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Geotechnical Engineering

Numerical Analysis of Porous and Granular Media

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A finite-element program, which simulates the coupled consolidation and contaminant transport problem, has been developed. The program has small-strain and finite-deformation options. A finite-deformation Cam-clay model was developed to model the behaviour of slurry clays, and it was implemented into the program to analyse the deformation of mineral wastes disposed of in containment ponds or impoundments.

Numerical modelling of pipeline-soil interaction continues with support from Tokyo Gas, as part of International Collaborative Soil/Pipe Interaction Research. Advanced soil models (bounding surface model and NorSand model) have been implemented into a finite-element program to estimate soil pressures applied to pipelines by lateral movements of soils due to landslides and earthquake.

Numerical modelling of compensation grouting has been conducted. Cavity-expansion type grouting was modelled and the effect of soil consolidation caused by the excess pore pressure generation during grout injection was investigated at various soil conditions. A simple compensation grouting model has been developed using the grout efficiency factor obtained from the numerical analysis. This model will be implemented in FLAC3D by Tractabel (Belgium)

as part of the COSMUS project (see below). Modelling of hydrofracturing type-grouting has also begun.

Construction Processes

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Work continues on the EC funded COSMUS project, in collaboration with Soletanche-Bachy, Tractabel, Glotzl, CEA-LETI and EPFL. The project aims at developing a tunnel construction system using improved monitoring techniques, a soil-characterisation system and an advanced computer-simulation model. The contributions from Cambridge are (i) to develop methods to help characterise in-situ soil conditions from drilling parameters and (ii) to model compensation grouting and tunnelling operations by the finite-element method. The standardised Soletanche-Bachy's ENPASOL drilling method has been tested at the Kennington site in London. The signal analysis of the data showed that the standardised method provides consistent data to identify the variation of soil layers in the ground. Based on extensive signal analysis of the data, a new method of eliminating the noise from the EPNPASOL signals has been proposed. Work continues to develop new drilling parameters for soils and to correlate them to soil properties.

A new finite-element program, which simulates the advancement and excavation processes of shield tunnelling operations, has been developed in collaboration with Dr K. Komiya of Chiba Institute of Technology as part of a COSMUS project. In this program, a new excavating finite element, which models the disturbed soil in front of the cutting face, is introduced, and the operation of shield advancement and of soil excavation is simulated by using the finite- element remeshing technique at each time step of the analysis.

A study of the effects of compensation grouting on tunnel linings has started with support from Nishimatsu Construction. Field monitoring was performed at the Docklands Extension Tunnel construction site, in London. Measurements of surface settlements and displacements of the tunnel lining were made during the construction of the tunnel. Centrifuge modelling of the problem has been undertaken and the influences of width of the grouted zone and its distance above the tunnel have been explored.

A new two-year EPSRC project "Investigation of ground loading applied to an old London Underground Ltd (LUL) tunnel" commenced in conjunction with London Underground and Geotechnical Consulting Group. The aim of the project is to assess the long-term ground-loading acting on tunnel linings in London Clay. A tunnel, which is part of the Kennington Loop on the Northern Line, was identified as being suitable for detailed field measurements. In order to determine the in-situ soil parameters, a series of self-boring expansion pressuremeter tests, self-boring load-cell pressuremeter tests and self-boring permeameter tests was performed. Other ground investigation included rotary-cored sampling for advanced soil testing and the installation of vibrating-wire piezometers from the ground surface and from inside the tunnel. The information obtained is to be used to interpret the long-term behaviour of the ground and of the tunnel lining and to assess the implications for current tunnel design methods.

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