Foreword: Advances in Crack Growth Modelling

Ferri Aliabadi[1, a], Pihua Wen[2,b]

[1]Imperial College London, South Kensington, London SW7 2BY

[2]Queen Mary, University of London, Mile End Road, London, TS1 4EN

[a]m.h.aliabadi@imperial.ac.uk, [b]P.H.Wen@qmul.ac.uk

Fatigue failure of strucutres is normally caused by cracks that extend beyond a safe size. Flaws are present to some extend in all structural parts, either as a result of manufacturing fabrication defects or damage in service. Crack growth is a complex phenomenon to model and simplifications are assumed. In recent years, there has been an increasing realisation that advanced computational methods such as the Finite Element Method, the Boundary Element Method and Meshfree Methods can be used to simulate crack growth in complex structural parts.

Early works to model crack growth using the Finite Element Method (FEM) can be traced back to works of Shephard et al [1] and, Valliappan and Marti[2]. More recent advances in the finite element method can be found in the work of Theilig et al [3] for two-dimensional mixed-mode crack problems, Buchholz and Richard [4], Citarella and Buchholz [5] and Li et al [6] for three – dimensional mixed-mode problems.

A recent successful application of the FEM to mixed-model crack growth modelling is due to the development of eXtended Finite Element Method (XFEM). The XFEM as developed by Black and Belytscho[7] and Rethore et al [8] are inspired by the enriched finite elements originally proposed by Benzely [9] and Foschi and Barrett[10] (see Aliabadi and Rooke[11] for an overview of enriched FEM). The work by Belytschko and Black enabled the enrichment of finite element approximations requiring minimal remeshing to solve crack growth problems. The partition of unity property of finite elements was later used in XFEM which allowed enriching of regions near the discontinuities. This method offers some unique advantages over earlier FEM methods proposed to model crack growth in structures. It does not require any projections between the meshes and has proved to be far better than finite element methods with continuous remeshing. The advantage of XFEM lies in the fact that it subdivides the crack problem into two parts where a mesh is generated without cracks/inclusions and then finite element functions can be enriched to simulate discontinuities. Belytschko and Black treated curved discontinuities by mapping a straight crack enrichment field which was further developed by Dolbow *et al.* [12]and Moes *et al*.[13]. Sukumar *et al.* [14] implemented the concept of Partition of Unity and XFEM to three dimensional problems by using a discontinuous function to simulate the crack surface and enriching the crack front by 2D asymptotic crack tip displacement fields.

The Boundary Element Method (BEM) has also a long history in fracture mechanics and crack growth modelling [11]. A robust method for modeling crack growth in general mixed-mode problems was developed by Portela, et al[12,13] and Mi and Aliabadi [14]. The method was an extension of the Dual Boundary Element Method (DBEM) earlier proposed by the same authors, as an effective way of modeling crack problems using the boundary integral equation. The DBEM was the first computational method that allowed modelling of mixed-mode crack problems without a need for continuous remeshing and user interferences. The crack extension was modelled with new boundary elements without having to remesh the previous crack geometry. Hence, the method remains the only computational method that is truly mesh independent. Early benchmarks used in [14] for the first times such as the mixed mode growth of an inclined elliptical crack have since been repeated in XFEM and Meshfree publications. In addition, DBEM has established itself as one of the most accurate numerical methods for the evaluation of stress intensity factors which is the key parameter for fatigue life assessment of structures. The extension of the DBEM to different linear, transient and nonlinear problems can be found in [15-25].

During the last decades, mesh-free methods, as an alternative to FEM and BEM have shown a promising potential and has found applications in fracture mechanics. Among different types of mesh-free methods proposed so far, Element free Galerkin and Meshless local Petrov-Galerkin (MLPG) have gained much attention both using Moving least square (MLS) approximation as the shape function construction. More recent, applications are reported in [27-31].

This special issue of *Key Engineerng Materials* contains original papers written by active researchers in the field of computational fracture mechnaics. The aim is to inform those in the fracture mechanics community who might not be at the forefront of computational research of the recent developments and techniques available and the wide range of applications for which solutions are now possible.

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