Concrete Beams

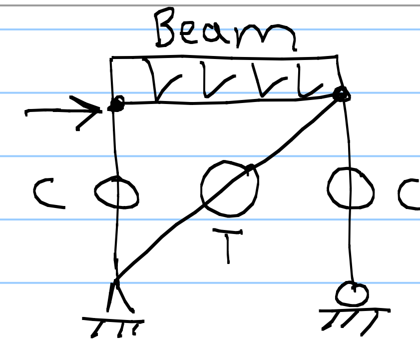
analysis flexure { Ch 2 (2.1, 2.2, 2.4)

{ Ch 3

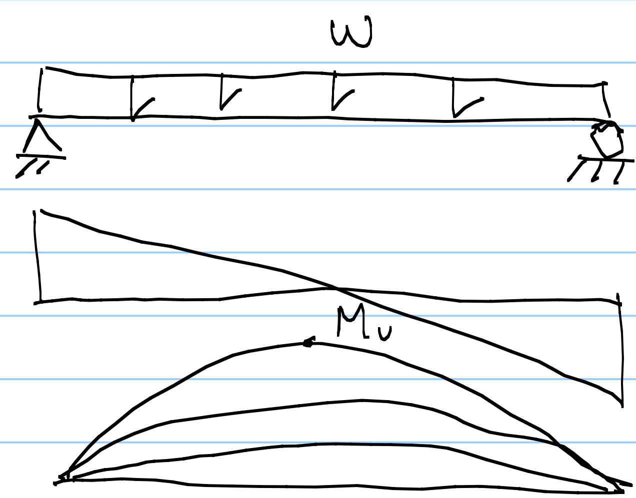
Design Ch 4 flexure → Moments

Ch 8 Shear

Ch. 6 (little) serviceability – Δ



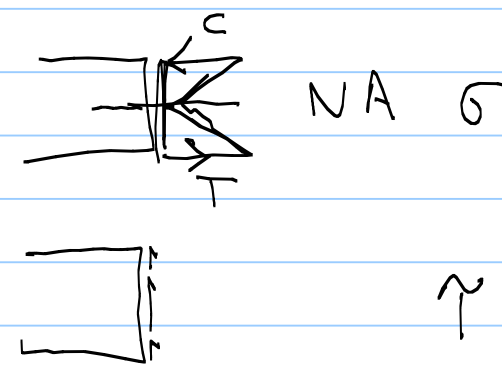
Braced frame

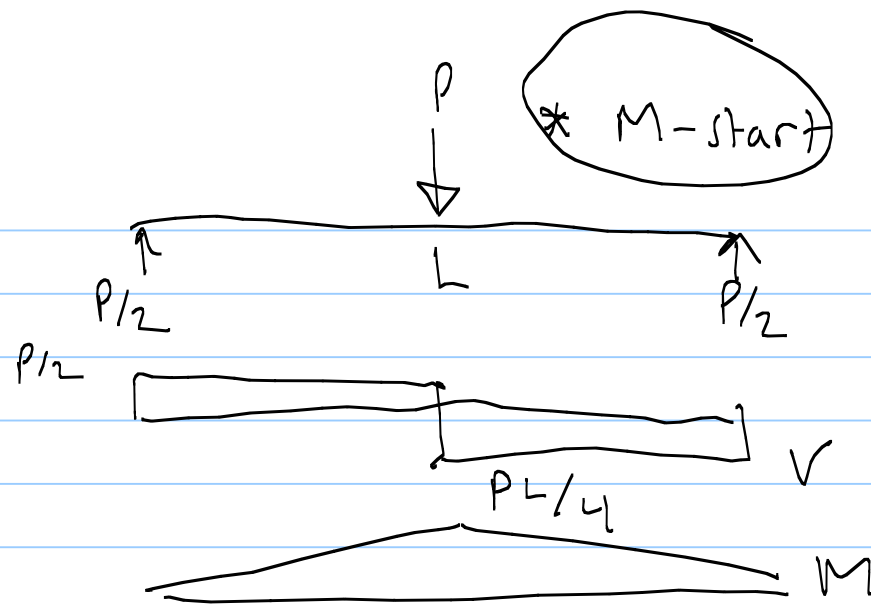


$\tau \leftarrow V$

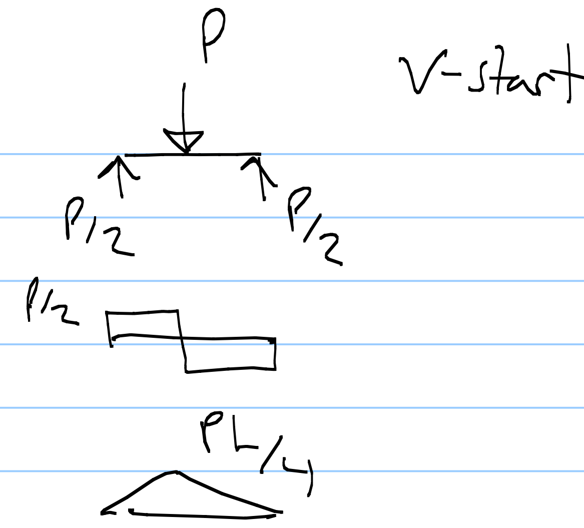
$\sigma \leftarrow M$

flexure

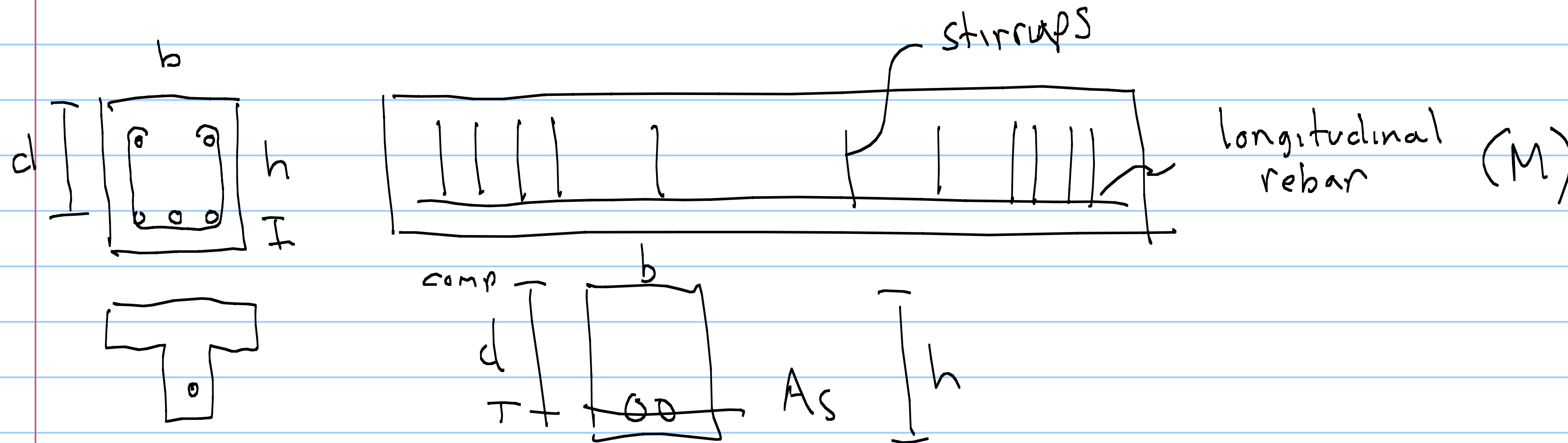




P
* M-start
L
P/2
P/2
P/2
V
PL/4
M



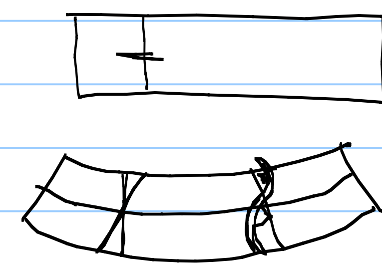
P
V-start
P/2
P/2
P/2
PL/4

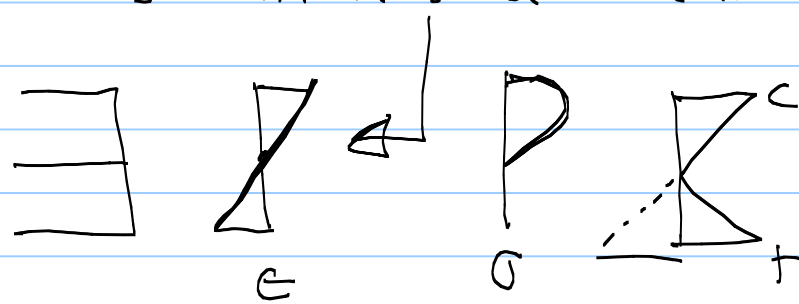


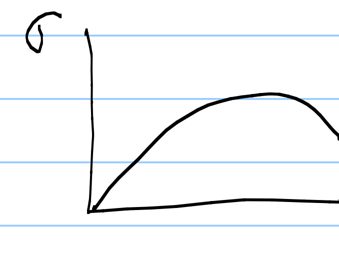
b
d
h
I
stirrups
longitudinal
rebar
(M)
comp
b
d
T
As
h

Capacity

* Plane sections remain plane
  strain has a linear distribution







nonlinear σ-ε dist.

* perfect bond
  between steel rebar
  + concrete

$\epsilon E \rightarrow \sigma$

$E_s \neq E_c$

Modular ratio

$n = E_s / E_c$

≈ 9

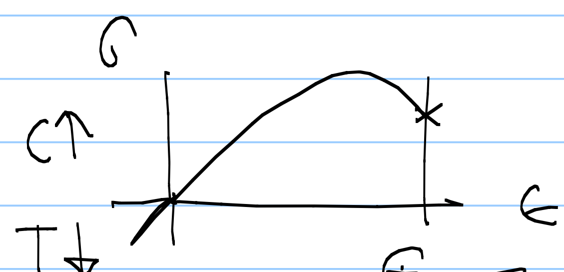
* concrete carries tension prior to cracking

$$f_r = 7.5\sqrt{f'_c}$$ modulus of rupture

psi psi

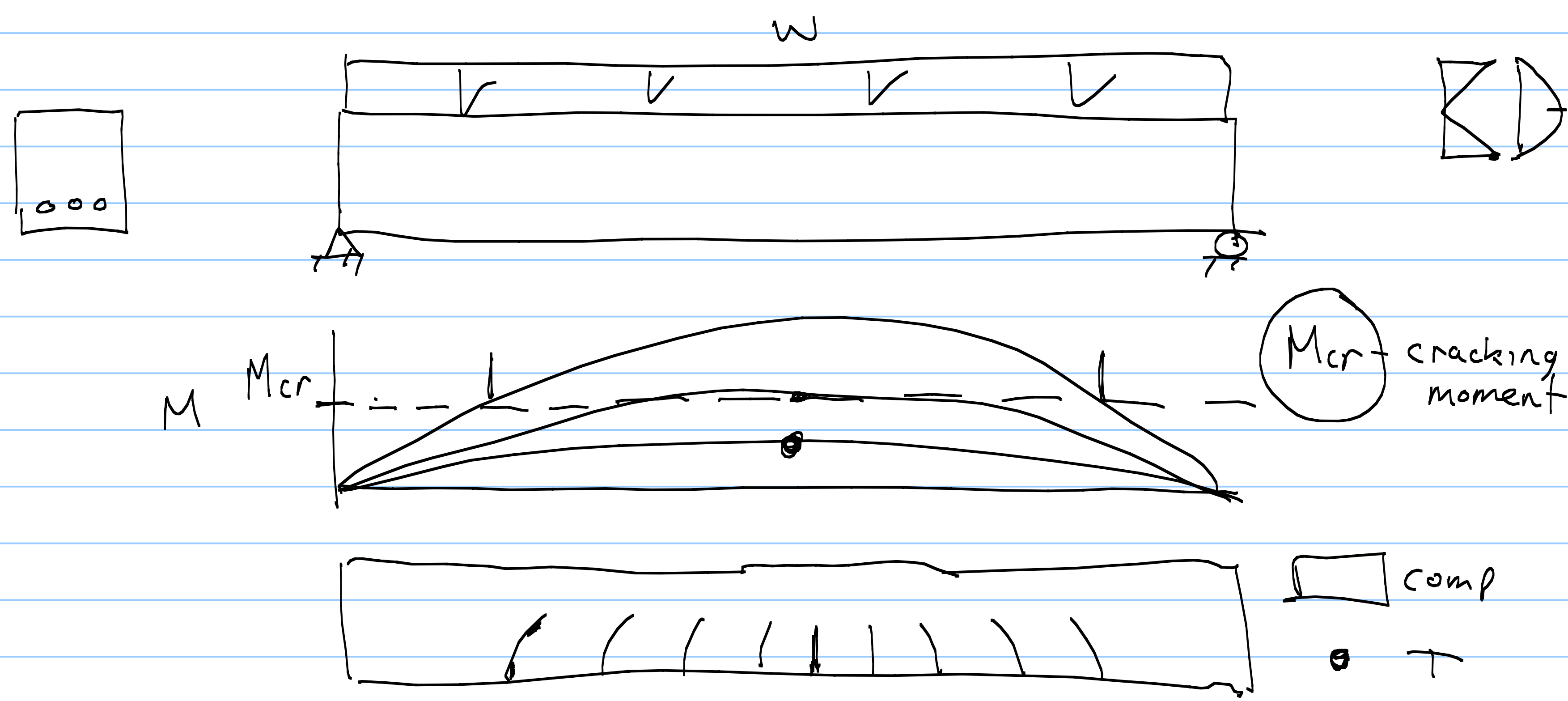
10-15% f'_c

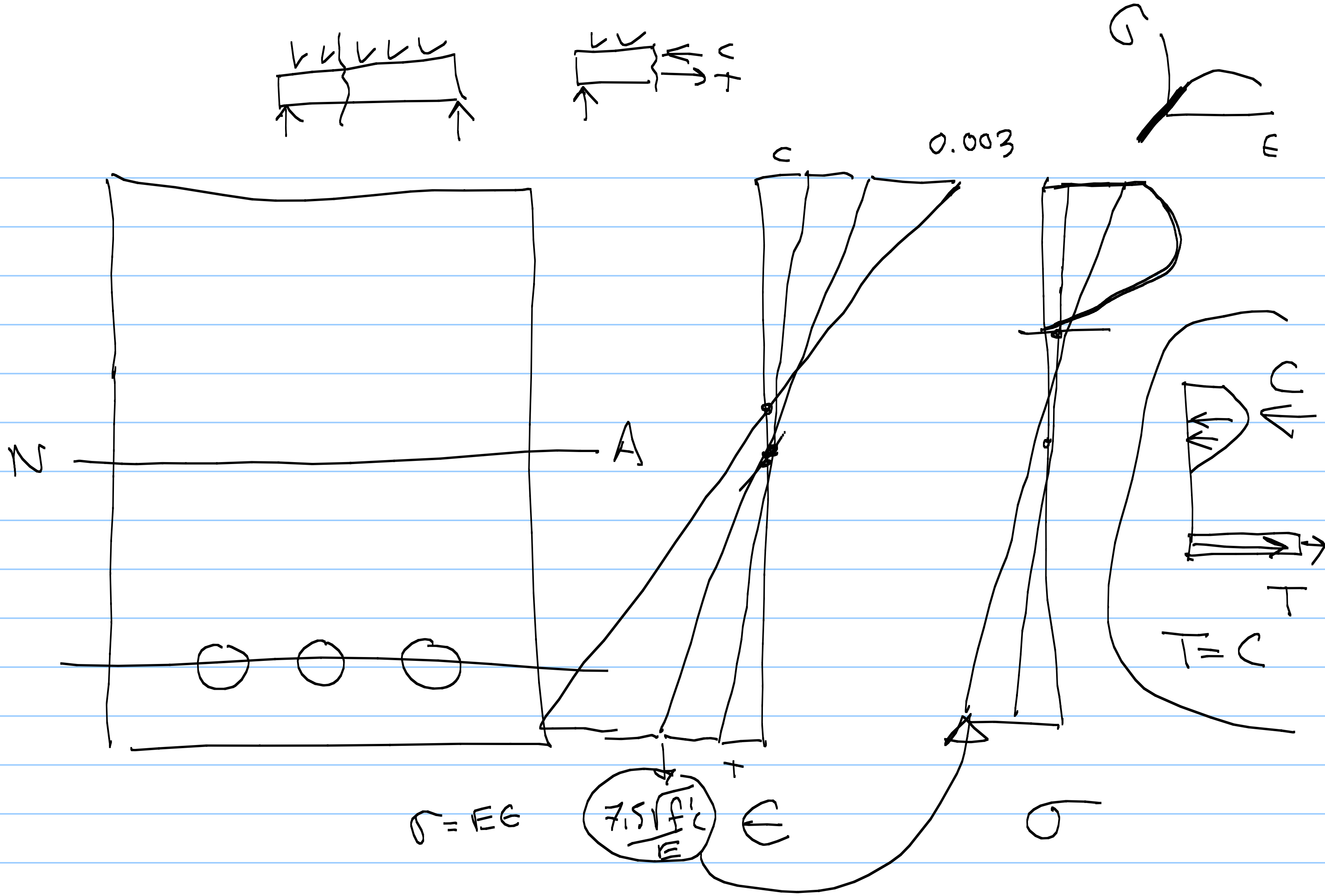
* once outer fiber cracks all tension concrete at that cross-section, cracks (carries no tension)

* 

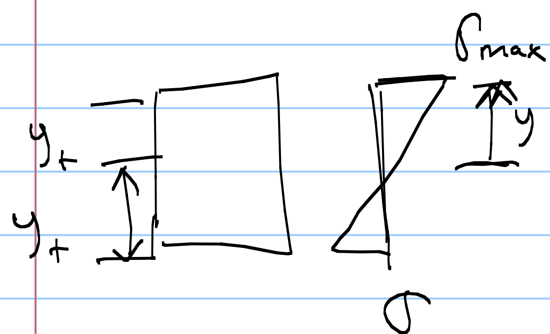
$\epsilon_{cu} = 0.003$ ult. concrete compression strain

* internal stresses are in equilibrium with the effects of the external loads




c
t
0.003
σ
ε
N
A
σ = Eε
7.5√f'c / E
ε
σ
C
T
T = C

$M_{cr} =$ c



$\sigma \leftrightarrow M$

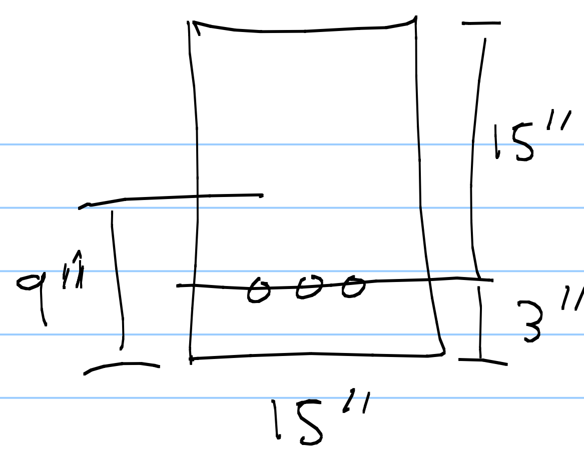
$$\sigma = \frac{M y}{I_g}$$

$$M = \frac{\sigma I_g}{y}$$

$$M_{cr} = \frac{f_r I_g}{y_t}$$

$$f_r = 7.5\sqrt{f'_c} \qquad f'_c\,(psi)$$

Ex 2.1



$f'_c = 4{,}000$ psi

$f_y = 60{,}000$ psi

3#9 bars

$M_{cr} = ?$

$$M_{cr} = \frac{f_r I_g}{y_t}$$

$$I_g = \frac{bh^3}{12} = \frac{(15)(18)^3}{12} = 5{,}832 \text{ in}^4$$

$$f_r = 7.5\sqrt{f'_c} = 7.5\sqrt{4000} = 474 \text{ psi}$$

$$= \frac{(474^{\text{psi}})(5832^{\text{in}^4})}{(9 \text{ in})} = 307{,}152 \text{ in-lb}$$

$= 25.6$ ft-k