

Agenda

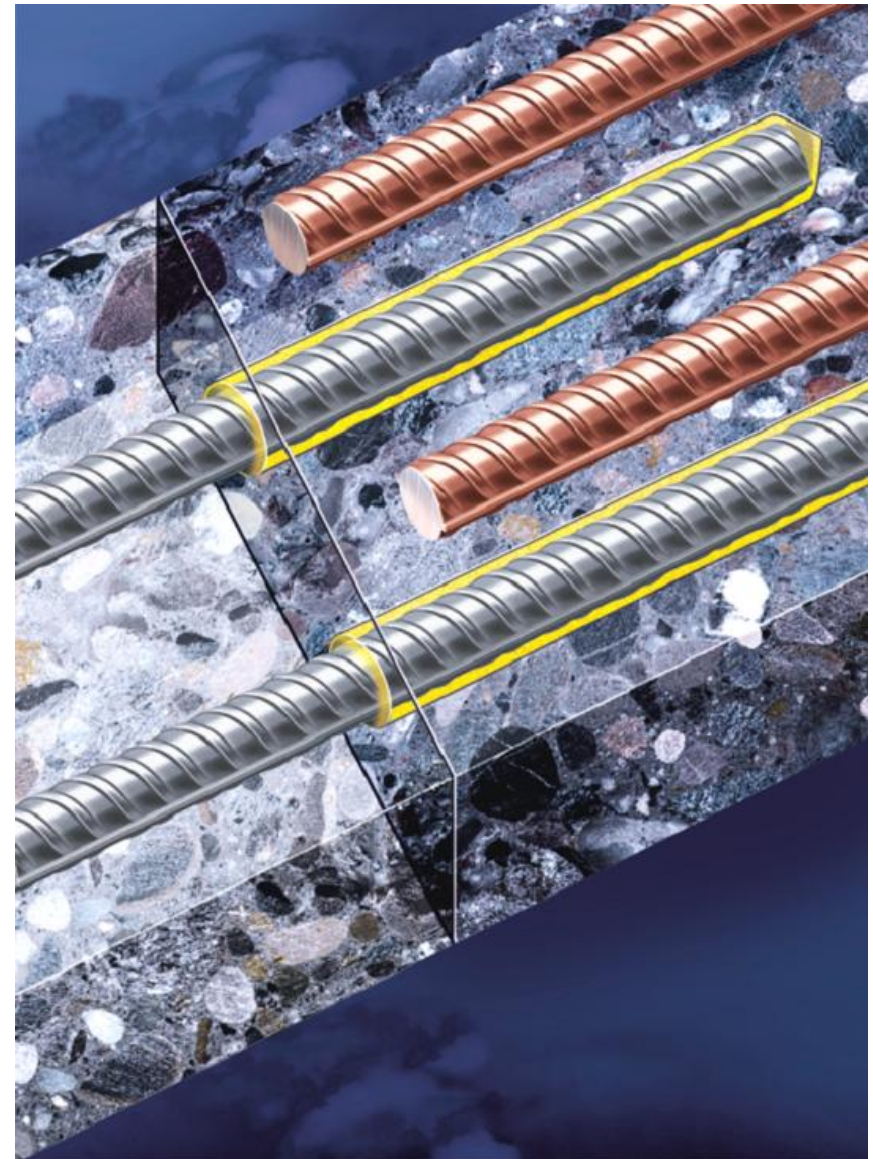
Application Examples

Design

Laboratory Testing

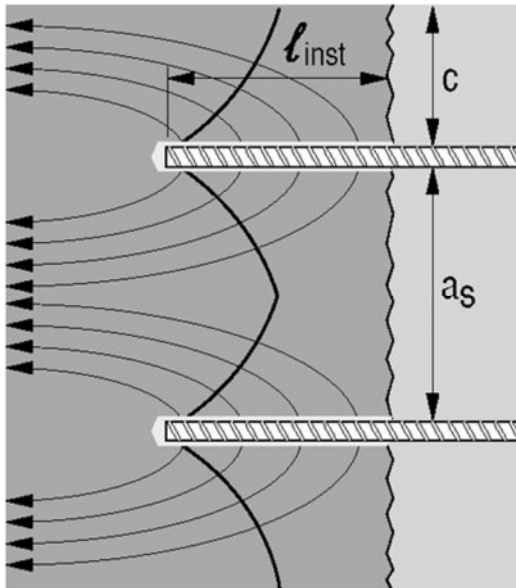
Installation

Questions, Answers & Discussion



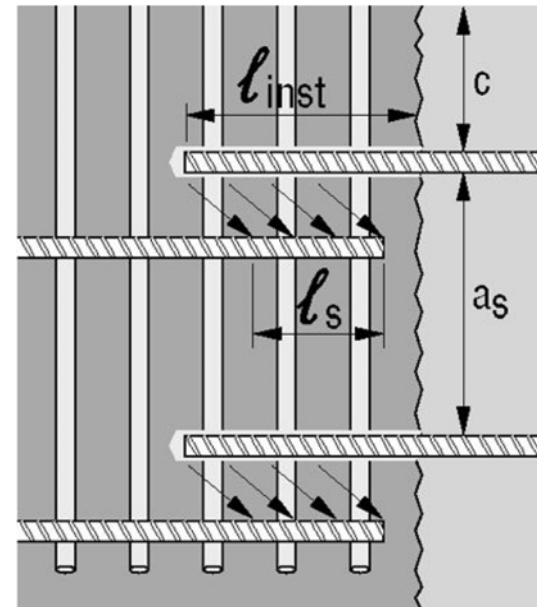
Design

Anchoring Theory **vs.** Reinforced Concrete Theory



Fragile Failure Modes (Concrete Breakout)

- Load transfer by tensile capacity of concrete
- Spacing and edge distance can be decisive

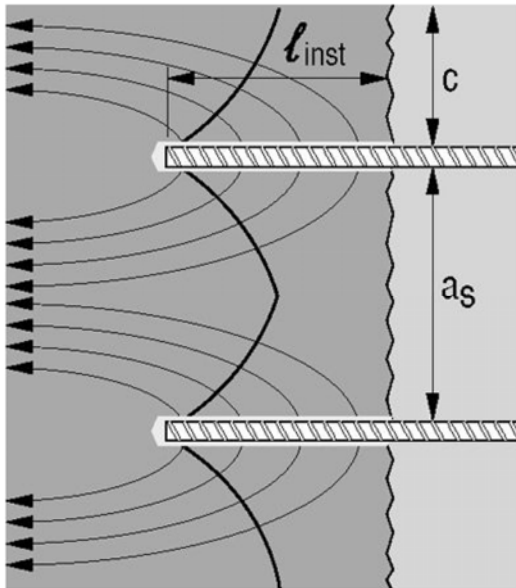


Ductile Failure Modes (Steel Bar Yielding)

- Load transfer like cast-in-place bars
- Spacing and edge distance are not decisive

Design

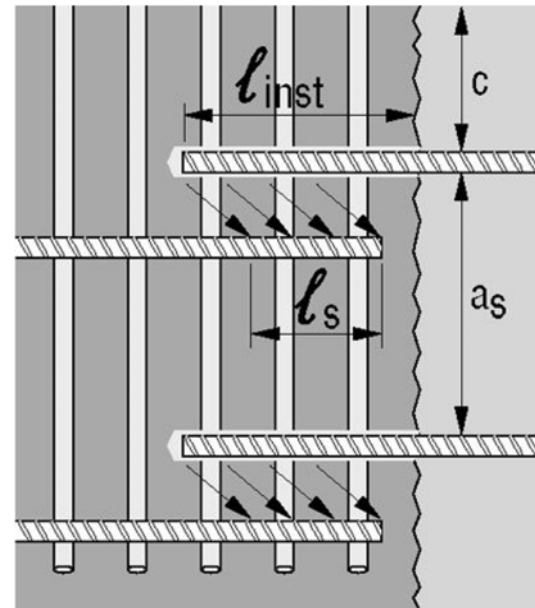
Anchoring Theory **vs.** Reinforced Concrete Theory



Anchor Theory

$l_{inst} = 4x \text{ to } 20x \text{ rod diameter}$

e.g: #6 bar 3" to 15"



Rebar Theory (assume $f'c = 4 \text{ ksi}$)

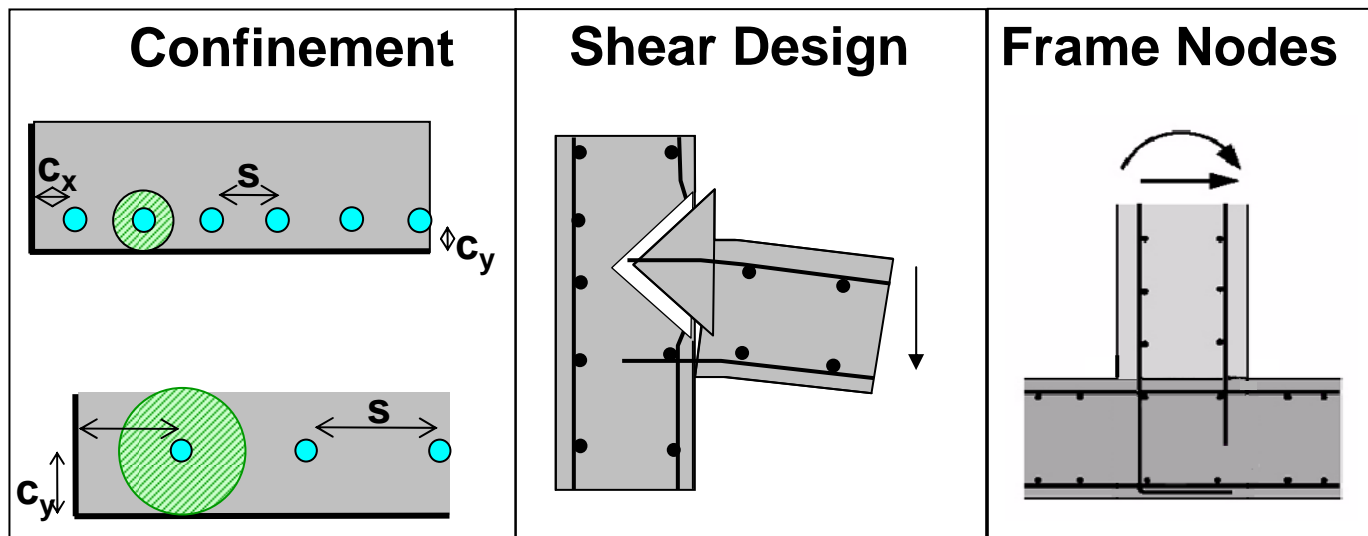
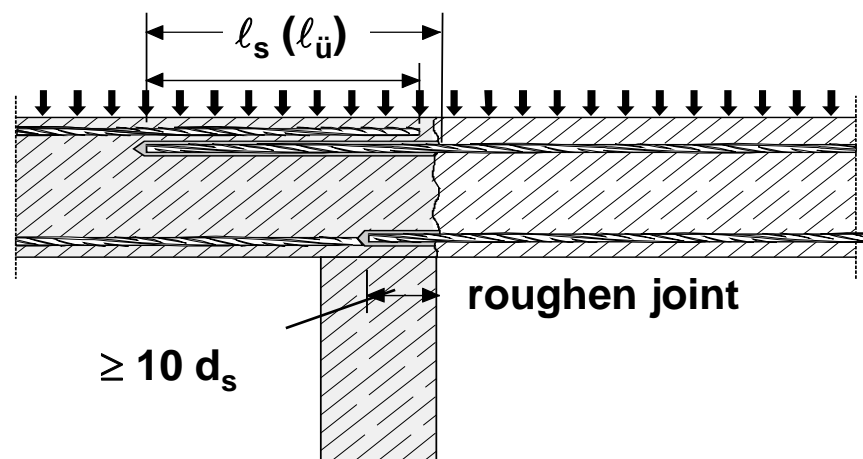
$l_{inst} = 28x \text{ to } 47x \text{ rod diameter}$

e.g: #6 bar 21" to 36"

Design

Design according to ACI
318-08, Chapter 12

Connections the same as
with cast-in straight bars



Design

Rebar Development ACI 318 Equation 12-1

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

Let's find out what bond stress ACI 318 Chapter 12 using?

Design

What bond stresses is ACI 318 Chapter 12 using?

1. Set bond strength equation equal to steel yield strength

$$l_d d_b \pi \tau_{\text{bond}} = f_y \pi \frac{d_b}{4}$$

2. Solve for development length

$$l_d = \frac{f_y d_b}{4 \tau_{\text{bond}}}$$

3. Substitute l_d into ACI 318 eq 12-1

$$\frac{f_y d_b}{4 \tau_{\text{bond}}} = \left(\frac{3}{40} \frac{f_y}{\sqrt{f'_c}} \frac{\psi_t \psi_e \psi_s \lambda}{\left(\frac{c_b + K_{tr}}{d_b} \right)} \right) d_b$$

Design

What bond stresses is ACI 318 Chapter 12 using?

4. Solve for τ_{bond}

$$\tau_{\text{bond}} = \frac{10}{3} \sqrt{f'_c} \left(\frac{c_b + K_{tr}}{d_b} \right) \frac{1}{\psi_t \psi_e \psi_s}$$

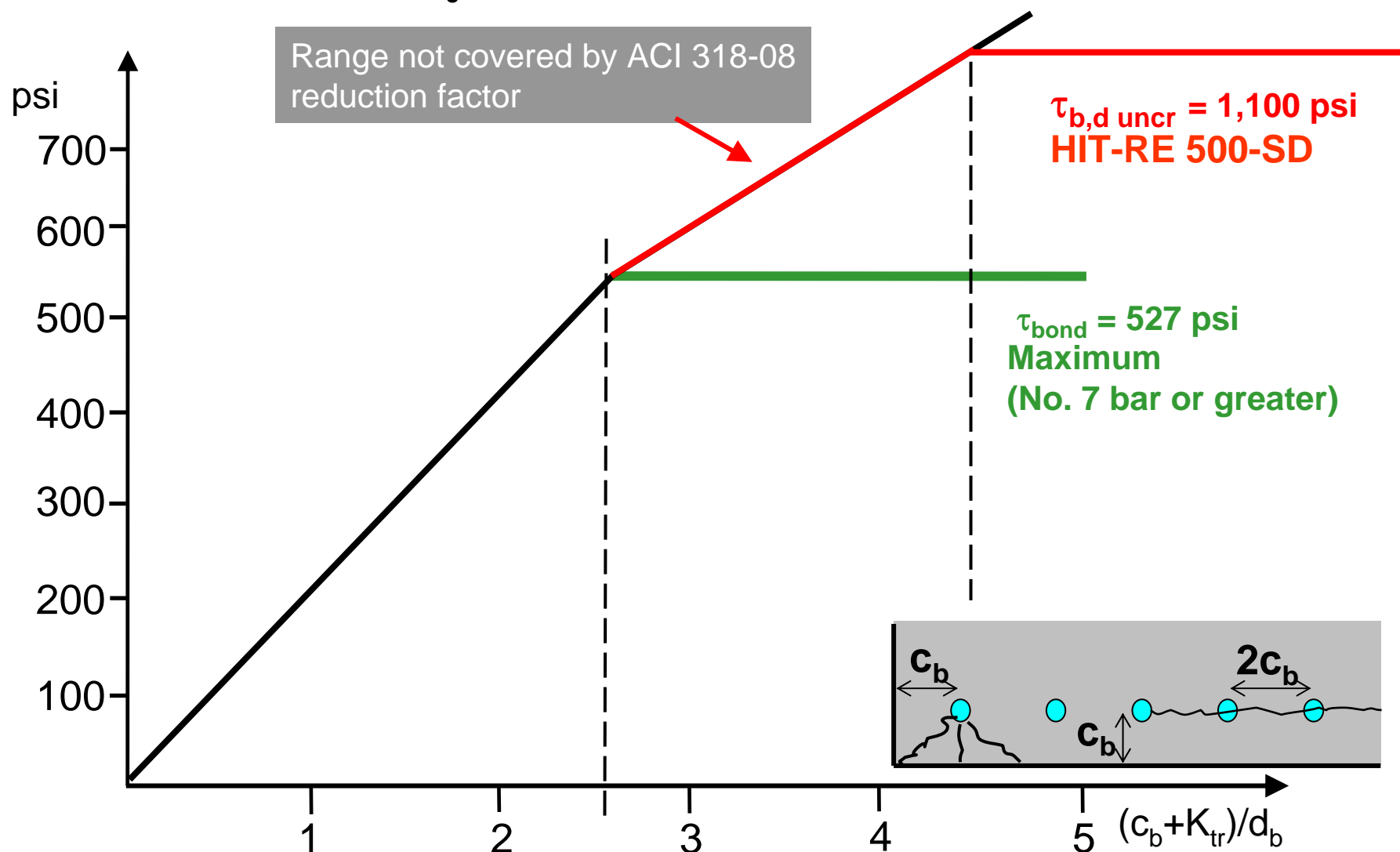
*Definition of bond stress
according to ACI 318-08,
Chapter 12, Eq 12-1*

5. Assume 4,000 psi Normal Weight Concrete and a #7 or bigger

$$\tau_{\text{bond}} = \frac{10}{3} \sqrt{4,000} \frac{2.5}{1 \times 1 \times 1} = 527 \text{ psi}$$

Design

Uncracked concrete, $f'_c = 4000$ psi



Design

Cracked concrete, $f'_c = 4000$ psi

