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Guest editorial: Characterisation of crack tip fields-CCTF5

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Joint special issues of the International Journal of Fatigue (IJFatigue, Elsevier) and Fatigue & Fracture of Engineering Materials & Structures (FFEMS, Wiley) containing selected and fully peer reviewed papers from the 5th IJFatigue and FFEMS Joint Workshop on Characterisation of Crack Tip Fields held in Heidelberg, Germany over April 8 – 10, 2019.

Single parameter characterisation of the crack/notch tip field using fracture mechanics parameters like K , J or CTOD has been extremely powerful in advancing predictive technologies for critical or sub-critical crack growth. It has also become clear over the last decades that single parameter approaches have limitations particularly in dealing with crack growth phenomena arising from crack tip shielding, often resulting from the plastic enclave surrounding a crack. Influences of this enclave on the crack tip stress field ahead of the crack are maximised during cyclic loading. In the case of a parameter like the stress intensity factor which characterises the crack tip field via an elastic approximation, it is not surprising that any set of plasticity-induced circumstances which perturb the size of the plastic enclave and its associated strain field leads to predictive difficulties. Over the last 40 years, notable areas of activity related to such difficulties include short cracks, plasticity-induced closure, variable amplitude and multiaxial loading and notch effects.

Considerable research effort has explored these areas of difficulty, including short cracks, plasticity-induced closure, variable amplitude and mixed-mode loading, as well as notch effects. Increasing attention has hence been focused on using more than one fracture mechanics parameter. In particular, plasticity-related crack growth phenomena are of major interest. The situation is further complicated where a crack experiences multiaxial loading where consideration of Mode II and III loading becomes necessary. Alongside this, new analytical models have been proposed and advanced experimental techniques, for example digital image correlation, now allow greatly improved measurement of the 2D and 3D fields associated with the crack tip zone.

These issues were discussed in the fifth international workshop on Characterisation of Crack Tip Fields which was organized by the Materials Mechanics Group of the Technical University of Darmstadt and the Italian Group of Fracture (www.gruppofrattura.it). This workshop retained the successful format of the first four workshops¹, based on a largely invited group of delegates. Adequate time for discussion after each paper was an integral part of the workshop, while a final overall discussion in the closing session summarised the work presented and identified key themes for future research to pursue, leading to an agreed summary of the current state-of-the-art in crack tip fields and identification of major remaining problem areas.

The following important points were recorded in these discussions:

- ensuring accuracy, repeatability, compatibility and correlation between various experimental techniques is a key to making further progress;

- the use of full field experimental measurement techniques (volumetric as well as surface) has to be encouraged;
- geometric and material non-linearity including crack closure and plasticity are crucial for understanding fatigue crack growth mechanisms;
- shielding effects require further studies;
- environmental conditions, e.g. vacuum, corrosion and temperature, influence the failure mechanisms;
- the modelling of non-proportional mixed mode remains a puzzle to scientists;
- harmonising the needs of engineering applications and academic research needs to be considered concurrently.

The papers selected for these joint Special Issues of IJFatigue and FFEMS present a range of research that illustrates both the complexity of the topic and the current endeavours that are giving detailed consideration to a number of these aspects.

The next IJFatigue and FFEMS Joint Workshop on Characterisation of Crack Tip Fields is proposed to take place in Dubrovnik, Croatia, between 12-14 April 2021.

The Guest Editors of this special issue warmly thank all the authors for their contributions and hope that this overview of current thinking in the area of crack tip fields in relation to fatigue and fracture is useful for the research community.

¹Forni di Sopra, Italy, 7–9 March 2011; Malaga, Spain, 15–17 April 2013; Urbino, Italy, 20–22 April 2015; Bonifacio, France, 10–12 April 2017