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EFFECT OF DISTRIBUTION OF INITIAL VOID RATIO AND BOUNDARY ROUGHNESS ON SHEAR LOCALIZATION IN GRANULAR BODIES

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ABSTRACT

Localization of deformation in the form of narrow zones of intense shearing is a fundamental phenomenon observed in granular soils under drained and undrained conditions. Thus, it is of primary importance to take it into account while modeling the behaviour of granulates. Localization under shear occurs either in the interior domain in the form of a spontaneous shear zone as a single shear zone, a multiple or a regular pattern of zones or at interfaces in the form of induced shear zones where structural members are interacting and stresses are transferred from one member to the other. The localized shear zones inside of the granular material are closely related to its unstable behaviour since they act as a precursor to the ultimate failure.

The numerical investigations of shear localization in granular bodies during a plane strain compression test were performed. The effect of the distribution of the initial void ratio and the roughness of horizontal boundaries on friction properties and shear localization formation was analyzed. To describe a mechanical behaviour of a cohesionless granular material during a monotonous deformation path in a plane strain compression test, a micro-polar hypoplastic constitutive model was used [1]. It includes particle rotations, curvatures, non-symmetric stresses, couple stresses and the mean grain diameter as a characteristic length. It was formulated within a micro-polar continuum which combines two kinds of deformations at two different levels, viz: micro-rotation at the particle level and macro-deformation at the structural level. For the case of plane strain, each material point has three degrees of freedom: two translations and one independent rotation. The gradients of the rotation are related to the curvatures, which are associated with the couple stresses. The presence of the couple stresses gives rise to a non-symmetry of the stress tensor and to a characteristic length.

The calculations were carried out with both an initially dense and initially loose granular material. The horizontal boundaries were smooth or very rough. The stochastically distributed initial void ratio was assumed to be spatially correlated [2], [3]. Truncated Gaussian random fields of the initial void ratio were generated using a conditional rejection method for correlated random fields [4].In this method, a “base

scheme" was defined which covered a limited mesh area (hundred points), and only these points were used in the calculations of the next random values. The simulation process was divided into three stages. First, the four-corner random values were generated using an unconditional method. Next, all random variables in the defined base scheme were generated, one by one, using a conditional method. In the third stage, the base scheme was appropriately shifted, and the next group of unknown random values was simulated. The base scheme was translated so as to cover all the field nodes. The proposed approach allows for generation of practically unlimited random fields (thousands of discrete points).

The approximated results were obtained using a Latin hypercube sampling method belonging to a group of reduced Monte Carlo Methods. This approach enables a significant reduction of the sample number without loosing the accuracy of calculations. The FE-results with an initially dense specimen at smooth horizontal boundaries were quantitatively confronted with corresponding laboratory experiments performed by Vardoulakis [5]. In turn, the type of shear localization numerically obtained was qualitatively compared with comprehensive plane strain compression laboratory tests carried out with sand at Grenoble University [6] for different initial void ratios, lateral pressures, specimen geometries, boundary roughness, imperfections and induced deformation along the top plate. During these experiments single and multiple shear zones were observed depending upon boundary conditions of the entire system.

REFERENCES

[1] J. Tejchman and W. Wu, "Modeling of textural anisotropy in granular materials with micro-polar hypoplasticity", *International Journal of Non-Linear Mechanics,* **42**, pp. 882– 894, (2007).

[2] J. Tejchman and J. Górski, "Deterministic and statistical size effect during shearing of granular layer within a micro-polar hypoplasticity", *Int. Journal for Numerical and Analytical Methods in Geomechanics*, (2007) (in press), doi: 10.1002/nag.617.

[3] J. Tejchman and J. Górski, "Computations of size effects in granular bodies within micro-polar hypoplasticity during plane strain compression", *Int. J. for Solids and Structures*, (2008), doi:10.1016/j.ijsolstr.2007.10.007.

[4] H. Walukiewicz, E. Bielewicz and J. Górski, "Simulation of nonhomogeneous random fields for structural applications", *Computers and Structures,* **64,** pp. 1-4, pp. 491-498, (1997).

[5] I.Vardoulakis, "Shear band inclination and shear modulus in biaxial tests", *Int. J. Num. Anal. Meth. Geomech.,* **4**, pp. 103-119, (1980).

[6] J. Desrues and C. Viggiani, "Strain localization in sand: overview of the experiments in Grenoble using stereophotogrammetry", *J. Num. and Anal. Methods in Geomechanics*, **28**, 4, pp. 279-321, 2004.