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Technical Note

A note on stress intensity factors for a crack emanating from a sharp V-notch

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ABSTRACT

A concise and precise formula for mode-I stress intensity factor of a short crack emanating from the bisector of a V-notch has been derived by Philipps et al. The crack tip stress intensity factor is directly evaluated via the mode-I generalized stress intensity factor of an uncracked notch. This note further supplements an accurate formula to calculate mode-III stress intensity factor for a short crack emanating from a V-notch.

1. Introduction

For structural components, the majority of fatigue life is frequently used up as cracks grow from an initial non-detectable flaw to a detectable flaw [1]. So the 'short crack regime' is of great importance in practice, such as a short crack presenting at a V-notch tip, a blunt crack tip or a hole. However, the finite element method, which is extensively used in engineering, have no more the advantage of solving this kind of problems. On one hand, it is often necessary to analyze a complex two-dimensional or three-dimensional flaw under arbitrary loading at every stage of the crack growth or every potentially critical point. This involves much repeated work and is extremely time consuming. On the other hand, the stress singularity along the flaw front requires a fine numerical mesh, which is more difficult for short cracks since the stress concentration takes place near the flaw front regions such as a notch and a hole.

To overcome this difficulty, much attention is paid on obtaining simple and accurate formulae for the stress intensity factors for short cracks at the stress concentration regions. Unfortunately, there are few exact solutions in open literature for this class of problems. However, many approximations have been developed. Smith and Miller [2] firstly suggested a simple engineering method for estimating the stress intensity factors for cracks emanating from holes. Schijve [3] proposed that the stress intensity factor for a crack emanating from a notch can be written as

$$K = C\sigma_{\max}\sqrt{\pi c} \tag{1}$$

where $\sigma_{\max}$ is the peak stress at the notch root, c is the crack length as measured from the notch root (see Fig. 1), and C is the geometry factor.

Subsequently, Kujawski [4] and Lucas [5] respectively proposed different revisions for specific problems based on the approximate formula (1). Jones and Peng [1] developed a more robust approximation which is suitable for cracks at notches

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Nomenclature

a	notch depth
c	crack length
b_z	Burgers vector component
α	notch internal half-alpha
B_z	Burgers vector density
K_{III}	crack-tip stress intensity factor of mode-III
K_{III}^N	generalized stress intensity factor of mode-III
r	radial distance measured from notch-root
λ	eigenvalue
μ	shear modulus
τ	remote shear stress
τ_{zy}	stress component along the notch bisector with the absence of the crack
τ_{zy}^D	stress component along the notch bisector with the presence of a screw dislocation
τ_{zy}^{Total}	total stress component along the notch bisector with the absence of an array of screw dislocations
u_z	crack-tip tearing displacement

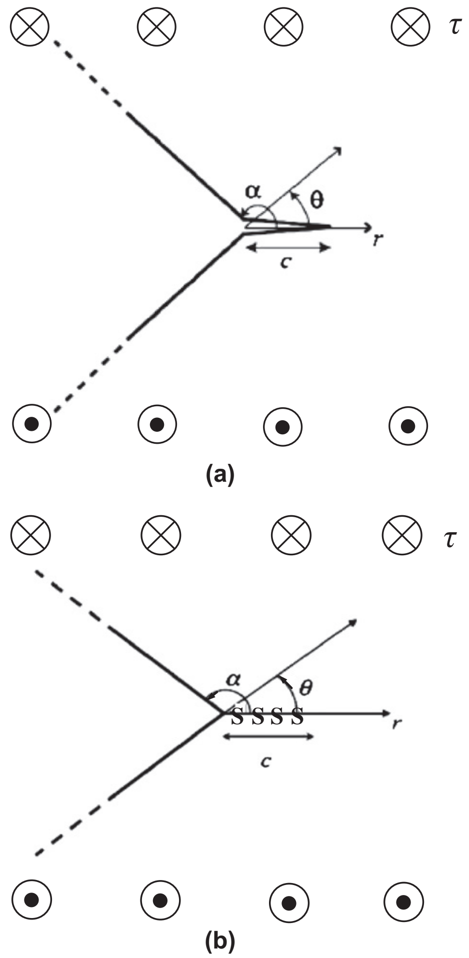

Fig. 1. (a) A finite crack of length c along the bisector of a semi-infinite notch with internal half-angle α. (b) A finite crack of length c represented using distributed screw dislocations along the bisector of a semi-infinite notch of internal half-angle α.