4.2 Stress-strain and elastic behaviour

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS engineering stress • true stress • Young's modulus

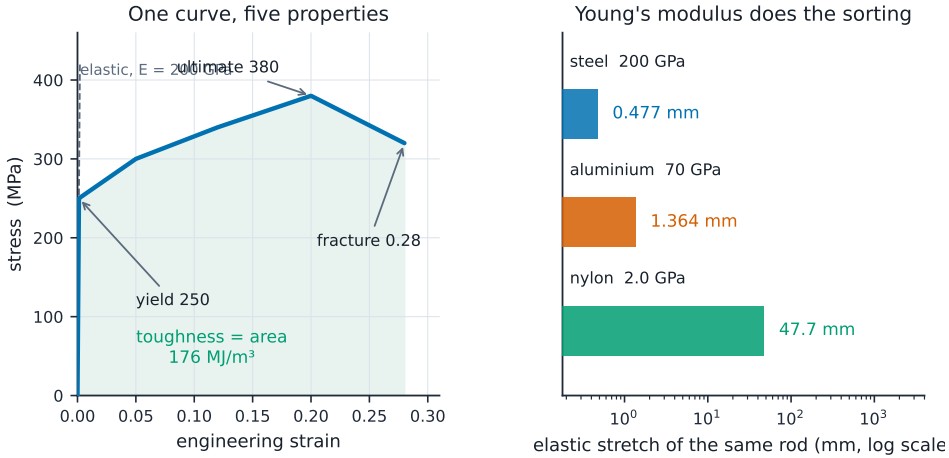
Objective

Read stiffness and strength off a tensile test: stress, elastic deflection by Hooke's law, and the true/engineering conversion.

1 Key knowledge and worked examples

■ The certificate

$\sigma = F/A_0$; elastic $\varepsilon = \sigma/E$, $\delta = \varepsilon L$; true: $\varepsilon_t = \ln(1+e)$, $\sigma_t = \sigma(1+e)$. E: 200 / 70 / 2.0 GPa.



*Young's modulus does the sorting

■ Worked example. The rod test

10.0 mm rod at 15.0 kN: $\sigma = 191.0$ MPa; steel stretches 0.477 mm, aluminium 1.364 mm - deflections scale as $1/E$ ✓.

2 Practice

A 12.0 mm steel rod, 1.20 m long, carries 20.0 kN in tension.

2.1 The cross-sectional area (four significant figures, mm^2) and the engineering stress (one decimal, MPa). [4]

2.2 The elastic extension in steel and in aluminium (three decimals, mm), with the modulus ratio stated. [4]

2.3 At an engineering strain of 0.15: the true strain (four decimals) and true stress as a multiple of engineering stress. [3]

2.4 One sentence each: what does the 0.2% offset convention fix, and why must ductility percentages quote a gauge length? [3]

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Solutions

2.1

- $A_0 = \pi(6.0)^2 = 113.1$ mm^2.
- $\sigma = 20{,}000/113.1 \times 10^{-6} \cdot 10^{6} = 176.8$ MPa.

2.2

- Steel: $\varepsilon = 176.8/200{,}000 = 8.84 \times 10^{-4}$, $\delta = 1.061$ mm.
- Aluminium: $\delta = 1.061 \times 200/70 = 3.032$ mm.

2.3

- $\varepsilon_t = \ln 1.15 = 0.1398$.
- $\sigma_t = 1.15\sigma$.

2.4

- The offset line defines where plastic flow counts as begun, removing judgement from the yield read.
- Necking localises strain, so the percentage depends on the length over which it is averaged.

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