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Review

Analytical flaw assessment

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ABSTRACT

The paper provides a review on analytical flaw assessment methods with the focus on fracture under monotonic loading and fatigue crack propagation. The first topic comprises linear elastic as well as elastic-plastic fracture mechanics approaches. It essentially follows their historical development. Topics which are separately discussed are reference/limit loads, the treatment of secondary stresses, strength mismatch, constraint, unstable crack propagation (monotonic R-curve analyses) and statistical aspects. With respect to fatigue crack propagation the analytical treatment of crack closure and constraint and the determination of the cyclic elastic-plastic crack driving force is discussed. Finally, cyclic R-curve analyses are briefly addressed.

Contents

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Nomenclature

a	crack length (crack depth for surface cracks)
a_{eff}	plastic zone corrected crack length a + r_p (Section 2.2.2)
a_i	initial crack depth (for cyclic fracture mechanics analysis; Fig. 51)
a_0	initial crack depth (for monotonic fracture mechanics analysis; Fig. 11)
a_0	El Haddad parameter, Eq. (185)
a^*	correction term for modified El Haddad's model, Eqs. (189) and (191)
a/c	crack aspect ratio
c	half crack length at surface (semi-elliptical crack)
$\bar{c}$	half length of an equivalent through-thickness crack (design curve)
C, n	fit parameters of the da/dN-ΔK curve in the Paris regime
d	length of plastic strip (Dugdale model, Section 2.2.3)
d_n	coefficient (HRR field solution)
da/dN	fatigue crack propagation rate
E	modulus of elasticity (Young's modulus)
E'	= E for plane stress and $E/(1-\nu^2)$ for plane strain conditions
f	crack closure function of the NASGRO equation, Eq. (146)
F_Y	net section yield load (general)
F_{YB}	F_Y of base plate material (weldments)
F_{YM}	equivalent strength mis-match corrected F_Y
F_{YW}	F_Y of weld metal (weldments)
f (L_r)	plasticity correction function (monotonic loading, reference stress method)
f (ΔL_r)	plasticity correction function (cyclic loading)
F^K	reserve factor (fracture resistance) in the FAD approach, Eq. (137)
F^σ	reserve factor (yield strength) in the FAD approach, Eq. (138)
G_Y	(elastic) energy release rate at the unset of general yield (Eqs. (21)–(28))
h_1, h_2	influence functions (EPRI scheme, Section 2.2.7) for J and δ
H	width or half width of the weld strip (strength mismatch consideration)
J	J-integral (monotonic loading)
J_c	critical J-integral
J_e	elastic component of the J-integral
J_i, $J_{0.2/BL}$	resistance against stable crack initiation (monotonic loading)
J_p	plastic component of the J-integral
J^s	J-integral due to secondary stresses
J_Y	J-integral at the onset of general yield
K	stress intensity factor (K-factor)
K_{eff}	plastic zone corrected K factor (Section 2.2.2)
K^J	K factor formally derived from J-integral
K_J^s	ligament yielding corrected K^J
K_{mat}	fracture resistance, monotonic loading (general)
K_{mat}^c	constraint-corrected K_{mat} (R6 routine; Eq. (130))
K_{max}	maximum K-factor in a loading cycle (fatigue crack propagation)
K_{min}	minimum K-factor in a loading cycle
K_{op}	K-factor at crack opening (cyclic loading)
K^p	K factor due to primary stresses
K_r	ordinate of the FAD diagram (= K/K_{mat})
K^s	K factor due to secondary stresses
K_I	K-factor for mode-I-crack opening (normal to the crack faces)
K_{Ic}	fracture resistance of the material (small scale yielding conditions)
L	characteristic dimension (EPRI scheme)
L_r	ligament yielding parameter for monotonic loading

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