Composite Engineer's Viewpoint

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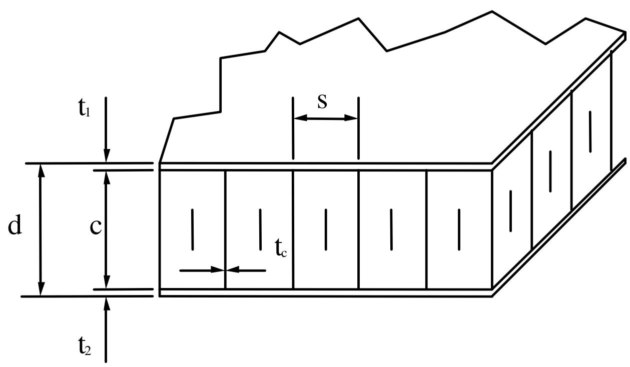
Designing with Composite Materials
Part 7E – Detail Design – Sandwich Structures

In this article we investigate the general design guidelines for sandwich structures with composite face sheets. Firstly, we define a sandwich structure as a face sheet (skin) of fibre reinforced composite material and a core of either honeycomb, or foam or some low density material. The dimensions of the skins and core are defined in the following diagram.



Where:
- d = panel depth
- t = facing thickness
- c = core thickness
- s = cell size (honeycomb)
- t_c = honeycomb cell wall thickness

Note:
- b = panel or beam width
- h = distance between skin centroid

$$= d - \frac{(t_1 + t_2)}{2}$$

The benefits and disadvantages with foam or honeycomb core sandwich structure are as follows:

- Benefits:
  - High flexural stiffness-to-weight ratio
  - Energy absorption capability with crushing
  - Low heat transfer with low conductivity through-the-thickness
  - Noise and vibration insulation and reduction
  - Better bending strength-to-weight ratio efficiency (skins take the axial loads more efficiently)

- Disadvantages
  - Relativity low damage tolerance
  - Moisture absorption potential
  - Repairability
  - Edgewise crushing

The basic sandwich structure sizing requirements can be estimated from a simplified analysis approach. This approach assumes that the skin thickness at least 1/10th the thickness of the core.

Face sheets bending stresses:

$$\sigma_{skin} \approx \frac{M}{t_s hb}$$

where: M = Panel bending moment

t_s = skin thickness

Skin dimpling stress:

$$\sigma_{cr_{\text{dim}\,pling}} \approx \frac{2E_s}{1-\upsilon_x\upsilon_y}\left(\frac{t_s}{s}\right)^2$$

Where: E_s = Composite skin Young's modulus

υ = Skin major and minor Poisson's ratios

Core shear stress:

Assumes that the core modulus $E'_c \approx 0$

$$\tau_{core} \approx \frac{V}{hb}$$

where: V = section transverse shear load

Skin wrinkling stress:

$$\sigma_{cr_{wrinkling}} \approx 0.82 E_s \sqrt{\frac{E_c t_s}{E_s t_c}}$$

Where: E_c = core compression modulus

Transverse Deflections: $\delta_{total} = \delta_{bending} + \delta_{shear}$

Bending: $$\delta_{bending} = K_b \frac{Pl^3}{D}$$

Core Young's modulus: $E'_c \approx 0$

Panel flexural rigidity: $$D \approx \frac{E_s t_s h^2}{2(1-\upsilon_x\upsilon_y)}$$

K_b = see table below

Shear: $$\delta_{shear} = K_s \frac{Pl}{hG_c}$$

G_c = core shear modulus

K_s = see table below

Beam Type	V_{max}	M_{max}	K_b	K_s
Simply supported with uniformly distributed load	0.5P	0.125Pl	0.0130	0.125
Fixed with uniformly distributed load	0.5P	0.0.833Pl	0.0026	0.125
Simply supported with central point load	0.5P	0.25Pl	0.0208	0.25
Fixed supported with central point load	0.5P	0.125Pl	0.00521	0.25
Cantilever with uniformly distributed load	P	0.5Pl	0.125	0.5
Cantilever with end point load	P	Pl	0.0667	0.333

In the next article I will comment on the issue of interlaminar stresses in a little more detail. The basic areas of concern were interlaminar stresses are considered a potential problem and methods of reducing excessive interlaminar stress build-up. As always I welcome questions, comments and your point of view. Feel free to contact me via r.heslehurst@adfa.edu.au. I may publish your questions and comments, and my response in future articles.