Shear of Bolts and Rivets Due to Eccentric Loading

\[ F' = \frac{V}{4} = \frac{V}{t} \]  
\[ F'' = \frac{M}{R_A + R_B} \]

Step 1

\[ M = F_a'' \cdot R_a + F_b'' \cdot R_b + \ldots \]

Step 2

\[ \frac{F_a''}{R_a} = \frac{F_b''}{R_b} \]

Step 3

Resulting force

\[ F_a'' \]

Total shear force

\[ F_a' \]

Because \( F_a'', F_b'' \ldots \) must have force balance (no external force in either x or y direction)
Tightening Sequence

Important tables, figures in chapter 8 for specifications

Fig. 8-1 Illustration of screw
8-3 Square thread & ACME thread

Table 8-1 mm UNC & UNF series
8-2 m.d.
8-7 Procedure in finding bolt stiffness
8-8 Stiffness for member materials
8-9 SAE specifications for steel bolts
8-10 ASTM
8-11 ISO
8-15 Torque factor K

E-29 Square & hexagonal bolts
E-30 Cap screws
E-31 Nuts
example on eccentric loading

If bolts have equal area

\[ A = 0.0775 \text{ in}^2 \]

\( \frac{d}{2} - 16 \text{UNF Bolt} \)

Find maximum shear stress on which bolt?

5 mins.

So:

\[ \text{primary shear} \quad \frac{2.500}{4} = 1875 \text{ lb} \]

secondary shear?

\[ \text{centroid} \quad \bar{x} = \frac{0.13 + 3.0}{4} = 1.5 \]

\[ \bar{y} = \frac{0.13 + 3.0 + 5.5}{4} = 2 \]

\[ M = 7.5 \times 10^3 (4.5 - 1.5) = 22,500 \]

\[ P_1 = \frac{MA}{R_1} \]

\[ R_1 = \sqrt{(0.25)^2 + (0.15)^2} = 0.33 \]

\[ R_2 = \sqrt{(3.0)^2 + (2.0)^2} = 3.5 \]

\[ R_3 = \sqrt{(3.0)^2 + (5.0)^2} = 5.5 \]

\[ R_4 = \sqrt{(0.25)^2 + (5.0)^2} = 5.0 \]

\[ R_1^2 + R_2^2 + R_3^2 + R_4^2 = 26.9625 \]

\[ R_1'' = \frac{22500 (0.35)}{26.9625} = 2090 \]

\[ R_2'' = \frac{22500 (1.8)}{26.9625} = 1500 \]

\[ R_3'' = \frac{22500 (5.5)}{26.9625} = 2090 \]

\[ R_4'' = \frac{22500 (5.0)}{26.9625} = 1500 \]

It turns out \( 3 \) is the biggest.

\[ 3.5 \]

\( (1.5, 3) \quad 1875 \)

\[ \tan \theta = \frac{5 - 3}{3 - 1.5} \quad \Rightarrow \theta = 53.1^\circ \]

\[ 1875 \times 0.53.1^\circ = 1254 \]

\[ 2090 \times 0.53.1^\circ = 1672 \]

\[ F_{33} = (1875 + 1254) + 1672 \]

\[ F_{33} = (1875 + 1254)^2 + 1672 \]

\[ = 3550 \text{ lb} \]

\[ \frac{3550}{0.0775} = 45800 \text{ psi} \]