Durability of Bonded Aerospace Structure

Lloyd Smith, Preetam Mohapatra, Yi Chen
Washington State University
Pullman, WA

ABSTRACT

The following considers the response of adhesive joints to mechanical loads using plasticity and viscoelasticity approaches. Plasticity models were compared to bulk adhesives in tension and bonded joints in pure shear, pure tension, and mixed shear/tension loading. Adhesive joints were observed to exhibit more plastic deformation prior to failure than bulk adhesives, which was attributed to load bridging through the adherend, around defects in the adhesive. The adhesive yield stress was shown to follow a von Mises criterion from biaxial testing. A toughened adhesive was shown to follow a kinematic hardening rule. While the response of a less tough adhesive was also dominated by kinematic hardening, it was shown to follow combined kinematic and isotropic hardening. Viscoelastic models were compared to bulk adhesives in tension and bonded joints in pure shear and mixed shear/tension loading. The adhesive viscoelastic response was observed to be non-linear at stress levels exceeding 50% of the adhesive ultimate strength. Viscoelastic models were fit to bulk adhesive creep and recovery tests and compared with low frequency cyclic tests. The viscoelastic models tended to overestimate strain accumulation from the cyclic bulk tensile tests at high stress levels. The viscoelastic models tended to underestimate strain accumulation from cyclic bonded joints in pure shear and mixed mode shear/tension tests. A time dependent numeric model was developed to compare with the analytical model and describe the response of mixed-mode lap shear coupons. The numeric model generally agreed with the analytical model. To identify constitutive responses needed to improve the numeric model, coupons with prior creep and repeated loading histories were tested to failure. The prior loading histories had little effect on adhesive modulus or strength, while their strain to failure was lower.