The value of C_r may be taken as 1.00 for values of D_p/D_h greater than 0.90.

The effective width shall be taken as the smaller of the values calculated as follows:

$$b_{eff} \leq 4t \leq b_e \tag{3-47}$$

$$b_{eff} \leq b_e\, 0.6 \frac{F_u}{F_y}\sqrt{\frac{D_h}{b_e}} \leq b_e \tag{3-48}$$

where

b_e = actual width of a pin-connected plate between the edge of the hole and the edge of the plate on a line perpendicular to the line of action of the applied load

The width limit of eq. (3-47) does not apply to plates that are stiffened or otherwise prevented from buckling out of plane.

The allowable single plane fracture strength beyond the pinhole P_b is

$$P_b = C_r \frac{F_u}{1.20N_d}\left[1.13\left(R - \frac{D_h}{2}\right) + \frac{0.92b_e}{1 + b_e/D_h}\right]t \tag{3-49}$$

where

R = distance from the center of the hole to the edge of the plate in the direction of the applied load

The allowable double plane shear strength beyond the pinhole P_v is

$$P_v = \frac{0.70F_u}{1.20\,N_d}A_v \tag{3-50}$$

where

A_v = total area of the two shear planes beyond the pinhole

$$A_v = 2\left[a + \frac{D_p}{2}(1 - \cos\phi)\right]t \tag{3-51}$$

where

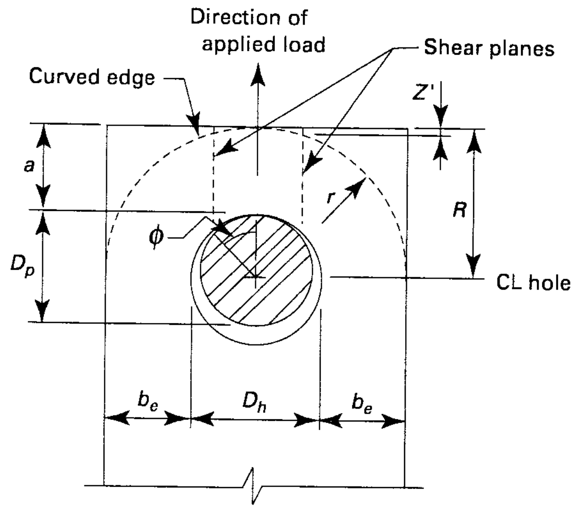
a = distance from the edge of the pinhole to the edge of the plate in the direction of the applied load, and

$$\phi = 55\frac{D_p}{D_h} \tag{3-52}$$

Commentary: A pin-connected plate may fail in the region of the pinhole in any of four modes. These are tension on the effective area on a plane through the center of the pinhole perpendicular to the line of action of the applied load, fracture on a single plane beyond the pinhole parallel to the line of action of the applied load, shear on two planes beyond the pinhole parallel to the line of action of the applied load, and by out of plane buckling, commonly called *dishing.*

The strength equations for the plates are empirical, based on research (Duerr, 2006). The effective width limit of the tensile stress area defined by eq. (3-47) serves to eliminate dishing (out of plane buckling of the plate) as a failure mode. Otherwise, the strength equations are fitted to the test results. The dimensions used in the formulas for pin-connected plates are illustrated in Fig. C3-3.

Fig. C3-3 Pin-Connected Plate Notation (08)



The ultimate shear strength of steel is often given in textbooks as 67% to 75% of the ultimate tensile strength. Tests have shown values commonly in the range of 80% to 95% for mild steels (Lyse and Godfrey, 1933; Tolbert, 1970) and about 70% for T-1 steel (Bibber, et al, 1952). The ultimate shear strength is taken as 70% of the ultimate tensile strength in eq. (3-50).

The shear plane area defined by eq. (3-51) is based on the geometry of a plate with a straight edge beyond the hole that is perpendicular to the line of action of the applied load. Note that the term in brackets in eq. (3-51) is the length of one shear plane. If the edge of the plate is curved, as illustrated in Fig. C3-3, the loss of shear area due to the curvature must be accounted for. If the curved edge is circular and symmetrical about an axis defined by the line of action of the applied load, then the loss of length of one shear plane Z' is given by eq. (C3-2), where r is the radius of curvature of the edge of the plate.

$$Z' = r - \sqrt{r^2 - \left(\frac{D_p}{2}\sin\phi\right)^2} \tag{C3-2}$$

Pin-connected plates may be designed with doubler plates to reinforce the pinhole region. There are two methods commonly used in practice to determine the strength contribution of the doubler plates. In one method, the strength of each plate is computed and the values summed to arrive at the total strength of the detail. In the second method, the load is assumed to be