Current status and remarks:

The main research objectives of subproject A5 are divided into two groups that concern:

1.) Adaptive constitutive modeling of soil in mechanized tunneling

In this part of the subproject the focus is on developing a conceptual approach in construction of a robust and efficient numerical model for simulating mechanized tunneling with the finite element code Plaxis 3D in interaction with subproject C2. The modified three dimensional finite element model for the simulation of mechanized tunneling have been set up after previous studies of the boundary effects and mesh dependency of the solution. The model (Figure 1) has been created by using the same mesh and boundary conditions for the shallow (1D overburden) and the deep tunnel (5D overburden) and includes the following subsystems of mechanized tunneling procedure:

- Sequential advance
- Face support
- Grouting pressure in the annular gap, which is applied with two methods (Pore water pressure in an additional thin layer or distributed pressure directly on the soil) and time dependency of the stiffness of the grouting material
- Conicity of the TBM
- Interface properties between the soil and the lining and the TBM
- Choice of an appropriate constitutive soil model (isotropic, elastoplastic model family are used at the moment: Mohr-Coulomb model, Hardening Soil model and Hardening Soil model with small-strain stiffness)
- Considering dry or fully water saturated soil

Figure 1: Three dimensional finite element model
The procedure to build up an adequate model for simulating mechanized tunneling includes the determination of criteria for geometric subareas (areas of influence) and spatial and temporal adaption of appropriate hierarchic constitutive models. For this reason the following analysis, that is in progress, is to investigate the displacements curves, stress paths and the distribution of pore water pressures in the measuring section. Doing this to evaluate the influence of:
- the interface properties (ϕ, E)
- application of the grouting pressure
- the overburden height (1D/5D)
- use of the three different soil models (MC, HS, HSS) in homogeneous soil
- adaptive exchange of soil models in defined areas with different dimensions in front of the tunnel face (Figure 2)
- undrained analysis and consolidation analysis
- exchange soil properties for sensitivity analysis

![Figure 2: Adaptive exchange of soil models](image)

2.) Anisotropic and structured clays under consideration of destructuration: Formulation and implementation of a new constitutive model

The formulation of the constitutive law is based on the “Modified Cam Clay Model” (MCC) within the elastoplastic framework and employing the critical state concept. The isotropic stress-strain relationship, with one single yield surface, is implemented in the FE-Software PLAXIS 3D as a user defined soil model (FORTRAN source code). The previously implemented integration procedure for the proposed material model was not sufficiently stable and robust. Consequently the basic model (MCC) is to be extended with further features included within the proposal (anisotropy, unsaturated soil formulation, concept of normalized bounding surface plasticity, state parameters, etc.) and results in the material model used in the project currently. Each feature of the constitutive model is to be calibrated by the use of element tests (PLAXIS soil test tool: 1D compression and triaxial compression/extension) and experimental results of standard laboratory tests for structured natural clays as well as for reconstituted clays. The experimental data are taken from literature. In parallel, the focus is set on the literature review for the development of a new concept for destructuration of anisotropic and structured natural clays.

List of publications in the frame of SFB 837:

Articles in conference proceedings: