

Granular-based continuum elasto-plastic–damage variational formulation for strain gradient solids

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Abstract: This work is devoted to the presentation of a continuum theory [1,2] for materials having granular microstructure [3,4]. It accounts for tension–compression asymmetry of grain interactions and for dissipative phenomena like damage and plasticity. The continuum description is constructed by assuming expressions of elastic and dissipation energies as well as postulating a hemi-variational principle. Granular micromechanics is connected kinematically to the continuum scale through Piola’s ansatz. Karush–Kuhn–Tucker (KKT)-type conditions, providing evolution equations for damage and plastic variables associated with grain–grain interactions, are derived solely from the fundamental postulates. Numerical experiments have been performed to investigate the applicability of the model. Results show: (i) damage and plastic induced anisotropy evolution including the emergence of a type of chiral behavior. (ii) formation of finite localization zones. (iii) loading–unloading histories have been considered to elucidate the material hysteretic features of the continuum. (iv) The interaction between damage and plasticity, each having an effect on the other, shows the fatigue behavior of the material. (v) A particular expression for the dissipation energy results in numerical simulations of the experimental behavior of the Ultra High Performance Concrete. (vi) Emergence of the critical state of a granular assembly has been derived with a systematic parametric analysis.

References:

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Bio: Luca Placidi graduated in Physics at the University of Naples Federico II in 2001 and in Engineering in 2002 at the Virginia Tech University. He graduated as PhD in 2006 at the University of Rome La Sapienza and during the course worked as visiting student at the Technical University of Darmstadt. After graduation he worked as researcher in several universities and is currently associate professor at the International Telematic University Uninettuno since 2019. His research interests include continuum mechanics, strain-gradient analysis and damage of condensed matter and metamaterials.

Luca Placidi is author of more that 70 papers published in international journals and contributed to more than 20 scientific projects. In addition, he has been involved several times in research appointments abroad: in 2005 at the Low Temperature Institute University (Hokkaido) of Sapporo in Japan working with Prof. R. Greve. In 2007 at the Poly Technical University of New York (USA) working with Prof. M. Porfiri. In 2007 and in 2015 at the Institut de Mathématiques de Toulon et du Var working with Prof. P. Seppecher. The last visit was financed by the Erasmus program. In 2015 two times at the Université Paris-Est Créteil Val de Marne working with prof. G. Rosi. This last 2 missions were financed by CNRS International Associate Laboratory Coss&Vita and the project was specifically devoted to this visit. In 2016 at the Laboratoire de Géologie (Ecole normale supérieure) working with Prof. Jérôme Fortin. Between the italian and abroad experiences, he has taught in many courses in subjects related to mechanics and structural mechanics. One of these courses was videotaped and posted on the website of the School of Excellence Tullio Levi-Civita.