Book of Abstract

Characterisation of Crack/Notch Tip Fields

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7th of June (Day 3)

Session VIII – *Chairman:* Thierry Palin-Luc

9.00-9.20 **Aleksandar Sedmak, Srdja Perkovic, Zijah Burzic, Zoran Radakovic.**
Notch vs. crack effects on impact toughness of a duplex steel .... *p. 61*

9.20-9.40 **Giovanni Meneghetti, Alberto Visentin, Alberto Campagnolo.**
Implementation of the Peak Stress Method for the automated FEA-assisted design of welded structures subjected to variable amplitude multiaxial fatigue loads .... *p. 43*

9.40-10.00 **Paolo Livieri, Roberto Tovo.**
Review of the design fatigue strength for steel butt welded joints: influence of geometrical factors and shape defects .... *p. 33*

10.00-10.20 **Paolo Livieri.**
Simplified analysis of stress intensity factors at weld toe .... *p. 31*

10.20-10.50 Coffee break

10.50-11.50 Discussion Session & Closure – *Chairman:* Michael Vormwald & Youshi Hong

End of Day 3

Simplified analysis of stress intensity factors at weld toe

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The J-integral is a path-independent integral introduced by Rice [1] and Cherepanov [2], that established a simple relationship between the path integral and the stress intensity factors (SIF) of a crack subjected to mode I, mode II and mode III loadings. Successively, Chiarelli and Frediani [3] and Huber et al. [4] considered the extension from a 2D to 3D model by considering an integral in a plane perpendicular to the crack front starting from Eshelby's energy momentum tensor.

The J-integral applied to a V-notch in a plate (namely J_V) is not constant if the initial and final integration points are moved along the side but the path independence of the integral is always verified. If we consider a path with fixed points at each end at the same distance ρ from the origin (see Figure 1), the J_V assume a simplified formulation [5,6]:

$$J_V = J_{V1} + J_{V2} + J_{V3} = \bar{J_1}\,\frac{{K_{N,1}}^2}{E'}\,\rho^{2\lambda_1-1} + \bar{J_2}\,\frac{{K_{N,2}}^2}{E'}\,\rho^{2\lambda_2-1} + \bar{J_3}\,\frac{{K_{N,3}}^2}{2\,G}\,\rho^{2\lambda_3-1} \qquad (1)$$

where K_N are the notch stress intensity factors, $\bar{J_i}$ are parameters that only depend on the opening angle 2α, E' is equal to the elastic modulus E for plane stress and $E'=E/(1-\nu^2)$ for plane strain, and G is the shear modulus. Furthermore, each J_V mode is proportional to the corresponding mode (I, II or III) of the classic J_i integral of a virtual embedded crack lying along the bisector of the V-notch and with a length equal to ρ (see Figure 2):

$$\frac{J_i\big|_a}{J_{V,i}\big|_{r=\rho}} = \nu_i \qquad i = 1,2,3 \qquad (2)$$

The parameters ν_i are reported in Table 1 for and opening angle of 135 degrees. So that, the stress intensity factors of a crack behind a sharp V-notch can be calculated by means of the J_V evaluated for the V-notch without modelling the crack with the same external load and boundary conditions. Table 3 reports the values of ν_i for a selected opening angle.

The aim of this paper is to verify the use of the J_V integral in welded structures for the evaluations of the stress intensity factors of a crack at the weld toe by means of the three-dimensional FE model without modelling the crack. Figure (2) shows a hollow section subjected to tensile loading (F) and torque (M_t). The opening angle is of 135 degrees. When the size of the weld toe tends to zero, accurate FE analysis show that the ν_i parameters tend to that reported in table 1. Figure 2 shows the trend of ν_1.

Table 1. ν_i parameters for an opening angle of 135 degrees

2α	ν_1	ν_2	ν_3
135°	1.74	2.12	1.23

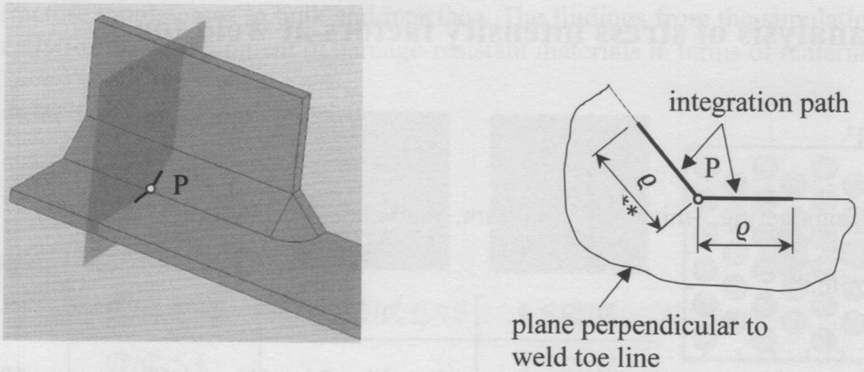

Figure 1. J_V for a welded joint with a sharpe V-notch.

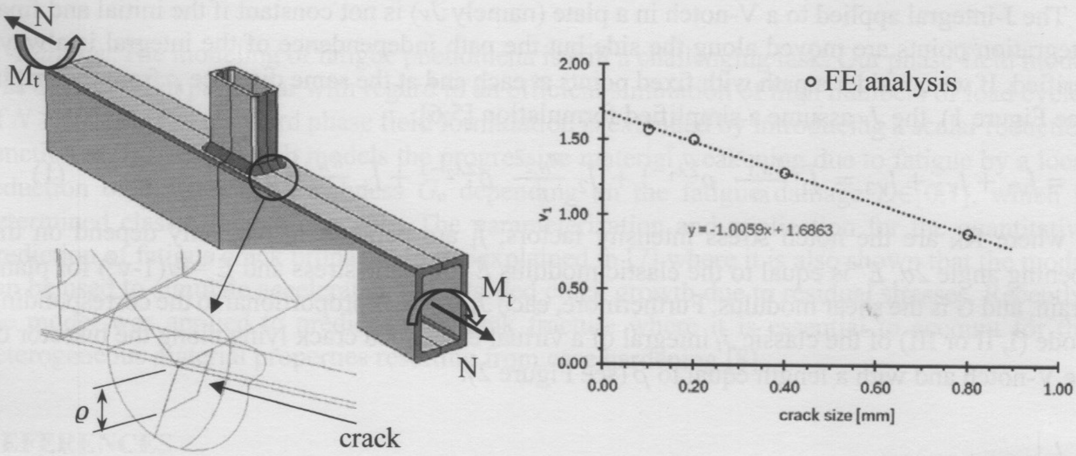

Figure 2. Value of the parameter v_1 at the weld toe obtained with a three-dimensional FE analysis.

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