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The present work aims at investigating the size effect of a spheroidal cavity in an infinite linear elastic continuum under remote tension, by means of the coupled Finite Fracture Mechanics (FFM) [1] approach. FFM is a coupled fracture criterion which allows to provide strength predictions based on the simultaneous fulfilment of a stress condition and the energy balance. Although initially proposed and applied only to static problems, FFM was later extended to assess the fatigue limit of structural components [2]. Whereas the static formulation requires the knowledge of the material ultimate tensile strength and of the fracture toughness, both the plain fatigue limit and the threshold value of the stress intensity factor range are needed in the fatigue regime.

To implement the FFM, the longitudinal stress field and the Stress Intensity Factor (SIF) related to an annular crack surrounding the spheroidal void, are obtained numerically through a parametric axisymmetric Finite Element Analysis (FEAs). In these analysis, to evaluate the effect of the void geometry, the void axis ratio is varied between 0.1 and 10. Furthermore, to encompass also the influence of the material, different Poisson's ratios are considered ranging between 0.1 and 0.5. Semi-analytical approximating functions providing the stress concentration factor K_t and the SIF itself are put forward.

In the framework of fatigue failure, one of the most important issues is that related to corrosion pitting, a very localized and critical form of damage. Studies focused on this topic have been proposed since the middle of the last century, by approximating the pit shape as in between hemispherical and hemispheroidal. In particular, different works focused on the estimation of K_t, through three-dimensional (3D) FEAs. On the down side, precise 3D FEAs are computationally expensive and thus not adequate for preliminary sizing of structural components. Furthermore, K_t based studies are not able to catch any size-effect according to classical linear elasticity. For these reasons, Härkegård (2015) [3] approximated the fatigue behaviour of a hemispherical pit by that of a spherical cavity in an infinite tensile body. Following this idea, in the present study, the strength estimations, obtained for a spheroidal void in an infinite linear elastic continuum under remote tension, are compared with experimental fatigue data related to corrosion pitting on two different material: (i) 12% Cr martensitic [4] and (ii) 17-4PH turbine-grade steels [5].

References

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