EUROMECH Colloquium 572

"Constitutive Modelling of Soil and Rock"

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Prediction of the mechanical behaviour of soil and rock is of great interest in geotechnical engineering. For modelling the complex behaviour of soil and rock a large number of advanced material models has been developed. They are based on different theories, like plasticity theory, damage mechanics and combinations of two additional theories: hypoplasticity and, recently, barodesy.

The aim of EUROMECH Colloquium 572 was to review the various existing constitutive models for soil and rock and to assess the potential and drawbacks of the different approaches in numerical simulations of geotechnical problems. Colloquium 572 was attended by 43 participants from 11 countries. A relatively broad spectrum of topics, related to numerical modelling of soil and rock, was covered in 24 presentations, which were organized in the following seven sessions:

1. Fundamental aspects of constitutive modelling (3 lectures);
2. Models of organic soils and clays (2 lectures);
3. Coupled and multiphase constitutive models (5 lectures);
4. Extensions of classical models (3 lectures);
5. Modelling of localisation (2 lectures);
6. Hypoplasticity and barodesy (4 lectures);
7. Modelling of rock, rock mass and rockfill (5 lectures).

The lectures led to lively and sometimes passionate discussions on the pros and cons of the approaches presented. The continuum models for soil and rock cover a large spectrum from very simple linear elastic and perfectly plastic models to sophisticated models with several yield surfaces, including complex hardening and softening laws. There is no consensus on the required complexity of the selected model. Ivo Herle demonstrated for an excavation process that model predictions can differ qualitatively for realistic stress paths. A further problem, addressed by several participants, is the large scatter of experimental data concerning the constitutive behaviour of soil and rock. In many cases this makes it very difficult to select a proper constitutive model. In addition, as pointed out by David Muir Wood, testing conditions may not be sufficiently severe to reach the limit state in all respects and this will influence the values of the mechanical properties reached at temporary critical states. An attractive alternative to classical continuum models for soil, the so-called multilaminate models, was presented by H. Schweiger. In two lectures by Aldo Madaschi and Christina Jommi, special aspects of modelling the behavior of peaty soils were addressed.

Coupled and multi-phase constitutive models were presented in different contexts, like unsaturated/saturated soil (P. Gamnitzer), chemo-mechanical interactions (A. Gajo), thermo-mechanical interactions (F. Cecinato), nonlocal integral-type models in combination with viscoplasticity for simulating strain softening (L. Sanavia) and the determination of transport properties of fractured rock (G. Meschke). Such models have great potential for enhancing the range of phenomena to be described, however, at the expense of a considerably higher degree of complexity for experimental investigations and far greater effort for developing efficient and robust numerical algorithms, both at the integration point level and the structural level.

Numerical models for shear localization and hydraulic fracturing were presented, based on the strong discontinuity approach. They were formulated within the framework of finite elements with embedded discontinuities (A. Alsahly) and the framework of the extended finite element method (J.M. Huyghe, G. Meschke). They still pose challenges, especially for three-dimensional applications. Extensions of classical models were presented for quite different applications, like artificial ground freezing (C.

Vrettos), the fabric evolution of sands with anisotropic material behaviour (A. Papadimitriou) and for demonstrating similarities between the so-called hydrodynamic theory and hypoplasticity (M. Liu).

A special session on new approaches in hypoplasticity and barodesy was devoted to Dimitrios Kolymbas on the occasion of his retirement to emeritus status in 2017. In this session, D. Masin presented an approach for incorporating any predefined form of asymptotic states into the hypoplastic model structure, G. Medicus described the application of barodesy to model the mechanical behavior of clay and W. Fellin focused on adaptive time integration schemes of constitutive rate equations for efficient implementations of constitutive models into FE codes. The session was finished by the laudatio for Dimitris Kolymbas by G. Gudehus.

The lectures on modelling of rock, rock mass and rockfill comprised topics like models of coarse grained materials for rockfill dams (P.Y. Hicher), modelling approaches for weathered rockfill materials (E. Bauer) and calcarenite rocks subject to weathering (C. Tamagnini), and constitutive modelling of rock (D. Unteregger) and of the respective cyclic behaviour (B. Cerfontaine).

At the end of the colloquium, the excursion to the construction site “Wolf” of the Brenner Basetunnel, close to the Italian border, served as a case study for the big challenges related to both the execution of such large-scale geotechnical projects and realistic numerical predictions of the complex behaviour of the ground-support system in tunnelling.

Summarising, EUROMECH Colloquium 572 can be viewed as a further step in obtaining a valuable basis for selecting problem-specific material models for soil and rock and in intensifying the interaction between experts in the fields of continuum mechanics, numerical modelling and geotechnical engineering. The organisers received very positive feedback on the scientific programme, the excursion and the organisation of the colloquium. In particular, participants appreciated the format with comprehensive lectures and sufficient time for discussions immediately after the presentations and during breaks. Some participants encouraged the organisation of a further colloquium on this topic in the future.