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

Cohesive zone modelling of beam-like delamination specimens: effects of shear deformability and transverse compliance

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Paper ID: 669
Symposium S8: Fracture, and damage of materials

Abstract

According to international standards, the experimental characterisation of interlaminar fracture toughness of composite laminates is carried out by using beam-like specimens. Data reduction procedures are based on linear elastic fracture mechanics and beam theory with added semi-empirical corrections. For some classes of composite materials (e.g., glass fibre-reinforced polymers), the fracture process may be further complicated by the presence of the bridging phenomenon. In such cases, standard approaches are not applicable, while a possible modelling approach is offered by the cohesive zone model (CZM). The CZM explicitly introduces traction-separation laws describing the behaviour of the interface. The CZM can be suitably formulated and combined with beam theories to model the behaviour of delamination specimens in the presence of large-scale bridging. However, the success of this modelling approach is strongly affected by the accurate definition of the traction-separation law and the adopted beam theory. In this study, we investigate the effects of shear deformability and transverse compliance of beam-like specimens on the CZM response. We developed an analytical solution for the double cantilever beam (DCB) specimen based on different beam theories (Euler-Bernoulli and Timoshenko) and a tri-linear traction-separation law. Comparison with 2D finite element analyses shows that the inclusion of shear deformability alone, according to Timoshenko beam theory, does not suffice to accurately capture the specimen response during static delamination propagation. Likewise, accounting for the transverse deformability of the material, via a Winkler-like foundation, in combination with the simple Euler-Bernoulli beam theory does not produce satisfactory results. Instead, accounting for both the shear deformability and the transverse compliance greatly enhances the matching between the analytical solution and the numerical results.

Keywords:

cohesive zone model delamination beam theory composite material large-scale bridging shear deformability transverse compliance