Master Thesis

Topic:

Numerical modeling of Cone Penetration Tests in sensitive soft lacustrine clay

Description:

The Cone Penetration Test with pore pressure measurement (CPTu), also known as the piezocone test, stands as a highly adaptable in-situ technique for geotechnical site investigation. However, understanding the cone penetration process is essential for a reliable interpretation of the measurements focusing on the estimation of soil parameters such as stiffness and strength. For interpretation the test data an appropriate soil model is needed. Simulating the boundary value problem entails grappling with the intricate large-scale soil deformations caused by the soil displacement during penetration—a notably complex mechanism to replicate.

Various concepts of models based on the finite element method have emerged to analyze and interpret cone penetration issues [1–4]. These approaches demand intricate procedures to circumvent numerical instabilities arising from substantial distortions of the finite element mesh during the simulation of the process of penetration. To address these challenges, Einging et al. (2015) [5] introduced a method, termed the Press-Replace method (PRM). PRM utilizes small strain calculations, refrains from mesh updates, and disregards the flow mechanism at the cone tip, offering a less complex yet effective alternative for simulation.

This scientific study aims to numerically model CPTu in sensitive soft lacustrine clay. The primary objective is to conduct back calculations (so-called class c prediction), using laboratory and field data, to calibrate the parameters of the suggested different constitutive models.

The study begins by investigating the behavior of the clayey soil through laboratory tests like Oedometer and Triaxial tests, which will inform the calibration of constitutive models. This calibration process involves established soil models such as the Soft-Soil model alongside more advanced models such the Creep-SClay1S by Karstunen et al. (2013) [6].

The calibrated parameters derived from the selected models will then be applied for simulating the boundary value problem. We suggest finite element simulations using the software PLAXIS. In a first evaluation the results from the simulation will be compared to CPTu tests conducted in the sensitive soft lacustrine clay within the Rosenheim basin (Rosenheimer Seeton). A subsequent second phase of simulation should adjust the parameters of the simulation to match the results from CPTu as precisely as possible. The robustness of the simulation should be evaluated by again simulating element tests such as the oedometer and triaxial test applying the adjusted parameters from the best match boundary value simulations.

The study aims to predict the state dependent soil parameters of undrained shear strength (c_u) and over consolidation ratio (*OCR*) at varying depths from the measurements by the CPTu as the cone tip resistance q_c and sleeve resistance f_s as well as the pore pressure at the cone shoulder (u_2). The outcome of the calculations and evaluations should be compared to conclusions from the literature as the current state of research.

Scope of work:

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1. Literature review about latest developments in the field of the simulation of cone penetration testing by the finite element method:
   Understanding and analyzing recent research and advancements pertaining to simulating cone penetration tests, focusing on methodologies, techniques, and innovations.

2. Calibration of selected constitutive models Parameters using element tests:
   Utilizing laboratory test such as the oedometer and triaxial test to calibrate the parameters of constitutive models. This process involves aligning model parameters with empirical data obtained from controlled laboratory experiments.

3. 2D finite element calculations of the boundary value problem as given by the cone penetration:
   Conducting 2D finite element calculations using the software PLAXIS, employing the Press-Replace Method (PRM), and integrating of novel adaptations to existing techniques in simulating cone penetration.

4. Validation of numerical Results for in terms of a class c prediction and subsequent back-calculation of element tests:
   Comparing and validating the results from the simulations by considering the data from experimental (field investigations and laboratory tests) findings.

5. Predicting c_u and *OCR* from CPTu simulations:
   Using the results from the cone penetration simulation in respect to the measurements of the CPTu (cone tip resistance q_c, sleeve resistance f_s and pore pressure u_2) in order to judge on the state dependent parameters of c_u and *OCR*. Compare the outcome with the current state of the art for CPTu interpretation.

Prerequisities:

- Fundamental understanding of the mechanical behavior of soft clay
- Good knowledge of Finite Element Modelling using the software PLAXIS or comparable finite element software
- Data management and evaluation using the software MATLAB is requested
- Basic knowledge of at least one programming language

Date of formulation :
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Supervisor :

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Bibliography

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