Elastic-Plastic Deformation in Edge-Notched Tension Specimens Under Plane Stress Conditions

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I have several questions of the author on the work in his paper. These are as follows:

1. From what I can determine in reading the author's manuscript, the FEA strains which are plotted are for the element closest to the notch root surface. This would normally be the strain for the centroid of the element, and not the notch root surface. For the higher net-section stress levels (i.e., ~40 to 50 ksl), the strain gradients in the specimens become very steep, and the surface strain could be somewhat greater than at the centroid of the element. I would think on this basis, that an extrapolation of the strain distribution to the notch root surface would yield a better comparison with experiment. Has the author investigated this possibility?

2. This is the first paper I have seen on notch specimen FEA where corrections have been included in the analysis for geometry changes. For the range of notch root strains studied, have similar analyses been completed without the geometry corrections? If so, can the author comment on the magnitude of strain where the large deformation correction becomes important, or conversely, the limitations in small deformation theory.

3. It appears to me that the definition of strain concentration factor used in developing the Neuber relationship, equation (1a) [i.e., \( KE = \frac{e_{net}}{e_{net+}} = \frac{e_{net}}{\sigma_{net}/E} = \frac{e_{net}E}{\sigma_{net}} \)], implies that the application of this relationship should be restricted to the range of strains where the net-section remains nominally elastic. Does the author agree or disagree on this point?

In conclusion I have the following comments from my own experience with notch specimen FEA. I have been a co-author of a paper in which FEA was used to study the nonlinear notch root stress and strain behavior of grooved cylinder and plate strain bending specimens. Comparisons in that paper of FEA calculated strains with experimental results showed excellent correlations for strains up to ~1.0 percent. Also, comparison with Neuber and Sotwell-Hardrath predictions, showed the latter relationships to always give conservative predictions of the notch root strains.

Author's Closure

The author wishes to thank Dr. Mowbray for his stimulating comments.

The computed notch root strains, \( e_{net} \), plotted in Figs. 3 and 4 of the author's manuscript represent the axial strain in the small element adjacent to the notch root surface at the base of the notch (see Fig. 2 of the author's paper). Because of the severe strain gradient beneath the notch root, this strain is no doubt somewhat less than that occurring immediately at the notch surface. In the present finite element analyses, however, this difference is expected to be small by virtue of the relatively fine grid network employed; the small element in question extends to a depth of only \( p/32 \) beneath the notch root surface (\( p \) refers to the notch root radius).

Following Dr. Mowbray's suggestion the author has recently utilized an extrapolation scheme to better approximate the notch surface strain. The axial strain distribution along the minimum section was determined in terms of a plot of log \( e_{ax} \) versus log \( (1 + x/p) \), where \( e_{ax} \) is the axial strain and \( x \) is the distance beneath the notch root. The value of \( e_{ax} \) at a given mode on the net section was computed as the average of the strains in the surrounding elements. When the curves are extrapolated back to the notch root surface, the resulting values of \( e_{net} \) are a maximum of 2 percent greater than those reported previously, even at load levels above general yielding when the strain gradients are most severe. Although incorporation of this correction will improve the comparison with the experimental data, other factors must also contribute to the observed 10 to 20 percent discrepancy near general yield.

The author certainly agrees with Dr. Mowbray in that the Neuber relationship should, at best, be restricted to nominally elastic loading. As stated in the author's paper, significant errors (~25 percent) in strain determination may arise in using Neuber's equation even at low, nominally elastic, stress levels.

The writer has not had the opportunity to assess the significance of the approximate correction for large displacements in the finite element calculations. The correction is quite straightforward and affords no appreciable penalty in computing time, and was utilized solely on this basis.

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