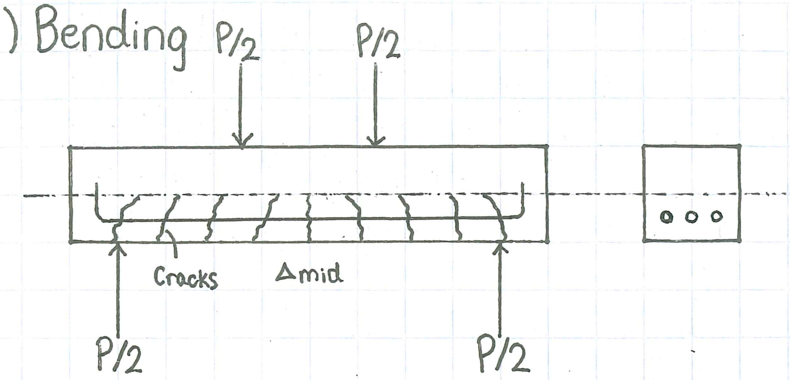
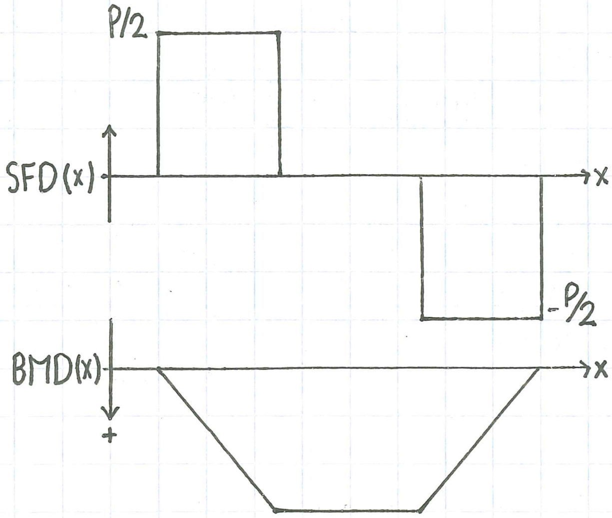
CIV102 - STRUCTURES and MATERIALS

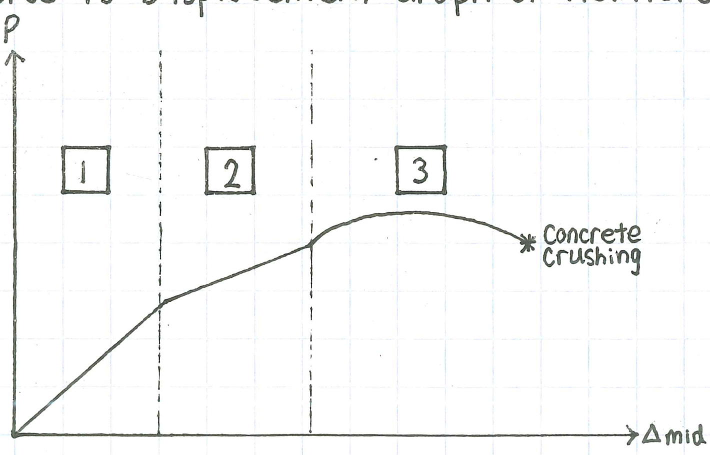
Topic: Reinforced Concrete Bending

1) Bending





Force vs Displacement Graph of Reinforced Concrete

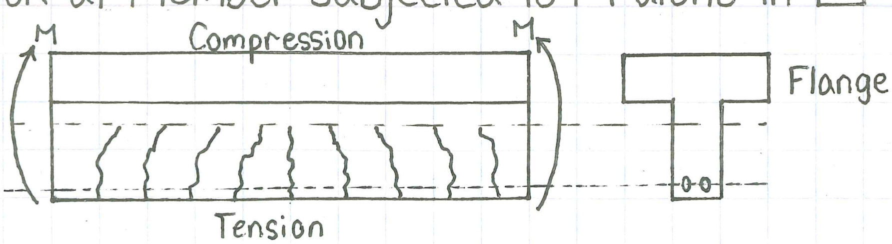


$\boxed{1}$ Uncracked Elastic

$\boxed{2}$ Cracked Elastic

$\boxed{3}$ Nonlinear Yielding

Look at Member Subjected to M alone in $\boxed{2}$

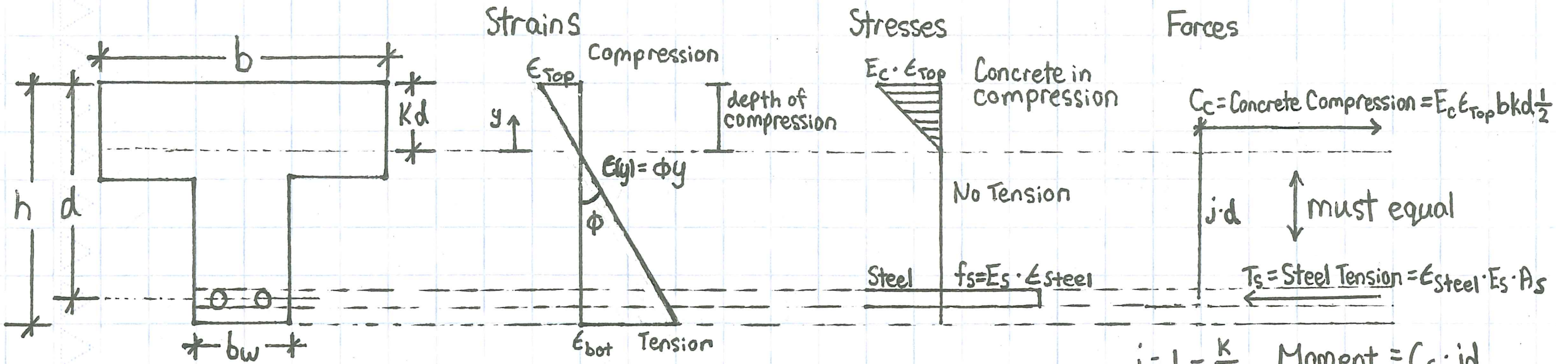


Assumptions

· Hooke's Law Applies to < Concrete in compression / Steel in tension

· No tensile concrete stress at all (Axial load = Zero)
· Plane sections remain plane
· Bond between steel and concrete is perfect
  ↳ $\therefore \epsilon_{concrete} = \epsilon_{steel}$ at depth of rebar
· Depth of compression is at flange

FOS for concrete in compression = 2
FOS for steel in tension = 1.67



$j = 1 - \frac{k}{3}$ Moment $= C_c \cdot jd$
or $= T_s \cdot jd$

$$K = \sqrt{(n \cdot \rho)^2 + 2n\rho} - n\rho$$

n = modular ratio = $\frac{E_s}{E_c}$

ρ = reinforcement percentage = $\frac{A_s}{bd}$

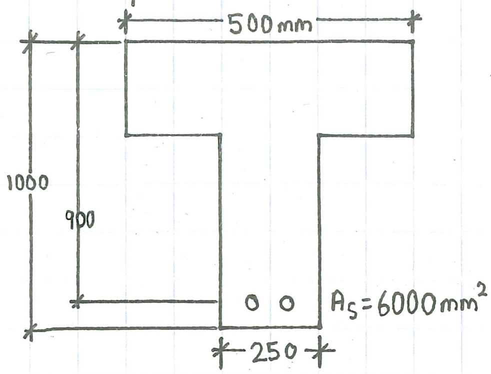
$$M = T_s \cdot j \cdot d$$
$$= A_s f_s \cdot j \cdot d \Rightarrow \underline{\underline{f_s = \frac{M}{A_s \cdot j \cdot d} \leq \frac{f_y}{FOS}}}$$

$$f_s = E_c \cdot \epsilon_{Top}$$

$$\epsilon_{Top} = \frac{K}{1-K} \cdot \epsilon_{steel} \qquad \epsilon_{steel} = \frac{f_s}{E_s}$$

$$\underline{\underline{f_c = \frac{K}{1-K} \frac{M}{j \cdot d \cdot A_s \cdot n} \leq \frac{f_c'}{FOS}}}$$

Example



$f_c' = 40MPa$
$f_y = 400MPa$

Moment = 1200KNm Is this safe?

1. $E_c = 4500\sqrt{f_c'}$
$= 28500 MPa$

2. $n = \frac{E_s}{E_c} = \frac{200000}{28500}$
$= 7.03$

3. $\rho = \frac{A_s}{b \cdot d} = \frac{6000}{500 \cdot 900}$
$= 0.01333$
or
1.3%

4. $k = \sqrt{(n\rho)^2 + 2n\rho} - n\rho$
$= 0.349$

5. $j = 1 - \frac{k}{3}$
$= 0.884$

Check f_s

$f_s = \frac{M}{A_s \cdot j \cdot d} = \frac{1200 \times 10^6}{6000 \cdot 0.884 \cdot 900}$
$= 251 MPa$

Allowable $= \frac{f_y}{1.67} = 239 \longrightarrow$ Not Safe

Check f_c

$f_c = \frac{k}{(1-k)} \frac{M}{j \cdot d \cdot A_s \cdot n} = 19.17 MPa$ Allowable $= \frac{f_c'}{FOS} = \frac{40}{2} = 20MPa \longrightarrow$ ok for f_c