R.C. Oct 4 ①

T-beams

$$b_{eff} = \min \begin{cases} \frac{1}{4} \text{ span length} \\ b_w + 2\boxed{(8)(h_{slab})} \quad [8.12.2(a)] \\ b_w + 2\boxed{(\frac{1}{2} \text{ clear span})} \quad [8.12.2(b)] \end{cases}$$

[8.12]

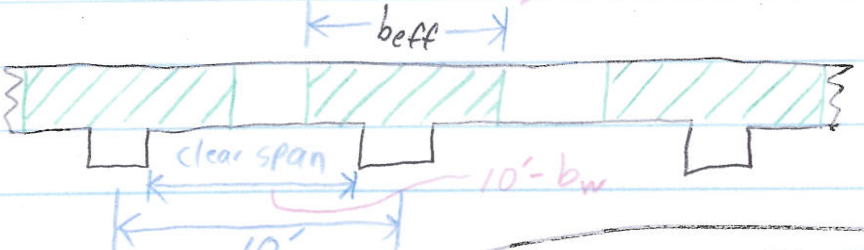
Ex 5.4

b_{eff}: (a) $\frac{1}{4}(20') = 5' = 60''$

(b) $12 + 2(8)(4) = 76''$

(c) $12'' + 2(\frac{1}{2}(9')) = 10'$

← wrong in Book



Ex. Hand out

① Calc. $M_{n,req.} = \frac{1200}{0.9} = 1333.3$ ft-k (Mu given)

② Calc. $A_{s_1} = \rho_{max} bd = 0.0181(14)(30) = 7.60 \text{ in}^2$

③ Calc. M_n, M_{n_1}, M_{n_2}

$\frac{M_u}{\phi b d^2} = 912$ [Table A.13]

$M_{u_1} = \phi b d^2 (912) = 0.9(14)(30)^2(912) = 861.84$ ft-k

$M_{n_1} = \frac{M_{u1}}{\phi} = 957.6$ ft-k

$M_n = M_{n_1} + M_{n_2} \rightarrow M_{n_2} = M_n - M_{n_1} = 1333.3 - 957.6 = 375.7$ ft-k

* Con't on Handout

① Calc $M_{n_{req}} = \frac{1200}{0.9} = \underline{1333.3 \text{ ft.K}}$ given Mu

② Calc $A_{s_1} = \rho_{max} bd = 0.0181(14)(30) = 7.60 \text{in}^2$

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Design of a Doubly Reinforced Beam #2
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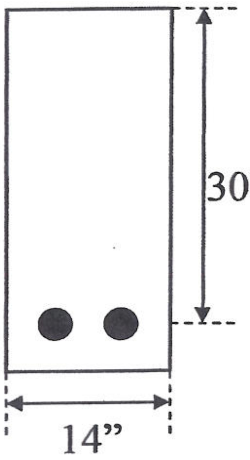
③ Calc M_n, M_{n_1}, M_{n_2}

$\frac{M_u}{\phi b d^2} = 912$ [Table A.13]



f'c = 4,000 psi
fy = 60,000 psi

Assume the compression steel will be placed at 3" o.c. from the compression face.

Determine the steel areas required for M_u = 1,200 ft-k.

$M_{u_1} = \phi b d^2 (912) = 0.9(14)(30)^2(912) = 861.84 \text{ ft-K}$

$M_{n_1} = \frac{M_{u1}}{\phi} = \underline{957.6 \text{ ft-K}}$

$M_n = M_{n_1} + M_{n_2} \rightarrow M_{n_2} = M_n - M_{n_1}$

$M_{n_2} = 1333.3 - 957.6 = \underline{375.7 \text{ ft-K}}$

④ Check if Compression Steel Yields

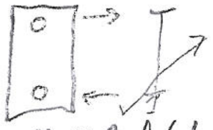
$a = \frac{A_{s_1}(f_y)}{0.85 f'_c (b)} = \frac{7.6(60)}{0.85(4)(14)} = 9.58 \text{in}$

$c = \frac{a}{\beta_1} = \frac{9.58}{0.85} = 11.27 \text{in}$

$\epsilon'_s = \left(\frac{c-d'}{c}\right)\epsilon_c = \left(\frac{11.27-3}{11.27}\right)(0.003) = 0.0022$

$> \underbrace{0.00207}_{\epsilon_y}$ ∴ Yields

⑤ Calc Compression Steel



$A'_s = \frac{M_{n_2}}{f_y(d-d')} = \frac{12(375.73)}{60(30-3)} = 2.78 \text{in}^2$

$M_{n_2} = A_s f_y (d-d')$

$A'_s f'_s = A_{s_2} f_y$

A_{s_2}

$A_s = A_{s_1} + A_{s_2} = 7.60 + 2.78 = 10.38 \text{in}^2$

Tensile Steel $A_s = 10.38 \text{ in}^2$

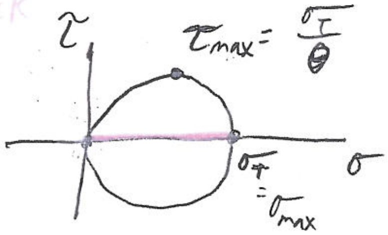
Comp steel $A'_s = 2.78 \text{ in}^2$

Review of Mohr's Circle

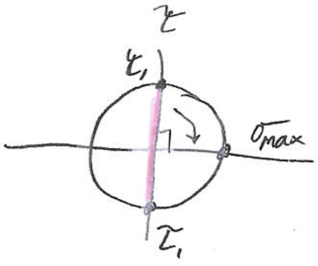
▨ = crack

Tension

$\tau_{max} = \frac{\sigma_T}{\theta}$



Shear



↖45° ↗90°

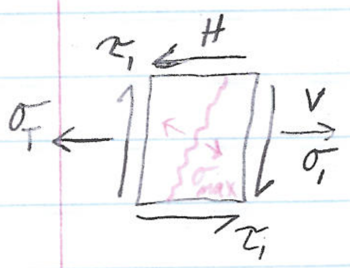
every 2 degrees on Mohr's Circle is 1 degree in real life

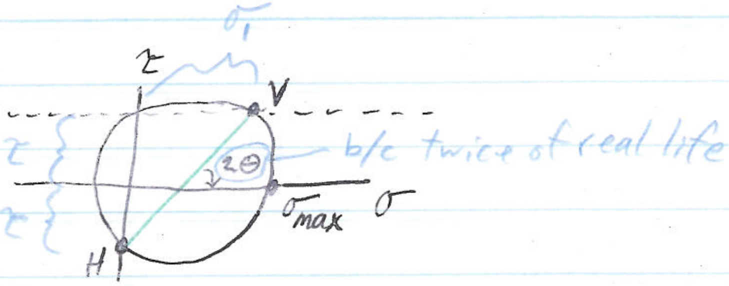
R.C. Oct. 4 P.2

See Review of Mohr's Circle on hand out

Con't:

Combination

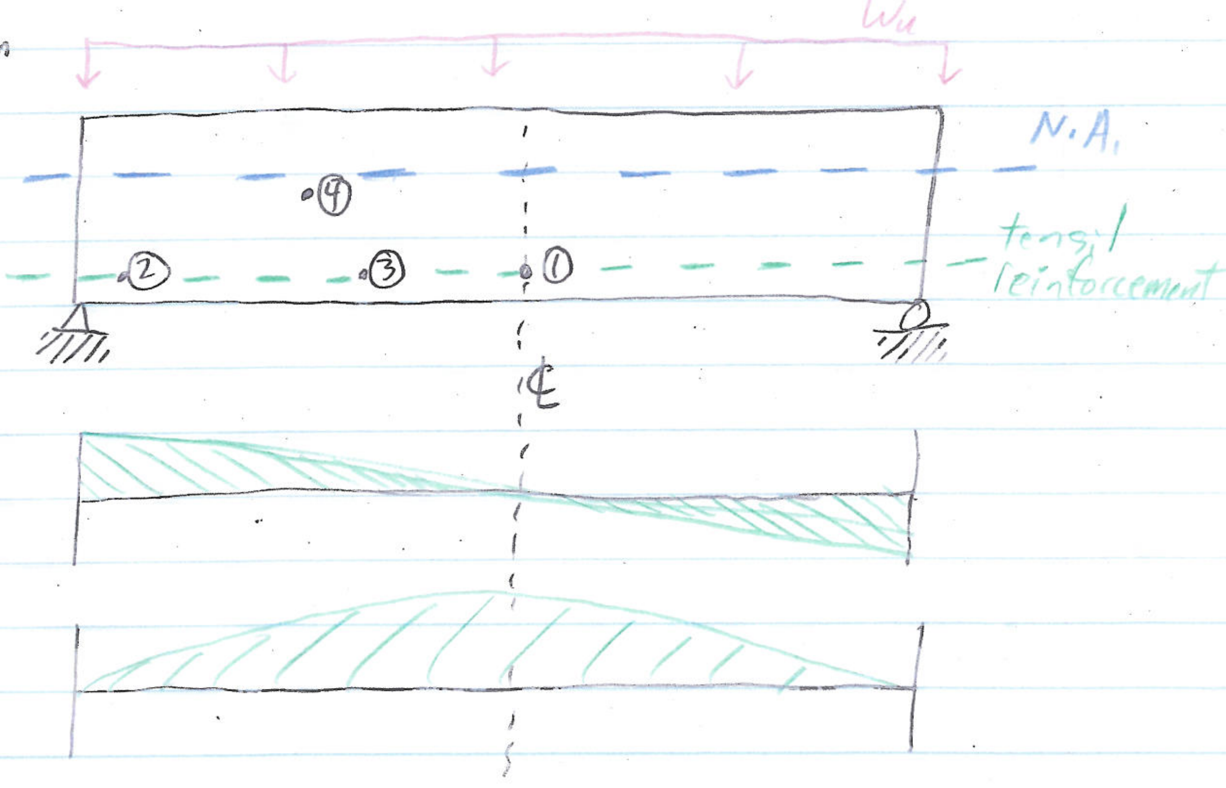




$0° < \theta < 45°$ from verticle

* Cracking occurs ⊥ to the plane of the principle tension stress

Application to R.C. Beam



R.C. Oct 4 ④

we dont do stirrup like: 

b/c difficut to construct

∴ we don't get full effectiveness out of stirrup.

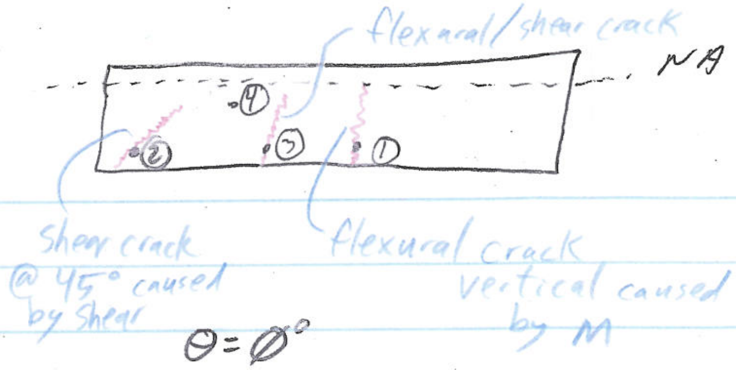
* Shear causes craks to approch 45°

* Tension causes cracks @ 90°

V_c = Shear capacity of concrete

* Aggregate interlock allow concrete to have more shear resistance inspite of cracks.

R.C. oct. 4 P.3



Crack Angles

Point 1

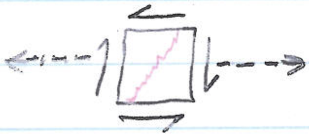
$\theta = 0°$

$V = 0$

$M =$ max

↳ $f =$ tension (axial force)

Point 2



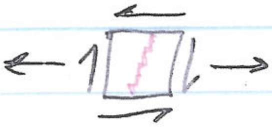
close to 45° b/c $V \gg M$

$V = \sim$ max

$M = \sim 0$

↳ $f =$ little tension

Point 3



$\theta \ll 45°$ b/c tension fairly high

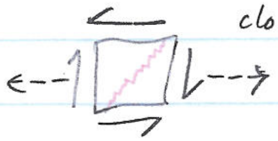
$V =$ medium

$M =$ high

↳ $f =$ tension

Point 4

tension low b/c close to N.A.



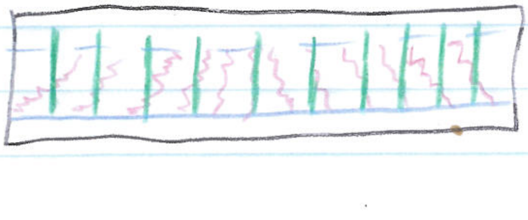
close to 45°

$V =$ medium

$M =$ high

↳ $f =$ very low

So Stirrup carries Shear Cracks



$) \text{ Calc } M_{n_{req}} = \frac{1200}{0.9} = \underline{1333.3 \text{ ft.K}}$ ← given Mu

$) \text{ Calc } A_{s_1} = \rho_{max} bd = 0.0181(14)(30) = 7.60 \text{ in}^2$

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Design of a Doubly Reinforced Beam #2

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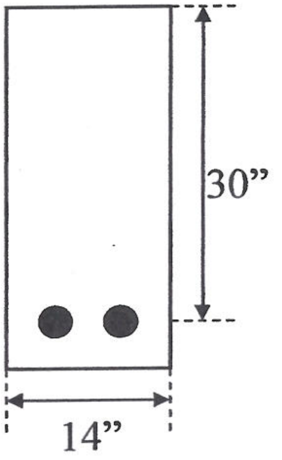
$) \text{ Calc } M_{n_1}, M_{n_1}, M_{n_2}$

$\frac{u}{12} = 912$ [Table A.13]



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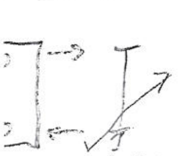
$\epsilon'_s = \left(\frac{c-d'}{c}\right)\epsilon_c = \left(\frac{11.27-3}{11.27}\right)(0.003) = 0.0022$

$> \underbrace{0.00207}_{\epsilon_y} \therefore \underline{\text{Yields}}$

$)$ Calc Compression Steel

$A'_s = \frac{M_{n_2}}{f_y(d-d')} = \frac{12(375.73)}{60(30-3)} = 2.78 \text{ in}^2$



$M_{n_2} = A_s f_y (d-d')$

$A'_s f'_s = A_{s_2} f_y$

52

f'c = 4,000 psi
fy = 60,000 psi

Assume the compression steel will be placed at 3” o.c. from the compression face.

Determine the steel areas required for M_u = 1,200 ft-k.

$A_s = A_{s_1} + A_{s_2} - 7.60 + 2.78 = 10.38 \text{ in}^2$

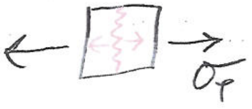
Tensile Steel $A_s = 10.38 \text{ in}^2$

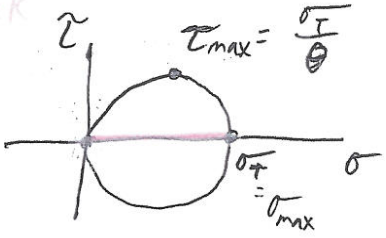
Comp steel $A'_s = 2.78 \text{ in}^2$

Review of Mohr's Circle

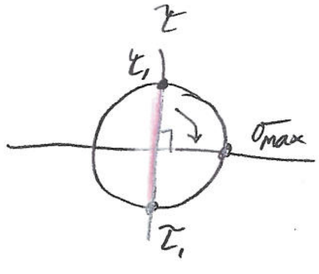
▨ = Crack

Tension





Shear



↖ 45° ↗ 90°

every 2 degrees on Mohr's Circle is 1 degree in real life

Simple Steel Stresses

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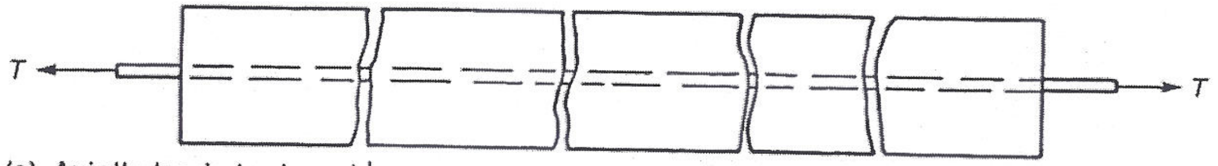
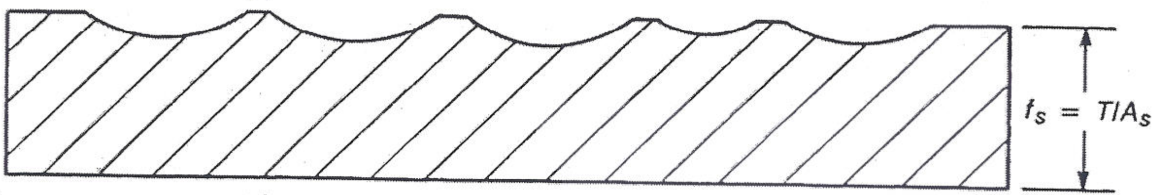
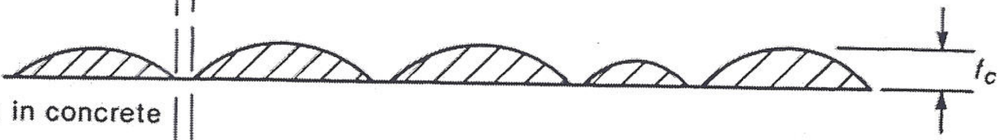


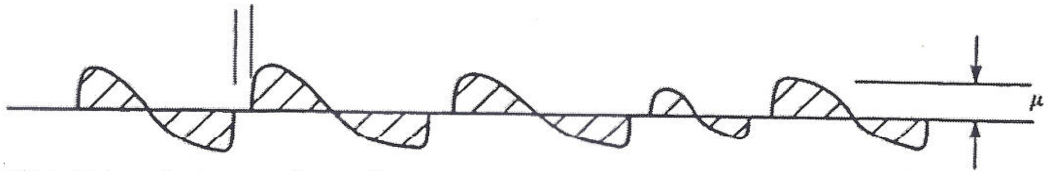
(a) Axially loaded prism.



(b) Variation in steel stress.



(c) Variation in concrete stress.



(d) Variation in bond stress—in-and-out bond stresses.

Steel Stresses in a Beam
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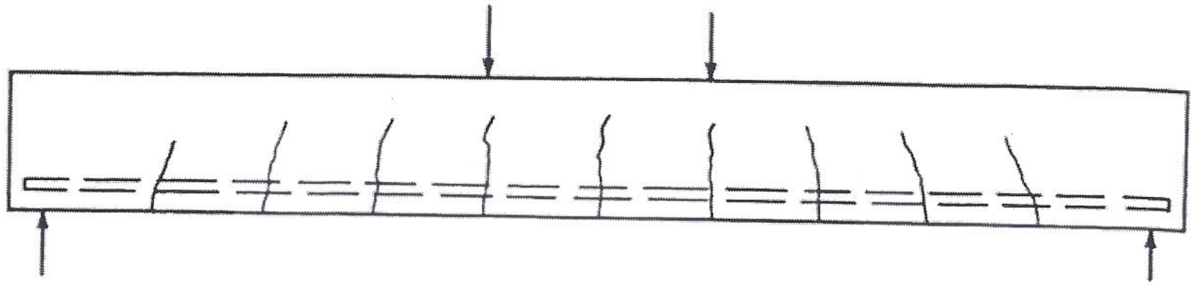
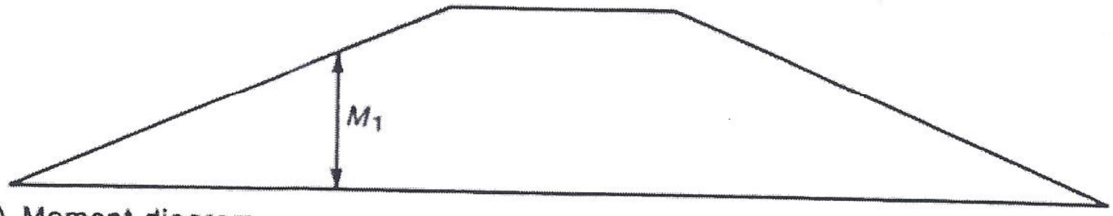
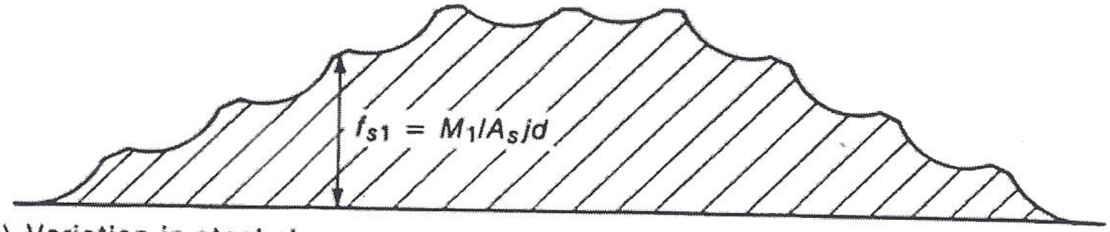


(a) Cracked beam.



(b) Moment diagram.



(c) Variation in steel stress.

(d) Tensile stress in concrete.

(e) In-and-out bond stresses.