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On the rate dependent behaviour of epoxy adhesive joints: experimental characterisation and modelling of mode I failure

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Abstract

The increasing use of adhesive joints in dynamic applications require reliable measurements of the rate-dependent stress-displacement behaviour. The direct measurement of the stress-displacement curve is necessary when using cohesive models in discretised solutions of boundary value problems in solid mechanics. This paper aims to investigate the rate-dependent tensile failure of adhesive joints by using a new experimental methodology – it relies upon the combination of the stress wave propagation theory and digital image correlation methods on high speed footage to quantify the tensile stress and the dissipated energy respectively. For this purpose, the Split Hopkinson Bar methodology was employed – the experimental configuration was optimised using numerical modelling. To prove the sensitivity of our framework, two different adhesives are characterised at different loading rates: the adhesive failure strength was found to increase considerably with the strain rate, while the plastic deformation of these adhesives was reduced. The film adhesive showed superior performance over the particle toughened one. In the final part, a rate-dependent cohesive zone model is proposed, one which captures the measured behaviour and which has the potential to be used in industrial applications.

Keywords: adhesive joints, rate-dependent, dynamic characterisation, cohesive zone model

1. Introduction

Composite materials are increasingly used in modern aerospace [1] and automotive structures [2]. The increased integration level of composite structures is beneficial to its affordability and development efficiency; adhesive bonding has been widely used for manufacturing integrated composite structures [3]. Some typical composite joints have been comprehensively investigated, such as single lap joints [4], double lap joints [5] and T-joints [6]. The strength and damage tolerance