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Discussion

Energy-Release Rate in Elastic-Plastic Fracture Problems[1]

A. G. Herrmann[2] and G. Herrmann.[2] It is believed that the analysis and results presented in this paper cannot be correct for several different and independent reasons.

1 So-called path-independent integrals can be meaningfully discussed only for closed paths enclosing a defect. They are derived via Gauss theorem which requires closed surfaces or contours. The authors, however, consider an open path. The same inadmissible consideration is also applied, incidentally, in references [5] and [6] of the paper by the same authors. This renders their proof of path-independence invalid.

2 Path-independence of an integral means that the path can be absolutely arbitrary as long as it is closed. But the authors are not able to let their path enter or cross the process zone and thus the very foundation on which the J, L, and M integrals are based, as discussed in references [2] and [3] of the paper, are violated. The decomposition (equation (20) of the paper) implies that all integrals involving $\hat{J}_\alpha$, $\hat{L}_3$, $\hat{M}$, and I are taken around a crack tip. Even for a straight crack in static elasticity the contours for L and M are taken around the whole crack. (See e.g. reference [3] of the paper.)

3 Rice's J integral is based on the translational invariance requirement. In the purely elastic body, as a plane crack grows, the stress field around the crack moves with the crack tip. In the case of elastic-plastic fracture, however the plastic deformation (or process region) is left behind (as a wake) and thus translational invariance is violated.

4 For a curved crack considered by the authors, translational invariance is again obviously violated as the crack grows, which renders their results invalid.

5 It has been shown [1] that even for a plane crack only one component of the so-called J-vector (namely Rice's integral) is path-independent, while the other is indeed path-dependent. Thus authors' proof concerning path-independence is again invalid.

[1]By S. Aoki, K. Kishimoto, and M. Sakata, and published in the December, 1981, issue of the ASME JOURNAL OF APPLIED MECHANICS, Vol. 48, pp. 825–829.

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References

1 Herrmann, A. G., and Herrmann, G., "On Energy-Release Rates for a Plane Crack," ASME JOURNAL OF APPLIED MECHANICS, Vol. 48, 1981, pp. 525–528.

Authors' Closure

We appreciate the discussers' interest and comments. Their remarks are thought to come from the difference in the interpretation of the crack model adopted in the paper. The authors have considered that the fracture process region is of a finite size. Since the usual continuum mechanics cannot be applied to this region where microstructural processes take place, an attempt has been made to relate Φ (i.e., the time rate of the energy change referred to the fracture process region A_{end} near a crack tip) to the physical quantities in the regular region A, where the continuum mechanics work.

1. The fact that the values of $\hat{J}_\alpha$, $\hat{L}_3$, and $\hat{M}$ do not depend on the choice of $\Gamma + \Gamma_s$ for a prescribed Γ_{end} is proved by using a closed contour $(\Gamma + \Gamma_s)$ and Gauss theorem in the Appendix of the paper.

2. It is noted that the J, L, and M integrals are thought to be defined using a model with an infinitesimal fracture process region. In the fracture process region with a finite size as considered in this paper, the usual continuum mechanics do not work; therefore one cannot consider a path entering or crossing the process region.

We have focused our attention on one crack tip. If we consider both crack tips simultaneously, it would be possible to take Γ_{end} as the sum of Γ_{end} of each crack tip plus the path along the crack surfaces, and Γ as a contour surrounding the whole defects, i.e., a crack and both process regions (Γ_s is not necessary here because the crack surfaces are included in the Γ_{end}). In the case, the path Γ is the same as the path for L and M in [3].

3. It is obvious that the assumption of translational invariance does not hold in the case of elastic-plastic fracture. Therefore, the authors have considered deformation of the process region during crack extension. This fact reflects that Φ cannot be presented only by the translation component $\hat{J}_\alpha$ (see equation (20)). The $\hat{I}$ includes the energy change associated with the nonsteady deformation and contributes considerably to Φ.

4. The authors have also thought that translational invariance is violated for a curved crack. This is why Φ includes not only $\hat{J}_\alpha$, but also $\hat{L}_3$, $\hat{M}$, and $\hat{I}$ as shown in equation (20). It is thought that $\hat{L}_3$ is important in this case.

5. By introducing Γ_s, i.e., the path along the crack surfaces, we have obtained the path-independent (in the sense of the first comment of this Closure) $\hat{J}_\alpha$ integral.