4.6 Failure and material selection

Name: _____ Class: _____ Date: _____ **Total: 15 marks**

KEY WORDS fatigue • material index

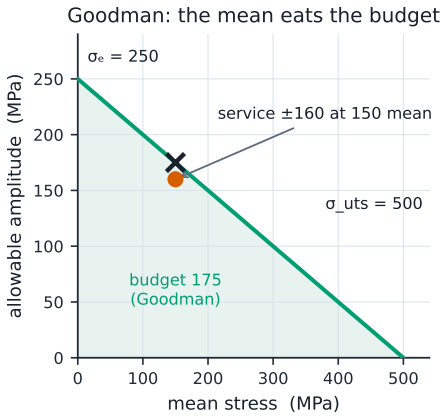
Objective

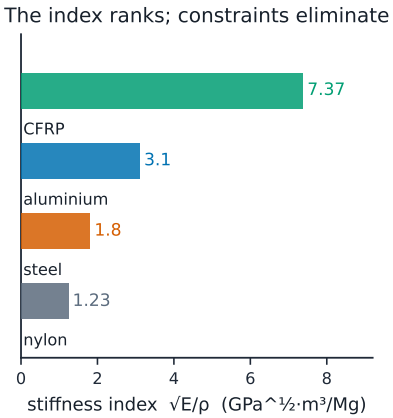
Close the failure file: Basquin amplitudes, the Goodman cut for mean stress, the corrosion budget, and one material index.

1 Key knowledge and worked examples

■ The three ledgers

Basquin $\sigma_a = \sigma'_f(2N)^b$; Goodman $\sigma_a/\sigma_e + \sigma_m/\sigma_{uts} = 1$; corrosion mm/yr; index $\sqrt{E}/\rho$.





*Fatigue prices the cycles; the index ranks

■ Worked example. The bracket

$\sigma'_f = 900$, $b = -0.10$: 226.1 MPa at 10^6, 142.6 at 10^8; Goodman cuts 250 to 175.0 at 150 mean ✓; 0.12 mm/yr × 25 = 3.0 mm ✓.

2 Practice

An aluminium part has $\sigma'_f = 800$ MPa, $b = -0.12$.

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]

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]

Solutions

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

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

2.3

- $0.08 \times 20 = 1.6$ mm.

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

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

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