Imperial College London

Year 1

AERO40005 - Materials 1

PROGRESS TEST n. 2 of 2

To solve in 27 minutes

81%

Section A

Question 1

IMPORTANT INFORMATION:

- *Please submit a clear summary of all your answers to Question 1 as the first page of your exam script.*
- *For multiple choice questions you are required to submit your full written solution along with your chosen answer. Failure to do so, or submission of a wrong solution, will result in a mark of 0. The markers will check your procedure only for questions answered correctly.*
- *For the true or false questionnaire you are not required to justify your answers. Note however that wrong answers will result in a negative mark, as detailed below.*

Part (a)

A metallic plate is subject, in service, to a uniaxial tensile stress $\sigma = 100\,\text{MPa}$. A small central crack of length $2a = 4\,\text{mm}$ is discovered in the plate after an inspection. Assuming $Y = 1$ and knowing that the material has modulus $E = 100\,\text{GPa}$, determine the minimum fracture energy G_{Ic} that the material should have to remain in operation, and state if this should be

A. $G_{Ic} = 124.3\ \text{J/m}^2$

(B) $G_{Ic} = 628.3\ \text{J/m}^2$

C. $G_{Ic} = 124.3\ \text{kJ/m}^2$

D. None of the above.

$$G_{IC} = \frac{K_{IC}^2}{E} = \frac{(Y6\sqrt{\pi a})^2}{E}$$

$$= 200\pi\ \text{J/m}^2 = 628.3\ \text{J/m}^2$$

20 [20%]

Part (b)

A unidirectional composite is manufactured by mixing high performance fibres (of modulus $E_F = 100\,\text{GPa}$, density $\rho_F = 2000\ \text{kg/m}^3$ and tensile strength $\sigma_F = 1\,\text{GPa}$) with a polymer matrix ($E_M = 2\,\text{GPa}$, $\rho_M = 1500\ \text{kg/m}^3$), leading to a

material with 10% voids content and fibre volume fraction $\varphi_F = 0.4$. Calculate the specific stiffness in the fibre direction E_1 / ρ and state if this is

(A) $0.02645\ \text{GPa/(kg/m}^3\text{)}$

B. $0.1245\ \text{GPa/(kg/m}^3\text{)}$.

C. $0.8657\ \text{GPa/(kg/m}^3\text{)}$

D. None of the above.

$\varphi_M = 1 - \varphi_F - 0.1 = 0.5$

$E_1 = \varphi_M E_M + \varphi_F E_F = 41\ \text{GPa}$

$\rho = \varphi_M \rho_M + \varphi_F \rho_F = 1550\ \text{kg/m}^3$

$\therefore \frac{E_1}{\rho} = 0.02645\ \text{GPa/(kg/m}^3\text{)}$

19 [19%]

Estimate the tensile ductility of this material in the fibre direction, assuming that failure occurs when the stress in the fibres attains the failure stress σ_F, and state if this ductility is

$\varepsilon = \frac{\sigma}{E} = 0.01$

A. $\varepsilon_F = 0.004$

B. $\varepsilon_F = 0.008$

(C) $\varepsilon_F = 0.01$

D. None of the above.

19 [19%]

Part (c)

State if the following are true or false. You will receive 7 points for each correct answer, -7 points for each incorrect answer, 2 points for each unanswered question.

F i. Fracture toughness K_{Ic} is equal to twice the surface tension for brittle materials.

F ii. The degree of crystallinity of a polymer quantifies the average length of its molecular chains.

T iii. Creep deformation of a solid refers to an increase of strain in time while stresses are kept constant in time.

T iv. Ceramics may display ductile behaviour in presence of high hydrostatic compressive stresses.

F T v. Increasing the porosity of a solid material decreases its strength, stiffness and densification strain.

vi. The modulus of a composite with a continuous matrix and spherical filler particles is comprised between the predictions of inverse and direct rule-of-mixture expressions.

23 [42%]