Example 5  The upper deck of a football stadium is supported by braces each of which transfer a load $P$ to the base of the column, as illustrated in the figure below. A cap plate at the bottom of the brace evenly distributes the load $P$ to four flange plates through a pin of diameter $d_p = 2$ in to two gusset plates. The ultimate shear stress in all pins is $\tau_u = 30$ ksi, the ultimate normal stress in each brace is $\sigma_u = 80$ ksi and the cross-sectional area of each brace is $A_b = 80$ in$^2$. Determine the allowable $P$ if a factor of safety $FS = 3.0$ is required.

$$P_{\text{max}} = ?$$

$$J = \frac{F}{A} = \frac{P}{A_b}$$

$$\frac{P}{A} = \frac{P}{4}$$

$$P < \frac{\sigma_u A_b}{FS}$$

$$P_{\text{max}} = \frac{\sigma_u A_b}{FS} = \frac{2133 \text{ kips}}{FS}$$

$$P_{\text{max}} = 1256 \text{ kips}$$

$$\tau_{\text{bolt}} = \frac{P}{2A_b}$$

$$\tau_{\text{bolt}} = \frac{P}{4A_b}$$

$\rightarrow$ fail $\sigma_u$ (truss member)

$\rightarrow$ fail $\tau_u$ (bolt)

$$\tau_{\text{bolt}} = \frac{P}{4A_b} \leq \frac{\tau_u}{FS}$$

$$P < \frac{\sigma_u 4A_b}{FS}$$

$$P_{\text{max}} = \frac{\sigma_u 4 \frac{\pi d_p^2}{4}}{FS} = 1256 \text{ kips}$$

$$[10^3 \text{ lb}]$$