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# Modelling load transfer and mixed-mode fracture of ductile adhesive composite joints

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**Abstract**

A new general computational framework for the stress and effective strength analysis of ductile adhesive composite joints is proposed. Composite adherends are modelled using First Order Shear Deformation Theory accounting for bending-extension coupling and an aysmptotic approach for the bondline within deformation theory of plasticity is employed. The governing one-dimensional boundary value problem is solved using an efficient finite-difference scheme in Matlab. Based on the proposed stress solution, different failure criteria motivated either by strength criteria or fracture mechanics are implemented and benchmarked against experimental data for an effective joint strength assessment.

A comparison to numerical finite element analyses demonstrates the model's ability to render the adhesive stress field accurately. The impact of different stress-strain curve approximations and effective stress quantities within deformation theory of plasticity are studied and discussed. Finally, effective joint strength predictions are compared to experimental data from literature. The paper concludes with a discussion on distinct failure criteria for elastic-plastic adhesive joints and recommendations for reliable accurate joint strength predictions.

*Keywords:* Ductile fracture, Adhesive joints, Deformation theory of plasticity, Joint strength prediction, Joint design



## 1. Introduction

In early design-stages, the mechanical behaviour of adhesive joints is typically predicted using simple linear-elastic analyses. These approaches are based on modelling the adhesive as an infinite set of linear elastic springs or on classical theory of elasticity. For brittle adhesives, these analyses may suffice since almost all deformations prior to failure are in the elastic regime. However, many adhesives as for instance rubber-modified epoxies show inelastic material behaviour even at low levels of external loading. In particular, stresses near the free edge of the adhesive layer in lap joints quickly reach the elastic limit due to the inhomogeneous load transfer and the present stress concentrations. Hence, the design analysis has to account for the adhesive's material nonlinearity in order to provide sufficiently accurate predictions of the adhesive stress field and effective joint strength.

The objective of the present work is (i) to provide a review of nonlinear adhesive joint models available in literature and (ii) to propose an efficient analysis framework for elastic-plastic adhesive joints with composite adherends

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