Numerical Simulation of
Selected Geotechnical and Structural Problems
in Civil Engineering

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Numerical simulations by means of the Finite Element Method have become a valuable tool in Civil Engineering to predict and to understand the behaviour of complex structures. The application of suitable nonlinear material models allows the identification of damage and - finally - of the failure modes of a structure subjected to particular loading scenarios.

The lecture deals with challenging problems in two important fields in Civil Engineering, namely concrete construction and tunnelling. At first, the potential of available numerical models for reinforced concrete to predict the structural behaviour up to the ultimate load and the corresponding failure mode will be demonstrated by problems from engineering practice. Subsequently, the challenges of the numerical simulation of the complex nonlinear behaviour of very large concrete structures, focussing in particular on concrete arch dams, will be outlined according to the conclusions of the thematic network IALAD (Integrity Assessment of Large Concrete Dams), which was funded by the EC within the Growth Programme of the fifth framework programme from 2002 to 2005. Because of the complexity of a three-dimensional FE-model of a concrete arch dam, including the surrounding rock foundation and artificial and natural joints, both the robustness and the efficiency of the employed algorithms play an important role.

The second part of the lecture is devoted to problems in geotechnical engineering. Commonly, the mechanical behaviour of soils is described either by single-phase material models or by two-phase material models. In the former case the single phase refers to the soil skeleton, in the latter case the two phases consist of the soil skeleton and the water within the pores of the soil skeleton, commonly assuming fully water saturated conditions. However, there are many challenging problems in geotechnical engineering, which require soil models for partially saturated conditions. Examples from engineering practice are embankment dams, slope instabilities, tunnelling in swelling rock and tunnelling by means of compressed air. The latter topic will be addressed in more detail. The complexity of a material model for a partially saturated soil is a consequence of the impact of the degree of water saturation (which is associated with the capillary pressure or suction) on the soil behaviour. Thus, it is not possible to describe the mechanical behaviour of partially saturated soils in terms of a single stress variable. Important issues in the context of numerical modelling of partially saturated soils are the identification of material parameters for the respective soil models from laboratory tests as well as the development of improved algorithms for the implementation of such material models into coupled solid-fluid FE-codes.