Mechanically Fastened Joints in Composite Structures

Composite Engineer's Viewpoint
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Part 9 – Multiple Row Limitations

In this article we will discuss the multiple row limitations in composite structures. Unlike metallic structures that have a better multiple row load-sharing capability (due to local ductility), composite structures, with a linear elastic behaviour to failure, require a better understanding of multiple rows of fastener bearing/by-pass load interactions.

The linear elastic failure behaviour of composite structures will more than likely exhibit failure at the first or last row of a multi-rowed bolted joint (Figure 1). The magnitude of the load share between rows is a function of the fastener flexibility and the stiffness of the material on which the fastener beds (Figure 2).

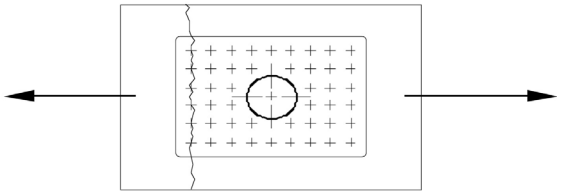

Figure 1: First Row Failure of a Bolted Joint

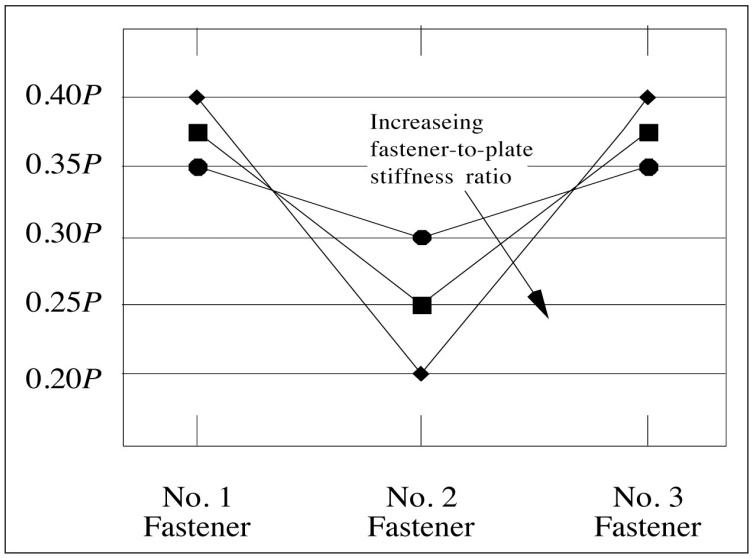

Figure 2: Fastener Row Load Share due to Fastener Flexibility and Plate Stiffness

Because the bearing strength of composite materials is significantly less than metal materials there is a need to reduce the bearing stress in the structure. Bearing stress can be reduced by increasing the fastener diameter, increasing the bearing effective surface area (Dt), reducing the fastener pitch distance, and/or increasing the number of fastener rows. Increasing the fastener rows is typically the most common approach.

However, as the number of fastener rows increases the failure mode will transition from bearing to net tension: see Figure 3. Once the net tension failure mode occurs the maximum strength of the bolted joint is achieved. Increasing the number of fastener rows beyond the failure transition row number will have limited effect on the structural efficiency, as illustrated in Figure 4.

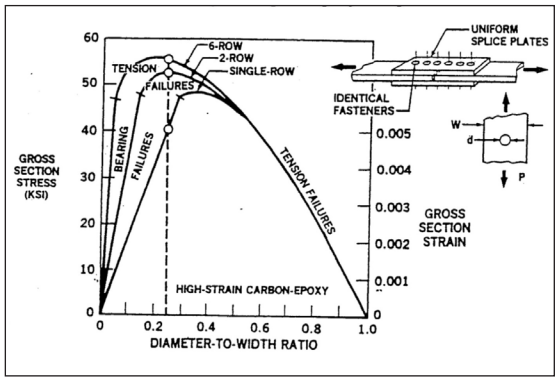

Figure 3: Effect of Increasing the Fastener Row Number of Structural Efficiency (Hart-Smith)

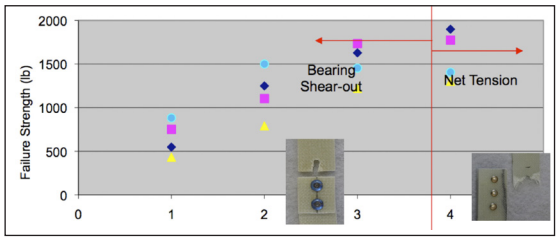

Figure 4: Transition from Bearing to Net Tension Failure Mode with Fastener Row Increase

In the next edition of **Connection** we will discuss ply configuration effects. Both the percentage of fibres in any one direction and the through-the-thickness placement of the plies require an understanding of the effects on structural performance of mechanically-fastened joints in composite structures. I welcome your comments and questions and may publish them and my response in future newsletters.

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