AISC *Manual of Steel Construction,* 7th Edition, are relatively simple, the selection of the optimum plate geometry cannot be determined directly and can be quite time consuming in a large steel structure. The previously presented design aids provided rapid solutions to the design problem, but sacrificed the accuracy of manual calculations. A graphical approach to the design will be presented in this paper, which provides rapid and accurate solutions to the design of steel bearing plates and can be expanded to cover all column sections and loading conditions.

The design procedure recommended by the AISC assumes that the bearing pressure on the bottom of the plate is of uniform intensity and that the column load is uniformly distributed over an effective rectangular area equal to 0.95 times the depth of the column section by 0.80 times the column flange width. Thus, the required bearing area based on the relationship of column loading to allowable concrete bearing pressure is first determined and the plate geometry selected to satisfy this requirement. The plate thickness is then determined by treating that portion of the plate that projects beyond the "effective rectangle" as an inverted cantilever and solving for the required thickness. For an economical design, the plate geometry should be selected such that the projection of the plate beyond the "effective rectangle" is the same on all sides of the plate, i.e., the optimum plate geometry can be expressed by the equation:

$$(L - B) = 0.95d - 0.80b$$

It can be seen that the optimum plate geometry cannot be established directly, but must be approached through a trial-and-error process of approximations. The design aid to be presented will provide a direct solution for the optimum plate dimensions while allowing the designer to view other possible solutions for the situations in which the plate geometry is governed by factors other than economy.

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The proposed plate selection charts consist of a background sheet indicating plate thicknesses and an overlay sheet indicating plate thicknesses. The background sheet must be prepared, using plate dimensions as a coordinate system, by plotting reference load level curves such that the coordinates of any point on the curve would yield plate dimensions which, given an allowable concrete bearing pressure, would provide the bearing area required (Fig. 1). Supplement No. 3 to the AISC Specification provides the designer with an allowable concrete bearing pressure of $0.35f'_c$ when bearing is over the full area of concrete support and may be increased by a factor of $\sqrt{A_{conc}/A_{steel}} \leq 2$ when bearing is on less than the full area of support. It is suggested that a set of design charts be prepared by allowable bearing stress values of $0.35f'_c$ and $0.70f'_c$, since these allowables are, in the writer's opinion, the ones most often encountered in practice.

The transparent overlay sheet consists of an arbitrary reference point and the corresponding plate thickness envelopes. With an allowable plate bending stress and the concrete bearing value of the corresponding background sheet given, the AISC plate thickness equation reduces to a linear form with only the plate thickness and projecting plate length as variables:

$$t = \sqrt{\frac{3F_p m^2}{F_b}}$$

$$F_b = 0.75f'_c = 0.75\ (36{,}000) = 27{,}000 \text{ psi}$$

For bearing over the full support area:

$$F_p = 0.35f'_c = 0.35\ (4{,}000) = 1{,}400 \text{ psi}$$

$$t = 0.394m$$

By substituting a desired thickness into the equation, the maximum plate projection can be determined. The resulting projection should be doubled to allow for the inverted cantilever on both sides of the plate and the thickness envelope boundaries indicated relative to the reference point. The same scale should be used in locating the envelope boundaries as was used for the coordinate system of the background sheet. As previously presented, the optimum plate geometry is one in which all plate projections are equal. Thus it can be seen that all optimum plate design solutions will be located on a line extending at a 1:1 slope

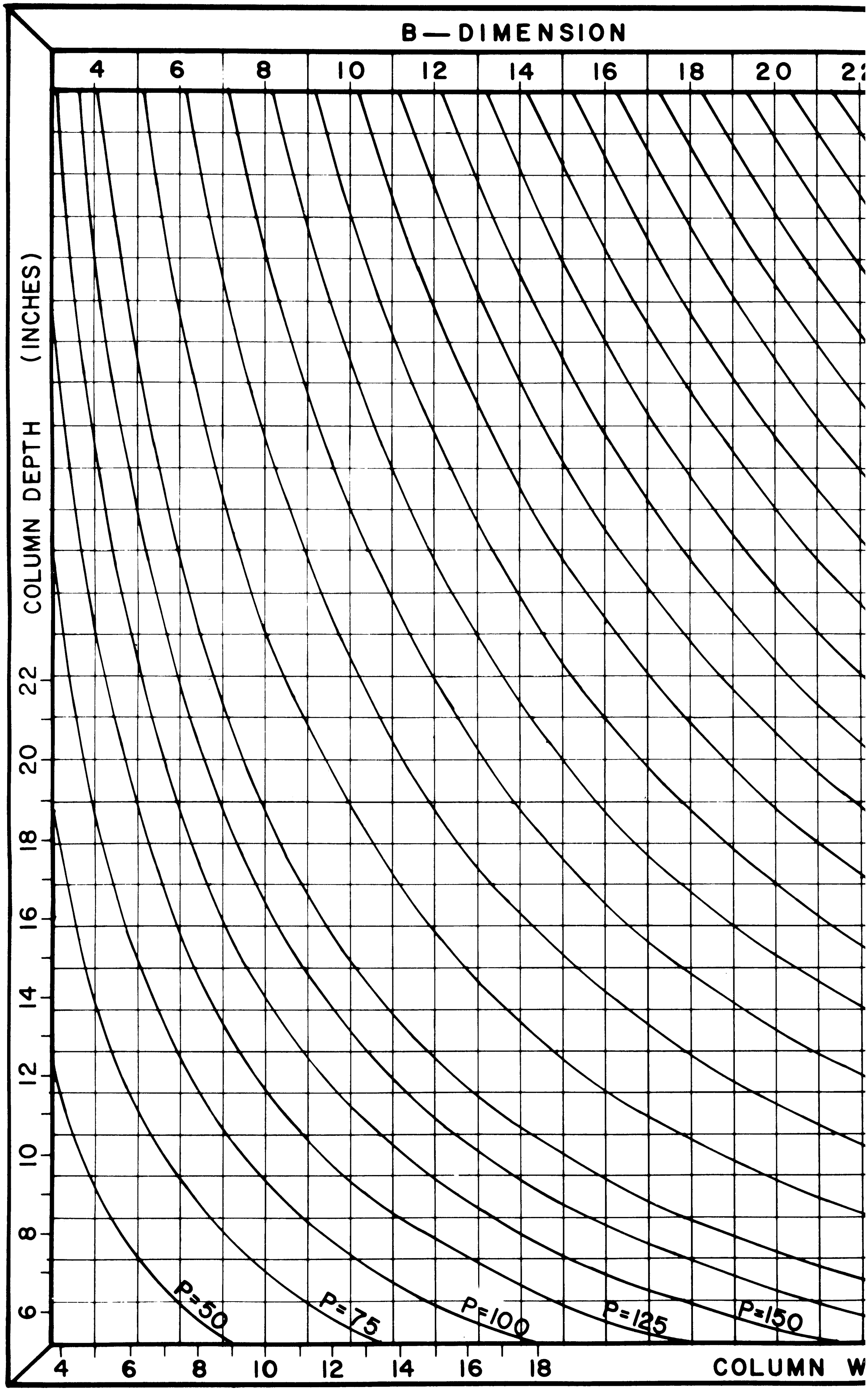
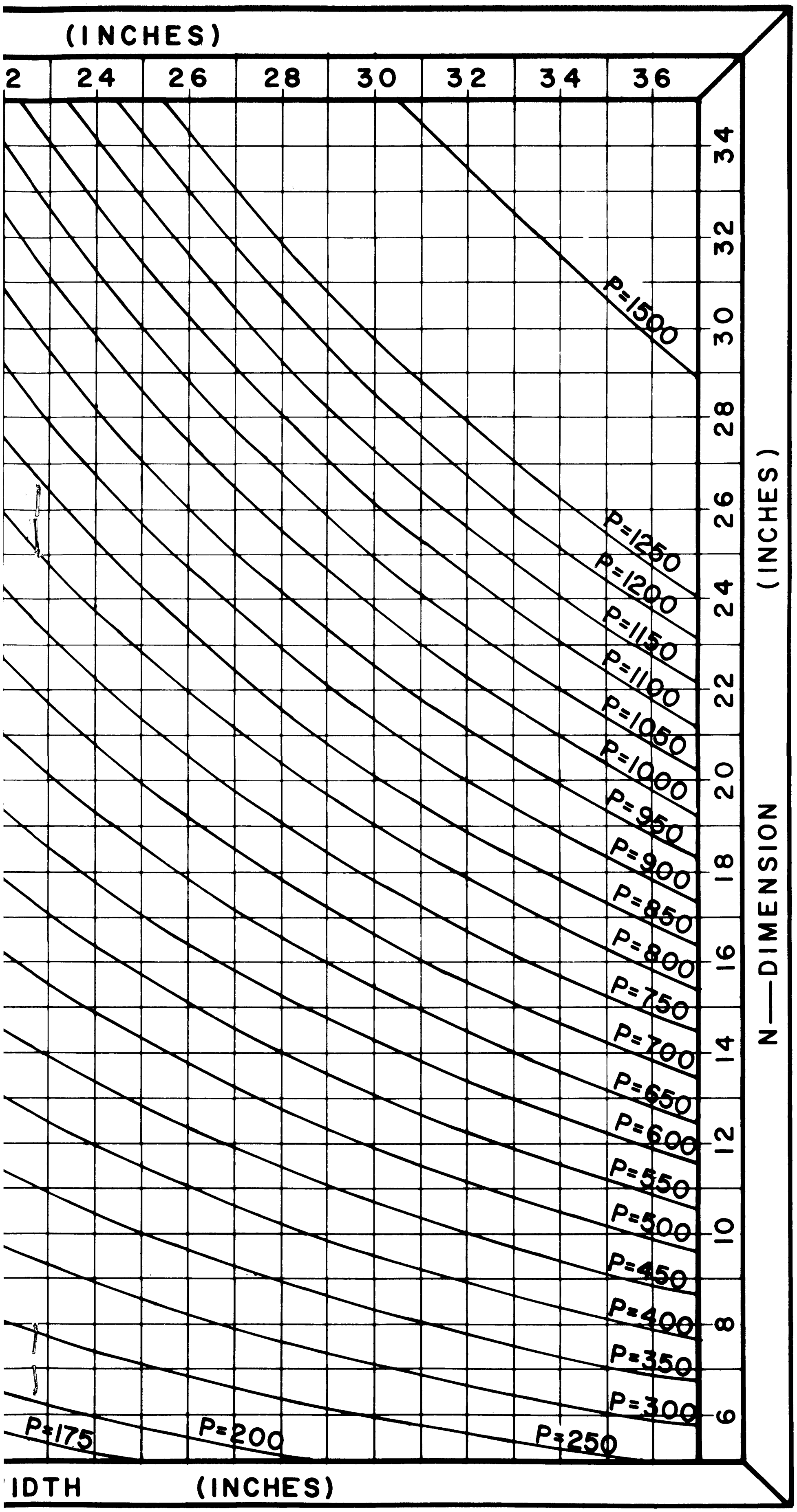


Fig. 1. Plate and column geometry as rel



$F_p = 0.35 f'_c$

$= 1400$ psi

$F_b = 27000$

ated to reference load level curves (to be used as a background sheet)

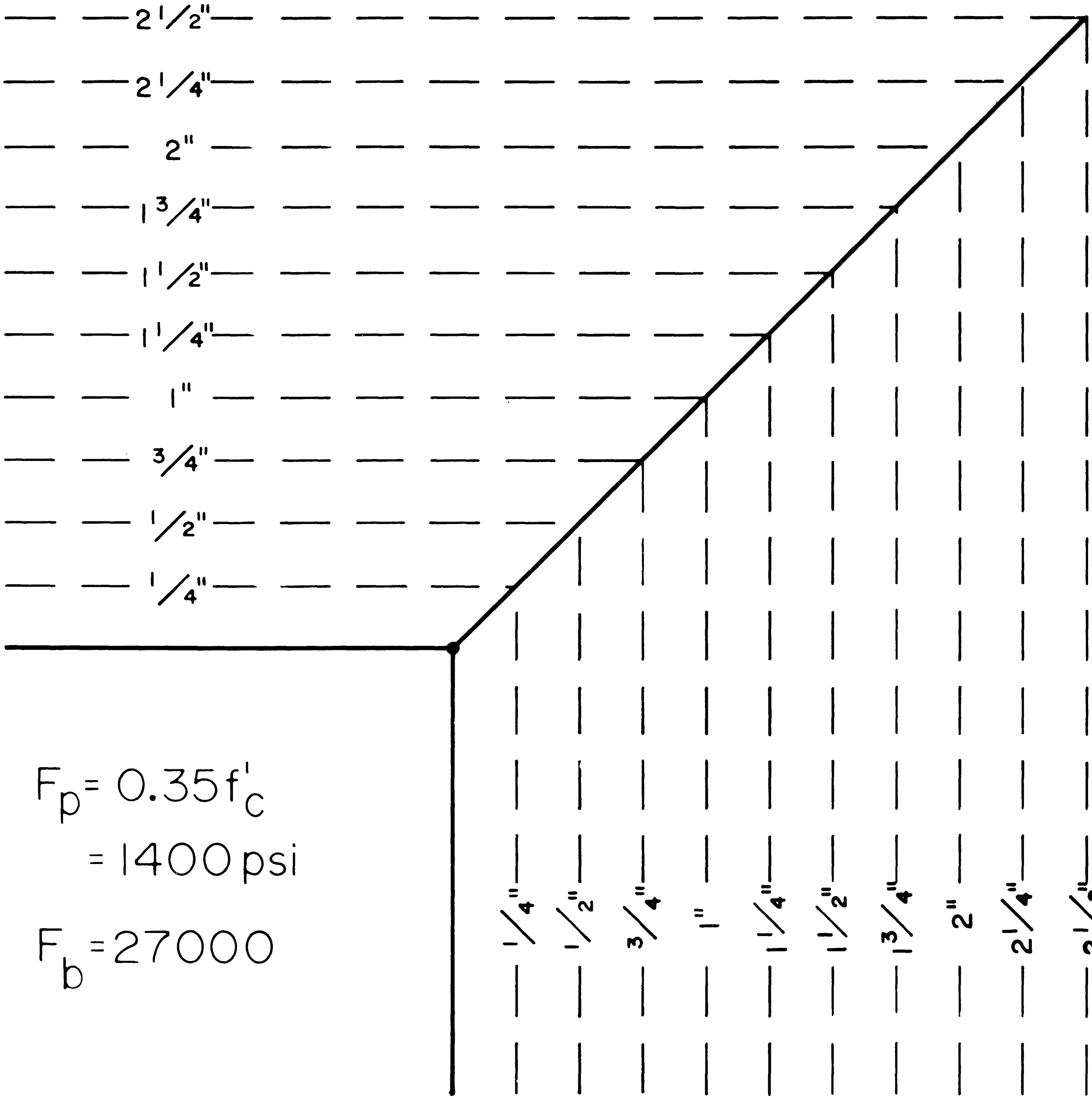


Fig. 2. Plate thickness envelopes and optimum plate selection line (to be traced on to a transparent overlay sheet)

from the reference point. This optimum plate selection line should be indicated and the thickness envelopes completed (Fig. 2).

The application of the charts to the sizing of column base plates will be illustrated in the following examples.

Example 1

Given: Design the column base plate.

Column: W14 × 103
Axial load: 550 kips
Concrete: $f'_c = 4{,}000$ psi
Allow. bearing: $F_p = 0.35f'_c$
Steel: $F_y = 36$ ksi

Solution:

From AISC tables: Column depth = 14.25 in.
Column width = 14.575 in.

Position the reference point so that its ordinate and abscissa coincide with the appropriate "effective rectangle" dimensions. Note that a second coordinate system has been added to the background sheet which automatically determines the "effective rectangle" dimensions (Fig. 1).

Follow the load level curve $P = 550$ kips until it intersects the optimum selection line (Fig. 3).

Optimum plate dimensions: 1½ × 19 × 21 in.

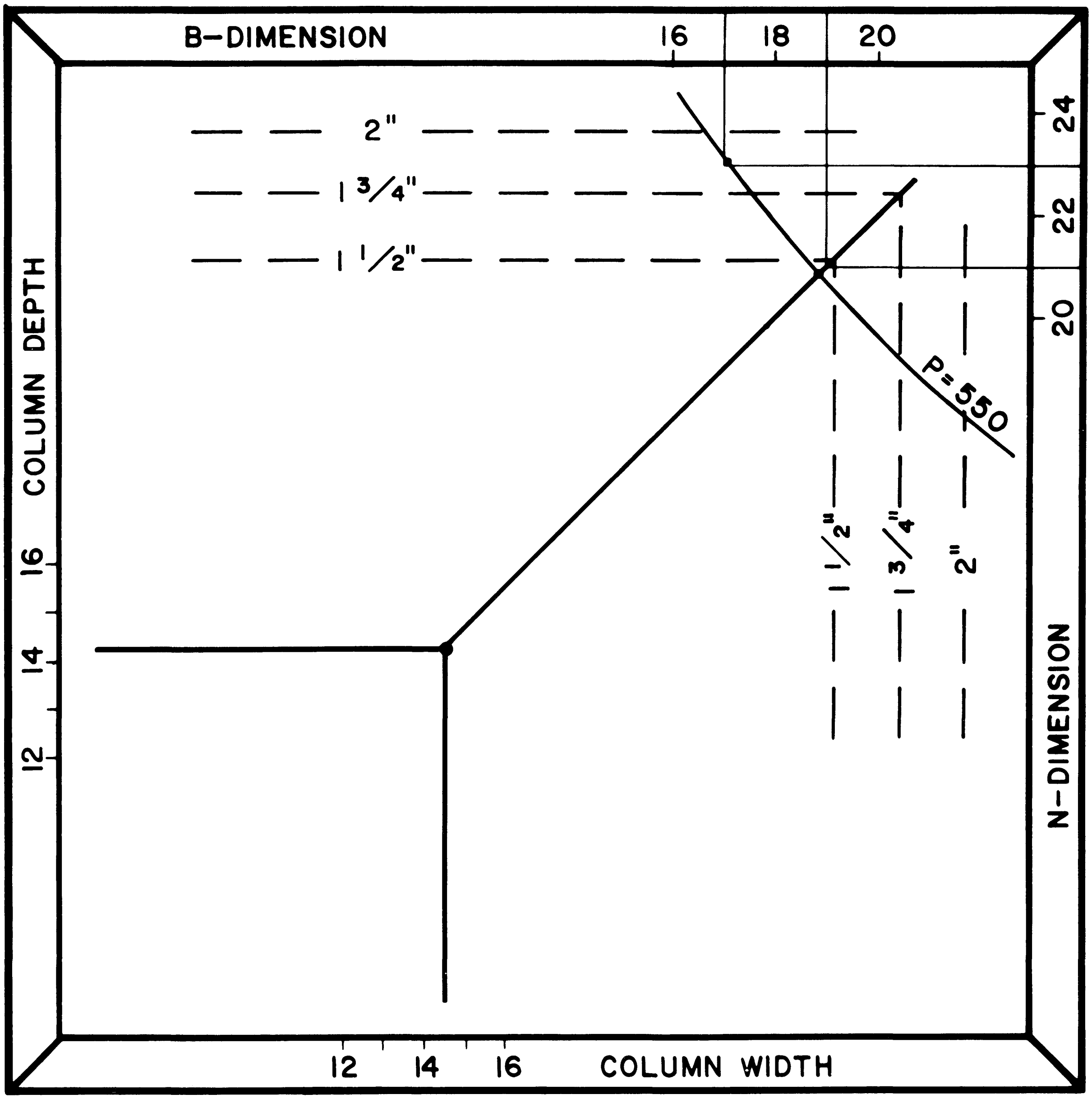


Figure 3

Note that a base plate $1\frac{7}{8} \times 17 \times 23$ in. would also work, but does not provide the most economical solution.

For steel yield stresses other than 36 ksi the base plate thickness must be adjusted by a correction factor equal to $\sqrt{9f'_c/F_y}$. For concrete strengths other than 4,000 psi, an equivalent column load must be used with the design charts and the thickness adjusted by the above correction factor.

Example 2

Given: Design the column base plate.

Column: W14 × 103

Axial load: 825 kips

Concrete: $f'_c = 6{,}000$ psi

Allow. bearing: $F_p = 0.35 f'_c$

Steel: $F_y = 50$ ksi

Solution:

Equivalent column load for 4,000 psi concrete:

$825 \times 4{,}000/6{,}000 = 550$ kips

Optimum plate from charts: $1\frac{1}{2} \times 19 \times 21$ in.

Adjusted pl. thickness: $t = \frac{9(6{,}000)}{50{,}000} \times 1.5 = 1.56$ in.

Optimum plate dimensions: $1\frac{9}{16} \times 19 \times 21$ in.