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3D Microstructural Effects on Plane Strain Ductile Crack Growth

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Ductile crack growth in structural metals occurs by the nucleation, growth and coalescence of microvoids. Quite typically, this mechanism involves two populations of void nucleating particles; larger inclusions that nucleate voids rather early in the deformation history and smaller particles that nucleate voids at larger strains. Even when the overall mode of crack growth is plane strain, the distribution of the larger inclusions plays a major role in setting the crack path which affects the material's crack growth resistance. In this study, ductile crack growth under mode I, plane strain, small scale yielding conditions is analyzed. An elastic-viscoplastic constitutive relation for a porous plastic solid is used to model the material. Two populations of second phase particles are represented, large inclusions with low strength, which result in large voids near the crack tip at an early stage, and small second phase particles, which require large strains before cavities nucleate. The larger inclusions are represented discretely and it is their spatial distribution that gives rise to the 3D effects in our analyses. Adiabatic heating due to plastic dissipation and the resulting thermal softening are accounted for in the analyses. The effect of the 3D distribution of the larger inclusions on the initiation of crack growth, on the evolution of the crack path and on the material's crack growth resistance are investigated.

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