Shear Band Localization Studies on a Second Gradient Elasto-Plastic Material using Isogeometric Analysis

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ABSTRACT

The aim of this work is to provide some insight into the shear band behaviour occurring in localized failure processes through a local second gradient model. Local second gradient models have proved to be an effective tool to simulate strain localization obtaining mesh-independent results. The model presented is based on [1] and [2] consisting in a generalization of the flow theory of plasticity for media with microstructure, which introduces implicitly an internal length through the ratio of two constitutive tensors in order to regularize the problem. We restrict our model to small strains, involving two independent mechanisms. A Von Mises model is used for the first gradient part, whereas for the second gradient one uses a simple elasto-plastic model with three different hardening laws in order to observe how the shear band width is affected by the change of the ratio of the two constitutive tensors.

The weak formulation is discretized by means of Isogeometric Finite element Analysis [3] to overcome the constraint of C1-continuity in second gradient theories. It allows a more straightforward implementation since only one unknown (displacements) field is required. Therefore, it results in a considerable decrease of computational time and smoother fields compared to classical Finite Element Method, which requires additional constraints to achieve higher continuity.

Simulations of shear band localization in biaxial tests show: i) using a linear hardening law for the second gradient part, despite the fact we obtain objective results, the shear band width increases constantly without any bound, ii) perfect plasticity and exponential hardening laws lost objectivity results when the second gradient tensor approaches to zero. These results are in accordance with the theory and set us another goal, which may be the use of one plastic mechanism involving first and second gradient terms to have a better control of the ratio that controls the internal length.

REFERENCES

[1] R. Chambon, D. Caillerie, T. Matsushima, Plastic continuum with microstructure, local second gradient theories for geomaterials: localization studies, *International Journal of Solids and Structures*, 2001, 38 (46 – 47): 8503–8527.

[2] P. Bésuelle, R. Chambon, F. Collin, Switching deformation modes in post-localization solutions with a quasibrittle material. *Journal of Mechanics of Materials and structures*, 2006, Vol. 1, No7.

[3] J.A. Cottrell, T.J.R. Hughes, Y. *Bazilevs, Isogeometric analysis: Toward Integration of CAD and FEA*. John Wiley & Sons, Chichester, England, 2009.