Case I—Neutral Axis Not at Center of Gravity

The shear per bolt due to the concentric force, r_{uv} or r_{av}, is determined as

LRFD	ASD
$r_{uv} = \frac{P_u}{n}$	$r_{av} = \frac{P_a}{n}$

where n is the number of bolts in the connection.

A trial position for the neutral axis can be selected at one-sixth of the total bracket depth, measured upward from the bottom (line X-X in Figure 7–6a). To provide for reasonable proportions and to account for the bending stiffness of the connection elements, the effective width of the compression block b_{eff} should be taken as

$$b_{eff} = 8t_f \le b_f$$

where

t_f = lesser connection element thickness, in.
b_f = connection element width, in.

This effective width is valid for bracket flanges made from W-shapes, S-shapes, welded plates, and angles. Where the bracket flange thickness is not constant, the average flange thickness should be used.

The assumed location of the neutral axis can be evaluated by checking static equilibrium assuming an elastic stress distribution. Equating the moment of the bolt area above the neutral axis with the moment of the compression block area below the neutral axis,

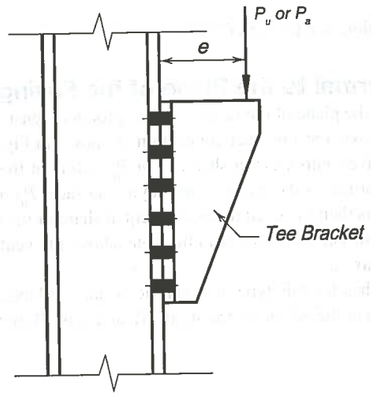


Figure 7–5. Tee bracket subject to eccentric loading normal to the plane of the faying surface.

$$\Sigma A_b \times y = b_{eff} \times d \times d/2$$

In the above equation,

ΣA_b = sum of the areas of all bolts above the neutral axis, in.^{2}
y = distance from line X-X to CG of the bolt group above neutral axis, in.
d = depth of compression block, in.

The value of d may then be adjusted until a reasonable equality exists.

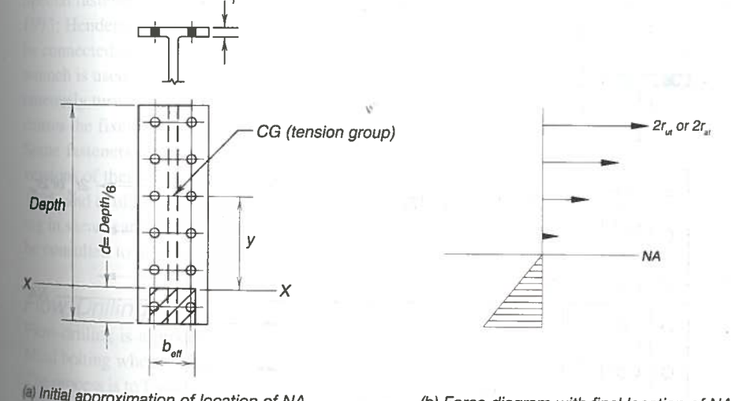
Once the neutral axis has been located, the tensile force per bolt, r_{ut} or r_{at}, as illustrated in Figure 7–6b, may be determined as

LRFD	ASD
$r_{ut} = \frac{P_u ec}{I_x} \times A_b$	$r_{at} = \frac{P_a ec}{I_x} \times A_b$

where

c = distance from neutral axis to most remote bolt in group, in.
I_x = combined moment of inertia of bolt group and compression block about neutral axis, in.^{4}

Bolts above the neutral axis are subjected to the shear force, the tensile force, and the effect of prying action (see Part 9); bolts below the neutral axis are subjected to the shear force only.



(a) Initial approximation of location of NA (b) Force diagram with final location of NA

Figure 7–6. Location of neutral axis (NA) for out-of-plane eccentric loading using Case I.