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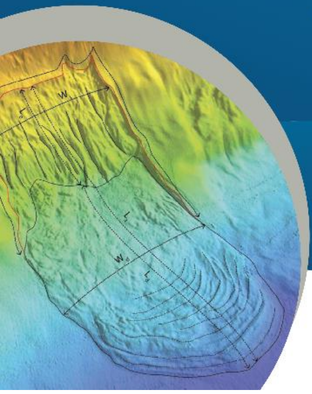

Abstract for SLATE webinar #19, Wednesday 29 September 2021

Speaker Stefano Collico

Title Optimal characterization of marine sediments via statistical analysis

Geotechnical site characterization at a project-site is a relative wide topic, whose output orientations depend on engineering design purposes. In the last decades, several studies stressed out the importance of facing and assessing uncertainties (i.e., both aleatory and epistemic), which inevitably intervene within soil characterization's tasks. Uncertainty is pervasive in every topic of geotechnical site characterization, whose nature and magnitude depends on several factors (i.e., project-site extension, site homogeneity and anisotropy, number of geotechnical parameters and properties involved, in-situ investigation's mode, and amount of information available at the site).

As a consequence, probabilistic methodologies for geotechnical data interpretations should be applied (e.g., random variables, random field theory) to assess multiple types of uncertainty. In addition, scarce amount of geotechnical data might be acquired at a project-site leading to inaccurate and unprecise estimates of geotechnical parameters. In this context, classic statistical approaches might not be appropriate to handle such diversity of information and a more advanced probabilistic line of thinking is requested.

Among all probabilistic approaches, Bayesian analysis provides a step forward with respect to classic (frequentist) statistics, since it provides subjective probabilities of unknown variables of interests and reducing their uncertainty. It enables to rationally assess different source of uncertainties by integrating engineer's heuristics and interpretation in the form of probability (prior knowledge) with geotechnical data acquired at the project-site (Likelihood) further computing the so-called posterior knowledge of variables of interest. Such updating requires the integration of joint density functions, which is often unfeasible to derive analytically and usually computational demanding, needing the application/implementation of algorithms to avoid integrations.

Aware of this, the present thesis aims to exploit different tasks of the geotechnical site characterization from Cone Penetration Tests ($CPTu$) under a probabilistic framework. Although novel Bayesian analysis applications are largely applied throughout the thesis, few simplified frequentist methodologies are also proposed aiming to provide user-friendly tools for practitioners. The proposed methodologies are applied to both onshore and offshore sites, making them generally applicable.

Initially the thesis exploits the probabilistic mechanical soil delineation task from $CPTu$. $CPTu$–based profile delineations inevitably require engineering interpretation, as the $CPTu$ record is affected both by inherent variability and measurements errors. A semi-automated $CPTu$ data treatment tool is presented aiming to simplify the soil delineation task while eliciting the assumptions and heuristics that designers apply in this process. Classification makes use of conventional class boundaries, which are applied in sequence with user-specified refinement. Such work provides a flexible and intuitive tool for practitioners. The proposed methodology is further compared qualitatively and quantitatively with two existing Bayesian methodologies.

Subsequently, the work focuses on the optimization of soil unit weight prediction from $CPTu$ readings through a Bayesian Mixture Analysis. The approach aims to identifies linear hidden soil classes among soil normalized total unit weight and normalized $CPTu$ parameters. Observations subdivided according to identified classes are then employed to revisit existing regressions and to propose novel correlations. Results highlight a general decrease of systematic transformation uncertainty and an improvement of accuracy of soil unit weight prediction from $CPTu$ at new sites.

Finally, the thesis illustrates a probabilistic earthquake-induced landslide susceptibility map of South-West Iberian margin. A simplified geotechnical pixel-based slope stability model is applied to whole study area by considering model's parameters as random variables. Soil parameters are derived from scarce amount of geotechnical data through a Bayesian analysis procedure. Outputs (i.e., landslide susceptibility maps) are derived from a reliability-based design procedure (Montecarlo simulations) providing a robust landslide susceptibility prediction at the site according to Receiver Operating Curve (ROC).