Composite Sandwich Structure Design Requirements

Composite Engineer's Viewpoint
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Part 5 – Composite Skin and Core Properties

This article discusses the properties of both the composite skins and core materials in terms of their importance and what is necessary in undertaking design stress analysis, and concludes with a short statement on adhesives used in sandwich panel construction.

Composite skin properties

The mechanical properties on composite material skins will differ with the different types of fibres, resins, fibre form (unidirectional versus cloth), the fibre-to-resin weight or volume ratio (or the fibre volume ratio) and, to a lesser degree, the laminate ply stack configuration. Assuming the fibre/resin selection has already been determined and the individual ply design fibre volume ratio achieved, then the basic ply properties of a composite material can be obtained from ply property tables. (See below.)

Material	V_f	E_x GPa	E_y GPa	u_x	E_s GPa
Graphite / Epoxy	0.70	181	10.3	0.28	7.17
Boron / Epoxy	0.50	204	18.5	0.23	5.59
Glass / Epoxy	0.45	38.6	8.27	0.26	4.14
Aramid / Epoxy	0.60	76	5.5	0.34	2.30

Material	V_f	Longitudinal Tension *X*	Longitudinal Compression *X'*	Transverse Tension *Y*	Transverse Compression *Y'*	Shear S
Graphite / Epoxy	0.70	1500	1500	40	246	68
Boron / Epoxy	0.50	1260	2500	61	202	67
Glass / Epoxy	0.45	1062	610	31	118	72
Aramid / Epoxy	0.60	1400	235	12	53	34

For a given fibre volume ratio the skin properties required for sandwich structure design and analysis are:

a. The in-plane longitudinal and transverseaxial Young's modulus (E_1 and E_2).
b. The in-plane shear modulus (G_{12}).
c. The in-plane major and minor Poisson's ratio (υ_{12} and υ_{21}).
d. The in-plane longitudinal, transverse and shear strengths (ultimate and first ply failure) (σ_1, σ_2, and τ_{12})
e. Through-the-thickness tensile, compression and shear strengths (σ_{z_T}, σ_{z_C}, τ_{13} and τ_{23}) for out-of-plane loading cases.

The skin engineering properties are determined through classical laminate plate analysis. If the laminate is made from the same materials (not a hybrid) and has an orthotropic lay-up (balanced and symmetric), then a set of simple expressions can be used to estimate the composite laminate skin properties. The Hart-Smith simplified method ('The Ten-Percent Rule for Preliminary Sizing of Fibrous Composite Structures', presented to 51st SAWE International Conference, Hartford, Connecticut, 18-20 May, 1992) for estimating the composite skin in-plane properties is very useful in designing sandwich structures.

Core properties

There are three fundamental types of core materials: foam, balsa and honeycomb. A comparative listing of typical core properties of common core materials is shown below. Note that these properties are for the same core density. (See below.)

Most honeycomb cores are orthotropic and we should identify the longitudinal (ribbon) direction properties and the transverse properties for thorough stress analysis and design purposes.

Adhesive properties (skin-to-core bonding)

Adhesives are primarily used in the construction of the sandwich structure to bond the core to the skins.

		TTT Compression		Transverse Shear	
Material	Density gcc	Strength MPa	Modulus MPa	Strength MPa	Modulus MPa
Aluminium Honeycomb	0.050	2.07	517	1.45	310
Nomex Honeycomb	0.048	2.24	138	1.21	41
Fibreglass Honeycomb	0.048	2.83	158	1.34	131
Rohacell Foam	0.050	0.88	69	0.79	21
Klegecell Foam	0.048	0.48	18	0.35	7.5
Rigicell Foam	0.048	0.55	14	0.48	17
Divinycell Foam	0.050	0.69	70	0.50	17

Adhesives are also used in connecting sandwich panels and repair of sandwich panels.

Detailed shear stress/strain behaviour must be obtained from tests or the adhesive vendor. Other adhesives used in sandwich panel construction include core splicing (foaming) adhesives that bond core pieces together.

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