

Mechanically Fastened Joints in Composite Structures

Composite Engineer's Viewpoint by **Rik Heslehurst** PHD, MEng, BEng(AERO) FIEAust, FRAeS, FSAMPE, CPENG



Part 7 – Fastener Clamp-Up

In this article we will discuss the fastener clamp-up. How much should you tighten a fastener that bears down on a composite structure? What is the through-the-thickness crushing resistance of composite structures? Such questions can be answered with proper understanding of composite material properties and their directional relationships.

Clamping of structure by applying torque to a fastener is highly recommended for improvement in component fatigue life, as shown in Figure 1.

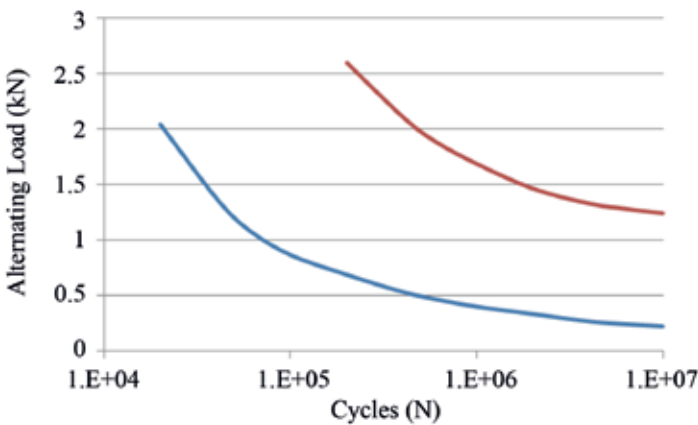


Figure 1: Benefits of Fastener Torque on a Bolted Joint Fatigue Life

However in composite materials the through-the-thickness compressive strength, that reacts against the clamping torqued fastener, is a matrix (resin) dominated property. The impact of fastener torque in composites and metals has been shown by Hart-Smith (Figure 2). Here the recommended torque value for metals is much greater than that of composite materials. This is primarily due to the through-the-thickness compressive strength limitations of the matrix constituent in the composite material.

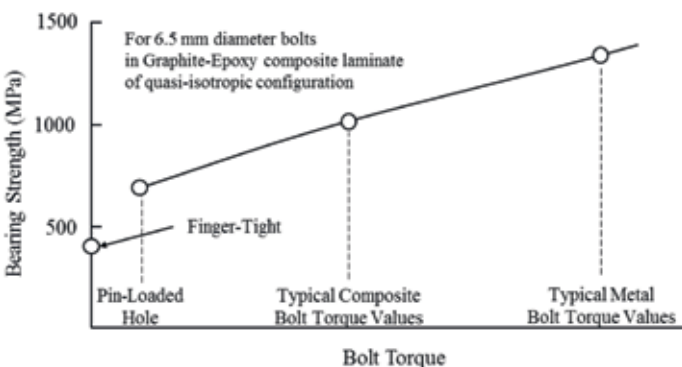
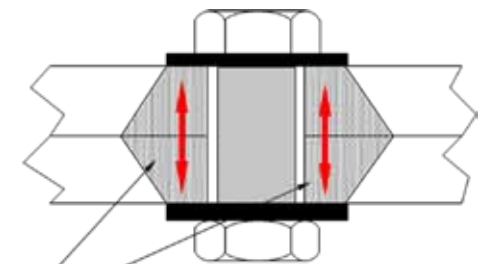


Figure 2: Bearing Strength Levels with Bolt Torque (Hart-Smith)

The clamping pressure is defined by a conical annulus under the bolt head or washer, Figure 3.



Compression Zones

Figure 3: Torqued Fastener Clamping Pressure Zone of Influence

The clamping force is limited in composite materials by the through-the-thickness compressive strength of the composite material. This compressive strength is of the order of 70 MPa and is resin material dependent. For design purposes a substantial factor of safety is applied and thus the recommended matrix dominated strength is limited to 20 MPa, for an applied torque is. Thus the applied torque of a bolt in a composite laminate (with washer) is given by:

$$T = 6.22\sigma_z D^3$$

For a washer diameter 2.2 x the hole diameter (D)

σ_z is the through the thickness compressive strength of the composite laminate

NEXT ARTICLE

In the next article we will discuss the bolted hole stress concentrations – whilst a bolt fills the open hole in a structure there is still a stress concentration effect in both tension and bearing failures modes. Composite laminate ply configurations play a key role in the variations of the local stress concentration factors of bolted joints.

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 newsletters. Feel free to contact me via r.heslehurst@adfa.edu.au