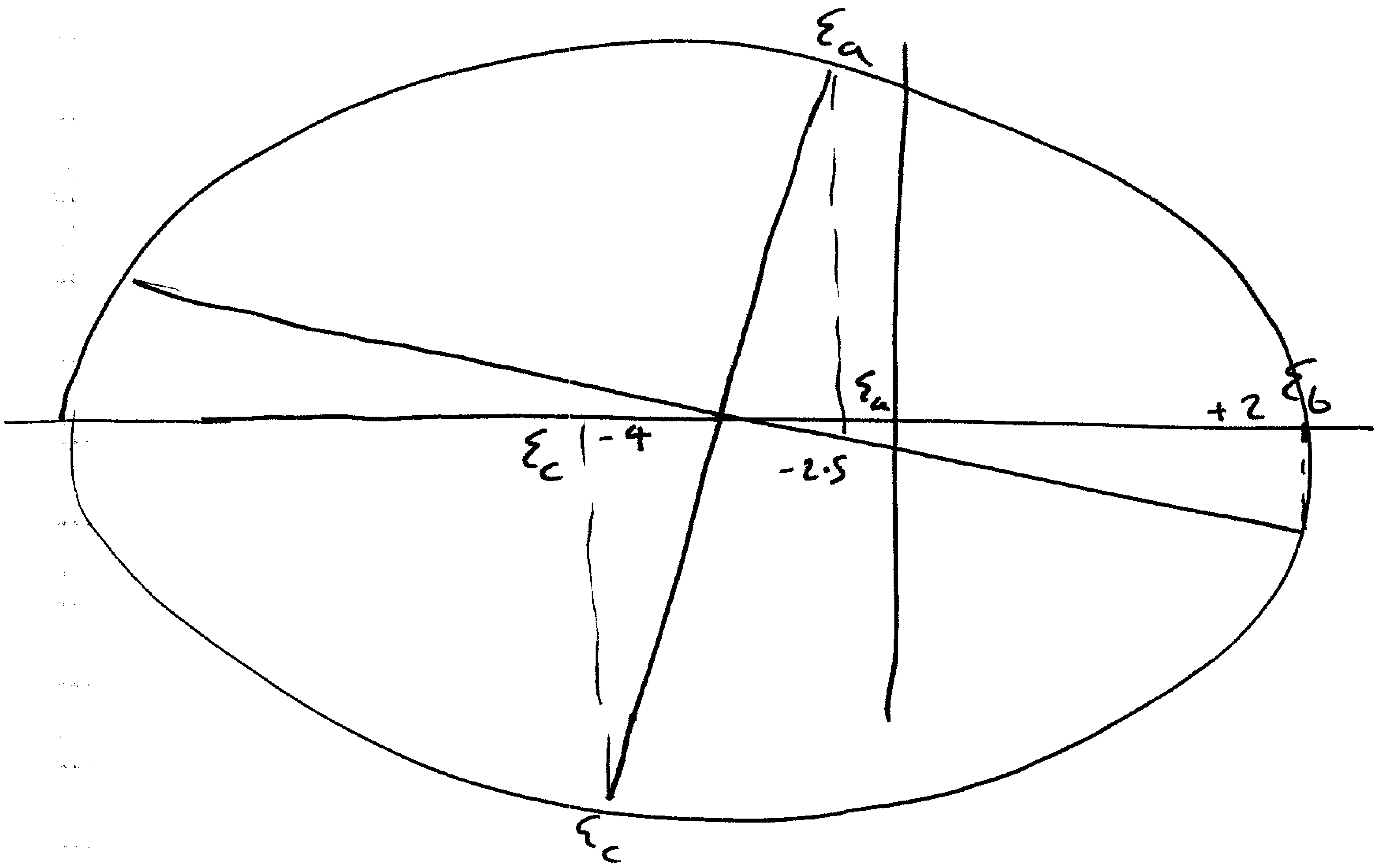
M20 45° Rosette $\varepsilon_a = -2.5\ m\varepsilon = 2500\ \mu\varepsilon$

$\varepsilon_b = +2.0\ m\varepsilon = 2000\ \mu\varepsilon$

$\varepsilon_c = -4.0\ m\varepsilon = 4000\ \mu\varepsilon$



Center of circle @ $-3.25\ m\varepsilon$

Radius $= \sqrt{(2-(-3.25))^2 + (3.25-2.5)^2} = 5.3\ m\varepsilon$

Principal Strains $= -3.25\ m\varepsilon \pm 5.3\ m\varepsilon$

$\varepsilon_I = +2053\ \mu\varepsilon$ $\quad \varepsilon_{II} = -8553\ \mu\varepsilon$

a) State of Strain

$\varepsilon_{11} = \varepsilon_a = -2500\ \mu\varepsilon$, $\varepsilon_c = \varepsilon_{22} = -4000\ \mu\varepsilon$, $\varepsilon_{12} = \frac{1}{2}(20-(-32.5))$
$= 2625\ \mu\varepsilon$

$\varepsilon_{\tilde{1}\tilde{1}} = \varepsilon_b = +2000\ \mu\varepsilon$, $\varepsilon_{\tilde{2}\tilde{2}} = -32.5-(52.5) = -8500\ \mu\varepsilon$, $\varepsilon_{\tilde{1}\tilde{2}} = \frac{1}{2}(7.5)$
$= 3750\ \mu\varepsilon$

From elasticity — Plane stress

$$\varepsilon_{11} = \frac{\sigma_{11}}{E} - \frac{\nu\sigma_{22}}{E} - \frac{\nu\sigma_{33}}{E} \quad (\sigma_{33}=0) \qquad (1)$$

$$\varepsilon_{22} = -\frac{\nu\sigma_{11}}{E} + \frac{\sigma_{22}}{E} - \frac{\nu\sigma_{33}}{E} = 0 \qquad (2)$$

Multiply through by (1) ~~and~~ by ν add to (2)

$$\nu\varepsilon_{11} + \varepsilon_{22} = \frac{\sigma_{22}}{E}(1-\nu^2)$$

$$\sigma_{22} = \frac{E(\nu\varepsilon_{11}+\varepsilon_{22})}{(1-\nu^2)} = \frac{70\times10^9(0.33\times(-2500)+(-4000))\times10^{-6}}{(1-(0.33)^2)}$$

$\sigma_c = \sigma_{22} = -380$ MPa $\Leftarrow$

$\sigma_a = \sigma_{11} = -300$ MPa $\Leftarrow$ $\left(\dfrac{E(\nu\varepsilon_{22}+\varepsilon_{11})}{(1-\nu^2)}\right)$

Similarly for $\sigma_b = \sigma_{\tilde{11}} = \dfrac{E(\nu\varepsilon_{\tilde{22}} + \varepsilon_{\tilde{11}})}{(1-\nu^2)} = -63$ MPa $\Leftarrow$

Principal stresses from principal strains

$$\sigma_I = \frac{E(\varepsilon_I + \nu\varepsilon_{II})}{(1-\nu^2)} = -60.4 \text{ MPa} \Leftarrow$$

$$\sigma_{II} = \frac{E(\varepsilon_{II} + \nu\varepsilon_I)}{(1-\nu^2)} = -618.7 \text{ MPa} \Leftarrow$$

$\sigma_{III} = 0$