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Example: IS. 3. A

Given: \( \bar{M} = 712 \text{ k-ft} \)
\( f'_c = 4000 \text{ psi} \)
\( f_y = 60,000 \text{ psi} \)

Find \( A_s \)

\[ M_{des} = \bar{M} = \frac{M_u}{\phi} = 712 \text{ k-ft} \text{ SEE ENGEL P. 2260} \]

1. Non-Rectangular Section - Must check the moment carrying capacity of the section by parts:

\[ M_1 = 0.85 f'_c A_c (e)^2 \]
\[ M_1 = 0.85(4000)(20(4)(24-2)) \]
\[ M_1 = 7181 \times 10^6 \text{ in-lb} \]
\[ M_1 = 598.4 \text{ k-ft} \]

\[ M_{2} = 118.6 \text{ k-ft} \]
\[ M_{2} = 1.363 \times 10^6 \text{ in-lbs} \]

We now have a two-part system of rectangular components which we can use to solve for the total area of steel.

\[ \text{Part 1} \]
\[ A_{s1} = \frac{M_1}{f_y(d_1 - a_1/2)} = \frac{7181 \times 10^6}{(60,000)(24-2)} \]
\[ A_{s1} = 5.44 \text{ in}^2 \]
Example 15.3 A cont

Use the iterative process to find \( A_{S_2} \) and \( a \). For the initial estimate of \( A_{S_2} \), guess \( 2_2 = 0.9d_2 \) for good behavior.

1. \[ A_{S_2} = \frac{M_2}{f_y(0.9d_2)} = \frac{1.363 \times 10^6}{(60,000)(0.9)(20)} \]

\[ A_{S_2} = 1.26 \text{ in}^2 \]

\[ a = \frac{A_2 f_y}{0.85 f'_c \cdot b} = \frac{(1.26)(60,000)}{(0.85)(4000)(8)} = 2.18 \text{ in} \]

2. \[ A'_{S_2} = \frac{M_2}{f_y(20 - 2.18)} = 1.22 \text{ in}^2 \]

\[ a' = \frac{1.22 f_y}{0.85 f'_c \cdot b} = \frac{2.69}{8} \text{ in} \]

3. \[ A''_{S_2} = \frac{M_2}{f_y(20 - 2.69)} = 1.2179 \text{ in}^2 \approx 1.22 \text{ in}^2 \text{ done} \]

Total steel area

\[ A_{\text{total}} = A_{S_1} + A''_{S_2} = 5.44 + 1.22 = 6.66 \text{ in}^2 \]

\[ A_{\text{total}} = 6.66 \text{ in}^2 \]

Check against the limit of \( a \)

\[ \lim a = 0.85 \left[ \frac{87}{87 + f'_c} \right] d (0.75) \]

\[ \lim a = 0.85 \left[ \frac{87}{87 + 60} \right] (2.4)(0.75) \]

\[ \lim a = 9.06 \text{ in} \]

\[ a = 4'' + 2.69'' = 6.69 \text{ in} \]

\( \cdot \) Beam is safely reinforced

Total steel area

\[ A_{\text{total}} = A_{S_1} + A''_{S_2} = 5.44 + 1.22 = 6.66 \text{ in}^2 \]

\[ A_{\text{total}} = 6.66 \text{ in}^2 \]