Preface

The history of engineering is replete with examples of catastrophic failures which have been directly attributed to the formation and propagation of cracks; from the sudden breakage of Liberty cargo ships during the Second World War, due to steel embrittlement, to the more recent incident of an Aloha Airlines Boeing 737 which landed with a missing major upper fuselage section. This failure was attributed to a fatigue crack propagating in a row of rivets along a lap joint. The reliable prediction of fracture in structural components remains a formidable challenge in engineering practice.

As a specific example, a damage tolerance assessment, required for airworthiness certification, still entails substantial physical testing which is costly and time consuming. Industry is exploring ways of reducing developmental costs and timescales through the increased use of simulation early in the design cycle. The shift towards a ‘virtual testing environment’ promises a step-change in current industrial design practice.

Advanced composite materials are also making rapid inroads in the design of large civil aerostructures. Whilst their use in military aircraft is well established, the utilisation of composites in the primary structure of civil aircraft has been more cautious. Composites on civil aircraft were first introduced on the Airbus A300 where 4.5% of the weight of the airframe was carbon fibre reinforced plastic (CFRP). The A380 contains 22% CFRP and 3% GLARE (glass fibre prepreg /aluminium) and the A350 will have 40% CFRP. The Boeing 787 uses an unprecedented level of composite material in its primary structure; 50% of the airframe is composites by weight. The prediction of fracture in these materials presents the analyst with new challenges. The shift towards adhesive bonding over mechanical fasteners in composite aerostructures, to further minimise weight, also requires the analyst to consider cohesive fracture as a possible failure mode.

This special issue of Key Engineering Materials reports new progress in the analysis and understanding of fracture and damage mechanics. The Finite Element Method is a well-established analytical tool for fracture analysis. The development of interface elements, which combine aspects of fracture and damage mechanics, enables the prediction of both crack initiation and propagation. A number of papers presented in this volume, deal with their use and further development.

Substantial progress has also been made in the use of the Boundary Element Method for crack problems. The inherent mathematical complexity of this method has resulted in a somewhat slower progress than that of the Finite Element Method and is still the focus of much research. This volume presents a number of contributions from this field.

A topic which is closely related to the study of fracture is structural repair. Whilst repairs are usually implemented when fracture occurs, the structural analyst must subsequently ensure that the repair itself is not prone to cracks or other forms of damage. Two approaches for the study of damage in a repaired structure are described in this special issue. The first uses the traditional finite element method and an interface element capable of modelling fatigue-induced damage. The second uses the boundary element method to investigate cracks in a bonded patch repair.

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Guest Editors