

## Elsewhere in *ICE Proceedings*

S. K. Fullalove, *Editor*

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### **Using gypsiferous soil for embankments in hot desert areas**

S. S. Razouki, D. K. Kuttah, O. A. Al-Damluji and I. H. Nashat  
*Proceedings of the Institution of Civil Engineers, Construction Materials*, **161**, No. 2, May, 63–71,  
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A study of the strength characteristics of a fine-grained gypsiferous soil intended for use as a construction material for forming highway and airport embankments in desert areas is reported herein. The tested soil was a sandy lean clay (CL) according to the Unified Soil Classification System and an A-6 (6) soil according to American Association of State Highway and Transportation Officials (AASHTO) soil classification system, containing about 35% total soluble salts (TSS) of which 33% was gypsum. To study the properties of the tested soil, various California bearing ratio (CBR) soil samples were prepared at the dry optimum moisture content of 2% and soaked for 0, 4, 7, 15 and 30 days. The CBR tests revealed that there was a serious drop in the CBR due to soaking, which is in full agreement with the drop in  $c$  and  $\phi$  with soaking period, indicating that if gypsiferous soils are used as fill material they should be protected from ingress of water. To study the deformation properties of the tested soil, vertical swelling/settlement measurements were carried out on each CBR sample during soaking using a 0.002 mm dial gauge. The effect of soaking period on the distribution of moisture, TSS and gypsum content was also studied. It was observed that there was an increase in moisture content and a decrease in TSS and hence gypsum with increasing soaking for CBR samples compacted at the dry optimum moisture content

### **A practical design approach for piles with negative friction**

H. Poulos  
*Proceedings of the Institution of Civil Engineers, Geotechnical Engineering*, **161**, No. 1, February, 19–27,  
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Misconceptions remain in the minds of some pile designers when negative friction effects have to be taken into account.

This paper outlines some of these misconceptions, and then describes a relatively straightforward approach for designing piles subjected to negative friction. This approach relies on the consideration of the portion of the pile that is located in the stable zone that is, that part of the ground profile that is not subjected to ground settlements. By designing this portion of the pile to have adequate length and strength, the key design requirements in relation to geotechnical capacity, structural capacity and pile head settlement can be satisfied. The case where the ground settlements extend to a large depth is also described briefly, and it is shown that it may then be prudent to design the piles to settle with the ground, rather than attempt to restrain them from settlement. Some other issues that can affect the response of piles to ground settlements are examined, including the presence of residual stresses in the pile, live load application and group effects. It is demonstrated that preloading a pile has the potential to reduce the axial force induced in the pile by the ground settlements.

### **Loading tests on compacted soil, bottom-ash and lime layer**

N. Consoli, A. Thom, M. Donato, J. Graham  
*Proceedings of the Institution of Civil Engineers, Geotechnical Engineering*, **161**, No. 1, February, 29–38,  
doi: 10.1680/geng.2008.161.1.29

This paper addresses the interpretation of loading tests bearing on a layered system formed by a compacted soil, coal bottom-ash and carbide lime top-layer overlying a compressible residual soil stratum. Loadsettlement behaviour is observed from tests carried out using circular steel plates ranging from 030 to 060 m diameter on the top of a 015060 m thick artificially cemented layer. Field data demonstrate the effectiveness of compacted soilashlime layers in increasing bearing capacity and reducing foundation settlements where shallow foundations are used on weak residual soils. The paper also stresses the need to express test results in terms of dimensionless variables in plots of normalised applied pressure against settlement-to-diameter ratio. The efficiency of existing analytical solutions for layered cohesive-frictional soils in determining the bearing capacity of footings on processed cemented soil overlying a weakly bonded residual soil with high void ratio is evaluated.

### **CFA pile behaviour in very stiff lodgement till**

E. Farrell, M. Lawler

*Proceedings of the Institution of Civil Engineers, Geotechnical Engineering*, **161**, No. 1, February, 49–57,  
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The design of CFA piles in the stiff/hard lodgement till that underlies most of Dublin is usually based on published experience from similar piles in other soils that lack the high density and stiffness of this till. The results of load tests on two instrumented test piles are presented, one 450 mm in diameter and 123 m long and the other 600 mm in diameter and 11 m long, which were loaded to 315 MN and 45 MN respectively. A 1 m long instrumented dummy pile was formed at the same time as the prototype and was tested in the laboratory to confirm the calibrations for use in interpreting the instrumentation. The instrumented piles showed that high average shaft resistances of 230 kPa and 270 kPa were mobilised, which were of similar magnitude to those recorded on an instrumented driven pile in this lodgement till that was reported previously. The pile load tests indicate an estimated  $N_c$  value of about 7 for the bearing capacity factor in ultimate end resistance, which is less than the value of 9 normally used and considerably less than a value of about 55 estimated from the tests on the driven pile. The results also indicate a change in the loadpile-head deflection curves with time, which could be related to disturbance of the ground caused by the construction process.

### **Constant rate of displacement test on ultra-soft soil**

M. Bo, K. Wong, V. Choa

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Loading consolidation test with hydraulic Rowe cell on ultra-soft soil takes several weeks to obtain a complete  $e$ - $\log s$ ' $v$  curve. An alternative method is to conduct the test at a constant rate of strain. This test can be carried out with the hydraulic Rowe cell by pumping water into the diaphragm cell at a constant rate of volume. A series of tests were carried out at various strain rates. A method is proposed for the selection of a suitable strain rate based on the estimated compression index. The best strain rate for the soil used in this study is 0.01%/min. The various compression indices at the different log-cycles can be determined from the  $e$ - $\log s$ ' $v$  curve obtained from this test. The large-strain coefficient of consolidation and permeability at various times and stresses can also be obtained, because the settlement and pore pressure are measured during the test.

### **Estimation of mean effective stress in clay soils**

D. C. Shoher

*Proceedings of the Institution of Civil Engineers, Geotechnical Engineering*, **161**, No. 3, June, 151–160,  
doi: 10.1680/geng.2008.161.3.151

This paper proposes a simple method for estimating the horizontal effective stress in clay soils, from which the mean effective stress can be determined. It is shown that the method is applicable to a wide range of clay soils with varying stress histories, including normally consolidated and heavily

overconsolidated clays. Although this paper is expected to be of use to many practitioners in the field of geotechnical engineering, it also has a particular relevance with respect to the effects of moisture abstraction on shrinkable clay soils by vegetation, or simply by seasonal variations. While the effects are well known, the methods for identifying clay desiccation and for calculating heave potential are often relatively expensive, and the results can be inconclusive. Using the proposed method, this paper describes a simple and low-cost alternative method for estimating the in situ mean effective stress in desiccated clay soils. This information can be used to confirm the likely depth of clay desiccation, and provides a means of calculating a further estimate of heave potential.

### **Axial resistance of CFA piles in Dublin Boulder Clay**

K. Gavin, D. Cadogan and L. Twomey

*Proceedings of the Institution of Civil Engineers, Geotechnical Engineering*, **161**, No. 4, August, 171–180,  
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This paper describes the results of static compression and tension load tests performed on three-instrumented large-diameter continuous flight auger piles installed in Dublin Boulder Clay. The piles developed very high shaft resistance and, in contrast to piles driven into Boulder Clay that exhibit friction fatigue, the shaft distribution was uniform along the pile shaft. This resulted in the normalised average shear resistance being mobilised by a bored pile exceeding that of a pile driven in similar ground conditions. In contrast, the base resistance of the test piles was significantly lower than that of a pile driven in similar ground conditions.

### **Identifying low-fines soils not suited to NEF testing**

A. Soroush, A.-H. Aminzadeh and P. T. Shourijeh

*Proceedings of the Institution of Civil Engineers, Geotechnical Engineering*, **161**, No. 4, August, 181–188,  
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Dam core cracking is responsible for the initiation of piping in many dam incidents. Filters capable of controlling the concentrated leak through a cracked core are relied on to prevent internal erosion. The no-erosion filter (NEF) test, widely used for filter substantiation, is predicated on the assumption that all the base soils sustain cracks in their volume, and critical filters should be designed to control a concentrated leak. This study is aimed at finding some of the soils that self-heal and collapse owing to wetting. Self-healing soils cannot withstand cracks upon flooding, thus negating the feasibility of the NEF test for such soils. A comprehensive testing strategy is introduced for the recognition of self-healing soils. The results reveal that soils containing less than 15% fines content will not sustain cracks, and the possible cracks formed will self-heal upon flooding.

### **The ground: clients remain exposed to unnecessary risk**

D. Egan

*Proceedings of the Institution of Civil Engineers, Geotechnical Engineering*, **161**, No. 4, August, 189–195,  
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The ground remains the greatest source of risk to construction projects. In spite of a wealth of freely available information

and guidance on the central importance of adequate site investigation in managing ground risk, many clients remain unnecessarily exposed to risk due to inadequate site investigation. The Federation of Piling Specialists undertook a comprehensive survey of geotechnical designers within its membership to evaluate the usefulness of site investigation information routinely provided to them. For nearly a third of all the piling and specialist geotechnical contracts surveyed, the site investigation information provided was poor, preventing optimisation of the foundation solution. The cost to clients arising out of poor site investigations far exceeds the savings that could be made by following good practice when investing in a site investigation. The survey indicates that good practice guidance is not being followed, resulting in investigations that are not adequately designed, specified or supervised.

### **The properties of Lias Clay for landfill liners**

A. Binns, P. N. J. Robinson, and C. S. Eccles  
*Proceedings of the Institution of Civil Engineers, Geotechnical Engineering*, **161**, No. 4, August, 197–207,  
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The design and specification of a landfill clay liner require compromises to be made between the requirements of low hydraulic conductivity (permeability), adequate shear strength, sufficient interface shear strength (when the clay is used in a composite liner), minimal shrinkage during service, and sufficient ductility to accommodate tensile and shear strains, which may increase permeability. This paper focuses mainly on the first three requirements. The results of construction quality assurance (CQA) from four landfill sites and the results of ground investigations from two landfill site extensions are reported. Proposals are made for a methodology to derive a specification, and for assessing the results of CQA tests. Undrained and effective stress strength parameters are presented for recompacted Lias Clay. The interface shear strength of clay against a geomembrane or geotextile is shown to be dependent upon the density and moisture content of the clay and normal pressure.

### **Using trenches to reduce tunnelling vibrations**

M. E. Rahman and T. L. L. Orr  
*Proceedings of the Institution of Civil Engineers, Geotechnical Engineering*, **161**, No. 5, October, 227–233,  
doi: 10.1680/geng.2008.161.5.227

Wave barriers are often used in engineering practice to reduce the ground vibrations induced by man-made sources such as traffic and machine foundations. In this paper, the results of a numerical study, with three-dimensional finite elements coupled with infinite elements, are presented to examine the effectiveness of open and backfilled trenches as wave barriers in reducing the ground surface vibrations due to tunnelling activities. The effects of the geometrical dimensions of the trenches and material properties of the backfill on the reduction of ground vibrations are studied. It is found that the percentage reduction in the vibration velocities increases with increasing depth of the trenches, and softer backfill materials yield a better screening effect than stiffer materials.

### **Refining shear strength characteristic value using experience**

D. J. Baxter, N. Dixon, P. R. Fleming and K. Cromwell  
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Determination of characteristic values for soil properties forms a critical step in the foundation design process. The refinement of such values to account not only for site-specific data but also for existing knowledge and previous experience can result in more efficient design and increased confidence. This paper presents a logical, pragmatic approach for the selection of characteristic values of shear strength for the design of piled foundations within the context of Eurocode 7. The process of refining conceptual models of geotechnical properties in a quantitative, objective manner to include previous knowledge and wider experience is described and demonstrated through case study examples. The result of applying the updating methods is to achieve a revised mean that is a weighted average of the site data and the prior knowledge; the weighting is a function of the variability of each set of data. Such refinement relies upon a quantification of previous knowledge: mean values, trends, variations and distributions of data are required, and in this paper a dataset for undrained shear strength of London Clay is presented and applied to case study examples. Application of the techniques described leads to a better estimate of the ground properties and a reduction in the risk attached to a design solution.

### **Foundation behaviour below an embankment on soft soils**

B. R. Rankine, B. Indraratna, N. Sivakugan, V. Wijeyakulasuriya and C. Rujikiatkamjorn  
*Proceedings of the Institution of Civil Engineers, Geotechnical Engineering*, **161**, No. 5, October, 259–267,  
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The Sunshine Motorway is one of the major traffic corridors that service the South East region of Queensland, Australia. Initial investigations for the construction of pavements in area 2, stage 2 of the motorway began in late 1990. Large areas of soft, highly compressible organic clays were found to exist over the length of the upgrade. Also, because the topography of the proposed alignment was mostly low lying, earthworks were required over a large portion of the route. Prior to any earthworks for the stage being undertaken, a trial embankment was constructed in the area to provide an understanding of the foundation behaviour and to also ensure the overall success of the project. The finite difference code FLAC was employed to investigate the performance of the full-scale trial embankment, and the underlying soft clay. Predictions of the excess pore pressure and both vertical and lateral displacements are made and compared with field observations.

### **Investigating anisotropy in shear strength of clayey soils**

M. F. Attom, and N. M. Al-Akhras  
*Proceedings of the Institution of Civil Engineers, Geotechnical Engineering*, **161**, No. 5, October, 269–273,  
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This study investigates the anisotropic behaviour of the shear strength of overconsolidated clayey soils. The results of the

study will help engineers and scientists to predict the lateral shear strength of clayey soils from the ordinary vertical shear strength. The main objective of this paper is to investigate experimentally the effect of anisotropy on the shear strength properties of clayey soil. Fifteen types of clayey soil were obtained from various locations in the Irbid area, Jordan, and from different depths. Three undisturbed samples were obtained from each location at three different inclinations (horizontal, vertical, and inclined at 45° to the vertical). Unconfined compression tests were conducted on all soil samples. It was found that the unconfined compressive strength values were greater in the vertical direction than in the inclined and horizontal directions, and increased as the overconsolidated ratio increased. It was also noticed that the failure strain in the horizontal samples was smaller than in the vertical samples. The anisotropic behaviour of clayey soils almost disappeared at greater depth for both unconfined compressive strength and failure strain.

#### **Working platforms for tracked plant**

J. A. Charles, D. Corke, and Hilary D. Skinner, R. Whitbybird  
*Proceedings of the Institution of Civil Engineers, Geotechnical Engineering*, **161**, No. 6, December, 279–281,  
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If a piling rig overturns there can be a risk of casualties. Working platforms are critical for plant stability, and a good practice guide to the design, installation, maintenance and repair of ground-supported working platforms for tracked plant has been prepared. A simplified approach to the design calculations has been based on a punching shear failure mechanism. The platform design is an integrated package, from track loading through to geotechnical design.

#### **Effect of core composition on seismic stability of earth dams**

A. Shafiee

*Proceedings of the Institution of Civil Engineers, Geotechnical Engineering*, **161**, No. 6, December, 283–290,  
doi: 10.1680/geng.2008.161.6.283

It is current practice to employ composite clay – a mixture of clay and aggregates that floats within the clayey matrix – as the core of embankment dams, which were previously constructed from pure clays. Experience has shown that significant pore pressure can build up during cyclic loading in composite clays. In this paper, the results of dynamic analyses performed on the Karkheh dam in Iran, incorporating different core materials, are presented. Pure clay and composite clay are used as the core materials and the results of the analyses are compared. It is shown that significant seismic pore pressure build-up in composite clays can significantly reduce the factor of safety against sliding for the fragment of the slip surface passing through the core, even though the overall factor of safety falls within a reasonable level.

#### **A statistical guide for dynamic-penetration test interpretation**

V. Navarro, A. Yustres, J. Sánchez and M. Candel

*Proceedings of the Institution of Civil Engineers, Geotechnical Engineering*, **161**, No. 6, December, 291–298,  
doi: 10.1680/geng.2008.161.6.291

This paper presents a methodology, implemented into a computer code, to support the interpretation of dynamic penetration super-heavy (DPSH) soil tests. The program is based on the analysis of variance (Anova) to evaluate the equality of means of groups of number of blows. The aim was to assess the identification of the different layers constituting the soil profile on which the penetration test was performed. The paper includes three examples of the application of the methodology, which will highlight both its capabilities and its limitations.