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# A cohesive zone element for mode I modelling of adhesives degraded by humidity and fatigue

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**Abstract**

A finite element is proposed, based on the cohesive zone model approach and implemented as a user element, for the modelling of adhesively bonded joints subjected to degradation by humidity and fatigue using software ABAQUS®. Functionality included in this element that is not available using standard cohesive zone elements includes: (a) various types of traction-separation laws, such as triangular with exponential softening, trapezoidal and exponential, (b) an intuitive and easy to use graphical interface built in MATLAB that helps visualize all traction-separation laws, create the mesh, run the simulation and visualize the results, (c) custom degradation laws for both humidity and fatigue which allow the user to easily model the effects of said degrading parameters. It is shown that the trapezoidal traction-separation law is the most appropriate to model the experimental data in both unaged and aged specimens. The proposed fatigue degradation approach correctly predicts the number of cycles until failure of all unaged and aged conditions, thus proving itself as a very useful tool capable of modelling a vast array of experimental conditions and details that adhesive joints are subjected to in real world applications.

*Keywords:* Cohesive zone model, traction-separation law, finite element analysis, humidity, fatigue, environmental degradation.

## 1. Introduction

Adhesive joints are being increasingly used in structures mainly due to their attractive strength to weight ratio, which leads to an overall reduction in weight, costs and, in the case of industries such as the automotive and aeronautical, emissions [1]. Due to the prevalence of adhesive joints in critical structures, precise experimental [2] and numerical methodologies [3] must be developed to characterise and predict joint behaviour for both static and cyclic conditions, while also evaluating the effect that environmental factors may have in a joint. Experimentally, temperature and humidity may be applied to standardized specimens such as bulk and double cantilever beams (DCBs) to obtain both static and cyclic behaviour, but numerical prediction of said phenomena is still not fully understood.

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