International CAE Conference – Poster session

Virtual simulation of strain localization in multiphase geomaterials by using a regularized approach

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1. Introduction

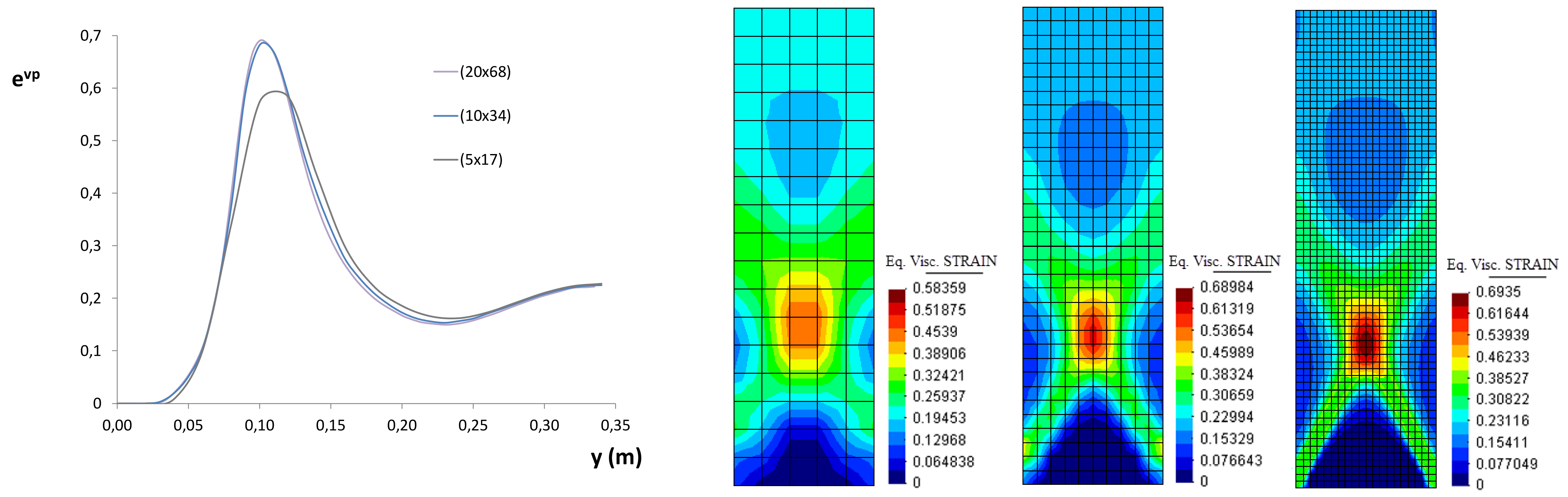
This work presents the implementation of a regularized constitutive model to avoid the mesh sensitivity problem in strain localization simulation of multiphase porous materials. For this purpose, a local viscoplastic constitutive model of Perzyna type [1] and its consistent viscoplastic tangent operator have been formulated and implemented in the finite element code Comes-geo developed at the University of Padua [2, 3, 5] based on the multiphase porous media model developed in [2] for quasi-static problems. For simplicity, the Drucker-Prager yield function with isotropic linear hardening/softening and non-associated plastic flow, has been incorporated in the viscoplastic algorithm. The regularizing effect of the viscoplastic model has been examined by the finite element simulation of a strain localization problem.

2. Problem description

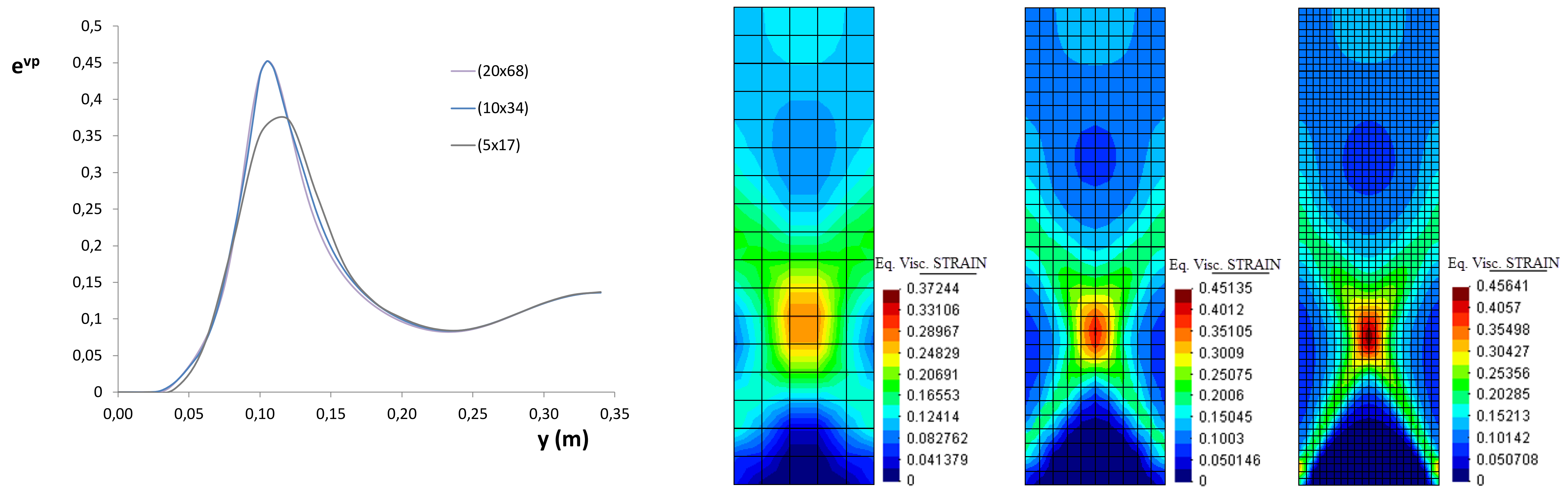
Viscoplastic regularization has been analysed in the simulation of an undrained plane strain compression test on dense sand inspired by [3, 4]. Isothermal condition is assumed. Mesh sensitivity of the results is examined by using three discretizations, namely a 5x17-mesh, a 10x34-mesh and a 20x68-mesh for a rectangular sample of homogeneous soil of 34 cm height and 10 cm width. To examine the influence of the loading velocity on the material response, two values of velocity, 1.2mm/s and 0.2mm/s, are applied on the top surface. The material is initially water saturated and the boundaries of the sample are impervious and adiabatic. Vertical and horizontal displacements are constrained on the bottom surface. The material parameters used in the computations are listed in Table 1.

3. Preliminary Numerical Results

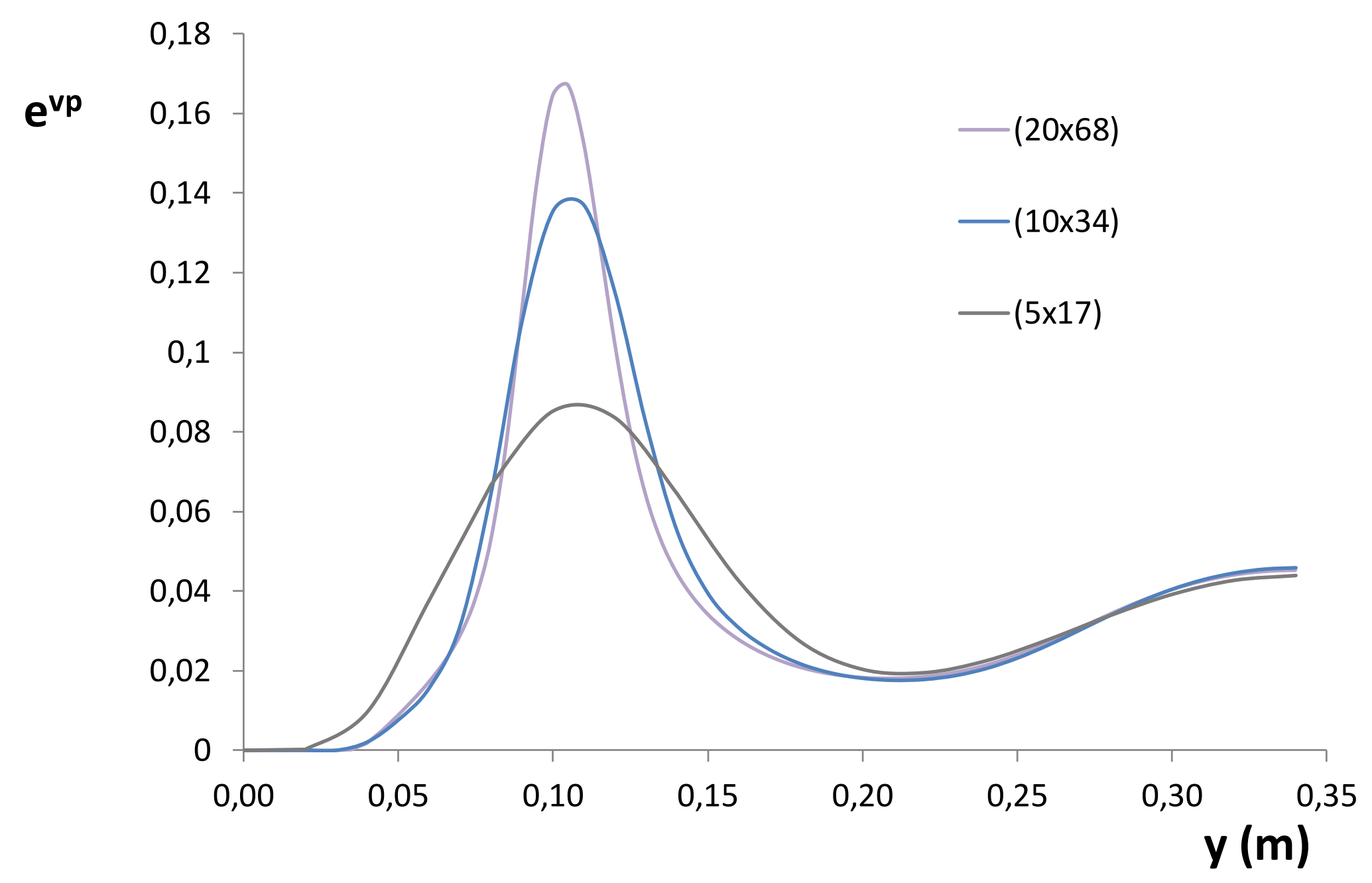
A. Loading velocity v=1.2mm/s & viscocity η=30s



B. Loading velocity v=0.2mm/s & viscocity η=110s



C. Loading velocity v=0.2mm/s & viscocity η=30s



- Case A, B: Mesh independent results are detected indicated from the contour of equivalent viscoplastic strain.
- Case C: For lower values of viscosity, mesh dependency appears, denoting the influence of the loading velocity on the viscous regularization of quasi-static processes.

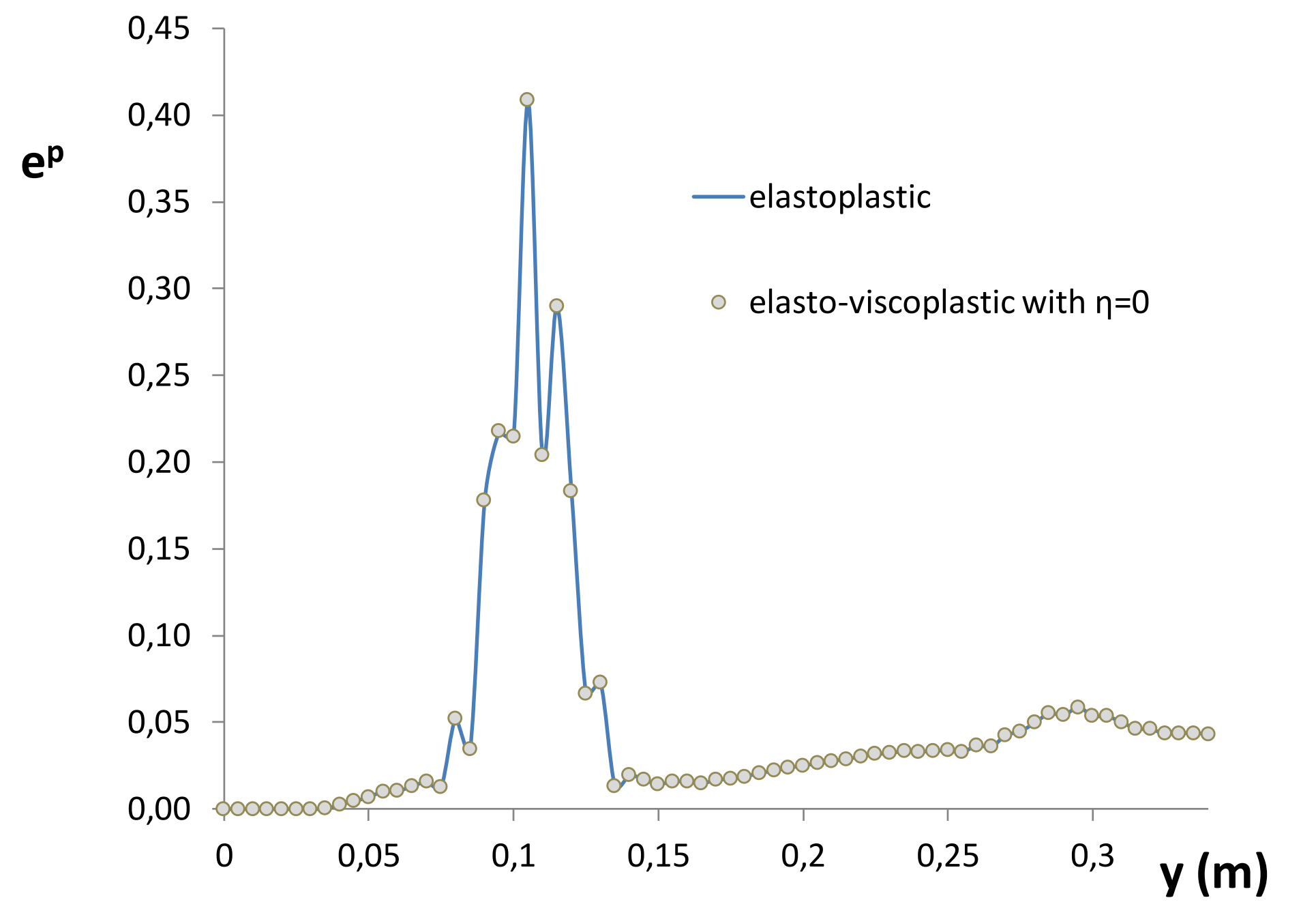


Table 1. Material parameters used in the computation

Solid density	ρ_s	2000	Kg/m^3
Water density	ρ_w	1000	Kg/m^3
Young modulus	E	3.00E+07	Pa
Poisson ratio	ν	0.4	
Initial porosity	n	0.2	
Initial apparent cohesion	c_0	5.00E+05	Pa
Linear softening modulus	h	-1.00E+06	Pa
Angle of internal friction	φ	30°	
Angle of dilatancy	ψ	20°	
Gravity acceleration	g	9.80665	m/s^2
Initial intrinsic permeability	k_w	1.00E-14	m^2

4. Future Work

- Investigation of the behaviour of fluids on this plane strain biaxial compression test.
- Implementation of a non-local viscoplastic model.

Acknowledgements

The authors would like to thank the University of Padua (projects: CPDA097373) and the 7th Framework Programme of the European Union (ITN MuMoLaDe project 289911) for the financial support of this work.

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Pacengo del Garda, Verona, (IT), October 21-22, 2013