EXAMPLE: CONCRETE BEAM DESIGN
WORKING STRESS METHOD

GIVEN:

\[ M = 200"k \]
\[ E_s = 29,000 \text{ ksi} \]
\[ f_s = 24 \text{ ksi} \]
\[ E_c = 3,025 \text{ ksi} \]
\[ f_c = 1.8 \text{ ksi} \]

DESIGN THE SECTION SO THAT IT IS EXACTLY BALANCED.

1. MODULUS RATIO: \[ \eta = \frac{E_s}{E_c} = \frac{29,000}{3,025} = 8 \]

2. FIND DEPTH, D, SO THAT BOTH MATERIALS ARE STRESSED TO ALLOWABLE:

\[ f_s = 3 \text{ ksi} \]
\[ f_c = 1.8 \text{ ksi} \]
\[ \frac{1.8}{x} = \frac{3}{D-x} \]
\[ \rightarrow 1.8D - 1.8x = 3x \]
\[ D = 2.67x \]

CONSIDERING THE INTERNAL COUPLE:

\[ M = R_c(D - \frac{x}{2}) \]
\[ R_c = \frac{f_c (B) (x)}{2} = \frac{(1.8 \text{ ksi})(14")(x)}{2} = 12.6x \]

\[ M = R_c \left( D - \frac{x}{2} \right) \]
\[ 200"k \times 12.1" = 12.6x \left( 2.67x - \frac{x}{2} \right) \]
\[ 2400"k = 33.64x^2 - 4.20x^2 \]
\[ = 29.44x^2 \]
\[ \rightarrow x = 9.0" \]
\[ D = 2.67x = 2.67(9") = 24.1" \]
3. Find area of steel:

\[ R_c = \frac{f_c(b)(x)}{2} = 12.6x \]
\[ = 12.6(9.0) \text{ in} \]
\[ = 113.4 \text{ in}^2 \]

\[ R_t = R_c \]

\[ R_t = A_s f_s \]

113.4 in\(^2\) = A_s (24 ksi) \quad \rightarrow \quad A_s = 4.73 \text{ in}^2