Composite Engineer's Viewpoint

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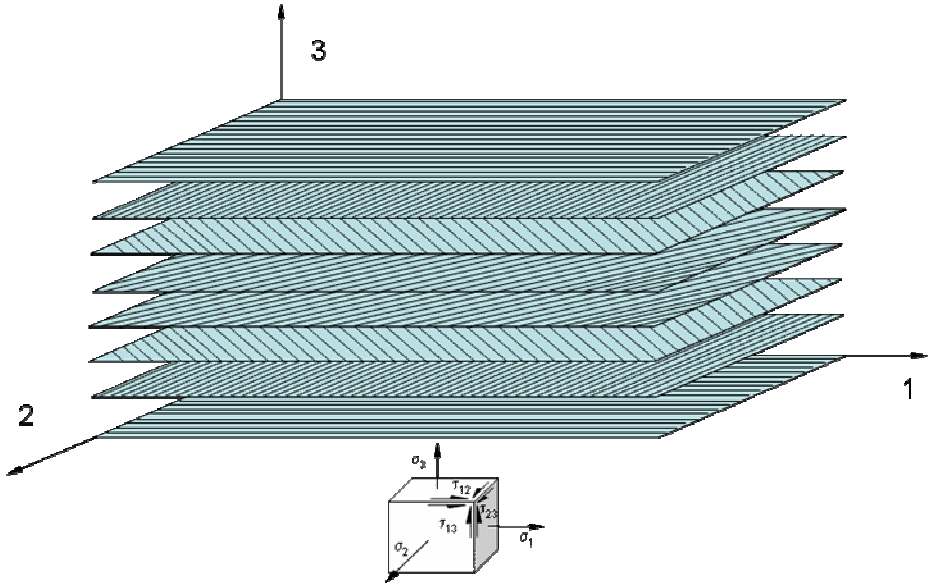
Designing with Composite Materials
Part 7F – Detail Design – Interlaminar Stresses

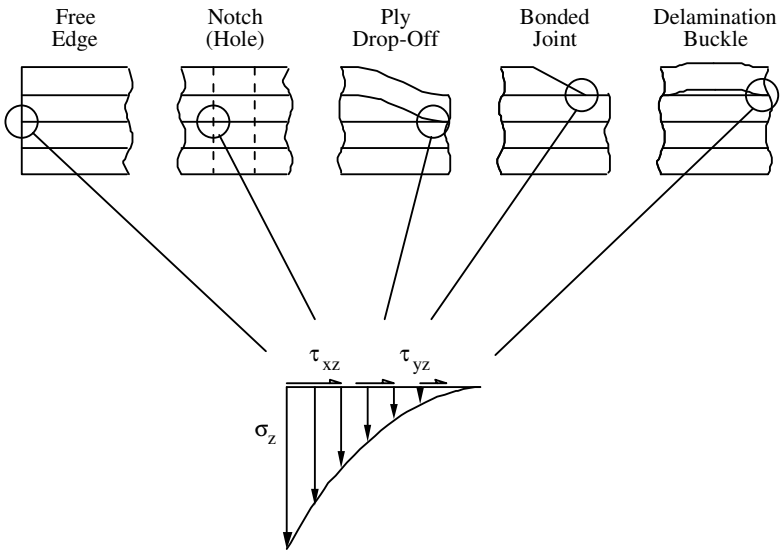
In this article we investigate the general design guidelines for the reduction of interlaminar stresses in composite structures.

By definition the interlaminar stresses are those stresses either normal to the plane of the laminate, and the shear stresses that are along the edge planes of the laminate. The normal (through-the-thickness) interlaminar stress is designated σ_3 or σ_z, and the two interlaminar shear stresses are designated τ_{23} and τ_{13} (or τ_{yz} and τ_{xz}). The interlaminar stresses are illustrated as such.



Stress State in a Composite Laminate

The free edge interlaminar stresses are of general concern as they have the potential of initiating edge delaminations. This in turn will reduce the strength capacity of the laminate as well as cause issues with environmental degradation. The typical locations of free edge interlaminar stresses are shown as follows:



Typical Locations of Free Edge Delaminations

As a general design guide the reduced of interlaminar stresses is principally by the selection of appropriate stacking sequence of the plies in the laminate and/or a reduction in the concentration of plies of the same orientation. In other words the ply orientations need to be uniformly disperses throughout the laminate thickness. Additionally it is good practice to have the mutual +ve and –ve angled plies stacked together, i.e. (±45) as this will reduce the flexural axis ply imbalance. Also, it is recommended to have the laminate symmetric about the mid-plane. Both these suggests will also reduce the on-set of high interlaminar stresses.

If interlaminar stresses can not be reduced satisfactorily then to react the interlaminar stresses there are three recommended procedures. Either install a edge strap that binds the free edge; or use the method of Z-pinning, where a fibre is ultrasonically driven through-the-thickness of the laminate prior to curing; or use edge stitching prior to laminate cure.

In the next article I will comment on the issue of a second Design Review. Now that we have modified the laminate to take care of the detailed design issues we need to check that the composite structure is still meeting the design specification. This review will take the form of a comparison of the design attributes against the performance and operations requirements. 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.