Statistical emulation of computationally expensive computer models of long term geotechnical infrastructure deterioration for assessing the impact of climate change

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The ACHILLES programme

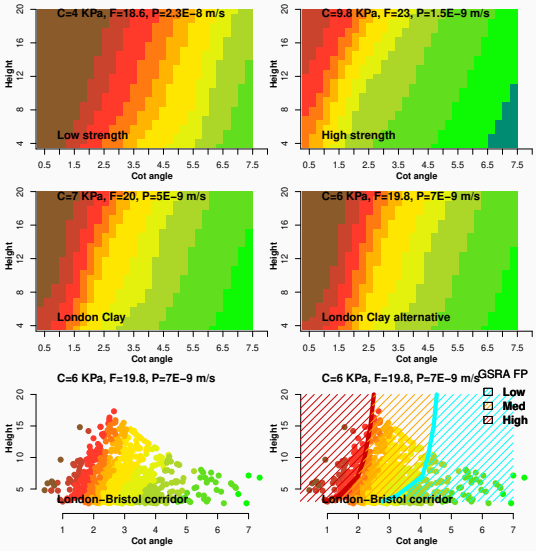
- Within the *ACHILLES programme* we have developed sophisticated computational models of the long-term weather-driven deterioration of engineered slopes such as cuttings and embankments
- The models allow us to study the detailed mechanisms of gradual deterioration leading to eventual catastrophic failure
- We can also examine the effects of interventions for prolonging serviceable life, or the change in deterioration associated with different future climate scenarios
- `www.achilles-grant.org.uk`

Statistical emulation

- We can simulate the long-term weather-driven deterioration of, say, railway cuttings
- We can simulate a given slope from construction to failure (or 200 years) in around one day of real high-end computer time
- But the models have many input parameters relating to slope geometry, soil properties, weather patterns, future climate scenarios, etc., and it is not practical to explore the behaviour and sensitivity of the model wrt all of these inputs simultaneously using the real slow computer model
- However, using a carefully designed set of inputs, we can use the associated model runs to build a Gaussian process emulator of the slow model, then use this emulator in place of the slow model for sensitivity analysis, parameter calibration and uncertainty quantification

The ACHILLES emulator

- We can use the emulator to build interactive tools to explore expected time-to-failure under various scenarios in real time
- We can embed the emulator into large Monte Carlo simulations of sections of the rail network to understand likely numbers of failures and the expected benefits of different intervention strategies (eg. soil nails, or drains)



Further reading

- Svalova, A., Prangle, D., Wilkinson, D. J., Helm, P., Rouainia, M., Glendinning, S. (2021) Emulating computer experiments of infrastructure slope stability in the London-Bristol rail corridor using Gaussian processes and Bayesian inference, *Data-Centric Engineering*, **2**:e12.
- Helm, P. R., Svalova, A., Morsy, A., Rouainia, M., El-Hamalawi, A., Smith, A., Wilkinson, D. J., Postill, H., Glendinning, S. (2024) Emulating long-term weather-driven transportation earthworks deterioration models to support asset management, *Transportation Geotechnics*, **44**:101155.

https://darrenjw.github.io/ https://www.achilles-grant.org.uk/