6.21 Composite Sheet: 50% by volume Carbon fibres Epoxy matrix. Describe how mode of failure will vary with $\theta$ (loading angle)

take $\underline{\sigma_2^* = 40\,MPa}$ $\underline{\tau_{12}^* = 70\,MPa}$

$\sigma_f^* = 3.2\,GPa$ $\sigma_m^* = 0.060\,GPa$

$E_f = 230\,GPa$ $E_m = 2.4\,GPa$

$$\varepsilon_f^* = \frac{\sigma_f^*}{E} = \frac{3.2}{230} = 0.01391$$

$$\varepsilon_m^* = \frac{\sigma_m^*}{E} = \frac{60}{2400} = 0.025$$

↑ smaller ⇒ fibre brittle

$$\sigma_m' = E_m \varepsilon_f^* = (2400)(0.01391) = 33.38\,MPa$$

Stress $\sigma_1 = \phi_f \sigma_f^* + \phi_m \sigma_m'$

$= (0.5)(3200) + (0.5)(33.38)$

$= 1617\,MPa$

matrix alone $(1-\phi_f)(\sigma_m^*) = (0.5)(60) = 30\,MPa$

$30 << 1617$ ∴ $\sigma_1^* = 1617\,MPa$.

small $\theta$ $\sigma_\theta^* = 1617/\cos^2\theta$ failure along the fibre

transition shear // fibres $\frac{\sigma_1^*}{\cos^2\theta} = \frac{\tau_{12}^*}{\sin\theta\cos\theta} = \sigma_\theta^*$

$\tan\theta = \frac{\tau_{12}^*}{\sigma_1^*} = \frac{70}{1617} = 0.04329$; $\theta = 2.48°$