11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

FATIGUE CRACK PROPAGATION AND THEIR INTERACTION MODELLING WITH A PERIDYNAMICS APPROACH

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Key Words: *peridynamics, fatigue crack propagation, non-local methods, computational mechanics*

In different fields of human activities structural components have to be in use, despite ageing and the continuous risk of damage growth and consequent possible failure. The modelling of damage propagation phenomena is usually a difficult task because it is necessary to have the capability of describing generation and growth of material discontinuities. For structural components, it is of the highest importance to be able to describe the damage process in order to evaluate their life expectancy for a safe use and to define a proper repair and maintenance program.

In the last thirty years some approaches have been proposed to deal with discontinuities in structural materials: interface elements and Cohesive Zone Models (CZM) [1] can only be applied if the path of the discontinuity is known a priori and it is limited by the element discretization; the extended finite element method (XFEM) [2] is more recent and, although overcoming some of the CZM drawbacks, its extension to 3D problems appears to be rather complex [3]. Recently a powerful method based on the peridynamic theory [4] has been introduced; the peridynamic equation of motion is formulated using spatial integral equations. The integral equations remain valid at discontinuities which enables to model crack initiation and propagation in a natural way even when cracks take place simultaneously at multiple locations. The theory is also able to predict crack branching and mutual crack interaction without any special additional criteria. The peridynamic theory is therefore a natural approach for the study of fatigue failure phenomena.

So the peridynamic formulation has been enriched introducing a damaging effect due to the high cycle fatigue phenomena, this formulation is inspired by previous work reported in references [5, 6].

The main parameters of the fatigue damage model are the material fatigue parameters and the number of the load cycles. It is possible also to simulate complex load history with many load cycle blocks with different applied stress value [7].

For the numerical implementation an incremental approach has been adopted, the number of cycles will be considered as a real-valued variable and a rate-independent model is assumed. The solution, including the bond fatigue damaging effect, is found using a standard Newton-Raphson technique.

A first study of the correlations between the peridynamic fatigue model parameters and the classical Paris law parameters has been presented on [8].

A distinguishing feature of this approach is its ability to treat the spontaneous formation of discontinuities at different locations together with their mutual interaction and growth in a consistent framework. The method does not require a separate crack growth law to be provided that governs cracks and damage initiation, growth, arrest, branching and so on: these features emerge from the equation of motion and constitutive models.
The peridynamic method will be applied to model a 2D structure in presence of voids and inclusions under fatigue load conditions considering isotropic materials. Results will be evaluated taking into account different mesh sizes, horizon dimensions, crack initial lengths and crack orientations.

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