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Numerical modeling of cone penetration test in slightly overconsolidated clay with arbitrary Lagrangian-Eulerian formulation

Jakub Konkol[a,*], Lech Bałachowski[a]

[a]Gdańsk University of Technology, Narutowicza 11/12, 80-233 Gdańsk, Poland

Abstract

In this paper the results of the cone penetration test (CPT) modeling with the arbitrary Lagrangian-Eulerian (ALE) formulation provided by Abaqus software package have been presented. The study compares the cone resistance and sleeve friction obtained in numerical analysis with values measured in soundings performed in the uniform layer of clayey soil in the Koszalin area. The clay layer was found to be slightly overconsolidated with OCR ranging from 3.5 to 4.5. The subsoil parameters used in the numerical model are based on laboratory tests data and the complementary CPT estimation. Evaluation of the most important factors influencing the numerical solution such as friction on the probe-soil interface and the undrained shear strength of the clay have been discussed. The possibilities of ALE method for soil parameters calibration are introduced and future challenges in large deformation problems modeling due to penetration issues are described.

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Keywords: Abaqus; arbitrary Lagrangian-Eulerian; ALE; CPT simulation; undrained analysis.

1. Introduction

The cone penetration testing (CPT) is a common geotechnical site investigation method to estimate soil strength parameters. In recent years many numerical studies, especially large deformation finite element calculations, have been performed to better understand the mechanisms which influence penetration resistance. Cone penetration into cohesive soil has been analyzed by Van den Berg [1], Abu-Farsakh et al. [2], Wei et al. [3], Sheng et al. [4] and

* Corresponding author.
E-mail address: jakub.konkol@pg.gda.pl

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others. However, in major part of the research only the cone resistance has been taken into consideration and the cone factor was investigated (e.g., [4,5]). In addition, the numerical model validation has been usually presented in comparison to the laboratory tests (e.g., [3]) and the verification with the field tests was not widely used. The main aim of this paper is to present the numerical simulation of the CPT with the influence of the friction between soil and probe in comparison with the field measurement. The secondary objective is the identification of CPT simulation sensibility to laboratory test data. The research performed is intended to shed more light on the cone-soil interaction and the possibility of CPT predictions based on laboratory test data.

The CPT numerical model is developed using Arbitrary Lagrangian-Eulerian (ALE) formulation with accordance to the total stress approach. The ALE formulation is widely used for calculating the cone penetration problems in homogeneous soil layer (e.g., [5]) and it provides better calculation efficiency due to the possibility of application of axisymmetric models in comparison to another numerical methods such as Coupled Eulerian-Lagrangian formulation where fully three-dimensional model is required (e.g., [6]). The geotechnical parameters of soil have been based on laboratory tests, but CPT correlations need to be used for initial lateral stresses estimation. Two friction coefficients for probe-soil interaction have been tested and their influence on the results has been presented. The numerical results are compared with field measurements including the cone resistance and sleeve friction. The interface friction influence is discussed and the possibility of geotechnical parameters validation with numerical CPT probing is also pointed out.

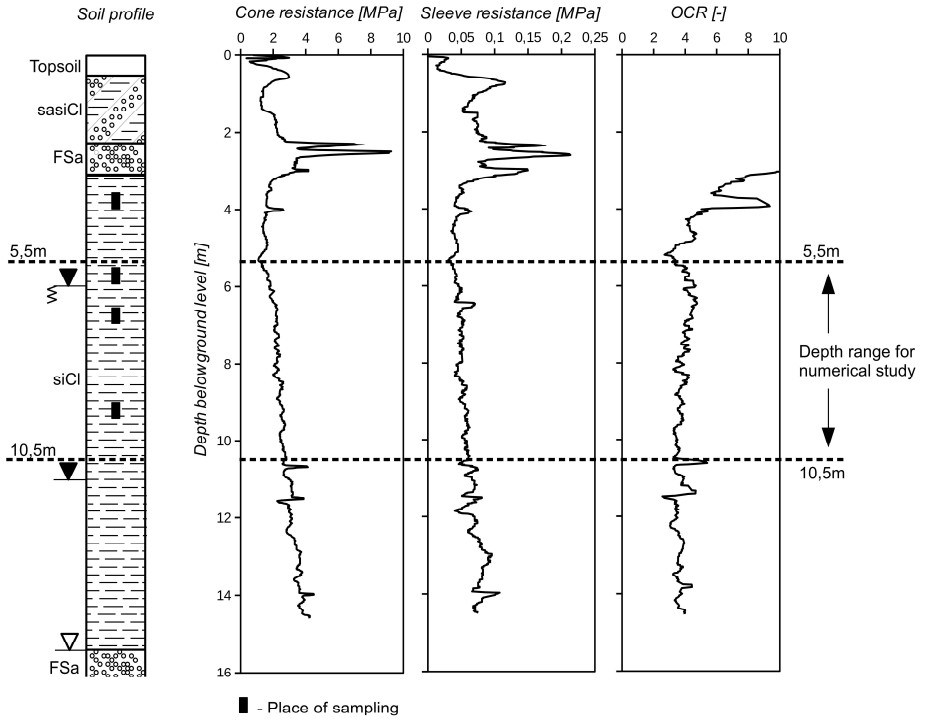

Fig. 1. Soil and CPT profiles for the WD-102 site.

2. Site geotechnical investigation

The WD-102 structure in the Koszalin area of the S6 highway currently under construction is selected as the reference localization. The geotechnical field investigation consists of one electrical CPT test done in clayey soil, one borehole drilled next to CPT point and two boreholes drilled in a distance of approximately 15 meters from the