Reg. No. :

Question Paper Code : 50088

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2023.

Sixth/Seventh Semester

Aeronautical Engineering

AE 8603 – COMPOSITE MATERIALS AND STRUCTURES

(Common to: Aerospace Engineering)

(Regulations 2017)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. List any two merits and applications of composite materials in aircrafts.
2. "Thermoset based matrices are mostly used in aircraft composite structures than the thermoplastic based matrices" – Justify.
3. State the generalized Hooke's law.
4. Define the term 'Off-axis shear strength' and illustrate with numerical expression.
5. A beam shown in Fig. 1 made of isotropic material and is subjected to the combined longitudinal load, P and bending moment, M.

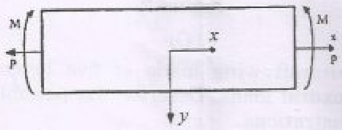

Fig. 1

Write the expressions for the mid plane strain and mid plane curvature.

6. What is warpage in laminates? Specify the effects.
7. List any two characteristics of composites produced using hand layup process and specify two applications.
8. Why the mechanical recycling process is commonly used to recycle short fiber-reinforced composites?
9. Mention any two merits and limitation of sandwich structures.
10. Illustrate any two failure modes of sandwich structures.

PART B — (5 × 13 = 65 marks)

11. (a) The acid digestion test left 2.595 g of fiber from a composite specimen weighing 3.697 g. The composite specimen weighs 1.636 g in water. If the specific gravity of the fiber and matrix is 2.5 and 1.2 respectively, find the theoretical volume fraction of fiber and matrix, theoretical density of composite, experimental density, weight fraction of fiber, matrix and void fraction. (13)

Or

(b) Find any four elastic constants of a graphite/epoxy unidirectional lamina with 60% fiber volume fraction using elasticity model equations. Use the properties of graphite and epoxy from Table 2 and Table 3 respectively. (13)

12. (a) A boron/epoxy lamina is subjected to in plane stresses of $\sigma_1 = 2$ MPa, $\sigma_2 = -3$ MPa, and $\tau_{12} = 4$ MPa respectively. Find the strain in 1-2 direction. Use the properties of boron/epoxy lamina listed in Table 1. (13)

Or

(b) List any four failure theories that are used to predict the failure of composite lamina. Which failure theory is best suited to predict the failure of angular lamina? – Justify your answer by deriving the failure criterion. (13)

13. (a) Find the extensional stiffness matrix [A] for a three-ply [0/30/–45] boron/epoxy laminate shown in Fig. 2. Use the unidirectional properties from Table.1 of boron/epoxy. Thickness of each lamina is 5 mm. (13)

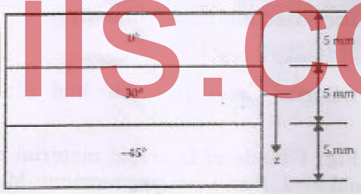

Figure 2.

Or

(b) A composite aircraft wing made of five layers of angular lamina is subjected to flexural loads. Describe the possible failure modes of wing with simple illustrations. (13)

14. (a) Explain with simple sketch, the automated filament winding process used to manufacture large size cylindrical parts for aircraft structures made of polymer matrix composites. (13)

Or

(b) Explain the steps in manufacturing composite panels using resin transfer moulding process with schematics. Also specify the advantages and limitations of resin transfer moulding process. (13)

15. (a) List the steps in construction of sandwich structures using sandwich moulding technique. Brief the merits of sandwich structures. (13)

Or

(b) Discuss in detail, the defects in sandwich honeycomb structure, and the bending theory of sandwich structure. (13)

PART C — (1 × 15 = 15 marks)

16. (a) A landing gear door of an aircraft is to be designed and developed using fiber reinforced polymer matric composite. List the steps in design of such structure based on classical laminate theory. Brief about the loads and factors that are to be considered.

Or

(b) Find any two environmental constants and three ultimate strength parameters of a unidirectional glass/epoxy lamina with 50 % fiber volume fraction. Assume circular fibers with circular array packing. Use the properties of glass and epoxy from Table 2 and Table 3.

Table 1

Typical Mechanical Properties of a Unidirectional Lamina (SI System of Units)

Property	Symbol	Units	Glass/epoxy	Boron/epoxy	Graphite/epoxy
Fiber volume fraction	V_f		0.45	0.50	0.70
Longitudinal elastic modulus	E_1	GPa	38.6	204	181
Transverse elastic modulus	E_2	GPa	8.27	18.50	10.30
Major Poisson's ratio	V_{12}		0.26	0.23	0.28
Shear modulus	G_{12}	GPa	4.14	5.59	7.17
Ultimate longitudinal tensile strength	$(\sigma_1^T)_{ult}$	MPa	1062	1260	1500
Ultimate longitudinal compressive strength	$(\sigma_1^C)_{ult}$	MPa	610	2500	1500
Ultimate transverse tensile strength	$(\sigma_2^T)_{ult}$	MPa	31	61	40
Ultimate transverse compressive strength	$(\sigma_2^C)_{ult}$	MPa	118	202	246
Ultimate in-plane shear strength	$(\tau_{12})_{ult}$	MPa	72	67	68
Longitudinal coefficient of thermal expansion	α_1	μm/m/°C	8.6	6.1	0.02
Transverse coefficient of thermal expansion	α_2	μm/m/°C	22.1	30.3	22.5
Longitudinal coefficient of moisture expansion	β_1	m/m/kg/kg	0.00	0.00	0.00
Transverse coefficient of moisture expansion	β_2	m/m/kg/kg	0.60	0.60	060

Table 2

Typical Properties of Fibers (SI System of Units)

Property	Units	Graphite	Glass	Aramid
Axial modulus	GPa	230	85	124
Transverse modules	GPa	22	85	8
Axial Poisson's ratio	–	0.30	0.20	0.36
Transverse Poisson's ratio	–	0.35	0.20	0.37
Axial shear modulus	GPa	22	35.42	3
Axial coefficient of thermal expansion	μm/m/°C	–1.3	5	–5.0
Transverse coefficient of thermal expansion	μm/m/°C	7.0	5	4.1
Axial tensile strength	MPa	2067	1550	1379
Axial compressive strength	MPa	1999	1550	276
Transverse tensile strength	MPa	77	1550	7
Transverse compressive strength	MPa	42	1550	7
Shear strength	MPa	36	35	21
Specific gravity	–	1.8	2.5	1.4

Table 3

Typical Properties of Matrices (SI System of Units)

Property	Units	Epoxy	Aluminum	Polyamide
Axial modulus	GPa	3.4	71	3.5
Transverse modulus	GPa	3.4	71	3.5
Axial Poisson's ratio	–	0.30	0.30	0.35
Transverse Poisson's ratio	–	0.30	0.30	0.35
Axial shear modulus	GPa	1.308	27	1.3
Coefficient of thermal expansion	μm/m/°C	63	23	90
Coefficient of moisture expansion	m/m/kg/kg	0.33	0.00	0.33
Axial tensile strength	MPa	72	276	54
Axial compressive strength	MPa	102	276	108
Transverse tensile strength	MPa	72	276	54
Transverse compressive strength	MPa	102	276	108
Shear strength	MPa	34	138	54
Specific gravity	–	1.2	2.7	1.2