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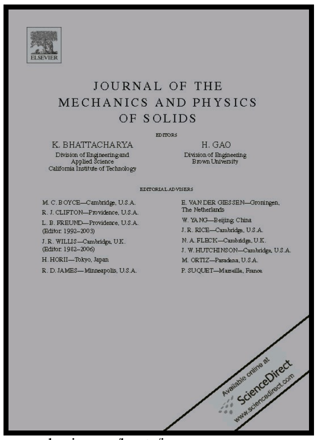

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Deformation mechanisms of idealised cermets under multi-axial loading

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Abstract
The response of idealised cermets comprising approximately 60% by volume steel spheres in a Sn/Pb solder matrix is investigated under a range of axisymmetric compressive stress states. Digital volume correlation (DVC) analysis of X-ray micro-computed tomography scans (μ-CT), and the measured macroscopic stress-strain curves of the specimens revealed two deformation mechanisms. At low triaxialities the deformation is granular in nature, with dilation occurring within shear bands. Under higher imposed hydrostatic pressures, the deformation mechanism transitions to a more homogeneous incompressible mode. However, DVC analyses revealed that under all triaxialities there are regions with local dilatory and compaction responses, with the magnitude of dilation and the number of zones wherein dilation occurs decreasing with increasing triaxiality. Two numerical models are presented in order to clarify these mechanisms: (i) a periodic unit cell model comprising nearly rigid spherical particles in a porous metal matrix and (ii) a discrete element model comprising a large random aggregate of spheres connected by non-linear normal and tangential "springs". The periodic unit cell model captured the measured stress-strain response with reasonable accuracy but under-predicted the observed dilation at the lower triaxialities, because the kinematic constraints imposed by the skeleton of rigid particles were not accurately accounted for in this model. By contrast, the discrete element model captured the kinematics and predicted both the overall levels of dilation and the simultaneous presence of both local compaction and dilatory regions with the specimens. However, the levels of dilation in this model are dependent on the assumed contact law between the spheres. Moreover, since the matrix is not explicitly included in the analysis, this model cannot be used to predict the stress-strain responses. These analyses have revealed that the complete constitutive response of cermets depends both on the kinematic constraints imposed by the particle aggregate skeleton, and the constraints imposed by the metal matrix filling the interstitial spaces in that skeleton.

Keywords: cermets, porous plasticity, kinematic constraints, discrete element, digital volume correlation, micro-computed tomography.

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