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Physically-based landslide assessment for railway infrastructure

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A new high-speed railway line in Eastern Norway passes through areas with Quaternary soil deposits where stability of natural slopes poses considerable challenges. The ground typically consist of thick layers of marine clay deposits, overlain by 8-10 m of silt and sand. Both shallow landslides in the top layers of silt and sand and deep-seated failures in clay must be accounted for.

In one section of the railway, the potential for performing stabilizing measures is limited due to existing cultural heritage on top of the slope. Hence, the stability of a steep top section of the slope needs to be evaluated. Assessment of the slope stability for rainfall-triggered slides relies on many parameters. An approach based only on empirical relations will not comply with the design criteria, which only allows deterministic safety margins. From a classic geotechnical approach, the slope would also normally be considered unsafe. However, considerable suction is assumed to exist in the silty and sandy deposits above ground-water level, which will improve the stability. The stabilizing effect however is highly dependent on rainfall, infiltration and soil moisture, and thereby varies continuously.

An unsaturated geomechanical approach was taken to assess the slope stability. Soil moisture sensors were installed to monitor changes of in situ water content in the vadose zone. Retention curves for silt/sand specimens samples were measured by pressure plate tests. Some triaxial tests soil strength were performed to check the effect of suction on soil shear strength (performed as drained constant water content tests on compacted specimens).

Based on the performed laboratory tests, the unsaturated response of the slope will be modelled numerically and compared with measured soil moisture in situ. Work is still on-going. Initial conditions after respectively dry and wet periods need to be coupled with selected rainfall intensities and duration to see the effect on slope stability.
The aim of the work is to reach a result informing the client about the probability of a landslide in the slope, based on expected critical rainfall. A strictly deterministic criterion for minimum safety margin may need to be replaced by scenarios for probability and geometry of potential failures for given return periods and rainfall events.