Engineering Materials

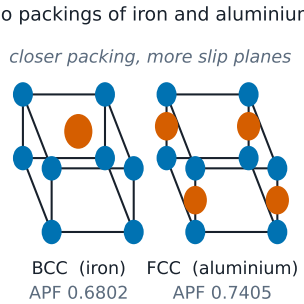
Curated undergraduate study track (not accredited, no external exam). Original explanations and practice only, following the reviewed course handout.

What the mount is made of

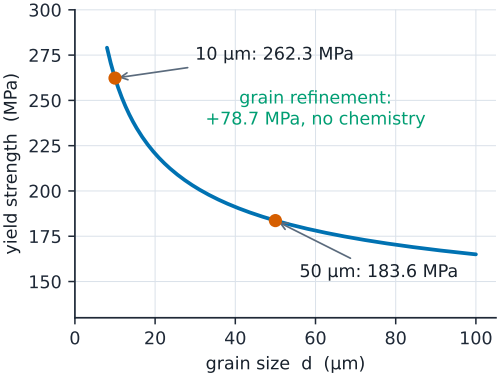
- Course 3 asked what the mount does; this course asks what it is made of - four candidates: low-carbon steel, aluminium 6061, cast nylon 6, carbon-epoxy laminate.
- The habit - **every property traced to structure, every choice shown with its index arithmetic**.

Structure and bonding: packing and blocking

Two packings of iron and aluminium



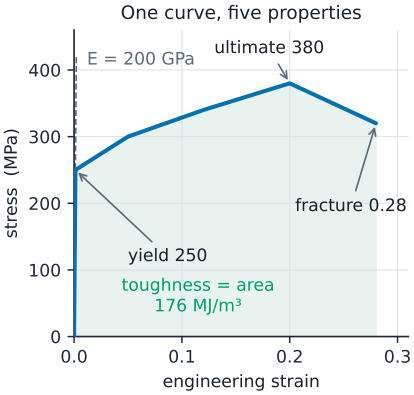
Hall-Petch: boundaries block dislocations

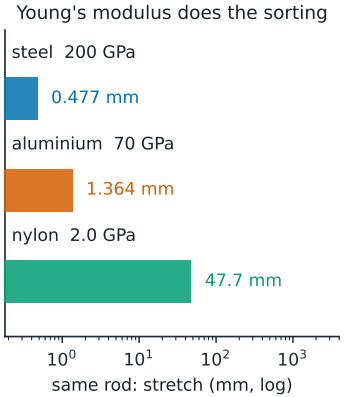


FCC packs **0.7405** against BCC **0.6802**; finer grains add **78.7** MPa.

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Stress-strain: the certificate convention



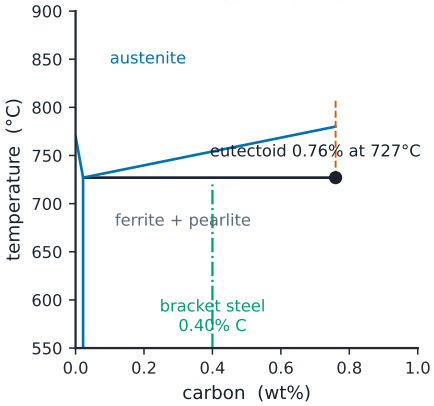


191.0 MPa is elastic in steel: the rod stretches 0.477 mm, aluminium 1.364 mm.

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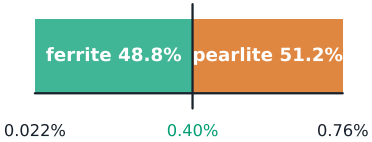
Metals and alloys: the state ships

The eutectoid corner



Just below 727°C: the tie-line weighed

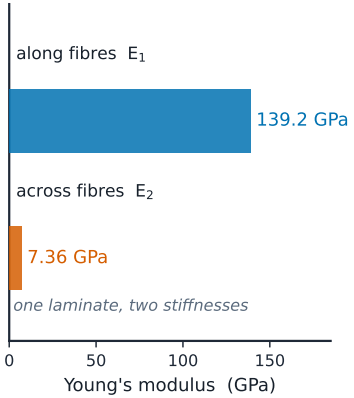
lever rule: $(0.40 - 0.022)/(0.76 - 0.022)$
$= 0.512$ pearlite



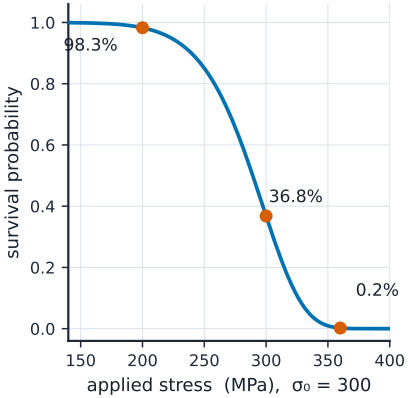
Just below 727°C the 0.40% steel is **0.512 pearlite** and **0.488** ferrite.

Polymers, ceramics and composites: the catches

Carbon-epoxy, $V_f = 0.60$: 18.9× anisotropy



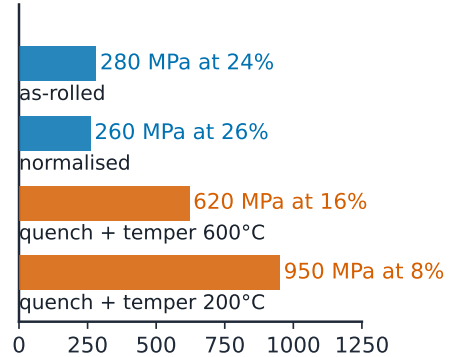
Ceramic strength is statistics (m = 10)



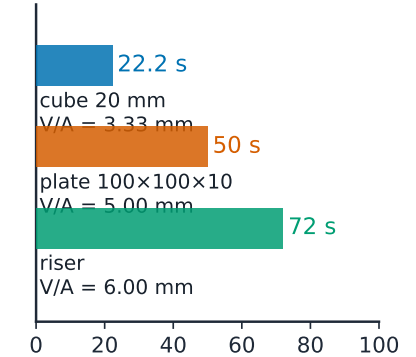
Carbon-epoxy is **18.9×** stiffer along the fibres; ceramics fail by statistics.

Processing: the furnace writes the datasheet

Same steel, four datasheets



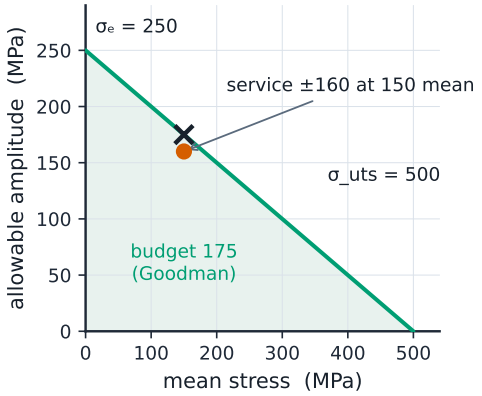
Chvorinov: volume per surface



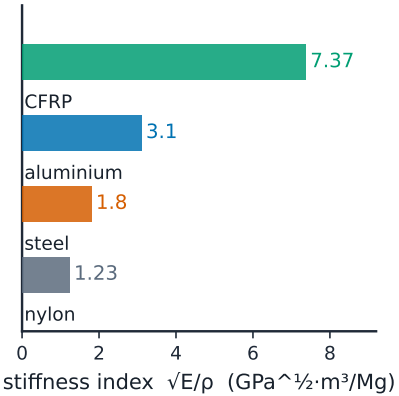
One steel, four routes: 280 to 950 MPa as elongation falls from 26% to 8%.

Failure and selection: show the arithmetic

Goodman: the mean eats the budget



The index ranks; constraints eliminate



Goodman cuts 250 to **175** MPa at 150 mean; CFRP leads the stiffness index.

Selection in action: one method, two answers

1. **Rank** $\sqrt{E}/\rho$: CFRP 7.37 wins stiffness-per-mass at 2.4× aluminium.
2. **Eliminate** Plain nylon fails the T_g constraint; ceramics fail the survival probability at these loads.
3. **Split** The mount ships quenched-and-tempered steel (620 MPa, 16%); the carry-handle ships CFRP.

The project sheet, reproducible

1. **Structure** BCC 0.6802, FCC 0.7405; Hall-Petch 183.6 $\rightarrow$ 262.3 MPa for 50 $\rightarrow$ 10 µm.
2. **Certificate** Rod 191.0 MPa: 0.477 vs 1.364 mm; true ln 1.2 $= 0.1823$; **toughness** 176 MJ/m^3.
3. **Choice** Routes 280/24, 260/26, 620/16, 950/8; Chvorinov 22.2 vs 50.0 s; Basquin 226.1 $\rightarrow$ 142.6; Goodman 175.0; index 7.37 / 3.10 / 1.80 / 1.23 - steel mount, CFRP handle.

Check yourself

- The packings and the refinement? (0.6802 / 0.7405; 183.6 $\rightarrow$ 262.3 MPa.)
- The certificate pair and the area? (0.477 vs 1.364 mm; 176 MJ/m^3.)
- The tie-line and the routes? (51.2% **pearlite**; 280/24 $\rightarrow$ 950/8.)
- The two stiffnesses and the budget? (139.2 vs 7.36 GPa; Goodman 175.0 MPa.)