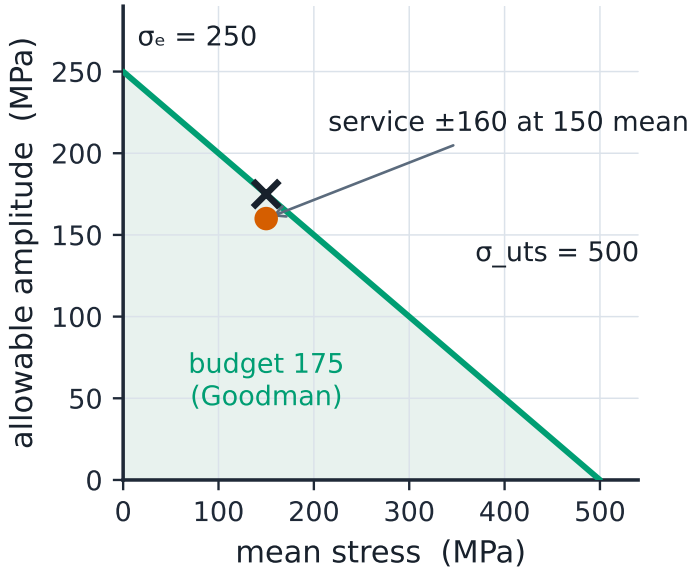
Exercise walk-through

4.6
Failure and material selection

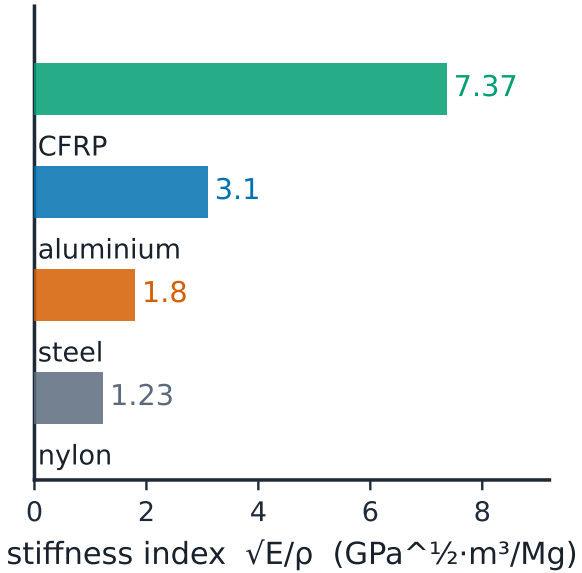
University Mechanical Engineering

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 2.1·2.3

2.1 The fatigue amplitude at 10^5 and 10^7 reversals (one decimal each). [4]

2.2 With $\sigma_e = 200$ MPa and $\sigma_{uts} = 400$ MPa: the allowable amplitude at a mean stress of 120 MPa (one decimal). [3]

2.3 A corrosion rate of 0.08 mm/yr for a 20-season design life: the wall loss (one decimal, mm). [2]

Exercises 2.1·2.3

2.1 The fatigue amplitude at 10^5 and 10^7 reversals (one decimal each). [4]

2.1

- $\sigma_a(10^5) = 800 \times 10^{-0.6} = 201.0$ MPa.
- $\sigma_a(10^7) = 800 \times 10^{-0.84} = 115.6$ MPa.

2.2 With $\sigma_e = 200$ MPa and $\sigma_{uts} = 400$ MPa: the allowable amplitude at a mean stress of 120 MPa (one decimal). [3]

2.2

- $\sigma_a = 200(1 - 120/400) = 140.0$ MPa.

2.3 A corrosion rate of 0.08 mm/yr for a 20-season design life: the wall loss (one decimal, mm). [2]

2.3

- $0.08 \times 20 = 1.6$ mm.

Exercises 2.4·2.5

2.4 The stiffness index $\sqrt{E}/\rho$ of titanium ($E = 110$ GPa, $\rho = 4.5$ Mg/m^3) against steel's 1.80 (two decimals), and one sentence on what the comparison does and does not decide. [4]

2.5 True or false with one line of reason: a component loaded well below yield cannot fail by fatigue. [2]

Exercises 2.4·2.5

2.4 The stiffness index $\sqrt{E}/\rho$ of titanium ($E = 110$ GPa, $\rho = 4.5$ Mg/m^3) against steel's 1.80 (two decimals), and one sentence on what the comparison does and does not decide. [4]

2.4

- Titanium: $\sqrt{110}/4.5 = 2.33$ vs steel 1.80 - 29% better per unit mass in bending stiffness.
- It ranks stiffness-per-mass only: cost, corrosion and the impact budget are constraints decided separately.

2.5 True or false with one line of reason: a component loaded well below yield cannot fail by fatigue. [2]

2.5

- False: fatigue crack growth occurs at amplitudes far below yield - that is its defining danger.