

Composite Engineer's Viewpoint

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Designing with Composite Materials Part 3 – Initial Sizing (Design Charts)

Following the selection of the fibre/resin systems and the manufacturing method the lay-up configuration can be developed. Knowledge of the expected fibre volume ratio, through micromechanics or testing, the base ply properties are determined. Now what lay-up configuration do we choose? One starting point is from the basic engineering or physical properties required to meet the engineering specification, for example a required stiffness, or strength, or thermal distortion control perspective. These design performance values can be measured against the base ply properties, say a stiffness ratio (E_{design}/E_{ply}). This ratio can be used to determine the relative number of plies in relative directions from Figure 1

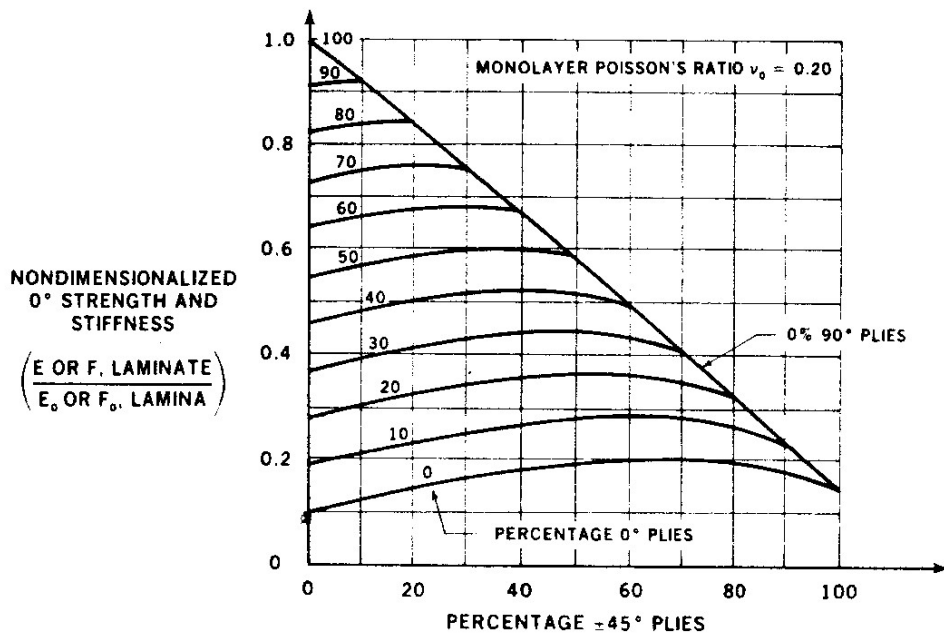


Figure 1: Strength and Stiffness Ratios with Ply Angle Variation
(from Hart-Smith)

For example, say an in-plane stiffness ratio of 0.6 is required. There are only a small number of ply orientations that would meet this stiffness ratio requirement. Using the percentage of ply arrangement of $[0, \pm 45, 90]$, then the possible arrangements could be $[55, 0, 45]$ to $[52, 48, 0]$ with increasing percentage of ±45 degree plies.

This approach does not consider ply position through the thickness at this stage, but the following guidelines are suggested to develop the through-the-thickness configuration of plies:

- The 0° , 90° , $\pm 45^\circ$ lay-up is optimum to take longitudinal, transverse and shear loads, but attempt to have a minimum of one layer in each direction.
- The $+45^\circ$ and -45° plies should be in direct contact to minimise interlaminar shear stresses.
- To minimise warping and interlaminar stresses, the laminate should be symmetric about its mid-plane.
- Minimise stress concentrations due to the linear elastic behaviour to failure.
- In most laminate designs the final two plies should be $\pm 45^\circ$, because these minimise buckling and provide a degree of surface damage tolerance.
- Strength of an entire laminate can be improved through the reduction of interlaminar stresses. This is done by having repeated sub-laminates throughout the laminate.
- Do not rely on carpet plots for final strength calculations.
- Always calculate the laminate properties.

In the next article, we will see how to undertake detailed sizing. This will require the support of the analysis with relatively simple PC based computer programs. I also 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 newsletter.
