20th European Mechanics of Materials Conference - EMMC20
Florence, Italy | May 27th-29th, 2026
www.emmc20.unifi.it

Multiscale analysis and lifetime prediction of adhesive lap joints in contact with aggressive environments

Pilar Ariza[1], Michael Ortiz[2]

[1] University of Seville, Spain. mpariza@us.es
[2] Caltech, United States. ortiz@caltech.edu

Paper ID: 126
Symposium S19: Mechanics of Materials: Current Frontiers and Emerging Challenges

Abstract

We present a multiscale framework to describe cohesive fracture in adhesive layers affected by impurities. The approach spans three levels. At the atomic level, fracture processes are dictated by interatomic separation, with separation energetics influenced by both temperature and impurity content. At an intermediate, mesoscale level, the response emerges from the collective behavior of many interatomic planes across the adhesive thickness, giving rise to a strength that depends on layer thickness; at this scale, environmental impurities are also absorbed and diffuse through the adhesive. At the macroscopic level, attention is restricted to lap joints exposed to static loading and hostile environments. Using this framework, we obtain analytical expressions for several key quantities, including the relationship between adhesive strength and thickness, the temporal evolution of edge cracks when present, the service life of the joint, and the degradation of joint strength as a function of prior environmental exposure. The model successfully reproduces experimentally observed trends. Moreover, we outline how its parameters can be informed by atomistic simulations, providing a pathway for the systematic assessment and design of new adhesive materials.

Keywords:

Adhesives lap joints hygrothermal degradation lifetime prediction