Small-strain analysis for a large excavation

**The Sülfeld navigable lock**

The existing Sülfeld lock was constructed between 1934-37. The lock’s southern chamber is currently being rebuilt in order to adapt it to raise ship traffic and generations of new ships. The high-speed railway link between Hannover and Berlin runs close to the construction site and needs to be kept operational at all times during construction. In order to simulate the interaction between the excavation and the neighboring structures, 3D finite element analyses were carried out. Furthermore, a measurement program has been initiated in order to measure: wall deformations, deformations and pore pressure of the adjacent soil masses, forces in anchors and struts, and the excavation heave.

**Finite Element Model**

The model’s structural features include two abutments on pile foundations, back-anchored and struttered retaining walls, sheet pile walls, and a floor slab in the struttered section. Embedded elements are used to model the floor slab and piles. All other structural features and the soil are discretised by fully integrated volume elements.

Four excavation stages are computed: One step before wall construction (pre-exavation), and three steps after wall construction (excavation step 1 to 3). The phreatic level is adjusted several times in the calculation.

**Constitutive law**

The HS-Small model, which is a small-strain stiffness extended version of the Hardening-Soil model, is used in the analysis. Being a multiaxial adaption of the Hardin-Drnevich model, its small-strain stiffness characteristics are defined by an initial small strain shear modulus $G_0$ and the threshold shear strain $\gamma_0$.4.

End of excavation and GW-lowering stage

**Results**

**Conclusions**

- The small stiffness model simulated realistically the deformations of the railway bridge.
- Large soil domains remain in a 'small-strain' state.
- This model accompanying the excavation process explained the observed soil-structure-interaction, verified the warning thresholds of measurements and helped in the decision process when to establish remedial measures.