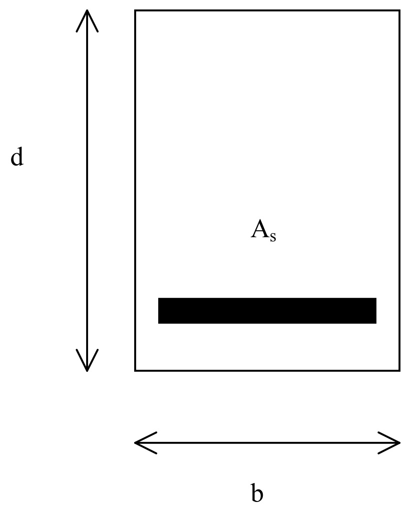
# RECITATION 2

## Example 1 (Flexural Strength of a Given Member)




b = 12"
d = 17.5"
$A_s$ = 4.00 in$^2$
$f_y$ = 60,000 psi
$f_c$' = 4000 psi

Find $M_n$, $M_u$

$M_u \leq \phi M_n$;  $\phi$ = 0.9 for flexure
Therefore, with $M_n$, $M_u$ can be calculated

$$M_n = \rho f_y b d^2 \left(1 - \frac{\rho f_y}{1.7 f_c'}\right)$$ → Equation (1)

$$\rho = \frac{A_s}{bd} = \frac{4.00}{12 \times 17.5} = 0.019$$ → Equation (2)

Check $\rho_{min} = \frac{200}{f_y} = 0.0033$ → Equation (3)

$$\frac{3}{4}\rho_b = \frac{3}{4} \cdot \frac{0.85 \beta_1 f_c'}{f_y} \cdot \frac{87000}{87000 + f_y} = 0.0214$$ → Equation (4)

$\therefore \rho_{min} \leq \rho \leq \frac{3}{4}(\rho_b)$ → Equation (5)

$\therefore$ **<u>$M_n$ = 3487 kips.in</u>** and **<u>$M_u$ = 0.9 x $M_n$ = 3138 kips.in</u>**

**Example 2 (Section Design with a Given Moment)**

| | |
|---|---|
| Unknowns: | b, d, h, $A_s$ |
| Given: | l = 15 feet |
| | DL = 1.27 kips/ft |
| | LL = 2.44 kips/ft |
| | $f_c$' = 4000 psi |
| | $f_y$ = 60,000 psi |
| | $\gamma_c$ = 150 psf |

1. Assume b and h for self-eight determination:

   Let b = 10 in and h = 18 in
   d = 18 – 2.5 = 15.5
   d/b = 1.5

   Minimum depth for simply supported beam = l/16 = 15/16 . 12 = 11.25; OKAY!

2. Find the applied moment to be resisted

   W = 150 . (10/12) . (18/12) . (1/1000) = 0.1875 kips/ft (this is to be revised)

   Therefore, $W_u$ = 1.4(1.27 + 0.1875) + 1.7(2.44) = 6.19 kips/ft

   $M_u = w_u l^2/8 = 6.19\ (15)^2/8 . 12$ (ft/in) = 2089 kips.in

3. Compute $\rho_{min}$ & $\rho_b$; and choose $\rho$

   $\rho_{min} = 200/f_y = 0.0033$
   ¾ $\rho_b$ = 0.0214; use $\rho$ = 0.0214 (Not economical, but adequate for demonstration purpose)

   Find the required $bd^2$

   $$M_u = \phi\rho f_y (bd^2)\left(1 - \frac{\rho f_y}{1.7 f_c^{'}}\right)$$

   $bd^2 = 2229\ in^2$

   Actual $bd^2 = 10. (15.5)^2 = 2403\ in^2$ > Required $bd^2 = 2229\ in^2$; **OKAY!**

4. Assign rebar arrangement

   $\rho = A_s/bd = 0.0214$

   $A_s = 0.0214.b.d = 0.0214.10.(15.5) = 3.32\ in^2$ (required)

**Provide 2#10 + 1#8**

$\therefore$ $A_s$ provide = 3.32 $in^2$

Note: ρ can be smaller and a larger section may be needed to improve cost and deflection performance. However, if there is architectural restrictions on sizes, a ρ with a value closer to the upper bound is normally used (to reduce section size as much as possible)

**Example 3 (Crack Width Determination)**

Given: b = 12”
h = 20”
$A_s$ = 4.00 $in^2$ (4 #9)
$f_y$ = 60,000 psi
Exposure = external

$$w = 0.000091 f_s \sqrt[3]{d_c A}$$ → Equation 1

$f_s = 0.6f_y$ in kips = 0.6 x 60 = 36 kips/in

$d_c$ = 2.5 in

$A = A_{eff} / N$ → Equation 2

$A_{eff}$ = web width x 2 x $d_c$ = 12 x 2 x 2.5 = 60 $in^2$

N = Total $A_s$ / area of largest bar = 4.00 / 1.00 = 4

Therefore, A = 60 / 4 = 15 $in^2$

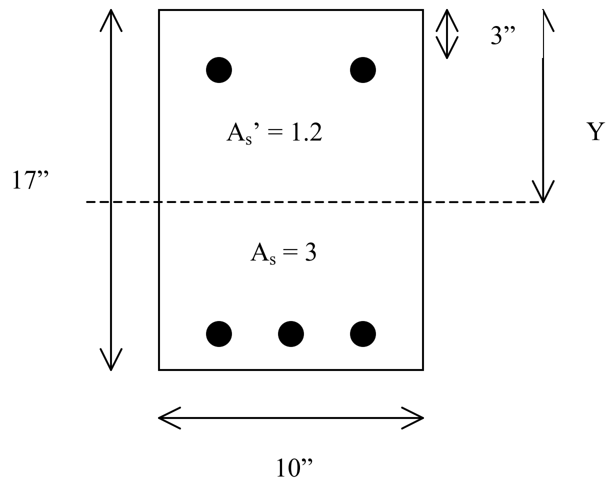
**W = 0.011 in**

ACI Stipulation
External exposure: $W_{max}$ = 0.013 in

Since, $W < W_{max}$; **OKAY!**

**Example 4 (Neutral Axis Location of Cracked Section)**

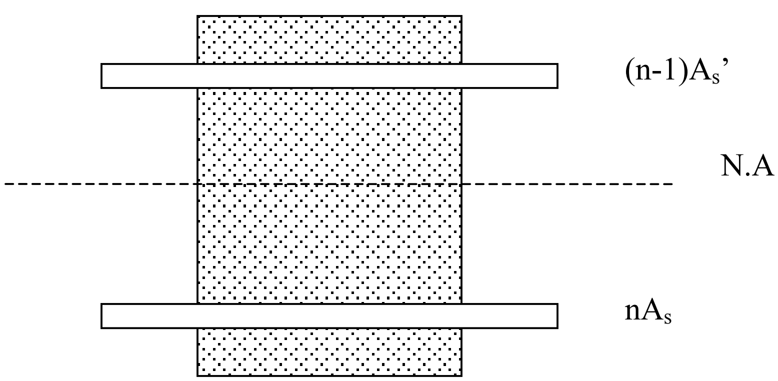
Given: $E_c$ = 3,625,000 psi
$E_s$ = 29,000,000 psi




$n = E_s/E_c = 8$

Locate the neutral axis by using **C = T**

**Transformed Section**




**Therefore,**

$Y\ (10)\ Y/2 + (n-1)\ A_s'\ (Y-3) = nA_s(17-5)$

$5Y^2 + 7(1.2)(Y-3) = 8(3)(17-Y)$

$Y = 6.62$ in

**Example 5 (Moment of Cracked section0**

$I_{cr} = bY^3/12 + (n-1)A_s'(Y-3)^2 + nA_s(17-Y)^2 = 10(6.62)^3/3 + 7(1.2)(6.62 – 3)^2 + 8(3)(17-6.62)^2 =$ **3663 in$^4$**