

METU Civil Engineering Department	CE 224 Mechanics of Materials Summer 2014	Quiz #4
Name: SOLUTION	Signature:	Time: 30 mins

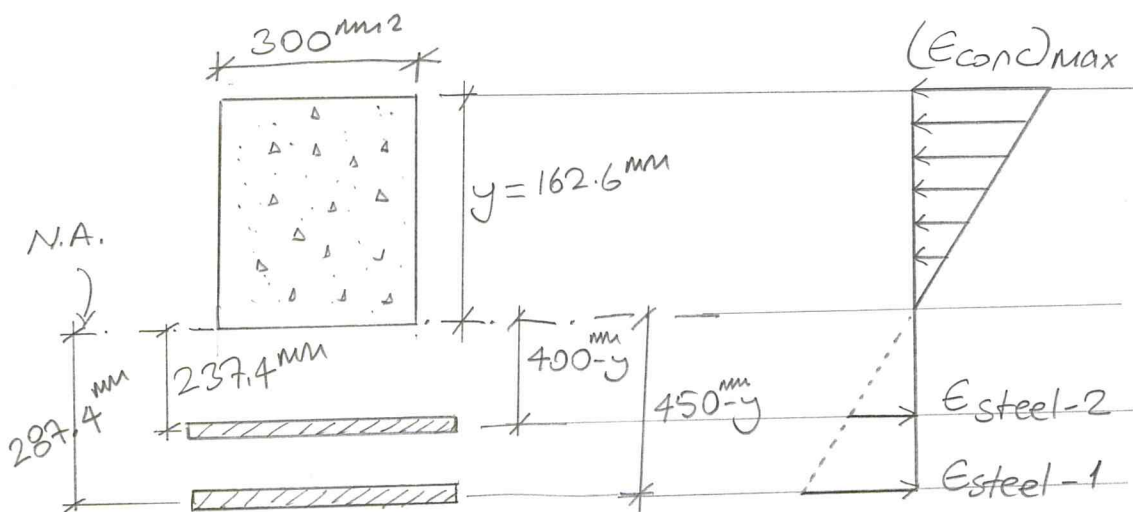
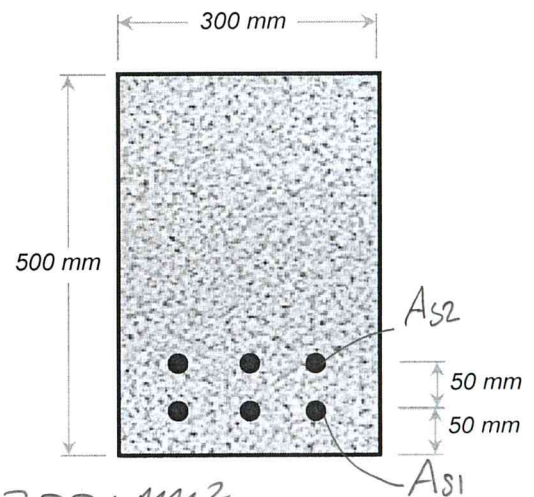
A concrete cross section reinforced with six 20 mm diameter steel reinforcing bars as shown is subjected to a positive bending moment of 200 kN-m. Determine the stress in each layer of steel reinforcing bars and the maximum stress in concrete. Assume that concrete takes no tensile stress.

$$E_{\text{concrete}} = 25 \text{ GPa} \quad E_{\text{steel}} = 200 \text{ GPa}$$

Please show all your calculations clearly!

$$A_{s1} = A_{s2} = 3 \left(\frac{\pi \times 20^2}{4} \right) = 942 \text{ mm}^2$$

$$(A_{s1})_{tr} = (A_{s2})_{tr} = 942 \text{ mm}^2 \times \frac{200 \text{ GPa}}{25 \text{ GPa}} = 7536 \text{ mm}^2$$



$$(300 \times y \times y/2) - (7536)(400 - y) - (7536)(450 - y) = 0$$

$$y^2 + 100y - 42700 = 0 \Rightarrow y = 162.6 \text{ mm}$$

$$I_{tr} = \frac{1}{3} \times 300 \times 162.6^3 + 7536 \times 237.4^2 + 7536 \times 287.4^2 = 1.48 \times 10^9 \text{ mm}^4$$

$$\sigma_{\text{conc-max}} = \frac{(200 \times 10^6)(162.6)}{1.48 \times 10^9} = \underline{\underline{22.0 \text{ MPa (comp.)}}} (\Rightarrow F = 537 \text{ kN})$$

$$\sigma_{st-2} = \frac{(200 \times 10^6)(237.4)}{1.48 \times 10^9} \times \frac{200}{25} = \underline{\underline{256.6 \text{ MPa (Tens)}}} (\Rightarrow F = 243 \text{ kN})$$

$$\sigma_{st-1} = \frac{(200 \times 10^6)(287.4)}{1.48 \times 10^9} \times \frac{200}{25} = \underline{\underline{310.7 \text{ MPa (Tens)}}} (\Rightarrow F = 294 \text{ kN})$$