Αρ. 16 – ΑΥΓΟΥΣΤΟΣ 2008

ΕΛΛΗΝΙΚΗ ΕΠΙΣΤΗΜΟΝΙΚΗ ΕΤΑΙΡΕΙΑ ΕΔΑΦΟΜΗΧΑΝΙΚΗΣ & ΓΕΩΤΕΧΝΙΚΗΣ ΜΗΧΑΝΙΚΗΣ

Τα Νέα της Ε Ε Ε Ε Γ Μ

16

Το καλοκαίρι πλησιάζει στο τέλος του, όσο και αν δεν μας αρέσει, όσο και αν προσπαθούμε να προσθέσουμε κάτι στις διακοπές μας, ξεκλέβοντας κάποιες Παρασκευές και Δευτέρες από τη δουλειά. Έρχεται το φθινόπωρο και μαζί του πολλές επιστημονικές και επαγγελματικές προκλήσεις για όλους.

Στα πλαίσια της Εκτελεστικές Επιτροπής της ΕΕΕΕΓΜ θα προσπαθήσουμε εφέτος να κάνουμε έναν προγραμματισμό των εκδηλώσεών μας για όλη την επόμενη χρονιά (μέχρι τον Ιούλιο 2009), εντάσσοντας σ' αυτόν την διεξαγωγή ημερίδων, σεμιναρίων, διαλέξεων, εκπαιδευτικών επισκέψεων κ.ά. τόσο στην Αθήνα όσο οπουδήποτε στην Ελλάδα υπάρχει ενδιαφέρον για γεωτεχνικά θέματα. Είναι προφανές ότι για να επιτύχη μια τέτοια προσπάθεια χρειαζόμαστε και την βοήθεια των μελών της ΕΕΕΕΓΜ με τις προτάσεις τους, για τις οποίες παρακαλούμε να επικοινωνείτε με την σύνταξη του περιοδικού. Ελπίζουμε ότι μέχρι το τέλος Οκτωβρίου θα σταλή το πλήρες πρόγραμμα σε όλα τα μέλη.

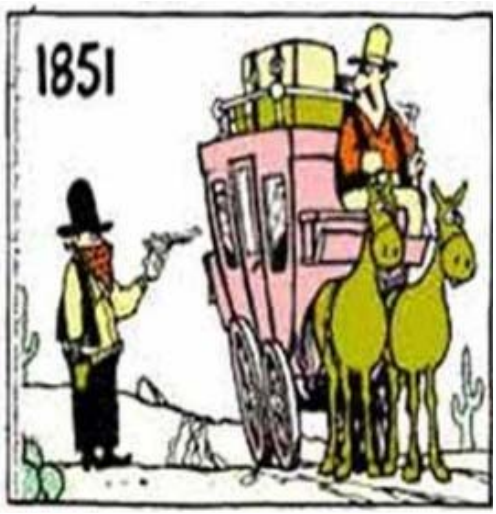
Πέρα, όμως, από τον προγραμματισμό της επόμενης χρονιάς, θα μας απασχολήσουν και δύο άλλα βασικά θέματα: η διοργάνωση του XV EUROPEAN CONFERENCE ON SOIL MECHANICS AND GEOTECHNICAL ENGINEERING, που ως γνωστόν θα διεξαχθή στην Αθήνα από τις 11 έως τις 15 Σεπτεμβρίου 2011 και η διοργάνωση, σε συνεργασία με το ΤΕΧΝΙΚΟ ΕΠΙΜΕΛΗΤΗΡΙΟ ΕΛΛΑΔΑΣ, του 6ου ΠΑΝΕΛΛΗΝΙΟΥ ΣΥΝΕΔΡΙΟΥ ΓΕΩΤΕΧΝΙΚΗΣ ΚΑΙ ΓΕΩΠΕΡΙΒΑΛΛΟΝΤΙΚΗΣ ΜΗΧΑΝΙΚΗΣ το 2010.

Φωτογραφία: Σφηνοειδής αστοχία ασβεστολιθικού πρανούς στην Αετιά Νομού Γρεβενών.

(συνέχεια στην σελίδα 3)

Π Ε Ρ Ι Ε Χ Ο Μ Ε Ν Α

Η εξέλιξη της ληστείας



(συνέχεια από την σελίδα 1)

Για το πρώτο θα ανακοινωθή συντόμως η Οργανωτική Επιτροπή, επί κεφαλής της οποίας έχουν τεθή οι Ανδρέας Αναγνωστόπουλος, ως Πρόεδρος και ο Μιχάλης Παχάκης, ως Γραμματέας.

Όσον αφορά στο 6ο ΠΣΓΓΜ, η Εκτελεστική Επιτροπή πρότεινε στο ΤΕΕ να διοργανωθή στην Κύπρο για τους παρακάτω λόγους:

i. Τη σύσφιξη των επιστημονικών και επαγγελματικών σχέσεων Ελλάδας - Κύπρου.

ii. Το γεγονός ότι δεν έχει πραγματοποιηθεί Γεωτεχνικό Συνέδριο στην Κύπρο.

iii. Το ζωηρότατο ενδιαφέρον και η αθρόα προσέλευση των Κυπρίων συναδέλφων κατά την διάρκεια διαλέξεων επί θεμάτων εδαφομηχανικής που διοργάνωσε το ΤΕΕ παλαιότερα στην Κύπρο.

iv. Τη βοήθεια στην προετοιμασία των Κυπρίων συναδέλφων για την σύσταση αντίστοιχης Επιστημονικής Εταιρείας με στόχο την εισδοχή της ως μέλους της Διεθνούς Ένωσης Εδαφομηχανικής και Γεωτεχνικής Μηχανικής. Σε ανεπίσημη συζήτηση με τον επί κεφαλής για την Ευρώπη της Διεθνούς Ένωσης αποκομίσθηκε η εντύπωση ιδιαίτερα θετικής ανταπόκρισης στο ενδεχόμενο τόσο της διεξαγωγής του Συνεδρίου στην Κύπρο όσο και της ίδρυσης της αντίστοιχης Κυπριακής Επιστημονικής Εταιρίας.

v. Τη σκοπιμότητα σύσφιξης των οικονομικών – επαγγελματικών σχέσεων Ελλάδας και Κύπρου, με την ευκαιρία της εισόδου της Κύπρου στην Ευρωπαϊκή Ένωση και μάλιστα στη ζώνη του Ευρώ, στην οποία μπορεί να συμβάλει το Συνέδριο, πράγμα που εντάσσεται στα πλαίσια της εξωστρέφειας που προωθείται συστηματικά από το ΤΕΕ.

   Σημειωτέον ότι μέχρι προσφάτως στην Κύπρο, τουλάχιστον στον γεωτεχνικό τομέα, επικρατούσαν κυρίως εταιρείες βρετανικών συμφερόντων.

vi. Την ύπαρξη σημαντικότατης και εξαιρετικής ξενοδοχειακής και συνεδριακής υποδομής.

vii. Την ευκαιρία για πολλούς συνέδρους από την Ελλάδα να γνωρίσουν την Κύπρο και τη γνωστή Κυπριακή φιλοξενία, κουζίνα και αξιοθέατα.

viii. Το εξαιρετικό κλίμα, τόσο την άνοιξη όσο και το φθινόπωρο (πιθανές εποχές διεξαγωγής του συνεδρίου), που δίνει μεγάλες δυνατότητες συνδυασμού του συνεδρίου με αναψυχή, ιδίως για τα συνοδά πρόσωπα.

ix. Το γεγονός ότι, με δεδομένες τις σημερινές τιμές των αεροπορικών εισιτηρίων, η δαπάνη αεροπορικής μετάβασης είναι απόλυτα συγκρίσιμη με άλλους ελληνικούς προορισμούς, όπως π.χ. η Ρόδος ή η Κρήτη.

Όμως, δεδομένου ότι το ίδιο έτος το ΤΕΕ προτίθεται να διοργανώση στην Κύπρο το Συνέδριο Σκυροδέματος, η Διοικούσα Επιτροπή του ΤΕΕ απεφάσισε να διοργανωθή το 6ο ΠΣΓΓΜ στον Βόλο.

ΑΡΘΡΑ

Τα ακόλουθα άρθρα αποτελούν συμμετοχή μελών της ΕΕ-ΕΕΓΜ στο πρόσφατο *E-UNSAT 2008 / 1st European Conference on Unsaturated Soils, 2 – 4 July 2008, Durham, UK*.

Modifying the Barcelona Basic Model to account for residual void ratio and subsequent decrease of shear strength relative to suction

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ABSTRACT

The paper presents modifications to the Barcelona Basic Model to account for two aspects of unsaturated soil behaviour affecting the predictions for both fine-grained and granular soils: stabilisation of void ratio and different patterns of shear strength evolution with increasing suction. The first modification improves predictions of volume change at suctions close to the residual state. The second modification improves predictions of shear strength evolution with increasing suction for various types of soils. It is shown how the proper selection of values for the new parameters introduced allows the prediction of either continuously increasing shear strength, or stabilising shear strength, or even subsequently decreasing shear strength after an initial increase. The paper concludes with a presentation of the differences caused by these modifications in the shape of the yield surface in the p-q-s space and the possible shape of the boundary of plastic volumetric deformation in the p-s plane.

1 INTRODUCTION

The Barcelona Basic Model (BBM) introduced by Alonso et al. (1990) was the first complete constitutive model for non-expansive unsaturated soils to capture all the fundamental aspects of unsaturated soil behaviour. Since then other models based on BBM have been proposed, which introduce more detail into the prediction of unsaturated soil behaviour. All these models are based on critical state theory as it has been extended to include suction as a separate stress parameter. While they succeed in predicting the general behaviour of unsaturated soils, like the increase of shear strength with suction exhibited by clays and the volume changes with suction expected for the corresponding total stress magnitude, they cannot predict certain specific characteristics which have been experimentally established. The first is the prediction of the range of suction in which shrinkage actually takes place for relatively low total stress. The second is the possibility of subsequent stabilisation or decrease of shear strength after an initial increase up to the air-entry pressure, as alternatives to continuous increase of shear strength exhibited by BBM and other models. The modifications introduced predict volume decrease only up to the shrinkage limit and the possibility of any shear strength evolution scenario past the air-entry pressure of the soil, i.e. further increase of shear strength, stabilisation of shear strength or even decrease to a lower value or even zero.

2 BBM AND OTHER MODELS

BBM remains until today the reference constitutive model describing the mechanical behaviour of non-expansive unsaturated soils. The model is formulated in the p-q-s space, where $p=(\sigma_1+2\ \sigma_3)/3-u_a$, $q=\sigma_1-\sigma_3$ and $s=u_a-u_w$ (u_a and u_w are the pressures of the pore air phase and the pore water phase respectively, and σ_1, σ_2 and σ_3 are the principal total stresses). The yield locus in the p-q plane is described by Equation 1, where p_s is the tensile strength developed by suction, as described by Equation 2, M is the slope of the critical state line, p_o the yield stress on the v-p plane ($s\neq0$) and k the rate of the tensile strength increase with suction.

$$f_1(p,q,s,p_o^*)\equiv q^2-M^2(p+p_s)(p_o-p)=0 \quad (1)$$

$$p_s=ks \quad (2)$$

The yield stress p_o evolves with suction according to Equation 3 where p_o^* is the yield stress on the v-p plane ($s=0$), p^c is a reference stress, κ and $\lambda(0)$ the compression indices on the v-p plane ($s=0$) and $\lambda(s)$ the compression index for $p>p_o$ ($s\neq0$) as described by Equation 4, where r, β are empirical parameters.

$$\frac{p_o}{p^c}=\left(\frac{p_o^*}{p^c}\right)^{\frac{\lambda(0)-\kappa}{\lambda(s)-\kappa}} \quad (3)$$

$$\lambda(s)=\lambda(0)\ [(1-r)\exp(-\beta s)+r] \quad (4)$$

The yield locus in the p-q-s space is supplemented by Equation 5, where s_o is the yield suction on the v-s plane.

$$f_2(s,s_o)\equiv s-s_o=0 \quad (5)$$

As it can be seen from Equations 1 to 5 (and from Curve a in Fig. 1), BBM incorporates only 3 parameters describing volume change directly associated to a variation of suction: κ_s, λ_s & s_o. These parameters allow the prediction of an initial low volume decrease (determined by κ_s) up to an essentially arbitrary value of suction s_o (which can be considered to describe physically the maximum suction applied to the soil) and then a further -and generally larger- value of volume decrease (determined by λ_s). Although this formulation is adequate for the range of suction significantly below the shrinkage limit of the soil, with the additional advantage that it is analogous to the formulation for volume decrease under zero suction conditions, it does not include a boundary corresponding to the shrinkage limit (either in terms of suction or void ratio) up to which volume may decrease, as presented by Curve b in Figure 1. For suctions close to residual water content, or higher, this type of formulation overestimates volume change as it underestimates final specific volume/void ratio values.

As far as shear strength is concerned, setting $p=0$ into Equation 1, and replacing p_s, p_o and $\lambda(s)$ from Equations 2, 3 and 4 respectively yields Equation 6 which represents the intersection of the 3-dimensional yield surface with the q-s plane (for $q>0$). Plotting Equation 6 in Figure 2 yields that BBM predicts continuous increase of shear strength with increasing suction. Although this is true for clays, it is not the case for sands, tuffs and sometimes silts, as shown by experimental results presented by Fredlund et al. (1995).

$$q=\sqrt{k}\cdot M\cdot\sqrt{s}\cdot\sqrt{p^c}\left(\frac{p_o^*}{p^c}\right)^{\frac{\lambda(0)-\kappa}{2\cdot\lambda(0)[(1-r)\cdot\exp(-\beta s)+r]-2\cdot\kappa}} \quad (6)$$

The terms in Equation 6 have been placed in such a sequence, so as the different effect of each factor can be distinguished. $k^{1/2}$ expresses the effect of the evolution of tensile strength. M expresses the direct effect of the slope of the critical state line on unsaturated shear strength. $s^{1/2}$ expresses the direct effect of suction increase on the increase of shear strength. The rest of the terms essentially express the effect of the loading history and the effect of drying-wetting cycles (indirect effect of suction on the evolution of shear strength). Despite the presence of numerous other factors however, none of them can alter the continu-

ous increase of shear strength shown in Figure 2 (as was proven by extensive parameter analyses carried out). For comparison, the curve shown in Figure 2 has been obtained for the set of values used by Alonso et al. (1990) for the 'reference soil' they used for their predictions with BBM ($\lambda(0)$=0.2, κ=0.02, r=0.75, β=12.5 MPa^{-1}, p_c=0.1 MPa, p_o^*=0.6 MPa, M=1, k=0.6).

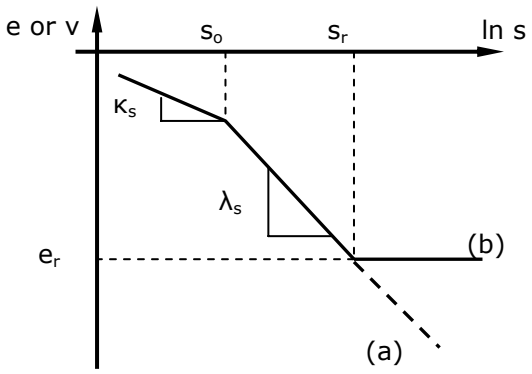

Figure 1. Void ratio/Specific volume changes with increasing suction under zero total stress: Curve a does not account for residual void ratio, while Curve b takes residual void ratio into account.

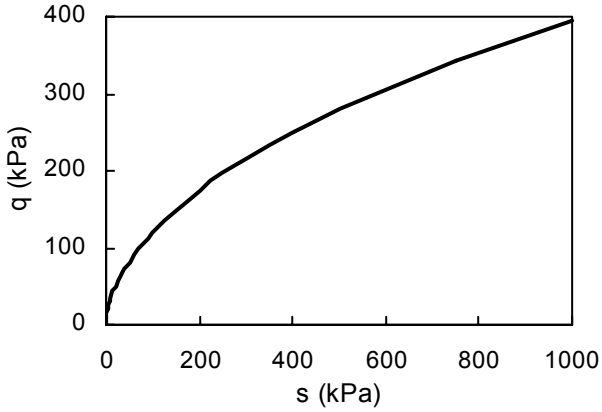

Figure 2. Shear strength evolution with increasing suction according to BBM (graphical representation of Eq. 6).

Other constitutive models which do not incorporate a limiting value of void ratio change or alternative possibilities for shear strength evolution have been proposed (e.g. Wheeler & Sivakumar, 1995). Toll (1995) presented a conceptual model for the drying and wetting of soil which predicts the limiting of void ratio changes and therefore the calculated volume changes up to the void ratio corresponding to shrinkage limit. Kohgo et al. (1993a & b) and Kohgo (2004) have proposed models which have limiting parameters for volume change and the capability to model alternative patterns of shear strength evolution. Georgiadis et al. (2003) proposed among other modifications that parameter k can vary with suction by setting k equal to degree of saturation and therefore the evolution of k with suction equal to the soil-water characteristic curve of the soil. This approach solves the problem for soils expected to exhibit an initial increase of shear strength with suction and then a subsequent decrease, like granular soils, but it does not provide a universally applicable equation for shear strength evolution, making it therefore necessary to switch between equations for k for each type of material.

Other approaches in constitutive modelling of unsaturated soils have focused on combining LC and SI curves into one single surface. Delage & Graham (1996) proposed first that the two curves are probably one single locus in the p-s plane. Sivakumar & Doran (2000) presented first experimental evidence to support this, while Tang & Graham (2002) took the effort one step further by proposing a conceptual but complete constitutive model with one single continuous 3-dimensional yield surface in the p-q-s space. This constitutes a different approach towards incorporating the capability to model various scenarios of shear strength evolution.

3 THE MODIFICATIONS TO BBM

Common shrinkage limit tests and a large number of published drying curves indicate that clayey soils shrink to a minimum value of their void ratio during drying and then shrink no more, irrespective of how large the suction becomes. As shown by Curve a in Figure 1 therefore the specific volume-suction curve described by only 4 parameters (initial value N of specific volume at atmospheric pressure p_{at}, κ_s, λ_s and s_o) should be substituted by the idealised Curve b shown in Figure 1 with a flat final portion corresponding to the residual void ratio e_r (v_r=1+e_r). This curve needs only one additional parameter for its description, either the residual void ratio e_r, or the suction it is first achieved. Recently, Bardanis & Kavvadas (2006) proposed an empirical relation predicting the residual void ratio of low to medium plasticity clays and marls which have been consolidated to various stresses from a slurry condition and then unloaded and left to dry to residual water content in atmospheric conditions. The residual void ratio is predicted from the physical properties of the soil (w_L, G_s) and its initial state before drying, as expressed by initial void ratio before drying, e_o, and an empirical parameter, m, found to be 0.43 for the soils tested by Bardanis & Kavvadas (2006). More recently Bardanis & Kavvadas (2008) proposed another empirical relation (derived from many more soils and test results) based on w_p rather than w_L and an empirical parameter, m_e, equal to -0.38, along with its conceptual generalisation for soils with structure by addition of another parameter, M_s. The proposed relations by Bardanis & Kavvadas (2006 & 2008) are represented by Equations 7 & 8 respectively for soils without natural structure, and by Equation 9 for natural soils.

$$e_r = e_o\left(1 - \frac{m}{w_L \cdot G_s}\cdot e_o\right) \quad (7)$$

$$e_r = e_o \cdot \exp\left(m_e \cdot \frac{e_o}{w_P \cdot G_s}\right) \quad (8)$$

$$e_r = M_s \cdot e_o \cdot \exp\left(m_e \cdot \frac{e_o}{w_P \cdot G_s}\right) \quad (9)$$

The set of Equations 7 to 9 allows the prediction of the residual void ratio and as a result the calculation of the residual specific volume for incorporation as a model parameter into BBM. The use of the residual void ratio in the formulation of the BBM allows more realistic predictions of volume changes due to suction increase under constant total mean stress during elastic or elasto-plastic loading. It allows for the derivation of a limiting line in the p-s plane up to which volume changes do actually occur due to suction changes for the same mean total stress magnitude. Past this line the only volume changes that may occur are due to mean stress p increase. This point is further discussed in Section 4.

For the more accurate prediction of shear strength, the most suitable term from Equation 6 was selected. This was k and it was given such a form so as to predict either continuous increase of shear strength, or initial increase and then stabilisation, or finally initial increase and then de-

crease of the shear strength. In order for this to take place it is proposed that k may be described by a function of the degree of saturation which takes the form of Equation 10.

$$k = \zeta_k \cdot S_r^{\eta_k} \qquad (10)$$

In Equation 10, k is the factor giving tensile stress, S_r is the degree of saturation and ζ_k and η_k are empirical parameters.

For η_k = 0 and arbitrary values of ζ_k, prediction of shear strength is essentially like in the BBM. For η_k = 1 and ζ_k = 1, k becomes equal to the degree of saturation as adopted by Georgiadis et al. (2003). For selected values of η_k and ζ_k the prediction of all scenarios of the evolution of shear strength with increasing suction is possible. In Figure 3 the effect of η_k for constant ζ_k is shown and in Figure 4 the effect of ζ_k for constant η_k is shown. In order to plot Figures 3 and 4 a soil-water characteristic curve was assumed for the material corresponding to the parameter values mentioned in Section 2. This soil-water characteristic curve was produced by use of the Fredlund & Xing (1994) equation assuming the following values for the empirical parameters of the equation: a=600 kPa, n=4, m=2 and s_r=5000 kPa. For the set of values selected to plot Figure 2 the same relation between q and s is predicted for ζ_k = k of BBM and η_k = 0. Continuous increase of shear strength is also exhibited for η_k=0.2, but the increase is smaller, while for a value of η_k=0.5 the strength practically stabilises after its initial increase, while for η_k=1 and η_k=2 rapid decrease occurs after the ini tial increase in strength. The parameter η_k can be used therefore for determining the evolution of the shear strength of unsaturated soils past the initial increase, whether that may be further increase, stabilisation, or decrease. As far as the parameter ζ_k is concerned, it determines the initial slope and subsequent position of the q-s curve.

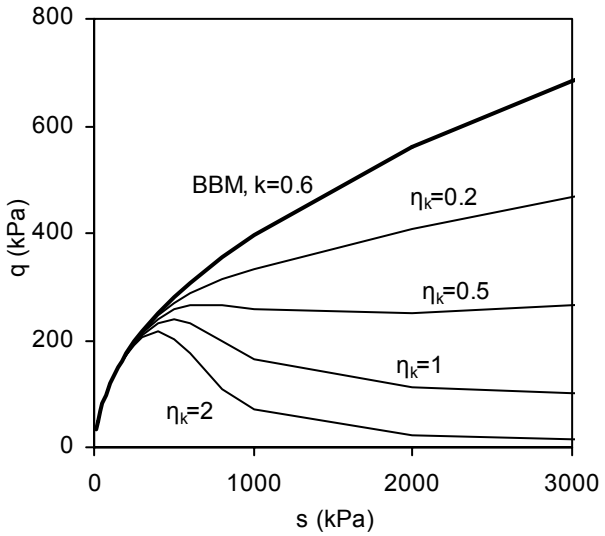

Figure 3. The effect of parameter η_k on the evolution of shear strength with suction. ζ_k is constant with a value of 0.6 and the rest of the parameter values are the same as those for the curve in Figure 2 (bold curve in this figure).

4 EFFECT ON THE SHAPE OF THE YIELD LOCUS

Apart from the direct effect on the predictions of volume change and shear strength evolution with increasing suction, the modifications introduced into BBM have a major effect on the shape of the yield surface in the p-q-s space. In Figure 5a the intersection of the 3-dimensional yield surface of the BBM with the p-s plane is presented. The increase in the size of the yield locus in the p-q plane (or its trace on the p-s plane) is continuous according to the ten-

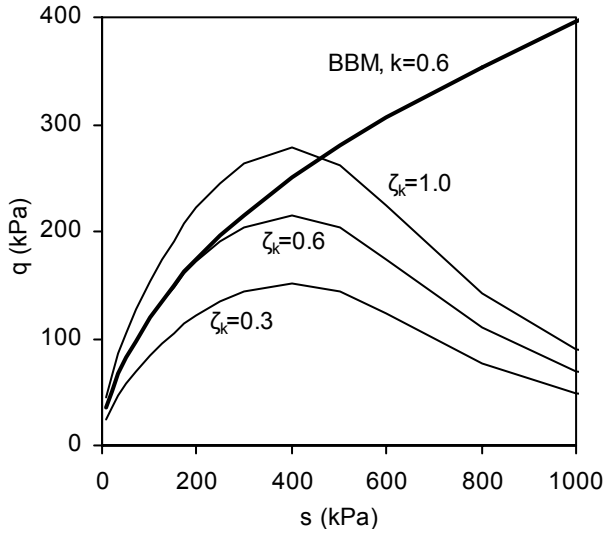

Figure 4. The effect of parameter ζ_k on the evolution of shear strength with suction. η_k is constant with a value of 2 and the rest of the parameter values are the same as those for the curve in Figure 2 (bold curve in this figure).

sile strength increase law on one side and the evolution of the LC curve with suction on the other. For a material exhibiting continuous increase of tensile/shear strength with suction, the shape of the intersection of the yield surface with the p-s plane for the modified BBM is expected to be the same as for BBM (Fig. 5a). For materials exhibiting shear strength stabilization or decrease after an initial increase of shear strength however, the shape of the intersection of the yield surface with the p-s plane is expected to change as shown in Figures 5b & 5c respectively. For a soil with continuously increasing shear strength with suction, the left point of the ellipse defining the yield locus will continuously move towards more negative values of total mean stress (Fig. 5a). For a soil with stabilizing shear strength after a certain value of suction, this point will stabilise in the p-q plane and the expansion of the yield locus will be only due to a mean total stress increase (Fig. 5b). Finally for a soil with initially increasing and subsequently decreasing shear strength with suction, this point of the ellipse on the p-q plane will tend to approach the origin of the plot of this plane and once again the expansion of the yield locus will be only due to a mean total stress increase (Fig. 5c).

As it has already been mentioned in Section 3, the use of the residual void ratio in the formulation of the BBM allows for the derivation of a limiting line in the p-s plane up to which volume changes do actually occur due to suction changes for the same mean total stress magnitude. Past this line the only volume changes that may occur are due to mean stress p increase.

Using one of the Equations 7 to 9 residual void ratio may be predicted. The initial void ratio e_o before drying needs to be specified first. Once the residual void ratio has been predicted, then using s_o and λ_s (already used parameters of BBM) the value of the suction at which the residual void ratio is achieved may be calculated. Introducing now the change in initial void ratio caused by κ for zero suction in the elastic region, then the evolution of the suction at which the residual void ratio is achieved for constant total stress suction paths (for $p<p_o^*$) is obtained. This is as shown by curve A-B in Figure 6 for the parameter values mentioned in Section 2 (assuming e_o=0.9 for p=10 kPa, which yields e_r=0.629 according to Eq. 8 for this value of net mean stress and e=0.840 for κ=0.02 at p=200 kPa, which itself yields e_r=0.601 according to Eq. 8). The space in the p-s plane between the SI locus and curve A-B constitutes the space where plastic volumetric strains (in the form of ire-

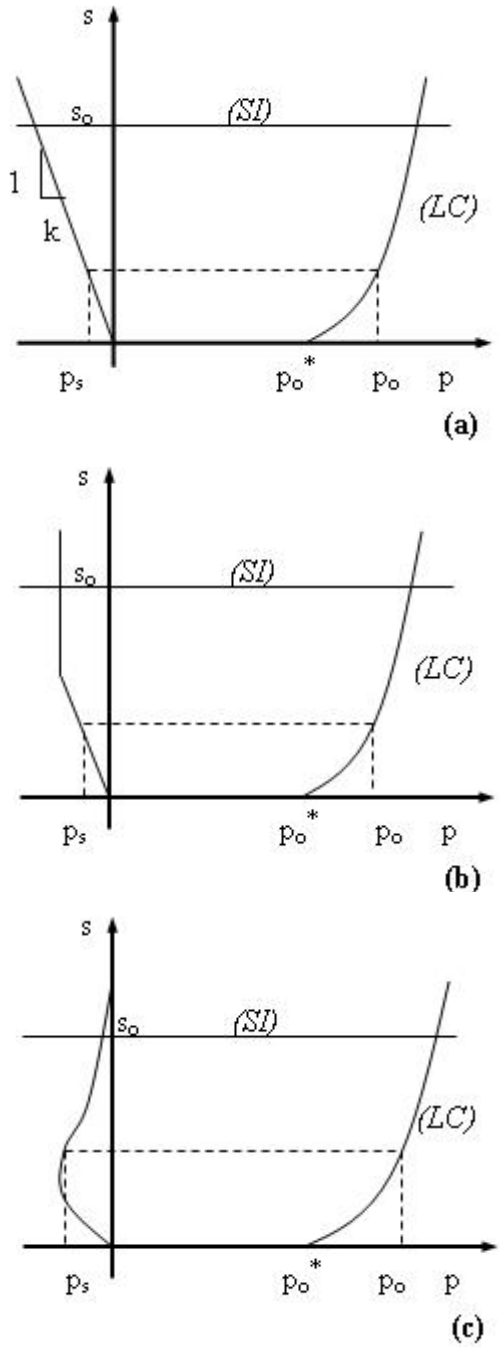

Figure 5. Intersection of the 3-dimensional yield surface with the p-s plane for a soil: a) with continuous increase of shear strength, b) with initial increase and then stabilisation of its shear strength, and c) with initial increase and subsequent decrease of its shear strength with suction.

coverable shrinking) due to suction increase will take place for p values in the elastic region of the fully saturated soil yield locus. For constant total stress suction paths corresponding to p values greater than p_o^* (which means that plastic volumetric deformation has already occurred before drying commences) and more complex paths involving alternations between constant total stress paths and constant suction paths or simultaneous p and s change paths it is considered that Equations 7 to 9 are not appropriate for an estimation of the locus limiting volume changes due to constant total stress suction changes.

This limiting line is strongly dependent on the value of κ as this parameter controls the values of initial void ratio in the elastic region of the fully saturated yield locus. Figure 7 shows the different lines defined for various values of κ ranging from 0 to 0.04. The limiting curves in Figure 7 do not start from the axis p=0 because of the logarithmic nature of the elastic relation between void ratio and mean net stress. A value of κ=0 yields a limiting line parallel to the SI locus as no change to initial void ratio before drying can occur in the elastic region. As the value of κ becomes higher, then the value of the suction that residual void ratio is achieved becomes smaller with increasing p, even more than 1.5 MPa for the values selected for the rest of the parameters in Figure 7. For simplicity the p axis in Figure 7 has been limited to 0.2 MPa, which is the fully saturated yield total stress (shown also in Figure 6), so as not to show the different LC yield locus that is derived for each of the κ values used.

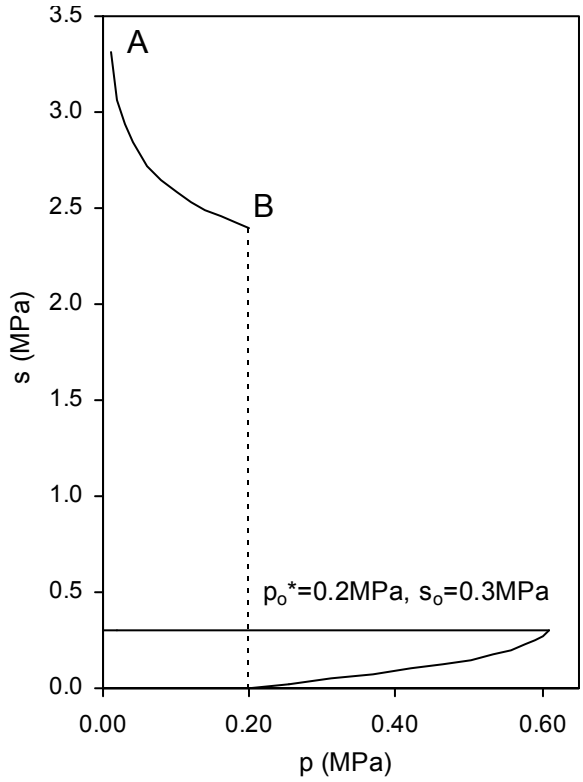

Figure 6. p-s plane with SI and LC loci and the predicted curve limiting the region of possible states for volume change to occur due to shrinkage for $p<p_o^*$.

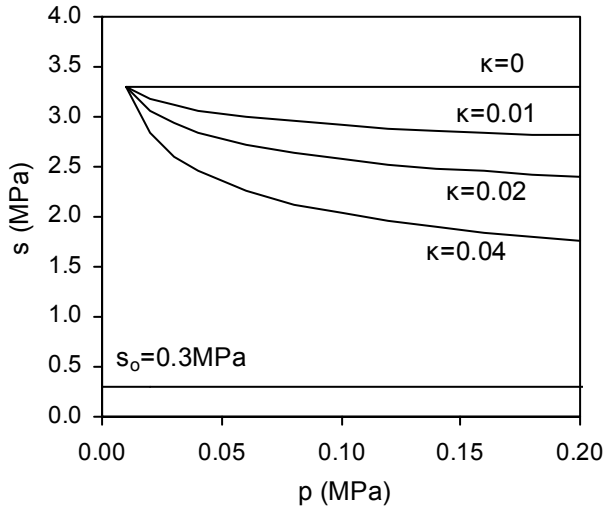

Figure 7. p-s plane with SI locus and the predicted curves limiting the region of possible states for volume change to occur due to shrinkage for various values of κ ($p<p_o^*$).

5 CONCLUSIONS

Most of the existing constitutive models cannot predict stabilization of void ratio as a result of attaining a minimum total volume during shrinkage. Also they do not incorporate the possibility to model various scenarios of shear strength evolution with suction increase (continuous increase, stabilization or decrease after an initial increase up to the air-entry pressure). Various approaches towards solving these two problems have been published but either they do not propose single equations predicting all types of response by controlling the values of parameters, or they have proceeded to totally different approaches in the treatment of the 3-dimensional yield surface; an approach that elevates constitutive modeling of unsaturated soils at another level of difficulty.

The modifications proposed for BBM in this paper maintain the capability to work with a well-established and well-understood framework, while capturing important aspects of unsaturated soil behaviour by the use of one single, universally applicable for all types of materials, equation: maximum volume shrinkage limited by residual void ratio, and various scenarios of shear strength evolution with suction. Apart from achieving the goals these modifications were introduced for, they also have a strong effect on the shape of the 3-dimensional yield locus in the p-q-s space as indicated by its intersections with the p-s plane in Figure 5. For a soil with continuously increasing shear strength with suction, the left point of the ellipse defining the yield locus will continuously move towards more negative values of total mean stress. For a soil with stabilizing shear strength after a certain value of suction, the distance of this point from the suction axis will stabilise and the expansion of the yield locus will be only due to a mean total stress increase. Finally for a soil with initially increasing and subsequently decreasing shear strength with suction, the distance of this point from the suction axis will tend to decrease to zero and once again the expansion of the yield locus will be only due to a mean total stress increase. As far as the effect of the residual void ratio is concerned, a line limiting the plastic strain due to constant total stress suction changes for total stress values lower than the yield stress of the fully saturated soil may be defined. The area between the SI curve of the BBM and this limiting line defines the area of possible plastic strains due to shrinkage in the p-s plane, for total stress values lower than the yield stress of the fully saturated soil.

ACKNOWLEDGEMENTS

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Prediction of the residual void ratio of clayey soils after drying, from their initial state, physical properties and structure

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ABSTRACT

Bardanis & Kavvadas (2006) proposed an empirical relation between residual void ratio e_r of clayey soils after drying and simple properties: initial void ratio e_o, liquid limit w_L and specific gravity G_s. Additional results are presented in this paper which support a new relation based on plastic limit w_P, along with new results from undisturbed soil specimens, which indicate the possible effect of structure due to natural processes. A generalised relation therefore would predict e_r from e_o, w_P, G_s and an empirical parameter related to the structure of natural soils. However, the findings of this study indicate great scatter in correlations of e_r with soil index properties. Additionally, studies on undisturbed soils indicate considerable influence of soil stress history on e_r, thus complicating the development of a generalized relation for predictive purposes.

1 INTRODUCTION

Prediction of volume changes occurring with changes in suction is fundamental for the study of the mechanical behaviour of unsaturated soils. Constitutive models proposed for unsaturated soils predict volume changes by the corresponding parameters for elastic and plastic strains, κ_s and λ_s respectively (Alonso et al. 1990). As shown in Figure 1 (curve a) for changes in suction under zero total stress, specific volume v (v=1+e), and therefore void ratio e, vary linearly with suction (in logarithmic scale), according to parameter κ_s for suction values up to suction s_o (an arbitrary value of suction corresponding to yielding during drying, physically representing the maximum suction applied to the soil) and according to parameter λ_s for suction values past s_o. This type of formulation is in agreement with the formulation for the prediction of volume changes due to total stress changes under constant suction, according to parameters κ and λ(s). Such models predict realistic volume changes for suctions lower than that corresponding to residual water content, down to which shrinking during drying occurs. For suctions close to residual water content, or higher, this type of formulation overestimates volume change as it underestimates final specific volume/void ratio values. Numerous published test results (e.g. Fredlund & Rahardjo, 1993) and common experience with shrinkage tests have shown that total volume and void ratio during drying under zero total stress are expected to reach a limiting lower value e_r, which corresponds to residual water content and will be referred to as the residual void ratio. The value of e_r (or its corresponding value of specific volume $v_r=1+e_r$) should be the lowest value predicted by constitutive models for unsaturated soils. Models have been proposed recently which introduce parameters limiting volume changes with increasing suction under constant total stress (e.g. Toll, 1995, Kohgo, 2004). Toll (1995) presented a conceptual model for the drying and wetting of soil which predicts the limiting of void ratio changes and therefore the calculated volume change up to the void ratio corresponding to shrinkage limit (curve b in Fig. 1). For this to be possible only one additional parameter is necessary. This is either the value of suction s_r at which e_r is first achieved (second inflection point of curve b in Fig. 1) or simply e_r itself. Residual void ratio e_r therefore emerges as a critical parameter for constitutive modeling of deformable unsaturated soils.

2 PREDICTION OF RESIDUAL VOID RATIO

Anticipating the advantages of using e_r rather than s_r for use in constitutive modeling, Bardanis & Kavvadas (2006) proposed an empirical relation predicting e_r on the basis of tests on low to high plasticity clays and marls (Eq. 1). Residual void ratio e_r is predicted from the initial state of the soil, as expressed by initial void ratio when drying starts, e_o, the physical properties of the soils, as expressed by their liquid limit w_L and specific gravity G_s, and an empirical parameter m, found equal to 0.43.

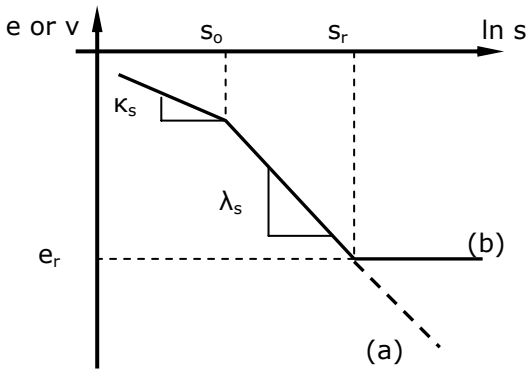

Figure 1. Void ratio/Specific volume changes with increasing suction under zero total stress: a) without accounting for residual void ratio, and b) taking residual void ratio into account.

$$e_r = e_o\left(1 - \frac{m}{w_L \cdot G_s}\cdot e_o\right) \quad (1)$$

Equation 1 was obtained from ten experimental points obtained for four materials. Residual void ratio values were measured on specimens left to dry in atmospheric conditions from a slurry condition or after being consolidated one-dimensionally and then unloaded to zero overburden stress. Since then experimental results from other soils have been collected and they are presented in Section 3. Index properties of the soils tested by Bardanis & Kavvadas (2006) are presented in Table 1, along with initial and residual void ratio values. The experimental results with the plot of Equation 1 are presented in Figure 2. Equation 1 obtained from the experimental results in Table 1 has 90% degree of correlation and passes through point $\{e_r/e_o=1, e_o/e_L=0\}$.

Table 1. Index properties of the soils tested by Bardanis & Kavvadas (2006) along with e_o and e_r values.

Soil	w_L (%)	I_p -	G_s -	Condition[1]	e_o -	e_r -
Chania Clay	24	9	2.68	Slurry	1.05	0.35
				Slurry	1.04	0.34
				100 kPa	0.59	0.33
				200 kPa	0.52	0.31
				400 kPa	0.51	0.34
				1600 kPa	0.43	
0.31						
Speswhite Kaolin	64	32	2.61	Slurry	2.81	0.72
Corinth Marl	34	12	2.67	Slurry	1.27	0.51
				800 kPa	0.66	0.51
Kifissia Marl	31	16	2.66	600 kPa	0.57	0.34

[1]: The stress reported in column "Condition" is the maximum stress applied one-dimensionally to a slurry of the soil and then removed before drying started.

Equation 1 was derived from a small number of experimental points. Still the degree of correlation was very high, the best-fit equation passes through point $\{e_r/e_o=1, e_o/e_L=0\}$, which is expected given the normalisations used, and the scatter of the points around the best-fit line is relatively small. For e_o/e_L tending to 0, e_r/e_o is logically expected to tend to unity. Using e_o to normalise e_r expresses essentially

how much the total volume of an initially saturated specimen decreases due to drying, while using e_L to normalise e_o as correlation parameter expresses that the state relative to the nature of the soil (expressed by the void ratio at liquid limit, $e_L=G_s \cdot w_L$) is the determining correlating factor.

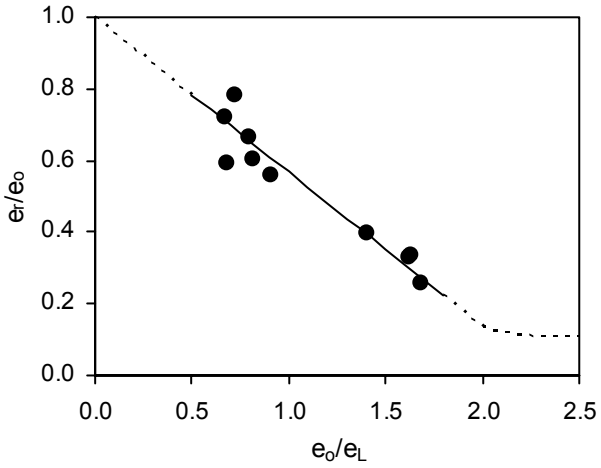

Figure 2. Normalised residual void ratio e_r/e_o vs normalised initial void ratio e_o/e_L at the beginning of drying with the empirical relation proposed by Bardanis & Kavvadas (2006) and expected extensions (dashed lines).

3 ADDITIONAL EXPERIMANTAL RESULTS FOR RECONSTITUTED DOILS

Although small, the number of experimental points used by Bardanis & Kavvadas (2006) was sufficient to support a conceptual relation between e_r and the initial state and physical properties of reconstituted soils and reconstituted soils consolidated to various stresses one-dimensionally and then unloaded. Still it was considered important that further experiment tal results were gathered in order to study residual void ratio and its correlation with the physical properties and the initial state of soil. In Table 2 additional experimental results obtained for two more soils tested at NTUA are presented and in Table 3 additional experimental results from various sources. With the experimental results presented in Tables 2 & 3 the total number of experimental points rose to 30, obtained for 21 materials, ranging from pure high plasticity clays (even pure kaolinites and montmorillonites) to silty sands.

Table 2. Index properties of additional soils tested along with e_o and e_r values.

Soil	w_L (%)	I_p -	G_s -	Condition[1]	e_o -	e_r -
Ioannina Lake Silt	24	1	2.55	100 kPa	0.69	0.58
Kifissia Clay	41	21	2.67	600 kPa	0.70	0.34

[1]: The stress reported in column "Condition" is the maximum stress applied one-dimensionally to a slurry of the soil and then removed before drying started.

In Figure 3, all the additional new data are plotted (empty circles) over the experimental points from Bardanis & Kavvadas (2006) and the empirical relation they proposed. As observed, the scatter of the sum of all data now is much larger, even though it seems evenly distributed on either side of the linear relation proposed. Regression analysis of the whole set of data shows that the equation describing the linear relation between e_r/e_o and e_o/e_L does not change significantly but the degree of correlation drops from 90% to 44%. This picture of the whole set of data on the e_r/e_o-e_o/e_L plot showed that an alternative relation should be investigated. Following the same line of thought regarding the parameters that should be used to express the relation of residual void ratio to physical properties and initial conditions, an alternative to e_L was examined.

Table 2. Index properties, initial void ratio and residual void ratio for soils from various sources.

Soil	w_L (%)	I_p -	G_s -	Condition[1]	e_o -	e_r -
Fleureau et al. (1993)						
Sterrebeek Loam	27	4	2.65[2]	Slurry	0.78	0.61
				200	0.61	0.52
Orly Loam	31	9.5	2.65[2]	Slurry	1.23	0.39
Jossigny Loam	37	17.5	2.65[3]	Slurry	1.26	0.46
White Clay	61	30	2.67[3]	Slurry	2.00	0.88
Montmorillonite	170	110	2.64[3]	Slurry	7.40	0.95
Dineen (1997)						
Speswhite Kaolin	64	32	2.61	200	1.15	0.76
London Clay	74	45	2.64	200	1.12	0.42
Melgarejo et al. (2002)						
Colluvium	95	48	2.65[2]	200	1.27	0.80
Fleureau et al. (2002)						
La Verne Clay	35	16	2.71	Slurry	1.42	0.75
Cunningham et al. (2003)						
Silty Clay	28	18	2.64	200	0.54	0.44
Fleureau et al. (2004)						
Silty Sand	19	9	2.69	Slurry	0.77	0.35
Fredlund (2004)						
Regina Clay	75	50	2.65	6.2 kPa	3.00	0.45
				400 kPa	1.40	0.45
Agus & Schanz (2006)						
Bentonite/Sand	130	97	2.65	Slurry	4.50	0.70
Abou-Bekr et al. (2006)						
Sikkak	50	27	2.64	Slurry	1.98	0.51
Peron et al. (2006)						
Bioley Silt	32	15	2.71	Slurry	1.33	0.57
Pineda & Colmenares (2006)						
Clayey Silt	28.3	10.7	2.64	Slurry	0.53	0.44

[1]: The stress reported in column "Condition" is the maximum stress applied one-dimensionally to a slurry of the soil and then removed before drying started.
[2]: Assumed value.
[3]: Value derived from the slope of the full saturation line in the e-w plots presented by the authors.

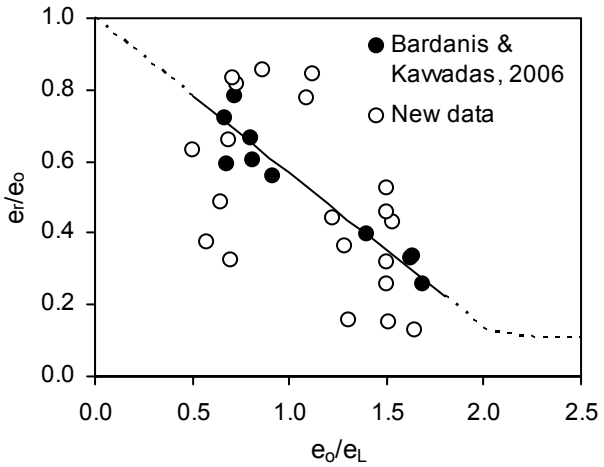

Figure 3. Normalised residual void ratio e_r/e_o vs normalised initial void ratio e_o/e_L with the empirical relation proposed by Bardanis & Kavvadas (2006), their experimental data and the new experimental data included.

In Figure 4 all the experimental data available are plotted but the void ratio at liquid limit has been substituted with the void ratio at plastic limit, e_P ($e_P=G_s \cdot w_P$). As observed, the scatter of data decreases significantly and an exponential relation between e_r/e_o and e_o/e_P appears as the best-fit curve. This is described by Equation 2.

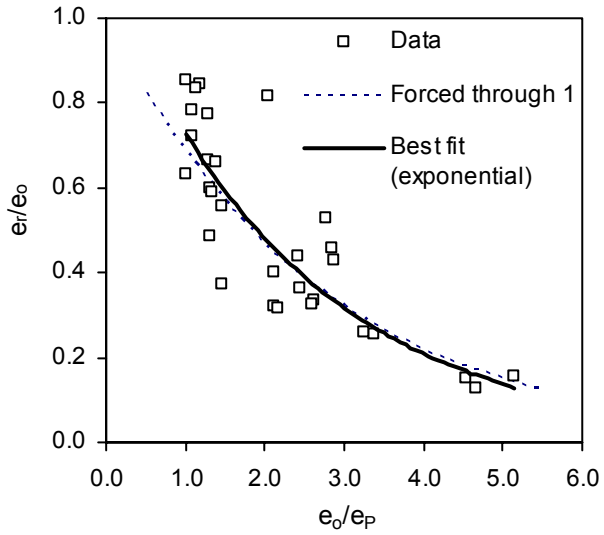

Figure 4. Normalised residual void ratio e_r/e_o vs normalised initial void ratio e_o/e_P with best fit (exponential) as is and if forced through point $\{e_r/e_o=1, e_o/e_P=0\}$.

$$\frac{e_r}{e_o} = 1.108 \cdot \exp\left(-0.42 \cdot \frac{e_o}{e_P}\right) \quad (2)$$

Equation 2 has 81% degree of correlation. The line described by Equation 2 does not pass through point $\{e_r/e_o=1, e_o/e_P=0\}$ as should theoretically be expected. If the best-fit line is forced to pass through point $\{e_r/e_o=1, e_o/e_P=0\}$ it is described by Equation 3 which has 80% degree of correlation. Equation 3 diverges only slightly from Equation 2 as shown by their comparison in Figure 4 (dashed and solid lines respectively).

$$\frac{e_r}{e_o} = \exp\left(-0.38 \cdot \frac{e_o}{e_P}\right) \quad (3)$$

As may be observed in Figure 5, all experimental data (with the exception of two outliers) lie within a range of ±35% from the line described by Equation 3. Predicted values of residual void ratio have been plotted against measured values in Figure 6. As it is observed, Equation 3 does not underestimate residual void ratio by more than 25% (except for the outliers shown in Fig. 5) although it may overestimate it even up to 50%. Still only 4 experimental points lie above the +25% line (and below the +50% line). Therefore for 24 out of 30 experimental points predicted values of e_r from Equation 3 lie within a range of ±25% of the measured values, and for the whole set of experimental points predicted values lie within a range of +50%/-40% of the measured values. This scatter is very large, especially for the empirical relation expressed by Equation 3 to be used for predictive purposes. Still it is the belief of the authors that this scatter is sufficiently low to support the theoretical relation between the parameters used. It is also sufficiently low to justify the need for further experimental research on various soils in pursuit of this type of empirical relation. Soils used in this research should be left to dry after they have been consolidated and unloaded to various e_o values, ranging from those corresponding to slurries to those corresponding to high stresses (in the order of MPa).

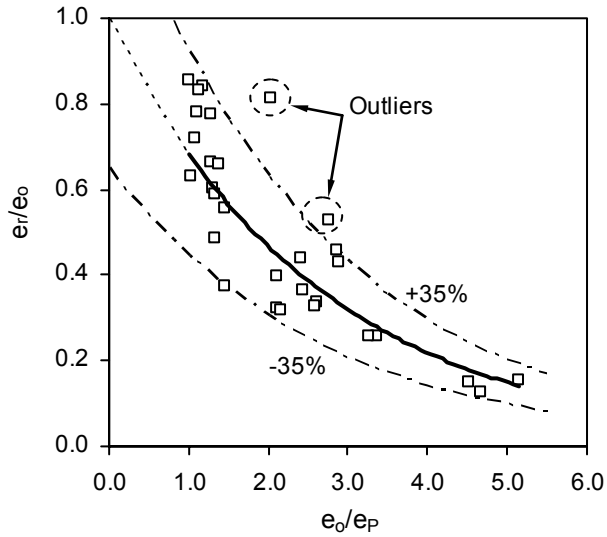

Figure 5. Normalised residual void ratio e_r/e_o vs normalised initial void ratio e_o/e_P with best fit (exponential) curve forced through point $\{e_r/e_o=1, e_o/e_P=0\}$, its extension to that point and curves defining ±35%. One outlier is marked by dashed circle.

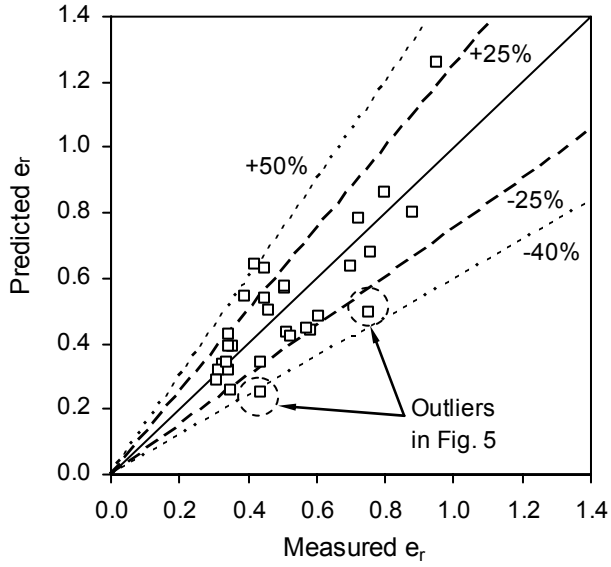

Figure 6. Predicted values of e_r against measured values.

4 EXPERIMENTAL EVIDENCE FOR NATURAL SOILS

Apart from the additional data for reconstituted soils left to dry from a slurry condition and reconstituted soils consolidated one-dimensionally to a maximum stress and then unloaded, a limited number of additional experimental data have been collected for natural soils with structure that were left to dry. The experimental results are presented in Table 4. One of the soils was undisturbed Corinth Marl and the other a natural colluvium reported by Melgarejo et al. (2006).

Bardanis & Kavvadas (2004) have presented a laboratory investigation of the virgin drying of the Corinth Marls. These naturally occurring marls are found in the greater area around the city of Corinth in Greece and especially along the 6.3km long and 80m high Corinth Canal. The excellent long-term stability of the canal's steep slopes (the canal is 115 years old and its slopes have an inclination of 4.5:1 without any benches or berms) has driven the research in the engineering behaviour of the Corinth Marls, as their structure and partial saturation contribute greatly to the stability of the slopes. Being cemented, the natural material exhibits higher air-entry pressure and residual void

ratio than when reconstituted and reconsolidated to the same void ratio as the natural material. Bardanis & Kavvadas (2004) have attributed this behaviour to the cementation of the undisturbed Corinth Marl, which does not exist in the reconstituted/reconsolidated specimens. This point seems to be the one more worthy of further investigation, as experimental results for unsaturated properties of marls (especially focusing on the effect of their cementation in their drying behaviour) are scarce, if any, in the literature. More information on the engineering behaviour of Corinth Marl and the role played by its cementation may be found in Kavvadas et al. (2003).

Melgarejo et al (2002) presented preliminary results from their investigation into the unsaturated properties of a colluvium from Brazil. What their results show is that although the natural structured soil has lower initial void ratio than the same soil reconstituted to a slurry condition, consolidated to 200 kPa and then unloaded, they both dry to the same value of residual void ratio.

Table 4. Index properties of natural soils tested or found in the literature along with e_o and e_r values.

Soil	w_L (%)	I_p -	G_s -	Initial Suction	e_o -	e_r -
Corinth Marl	34	12	2.67	9 kPa[1]	0.64	0.62
Colluvium[2]	95	48	2.65	1000 kPa	1.10	0.80

[1]: Average value of suction measured in-situ with a Soil-Moisture Quickdraw tensiometer.
[2]: Melgarejo et al. (2002).
[3]: Measured with calibrated filter papers.

In Figure 6 all the experimental data are plotted along with these additional data for undisturbed specimens of natural soils which are indicated by arrows starting from the experimental points corresponding to the same soils reconstituted, reconsolidated and then unloaded. These data are very few. They indicate however that natural soils exhibit a higher e_r/e_o ratio than that exhibited by the same soils when reconstituted, reconsolidated and unloaded. A general form of an empirical equation predicting residual void ratio therefore would have the characteristics of Equation 4; a parameter m_e controlling the curvature of the exponential equation and a parameter M_s introducing the structure of natural soils. In this study m_e was found equal to -0.38.

$$\frac{e_r}{e_o} = M_s \cdot \exp\left(m_e \cdot \frac{e_o}{e_P} \right) \qquad (4)$$

Parameter M_s cannot be measured yet with the very limited data available so far and should be considered conceptual for the time being. Still its presence is evident from the differences observed between reconstituted / reconsolidated soils and natural soils. Parameter M_s must take such values that e_r/e_o never becomes higher than unity. From Equation 4 therefore it is easily obtained that although M_s is higher than unity, it also has an upper bound found to be equal to $\{\exp[m_e \cdot e_o/e_P]\}^{-1}$. It must be emphasized that the increasing factor M_s reflects the structure of natural materials rather than that created by loading history. The effect of this type of structure created in reconstituted soils is already taken into account in the empirical relation by using as a correlating parameter the ratio e_o/e_P rather than initial void ratio e_o by itself.

5 CONCLUSIONS

The initial empirical relation proposed by Bardanis & Kavvadas (2006) that relates residual void ratio e_r with initial void ratio e_o, liquid limit w_L and specific gravity G_s has been found valid for additional experimental data from new tests and test results collected from various publications. Although the scatter of the additional experimental points

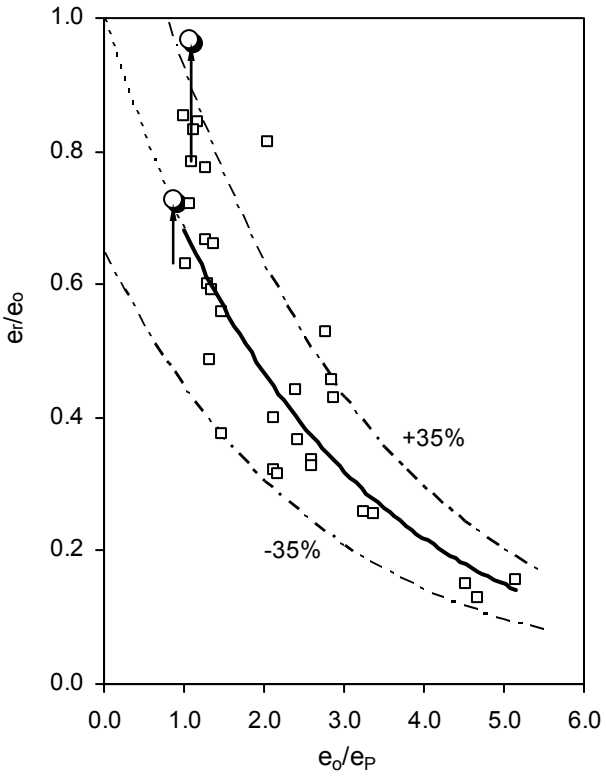

Figure 7. Experimental points for slurries and overconsolidated samples with best-fit curve (exponential) forced through point $\{e_r/e_o=1, e_o/e_P=0\}$, its possible extension to that point, the lines defining ±35% from the best-fit curve and two points for soils with natural structure (empty circles with shade). The arrows start from points corresponding to the same material reconstituted and reconsolidated.

seems evenly distributed on either side of the linear relation proposed by Bardanis & Kavvadas (2006), it is so large and the degree of correlation has dropped so much that an alternative relation where w_L has been substituted with w_P is proposed as this exhibits higher degree of correlation. All experimental points but two (out of a total of 30) lie within a range of ±35% from the best-fit exponential equation. As far as actual values of e_r are concerned, for 24 out of 30 experimental points the predicted values lie within a range of ±25% of the measured values, and for the whole set of experimental points predicted values lie within a range of +50%/-40% of the measured values. These ranges are very large for the proposed equation to be used for predictive purposes. Still this scatter is sufficiently low to support a soundly based theoretical relation between the parameters used. It is also sufficiently low to justify the need for further experimental research on various soils in pursuit of this type of empirical relation.

Despite these limitations of the proposed empirical relation, comparison of the experimental data for reconstituted/reconsolidated soils with the very few experimental points from tests on undisturbed samples of soils indicates that natural soils exhibit a higher e_r/e_o ratio than that exhibited by the same soils when reconstituted, reconsolidated and unloaded. Although this latter observation cannot yet be quantified (especially given the very small number of experimental data available for soils with natural structure), it may be conceptually expressed by the formulation of Equation 4, which introduces an empirical factor increasing the value of residual void ratio predicted from e_o, w_P and G_s. This increasing factor is expected to be a function of the structure of natural soils. Additional experimental data for more natural soils with the accompanying data for the same soils after reconstitution and consolidation to a void ratio similar to that of the natural soils, along with measurement of the structure of these soils (for example by

measuring the yield stress of both the undisturbed samples and the reconstituted samples –after a loading unloading loop to the in-situ vertical stress- under one-dimensional conditions) will exhibit if this conceptual formulation is sound, and, if so exhibited, yield a relation between empirical factor M_s and structure.

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Soil-water characteristic curves and void ratio changes relative to suction for soils from Greece

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ABSTRACT

The paper presents the drying portions of the soil-water characteristic curves of five soils from Greece, along with the void ratio vs suction curves over the same drying portion, the one-dimensional compression curves of the same soils and their comparison. The curves were measured using the pressure plate extractor technique. The soils tested included one silt, two clays and two marls. Soil specimens used for soil-water characteristic curve determination were first reconstituted, reconsolidated under one-dimensional conditions to the in-situ vertical stress of each soil, and then unloaded. Undisturbed samples were available for one soil as well and the drying portion of the undisturbed material was measured for this soil too. The soil-water characteristic curve data presented are the first for soils from Greece and among the few presented for marls.

1 INTRODUCTION

Despite climatic conditions favouring the presence of unsaturated soils in Greece, the research in this subject has lagged behind research in fully saturated soils. This paper constitutes one of the first efforts to report unsaturated soil properties for soils from Greece. The property considered first and presented here is the drying portion of the soil-water characteristic curve (SWCC) of five soils. The SWCC constitutes a fundamental property for the study of unsaturated soils. It represents the relation between the distribution of solid, liquid and air phase in the volume of soil (as expressed by degree of saturation, S_r, gravimetric or volumetric water content, w or θ, and void ratio, e), as well as the total volume of the soil itself, and the negative pressure sitting on the liquid phase until desaturation occurs, or suction after desaturation has occurred. The soils tested included marls and other soils containing large amounts of calcite, for which it is hard to find SWCC data presented in the literature. Given that the compressibility properties of the soils have also been studied, and that the SWCC tests involved measurement of both void ratio and water content changes with suction, the comparison between void ratio changes with suction and vertical stress increase under one-dimensional conditions of loading is also presented.

2 THE SOILS TESTED

The soils studied were Ioannina Lake Silt, Corinth Marl, Chania Clay and Kifissia Clay and Marl. The names used to describe the soils are empirical and the actual physical properties dictating the nature of each soil are presented in this paragraph.

Samples from all soils were disturbed samples from excavation materials or relatively low quality borehole cores, except for the samples of Corinth Marl which were carefully cut and preserved samples removed from the toe of the north slope of the Corinth Canal. For this reason, the soil-water characteristic curve of undisturbed samples was measured only for Corinth Marl, while for the others it was measured on specimens reconstituted, then reconsolidated to the estimated in-situ vertical stress and unloaded. This took place for Corinth Marl as well for comparison with the SWCC of the other soils and the SWCC measured on the undisturbed specimens of this material.

Classification tests and mineralogical analyses were carried out on all five soils. The index properties of the soils tested are presented in Table 1 and the basic minerals found by x-ray diffraction and methylene blue methods are presented in Table 2. Ioannina Lake Silt is categorised as SM according to USCS, while all others are categorised as CL. Corinth and Kifissia Marls have the highest percentages of calcite. Kifissia Clay has a considerably high percentage of calcite as well, and Chania Clay has a very high percentage of quartz, despite the fact that both soils are commonly referred to as "clays". Highly active minerals such as illite and montmorillonite are present in all five soils, ranging from 3 to 10% and from 7 to 17% respectively. The absence of kaolinite is typical of most soils from Greece.

Table 1. Index properties of the soils tested.

Soil	w_L (%)	I_p -	G_s -	Clay (%)	Silt (%)	Sand (%)
Ioannina Lake Silt	24	1	2.55	8	27	65
Corinth Marl	34	12	2.67	11	86	3
Chania Clay	24	9	2.68	18	50	32
Kifissia Clay	41	21	2.67	33	64	3
Kifissia Marl	31	16	2.66	25	68	7

Table 2. Basic minerals of the soils tested (measured on percentage passing through sieve No. 200).

Mineral	Ioannina Lake Silt	Chania Clay	Corinth Marl	Kifissia Clay	Kifissia Marl
Quartz	75	60	16	16	18
Albite	5	3	3	-	2
Calcite	2.5	3	60	37	52
Dolomite	-	-	2	1	-
Illite	3	3	7	10	5
Montmorillonite	7	9	7	12	17
Halloysite	-	10	-	8	-
Chlorite	3	3	1.5	4	2
Serpentine	2	-	1.5	4	-
Muscovite	-	5	1	7	3

3 EXPERIMENTAL METHOD

Soil water characteristic curves were measured using the axis translation technique, as realised with a conventional Soil-Moisture Inc. pressure extractor with 15 Bar air-entry pressure ceramic porous stones. Air pressure was provided from an air compressor with the necessary filters connected to the air supply for air dehumidification. Different specimens were used for each suction value applied in the pressure extractor, rather than use the same specimen and measure the amount of water being extracted. This was considered important for the measurement of total volume changes (which in combination with water content measurement allow the calculation of void ratio changes with suction), as with the water movement measurements, both system complexities and assumptions involved may limit accuracy. With different samples, accuracy is determined only by soil homogeneity for undisturbed samples and careful preparation of identical reconstituted soil samples. Air pressure is supplied to the pressure extractor for the time needed for the suction to reach equilibrium in the specimens, the air pressure is removed and then the soil specimens are taken out immediately, cut in half, with one half used for water content measurement and the other half being immersed in melted paraffin wax for total volume measurement. Assuming that the water content measured on one half is the same throughout the specimen, then the mass of the water in the half used for total volume measurement can be calculated from the total mass of this half. Once the mass of the water is known, the mass of the solid particles is also known, and then their volumes are calculated from the known density of water and specific gravity respectively. Having calculated the volumes of the water phase (V_w) and the solid phase (V_s) in the half of the specimen where total volume has been measured (V_{tot}), the volume of the voids (V_v) is calculated ($V_v = V_{tot} - V_s$) and the degree of saturation (S_r) of the sample is calculated by its definition as a property ($S_r = V_w / V_v$). Once the degree of saturation has been calculated and the water content w and specific gravity G_s are already known then void ratio e can be calculated ($e = w \cdot G_s / S_r$). These calculations are based on

the reasonable assumptions that the water content measured on one half of the specimen and the degree of saturation calculated for the other are the same throughout the specimen. An important detail is that when cutting the specimen, utmost care must be exhibited that the surface of the section in the half used for total volume measurement must be as flat as possible without cavities where air may be trapped.

As far as one-dimensional consolidation is concerned, conventional deadweight, front-loading oedometers were used with a 10:1 beam-lever ratio and fixed-ring cells with lightly lubricated, smooth and polished inner surface rings, with a 70mm internal diameter and 19mm height.

Reconstitution involved breaking of particle aggregations and thorough mixing with de-aired, de-ionised water until a slurry of $1.5w_L$ water content was prepared. All slurries were left to hydrate under vacuum for sufficient time with occasional measurement of their water content and drying or addition of water to ensure homogeneity of the slurries prepared for each soil and consistent initial conditions for all reconstituted soils. As a general rule, a water content of ±10% from the target value of initial slurry water content was set, which has been found to ensure homogeneity of later consolidated specimens of reconstituted soils, provided the maximum vertical stress exceeds 50-100 kPa (Bardanis, 1999) as was the case for all 5 soils.

All soils were consolidated to a maximum vertical stress corresponding approximately to the depth they came from and then unloaded; Ioannina Lake Silt to 100 kPa, Chania Clay to 200 kPa, and Kifissia Clay and Marl to 600 kPa. Finally, Corinth Marl specimens were consolidated to 800 kPa and then unloaded, mostly on the basis that this stress history created the same initial void ratio that was measured on the undisturbed specimens removed from the toe of the Corinth Canal slopes (approximately 70-75m high).

As far as the samples of the undisturbed Corinth Marl are concerned, these were carefully preserved in a controlled humidity chamber. Larger blocks were taken out of the chamber when specimens had to be trimmed from them in order to be put in the pressure extractor. Corinth Marl as a geological formation may by no means be considered a homogeneous material; still the largest possible block of visually homogeneous material was used. Homogeneity within this block was later verified by numerous index tests on specimens from various positions in the block. The blocks came from the toe of the canal slope just above sea level (ca. 0.50m) and in-situ suction was measured with a Quickdraw Tensiometer and found to be approximately 10 kPa.

4 RESULTS AND DISCUSSION

In Figure 1a degree of saturation is plotted against suction for Ioannina Lake silt, while in Figure 1b void ratio is plotted against the corresponding value of water content during drying. The solid line in Figure 1b is the full saturation line corresponding to the specific gravity, G_s, of the material ($e = w \cdot G_s$, for $S_r = 100\%$). As seen in Figure 1a, desaturation occurred between 25 and 30 kPa, while the second inflection point occurred between 150 and 200 kPa corresponding to a degree of saturation between 45 and 50%. This value seems too high to be the residual value of the degree of saturation. Specimens of the soil left to dry completely in the air yielded a value of the degree of saturation on average 7%. This value seems more likely to reflect residual conditions, whereas the value of 45-50% observed on the SWCC corresponds most probably to the point where water retention characteristics start to be dictated primarily by the finer fraction of the soil's grains. The grain size distribution of this soil (Fig. 2) is gap-graded, although slightly and only for the small percentage passing through sieve No.200. Still, this type of grain size distribution would justify a 'bimodal' SWCC with one inflection point at S_r 45-50% and a second one at approximately 7%, which was not observed however as the maximum applied suction was 1500 kPa. Also as seen in Figure 1b, the scatter of void ratio values is very large, as this is probably the coarsest material for which immersion in melted paraffin wax for total volume measurement may be applied.

In Figures 3a & 3b degree of saturation is plotted against suction and void ratio against the corresponding water content during drying respectively for both reconstituted/reconsolidated and undisturbed Corinth Marl. As seen in Figure 3a, desaturation occurred for both types of Corinth Marl, although a second inflection point was not observed for neither type up to the maximum applied suction of 1500 kPa. Similarly, a clear departure from the full saturation line can be observed for both types of this soil in Figure 3b. Two other observations can be made. First, the scatter of measured values is larger for the undisturbed Corinth Marl, almost at the point of rendering the results meaningless, especially in the e-w plot of Figure 3b. Still it is clear in Figure 3a that, despite the large scatter, the undisturbed Corinth Marl desaturates at a higher suction than the reconstituted and reconsolidated one (between 200 and 300 kPa as opposed to 100 to 200 kPa) and retains a higher degree of saturation for the same suction after desaturation of both materials, although both materials have the same void ratio at the beginning of drying. Bardanis & Kavvadas (2004) have elaborated more on this observation and attributed the observed behaviour to the cementation of the undisturbed Corinth Marl, which does not exist in the reconstituted/ reconsolidated specimens. This point seems to be the one more worthy of further investigation, as ex-

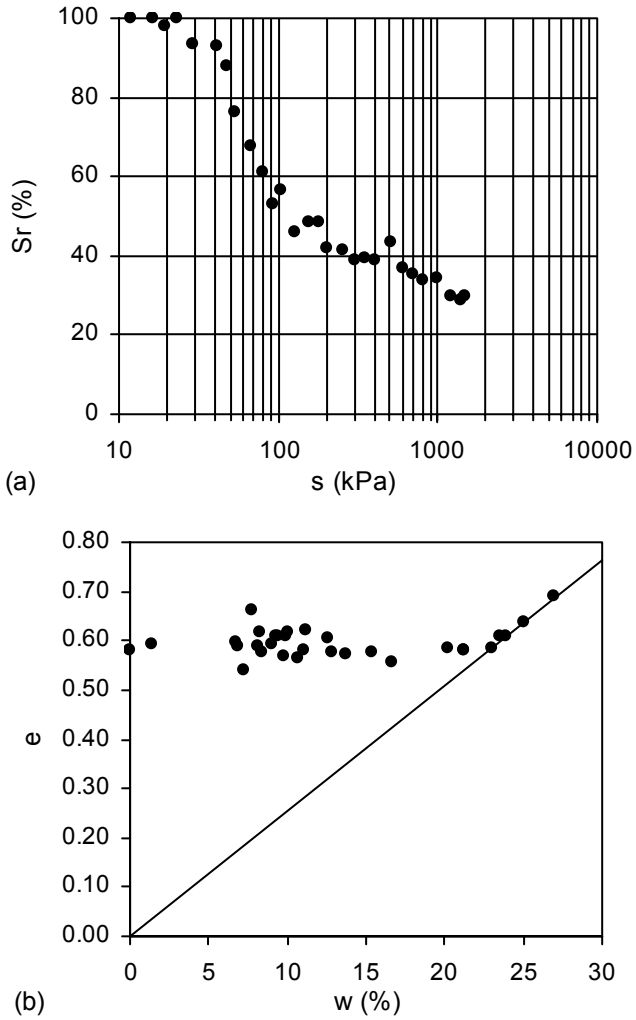

Figure 1. a) Degree of saturation S_r vs suction s, and b) void ratio e vs water content w for Ioannina Lake Silt.

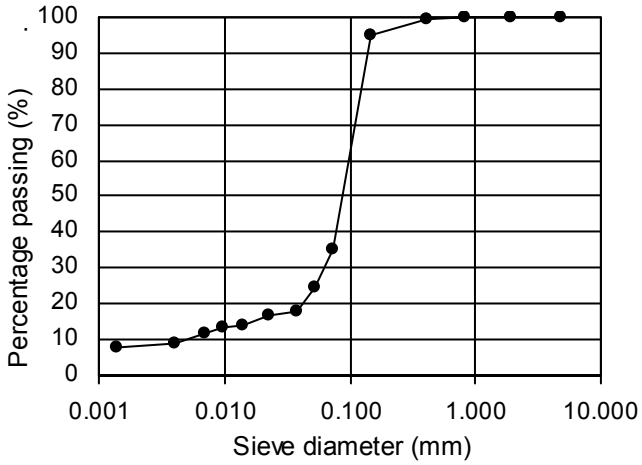

Figure 2. Grain-size distribution curve of Ioannina Lake Silt.

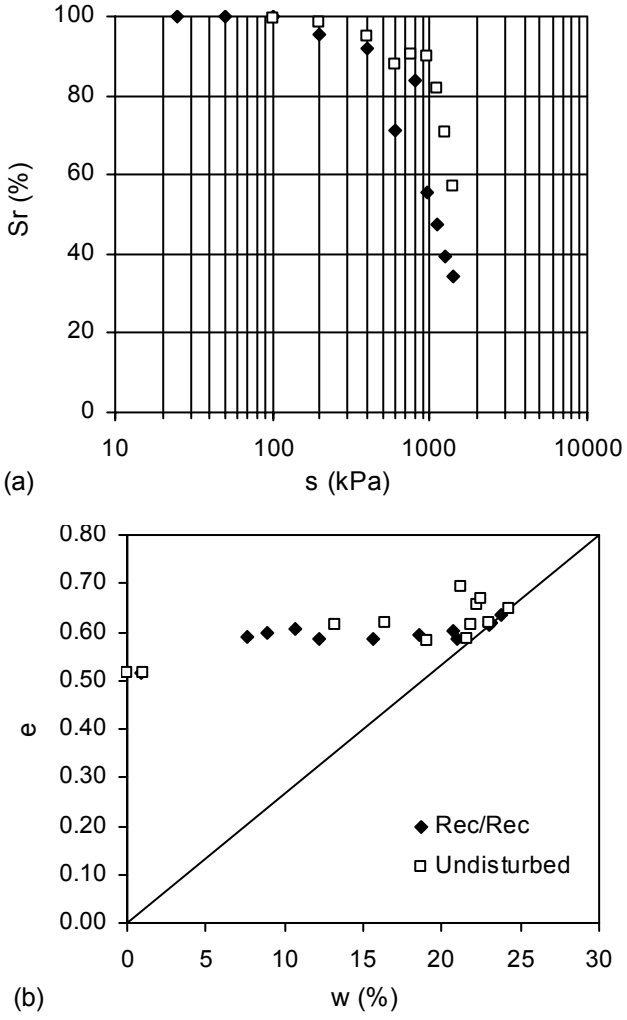

Figure 3. a) Degree of saturation S_r vs suction s, and b) void ratio e vs water content w for Corinth Marl.

Perimental results for unsaturated properties of marls (especially focusing on the effect of their cementation in their drying behaviour) are scarce, if any, in the literature. More information on the engineering behaviour of Corinth Marl and the role played by its cementation may be found in Kavvadas et al. (2003).

In Figures 4a & 4b degree of saturation is plotted against suction and void ratio against the corresponding water content during drying respectively for Chania Clay. As seen in Figure 4a, desaturation seems to start occurring at approximately 1000 kPa but this is not supported by a similarly clear departure from the full saturation line in Figure 4b. The observed departure is not considered clear given the accuracy of measurements, still the picture is that the air entry pressure of Chania Clay must be between 1000 and 1500 kPa, although a few measurements at slightly larger values would have ascertained whether desaturation did actually occur or not.

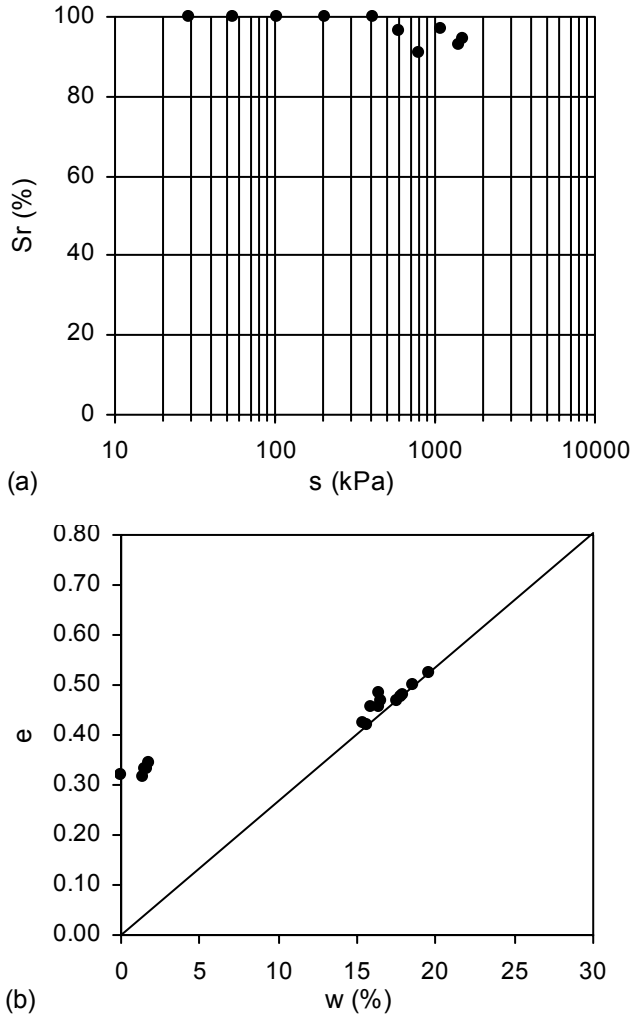

Figure 4. a) Degree of saturation S_r vs suction s, and b) void ratio e vs water content w for Chania Clay.

In Figures 5a & 5b degree of saturation is plotted against suction and void ratio against the corresponding water content during drying respectively for both Kifissia Clay and Marl. Given the same stress history of the two materials, the Clay retains a higher void ratio, in agreement with its higher liquid limit. Kifissia Clay seems to desaturate close to 1000 kPa (Fig. 5a), which is supported by signs of departure from the full saturation line (Fig. 5b). Both the departure from line S_r=100% in Figure 5a and the full saturation line in Figure 5b are rather obscure relative to the accuracy achieved. As far as Kifissia Marl is concerned, desaturation has not occurred, as no departure is observed from the line S_r=100% or the full saturation line. The opposite would have been expected given that the Marl contains slightly less clay-size material than the Clay (25% vs 33%), slightly more sand (7% vs 3%) and less clayey minerals in the fraction passing sieve No. 200 (a total of 27% vs 45%). The observed lack of desaturation up to 1500 kPa may therefore be attributed either to the presence of more montmorillonite (17% vs 12%) or to experimental error with the results of Kifissia Clay, which record desaturation.

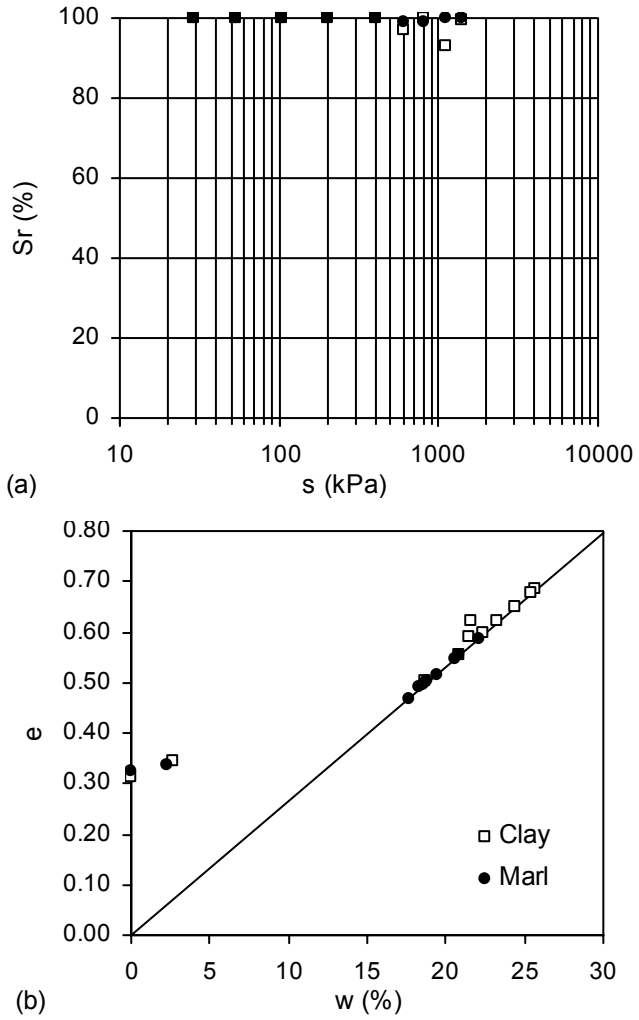

Fig. 5. a) Degree of saturation S_r vs suction s, and b) void ratio e vs water content w for Kifissia Clay and Marl.

5 VOID RATIO CHANGES WITH SUCTION AND VERTICAL STRESS

Given that the one-dimensional curves of most of the soils had already been studied, a comparison was attempted between void ratio changes due to suction and due to one-dimensional compression.

In Figures 6a & 6b the void ratio-suction curve and the one-dimensional compression curve for reconstituted / reconsolidated specimens and undisturbed specimens of Corinth Marl are plotted respectively. For Corinth Marl, sufficient quantities of the material were available for a special test with a loading-unloading loop, similar to that applied to reconstituted specimens before drying, to be performed and the compression curve for this test is shown in Figure 6a. The compression curve shown in Figure 6b is an average of the one-dimensional compression tests performed on undisturbed Corinth Marl. The larger scatter of void ratio values of undisturbed specimens during drying relative to that of the values of the reconstituted/reconsolidated specimens is apparent in these plots as well. Still, for reconstituted/reconsolidated specimens there seems to be fair agreement up to 100 kPa. After that value of suction/stress, the void ratio during drying becomes smaller than that for the compression curve, up to the value of stress where the intrinsic compression curve is reached and the opposite seems to happen.

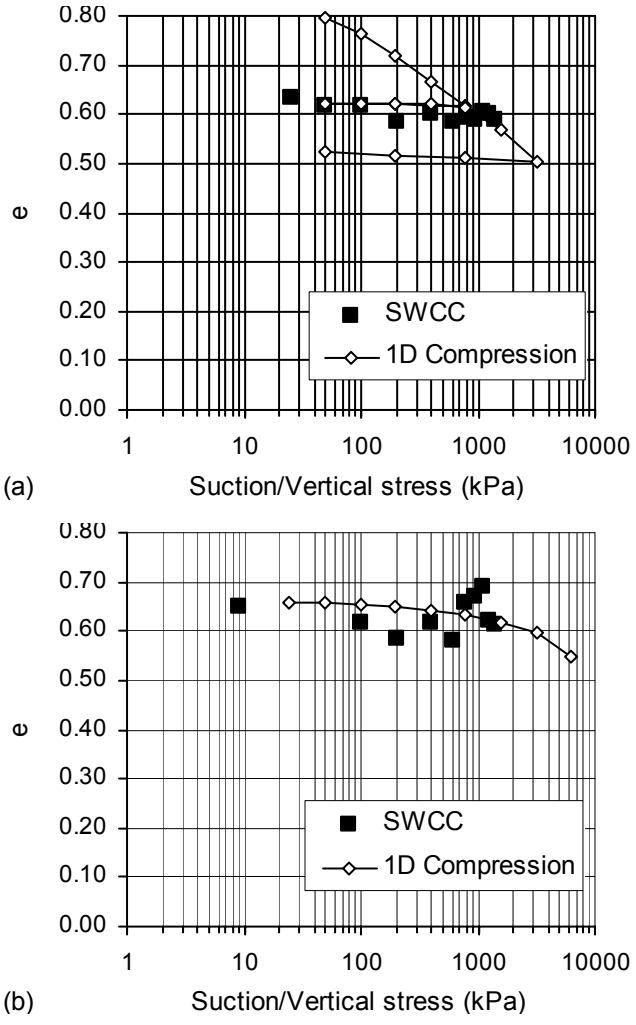

Figure 6. Void ratio vs suction during drying and one-dimensional compression curves for a) reconstituted and reconsolidated Corinth Marl, and b) undisturbed Corinth Marl.

In Figures 7 and 8 the same curves are compared for Kifissia Clay and Marl respectively. Limited quantities of the samples from each material did not allow for special one-dimensional compression tests to be carried out with a loading-unloading loop to the maximum stress applied to reconstituted specimens before drying. One point on the void ratio-suction curve of Kifissia Clay corresponding to 1100 kPa (Fig. 7) departs significantly from the curve the

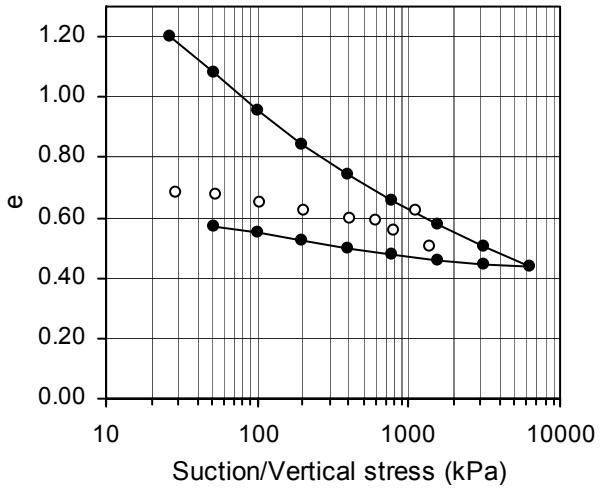

Figure 7. Void ratio vs suction during drying and one-dimensional compression curves for reconstituted and reconsolidated Kifissia Clay.

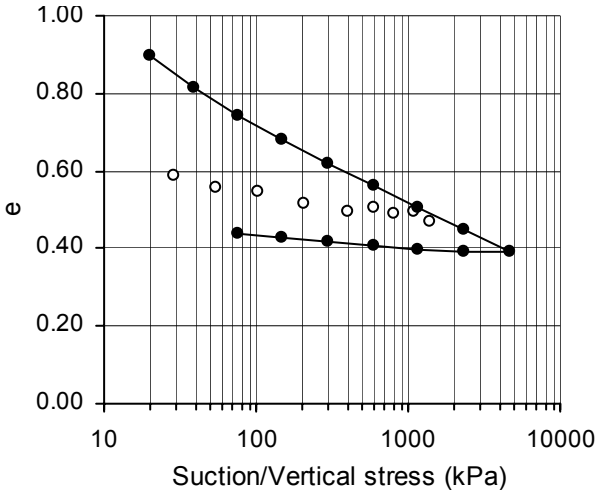

Figure 8. Void ratio vs suction during drying and one-dimensional compression curves for reconstituted and re-consolidated Kifissia Marl.

rest of the points seem to follow. This point corresponds to the point indicating desaturation in the curves on Figures 5a & 5b. This distinct departure from the curve the rest of the points seem to follow in Figure 7 seems to support that either the particular specimen had different properties or there has been some experimental error. Therefore it will not be considered that Kifissia Clay achieved desaturation.

Returning to the comparison between void ratio vs suction and one-dimensional compression curves for each of the two materials, two observations can be made. First, the void ratio vs suction curves are for all practical purposes (and at least up to the maximum stress applied to specimens used for SWCC measurement) parallel to the unloading branches of the one-dimensional curves. This point seems to support that void ratio decrease with increasing suction up to the air-entry pressure during drying and increasing vertical stress during one-dimensional loading may be described by the same indices. The second observation regards the void ratio vs suction curve of Kifissia Clay, which seems to exhibit a change in its slope at 600 kPa (if the point at 1100 kPa is omitted). Unfortunately this has not been observed on the same curve for Kifissia Marl. Still it would be logical to expect such a change in this slope when such conditions occur, i.e. a maximum preconsolidation pressure smaller than the air-entry pressure and a zero total stress suction path extending to suctions higher than the preconsolidation pressure. These observations need certainly to be supported by further experimental research (especially with tests where high values of suction will be applied so that desaturation does actually occur) as they are of considerable value in constitutive modelling of unsaturated soils. Void ratio vs suction curves described by the same indices as with compression curves could mean that κ_s could be substituted by κ in the Barcelona Basic Model (Alonso et al. 1990) family of constitutive models for air-entry pressure smaller than the maximum preconsolidation pressure. This would itself change to λ for air-entry pressure larger than the maximum preconsolidation pressure, in the suction range between preconsolidation pressure and the air-entry pressure.

6 CONSLUSIONS

The drying portions of the soil-water characteristic curve presented constitute the first ones for soils from Greece. Except for this they are among the few such results presented for marls and generally clay-size soils containing large amounts of calcite. Although they may by no means be considered representative of the properties of soils found throughout Greece or soils with high calcite fractions, they draw attention to the properties of such materials. The most important aspect needing further research is the possibility that cementation of undisturbed marls leads to retaining higher degrees of saturation for the same suction in the same soils with the same loading history but without cementation. Further investigation into the decrease of void ratio with increasing suction for soils with a maximum preconsolidation pressure smaller and higher than their air-entry pressure may also help redefine the parameters used in constitutive modelling to describe these changes.

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ΑΝΑΦΟΡΕΣ ΤΟΥ ΤΥΠΟΥ ΣΕ ΤΕΧΝΙΚΑ ΘΕΜΑΤΑ

Harmonica: instrumental in tunnelling method

Technology used in the Harmonica Tunnelling Method won the excellence prize of the 9th Infrastructure Technology Development Award 2007 of the Japan Institute of Construction Engineering (JICE).

This new approach is a non-open cut tunnelling method for constructing large section tunnels or underpasses by integrating small section tunnels that are excavated with a rectangular shaped shield machine.

An artist's impression of how the Harmonica Tunneling Method

It was named after the harmonica because the finished shape is similar to that of a harmonica.

A wagging cutter face-type earth pressure balanced excavating machine is used because it can excavate a rectangular cross section effectively. A rectangular-shaped steel segment is used for the tunnel lining.

According to the Japanese Infrastructure Development Institute (IDI), the tunnelling method has drawn attention as a quick and economical method for constructing tunnels and underpasses.

Recently, underpasses at intersections and railroad crossings have become necessary to reduce traffic congestion and the closure of the crossings during peak times. The open cut tunnelling method is normally used to construct underpasses.

However, this method requires traffic enforcement, reduction of traffic lanes, and a long construction time. Therefore, a new method for building underpasses using a non-cut and cover method became necessary.

The preceding outer shell excavation methods such as the Prestressed Concrete Roof method (PCR method), an Under Railway/Road Tunnelling method (URT method), and High Speed Element Pull & Jointed Element Structure method (HEP&JES Method) are well known in Japan as non-open cut construction methods.

However, these existing tunnelling methods incur various technical problems, such as the inability to excavate along curved alignments or long distances, says IDI.

The Harmonica Tunnelling Method has been developed to solve these problems.

Effect of technique

Because the Harmonica Tunnelling Method uses a smaller machine than the large section shield tunnelling method, it is possible to construct a shallow earth cover tunnel and underpass.

Completion of excavation (vertically curved alignments) using the Harmonica Method

By using a small shield machine, it is possible to reduce the machinery and equipment required for excavating work and to decrease the area of the work zone on the road. It is also possible to excavate along vertically or horizontally curved alignments, and the total construction cost is reduced because the departure and arrival shafts are smaller than those required using existing methods.

By using the shield machine, it is possible to construct a long distance tunnel or underpass.

Although the preceding outer shell excavation methods require internal excavation of the area surrounded by the outer shell, the Harmonica Tunnelling Method does not require such work, and even though it uses steel segments, which serve as struts and supports, it does not require any special tunnel supports.

Work procedure

First, a baseline tunnel is excavated, and then the adjacent tunnel segment is also excavated along the baseline tunnel by using the same excavating machine. After the completion of lower tunnel excavation, upper tunnel segments are excavated using the same procedure.

Before the rebar fabrication work for the base slab is completed, obstacle steel plates and vertical ribs of each steel segment are removed, and when rebar fabrication work is completed, the base concrete placement work is carried out (wall and roof slab construction uses the same procedures.

After the concrete work is completed, the remaining steel girders and skin plates in the new culvert are removed, and the interior and finishing work is carried out.

Among participants in this tunnelling method are Taisei Corporation, IHI Corporation, and Ishikawajima Construction Materials, and applications include underground passageways in the Japanese capital Tokyo (a 40m long tunnel, 5.3m×7.45m and a 30m tunnel, 4m×5.5m) along with an ongoing railway extension project in Osaka involving a 21.5m long tunnel, 7.35mx9.8m.

(Published in WORLD HIGHWAYS – TUNNEL CONSTRUCTION, May 2008)

Better soil consolidation

Colbond (www.colbond-geosynthetics.com) claims that its latest prefabricated vertical drain (PVD) will help consolidation of soft soils and suits duties in a wide range of civil engineering applications.

Using Colbond's latest prefabricated vertical drain product is said to help ground consolidation, particularly in soft soil conditions

This new product features a novel, hydraulically designed drainage core that is bonded to non-woven filter layers over its entire surface. The core is shaped into a solid channel profile and according to the firm this ensures high water flow rates.

As a result the product is said to allow quicker settlement of soft soils and a significant reduction of the construction time for infrastructure projects on marshland areas or reclaimed land. The product combines a patented solid core with a strong, permeable non-woven covering and the company claims that this boosts water flow capacity by over 50%.

The fully-bonded composite maintains discharge rates even when buckled beyond 90º, which can happen as upper clay layers settle. Using the product cuts consolidation time and costs, resulting in major cost savings.

(Published in WORLD HIGHWAYS – TECHNOLOGY, 22 May 2008)

Discovery may lead to quake early-warning system

WASHINGTON (Reuters)—Scientists working at California's San Andreas Fault have detected subtle geological changes occurring hours before an earthquake that could enable them to develop an early-warning system aimed at saving lives.

Their instruments detected geological changes most likely caused by tiny fractures forming in the rock ahead of an impending earthquake due to stress in the Earth's crust, according to seismologist Paul Silver of the Carnegie Institution in Washington, one of the researchers.

"It's the opening up of cracks before an earthquake," Mr. Silver said in a telephone interview.

The research, published on Wednesday in the journal Nature, was conducted using wells dug 0.6 miles deep into the quake-prone fault at Parkfield, Calif.

Their equipment generated and recorded seismic waves before, during and after two small quakes, allowing them to observe these small, predictive geological changes.

In the first case, the geological signals occurred 10 hours before a magnitude 3 quake in December 2005. The same sort of signals also occurred two hours before a magnitude 1 quake that happened five days later, the researchers said.

"We are very encouraged by these observations, and we are planning for more experiments to confirm whether these changes are part of the general physical processes before an earthquake," seismologist Fenglin Niu of Rice University in Houston said in a telephone interview.

Evacuations?

Scientists have made strides in understanding earthquakes, but finding changes in the Earth's crust that could allow for an advance prediction has remained difficult.

Current earthquake warning systems provide at best a few seconds notice before an earthquake strikes.

The findings were published just two months after a powerful earthquake in China. The May 12 quake in Sichuan province killed about 80,000 people, with many killed when buildings such as schools collapsed.

"To get the point where we have a practical early warning system for earthquakes, that's still a ways off—10 years, maybe 20," Mr. Silver said.

If more research finds this effect to be pervasive before earthquakes, these findings may make that goal attainable, the researchers said.

"No matter how much time you have, there's something you can do. Even with a few seconds, you can automatically turn off gas valves. You may even be able to get a hard hat on your head or run outside of a building," Mr. Silver said.

"But with something on the order of 10 hours, you could perhaps evacuate populations, you could certainly get people out of city centers and areas that are deemed dangerous."

(July 10, 2008 1:04 PM CST, Copyright 2008 Reuters Limited)

What are bridges for these days?

No longer solely in the business of getting people from A to B across a waterway, bridges are now also about putting a place on the map and kick-starting wider investment.

Get bridge. Make bridge. Thrive.

Once upon a time bridges were all about getting people from one side of a river to the other.

Whether it was traders or workmen or retreating soldiers, bridges existed for a purely practical purpose. They might have been designed or built with great flair, using materials chosen to dazzle the observer, but they were, first and foremost, conceived because of man's inability to walk on water.

But in the past few decades, not just in Britain but also elsewhere in Europe, the bridge has started to be used as something more than a mere means of conveying traffic across water.

In dilapidated areas they are being used as emblems; glistening standards for major urban redevelopment projects.

Clockwise, from left: London, Castleford and Gateshead footbridges

The residents of Castleford, as part of a project chronicled by Channel 4, have got themselves a slinky new S-shaped footbridge across the fast-flowing River Aire.

Castleford is a former mining town, a former mill town, with some deprived areas. But it is also close to Leeds and close to the motorway and there is a belief that it can be economically successful again.

Gateshead example

A regeneration programme, part-inspired by Channel 4 and overseen by residents acting as "champions" for various projects, has a bridge at its heart.

"Anybody who wants to come into a place like Castleford has to be attracted by the potential," says Alison Drake, one of the champions.

"To not have access to the river or the views was a waste. The bridge has brought all that into play. You need to make a bold statement - the bridge makes that bold statement."

The centre of Castleford was previously accessible by a cramped road bridge and probably did need another way for pedestrians to get over the foaming and flood-prone Aire.

But the town can still be seen to have followed the example of Gateshead, which, a few years ago, built a bridge that many could have argued it didn't really need.

The Tyne is replete with bridges on the narrow stretch where the centre of Gateshead meets the centre of Newcastle. Prior to the opening of the Gateshead Millennium Bridge, it was easy to walk across from Newcastle into Gateshead.

But that did not stop the town fathers putting their weight behind a multimillion pound bridge that would really put Gateshead on the map.

Flash of confidence

"It was seen as part of a package of regeneration, it wasn't seen entirely as a transport project," says David Leeder, head of the council's Major Initiatives Team.

And since the bridge - better known as the Blinking Eye Bridge - was plonked down onto the Tyneside skyline at the tail end of 2000 by the giant floating crane Asian Hercules II, it has made its mark in two respects.

Clifton Suspension Bridge

It is a Millennium project that was not greeted with derision in the press and it is a structure that has won numerous awards. It cost over £20m, half of it from the Millennium Commission, but the council feels it was money well spent.

Since the bridge opened in 2001, Gateshead has also seen half a dozen other big projects come to fruition, most notably the Sage music centre and the Baltic Art Centre. And with perhaps even more direct consequences for the citizens of Tyneside, the Baltic Business Quarter seems to be a concrete result of the redevelopment that the bridge led.

Somehow, building a flashy, expensive and not immediately necessary bridge led to a re-evaluation of an area that had been depressed for a long time. As one newspaper described the changes heralded by the bridge: "Geordie pride is being restored."

"It is one [view] of the area that people photograph," says Mr Leeder. "The image of the bridge is a very striking image. It is very widely used on publicity photographs, and on all sorts of tourist mementoes. The bridge is integral. It is such a unique design. It doesn't look like any other bridge."

Backdrop to the Great North Run

At the other end of the spectrum is the Millennium Bridge in London, which links St Paul's and Southwark, and opened in June 2000.

The bridge should have been a triumph to complement the recently opened Tate Modern, but an excessive vibration led to a temporary closure. Its designers had wanted it to be nicknamed the "blade of light" but posterity will call it the "wobbly bridge".

Best known as the "wobbly bridge"

Bridging communities

Castleford wants a bit of the Gateshead experience to guarantee its future, but there are places in Europe where there's even more at stake.

In Mostar in Bosnia, the Stari Most has stood imperiously over the Neretva for more than four centuries until it was deliberately blown up during the war in Bosnia in 1993. A Unesco-led project saw millions spent on restoring the bridge, not just to attract tourists or provide another crossing, but also to connect Bosniak and Croatian communities.

The Stari Most Bridge

Esad Humo worked on the bridge project and is now the minister for economics in the local government.

"The bridge was a landmark of this area and this ancient bridge was very well-known all around the world. Destroying a bridge was a signal of the destroying of our connections and our past. To reconstruct the bridge, the idea was to reconstruct our connections."

And that is perhaps the greatest reason to build a bridge.

(Finlo Rohrer, BBC News Magazine, Thursday, 21 August 2008)

Greek highway finds consortium partners

Vinci and Hochtief now have a major stake in the PPP toll road project Elefsina-Patras-Tsakona n Greece. The highway is the country's most important traffic corridor linking Athens and the Peleponnese, with Patras, the country's second-largest port. The Olympia Odos consortium was formed to run the 30 year concession and the project has a total cost of around EUR 2.1 billion. The consortium partners are: Vinci with 36%, Hochtief's PPP Solutions division with 25% and the three Greek partners Aktor Concessions with 18%, J&P-Avax with 18% and Athena with 3%.

Olympia Odos already took over operation of the toll road yesterday and will use the income generated to upgrade and widen the highway. Of the 365km of highway that the project will encompass, 82km is already suitable, 163km has to be built and 120km will have to be upgraded. Construction work, the biggest highway project in Greece, is starting now and will take around six years to complete. The construction work is also in the hands of a joint venture for which Vinci again has 36%, Hochtief has 23%, J&P-Avax 18%, Aktor 18% and Athena 5%.

Altogether, the Hochtief Group now participates in the development, financing, construction and operation of 16 toll road projects around the world, with a total length of more than 1,000km.

(WORLD HIGHWAYS, Wednesday 13 August 2008)

ΑΝΑΣΚΟΠΗΣΗ ΓΕΓΟΝΟΤΩΝ ΓΕΩΤΕΧΝΙΚΟΥ ΕΝΔΙΑΦΕΡΟΝΤΟΣ

E-UNSAT 2008
1st European Conference on Unsaturated Soils
2 – 4 July 2008, Durham, UK
www.e-unsat.dur.ac.uk

Το 1ο Ευρωπαϊκό Συνέδριο για τα Μη Κορεσμένα Εδάφη διεξήχθη από 2 μέχρι 4 Ιουλίου 2008 στο Durham της Βρετανίας και συμμετέσχε το μέλος της ΕΕΕΕΓΜ κ. Μιχάλης Μπαρδάνης με την παρουσίαση τριών άρθρων σε συνεργασία με τον Γενικό Γραμματέα της ΕΕΕΕΓΜ καθ. Μιχάλη Καββαδα (βλέπε τμήμα ΑΡΘΡΑ). Στη συνέχεια παρουσιάζεται από τον Μ. Μπαρδάνη σύντομη ανασκόπηση των εργασιών του συνεδρίου.

Το συνέδριο διοργανώθηκε από τα Πανεπιστήμια του Durham και της Γλασκώβης υπό την αιγίδα της Τεχνικής Επιτροπής TC6 (Μη Κορεσμένα Εδάφη) της Διεθνούς Ένωσης Εδαφομηχανικής και Γεωτεχνικής Μηχανικής. Απετέλεσε το πρώτο πανευρωπαϊκό συνέδριο επί του αντικειμένου, καθώς μέχρι σήμερα έχουν διοργανωθεί τέσσερα Παγκόσμια Συνέδρια Μη Κορεσμένων Εδαφών (το 5ο θα πραγματοποιηθεί στην Βαρκελώνη το 2010 – για περισσότερες πληροφορίες απευθυνθείτε στην ηλεκτρονική διεύθυνση: http://congress.cimne.upc.es/UNSAT2010/), δύο Πανασιατικά (το 3ο θα πραγματοποιηθεί στο Νιούκαστλ της Αυστραλίας τον Νοέμβριο του 2009 – για περισσότερες πληροφορίες απευθυνθείτε στην ηλεκτρονική διεύθυνση: http://livesite.newcastle.edu.au/sites/cgmm/UNSAT2009.page) και μόνο συμπόσια και ημερίδες στην Ευρώπη.

Στο συνέδριο παρουσιάστηκαν 136 άρθρα και ειδικές ομιλίες, ενώ στην τελευταία συνεδρία πραγματοποιήθηκε ανοικτή συζήτηση επί τεχνικών και επιστημονικών θεμάτων για το ιδιαίτερο αντικείμενο. Οι συνεδρίες κάλυψαν επιμέρους θέματα όπως προόδους στις τεχνικές εργαστηριακών και επιτόπου δοκιμών σε μη κορεσμένα εδάφη (και για τον έλεγχο και την μέτρηση της μύζησης – suction), την μηχανική συμπεριφορά των μη κορεσμένων εδαφών ως προς την χαρακτηριστική καμπύλη εδάφους-νερού, τις μεταβολές όγκου και την διατμητική αντοχή, θέματα καταστατικής και αριθμητικής προσομοίωσης και παρουσιάσεις εφαρμογών στην πράξη (case studies). Οι ειδικές διαλέξεις κάλυψαν τις εξελίξεις στην εδαφομηχανική μη κορεσμένων εδαφών ως εφαρμόζεται στα χωμάτινα και λιθόρριπτα φράγματα (καθ. E. Alonso), τις μεθόδους ελέγχου και μέτρησης της μύζησης (καθ. P. Delage), την καταστατική προσομοίωση της μηχανικής συμπεριφοράς των μη κορεσμένων εδαφών (καθ. A. Gens) και την συνδυασμένη θερμο-υδρο-μηχανική καταστατική προσομοίωση της συμπεριφοράς αργιλικών διαφραγμάτων όπως χρησιμοποιούνται για την υπόγεια ταφή πυρηνικών αποβλήτων (καθ. L. Laloui).

Τα πρακτικά του συνεδρίου κυκλοφόρησαν υπό τον τίτλο «Unsaturated Soils. Advances in Geo-Engineering», υπό τους Toll, Augarde, Wheeler και Gallipoli, από τις εκδόσεις Taylor & Francis.

ΠΡΟΣΕΧΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΚΔΗΛΩΣΕΙΣ

Για τις παλαιότερες καταχωρήσεις περισσότερες πληροφορίες μπορούν να αναζητηθούν στα προηγούμενα τεύχη του «περιοδικού» και στις παρατιθέμενες ιστοσελίδες.

1st South American Symposium on Rock Excavations, 1 – 2 September 2008 Santa Fé de Bogota, Colombia, www.scg.org.co

2nd International Workshop on GEOTECHNICS OF SOFT SOILS, 3 – 5 September 2008, University of Strathclyde, Glasgow, Scotland, www.iwgss.org

19th European Young Geotechnical Engineers Conference 4 - 5 September 2008, Gyor, Hungary, issmge@ymmfk.szie.hu, imreemok@hotmail.com

EuroGeo4 - 4th European Geosynthetics Conference, 7 – 10 September 2008, Edinburgh, Scotland, United Kingdom - www.eurogeo4.org

International Workshop on Geoenvironment & Geotechnics, 8 – 9 September 2008, Milos Island, Greece - milos.conferences.gr/?geoenv2008

"Stress Wave", 8 – 10 September 2008, Lisbon, Portugal, www.stresswave2008.org

5th International Geotechnical Seminar "Deep Foundations on Bored and Auger Piles", September 8 ÷ 10, 2008, Ghent, Belgium, terzaghi.ugent.be

12th International Conference "Geotechnika - 2008 – Geotechnics" on Techniques, Technologies and Monitoring of the Geotechnical Construction, The High Tatras, Slovak Republic, 10 - 12 September 2008, orgware@mail.t-com.sk

ISSMGE TC28 International Symposium "Questions about the construction work of Metro line 4 in Budapest", 12-13 September 2008, Budapest, Hungary, issmge-tc28-hungary.net/main.php?menu=1

11th Baltic Sea Geotechnical Conference "Geotechnics in Maritime Engineering", 15 – 18 September 2008, Gdansk, Poland - www.11bc.pg.gda.pl

Regional Conference on Geomorphology "Landslides, Floods and Global Environmental Change in Mountain Regions", Brasov, Romania, 15 - 25 September 2008, www.geomorph.org, www.geoinst.ro

1st Southern Hemisphere International Rock Mechanics Symposium, 16 - 19 September 2008, Western Australia, www.shirms.com

ITA – AITES World Tunnel Congress and 34th General Assembly of ITA – AITES, 19 ÷ 25 September 2008, Agra, India - www.cbip.org

4th International Symposium on Pre-Failure Deformation Characteristics of Geomaterials and Symposium Deformation Characteristics of Geomaterials (IS-Atlanta 2008), 21 – 24 September 2008, Atlanta, U.S.A., www.isatlanta2008.org

International Symposium on Conservation of Ancient Sites 2008, 21 – 24 September 2008, Dunhuang, China, www.dha.ac.cn

4th International Symposium on Pre-Failure Deformation Characteristics of Geomaterials AND Symposium on Characterization and Behaviour of Interfaces, 22 – 24 September 2008, Atlanta, Georgia, USA, glenn.rix@ce.gatech.edu

Karst Conference 2008
11th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst: Integrating Science and Engineering to Solve Karst Problems
September 22-26, 2008, Ramada Conference Center Tallahassee, Tallahassee, FL, USA
content.asce.org/conferences/KARST08/contact.html

This is the 11th in this series of highly successful interdisciplinary conferences which were first organized by the Florida Sinkhole Research Institute in 1984 as a means for geologists and geographers, who study how and where karst develops and how sinkholes form, to interact with engineers, planners and others, who must apply this information to build and maintain society's infrastructure and protect our environment. Since the first meeting in 1984, these biennial conferences have grown into the single most important international professional meeting concentrating on the practical application of karst science.

The goal of this conference is to share knowledge and experience among disciplines by emphasizing scientific and technological aspects of karst that have practical applications, together with case histories of those applications. Since karst topography impacts ground and surface water resources, waste disposal and management, highways and other transportation facilities, structural foundations and utilities and other infrastructure, civil, geotechnical and environmental professionals should all attend this most relevant conference.

Registration-specific questions: please send your inquiry to registrations@asce.org

ΤΕΤΑΡΤΟ ΠΑΝΕΛΛΗΝΙΟ ΣΥΝΕΔΡΙΟ "ΔΙΑΧΕΙΡΙΣΗ ΚΑΙ ΒΕΛΤΙΩΣΗ ΠΑΡΑΚΤΙΩΝ ΖΩΝΩΝ", 23 – 27 Σεπτεμβρίου 2008, Μυτιλήνη.

The 12th International Conference of IACMAG - International Association for Computer Methods and Advances in Geomechanics, 1 ÷ 6 October 2008, Goa, India, www.12iacmag.com

AFTES – International Congress "Building underground for the future", 6 – 8 October 2008, Monaco, www.aftes.asso.fr

HYDRO 2008 "Progressing World Hydro Development" CONFERENCE and EXHIBITION, Ljubljana, Slovenia ~ 6 - 8 October 2008, www.hydropower-dams.com

57th Geomechanics Colloquy 2008 in honour of the 100th birthday of Leopold Műller and the 40th birthday of the ÖGG, Salzburg, 9 – 10 October 2008, www.oegg.at/english/events/events.htm

14th World Conference on Earthquake Engineering (14WCEE), 12 - 17 October 2008, Beijing, China - www.14wcee.org

content.asce.org/conferences/pavements2008/index.html

You are invited to attend the ASCE's 2008 Airfield & Highway Pavements Conference to explore "**Efficient Pavements Supporting Transportation's Future**".

If you are on the frontline and are constantly challenged to construct and rehabilitate airport and highway pavements that are durable, smooth, quiet, efficient, cost-effective and capable of supporting projected traffic operation, while minimizing closures during construction, this is the conference for you. More and more of the airfield and highway pavement industry is challenged to find cost-effective solutions to ensure long-term quality for its finished product. Successful use of new technology is often the key solution.

As part of the Technical Session, distinguished presenters, addressing all areas of current thinking and experience, will cover **New Technologies in Pavement Design**, **Evaluation of Pavements, New and Innovative Materials** and **New Construction Techniques.**

Workshops include:

- **Back-to-Basics**, which will explore current technology in airfield pavement engineering fundamentals and pavement thickness design for airfields and roadways. This workshop is aimed at the newer pavement design professional.
- **Thickness Design**, which will explore how to use the latest FAA and AASHTO thickness design procedures.

Tunnelling 2008
Planning, procuring and delivering major projects
16th October 2008,
Earls Court Conference Centre, London
www.tunnelling2008.co.uk

NCE/BTS's Tunnel Construction focuses on the key strategic and technical challenges of the UK's tunnelling sector.

- Examine the latest procurement and technical challenges on Crossrail, Thames Tideway, the National Grid project and the London Underground
- Examine key projects including the New Tyne Crossing, Kings Cross and Glendoe Power Station
- Assess key techniques including spray concrete, fire suppression and geotechnical design
- Get updated on the latest health and safety best practice guidance
- Debate how the industry can overcome the resources problem

Για περισσότερες πληροφορίες αποτανθείτε στην γραμματεία του συνεδρίου στην ηλ.δι. conferences@emap.com

Vail, Colorado, USA
www.tailingsandminewaste.org

Tailings and Mine Waste '08 is the next of a series of symposia on mill tailings management started at Colorado State University in 1978. The primary purpose of the Conference is to provide a forum for members of the mining community, engineers and scientists serving the mining industry, regulatory groups, and other interest groups concerned with environmental issues related to tailings and mine waste management. Issues of environmental science and engineering, geochemistry, geotechnics, hydrogeology, milling, mining, mining engineering, tailings management, and other topics related to tailings and mine waste will be covered in focused sessions.

For more infomation contact:
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Tel: (970) 491-5049

SURF 2008 – International Symposium on Pavement Surface Characteristics, 20-22 October 2008, Portoroz, Slovenia. bojan.leben@zag.si

Xth International Conference "Underground Urban Infrastructure 2008", 22 - 24 October 2008, Wroclaw, Poland, www.wbliw.pwr.wroc.pl/uiua2008

NUCGE 2008 – International Conference on Numerical Computation in Geotechnical Engineering, October, 27-29 2008, Skikda, Algeria - www.univ-skikda.dz/conference/accueil1.html

ICSE-4 Fourth International Conference on Scour and Erosion, Tokyo, 5 - 7 November 2008, icse-4.kz.tsukuba.ac.jp

3ο Πανελλήνιο Συνέδριο Αντισεισμικής Μηχανικής και Τεχνικής Σεισμολογίας, 5 – 7 Νοεμβρίου 2008, Αθήνα, www.civil.ntua.gr/3-PCEEES

Atlantis 2008 - The Atlantis Hypothesis Q Searching for a Lost Land, Athens, 10 - 11 November 2008, atlantis2008.conferences.gr/4299.html

International Conference on Deep Excavations (ICDE), 2008 10 - 12 November 2008, Singapore, www.icde2008singapore.org

International Conference on Management of Landslide Hazard in the Asia-Pacific Region, 11 - 15 November 2008, japan.landslide-soc.org/index-e.html

1ο Πανελλήνιο Συνέδριο Μεγάλων Φραγμάτων, 13 – 15 Νοεμβρίου 2008, Λάρισα, portal.tee.gr/portal/page/portal/teelar/EKDILWSEIS/damConference

The First World Landslide Forum - Implementing the 2006 Tokyo Action Plan on the International Programme on Landslides (IPL) - Strengthening Research and Learning on Earth System Risk Analysis and Sustainable Disaster Management within UN-ISDR as Regards "Landslides", 18 - 21 November 2008, United Nations University, Tokyo, Japan - www.iclhq.org

5th Asian Rock Mechanics Symposium "New Horizons in Rock Mechanics - Development and Applications", 24 - 26 November 2008, Tehran, Iran, www.arms2008.org

5th WBI-International Shortcourse "Rock Mechanics, Stability and Design of Tunnels and Slopes", 27 – 30 November 2008, WBI, Aachen, Germany, www.wbionline.de

3rd International Conference on GEOTECHNICAL & GEOENVIRONMENTAL ENGINEERING, ROCK MECHANICS & ENGINEERING GEOLOGY "Recent Advances", 10 - 12 December 2008, Chiangmai, Thailand, www.cipremier.com/ciframeset.htm?index2.htm

GEOAGE Advances in Geotechnical Engineering – IGC 2008, 17 – 19 December 2008, Bangalore, India, civil.iisc.ernet.in/~igc 2008

International Conference on Rock Joints and Jointed Rock Masses, 4 – 11 January 2009, Tucson, Arizona, USA, www.jointedrock2009.org

RGMA-09 International Symposium on Rock Mechanics and Geoenvironment in Mining and Allied Industries, 12 - 14 February 2009, Varanasi, Uttar Pradesh, India, www.itbhu.ac.in/min/conferences

Geosynthetics 2009, 25 - 27 February 2009, Salt Lake City, Utah, USA www.geoshow.info

International Foundation Congress & Equipment EXPO '09, 15 – 19 March 2009, Orlando, Florida, USA, www.ifcee09.org

22nd Annual Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP 2009)
March 29-April 2, 2009, Fort Worth, TX
www.eegs.org/sageep/index.html

The Environmental and Engineering Geophysical Society (EEGS) invites you to submit an abstract for the 22nd Annual Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP) held in Fort Worth, a city filled with culture and western heritage, and known as the city "Where the West Begins".

Abstracts not to exceed 200 words are due no later than September 19, 2008 and may be submitted electronically at www.eegs.org. Abstracts that focus on recent developments in near-surface geophysical methods, innovative uses of geophysics for challenging engineering and environmental problems and case histories are welcome. If accepted, full manuscripts will be due December 12, 2008.

The SAGEEP 2009 theme is "Expanding Horizons for Near-Surface Geophysics".

General Topics:

- Magnetic Susceptibility and Soil Magnetism
- Nondestructive Evaluation of Infrastructure
- Karst Characterization
- Advances in GPR Modeling, Imaging, and Inversion
- Acoustic Geophysical Techniques—Body Waves or Surface Waves?
- Electromagnetic Induction: Methods and Concepts
- Archaeological Applications
- Resistivity and Self-Potential
- Geophysics for Performance Monitoring
- High Resolution Potential Fields: Microgravity and Magnetometry
- General: Engineering and Environmental Applications
- Airborne Geophysics
- Archaeology and Forensics
- Borehole Logging
- Contaminant Charactization
- Dam, Bridge, and Levee Assessments
- Data Integration, Management, and Visualization
- Electrical and Electromagnetic Methods
- Extreme Geophysics and Novel Applications
- Geological or Environmental Hazards
- Geotechnical Applications
- Gravity and Magnetics
- Ground Penetrating Radar
- Groundwater Investigation; Hydrogeophysics
- Homeland Security Applications
- Humanitarian Geophysics and Case Histories
- Infrastructure Applications
- Lake and Coastal Marine Applications

- Mining and Geophysics
- Monitoring Concepts and Applications
- Nuclear Geophysics
- Salt Water Intrusion Assessment
- Seismic and Vibration Monitoring
- Seismic Methods
- Surface Water Analysis
- Transportation Applications
- Tunnel and Underground Facility Characterization
- UXO Applications
- Water Resources and Supply
- Wind Energy Applications

7th International Conference on GROUND IMPROVEMENT TECHNIQUES, 20 - 22 April 2009, Macau, China, www.cipremier.com/ciframeset.htm?index2.htm

SINOROCK2009 International Symposium on Rock Mechanics "Rock Characterization, Modelling and Engineering Design Methods", 19 - 22 May 2009, Hong Kong, www.hku.hk/sinorock

SINOROCK2009 Extra-terrestrial rock mechanics.

"Safe Tunnelling for the City and Environment" ITA-AITES World Tunnel Congress 2009 and the 35th ITA-AITES General Assembly, Budapest Congress and Word Trade Center, Budapest, Hungary, 23 - 28 May 2009 - www.wtc2009.org

Géotechnique SYMPOSIUM IN PRINT 2009, May 2009, www. geotechnique-ice.com

3rd International Conference on New Development in Rock Mechanics and Engineering & Sanya Forum for the Plan of City and City Construction (NDRM'2009), 24 - 26 May 2009, Sanya, Hainan Island, China, www.ndrm2008.cn

International Symposium on Prediction and Simulation Methods for Geohazard Mitigation IS-Kyoto, 25 – 27 May 2009, Kyoto, Japan, nakisuna2.kuciv.kyoto-u.ac.jp/tc34/is-kyoto

IS-Tokyo 2009 "International Conference on Performance-Based Design in Earthquake Geotechnical Engineering - from case history to practice", 15 – 17 June 2009, Tokyo, Japan, www.comp.tmu.ac.jp/IS-Tokyo

WCCE – ECCE – TCCE Joint Conference "EARTHQUAKE & TSUNAMI", 22 – 24 June 2009, Istanbul, Turkey - www.imo.org.tr/eqt2009

Lifeline Earthquake Engineering in a Multihazard Environment
content.asce.org/conferences/tclee2009

The TCLEE 2009 conference will be the seventh in a series of international lifeline earthquake engineering conferences held approximately every four years since 1977.

Over the years, major natural hazards (earthquakes, floods, extreme winds, tsunami) and man-made hazards have caused significant regional disruptions that have often had national and even international impacts. Furthermore, this experience has consistently shown that the disrupted region's post-event resilience and sustainability will strongly depend on the performance of its lifelines during and after the event.

TCLEE 2009 will address this issue by providing a comprehensive array of technical papers pertinent to current practices, recent innovations, and future directions associated with performance requirements, design, analysis, and planning of lifelines subjected to natural and man-made hazards. In the TCLEE conference tradition, emphasis will be placed on technologies for reducing risks from earthquakes. However, TCLEE 2009 will address these technologies from a unique perspective that includes comparisons with lifeline risk-reduction technologies for other natural hazards and man-made hazards. In particular, the conference will include sessions that focus on:

- Differences and commonalities of technologies used to engineer lifelines to resist earthquakes vs. other natural and man-made hazards, and

- How engineering and risk-reduction technologies for each of these hazard types might benefit from exposure to technologies developed for other hazard types.

With this unique perspective, this conference will attract a diverse group of attendees involved in the innovative application of technologies for enabling lifelines to resist not only earthquakes but the full range of other natural and man-made hazards as well. These attendees will exchange ideas; debate points of view; discuss case studies, methods, and standards; and share experiences, solutions, and lessons learned.

Conference Topics

- Seismic performance requirements
- Seismic design and retrofit
- Seismic performance evaluation
- Design and analysis for flood, extreme wind, and man-made hazards
- In-common issues for lifelines subjected to earthquakes, other natural hazards, and man-made hazards:
  - System risk analysis and management
  - Hazard estimation
  - Codes and standards
  - Performance during past events
  - Lifeline interdependence
  - Socio-economic impacts
  - Emergency response and recovery planning
  - Capital improvement programs
  - Lifeline resilience and sustainability

The 3rd International Geotechnical Symposium (IGS2009) on Geotechnical Engineering for Disaster Prevention and Reduction, 22 - 25 July 2009, Harbin, China, igs2009.hit.edu.cn

GeoHunan International Conference: Challenges and Recent Advances in Pavement Technologies and Transportation Geotechnics, 3 – 6 August 2009, dchen@dot.state.tx.us

GeoAfrica 2009 "Geosynthetics For Africa", 2 – 4 September 2009, Cape Town, South Africa, www.gigsa.org

17th International Conference on Soil Mechanics and Geotechnical Engineering "Future of Academia & Practice of Geotechnical Engineering", 5 – 9 October 2009, Alexandria, Egypt - www.2009icsmge-egypt.org

AMIREG 2009

3rd International Conference
Advances in Resources & Hazardous Waste Management Towards Sustainable Development

heliotopos.conferences.gr/amireg2009

The aim of this 3rd Conference is to provide a forum for the world's leading scientific and technical communities to interact and address the main issues and the key challenges related to all aspects of resources and hazardous waste management in the beginning of the 21st century in order to improve industry's sustainability, reduce its environmental and health impacts in substantial and measurable terms, enhance resource recovery efficiency and reduce consumption of resources.

Topics

- Hazardous Wastes (Regulations, Registration, Characterization, Toxicity, Minimization, Recycling, Treatment, Management and Disposal)
- Waste Valorisation to Materials and Energy
- Geotechnical aspects of solid wastes, dams and waste dumps
- Environmental geochemistry of wastes
- Treatment of Liquid and Gaseous Effluents
- Contaminant Release and Transport
- Acid rock drainage
- New developments on permeable reactive barriers technology and modeling
- Remediation of contaminated sites
- Mine - quarry reclamation / revegetation
- Mine closure practices - Advanced modelling techniques in geotechnical and geo-environmental engineering
- Life cycle – risk assessment in industrial and waste disposal sites
- Health and safety impact assessment
- New approaches / prospects in the industrial sector towards sustainability
- Environmental biotechnology and forensics
- Industrial Minerals – New uses / technologies
- Modern mining and tunnelling technologies
- New materials, nano-materials
- Ornamental stones
- Recent developments in pyro-, hydro-, bio-hydrometallurgy
- Engineering geology applications - Energy Resources
- Advanced monitoring techniques (remote sensing, decision support and alerting techniques)
- Hazard detection and control
- CO2 Sequestration
- Preservation of industrial heritage

Heliotopos Conferences
28, Ypsilantou Str., GR-17236, Dafni-Athens, Greece
Phone: +30 210 9730697. Fax: +30 210 9767208
amireg2009@heliotopos.net

EUROCK'2009 Rock Engineering in Difficult Ground Conditions - Soft Rocks and Karst, 29 - 31 October 2009, Dubrovnik-Cavtat, Croatia, www.eurock2009.hr

IX International Conference on Geosynthetics, Brazil, 2010 - www.igsbrasil.org.br/icg2010

ISRM Regional Symposium on Rock Mechanics, Lausane, Switzerland, 23-25 June 2010

XV African Regional Conference on Soil Mechanics and Geotechnical Engineering Maputo, Mozambique, 13-16 June 2011.

XV European Conference on Soil Mechanics and Geotechnical Engineering, 12 – 15 September 2011, Athens, Greece.

Beijing 2011, 12th International Congress on Rock Mechanics, 16 – 21 October 2011, Beijing, China, www.isrm2011.com

ΝΕΑ ΑΠΟ ΤΟΝ ΚΟΣΜΟ

The airport with an X factor

New Dubai hub to handle up to 120 million passengers a year

Dubai doesn't do small.

The world's tallest tower, largest mall, longest bridge -- it has them all, or will soon. The new airport complex, under construction about 40 kilometers (25 miles) southwest of old Dubai, is no exception.

At 140 square kilometers (54 square miles), the land set aside by former Dubai ruler Sheikh Rashid bin Saeed Al Maktoum 30 years ago for the visionary $33 billion urban aviation project is almost twice the size of the island of Hong Kong. The heart of this new city, known as Dubai World Central, will be the Al Maktoum International airport. Upon completion, it will be the world's largest airport, bigger than London's Heathrow and Chicago's O'Hare combined.

"It's not just an airport, it's a whole new concept," Abdulla Ahmed Al Qurashi, the head of DWC's aviation division, told MarketWatch in an interview.

The sheer dimensions of the $10 billion Al Maktoum airport are difficult to convey. It will have two huge terminals, six concourses, six parallel runways and a smaller terminal for low-cost and regional airlines. The terminals and concourses will be linked by a light railway system.

To give potential partners and investors an idea of what the new airport, and the whole city around it, will look like, DWC has built large models of the project at its headquarters. They are neat and orderly, all perpendicular streets lined with palm trees and pastel-toned buildings. At Al Maktoum, the lights are flashing on the runways and miniature helicopters are on standby on a dozen helipads. The planes are barely an inch long on a model several meters wide.

The airport will eventually have an annual capacity of about 120 million passengers and 12 million tons of cargo. London's Heathrow airport, the world's busiest international airport, handles about 68 million passengers annually. Memphis and Hong Kong, the world's top cargo hubs, deal with about 4.5 million tons of cargo each year.

Although operations won't be in full swing at Al Maktoum until 2015, parts of the project are already well underway. The first runway, aerial control tower and fuel tanks are finished and the first passenger flight is expected next year. A low-cost terminal that will be home to Dubai's new budget carrier should be ready in the third quarter of 2009.

The new airport, executives say, is essential for Dubai to deal with a predicted surge in air travel.

The International Air Transport Association sees average passenger growth in the Middle East of 6.8% a year until 2011. European aircraft maker Airbus, meanwhile, predicts that passenger traffic in the region will increase by 8.1% a year until 2016, compared with a global average growth of 5.4%.

At its heart though, DWC is much more than an aviation project.

It will "not only impact future airports around the world, but also regional economic development," DWC Executive Chairman Khalifa Al Zaffin told the audience of the Future Airports Congress in Dubai in early June.

Dubai World Central

The first runway at Al Maktoum International.

Industry analysts agreed the region approaches its airports differently.

"The development and financing of airports in the Gulf does not follow the same pattern as airports in the rest of the world. In Dubai for instance we're talking about a wider economic development plan of which the airport is an essential part," said Christopher Preece, managing director of U.K.-based Falcon Consultancy.

Many firms involved

At Al Maktoum, the opportunity for airport infrastructure and equipment specialists is enormous.

While the runway was built by the UAE's Al Naboodah, international contractors are heavily represented. The first terminal, which will cater to 7 million passengers, is the responsibility of a joint venture between the UAE's Arabtec and Germany's Max Bogl, while France's Thales (FR:012132: news, chart, profile) and the U.K.'s Park Air Systems are providing the navigational aids package. U.S.-based Raytheon Co. (RTN) has been selected for the instrument landing system.

A visit to the site reveals construction continuing at an unabated pace. Roughly 20,000 workers are toiling by 100-degree heat under the leadership of 600 engineers to transform tasteful models into reality. The scale of the job hits with one 360-look at the site. In every direction, as far as the eye can see: sand, rocks, pits and dunes.

The issues confronting workers, planners and engineers are as exotic as the climate: The runway must be fenced to prevent camels and antelope from crossing it at night. An indigenous Ghaf tree, which has stood undisturbed in the middle of the desert for 200 years, now finds itself in the middle of a construction site. Its longevity is such a rare occurrence in this harsh climate that it's been uprooted and moved to a conservation park. Desert wildlife, consisting mainly of birds, snakes and rabbits, must be relocated.

The desert landscape also means a special chemical will have to be sprayed onto the sand to prevent it from scattering and hampering visibility on takeoff and landing.

Around the airport, five more developments are planned. Residential City and Golf City will house the bulk of the 900,000 people expected to live and work at DWC while Commercial City, roughly the size of Manhattan, will be home to various firms and businesses and likely become the financial center of the development.

Logistics City will take advantage of its proximity to the existing Jebel Ali port and free zone, making sea to air connectivity achievable in less than 4 hours.

Although construction is just starting on Logistics City, Al Qurashi said international firms are already jostling to re-

serve lots to build warehouses. Nearly 50, including Swiss logistics giant Panalpina (CH:003251336: news, chart, profile) (PLWTF) , have already signed contracts and 150 have reserved land.

Eventually, most firms with operations at the current Jebel Ali free zone will relocate to Logistics City. The list of current tenants of the free zone reads like a who's who of the manufacturing world and includes Acer, Daimler (DAI) (DE:710000: news, chart, profile) , Volvo (SE:VOLVB: news, chart, profile) , SAP (SAP) (DE:716460: news, chart, profile) and Siemens (DE:723610: news, chart, profile) (SI).

Other airports getting a face lift

Although Al Maktoum will dwarf other airports in the region, many are expanding their facilities and undergoing facelifts. Dubai neighbor Abu Dhabi plans a revamp that will increase its airport's capacity to 40 million passengers a year. Meanwhile, Qatar's Doha International Airport will be able to handle 50 million passengers in 2020.

Ultimately, some industry experts said, most of the United Arab Emirates' airports could be linked. There are already plans for a light rail to link DWC and the existing Dubai International Airport.

"At the beginning there's always lots of competition, but I think at the end we will have one main UAE airline and one main airport," said Diogenis Papiomytis, consultant in the aerospace and defense practice of Frost & Sullivan.

(Aude Lagorce. DUBAI MARKETWATCH, June 23, 2008)

World's longest cable-stayed bridge opens in China

SHANGHAI (AFP) - The world's longest cable-stayed bridge has officially opened in eastern China, linking the two banks of the Yangtze river, state media reported Tuesday.

The Sutong bridge, which spans 1,088 metres (3,570 feet) over China's longest waterway and links the cities of Suzhou and Nantong, officially opened with a ceremony Monday after a month-long trial, the Shanghai Daily reported.

The six-lane bridge is expected to boost economic growth in the region and cut the travel time between Shanghai and Nantong to one hour from the previous four hours, the report said.

Up to 30,000 vehicles a day crossed the bridge during the trial, the Xinhua news agency reported.

"With the bridge, it takes just seven minutes to drive across the Yangtze," the agency quoted Jiangsu province's transportation director, You Qingzhong, as saying.

The 1.15-billion-dollar bridge, which overtakes Japan's 890-metre (2,900-foot) Tatara Bridge as the longest of its kind, is a feat of modern Chinese engineering, the project's chief engineer Wu Shouchang said.

"The bridge is a good demonstration of China's scientific achievements in bridge construction over the past years," Xinhua quoted Wu as saying.

The bridge, 108 kilometers (67 miles) upstream from the mouth of the Yangtze River, joins the national highway network on both banks, Xinhua said.

The bridge is supported by soaring steel and concrete towers that stand 300 meters tall.

YAHOO! NEWS Tuesday, July 1, 2008, 12:05 PM ET)

The world's top 10 largest contractors in 2007

Vinci was the world's largest contractor in 2007 according to the results of International Construction's annual ranking of the worlds largest construction companies. Fellow French company Bouygues maintained its second place, but further down the top 10 there were major changes.

New in third position is Spain's ACS, rising two places from fifth last year. The company pushed the largest US company in the ranking, Bechtel, down one place to fourth.

Fifth and sixth places are taken by Chinese contractors, with China Railway Construction Corporation taking a huge leap up 17 positions from no. 23 in last year's rankings. Also new to the top 10 this year is China Communications Construction Group in ninth place.

Spain's Ferrovial is the other new addition to the top 10, in eighth position, while Hochtief and Skanska lost places compared to their rankings in last year's edition of the table.

Position	Sales (US$ million)	Company	Country	2007 Position	Change
1	41650	Vinci	France	1	-
2	29843	Bouygues' Construction Divisions	France	2	-
3	29171	ACS	Spain	5	2
4	27000	Bechtel	US	3	-1
5	23739	China Railway Group	China	6	1
6	23342	China Railway Construction Corporation	China	23	17
7	22519	Hochtief	Germany	4	-3
8	20053	Ferrovial	Spain	11	3
9	19806	China Communications Construction Group	China	14	5
10	19602	Skanska	Sweden	9	-1

For the first time in the league table's history, there are no Japanese companies in the global top 10. The highest placed this year was Kajima - last year's eighth placed company - at no. 14. Taisei also fell sharply, ranking at no. 17 this year, compared to no. 10 last year.

But the biggest fall from last year's top 10 was for Lennar of the US. The house building specialist was ranked seventh

in last year's rankings, but this year has been placed at no. 31, some 24 places lower. This is just one of the symptoms of the residential construction crash in the US, which has seen operating profit margins for the 44 US companies in the global top 200 fall from 6.52% last year (based on 2006 results) to an operating loss of -5.08% 12 months on.

For more analysis of the world's 200 largest construction contractors, as well as the full league table, see the July-August edition of International Construction, http://www.khl.com

(WORLD CONSTRUCTION WEEK, 8 July 2008, Editor: Chris Sleight)

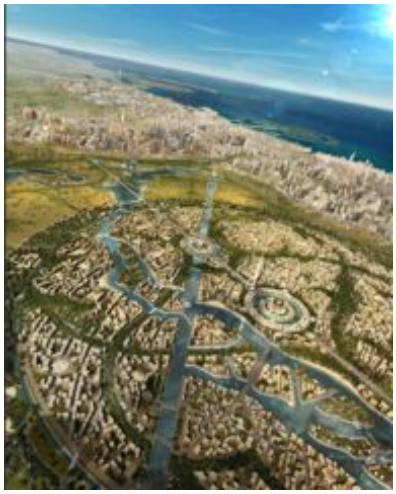
Mohamed Bin Rashid Gardens

Developer Dubai Properties' AED 200 billion (US$ 54.5 billion) Mohamed Bin Rashid Gardens will cover 8.19 million m2 when complete in 2026.

Developer Dubai Properties' AED 200 billion (US$ 54.5 billion) Mohamed Bin Rashid Gardens will cover 8.19 million m2 when complete in 2026.

Part of Dubai's 2015 Strategic Plan, which is the vision of His Highness Sheikh Mohammed Bin Rashid, it is divided into four zones - the House of Humanity, the Trade House, the House of Nature and the House of Wisdom, which are inspired by the Arab renaissance in science, literature and humanity of the 12th Century.

The project, which is located between Al Khail Road and Emirates Road, aims to "bring life to the desert", via a 42 km water canal that will stretch from phase 3 of the Business Bay development, and pour out into the Arabian Gulf. It will also contain the Zodiac garden (73% of the project is green), universities, a museum, Dubai Festival Hall, the Mohamed Bin Rashed Foundation and an Avenue of Nations.



A low-density project with huge public open spaces, the gardens will be a mixed-use development over six phases that will cater up to 150000 employees, as well as provide living space for 200000 more.

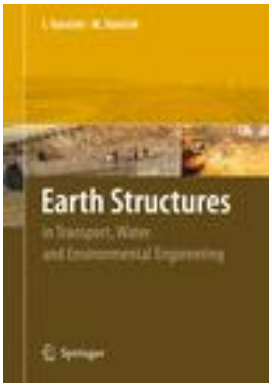
(WORLD CONSTRUCTION, 18 July2008, Editor: Richard High)

Facade completed on OMA's CCTV headquarters

Construction of the 600000 m2, Office of Metropolitain Architecture (OMA) designed CCTV building, which will be home to China's national broadcaster, has reached a new milestone with the installation of the final glass panels of the façade.

(WORLD CONSTRUCTION, 11 August 2008, Editor: Richard High)

ΝΕΕΣ ΕΚΔΟΣΕΙΣ ΣΤΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΠΙΣΤΗΜΕΣ



Earth Structures in Transport, Water and Environmental Engineering

Vanicek, Ivan, **Vanicek**, Martin

While soil is the oldest, most commonly used building material, there is a paradox in that the subject of Earth Structures has never previously been comprehensively covered. This book describes the principles of working with soil as a construction material, including two basic ways of treating it: geosynthetics and stabilization. The book discusses the design logic and ways to control Earth Structures, which differ significantly from other construction materials. Building with Earth involves greater uncertainty and risk, which means that there is a need for better design detailing and improvement in the quality of financial calculations.

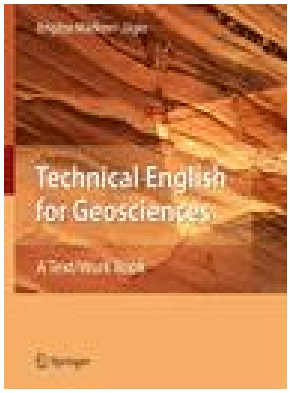
The general part of the book gives a detailed description of the principles of limit states according to Eurocode 7, after which geotechnical design is also described. Subsequent chapters concentrate on earth structures for transport, water, and environmental projects.

The chapter on Earth Structures in transport engineering presents detailed coverage of limit states of stability and deformation. 'Earth Structures in water engineering'prioritizes the limit state of internal erosion. 'Earth Structures in environmental engineering' describes new designs, in which part of the structure is created from non-standard materials which are usually susceptible to internal collapse, double porosity, unsaturation, etc. It also focuses on protecting the surrounding environment from contamination.

With its emphasis on principles, the logic of processes, and understanding the most important problems, the book allows all those involved with a construction (client, designer, contractor and supervisor) to build such earth structures more safely and economically.

This book will be of interest to civil and environmental engineers; transport, hydraulic and planning engineers; geotechnical and geo-environmental engineers; scientists, designers, contractors, clients and supervisors; postgraduate students.

(Springer, September 3, 2008)

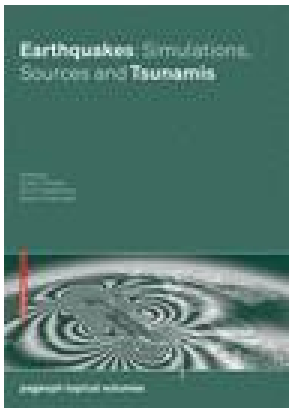


Technical English for Geosciences
A Text/Work Book

Markner-Jäger, Brigitte

The course book Technical English for Geosciences is a real gold mine for all – most especially students and lecturers – who need to enhance their command of the English language with the terminology of geosciences. Subjects from all branches and disciplines of geosciences are discussed: Applied Geology, Geotechnology/Geoengineering, Mineralogy, Hydrology, Mining and Rehabilitation, Meteorology, and Water and Waste Management – subjects which are closely related to Bachelor's or Master's degree studies. Texts are taken from various authentic material including advertisement brochures, scientific monographs or internet sources. Terminology is practiced through multiple tasks and interesting exercises. The book is meant for learning in classes as well as for self-study. A glossary and proposals for solutions are provided at the end of the book.

(Springer, 2008)



Earthquakes: Simulations, Sources and Tsunamis Series: Pageoph Topical Volumes

Tiampo, K. F., Weatherley, D. K. and Weinstein, S. A. (Editors)

In recent years, large earthquakes in the circum-Pacific region have repeatedly demonstrated its particular vulnerability to this potentially devastating natural hazard, including the M ~ 9.2 Northern Sumatra earthquake and tsunami of 2004 which resulted in the deaths of nearly 300,000 people. In the late-1990s, major advancements in seismic research greatly added to the understanding of earthquake fault systems, as large quantities of new and extensive remote sensing data sets, that provided information on the solid earth on scales previously inaccessible, were integrated with a combination of innovative analysis techniques and advanced numerical and computational methods implemented on high-performance computers. This book includes a variety of studies that focus on the modeling of tsunamis and earthquakes, both large-scale simulation and visualization programs, as well as detailed models of small-scale features. Particular attention is paid to computational techniques, languages, and hardware that can be used to facilitate data analysis, visualization, and modeling. Also included are studies of several earthquake forecasting techniques and associated comparisons of their results with historic earthquake data. Finally, the volume ends with theoretical analyses of statistical properties of seismicity by internationally recognized experts in the field. This volume will be of particular interest

to researchers interested in the multiscale simulation and visualization of large earthquakes and tsunamis.

(Springer, 2008)

2008 Seismic Engineering Conference

Commemorating the 1908 Messina and Reggio Calabria Earthquake

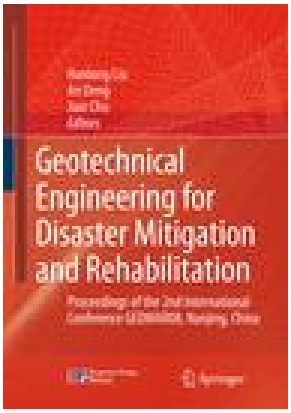
Reggio Calabria, Italy, 8-11 July 2008

Series: AIP Conference Proceedings , Vol. 1020

Santini, A. and Moraci, N. (Editors)

The MERCEA'08 Conference provided a forum to discuss the state-of-the-art, the best practices and the new research results in the field of earthquake engineering and geotechnics. Both the wide range of covered topics and the high level of its contents, address the Proceedings to researchers and professional engineers involved in structural design in seismic prone areas.

(Springer, 2008)



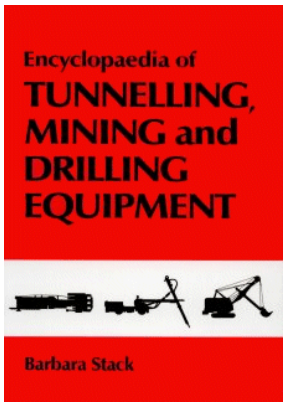
Geotechnical Engineering for Disaster Mitigation and Rehabilitation

Proceedings of the 2nd International Conference GEDMAR08, Nanjing,China

Liu, Han-Long; Deng, An; Chu, Jian (Editors)

"Geotechnical Engineering for Disaster Mitigation and Rehabilitation" presents the latest developments and case studies in the field. All contributions to this proceedings were rigorously reviewed to cover the newest developments in disasters related to earthquakes, landslides and slopes, soil dynamics, risk assessment and management, disaster mitigation and rehabilitation, and others. The book will be a useful reference for geotechnical scientists, engineers and professionals in these areas.

(Springer - Science Press, October 4, 2008)



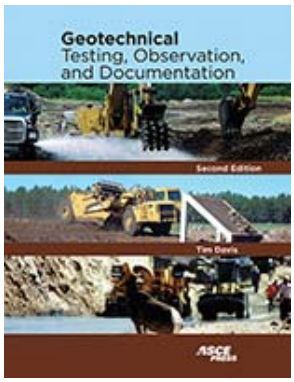
Encyclopaedia of Tunnelling Mining and Drilling Equipment

Volumes 1, 2 & 3 + CD

B. Stack

This comprehensive encyclopaedia of tunnelling, mining and drilling equipment follows the evolutionary development of the machines from their earliest inception to latest units operating today. It is of interest to all those concerned with tunnelling, mining, excavating or drilling including, construction companies, machine manufacturers, engineering students and lecturers, and government organisations. Whilst giving technical details of the equipment the encyclopaedia is written in such a way as to be accessible to interested non-specialists.

(Muden Publishing Company, 2008)



Geotechnical Testing, Observation, and Documentation, Second Edition

Tim Davis

Geotechnical Testing, Observation, and Documentation is an in-depth field manual for soil technicians and geotechnical engineers. This indispensable reference guide – designed for use during the investigation, grading, and construction phases of geotechnical projects – has helped thousands of readers understand common laboratory and field tests, classify soil accurately, interpret project recommendations, and document the entire construction monitoring process.

This updated and expanded edition offers new material on topics such as deep foundations, shallow foundations, retaining walls, and loss prevention. Sample test questions appear at the end of every chapter, and a comprehensive case study presents each step of a sample project, from site investigation and lab work through construction and documentation. A quick reference chapter summarizes current tools and references, evaluates compaction equipment, and presents frequently used formulas and equations. The appendixes offer a glossary with more than 500 geotechnical terms, an answer key to chapter questions, and a collection of blank ready-to-use forms.

Geotechnical Testing, Observation, and Documentation, Second Edition, is valuable for training new technicians and providing a refresher course for veterans. Soil technicians contemplating the NICET or ICC certification exams will find Tim Davis's book an essential test preparation aid.

(ASCE, 2008)

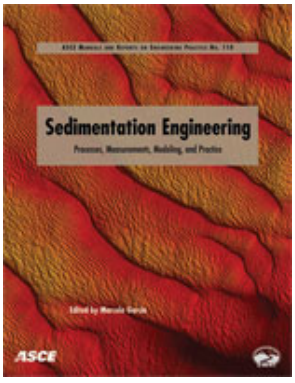
ice
Ground anchorages and anchored structures in service

Ground Anchorages and Anchored Structures in Service

G.S. Littlejohn (Editor)

This book shows how routine inspection and monitoring can extend the service life of the anchored structures that represent key elements of a country's infrastructure. Where inspection highlights unacceptable tendon corrosion or over-stressing, the results provide early warning of the need for precautionary or remedial measures, in order to safeguard the integrity of the anchored structure. The findings in this book show that in spite of these benefits, sufficient attention is not currently paid to routine maintenance inspection and service behaviour monitoring. Contents Include:

- Maintenance testing and service behaviour monitoring of permanent ground anchorages
- Inspection procedures and physical conditions recorded in service
- Service behaviour monitoring procedures and performance in service
- North American Dam rehabilitation
- Rock bolts in tunnels and mines
- Non-destructive integrity testing
- Corrosion monitoring and corrosion protection systems
- Case histories of satisfactory performance, shortcomings and failures in service
- Recommendations and standards for inspection, monitoring and repair



Sedimentation Engineering

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(ASCE, 2008)

ΝΕΟ ΠΕΡΙΟΔΙΚΟ

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ΗΛΕΚΤΡΟΝΙΚΑ ΠΕΡΙΟΔΙΚΑ

International Journal of Geoengineering Case Histories

casehistories.geoengineer.org

As of June 2008, **the International Journal of Geoengineering Case Histories (IJGCH) is the official journal of the International Society for Soil Mechanics and Geotechnical Engineering.**

Κυκλοφόρησε το τεύχος αρ. 2 του 24ου τόμου (Ιούλιος 2008) του ενημερωτικού περιοδικού της IGS

www.geosyntheticssociety.org

Κυκλοφόρησε τα τεύχη αρ. 2 και 3 του 15ου τόμου (Απρίλιος και Ιούνιος 2008) του περιοδικού

Geosynthetics International
An Official Journal of the IGS
www.thomastelford.com/journals

Κυκλοφόρησε τα τεύχη αρ. 3 και 4 του 26ου τόμου (Ιούνιος και Αύγουστος 2008) του περιοδικού

Geotextiles & Geomembranes
An Official Journal of the IGS
www.geosyntheticssociety.org/journals.htm

*Geotextiles and Geomembranes*is dedicated to the mission of the IGS, which is to promote the scientific and engineering development of geotextiles, geomembranes, related products, and associated technologies.

The Journal publishes technical papers, technical notes, discussions, and book reviews on all topics relating to geosynthetics, research, behaviour, performance analysis, testing, design, construction methods, case histories, and field experience.

Geotextiles and Geomembranes is now available free in electronic format to IGS Members.

www.geoengineer.org

Κυκλοφόρησαν τα Τεύχη #43 και #44 του Newsletter του Geoengineer.org (Ιούλιος και Αύγουστος 2008) με πολλές χρήσιμες πληροφορίες για όλα τα θέματα της γεωτεχνικής μηχανικής. Υπενθυμίζεται ότι το Newsletter εκδίδεται από τον συνάδελφο και μέλος της ΕΕΕΕΓΜ Δημήτρη Ζέκκο (secretariat@geoengineer.org).

Announcing the "Geoengineering Community Blogs"

A monthly publication of Geoengineer.org website

After several months of development, the Geoengineer.org team is happy to announce the Geoengineering Community Blogs.

The Geo-blogs intend to facilitate the access and exchange of information within the international geoengineering community. Organizations, companies and individuals are welcome to participate and create their own blogs within this community. Geoengineer.org will be promoting this information and helping your blog reach out to the geoengineering profession.

Organizations may establish blogs to announce news, promote activities, and solicit the participation of the community. Committees, working groups and other initiatives may choose to establish a blog to record their activities and promote their work.

Companies may establish a blog to promote their services or products, promote announcements, or simply support their website. Blogs may be used to create a forum of information exchange with clients or users of the company's products.

Individuals may also decide to establish a personal blog and share their interests, experiences, photos or other materials.

In all cases, new postings within each blog will continuously be promoted by Geoengineer.org, ensuring unique exposure to the international geoengineering community.

We invite you to participate in this new service that was developed as a part of our continuing efforts to support the Geoengineering Profession. To create your blog, register at "Geoengineering Community Blogs".

There are more projects currently being developed by the Geoengineer.org. As always, we encourage you to share with us what activity you believe could make a difference to the profession.

We hope you enjoy "Geoengineering Community Blogs" and find this new feature valuable.

On behalf of the Geoengineer.org team,
Dimitrios Zekkos, Ph.D., P.E., Managing Director

Useful Information About the Blogs

The Geoengineering Community Blogs is a service provided by Geoengineer.org. This service is:

- FREE for Organizations
- FREE for personal websites
- FREE for Corporate Sponsors

Companies that are not Corporate Sponsors may create blogs at a small annual cost.

Creating a blog is simple and fast. Geoengineer.org has also created a quick guide that will allow you to set up and operate your blog at no time. Just click on the instructions link at the main page of our blog.

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