NAPLES, ITALY 30 JUNE - 4 JULY
ACEX2025 NAPLES
18th International Conference on Advanced Computational Engineering and Experimenting

ABSTRACT

A Hemivariational Approach for Plasticity:
Hysteric Cycles, Fatigue and Application to Granular Micromechanics

In this presentation we report a new framework for plasticity, that was developed in [A] for the 1D axial case. It is based on a hemivariational procedure, similar to that developed in damage mechanics in [B], where a damage variable is assumed to have a mono lateral behaviour by imposing positive sign of damage velocity. In order to do this, the plastic displacement of an elasto-plastic spring is decomposed with the difference of two accumulation variables, having the same mono lateral property of the damage in [B]. We show, in this hemivariational approach, the derivation of the phenomenology of standard perfect plasticity, of linear (see e.g. [C]) and isotropic hardening. Besides, by insertion of proper coupling between damage and plastic variables, also the derivation of fatigue's effect, with the inclusion of the Wholer diagram, is possible. We end this first part with the derivation of a 1D elasto-plastic Euler-Bernoulli beam. 3D generalization is not easy with this approach. However, in granular micromechanics the pair interaction is of the same nature of those springs developed in the first part of the presentation. Thus, in the second part, we will derive it according to [D]. Finally, we will show applications in geotechnics [E] and in ultra high performance fiber-reinforced concrete (uhp frc) [F].

Bibliography of the abstract:
[A] Placidi, L. (2016). A variational approach for a nonlinear one-dimensional damage-elasto-plastic second-gradient continuum model. Continuum Mechanics and Thermodynamics, 28, 119-137.
[B] Francfort, G. A., & Marigo, J. J. (1998). Revisiting brittle fracture as an energy minimization problem Journal of the Mechanics and Physics of Solids, 46(8), 1319-1342.
[C] Placidi, L., Misra, A., Kandalaft, A., Nayeban, M. M., & Yilmaz, N. (2024). Analytical results for a linear hardening elasto-plastic spring investigated via a hemivariational formulation. Constructive Mathematical Analysis, 7(Special Issue: AT&A), 50-75.
[D] Placidi, L., Barchiesi, E., Misra, A., & Timofeev, D. (2021). Micromechanics-based elasto-plastic–damage energy formulation for strain gradient solids with granular microstructure. Continuum Mechanics and Thermodynamics, 33(5), 2213-2241.
[E] Yilmaz, N., Yildizdag, M. E., Fabbrocino, F., Placidi, L., & Misra, A. (2024). Emergence of critical state in granular materials using a variationally-based damage-elasto-plastic micromechanical continuum model. International Journal for Numerical and Analytical Methods in Geomechanics, 48(13), 3369-3391.

[F] Placidi, L., Dell'Isola, F., Kandalaft, A., Luciano, R., Majorana, C., & Misra, A. (2024). A granular micromechanic-based model for ultra high performance fiber-reinforced concrete (uhp frc). International Journal of Solids and Structures, 297, 112844.