AD 252

Axially Loaded Columns – Base Plate Design Effective Area Method BS 5950-1:2000

The empirical method for determining the size of base plates in BS 5950-1: 1990 has been replaced by the effective area method in BS 5950-1: 2000. Doubt has been raised as to the theoretical validity of the empirical method when used with deep UB's or with bases that have very small outstand dimensions *a* and *b* (see Fig. 1). The effective area method offers more economy than the empirical method, while still producing safe designs when compared to test results.

The effective area method for base plate design may initially seem to be more complex than the empirical method given in BS 5950-1: 1990. However, the approach is much more reliable and can be used for all column sections. The forthcoming revision of the SCI and BCSA Green Book *Joints in Steel Construction: Simple Connections* will include design procedures for base plates using the effective area method and will include standard base plates and their capacities for I, H and hollow section columns.

We have received several questions concerning the effective area method for base plate design and in particular what to do when the effective area does not fit on the base plate selected.

The basic design procedure is set out below.

1. Calculate required area = axial load / 0.6 f_{cu}

   Where:
   f_{cu} is the cube strength of either the concrete or the grout which ever is weaker.

2. Calculate outstand c (see Fig. 1) by equating required area to actual area expressed as a function of *c*. The expression for the actual effective area of an I or H section may be approximated to $4c^2$ + (column perimeter) (c + column area).

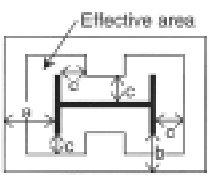

Fig. 1.

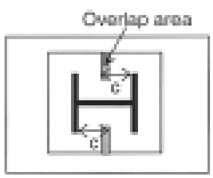

Fig. 2.

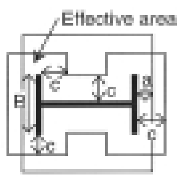

Fig. 3.

3. Check that there is no overlap of effective area between flanges (see Fig. 2). This will occur if $2c$ > the distance between the inner faces of the flanges. If an overlap exists, modify the expression for effective area and recalculate *c*.

4. Check the effective area fits on the size of base plate selected (see Fig. 3). If effective area does not fit on the base plate, modify the expression for effective area to allow for the limitations of the plate size and recalculate *c*, or select a larger base plate. For the case shown in Figure 3, the modified expression for the effective area will be:

   $4c^2$ + (column perimeter) (c + column area - $2 \times (B+2c) \times (c - a)$

5. If *c* has been recalculated step 3 will need to be repeated.

6. Calculate required plate thickness t_p using expression below (given in Clause 4.13.2.2):

   $$t_p = c\left(\frac{3w}{p_{yp}}\right)^{0.5}$$

   Where:
   $w = 0.6 f_{cu}$
   p_{yp} is the plate design strength

The expression for the plate thickness can be derived from equating the moment produced by the uniform load *w* to the elastic moment capacity of the base plate (both per unit length).

Moment from uniform load on cantilever = Elastic moment capacity of plate

$$w\,c^2 / 2 = p_y Z \text{ (per unit length)}$$

$$w\,c^2 / 2 = p_y\, t_p^2 / 6$$

Rearranging gives $t_p = c(3\,w / p_y)^{0.5}$

When the outstand of the effective area is equal either side of the flange (as in Fig. 1 and Fig. 4) the cantilevers are balanced and there is no resultant moment induced in the flange. However, if the cantilevers do not balance either side of the flange, as would be the case in Figure 3, then theoretically to satisfy equilibrium there is a resultant moment induced in the flange (see Fig. 5 and Fig. 6).

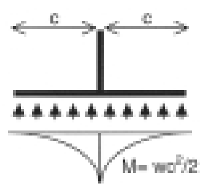

Fig. 4.

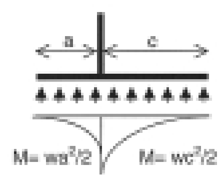

Fig. 5.

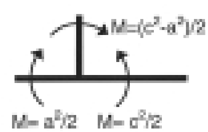

Fig. 6.

It is important to remember that the method given in BS 5950-1 is only a design model and does not exactly represent what will happen in practice. The remainder of the plate (not only the 'effective' area) does exist and does carry load. With this in mind, the moment induced in the column flange due to unbalanced cantilevers does not need to be explicitly considered in the design of either the column or the base plate.

Contact : Andrew Way, SCI. E-mail: a.way@steel-sci.com