Research on the Face Stability during Earth Pressure Balance Shield Tunnelling

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In mechanised tunnelling with earth pressure balance (EPB) shield machines, the soil in the excavation chamber is used as support medium to provide face stability. The support material is pressurised up to the required support pressure. Because most soils do not inhabit necessary properties concerning material flow or face support (consistency, viscoelasticity, permeability), the soil is typically conditioned with foam. Soil conditioning usually is based upon individual jobsite experience. Therefore, research on fundamental mechanic properties of the conditioned support medium (particle-foam-mixture) is urgently needed, i. e. the stress ratio and the flow behaviour in the excavation chamber as well as hence adapted computational models for face stability.

In this subproject the first key aspect is experimental research on the basic properties of the support material, consisting of the excavated ground and conditioning agents. Through these investigations, information shall be gathered with respect to the conditioning behaviour of cohesionless soils in dependence of the corresponding grain-size distribution, the permeability of different soil-foam-mixtures, the rheological behaviour of the support medium and the pressure transfer within the support material. Generation and sampling of the soil-foam-mixtures will be made under realistic (support) pressure conditions.

The second main aspect focuses on microscopic laboratory tests on the rheology of artificial particle-foam-mixtures. In contrast to soil-foam-mixtures, the characteristic properties of the particles (diameter, mono- or polydispersity, etc.), of the foam (cell-size, mono- or polydispersity, saturation) and of the mixture (volumetric contingent, diameter ratios) can be easily varied. Thus, an essential characterisation and a modification of the effective rheological and hydro-mechanical properties of the particle-foam-mixture are foreseen. The results from the rheological experiments are being used for the development of a phenomenological continuum model, which describes the hydro-mechanical behaviour of particle-foam-mixtures.

Furthermore, the results from the microscale and macroscale experiments will be combined as base for a multiphase soil-foam-model. This phenomenological continuum-mixture-model is then used as starting point for a realistic computation of the face support process in EPB-tunnelling using coupled finite-elements-methods.