DISCUSSION

Beam-Column Base Plate Design—LRFD Method

Paper by RICHARD M. DRAKE and SHARON J. ELKIN
(First Quarter, 1999)

Discussion by James M. Doyle and James M. Fisher

In the Introduction section of the paper, the authors describe four load cases, A through D, that represent different behaviors of base plates when subjected to varying combinations of axial load and moment. Cases B and C address cases in which bending moments exist and uplift is not expected, hence there will be no anchor rod tension. Case D examines the behavior of plates, which will require anchor rod tension for equilibrium.

In the following, force and moment combinations corresponding to non-uplift situations, Cases B and C, are referred to as *small* moments, while combinations corresponding to Case D are referred to as *large* moments. As presented, the procedures for analyzing the different Cases contain inconsistencies. In particular, using the given methodologies, based on uniform bearing pressure between base plates and concrete or grout, the following can occur:

- Anchor rod tensions will not be required for equilibrium of some P_u–M_u combinations that meet the *large* moment criterion.
- Anchor rod tensions will be required to maintain equilibrium for other P_u–M_u combinations that would meet the *small* moment criterion.
- The values of pertinent quantities calculated by the two procedures do not match at the critical value of eccentricity separating the *small* and *large* moment conditions.

James M. Doyle is a consultant, Chaplin, KY.

James M. Fisher is vice president, Computerized Structural Design, Milwaukee, WI.

Fortunately, all three problems can be eliminated by changing the critical value of the eccentricity from

$$e_{critical} = \frac{N}{6}$$

to

$$e_{critical} = \frac{N}{2} - \frac{P_u}{2q_{\max}}$$

A discussion of the proposed change is given in the following.

Critical Eccentricity

The authors define the borderline between *small* and *large* as an eccentricity, e, equal to one-sixth of the plate dimension, $N/6$. The fact that the distribution of total bearing stress is assumed to be uniform for the analyses in both ranges of moments does lead to some results that could be confusing for a designer when the one-sixth of plate dimension limit is employed. The eccentricity $e = N/6$ is related to a triangular (linear elastic) distribution of stress between the base plate and the concrete, not the assumed uniform plastic distribution used in the paper. The $N/6$ criterion defines the old "kern" or "kernel" of the connection. As long as the load is within this kernel, there is no "tension" between the base plate and concrete. This concept does not apply to the modern plastic stress distribution.

Consider the force diagram shown in Figure 3. In addition to the dimensions shown, call the distance from the plate centerline to the resultant of the bearing pressure, ε. For equilibrium,

$$\varepsilon = e$$

If e is greater than ε, addition of anchor tensions at the left edge of the diagram are necessary for equilibrium. If e is equal to or less than ε, no anchor tension will exist.

From the diagram in Figure 3, it is observed that

$$\varepsilon = \frac{N}{2} - \frac{Y}{2}$$

To maintain concrete bearing stress within its limit,

$$Y \geq \frac{P_u}{q_{max}}$$

where

$q_{max} \;=\; \phi_c 0.85 f'_c B$

therefore

$$\varepsilon \leq \frac{N}{2} - \frac{P_u}{2q_{max}}$$

It follows that no anchor tension will be required for equilibrium if the eccentricity is less than

$$e_{critical} = \frac{N}{2} - \frac{P_u}{2q_{max}}$$

The right side of the foregoing inequality depends on the applied axial load and the compressive strength of the concrete support as well as the plate dimension. In the event that

$$\frac{P_u}{2q_{max}} \geq \frac{N}{3}$$

then

$$e_{critical} \leq \frac{N}{6}$$

For smaller values of P_u/q_{max}, $e_{critical}$ would be greater than $N/6$.

Bearing Area for $e = e_{critical}$

The bearing area is defined by the variable Y, per Figure 3. Consider the case for which the eccentricity is just equal to the critical value. Hence, Y is calculated by Equation 5 for the *small* moment case and by Equation 20 for the *large* moment case. Use of Equation 5 gives

$$Y = N - 2e = N - 2\left(\frac{N}{2} - \frac{P_u}{2q_{max}}\right) = \frac{P_u}{q_{max}}$$

Now, when Equation 20 is used, again for the critical value of e, there results,

$$Y = \left(f + \frac{N}{2}\right) \pm \sqrt{\left(f + \frac{N}{2}\right)^2 - \frac{2P_u\left[f \quad \left(\frac{N}{2} \quad \frac{P_u}{2q_{max}}\right)\right]}{q_{max}}}$$

Rearrangement of the terms gives

$$Y = \left(f + \frac{N}{2}\right) \pm \sqrt{\left(f + \frac{N}{2}\right)^2 - \frac{2P_u}{q_{max}}\left(f + \frac{N}{2}\right) + \left(\frac{P_u}{q_{max}}\right)^2}$$

$$= \left(f + \frac{N}{2}\right) \pm \left[\left(f + \frac{N}{2}\right) - \frac{P_u}{q_{max}}\right]$$

When the root corresponding to the negative sign is retained, the result for Y becomes

$$Y = \frac{P_u}{q_{max}}$$

Modification of Equation 20 for Zero Axial Load Case

Finally, with a slight modification of Equation 20 the case for a moment with no axial load could also be addressed. In particular, if the term

$$\frac{2P_u(f + e)}{q}$$

is replaced by its equivalent

$$\frac{2P_u f + 2M_u}{q}$$

Equation 20 can be solved for Y in the case where $P_u = 0$ as well as cases for which $P_u > 0$. Such a step would provide for more generality and not lose anything in the process. It is obvious that any case of moment only would be treated as a *large* moment case.