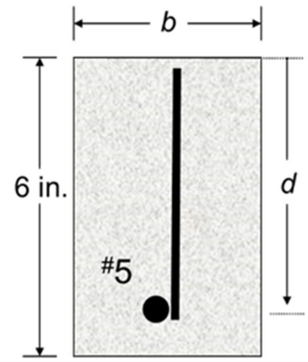
Example 4 - TopHat

Let's use the failure models to predict the ultimate strength-to-weight (SWR) of one of our reinforced concrete beams from lab.



Consider a beam with the following characteristics:

- Concrete strength $f'_c = 6{,}000$ psi
- Steel strength $f_y = 60{,}000$ psi
- The tension reinforcement will be one #5 rebars
- The shear reinforcement will be one #3 rebars installed vertically at 3 in. spacing
- Use minimum cover of 1 in. and a width to accommodate the reinforcement

Consider the following mix for a yd^3 of concrete developed using the ACI mix design procedure.

Component	Amount (lb.)
water	315
cement	768
coarse aggregate	1,658
fine aggregate	1,242

Bar #	Diameter (in.)	As (in.^{2})
3	0.375	0.11
4	0.500	0.20
5	0.625	0.31
6	0.750	0.44

4.1 What is the minimum width *b* of the beam:

b =

4.2 What is the Minimum depth *d* (in.) of the beam?

d =

4.3 Compute A_s =

4.4 What is the value for *a* (depth (in.) of the Whitney compression block)?

$$a = \frac{A_s f_y}{0.85 f'_c\, b} =$$

4.5 What is the moment capacity M (lb.-in.) of the beam?

$$M = A_s f_y \left(d - \frac{a}{2} \right) =$$

4.6 What is the predicted strength *P* (k) based on the tension model?

4.7 What is the predicted strength P (k) based on the shear model?

$$P_{shear} = 2\left(\frac{A_v f_y d}{s} + 2\sqrt{f'_c}bd\right) =$$

4.8 What is the beta value for this design?

$$f'_c \le 4000\ psi \quad \Rightarrow \quad \beta_1 = 0.85$$

$$f'_c \ge 4000\ psi \quad \Rightarrow \quad \beta_1 = 0.85 - 0.05\left(\frac{f'_c - 4000}{1000}\right) \ge 0.65$$

4.9 What is reinforcement ratio ρ for tension control (c/d = 0.375)

$$\rho = 0.85\beta_1 \frac{c}{d}\frac{f'_c}{f_y} =$$

4.10 What is reinforcement ratio ρ for the RC beam

$$\rho = \frac{A_s}{bd} =$$

4.12 Which value for P controls the design? S =

4.13 What is the estimated weight of the beam (lb.)?

$$W = \frac{bhL}{1728\,\text{in.}^3/\text{ft.}^3}\left(\frac{145\,\text{lb.}}{\text{ft.}^3}\right) + \frac{A_s L}{1728\ \text{in.}^3/\text{ft.}^3}\left(\frac{490\,\text{lb.} - 145\,\text{lb.}}{\text{ft.}^3}\right)$$

W =

4.14 What is the estimated $SWR = \frac{Ultimate\,Load(lb.)}{Beam\,Weight(lb.)} =$