Fatigue life and crack path predictions in 2D structural components using the boundary element method

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A reliable and cost-effective two-phase methodology is proposed to predict fatigue crack paths and propagation lives in generic two-dimensional structural components. In a first step, a general curved fatigue crack path and the corresponding stress-intensity factors are calculated for small crack increments using a robust boundary element (BE) software that combines the conceptual and computational advantages of both conventional (collocation) and variationally-based formulations [1]. The software makes use of sub-regions, advanced numerical techniques for the evaluation of the J integral, and appropriate crack increment criteria. The crack paths and stress intensity factors predicted by this BE program are compared with similar predictions made by a specially developed finite element program [2-4], and their advantages and shortcomings are highlighted. Then, the computed stress-intensity factors are transferred to a general-purpose fatigue-design program, designed to predict both initiation and propagation fatigue lives by means of classical design methods. Particularly, its crack propagation module accepts any $\mathbf{K_I}$ expression and any crack growth rate model, which are obtained numerically from the analysis software, considering sequence effects such as overload-induced crack retardation to deal with one- and two-dimensional crack propagation under variable amplitude loading. Non-trivial application examples compare the numerical simulation results with those measured in physical experiments.

Keywords: Crack propagation, Boundary elements, 2D structural components, Variable amplitude loading.

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