Engineering Risk Analysis Group
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Master's thesis

# Risk-Based Decision Making in Geotechnical Engineering – Optimal Pre-Loading of an Embankment

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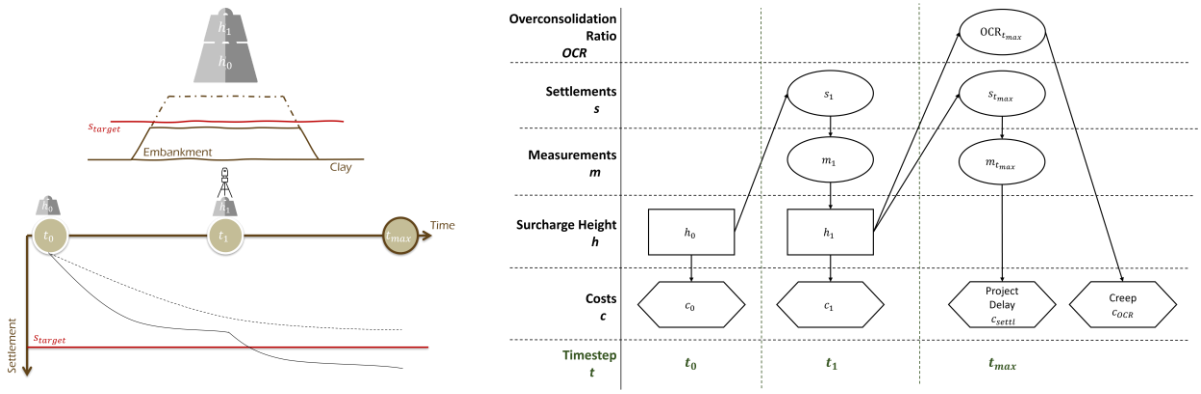
## Background

The field of geotechnical engineering is characterized by significant epistemic uncertainty of the ground conditions, which requires an iterative decision-making process. A common geotechnical engineering challenge is the construction of an embankment on soft soils. Without mitigating measures, the embankment and any superstructure could be damaged by the residual ground settlements occurring after commissioning. Pre-loading of the soil can accelerate soil consolidation and ensure that these residual settlements are below a predefined target. Due to the uncertain consolidation process, finding the optimal pre-loading surcharge and, possibly, adapting it to the observed settlement is a sequential decision problem under uncertainty.




*To ensure sufficient soil consolidation within a timeframe, the embankment can be pre-loaded initially and the surcharge can be adjusted at time $t_1$ (left), based on the observed settlement. An influence diagram (right) describes the decision setting and formalizes the decision process within a decision-theoretic framework.*

## Methodology

We propose a risk-based decision theoretic approach to finding the optimal pre-loading sequence. It utilizes a probabilistic geotechnical model of the soil settlement evolution under staged pre-loading. The optimization problem consists in finding the pre-loading strategy, which best balances the costs of adding a surcharge against the financial penalties associated with delays due insufficient soil consolidation. The approach adopts a parametric description of preloading strategies, so-called *heuristics*. It enables to design strategies which optimally account for settlement measurement information. The optimization of the heuristic parameters is performed with the Cross Entropy Method.

## Results

We solve the pre-loading planning problem for different decision settings, going from optimizing a constant pre-loading surcharge to optimally planning the time for adjusting the surcharge. The strategy parametric description includes a calibrated settlement prediction model based on weekly measurements. The adopted framework allows us to quantify the significant improvements in the decision-making process between different pre-loading strategies. This work highlights the potential of risk-based decision planning in the field of geotechnical engineering.

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