Anisotropic failure criterion for an argillaceous rock: formulation and application to an underground excavation case

Miguel A. Mánica*†, Antonio Gens†, Jean Vaunat† and Daniel F. Ruiz†

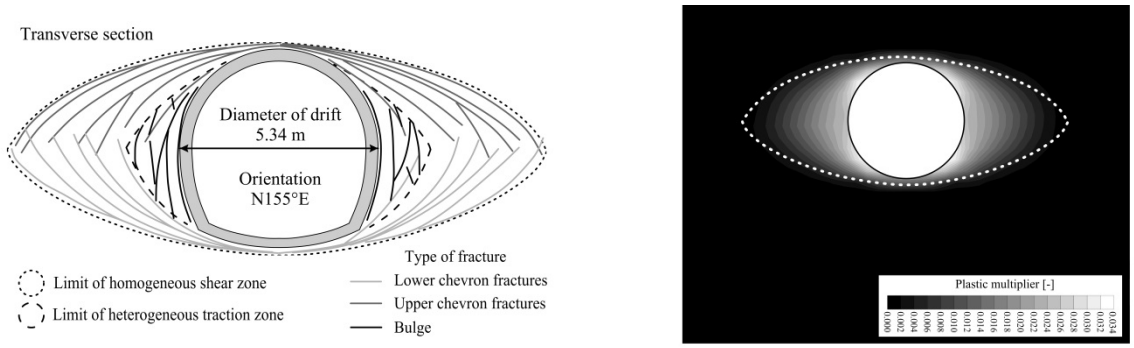
†Centre Internacional de Mètodes Numèrics en Enginyeria (CIMNE)
Departament d'Enginyeria del Terreny
Universitat Politècnica de Catalunya
Jordi Girona 1-3, Campus Nord UPC, 08034 Barcelona, Spain
e-mail: miguel.angel.manica@estudiant.upc.edu, antonio.gens@upc.edu,jean.vaunat@upc.edu, daniel.ruiz.restrepo@gmail.com Web page: https://www.etcg.upc.edu/

ABSTRACT

Because of their limited strength, an important issue in underground excavations in argillaceous rocks is the generation of a damaged zone around the cavity caused by the process of excavation itself. Field observations show that often the extent and features of the damaged zone are affected by the anisotropic nature of the material concerning especially the failure conditions of the rock. This is especially apparent in cases where the in situ stress is quasi-isotropic where the non-uniform configuration of the damaged zone can only be ascribed to the anisotropic properties of the material.

In this contribution, a cross-anisotropic extension of an elastoplastic constitutive model is described, based on a non-uniform scaling of the stress tensor. The Mohr-Coulomb yield condition is employed, although this concept can be applied to any other stress-based criterion. It has as main advantage the possibility of being incorporated into an already implemented constitutive model with only minor modifications.

The resulting constitutive model has been applied to the coupled hydromechanical simulation of an excavation of a horizontal tunnel in the underground research laboratory at Bure (France). The orientation of the tunnel ensures that the transverse in situ stress state is nearly isotropic. The tunnel excavation has been intensely monitored and the nature and extension of the damaged zone have been studied by a variety of field techniques. As the Figure shows, the analysis performed using the elastoplastic model incorporating the anisotropic failure criterion is able to reproduce the observed geometry of the damaged zone. The anisotropy of convergence measurements is also matched satisfactorily.



a) b)

Excavation damaged zone a) Observed [1] b) Computed

REFERENCES

[1] G. Armand, F. Leveau, C. Nussbaum, R. de La Vaissiere, A. Noiret, D. Jaeggi, P. Landrein, C. Righini,. "Geometry and properties of the excavation-induced fractures at the Meuse/Haute-Marne URL drifts", *Rock Mechanics and Rock Engineering*, **47**, 21-4 (2014).

.