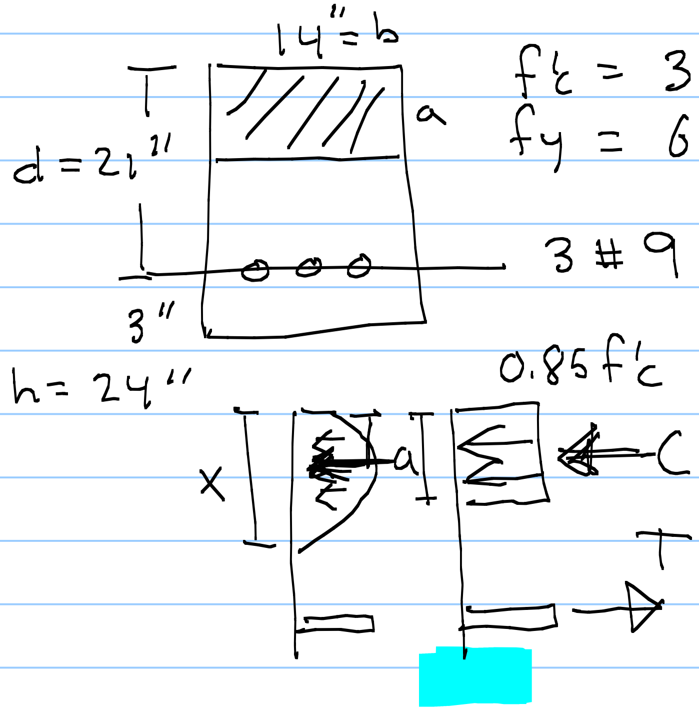
Note Title 4/10/2007

M_{cr} - Cracking Moment

M_n - Nominal Moment "Ultimate"

Ex. 2.6



$f'_c = 3 ksi$

$f_y = 60 ksi$

$M_{cr} = 46$ ft-k

$M_n = ?$

① $f_s = f_y$

② $T = A_s f_y$

③ $C = T$

$C = 0.85 f'_c ba$

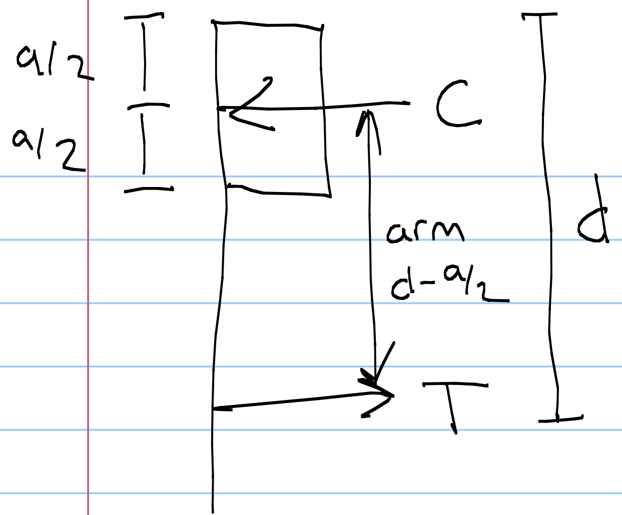
σ

solve for a

Whitney Stress Block

$a = \beta_1 x$

$\beta = f(f'_c)$ 0.85 - 0.65



④ $M_n = T(d - a/2)$ on C

⑤ $\epsilon_s > \epsilon_y$

① $f_s = f_y$

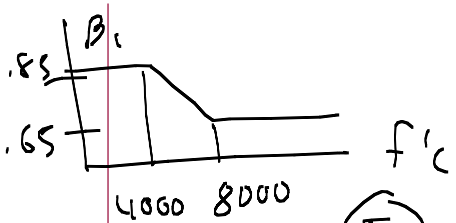
② $T = A_s f_y = (3.0\ in^2)(60\ ksi) = 180\ kips$

③ $C = T$ $\quad (0.85 f'_c)\, b a = 180\ kips$ ($A_s f_y$)

$a = \dfrac{A_s f_y}{0.85 f'_c b}$ $\qquad a = \dfrac{180}{(.85)(3)(14)} = 5.04''$

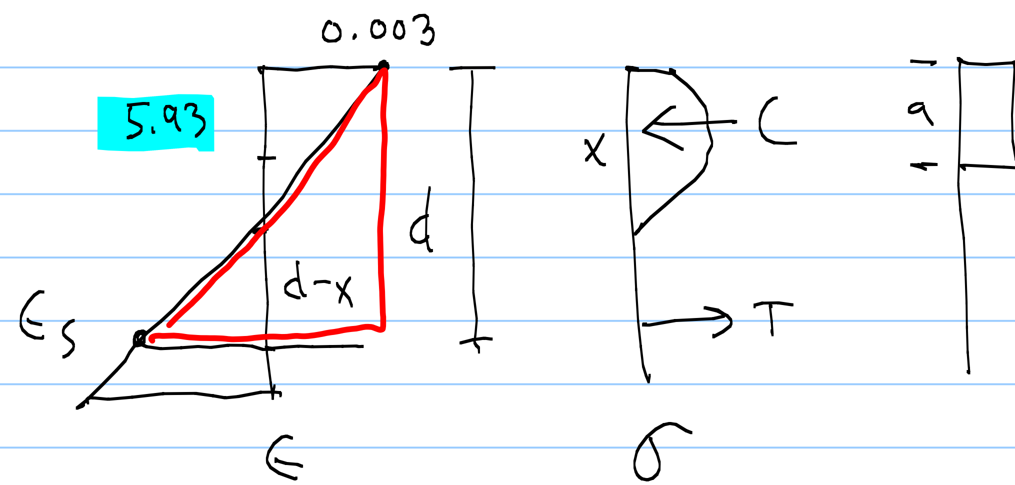
equilibrium

④ $M_n = T(d - a/2) = 180k\left(21 - \frac{5.04}{2}\right) = 3{,}326\ in\text{-}k$



$M_n = 277.2$ ft-k $\qquad M_{cr} = 46.0$ ft-k

(5) $\epsilon_s = ?$



$a = \beta_1 x$

$5.04 = (.85)x$

$x = 5.93$

$$\frac{\epsilon_s}{d-x} = \frac{0.003}{5.93}$$

$(21 - 5.93)$

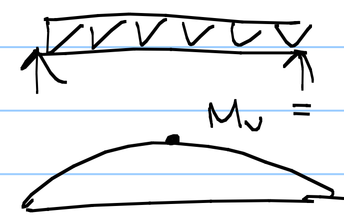
$\epsilon_s = 0.0076$ ✓ $> .00207$

Design

$\phi P_n \geq P_u$

internal cap. — applied loads

$\phi_b M_n \geq M_u$ →



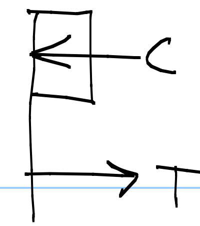
$\phi_b = 0.90$

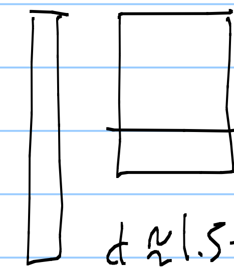
satisfy

find A_s, b, d, f'_c, f_y
(A_s, b, d → ρ; f'_c given, f_y given)

$M_n = T\,(d - a/2)$

$A_s f_y\,(d - a/2)$





$\rho = \frac{A_{st}}{A_g}$

$\rho =$

$$\rho = \frac{A_s}{bd} \qquad A_s = \rho b d$$

$$C = T$$

$$.85 f'_c b a = A_s f_y$$

$$a = \frac{A_s f_y}{.85 f'_c b} = \frac{A_s}{bd} \, \frac{f_y d}{.85 f'_c} = \frac{\rho f_y d}{0.85 f'_c}$$

$$M_n = A_s f_y \left(d - a/2 \right)$$

$$\phi M_n = \phi A_s f_y \left(d - a/2 \right) \geq M_u$$

$$\phi M_n = \phi (\rho b d) f_y \left[d - \frac{\rho f_y d}{0.85 f'_c (2)} \right] \geq M_u$$

$$\phi M_n = \phi \, [illegible] \, \rho b d^2 \, [illegible] \, \frac{[illegible]}{1.7 f'_c} \Big] \geq M_u$$

$$\phi M_n = \phi R_n bd^2 \geq M_u$$

$$R_n \geq \frac{M_u}{\phi bd^2}$$

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

Table A.8 - A.13 $\rightarrow R_n = \rho f_y \left[1 - \frac{\rho f_y}{1.7 f'_c}\right]$

select $\rho, f_y, f'_c \rightarrow R_n$

M_u

$\phi = 0.90$ $\qquad \phi$

2-3% - ρ

Selecting ρ $\qquad \rho_{min} \geq \frac{200}{f_y}$

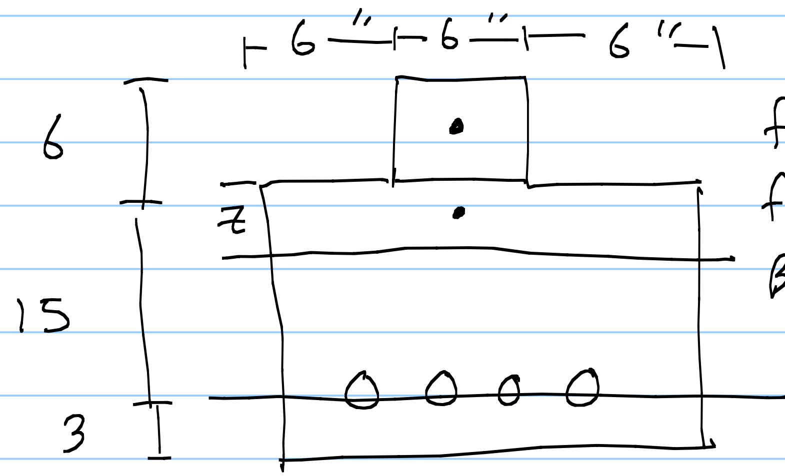
$f_y = 60{,}000$ $\quad \rho = 0.0033$

f_y - psi $\quad$ 0.3%

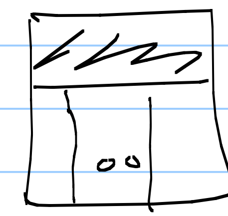
$M_n = 2.5 M_{cr}$ $\qquad f'_c \uparrow$ $\qquad \geq \frac{3\sqrt{f'_c}}{f_y}$

ρ_{max} → making sure steel yields

Ex 2.7



$f'_c = 3$ ksi
$f_y = 60$ ksi
$\beta_1 = .85$



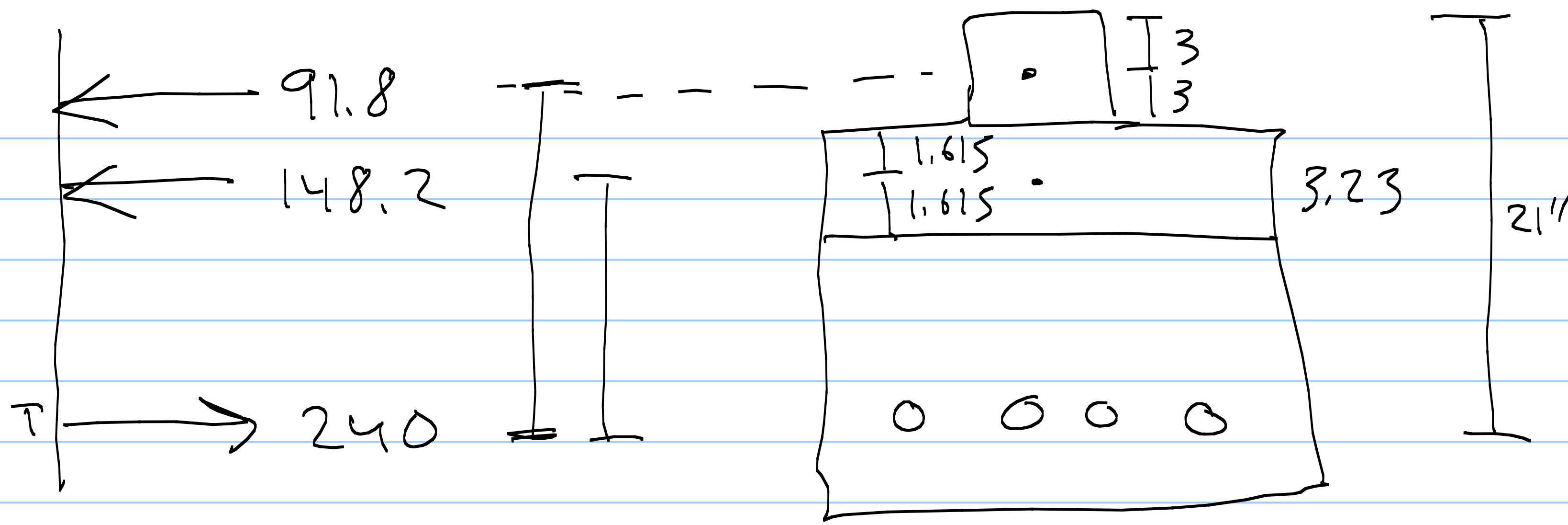
4 #9 $A_s = 4.0 \text{ in}^2$

$f_s = f_y$

$T = A_s f_y = (4)(60) = 240\text{K}$

$a = 6''$ $\quad C = 0.85 f'_c b a = 0.85(3)(6)(6) = 91.8\text{K}$

$240 = \underset{.85 f'_c b a,\ 6''}{91.8} + \underset{(.85)(3)(18'')z \;=\; 148.2}{.85 f'_c b z}$ $\quad z = 3.23''$



ΣM_T

$$M = 91.8\,(21-3) + 148.2\,\underbrace{\left(d - (6+1.615)\right)}_{21\,-\,7.615} = 3{,}636 \text{ in-k}$$

$$= 303 \text{ ft-k}$$