Note Title 4/12/2007

Advising 4/16 - 4/27

Senior Design 2 + 2 1 + 3 3 + 1
FEM -
Building Design
Adv. Steel Design

Deep Foundations

Traffic Eng + Modeling
Urban Trans Systems

May 11th Fri 12:30

April 23 @ 6:00 PM

Senior Design Final Presentations

140 Smith

Analysis of Reinforced Concrete Beams

$$M_n = \underbrace{A_s f_y}_{T} \left(d - a/2\right)$$

$$\phi M_n \geq M_u \qquad \phi = 0.90_{\text{bending}}$$

$$\boxed{R_n \geq \frac{M_u}{\phi b d^2}}$$ Design Eq.

$$R_n = f(f_y, f'_c, \rho)$$

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

f'_c, f_y, ρ_{design}, DL, LL

$$\rho_{min} \geq 200 / f_y$$
$$\geq 3\sqrt{f'_c} / f_y$$

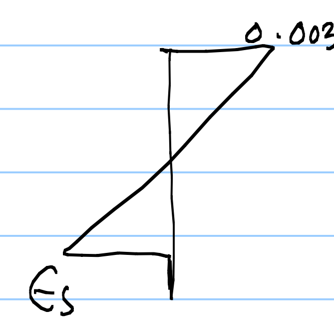
$f'_c > 4400$ psi

steel won't fracture instantaneously when concrete cracks

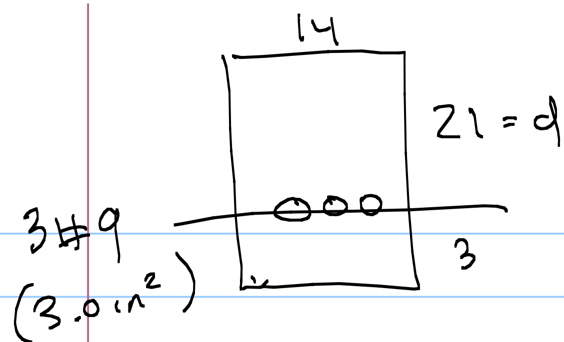
M_{cr}

Ensure steel yields before concrete in compression crushes

$\epsilon_s > \epsilon_y$ when $\epsilon_c = 0.003$

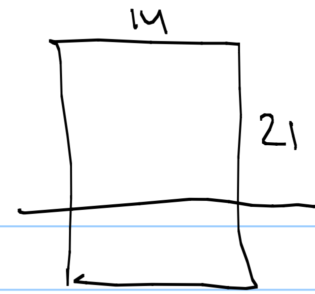


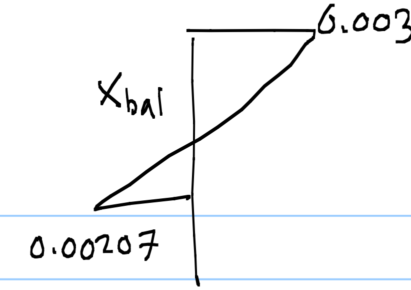
ductile failure
tension controlled beam



$f'_c = 3$ ksi

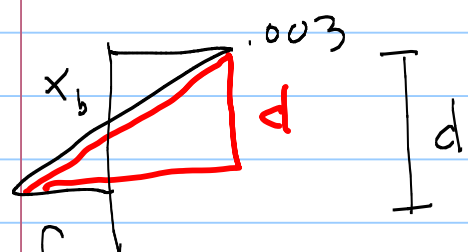
$f_y = 60$ ksi





Balanced Condition ρ_{bal}

% steel that will cause the concrete to crush ($\epsilon_c = 0.003$) at the same time that the steel (in tension) yields ($\epsilon_s = 0.00207$)



$\epsilon_y = \frac{f_y}{E_s}$

$$\frac{x_b}{.003} = \frac{d}{.003 + f_y/E_s} \qquad E_s = 29{,}000{,}000 \text{ psi}$$

$$x_b = \left[\frac{87{,}000}{87{,}000 + f_y}\right] d \qquad f_y - \underline{\text{psi}}$$

$$C = T$$

$$.85 f'_c b a = A_{s_b} f_y \qquad a_{bal} = \frac{A_{s_b} f_y}{0.85 f'_c b} \quad \frac{d}{d}$$

$$\rho = \frac{A_s}{bd} \qquad a_{bal} = \frac{\rho_{bal} f_y d}{0.85 f'_c}$$

$$x = a/\beta_1 = \frac{\rho_{bal} f_y d}{.85 f'_c \beta_1}$$

$$\left[\frac{87000}{87000 + f_y}\right] d = \frac{\rho_{bal} f_y d}{0.85 f'_c \beta_1}$$

$$\boxed{\rho_{bal} = \frac{0.85 f'_c \beta_1}{f_y} \left[\frac{87{,}000}{87{,}000 + f_y}\right]} \qquad \rho_{bal} = f(f'_c, f_y)$$

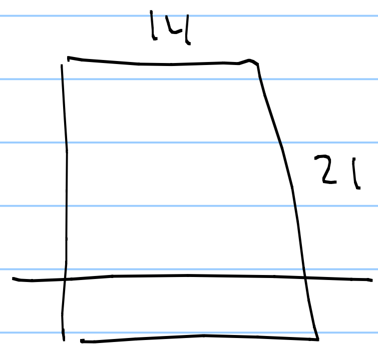
$$\rho_{des} < \rho_{bal}$$

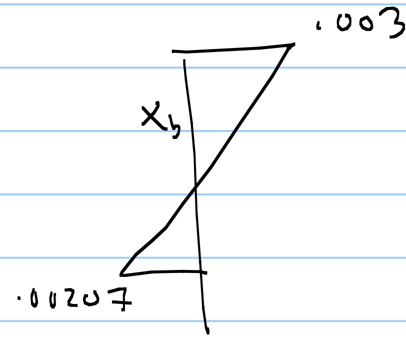
A.7 Table

Calculate A_{s_b}

$f'_c = 3\ ksi$

$f_y = 60\ ksi$





$$\frac{x}{.003} = \frac{d = 21}{.003 + .00207}$$

$$x_b = 12.426''$$

$$C = T \qquad a = \beta_1 X$$

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

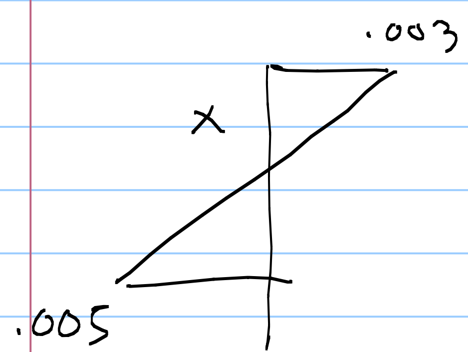
$$0.85(3)(14)(0.85)(12.426) = A_{s_b}(60) \qquad A_{s_b} = 6.28\ in^2$$

3#9 bars (3.0)

$$\rho_b = 0.0214 \qquad A_{s_b} = \rho_b b d$$

$$= 0.0214(14)(21) = 6.28\ in^2$$

$\rho_{0.005}$



$$\frac{x}{.003} = \frac{d}{.008} \qquad x = \frac{3}{8}d$$

$$C = T$$

$$0.85 f'_c b a = A_s f_y$$

$$a = \beta_1 x$$

$$0.85 f'_c b \beta_1 x = A_s f_y$$

$$0.85 f'_c b \beta_1 \left(\frac{3}{8}d\right) = A_s f_y$$

$$\frac{A_s}{bd} = 0.85 \frac{\text{[illegible]}}{\text{[illegible]}} \beta_1 \left(\frac{3}{8}\right) = \rho_{0.005}$$

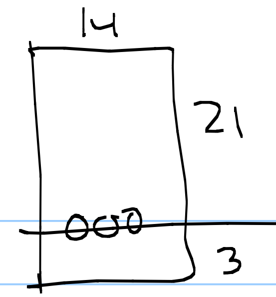
$\rho \leq 0.75 \rho_{bal}$

	$\frac{1}{2}\rho_{bal}$	$\rho_{0.005}$	ρ_b
$\beta_1 = .85$	$0.21\, f'_c/f_y$	$0.27\, f'_c/f_y$	$0.43\, f'_c/f_y$
$\beta_1 = .65$	$0.16\, f'_c/f_y$	$0.21\, f'_c/f_y$	$0.33\, f'_c/f_y$

→ * $\frac{1}{2}\rho_{bal}$ $= \rho$

$0.18\, f'_c/f_y$

Check the Beam



$f'_c = 3\,ksi$
$f_y = 60\,ksi$
$\beta_1 = 0.85$

$C = T \rightarrow a = 5.04''$

$x = 5.93$

$M_n = 277.2$ ft-k

$\epsilon_t = 0.0076$

$\rho_{bal} = 0.0214$ 2.1%

$A_{sb} = 6.28$

$\rho_{min} \geq 3\sqrt{f'_c} / f_y = 0.0027$

$\geq 200 / f_y = 0.0033$ *

$\rho_{bal} = 0.0214$ $.85 \beta_1 f'_c / f_y \left(87000 / 87000 + f_y \right)$

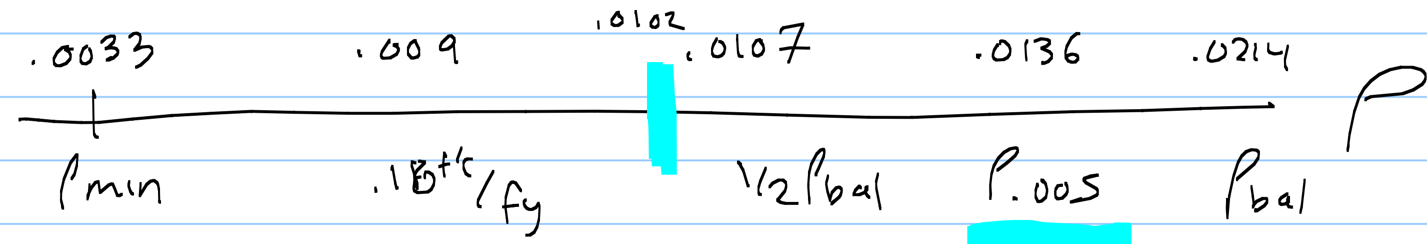
$\rho_{.005} = 0.0136$ $.85 \beta_1 \frac{f'_c}{f_y} (3/8)$

$\frac{1}{2}\rho_b = 0.0107$

$0.18\, f'_c / f_y = 0.009$

$\rho_{act} = \frac{3}{14 \times 21} = 0.0102$ ⟵ ✱

f'_c, f_y



Next Class

- Design a beam
- practical spacing requirements