Estimating Composite Bearing Strength

In this article we look at estimating bearing strength in composite materials based on a relationship with in-plane strength properties. Is bearing strength related to compression strength or shear strength in composite laminates?

In the design and analysis of mechanically fastened joints the bearing strength of the material is of prime importance. Bearing of pin loaded joints is a local through-the-thickness compressive stress (Figure 1) that is distributed around half the hole diameter in a non-linear manner (Figure 2).

Figure 1: Through-the-Thickness Bearing Stresses in a Pin Loaded Joint

Figure 2: Radial Distribution of the Bearing Stress

Figure 3: Normalized Bearing Strength of a Graphite/Epoxy Composite with Variation in the Percentage of 45° Plies
In metallic structures the bearing strength is typically about twice the yield strength of the metal. However, in composite materials the bearing strength is not as simply defined as in metals. In a composite laminate the bearing strength will vary with ply orientation changes. Figure 3 illustrates this effect for a typical graphite/epoxy. We noted that the maximum bearing strength is obtained with all 45 degree lay-up and as the number of 45 degree plies is reduced the bearing strength will also drop. This strength reduction behaviour is similar with shear strength, that with the more 45 degree plies the shear strength of a laminate will increase, Figure 4.

![Figure 4: Shear Strength of a Graphite/Epoxy Composite with Variation in the Percentage of 45° Plies](image)

Thus, as a first approach in estimating the bearing strength of composite laminate a relationship with shear strength seems more appropriate. This relationship in its simplest form is given as:

\[
\sigma_{br} = 5\tau_{FF}\]

where the first ply failure shear strength \(\tau_{FF}\) is used, or

\[
\sigma_{br} = 3\tau_{ult}\]

where the ultimate shear strength \(\tau_{ult}\) is used, or

A more elaborate relationship can be developed, but for early stages of composite joint design the above relationship holds well for typical laminate configurations.

The above relationship has been validated with a series of experiments that firstly examined any correlation with compressive strength and bearing strength. The results correlated well for near quasi-isotropic configurations, but when bearing strength reduced with increasing numbers of 0 degree plies the compressive strength was increasing. The experimental correlation of bearing strength with shear strength trend in the manner suggested in this article.
In the next article we examine the determination of composite heat damage. What is heat damage and how can it be easily identified? Is surface discolouration the true extent of heat damage or is it just that, surface discolouration? 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.