4.4 Continued: For yield of the steel bars, \( u = \frac{Y_{YS}}{E_s} \) or
\( u = 250(1.5)/200 = 1.875 \text{ mm}. \) For yield of the aluminum bar
\( u = \frac{Y_{YA}}{E_A} = \frac{500(1.2)}{22} = 8.333 \text{ mm}. \) Therefore, the
steel bars yield first. With \( u = 1.875 \text{ mm}, \) the
stress in the steel bars is \( \sigma_S = 250 \text{ MPa}, \) and the
stress in the aluminum bar is \( \sigma_A = E_A Y_A = \frac{220,000(112.5)}{12} = 112.5 \text{ MPa}. \)

(a) At yield of the steel bars, summation of forces
in the vertical direction yields the result
\[ P = P_Y = 2\, \sigma_S \, A + \sigma_A \, A = [2(250) + 112.5](100) = 612.5 \text{ kN}. \]

(b) Similarly, at yield of the aluminum bar,
\[ P = P_P = 2\, \sigma_S \, A + Y_A \, A = [2(250) + 500](100) = 100 \text{ kN}. \]

4.5 Consider the joint B, Fig. a, subject to displacement \( u. \)

\[ F_{AB} \quad B \quad P \quad F_{BC} \]

Fig. a

By equilibrium,
\[ P = F_{AB} + F_{BC}. \]

Also, the strain in
each bar is \( \varepsilon = u/L \) (\( L = 1.0 \text{ m}. \)). Therefore,
\( F_{AB} = \sigma_{AB} A = E \varepsilon A = E A u/L \) and
\( F_{BC} = \sigma_{BC} A = E \varepsilon A = E A u/L = F_{AB} \) (as long as
AB remains elastic). At initiation of yield in bar AB,
\( F_{AB} = Y_{AB} A = F_{BC}. \) Thus, at initial yield (in tension),
\[ F_{AB} = F_{BC} = Y_{AB} A = 250 \times 25 = 6250 \text{ kN}. \]
Therefore,
\[ P = P_Y = F_{AB} + F_{AC} = 2(6.25) = 12.5 \text{ kN}, \]
and
\[ u = \frac{Y_{AB} L}{E} = \frac{250(1)}{200} = 1.25 \text{ mm}. \]

When \( P = 20 \text{ kN}, \) \( F_{AB} = 6.25 \text{ kN} \) and \( F_{BC} = P - F_{AB} = 13.75 \text{ kN}. \)