MONITOR

Recently in *Géotechnique*

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The following are a selection of papers published recently in *Géotechnique* that readers of *Geotechnical Engineering* may find of particular interest. The selection concentrates on applied rather than pure research topics and covers issues published from April to September 2002.

Three-dimensional modelling of NATM tunnelling in decomposed granite soil

J. H. Shin, D. M. Potts, and L. Zdravkovic
Géotechnique, 2002, **52**, No 3 (April), 187–200.

Three-dimensional analyses of tunnel excavation and lining construction are rarely performed in practice, because it is difficult to reproduce the exact boundary conditions involved in this process, and because such analyses require considerable computing resources if realistic non-linear soil behaviour is to be reproduced. This paper presents a pseudo-three-dimensional analysis of tunnel construction by utilising the Fourier series aided finite element method (FSAFEM). The theory behind this approach, and its validation when applied to a tunnelling problem, are described. The method is then used to predict the behaviour of tunnels forming part of the Seoul Subway system in Korea. The results are compared with field measurements.

Movements in the Piccadilly Line tunnels due to the Heathrow Express construction

M. L. Cooper, D. N. Chapman, C. D. F. Rogers, and A. H. C. Chan.
Géotechnique, 2002, **52**, No 4 (May), 243–257.

This paper presents the results of analyses of monitoring records taken from inside one of the existing Piccadilly Line tunnels during the construction of three station tunnels at the Heathrow Express Central Terminal Area. The monitoring data allow a detailed picture of the way in which existing segmental concrete-lined tunnels behave as a result of tunnelling works below. Settlement curves at critical construction stages are presented. It is shown that the computed 'volume loss' varied between 1·3% and 2·5%. Long-term settlement records indicate that the maximum settlement increased by 27% for a period three years after tunnel completion. This result is compared with earlier findings from the Heathrow trial tunnel. Asymmetry of the settlement troughs caused by the outer tunnels, constructed after the central concourse tunnel, is discussed, and asymmetry parameters are defined from a number of case histories. The relationship of asymmetry parameters to pillar width between tunnels is presented and discussed. This suggests that interaction between the adjoining tunnels becomes negligible when the separation is six to seven diameters. Rotation in the existing tunnels at various construction stages is described, and the progressive rotation of the existing tunnel immediately above the concourse is shown. A tunnel longitudinal section showing ground movement contours predicted using a semi-empirical method illustrates the development of rotation. Distortion patterns along the existing tunnel, obtained from tape extensometer readings taken after completion of new tunnelling, are illustrated. These results together represent the first comprehensive study of tunnel and lining response to adjacent tunnelling published in the literature. The patterns of settlement, rotation and distortion, when considered together, provide a graphic description of a complex soil–structure interaction response to stress changes in the ground. The data can be used to predict responses in other soils and for other geometries by extrapolation.

Numerical modelling of group effects on the distribution of dragloads in pile foundations

C. J. Lee, M. D. Bolton, and A. Al-Tabbaa
Géotechnique, 2002, **52**, No 5 (June), 325–335.

Negative skin friction on pile foundations, predicted from the results of numerical analyses, is presented. Soil slip at the pile–soil interface has been found to be the most important factor in governing pile behaviour in consolidating ground. Reduction in dragload is predicted for piles in a group owing to interaction between soil and pile. It has been demonstrated that the group effect depends not only on the configuration of the pile group, but also on soil slip along the pile–soil interface, governed mainly by the interface friction coefficient and the soil settlement. Various factors should be included in an evaluation of the group effect, including the pile spacing, the number of piles in a group, the relative location of piles in a group, the pile type, the pile installation method, the surface loading and the stiffness of the soil. Existing design approaches result in overprediction of dragload for a single pile and of group effect for a pile group. Back-analysed dragloads and group effects considering soil slip are compared with a number of case histories.

A numerical study of the effect of groundwater movement on long-term tunnel behaviour

J. H. Shin, T. I. Addenbrooke, and D. M. Potts.
Géotechnique, 2002, **52**, No 6 (August), 391–403.

Soft ground tunnelling beneath the water table induces pore water pressure changes and alters the hydraulic regime in the ground. There are various factors that control the tunnel/soil interaction behaviour during the equilibration period after tunnel construction through to the long-term steady state. Through the presentation of results from coupled non-linear finite element analyses, this paper considers the differences in predicted ground and lining responses in the long term for different post-tunnelling flow conditions. A 4 m diameter circular tunnel constructed 20 m below ground level is adopted for the geometry, with the soil conditions based on those found in London, UK, and

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Seoul, South Korea. The lining permeability is varied from fully permeable to impermeable, and an approach to modelling finite lining permeability is presented and assessed. For the permeable lining analyses two flow regimes are modelled, one in which the water table is maintained at its original elevation and one in which the water table is drawn down towards the tunnel. The importance of giving careful consideration to lining permeability and hydraulic boundary conditions is highlighted. The effects of groundwater movements on numerical predictions of tunnel behaviour are also identified.

Deformation and failure modes of drystone retaining walls

W. Powrie, R. M. Harkness, X. Zhang, and D. I. Bush.
Géotechnique, 2002, **52**, No 6 (August), 435–446.

In this paper, the factors controlling the deformation of drystone retaining walls are investigated by means of discrete element analyses. It is shown that toppling failure of unweathered drystone retaining walls is likely to occur in a brittle manner, with wall crest deflections not exceeding 1% of the backfill height until the factor of safety (based on soil strength) falls below 1·05. A compressible sub-base and weathering of the blocks will both tend to reduce the backfill height at failure to below that indicated by a limit equilibrium analysis. Bulging failure is more likely to be associated with a deterioration in block joint stiffness due to weathering than a compressible sub-base, although the latter will decrease the reduction in joint stiffness needed to cause bulging failure. Bulging is much less brittle than toppling, and the proximity to failure of bulging walls could in some circumstances be assessed on the basis of the size of the bulge.

Methods for determining representative density-depth profiles using nuclear density gauges

M. G. Winter and B. G. Clarke.
Géotechnique, 2002, **52***, No 7 (September), 519–525.*

Most fills when compacted in layers will, to some degree, experience variations in density with depth. When measured using a nuclear density gauge in direct transmission mode, such variations in density through the layer will lead to unrepresentative density–depth profiles. This is because each measurement used to generate the profile is the mean density between the surface and the depth of measurement, and no correction for this is currently made. Uniform sands and silts, and pulverised fuel ash (PFA), often go through a process of over-stressing during compaction, leading to significantly lower densities in the upper part of a compacted layer. Under these circumstances the errors recorded in nuclear density gauge determinations of the density–depth profile may become significant. In extreme cases the usual guidance is to remove the upper part of the compacted layer prior to density testing. This paper describes numerical techniques to determine the mean density between successive measurement depths for the cases of both equal and unequal depth increments, thus giving a density–depth profile that is much closer to reality.

Ground improvement: the interaction of engineering science and experience-based technology

J. A. Charkes.
Géotechnique, 2002, **52**, No 7 (September), 527–532.

Technical note (no abstract available).