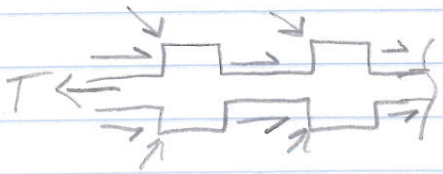
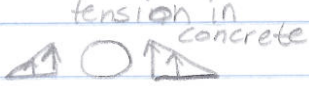
Development Length
Bond Stress
l_d
Example

HW #6 & 7
Due Wed

What is Bond Stress

A Local Shearing stress on the bar surface





Why is it important

- to transfer stress from concrete to the reinforcing steel

✡ It's difficult to predict

Factor contributing to bond

① Mechanical interlock

② Adhesion between steel & concrete

③ Frictional Resistance - gripping of the bar based on drying shrinkage

Development Length l_d

Length of embedment of rebar in concrete to develop the yield stress in the steel.

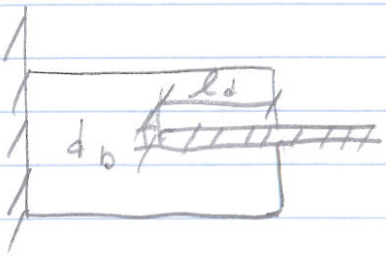
For Example

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

$$V_n = V_s + V_c = \frac{A_v f_y d}{s} + V_c$$

Both Assuming steel has yielded

More on l_d



$\rightarrow T = A_s f_y = \frac{\pi d^2}{4} f_y$

Assuming bar does not pull out of block $T = A_s f_y$

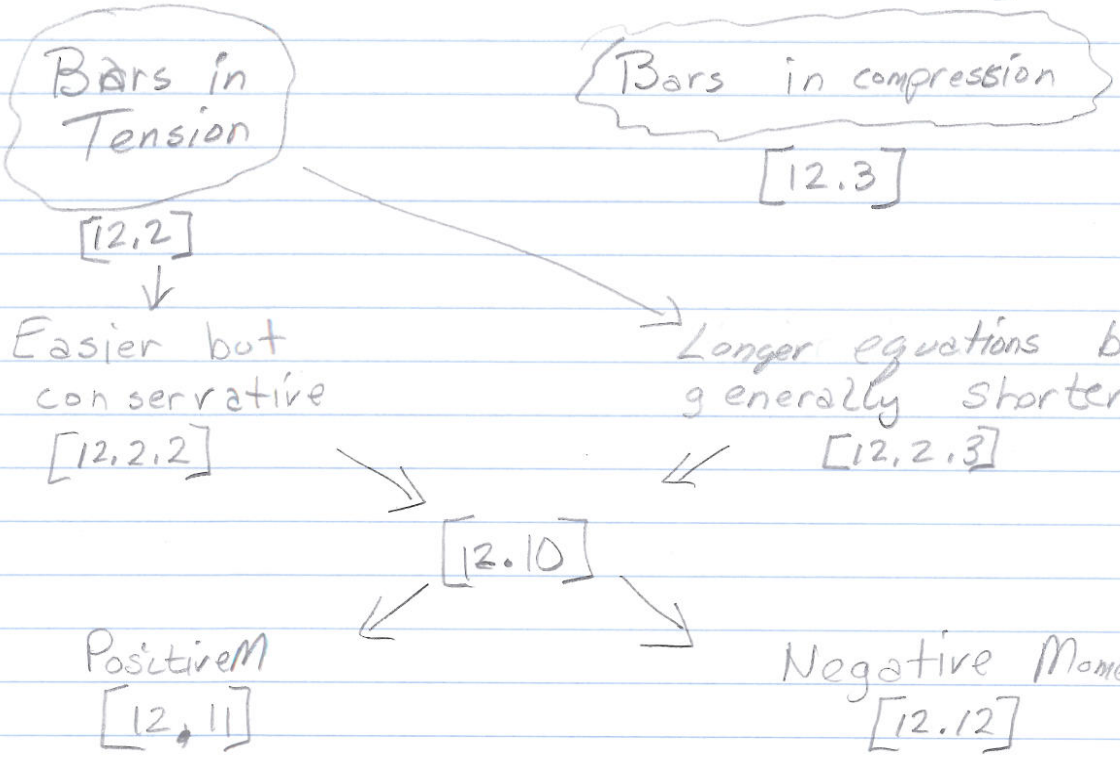
$$\pi d_b l_d u = \frac{\pi d^2}{4} f_y$$

$$l_d = \frac{d_b f_y}{4u}$$ but what is u

Factors Affecting l_d

1. Concrete quality
2. f_y of steel
3. confinement
4. bar surface coating
5. Size
6. cover & spacing
7. tension Vs. Compression

How does ACI deal with l_d



The Factors [12.2.4]

$\psi_t = \alpha \equiv$ reinforcement location factor (top bar effect)

$\psi_e = \beta \equiv$ coating factor

$\psi_s = \gamma \equiv$ reinforcement size factor

$\lambda \equiv$ light weight concrete factor

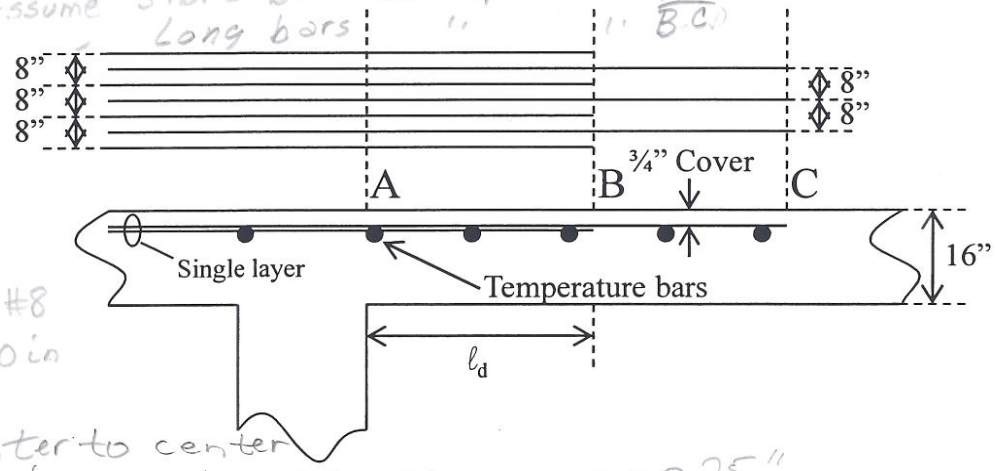
$c \equiv$ spacing or cover deminsion

Development of Bars in Tension
ENCE 4359 Structural Concrete Design
Dr. Lamanna

according to [12.2.3] & [12.2.2]

Calculate the required tension development length for the No. 8 bars (alternate short bars) in the "sand-lightweight" one-way slab shown below. Use $f'_c = 4{,}000$ psi and $f_y = 60{,}000$ psi, and uncoated bars.

Assume short bars developed in $\overline{AB}$
Long bars " " $\overline{BC}$



Normal ϕ of #8 bars is 1.00 in (diameter)

[12.2.2] Center to center spacing = $8 d_b = 8$ in. Clear cover = 0.75"

Since clear cover $< d_b$ & $d_b = 1.00$

$$\ell_d = \left(\frac{3 f_y \psi_t \psi_e}{\lambda\, 40 \sqrt{f'_c}}\right) d_b \quad [\text{tbl } 12.2.2]$$

$\psi_t = 1.3$ for top bar [12.2.4a]

$\psi_e = 1.0$ for uncoated bars [12.2.4(b)]

$\lambda = 0.75$ for light weight concrete [12.2.4.(d)]

$$\ell_d = \frac{(3)(60{,}000)(1.3)(1.0)}{40\sqrt{4000}\,(0.75)}(1.0) = 123.3 \text{ in}$$

[12.2.3]

$$\ell_d = \left[\left(\frac{3}{40}\right)\left(\frac{f_y}{\lambda\sqrt{f'_c}}\right)\frac{\psi_t \psi_e \psi_s}{\left(\frac{C_b + K_{tr}}{d_b}\right)}\right]$$

$\psi_s = 1.00$ for #7 & larger bars

$C_b = \min$ { side cover — 1.25" [12.2.4(c)]
cover over bar to bar center
½ center to center spacing of bars } [12.2 comment]

$$K_{tr} = \frac{40 A_{tr}}{sn} = \phi \text{ (no transverse reinforcement)}$$

over