DISCUSSION

Design of Pipe Column Base Plates Under Gravity Load

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(2nd Quarter, 1993)

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The author has provided useful suggestions for this particular design problem based on yield-line analysis. The purpose of this discussion is to clarify some aspects of these solutions and to re-organize them in concise decision form for ease of calculations.

While the AISC Manuals have only exclusively addressed base plates for wide-flange column shapes, the AISC Design Guide No. 1 *Column Base Plates* (Ref. 3) does briefly cover tubular and pipe columns. It suggests that the usual cantilever plate model employed under wide-flange columns can be extended to such closed sections: the critical overhang dimension (m or n) for determining plate thickness becomes 0.95 times the outside column dimension for rectangular tubes and 0.80 times the outside dimension for round pipes.

Also, similar to base plates with wide-flange columns, an important consideration is the limiting case when the column approaches the size of its base plate. For this so-called "small" plate condition, the cantilever overhang distance m can become rather short and almost zero, thereby rendering this simple model useless for design. The proposed yield-line Equation 2 possesses this same characteristic since for $R / D = 1$, the required thickness reduces to zero. Fortunately, Equation 1 does provide a rational design answer for $R / D = 1$.

While Equations 1 and 2 in combination offer valid and complementary design solutions, the presented application of lightly loaded Equation 3 in this context is confusing. The paper states that Equation 3 is a special case of Equation 1. The required plate thickness is limited to no more than given by Equation 1 and, finally, the greater of Equations 1 or 3 and 2. Based on this rationale, it is never necessary to check Equation 3. In order to parallel the logic of the revised AISC small-column base-plate procedure for wide-flange shapes, it appears that the real intent should be for the required thickness to be the greater of:

a. the *lesser* of Equations 1 and 3 or, conservatively, Equation 1
b. Equation 2

The author's Equations 1 and 2 may be interpreted such that the former applies to "small" plates (R/D near 1.0) whereas the latter covers the "larger" plates (smaller R/D). Use of Equation 3, in my opinion, is optional in conjunction with Equation 1 for lightly loaded conditions. The recommended practical limit of $R/D \geq 0.5$ gives an actual design range of $0.5 \leq R/D \leq 1.0$. One may easily compute that the intersection of Equations 1 and 2 occurs at about $R/D = 0.7$, hence, the following general design criteria can be formulated to minimize calculations:

If $0.5 \leq R/D \leq 0.7$, (large base plate case) use Equation 2.

If $0.7 < R/D \leq 1.0$, (small base plate case) use the lesser of Equations 1 and 3, or, conservatively, Equation 1.

In the original example, $R/D = 0.61 < 0.7$, and Equation 2 governs, as expected.

As alluded to previously, the cantilever bending model could also be utilized for the large base-plate case. Because its solution is slightly more conservative than given by Equation 2, the $R/D = 0.7$ limit should be increased to 0.8 for its range of applicability. Applying this procedure to the author's example problem results in:

$$R/D = 0.61 < 0.8 \quad \textbf{o.k.}$$

$$m = D - 0.8R = 3.5 - 0.8\,(2.13) = 1.796 \text{ in.}$$

$$f_p = \frac{P}{4D^2} = \frac{12}{4(3.5)^2} = 0.245 \text{ ksi}$$

$$t = 2m\sqrt{\frac{f_p}{F_y}} = 2(1.796)\sqrt{\frac{.245}{36}} = 0.296 \text{ in.}$$

This solution requires an extra one-sixteenth base-plate thickness compared to the yield-line based Equation 2. However, it can also serve to demonstrate the reasonableness of both methods.

Easy conversions can be made for LRFD design equivalent to the proposed ASD Equations 1, 2, and 3:

1. replace M by $\phi M_p = 0.9t^2F_y / 4$
2. replace P by P_u (factored loads) in f_p
3. solve appropriate work balance expressions for required thickness

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