Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

LOCATION: SWANSEA | **LLEOLIAD: ABERTAWE**

LEVEL 6 | **LEFEL 6**

EXAMINATION PERIOD | **CYFNOD ARHOLIADAU**
MAY 2020 | **MAI 2020**

MODULE CODE:
M6X01201: MATERIALS & MANUFACTURING FOR NICHE MARKETS

TIME: 2 HOURS

ANSWER 3 FROM 4 QUESTIONS

Equipment or materials required – None

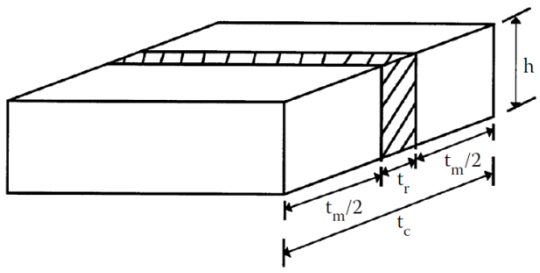
Adnoddau neu ddefnyddiau sydd eu hangen – Dim

A formula sheet is provided for reference. Calculators are permitted. Assume 'g' = 9.81 m/s^2.

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 $\frac{1}{E_2} = \frac{V_f}{E_f} + \frac{V_m}{E}$ 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 70% given that $E_f = 85$GPa and E_m=2.5GPa

[2 Marks]

TWO

a) Given the following for an isotropic material;

$$\begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \gamma_{23} \\ \gamma_{31} \\ \gamma_{12} \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} & S_{15} & S_{16} \\ S_{21} & S_{22} & S_{23} & S_{24} & S_{25} & S_{26} \\ S_{31} & S_{32} & S_{33} & S_{34} & S_{35} & S_{36} \\ S_{41} & S_{42} & S_{43} & S_{44} & S_{45} & S_{46} \\ S_{51} & S_{52} & S_{53} & S_{54} & S_{55} & S_{56} \\ S_{61} & S_{62} & S_{63} & S_{64} & S_{65} & S_{66} \end{bmatrix} \begin{bmatrix} \sigma_1 \\ \sigma_2 \\ \sigma_3 \\ \tau_{23} \\ \tau_{31} \\ \tau_{12} \end{bmatrix}.$$

And the fact that for an Orthotropic composite the compliance matrix reduces to;

$$[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} & 0 & 0 & 0 \\ S_{12} & S_{22} & S_{23} & 0 & 0 & 0 \\ S_{13} & S_{23} & S_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & S_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & S_{55} & 0 \\ 0 & 0 & 0 & 0 & 0 & S_{66} \end{bmatrix}.$$

Prove that the compliance matrix in terms of the 9 engineering constants for an orthotropic material is given by;

$$[S] = \begin{bmatrix} \frac{1}{E_1} & \frac{-\upsilon_{12}}{E_1} & \frac{-\upsilon_{13}}{E_1} & 0 & 0 & 0 \\ \frac{-\upsilon_{12}}{E_1} & \frac{1}{E_2} & \frac{-\upsilon_{23}}{E_2} & 0 & 0 & 0 \\ \frac{-\upsilon_{13}}{E_1} & \frac{-\upsilon_{23}}{E_2} & \frac{1}{E_3} & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1}{G_{23}} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{G_{31}} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{1}{G_{12}} \end{bmatrix}$$

[10 Marks]

b) Hence find the compliance matrix for an orthotropic Graphite/Epoxy lamina whose material properties are as follows;

$E_1 =$ 175 GPa
$E_2 =$ 10 GPa
$E_3 =$ 10 GPa
$\upsilon_{12} =$ 0.2
$\upsilon_{23} =$ 0.4
$\upsilon_{13} =$ 0.2
$G_{12} =$ 6 GPa
$G_{23} =$ 2 GPa
$G_{31} =$ 6 GPa

[5 Marks]

c) For the material in b), what will the strain in the 1 direction (ε_1) be if $\sigma_1 =$ 6 MPa $\sigma_2 =$ -6 MPa and $\sigma_3 =$ 5 MPa

[5 Marks]

THREE

a) When considering the failure of a composite, explain with the help of a diagram, what a failure envelope is.

[8 marks]

b) Name 4 failure theories that may be used to identify failure in a single lamina.

[4 marks]

c) Explain what is meant by first ply failure and last ply failure and explain with the aid of a diagram, why the stiffness of a laminate is non-linear during failure.

[8 marks]

FOUR

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) Explain why Hygrothermal stresses and strains may be seen in a laminate and the consequences of these on the design of laminates.

[8 marks]

c) Using a diagram, explain how the stress may differ through the thickness of a Laminate, the causes of this, and discuss how this is different to that seen through the thickness of a structure formed from an isotropic material.

[8 marks]

Diwedd/End