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Proper Nominal Stress Distribution Subjected to Combination of Wedge-Splitting and Bended Geometry Tests

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Abstract

The paper focuses on the determination of proper value of the nominal stress distribution on the combination of wedge-splitting/bended test geometry during the loading through steel platens. Since past, the parameters like stress intensity factor (e.g.) have been obtained with stress value simplified into same formulation, which means that the stress distribution is uniform. But during the real testing the stress is definitely not uniform because the splitting forces produce bending of the test specimen. That is the main goal of this study.

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Keywords: Wedge-splitting test; bending; Williams power series; Over-deterministic method; nominal stress

1. Introduction

General knowledge of stress and displacement fields in cracked bodies is crucial in the field of fracture analysis. Especially for stress state analysis, where the stress intensity factor (SIF) K is the main part of the linear elastic fracture mechanics (LEFM [1,2]). SIF characterizes stress state of some fracture problem and it depends on the same geometry, size and crack length of a body (generally, in fracture mechanics the bodies are substituted by test specimens). There are three basic loading modes of its magnitude. For normative test specimens (and other basic cases, e.g. centre crack in plate) the values of K can be found in literature by plenty of authors (e.g. [1,3,4,5]). But for special (or atypical) test geometries it is not simple to find out their values. Some techniques make it possible to obtain SIF from numerical calculations or crack elements [3,6]. The expression (1) contains variable $\sigma -$ stress

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(nominal stress in a case of uniaxial loading), which is taken with its uniform value, because there is an assumption of the same value along whole body.

Nomenclature

a	crack length [m]
A_n	term of William series [-]
α	relative crack length [-]
α_w	wedge angle [°]
B	breadth of the test specimen [m]
d_n	characteristic dimension of the test specimen [m]
E	Young's modulus [Pa]
f	characteristic dimension of the test specimen [m]
$f_{ij,\sigma}$	known functions (stress field)
$f_{i,u}$	known functions (displacement field)
g_n	dimensionless shape function [-]
G_1	gravity force, specimen [N]
G_2	gravity force, specimen [N]
G_3	gravity force, specimen [N]
G_p	gravity force, platen [N]
G_w	gravity force, loading wedge [N]
h	characteristic dimension of the test specimen [m]
i	characteristic dimension of the test specimen [m]
k	number of selected nodes around the crack tip [-]
L	length of the test specimen [m]
n	coefficient [-]
N	selected terms of Williams series [-]
ν	Poisson's ratio [-]
p	characteristic dimension of the test specimen [m]
P_{sp}	splitting (horizontal) force [N]
P_v	vertical force [N]
π	Ludolph's constant [-]
r	polar coordinate [m]
R	overall reaction [N]
S	span between supports [m]
σ_{nom}	nominal stress in the central plane of the specimen caused by the applied load [Pa]
σ_{pnom}	proper nominal stress distribution in the central plane of the specimen caused by the applied load (all) [Pa]
θ	polar coordinate [deg]
W	width of the test specimen (ligament) [m]
W_{ef}	effective width of the test specimen, conceptual misinterpretation with W [m]

In the case of wedge-splitting test specimen (WST [7]) the assumption about uniform distribution of nominal (gross) stress is based on the compact tension (CT) test specimen and it is simply given by the formula $\sigma_{nom} = P_{sp}/BW$ (splitting force of the general load divided by breadth and width of the test specimen) in the central plane of the specimen. But in a real situation, there are plenty of different boundary conditions (mostly given by the loading) which influence the stress distribution along the body. New way of obtaining different constraint condition in front of the propagating crack was introduced in work [8,9] – combination of wedge-splitting/bended test configuration, see Fig. 1. Change of specimen's dimensions leads to non-uniform stress distribution and it is necessary to count down with many bending moments given by applied forces (from loading wedge), dead load and overall reaction.