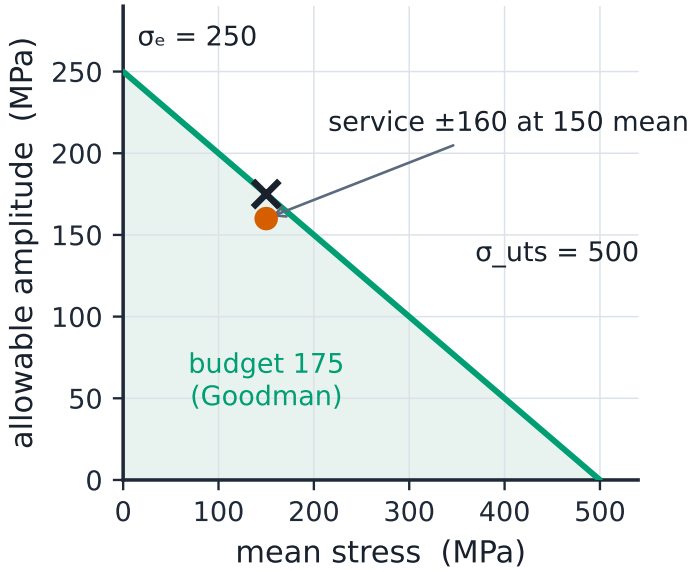
Exercise walk-through

4.3 Metals and alloys

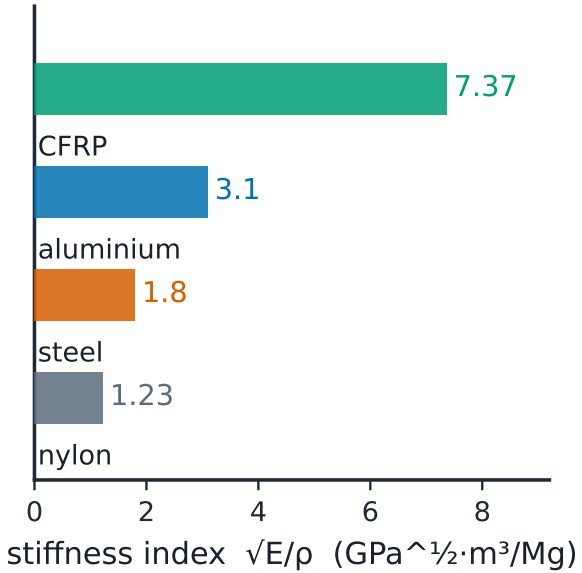
University Mechanical Engineering

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.

Exercises 2.1·2.2

2.1 For a 0.60 wt% C steel just below 727°C: the pearlite and ferrite fractions (four decimals). [4]

2.2 A copper alloy has $K = 600$ MPa and $n = 0.25$: the true stress at a true strain of 0.16 (one decimal). [3]

Exercises 2.1·2.2

2.1 For a 0.60 wt% C steel just below 727°C: the pearlite and ferrite fractions (four decimals). [4]

2.1

- Pearlite $= (0.60 - 0.022)/(0.76 - 0.022) = 0.7832$.
- Ferrite $= 1 - 0.7832 = 0.2168$.

2.2 A copper alloy has $K = 600$ MPa and $n = 0.25$: the true stress at a true strain of 0.16 (one decimal). [3]

2.2

- $\sigma = 600 \times 0.16^{0.25} = 379.5$ MPa.

Exercises 2.3·2.4

2.3 State the phases and their carbon contents at the eutectoid point, and name the product of a fast quench from the austenite field. [4]

2.4 One sentence each: why can the same grade ship at two yield strengths, and why is martensite tempered before service? [3]

Exercises 2.3·2.4

2.3 State the phases and their carbon contents at the eutectoid point, and name the product of a fast quench from the austenite field. [4]

2.3

- Austenite (0.76% C) decomposes to ferrite (0.022%) + cementite (6.67%) as lamellar pearlite at 727°C.
- A fast quench gives martensite.

2.4 One sentence each: why can the same grade ship at two yield strengths, and why is martensite tempered before service? [3]

2.4

- The processing state - cold work or heat treatment - sets the properties; the grade only fixes the chemistry.
- Untempered martensite is hard but brittle; tempering restores toughness at some strength cost.