Funded PhD Opportunity in University College Dublin

A Combined Experimental/Numerical Investigation into the Structure-Property Relationship of Structural Adhesives.

Experimental determination of the fracture toughness of modern structural adhesives is far from straightforward, and appears to depend strongly on the state of stress in the immediate vicinity of the crack edge. An important characteristic of the stress field in this context is the degree of tri-axiality or constraint which exists in this region. A detailed analysis of the constraint distribution in commonly encountered test geometries will be conducted using the Finite Volume numerical method. A powerful suite of simulation software called OpenFOAM (http://www.opencfd.co.uk/) is extensively used by the fracture mechanics research group at UCD to study a wide range of complex problems. The state of the art computational facilities available for this research includes a brand new 92-node high performance computer cluster, one third of which is under the control of this group. Each node consists of two high speed quad-core processors. The OpenFOAM software is designed to operate in a parallel processing environment. As a result, the execution times for complex problems may be reduced by up to two orders of magnitude. This will enable exciting, realistic simulations to be performed to gain unprecedented insight into material behaviour close to the crack tip. Several approaches may be considered. Firstly, micromechanical modelling of the damage and fracture of toughened adhesives may be performed using a unit-cell approach representing a bulk material volume. The unit-cell will be subjected to various multi-axial states of loading to achieve a range of constraints. As a result, traction-separation laws will be obtained as a function of constraint and compared to experimentally calibrated laws. These traction-separation laws may then be used in a cohesive zone model (CZM) to bridge the scales between the microstructural and continuum levels of material description. This analysis will also be used explore micro scale damage and fracture mechanisms of adhesives and their structure-property relationships. A second approach would be to employ a continuum damage law at the unit-cell level, where, rather than modelling the details of the microstructure explicitly within the volume, additional parameters are used to describe the distribution and evolution of microstructural features in the fracture process region. High resolution microscopy (both atomic force microscopy (AFM) and field emission gun scanning electron microscopy (FEG-SEM)) will also be carried out to determine the failure mechanisms for different classes of adhesives for comparison with and calibration of the numerical models.

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