Bend Testing

Tensile testing of materials

One important property of materials that we can measure is its tensile strength. That is the load (or more specifically, the stress) that the material can carry before it fractures.

The **stress** in a material is defined as the **Force (N)**(or **Load**) that is applied, divided by the **cross sectional area (m^2)** of the material. Stress therefore has units of **Newtons per square metre** $[\boldsymbol{N/m^2}]$ or **Pascal [Pa].** Stresses in materials are typically come out to be on the order of 1,000,000 Pa or greater, so we instead typically talk in terms of Megapascals [MPa] where 1 MPa = 1,000,000 Pa.

$$Stress\ [MPa] = \frac{Force\ [N]}{Cross\ Sectional\ Area\ [mm^2]}$$

Tensile testing is typically carried out in a tensile testing machine, or *tensometer*. You encountered one of these at the introduction day in London where we tested steel and polyethylene samples.

The *yield stress* of a material is defined as the stress at which the material permanently deforms. Materials which take a greater force to permanently deform them will have a higher yield stress.

$$Yield\ Stress\ [MPa] = \frac{Force\ to\ permanently\ deform\ material\ [N]}{cross\ sectional\ area\ [mm^2]}$$

The *tensile strength* of a material is defined as the stress at which the material fails or cracks. Materials which take a greater force to break them will have a higher tensile strength.

$$Tensile\ strength\ [MPa] = \frac{Force\ at\ failure\ [N]}{Cross\ sectional\ area\ [mm^2]}$$

Why bend testing?

Tensile testing requires specialised equipment and therefore is not easily performed in a classroom environment. Bend testing allows a rough measurement of the tensile strength of a material to be measured without this equipment.

The specimen is clamped to the edge of the table, and slotted masses are hanged off the free end. Masses are added until the material either permanently deforms (yields) or fails.

The stress in the material can be related to the applied force:

$$stress\ [MPa] = \frac{6 \times Length\ [mm] \times Mass\ added\ [g] \times 9.81}{Width\ [mm] \times Height\ [mm] \times Height[mm]}$$

The overhanging part of our samples are 100mm long, 30mm wide and 1mm high so:

$$stress\ [MPa] = \frac{6 \times 100 \times Mass\ added\ [g] \times 9.81}{30 \times 1 \times 1}$$

$$\boldsymbol{stress\ [MPa] = 196.2 \times Mass\ added\ [g]}$$

Instructions for your experiment

You will need

Material samples (150mm x 30mm x 1mm) with a hole drilled in one end to attach the masses (provided)

100g slotted masses with hooked holder

1x G clamp

Safety glasses

Cardboard box/tray

Set up

Clamp the material to the table with the G-clamp such that 150 mm is overhanging.

Position a box (or something similar) below the sample to catch the masses in case they fall.

Safety

Wear safety glasses throughout the duration of the experiment. Place a box underneath the slotted masses to catch them when the sample breaks. Stand throughout the experiment to avoid injury.

Yield stress measurement

Set up the experiment as shown above. Load the slotted masses one at a time, starting with the hooked holder. After a mass has been added, remove the total load to check for permanent deformation. Record the mass at which this deformation occurs.

Tensile strength measurement

Once permanent deformation occurs and the mass has been recorded, continue to add slotted masses until the sample breaks. There is no need to continue unloading after each mass is added.

Analysis of your results

Which material has the highest yield stress? Which has the lowest?

Why might the strength measured by bend testing differ from that measured in conventional tensile testing?

Have a look online for the tensile strength of some of your materials. Are the values you have measured similar to those which you find online?

If they are different, why do you think that is?

Do all of the materials break in the same place? If yes, why is this? If not, why not?

How could you improve your experiment?

How might these measurements help you select materials for designing armour? Which property (yield stress or tensile strength) is the most relevant/important?

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Results Table

Material	Yield Load (g)	Load at failure (g)	Yield Stress (MPa)	UTS (MPa)