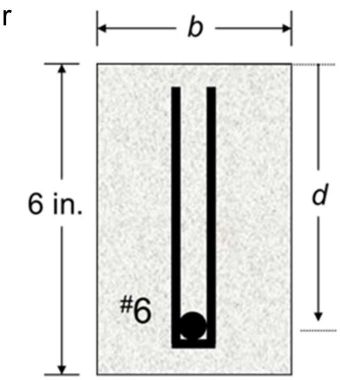
Example 3 - TopHat

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 $f'_c = 4{,}000$ psi
- Steel strength $f_y = 60{,}000$ psi
- The tension reinforcement will be 1 #6 rebars
- The shear reinforcement will be #3 rebars, U-shaped, 3 in. spacing
- Use minimum cover of 0.75 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	553
coarse aggregate	1,641
fine aggregate	1,431

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

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

b =

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

d =

3.3 Compute A_s =

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

$$M = A_s f_y \left(d - 0.59 \frac{A_s f_y}{f'_c b} \right) =$$

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

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

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

3.6a Which value for *P* controls the design? *S* =

3.7 What is the beta value for this design?

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

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

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

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

3.9 What is reinforcement ratio ρ for compression control (c/d = 0.6)

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

3.10 What is reinforcement ratio ρ for the RC beam

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

3.11 What is the stress in the steel f_y?

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

$$c = \frac{a}{\beta_1} =$$

$$f_{steel} = 87{,}000\, psi\left(\frac{d - c}{c}\right) =$$

3.12 What is the predicted strength (k) due to compression failure?

$$P_{compression} = \frac{A_s}{4}\left(\frac{d-c}{c}\right)\left(d-\frac{a}{2}\right)87{,}000\, psi =$$

3.13 What is the predicted strength (lb.) of the beam?

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

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

$W =$

3.12 What is the estimated *SWR*?

$$SWR = \frac{Ultimate\,Load(lb.)}{Beam\,Weight(lb.)} =$$