Chapter 5
Short answer question

Here are some data relevant to the strength of materials.

Material	**Density kg m^{-2}**	**Young modulus 10^9 N m^{-2}**	**Tensile strength 10^6 N m^{-2}**	**Compressive strength 10^6 N m^{-2}**
Steel	7700	200	250*	250*
Aluminium	2700	70	100*	100*
Wood	600	16 along grain	18 along grain	15 along grain
Glass reinforced plastic	1500	6	500	400
Concrete	2200	40	low	30

Tensile strength is the *tensile stress* at which the material breaks, or, in the case of values marked *, yields.

Compressive strength is the *compressive stress* at which the material fractures, is crushed, or, in the case of values marked *, yields.

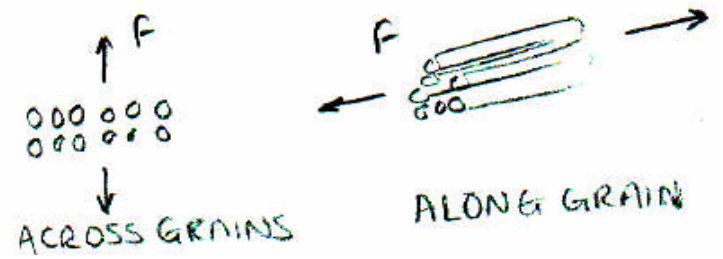
(a) Why is it appropriate to give the tensile strengths for steel and aluminium (but not for the other materials) as the stresses at which they *yield*?

Steel and aluminium are no longer useful when plastic deformation occurs, therefore consider yield stress.
Wood, GRP etc. are brittle therefore it is only necessary to consider stress at fracture.

(b) Would you expect the tensile strength of wood across the grain to be larger, smaller, or much the same as its tensile strength along the grain? Smaller.....

Explain why.

Straws model:



Much easier for cracks to propagate through material across grain where fibres separate rather than being broken as along grain.

(c) Explain why it is reasonable that the tensile and compressive strengths both have the same value for steel and aluminium, but not for wood and concrete.

Pure metals have a uniform structure. Tensile strength in steel and aluminium is a measure of the stress at which the crystal planes begin to slip.
Wood and concrete are composite materials and their properties will not be the same in each direction. In wood, strength depends upon the relative direction of the applied force and the fibrous nature of the material. Concrete is made from brittle components and under tension cracks can grow easily, but in compression any cracks are forced together.

(d) Calculate the cross-sectional area of a rod of aluminium which would just yield under tensile stress if it carried a load of 1 tonne (10^3 kg).

$$\text{Stress} = \frac{F}{A}$$

$$\therefore 100 \text{x} 10^6 = \frac{10^3 \text{x} 9.8}{A}$$

$$\therefore A \approx 1 \text{x} 10^{-4} \text{m}^2$$