Case studies of computational simulations of fatigue crack propagation using finite elements analysis tools

V. Infante a,⇑, J.M. Silva b

a Departamento de Engenharia Mecânica, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal
b Departamento de Ciências Aeroespaciais, Universidade da Beira Interior Edifício II das Engenharias, 6200-358 Covilhã, Portugal

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ABSTRACT

This paper presents three case studies based on the numerical determination of the stress intensity factor ($K$) related with different crack front geometries due to fatigue using two commercial finite element analysis codes (ZENCRACK® and ABAQUS®).

Cases 1 and 2 considered a double-U notch specimen used in high temperature fatigue testing. Stress distribution in the vicinity of the U notch has been obtained, as well as numeric solutions of $K$ for crack front geometries with rectilinear, corner and unconventional crack front shapes. In the case of the standard crack geometries the results have been validated with classic solutions existing in literature.

In the third case study, several computational simulations were carried out aiming at determining the $K$ solution for distinct crack front positions, considering the influence of different geometric features of the specimen. Additionally, a stress triaxility parameter was used in order to confirm the stress state condition in the crack propagation region.

The conclusions of this study are encouraging concerning the possibility of using ZENCRACK® as an advantageous computational tool for obtaining $K$ solutions in the case of particular crack front geometries as obtained from fatigue experimental testing.

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1. Introduction

Numerical procedures based on the finite element method (FEM) are often used to determine fracture mechanics parameters, such as the stress intensity factor, $K$. Testing real size or event test components in simulated conditions can be a very expensive and time consuming procedure [1]. In some cases, $K$ solutions are available in literature for geometries and load conditions similar to those experimentally obtained. Murakami [2,3] and Pickard [4] are examples of relevant references in this area. However, there are a number of practical situations where the $K$ solutions are not available in literature. In these cases the stress intensity factor solutions can be obtained using a numerical approach, such as the finite element technique. Currently, a significant number of FEM commercial codes are available with some Fracture Mechanics features, alloying obtaining accurate solutions for conventional crack geometries. However, these codes are not appropriate for more complicated problems, in particular those dealing with 3D unconventional crack front geometries and complex loading conditions. These limitations are mainly due to some restrictions regarding the mesh generation and the element type at the crack front. To overcome these handicaps a few recently developed programs introduced some specific capabilities concerning the crack front modeling, but there is still a lack of confidence about the validity of their solutions.

⇑ Corresponding author. Tel.: +351 21 8417643; fax: +351 21 8417915.
E-mail address: virginia@dem.ist.utl.pt (V. Infante).