

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 6

LEFEL 6

EXAMINATION PERIOD
MAY 2018

CYFNOD ARHOLIADAU
MAI 2018

MODULE CODE:
M6X01201: MATERIALS & MANUFACTURING FOR NICHE
MARKETS

TIME: 2 HOURS

ANSWER 3 FROM 4 QUESTIONS

Equipment or materials required – None

Adnoddau neu ddefnyddiau sydd eu hangen – Dim

A formula sheet is provided for reference.

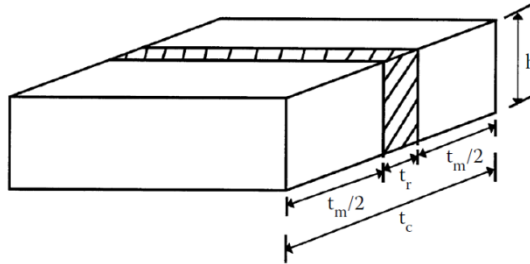
Calculators are permitted.

Assume 'g' = 9.81 m/s².

ONE

- a) Composite materials are composed of two phases. Identify these, and discuss how the primary phase can be used to classify composites. Discuss the different physical forms that the secondary phase can take.

[11 Marks]



The above Representative Volume Element represents a unidirectional composite.

- b) Given that $\Delta_c = \Delta_f + \Delta_m$, where Δ is the transverse extension of the structure when subjected to a transverse load, and the subscripts c, f and m represent the composite, the fibre and the matrix respectively, prove $\frac{1}{E_2} = \frac{V_f}{E_f} + \frac{V_m}{E_m}$ from first principles.

E represents the Young's Modulus, V is the volume fraction and the subscript 2 represents the transverse (or across fibre) direction.

[7 Marks]

- c) Hence find the transverse Young's Modulus of a Glass/Epoxy lamina with a fibre volume fraction of 75% given that $E_f = 90\text{GPa}$ and $E_m = 3\text{GPa}$

[2 Marks]

TWO

a) Given the following for a unidirectional material;

$$\begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \gamma_{12} \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} & 0 \\ S_{12} & S_{22} & 0 \\ 0 & 0 & S_{66} \end{bmatrix} \begin{bmatrix} \sigma_1 \\ \sigma_2 \\ \tau_{12} \end{bmatrix}$$

Prove that the compliance matrix in terms of the engineering constants is given by;

$$[S] = \begin{bmatrix} \frac{1}{E_1} & \frac{-\nu_{12}}{E_1} & 0 \\ \frac{-\nu_{12}}{E_1} & \frac{1}{E_2} & 0 \\ 0 & 0 & \frac{1}{G_{12}} \end{bmatrix}$$

[5 Marks]

b) Prove also that $S_{12} = -\frac{\nu_{12}}{E_1} = -\frac{\nu_{21}}{E_2}$

[3 Marks]

- c) Hence find the compliance matrix for an unidirectional Graphite/Epoxy lamina whose material properties are as follows;

$$\begin{aligned} E_1 &= 181 \text{ GPa} \\ E_2 &= 10.3 \text{ GPa} \\ \nu_{12} &= 0.28 \\ G_{12} &= 7.17 \text{ GPa} \end{aligned}$$

[3 Marks]

- d) For the material in c), what will the following strains be if $\sigma_1 = 2 \text{ MPa}$, $\sigma_2 = -3 \text{ MPa}$ and $\tau_{12} = 4 \text{ MPa}$;

- the strain in the 1 direction (ϵ_1)?
- the strain in the 2 direction (ϵ_2)?
- the shear strain (γ_{12}) be if

[5 Marks]

- e) In order to reduce the generalised compliance matrix for an isotropic material to that of a unidirectional composite, i.e. to reduce

$$\begin{bmatrix} \epsilon_1 \\ \epsilon_2 \\ \epsilon_3 \\ \gamma_{23} \\ \gamma_{31} \\ \gamma_{12} \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} & S_{15} & S_{16} \\ S_{12} & S_{22} & S_{23} & S_{24} & S_{25} & S_{26} \\ S_{13} & S_{23} & S_{33} & S_{34} & S_{35} & S_{36} \\ S_{14} & S_{24} & S_{34} & S_{44} & S_{45} & S_{46} \\ S_{15} & S_{25} & S_{35} & S_{45} & S_{55} & S_{56} \\ S_{16} & S_{26} & S_{36} & S_{46} & S_{56} & S_{66} \end{bmatrix} \begin{bmatrix} \sigma_1 \\ \sigma_2 \\ \sigma_3 \\ \tau_{23} \\ \tau_{31} \\ \tau_{12} \end{bmatrix} \text{ to } \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \\ \gamma_{12} \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} & 0 \\ S_{12} & S_{22} & 0 \\ 0 & 0 & S_{66} \end{bmatrix} \begin{bmatrix} \sigma_1 \\ \sigma_2 \\ \tau_{12} \end{bmatrix}$$

what assumptions must be made?

[4 Marks]

THREE

- a) Discuss why a typical composite structure manufactured from a FRP would have several lamina stacked on top of each other in order to form a laminate. [4 Marks]
- b) Discuss what problems and opportunities this presents and engineer when designing a structure. [4 Marks]
- c) With the aid of a diagram, show the lay-up of the following laminates. For Example $[0/-45/90/60/30]$ would be shown diagrammatically as;

0
-45
90
60
30

- i) $[0/-45/90_2/60/0]$
- ii) $[0/-45/60]_s$
- iii) $[0/-45/\overline{60}]_s$
- iv) $[0^{Gr}/\pm 45^B]_s$ [4 Marks]
- d) Discuss what is mean by the following terms
- i) A cross-ply laminate
- ii) An angle ply laminate
- iii) An antisymmetric laminate
- iv) A balanced laminate [4 Marks]
- e) Discuss what causes hygrothermal stresses and strains in a laminate and how this can be minimised. [4 Marks]

FOUR

- a) When considering failure in a laminate in the 12 plane, what is considered instead of the principal stresses?[7 Marks]
- b) Discuss 4 failure theories that are used to predict failure in composites[8 Marks]
- c) With the aid of a diagram, show how the four theories compare to experimental results and comment on their relative predictions.[5 Marks]

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