

# Design of Base Plates for Wide Flange Columns— A Concatenation of Methods

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The Murray Stockwell<sup>1</sup> (MS) method for design of base plates has the capability of producing very thin, and hence economical, small base plates (a small base plate is approximately the size of the column  $d \times b_f$ , Fig. 1) for lightly loaded columns. The method has two problems, however, which make its incorporation into a general method for all base plates, i.e., large as well as small plates, and heavily as well as lightly loaded plates, difficult.

First, the boundary between lightly and heavily loaded plates is not defined. Application of the MS method to a particular situation can lead to a base plate thicker than would be required by the AISC 8th Ed. Manual method, or can lead to a numerical failure of the method as indicated by mathematically imaginary solutions in terms of complex numbers. This problem has been demonstrated by Ahmed and Kreps.<sup>2</sup>

Second, the MS method assumes a peak bearing pressure of  $F_p$  over an H-shaped region adjacent to the column cross-section whereas the conventional assumption (i.e., AISC Manual 8th Ed.<sup>3</sup> and AISC LRFD Manual 1st Ed.<sup>4</sup>) is a uniform pressure  $f_p$  over the entire contact area between the plate and the concrete. This problem led the author<sup>5</sup> to propose a yield line method (referred to as Model 2 in Ref. 5) to replace the MS method for small base plates. Ref. 5 demonstrates that Model 2 coupled with the cantilever method for large base plates yields plate thicknesses equal to or less than the AISC 8th Ed. method. However, Model 2 yields thicker plates than the MS method when the plate is lightly loaded.

In order to maintain the benefit of the MS method for lightly loaded plates, to define the boundary between lightly and heavily loaded plates, and to effect a merger of the two different pressure distributions and three methods into a single method, consider the following analysis.

The yield line method for small base plates (Model 2) has been formulated as<sup>5</sup>

$$t_p = 2n' \sqrt{\frac{f_p}{F_y}} \quad (1)$$

where

$$n' = \frac{1}{4} \sqrt{db_f}$$

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The Murray Stockwell (MS) method is given by

$$t_p = 2c \sqrt{\frac{F_p}{F_y}} \quad (2)$$

where  $c$  is defined in Fig. 2. Let the total load on the column be denoted by  $P$ . Then from Fig. 1

$$f_p = P/(BN) \quad (3)$$

where  $f_p$  is uniform over  $B \times N$ . Let the portion of load acting over the cross-hatched region of Fig. 1 be denoted by  $P_o$ . Then

$$P_o = f_p b_f d \quad (4)$$

In the MS method the load  $P_o$  acts over an area  $A_H$  as shown in Fig. 2. From Fig. 2

$$A_H = 2cL - 4c^2 \quad (5)$$

where  $L = b_f + d$

Thus, we can write

$$P_o = f_p b_f d = F_p A_H = F_p (2cL - 4c^2) \quad (6)$$

because the area  $A_H$  is determined so that the contact pressure between the plate and the concrete over  $A_H$  is  $F_p$ . This idea of introducing the statically equivalent pressure distribution over areas  $b_f d$  and  $A_H$  which yield the force  $P_o$  is introduced in the AISC LRFD Manual.<sup>4</sup>

From Eq. 6

$$F_p = \left( \frac{db_f}{2cL - 4c^2} \right) f_p \quad (7)$$

Substituting Eq. 7 into Eq. 2

$$t_p = \frac{2c \sqrt{db_f}}{\sqrt{2cL - 4c^2}} \sqrt{\frac{f_p}{F_y}} \quad (8)$$

Also, from Eq. 6,  $P_o = F_p (2cL - 4c^2)$ , and solving for  $c$

$$c = \frac{L}{4} (1 - \sqrt{1 - X}) \quad (9)$$

where

$$X = \frac{4P_o}{L^2 F_p}$$

Substituting Eq. 9 into Eq. 8, and rearranging, yields

$$t_p = 2\lambda n' \sqrt{\frac{f_p}{F_y}} \quad (10)$$

where

$$\lambda = \frac{2\sqrt{X}}{1 + \sqrt{1-X}} \text{ or, equivalently, } \lambda = \frac{2(1-\sqrt{1-X})}{\sqrt{X}}$$

$$n' = \frac{1}{4}\sqrt{db_f}$$

$$X = \frac{4P_o}{L^2 F_p} = \frac{4}{L^2 F_p} \left( \frac{db_f}{BN} \right) P = 4 \left( \frac{db_f}{L^2} \right) \frac{f_p}{F_p} < 1.0$$

Equation 10 has been arranged to effect the merger of the MS method with Model 2. It is obvious by comparison of Eqs. 1 and 10 that if  $\lambda > 1$ , the MS method yields a thicker base plate than Model 2. Therefore,  $\lambda = 1$  can be considered the limit of usefulness of the MS method or, put another way,  $\lambda = 1$  defines the load at which a base plate is no longer lightly loaded.

To complete the concatenation of the MS method and Model 2 with the cantilever method for large base plates, write

$$t_p = 2l \sqrt{\frac{f_p}{F_y}} \quad (11)$$

where

$$l = \max(m, n, \lambda n')$$

$$m = (N - .95d)/2$$

$$n = (B - .8b_f)/2$$

$$n' = \frac{1}{4}\sqrt{db_f}$$

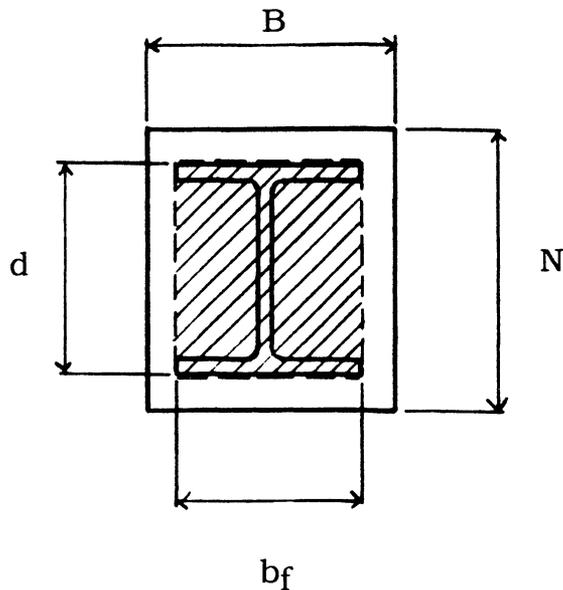


Fig. 1. Large base plate ( $B \times N$ ) and cross-hatched area for small base plate ( $b_f \times d$ ).

and  $\lambda$  is redefined as

$$\lambda = \min \left( 1, \frac{2\sqrt{X}}{1 + \sqrt{1-X}} \right) \quad (12)$$

Note that  $\lambda$  can always conservatively be taken equal to 1 to simplify the calculations. Note also that if  $X > (4/5)^2$ ,  $2\sqrt{X}/(1+\sqrt{1-X}) > 1$  and need not be calculated since the redefined  $\lambda = 1$  by Eq. 12. Thus, we can take  $X = (4/5)^2 = 0.64$  as the definer of the boundary between lightly and heavily loaded plates. If  $X < 0.64$  the plate is lightly loaded.

#### NOTATION

The symbols used in this paper follow the usage of the AISC Manual, 8th Edition and the AISC LRFD Manual, 1st Ed.

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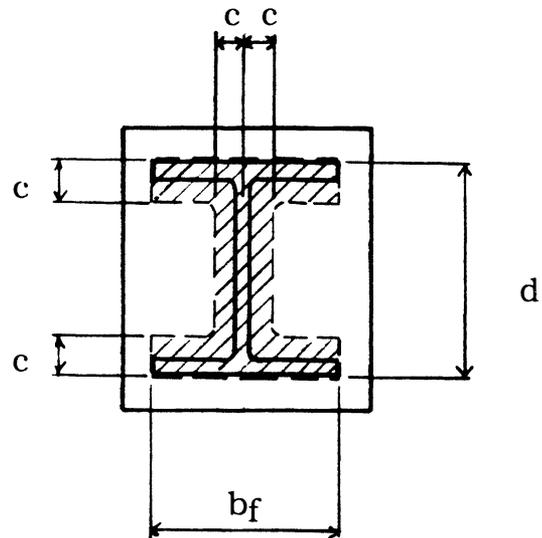


Fig. 2. Load Area  $A_H$  for Murray Stockwell Method (cross-hatched).

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