Available online at www.sciencedirect.com
SCIENCE DIRECT®
Engineering Fracture Mechanics 73 (2006) 91–111
Engineering Fracture Mechanics
www.elsevier.com/locate/engfracmech

Stress intensity factors for cracked T-sections and dynamic behaviour of T-beams

P. Ricci, E. Viola *

Distart-Department, University of Bologna, Viale Risorgimento 2, Bologna 40136, Italy

Received 21 September 2004; received in revised form 25 May 2005; accepted 24 June 2005
Available online 22 September 2005

Abstract

This paper presents an extension of a simple and convenient method proposed by Kienzler and Herrmann [An elementary theory of defective beams. Acta Mech 1986;62:37–46] to estimate the stress intensity factors of cracked beams and bars. This method is based on an elementary beam theory estimation of the strain energy release as the crack is widened into a fracture band. As an extension, the power of the simple beam theory analysis is demonstrated by application to cracked T-beams subjected to a bending moment, shear forces and a torsion. Moreover, the present work addresses the coupled bending-torsional vibration of cracked T-beams within the context of the dynamic stiffness matrix method of analysing structures.

Keywords: Fracture mechanics; Line spring model; Stress intensity factor; Dynamic stiffness matrix; T-beams

1. Introduction

The knowledge of the stress intensity factors plays an important role in fracture control. Stress intensity factors for many configurations are available in the literature [2–4]. The results were obtained by means of analytical and numerical methods as well as by finite element and boundary element methods. Unfortunately, solutions for many structural configurations are not available in the handbooks. Simple engineering methods for a fast and close approximation of stress intensity factors in cracked or notched beams have been proposed by a large number of researchers. In 1986, Kienzler and Herrmann [1] assumed that the strain energy release rate G for crack extension is equal to that for crack widening so that Irwin's G–K relation can be used to determine the stress intensity factors K.

* Corresponding author. Tel.: +39 051 209 3510; fax: +39 051 209 3495.
E-mail address: erasmo.viola@mail.ing.unibo.it (E. Viola).

0013-7944/$ - see front matter
doi:10.1016/j.engfracmech.2005.06.003

Nomenclature

M	bending moment
EI	bending stiffness of the uncracked section
EI^c	bending stiffness of the cracked section
I	moment of inertia of the uncracked section
I^c	moment of inertia of the cracked section
E, G	Young's modulus and shear modulus
w	width of the fracture band
U	strain energy of the body
N	axial force
EA	tension stiffness
A	area of the uncracked section
A^c	area of the cracked section
T	torque
GJ	torsional rigidity
$\mathbf{L}$	localization operator or Boolean matrix
J	polar moment of inertia of the uncracked section
J^c	polar moment of inertia of the cracked section
S	shear force
χ	shearing factor
β	slope of the stress diffusion lines
$K_{\rm I}$	stress intensity factor for mode I
$K_{\rm II}$	stress intensity factor for mode II
$K_{\rm III}$	stress intensity factor for mode III
v	Poisson's coefficient
a	crack length
d	flange width of the T-section
$\bar{d}$	width of the rectangular cross-section
h	height of the cross-section
b	breadth flange of the T-section
c	web width of the T-section
e	eccentricity of the neutral axis
F	geometric function
G	strain energy release rate
$\lambda_{\rm mm}$, $\lambda_{\rm ss}$, $\lambda_{\rm tt}$	compliances for bending moment, shear force and torsion
θ, ψ, h'	rotations and deflection of the cross-section across the line-spring
$\mathbf{k}_{\rm c}$	stiffness matrix of the line-spring
$E_{\rm s}$	shear centre of the T-section
$G_{\rm s}$	mass centre of the T-section
m	mass per unit length
I_α	polar mass moment of inertia per unit length
x_α	distance of separation between the elastic axis and the mass axis
t	time
H^*	coefficient for plane stress and plane strain
$H(y)$	amplitudes of the sinusoidally varying vertical displacement