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Add stronger singularities to improve numerical accuracy - Discussion of fracture paper #20

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2018

Document Version:
Förlagets slutgiltiga version

Link to publication

Citation for published version (APA):
Ståhle, P. (Red.), & Ståhle, P. (2018). Add stronger singularities to improve numerical accuracy - Discussion of fracture paper #20. Elsevier.

Total number of authors:
2

Engineering Fracture Mechanics
An International Journal

ELSEVIER

iMechanica Blog

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10 June 2018

It is common practice to obtain stress intensity factors in elastic materials by using Williams series expansions truncated at the r^(-1/2)-stress term. I ask myself, what if both evaluations of experimental and numerical data is improved by including lower order (stronger singularities) terms? The standard truncation is done in a readworthy paper
"Evaluation of stress intensity factors under multiaxial and compressive conditions using low order displacement or stress field fitting", R. Andersson, F. Larsson and E. Kabo, in Engineering Fracture Mechanics, 189 (2018) 204–220,
where the authors propose a promising methodology for evaluation of stress intensity factors from asymptotic stress or displacement fields surrounding the crack tip. The focus is on cracks appearing beneath the contact between train wheel and rail and the difficulties that is caused by compression that only allow mode II and III fracture. The proposed methodology is surely applicable to a much larger collection of cases of fracture under high hydrostatic pressure such as at commonplace crushing or on a different length scale at continental transform faults driven by tectonic motion. In the paper they obtain excellent results and I cannot complain about the obtained accuracy. The basis of the analysis is XFEM finit element calculations of which the results are least square fitted to a series of power functions $r^{n/2}$. The series is truncated at n=-1 for stresses and 0 for displacements. Lower order terms are excluded. We know that the complete series, converges within an annular region between the largest circle that is entirely in the elastic body and the smallest circle that encircles the non-linear region at the crack tip. In the annular ring the complete series is required for convergence with arbitrary accuracy. Outside the annular ring the series diverges and on its boundaries anything can happen. A single term autonomy is established if the stress terms for n<-1 are insignificant on the outer boundary and those for n>-1 are insignificant on the inner boundary. Then only the square root singular term connects the outer boundary to the inner boundary and the crack tip region. Closer to the inner boundary the n≤-1 give the most important contributions and at the outer the n≥-1 are the most important.

I admit that in purely elastic cases the non-linear region at the crack tip is practically a point and all terms n<-1 become insignificant, but here comes my point: Both at evaluation of experiments and numerics the accuracy is often not very good close to the crack tip which often force investigators to exclude data that seem less accurate. This was done in the reviewed paper, where the result from the elements closes to the crack tip was excluded. This is may be the right thing to do but what if n=-2, a r^-1 singularity is included? After all the numerical inaccuracies at the crack tip or the inaccurate measurements or non-linear behaviour at experiments are fading away at larger distances from the crack tip. In the series expansion of stresses in the elastic environment this do appear as finite stress terms for n≤-1.
It would be interesting to hear if there are any thoughts regarding this. The authors of the paper or anyone who wishes express an opinion is encouraged to do so.

Per Ståhle