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: Experimental and numerical study to integrate viscous effects in the modelling of crack propagation of adhesively bonded joints in composite structures

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Abstract

From the point of view of efficient use of materials, adhesively bonded joints have an advantage over other connection types, such as bolted joints, e.g. through a uniform load transfer. The mechanical behavior of a polymer adhesive is well-known to be highly time- and temperature-dependent. Such viscous effects give rise to phenomena like strain rate dependence and stress relaxation. Furthermore, polymers exhibit pressure-dependent behavior and are susceptible to chemical and physical ageing. Due to the complexity of adhesive behavior and the limited availability of suitable material models, the above-discussed dependencies are often discarded. However, these effects can have a major impact on the accurate prediction of the damage growth and failure of an adhesively bonded joint. This study presents the results of an experimental and numerical study to integrate viscous effects in the modelling of damage propagation in adhesives. Two distinct adhesives were used: an epoxy-based system and a methyl methacrylate-based system. The first adhesive exhibited a more rigid and stronger but brittle behavior, while the second was characterised by a less stiff and less strong but ductile response. The Eindhoven Glassy Polymer (EGP) model is employed to model the viscous and pressure-dependent material behaviour. Material and model parameters were determined and validated using experiments conducted under different basic stress states and strain rates.

A continuum damage model was incorporated into the EGP model, enabling simulation of damage progression. The developed damage model was implemented in an in-house finite element code. Numerical simulations of the conducted compact tension experiments demonstrated the model's ability to capture damage propagation under varying strain rate conditions.

Keywords:

Adhesively bonded joints Continuum damage mechanics Viscous material Strain-rate