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Surface and corner cracks departing from elongated notches in thick plates

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Classical fatigue design methodologies rely in stress and strain concentration factors (SCF) to correlate the stress/strain state at notch tips with nominal loads applied away from the notches. Such SCF are then used with stress or strain-life curves to predict crack initiation lives, eventually considering semi-empirical notch sensibility factors to improve the predictions accuracy. However, almost all SCF available in the literature are based on plane solutions, neglecting 3D thickness effects at notch roots, which can be significant in many practical cases. Moreover, structural components which must endure very long fatigue lives should be designed to avoid fatigue crack initiation AND to be tolerant to undetectable or to unavoidable short cracks. Nevertheless, due to modeling limitations, this last criterion is still rarely if ever used in engineering design applications, a risky option that needs to be corrected. To start developing an useful design criterion, it is important to recognize that the fatigue propagation of short cracks that depart from notches is highly dependent on the stress gradient ahead of their tips. Hence they should be described considering the 3D effects that can affect their stress intensity factors (SIF). This problem is particularly important when modelling cracks that start at elongated notches, which have both steep stress gradients and high sensitivity to thickness effects around their tips. Besides, notch sensitivity is also highly dependent on these parameters too, and should be properly considered when predicting crack initiation at elongated notches. To improve such crack initiation and crack tolerance predictions, detailed 3D numerical models have been developed to calculate SIF for short (and long) semi-elliptical and quart-elliptical cracks that depart from notch tips, using M-integral techniques available in FRANC3D software. These results are then used in representative calculations to highlight how important they can be in practical applications.

Keywords: crack, 3D, elongated notch, stress concentration