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The lay-out of a numerical solution procedure for the strain gradient flow (rate-independent) theory by Fleck and Willis [A mathematical basis for strain-gradient theory – Part II: Tensorial plastic multiplier, 57:1045–1057; 2009, JMPS] has been an open issue, and its finite element implementation is yet to be completed. Only recently, a sound solution procedure that allows for elastic–plastic loading/unloading and the interaction of multiple plastic zones has been put forward, and demonstrated within a 1D model set-up. The aim of the present work is to extend this procedure to form a basis for 2D and 3D calculations, and thereby to broaden its use within engineering applications. Focus is on the numerical implementation that adopts image analysis techniques to identify individual plastic zones and to treat none-regular mesh configurations. The developed finite element model is demonstrated through; i) tensile loading of a finite homogeneous material slab that offers a simple interpretation of results, ii) tensile loading of a double edge notch tension specimen involving symmetry considerations, and iii) shearing of a periodically voided structure that displays the ability of the procedure to treat periodic boundary conditions. A comparison between the implemented flow theory model and the corresponding rate-dependent visco-plastic version of the model shows coinciding results in the limit of zero rate-sensitivity.
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 1.231 SNIP 1.681
Web of Science (2010): Impact factor 1.414
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 1.642 SNIP 1.617
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.644 SNIP 1.659
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 1.389 SNIP 1.578
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 1.023 SNIP 1.574
Scopus rating (2005): SJR 1.17 SNIP 1.085
Scopus rating (2004): SJR 1.401 SNIP 1.25
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.348 SNIP 1.468
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.464 SNIP 1.349
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 0.971 SNIP 1.259
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 1.324 SNIP 1.212
Scopus rating (1999): SJR 1.423 SNIP 1.261
Original language: English
Keywords: Higher order theory, Size effects, FEM
DOIs:
10.1016/j.euromechsol.2013.03.002
Source: dtu
Source-ID: n::oai:DTIC-ART:elsevier/386500330::28511
Research output: Research - peer-review › Journal article – Annual report year: 2013