Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

A ductile (neck, cup and cone); B brittle (flat, chevrons point to the origin); C fatigue (beach marks from the origin); D intergranular corrosion (attack along the grain boundaries)

2.2

damage so far $= \dfrac{4.0 \times 10^4}{10^5} + \dfrac{3.0 \times 10^5}{10^6} = 0.70$; left $0.30 \times 10^5 = \mathbf{3.0 \times 10^4}$ **cycles**

2.3

$E^{1/2}/\rho$: Al 3.1, steel 1.8, CFRP 6.6, wood 5.8; order: **CFRP > wood > Al > steel**

2.4

steel is the anode and corrodes; the **steel bolt in copper** is worse: a small anode next to a large cathode is attacked fast, and the joint fails

3.1

$\sigma_m = 150$ MPa, $\sigma_a = 200$ MPa; $\dfrac{1}{n} = \dfrac{200}{380} + \dfrac{150}{900} = 0.693$, $n = \mathbf{1.44}$

$1.44 < 1.5$: **not acceptable**; need $\dfrac{200}{S_e} = 0.667 - 0.167$, $S_e \geq \mathbf{400\ MPa}$, for example by shot peening

3.2

objective $m = AL\rho$; constraint $\dfrac{F}{A} \leq \sigma_f$, so $A = \dfrac{F}{\sigma_f}$; $m = FL\dfrac{\rho}{\sigma_f}$: maximise $\sigma_\mathbf{f}/\rho$

steel 45, Al 111, CFRP 375, Ti 200; **CFRP > Ti > Al > steel**

3.3

(a) $\sigma = \dfrac{10 \times 200}{10} = \mathbf{200\ MPa}$; A: 4.5, B: 2.0

(b) A: $a_c = \dfrac{1}{\pi}\left(\dfrac{30}{200}\right)^2 = \mathbf{7.2\ mm} < 10$ mm; B: **51 mm** > 10 mm: only B leaks before it breaks

(c) choose B; in A a crack bursts the vessel before it is through the wall, with no warning; the strength margin of A does not help, because failure is set by toughness, not by yield

exercises.lol exercises.com.cn