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ΑΡΘΡΑ

Γεφύρωση της κατολίσθησης της Τσακώνας Γεωτεχνικός και στατικός σχεδιασμός βάθρων μέσα στην ολισθαίνουσα εδαφική μάζα

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Bridging over Tsakona Landslide Geotechnical and structural design of piers within the sliding soil mass

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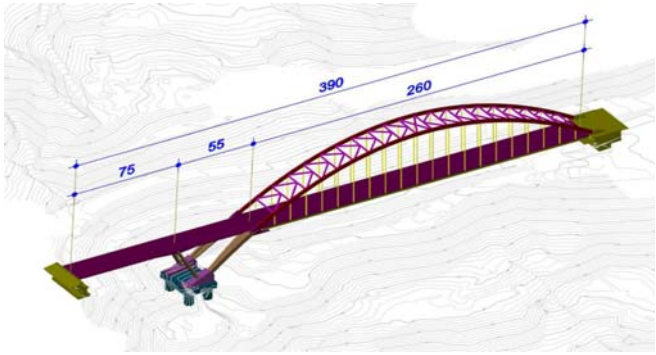
Abstract

The landslide of Tsakona is one of the largest landslides occurred in Greece with significant impact on the economic and social life of southern Peloponnese. It occurred in February 2003, causing large soil mass movement within a range of hundreds of meters and the closing section of the National Highway Corinth - Kalamata. For the rehabilitation of the Highway it was decided to construct an arched steel bridge over the sliding slope, 390m long. For the erection of the steel arc and deck of the bridge, 14 twin steel temporary towers, reaching the height of 60m, were required. The foundation of the towers consisted of piles connected with pile-caps. Between the pile-caps small temporary bridges on pile systems were also constructed, which were used for the assembling/welding of the arc and deck segments. Most of the deep foundation and the supporting structures were built in the old active landslide where the evolving movements were observed. The main assumptions of the deep temporary foundation design are underlined in this work, incorporating the monitoring results and the profiles of the ground movement and setting the proper geotechnical and structural models to predict the influence of the ground movements on the piles and pile-caps. Several two and three-dimensional finite element models were set up, and numerical analyses were conducted for this reason. Key issues of the design were the depth of the piles in relation to the steep underlying bedrock, the estimation of the bearing capacity of the piles under the condition that the whole system was temporary and the cost optimization, which was always a requirement by the contractor.

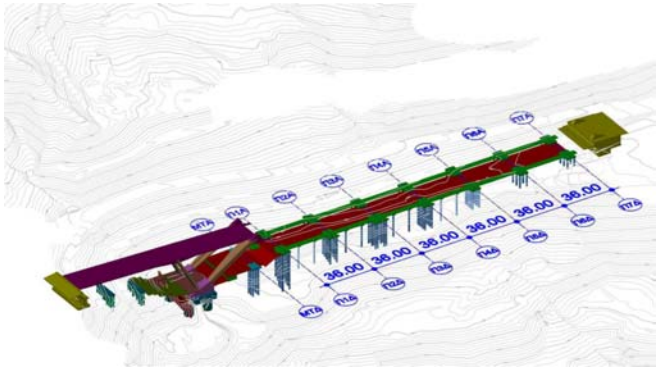
Εισαγωγή

Η γέφυρα της Τσακώνας, συνολικού μήκους 390m, κατασκευάστηκε για να γεφυρώσει τη μεγάλη κατολίσθηση που συνέβη το 2003 στον αυτοκινητόδρομο Τρίπολης – Καλαμάτας. Το έργο ολοκληρώθηκε με επιτυχία, τα έργα θεμελίωσης (μόνιμα και προσωρινά) δεν φαίνονται πλέον, όμως η γέφυρα στέκει εντυπωσιακά πάνω από την Τσακώνα χάρη στην ασφάλεια που του παρέχουν (ή του παρείχαν προσωρινά), αυτά ακριβώς τα θαμμένα έργα. Στο άρθρο αυτό περιγράφεται η μεθοδολογία που ακολουθήθηκε για τη γεωτεχνική και στατική μελέτη των θεμελιώσεων των πύργων που χρησιμοποιήθηκαν για την ανέγερση των τόξων και του καταστρώματος της γέφυρας στην Τσακώνα, οι οποίοι θεμελιώθηκαν εντός του σώματος της ενεργής κατολίσθησης της περιοχής. Η ιδιομορφία των έργων είχε ως κυρίαρχα χαρακτηριστικά, (α) την χρήση μιας κατολισθαίνουσας μάζας ως εδάφους θεμελίωσης, (β) την εξαιρετικά ασύμμετρη και έντονη μορφολογία του φυσικού ανάγλυφου αλλά και του γεωλογικού υποβάθρου, (γ) την εξαιρετικά κρίσιμη διαδικασία ανέγερσης και συναρμολόγησης του τόξου και (δ) το χαρακτηρισμό των έργων ως προσωρινών γεγονός που επέβαλε την τεχνικοοικονομική βελτιστοποίηση και την ταυτόχρονη εξασφάλιση της σταθερότητας και επάρκειας των έργων. Αυτά ακριβώς τα χαρακτηριστικά αποτέλεσαν την πρόκληση ώστε να χρησιμοποιηθούν πολλαπλές φάσεις και προσεγγίσεις για την προσομοίωση, ανάλυση και διαστασιολόγηση των απαιτούμενων έργων.

Το τμήμα της ανωδομής, ανάμεσα στο μεσόβαθρο και το ακρόβαθρο προς Καλαμάτα, που γεφυρώνει το κύριο σώμα της ενεργής κατολίσθησης, διαμορφώθηκε από μεταλλικό κατάστρωμα και πλάκα από σκυρόδεμα, το οποίο αναρτήθηκε από 2 μεταλλικά τόξα, ανοίγματος 260m (Σχήμα 1). Για την κατασκευή της γέφυρας απαιτήθηκε η κατασκευή σημαντικών προσωρινών έργων υποδομής. Με βάση την επιλεγείσα μεθοδολογία κατασκευής, το μεγαλύτερο μέρος αυτών έπρεπε να θεμελιωθεί εντός της κατολισθαίνουσας μάζας. Τα έργα υποδομής χρησιμοποιήθηκαν για τη συναρμολόγηση των χαλύβδινων σπονδύλων των τόξων και του καταστρώματος, την ανύψωση των επιμέρους τμημάτων τους και την τελική σταδιακή συναρμολόγησή τους (συγκόλληση) στον «αέρα». Περιελάμβαναν τα εξής δομικά συστήματα (Σχήμα 2): (α) 14 δίδυμους χαλύβδινους πύργους βαριάς ανύψωσης (Π1Α-Π7Α για τον αριστερό κλάδο και Π1Δ-Π7Δ για το δεξιό



Σχήμα 1. Σχηματική απεικόνιση γέφυρας της Τσακώνας



Σχήμα 2. Σχηματική απεικόνιση έργων υποδομής

κλάδο), (β) δύο ειδικούς χαλύβδινους πύργους (ΜΤΑ για τον αριστερό κλάδο και ΜΤΔ για το δεξιό κλάδο), φέρουσας ικανότητας 12000KN ο καθένας, οι οποίοι τοποθετήθηκαν κάτω από τις καμπύλες αντηρίδες του μεσοβάθρου, (γ) 16 ανεξάρτητες θεμελιώσεις (πάσσαλοι συνδεδεμένοι με κεφαλοδέσμους) για κάθε πύργο, (δ) διαδρόμους από οπλισμένο σκυρόδεμα επί εδάφους, ή τύπου γέφυρας όπου το ανάγλυφο δεν επέτρεπε την ανάπτυξη χωματουργικών διαμορφώσεων, για την προ-συναρμολόγηση των υποτμημάτων των μεταλλικών τόξων. Παράλληλα, κατά τη διάρκεια της κατασκευής της γέφυρας η κυκλοφορία του Αυτοκινητοδρόμου Τρίπολης – Καλαμάτας διευκολύνθηκε μέσω προσωρινής οδού διέλευσης. Για την πραγματοποίηση αυτής και τη βελτίωση της ευστάθειας του πρανούς που διαμορφώθηκε, απαιτήθηκε ένας πασσαλότοιχος αντιστήριξης. Τα έργα υποδομής φαίνονται στην Εικόνα 1.

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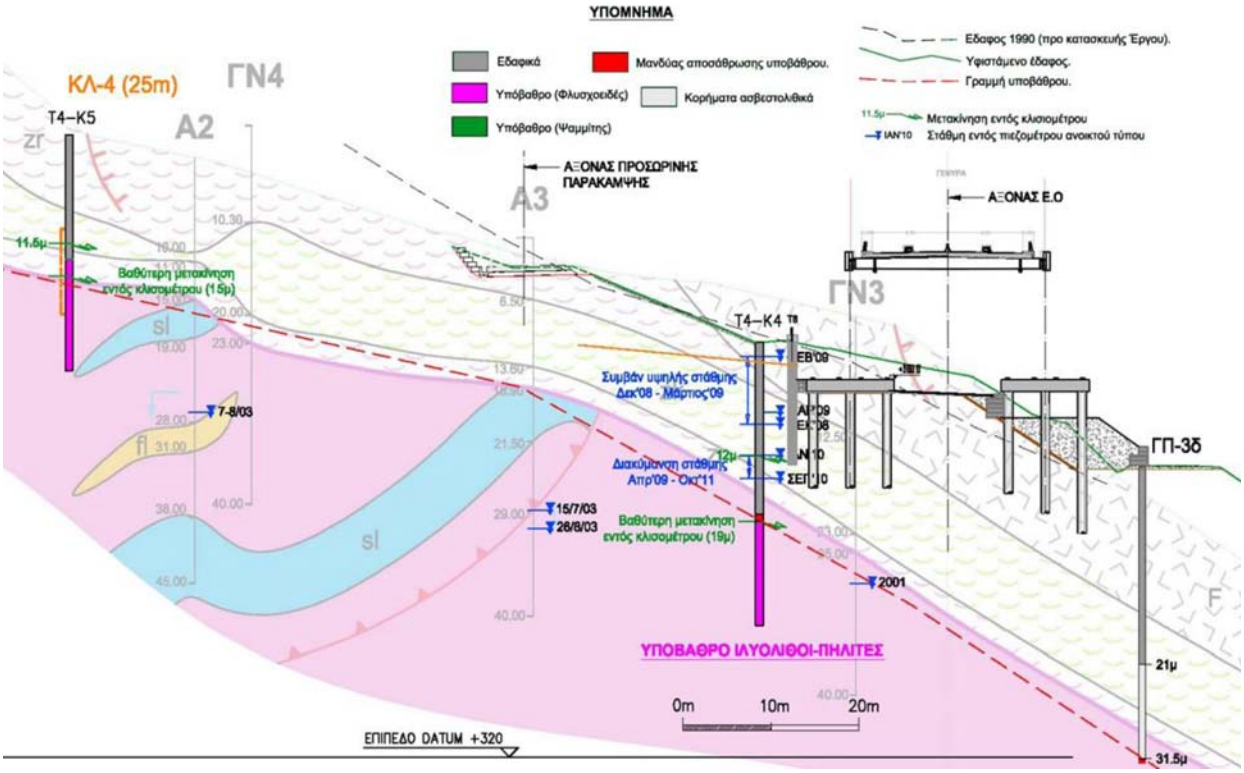
Εικόνα 1. Συνολική άποψη των έργων υποδομής κατά τη διάρκεια κατασκευής της γέφυρας (λήψη προς Καλαμάτα)

2. Θεμελίωση Πύργων

2.1. Γενικός σχεδιασμός

Για τη θεμελίωση των 14 πύργων ανέγερσης εξετάσθηκαν δύο βασικές λύσεις (α) λύση επιφανειακής θεμελίωσης και (β) λύση βαθιάς θεμελίωσης επί ομάδας πασσάλων. Η επιλογή της κατάλληλης λύσης καθορίσθηκε αρχικώς από τις γεωτεχνικές συνθήκες στη συγκεκριμένη περιοχή όπου επικρατούν ανομοιόμορφα υλικά (προϊόντα της κατολίσθησης, υλικά αποσάθρωσης του φλυσχοειδούς υποβάθρου, ασβεστολιθικά κορήματα, τεχνητές επιχώσεις), τα οποία κάθονται πάνω στο σταθερό βραχώδες υπόβαθρο. Στην Εικόνα 2 παρουσιάζονται χαρακτηριστικά δείγματα των υλικών αυτών από διάφορα βάθη όπου φαίνεται πως πρόκειται για τυχαίες αποθέσεις ασύνδετων υλικών. Η μορφολογία της ζώνης των κατασκευών αποτέλεσε βασικό επίσης παράγοντα για τον σχεδιασμό. Όπως φαίνεται ενδεικτικά στο Σχήμα 3, το ανάγλυφο στις θέσεις των πύργων Π1 – Π5 ήταν εξαιρετικά έντονο, με μεγάλες εγκάρσιες κλίσεις αμέσως κατάντη των θεμελίων. Η εξίσου έντονη μορφολογία του βραχώδους υποβάθρου πάνω στο οποίο κάθονται οι εδαφικές μάζες, σε συνδυασμό με την αποδεδειγμένη και συνεχώς μετρούμενη ολίσθηση προς τα κατάντη, δεν μπορούσε να αγνοηθεί. Η λύση της επιφανειακής θεμελίωσης αποκλείσθηκε άμεσα. Όπως φαίνεται στην Εικόνα 3, η γραμμή συναρμολόγησης του δεξιού κλάδου βρισκόταν κοντά στην άκρη του επισφαλούς πρανούς εντός της κατολισθαίνουσας μάζας και οι κίνδυνοι από τοπικές αστοχίες αλλά και έντονες υποχωρήσεις μέσα στο ανομοιόμορφο ασύνδετο γεωυλικό, ήταν μεγάλοι. Σημειώνεται ότι υπερβολικές υποχωρήσεις ή έστω και μικροαστοχίες στη θέση αυτή της μάζας ήταν πολύ πιθανές και βέβαια θα ήταν καταστροφικές κατά την ανέγερση και κυρίως κατά τη συναρμολόγηση και συγκόλληση των τμημάτων των τόξων. Επιπροσθέτως, όπως φαίνεται στην Εικόνα 3, για την δημιουργία δαπέδων επιφανειακής θεμελίωσης έπρεπε να τοποθετηθούν πρόσθετες εδαφικές μάζες πάνω στο σώμα της αστοχίας, ενέργεια που θα αύξανε τους κινδύνους τοπικών αστοχιών που θα μπορούσαν να αποβούν εξίσου καταστροφικές για το εγχείρημα της ανέγερσης.

Εικόνα 2. Δείγματα από γεώτρηση στην περιοχή της κατολίσθησης



Σχήμα 3. Εγκάρσια τομή στη θέση του πύργου Π3

Εικόνα 3. Θεμελίωση πύργων ανέγερσης και διάδρομοι / γέφυρες συναρμολόγησης τόξου δεξιού κλάδου

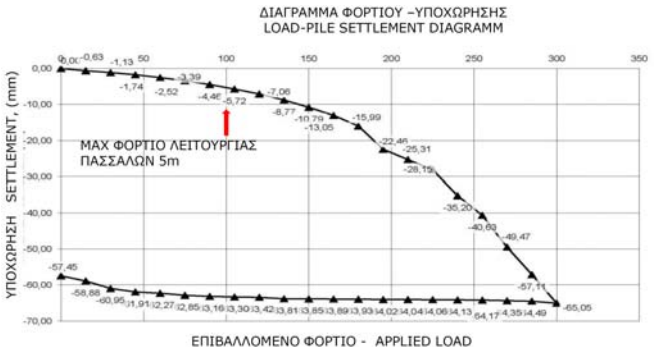
Επιλέχθηκε τελικά η λύση ανεξάρτητων ομάδων πασσάλων για κάθε ένα πύργο. Αρχικώς αντιμετωπίσθηκε η λύση υποχρεωτικής έδρασης όλων των πασσάλων στο βραχώδες υπόβαθρο, διαπερνώντας την επιφάνεια ολίσθησης. Η συγκεκριμένη επιλογή απορρίφθηκε για δύο λόγους. Αφενός, επειδή η έμπηξη στο βραχώδες υπόβαθρο δεν θα προσέφερε τίποτε στον έλεγχο των επιβεβλημένων μετακινήσεων παρά μόνο στην φέρουσα ικανότητα των πασσάλων σε κατακόρυφο φορτίο. Επισημαίνεται ότι η μέση σχετική μετακίνηση στην επιφάνεια ολίσθησης είναι της τάξης των 2,5mm/μήνα και κατά συνέπεια εφόσον οι πάσσαλοι διαπερνούσαν τη ζώνη ολίσθησης, θα αστοχούσαν διατμητικά σε λίγες εβδομάδες. Αφετέρου, το ανάγλυφο του υποβάθρου ήταν τόσο απότομο που στον δεξιό κλάδο οι πάσσαλοι θα είχαν πολύ μεγάλο μήκος ανεβάζοντας το κόστος ενός προσωρινού έργου σε ανεπίτρεπτα ύψη.

Λαμβάνοντας υπόψη τις εκτιμήσεις του φορτίου λειτουργίας κάθε πασσάλου (περίπου 2000kN,max), επιλέχθηκε τελικά η λύση της χρήσης πασσάλων τριβής κατασκευασμένων μέσα στην ολισθαίνουσα μάζα με εξαίρεση τις περιπτώσεις όπου το πάχος των εδαφικών υλικών ήταν πολύ μικρό (<5m), οπότε οι πάσσαλοι εισήλθαν μέσα στο βραχώδες υπόβαθρο ώστε να εξασφαλισθεί ικανοποιητική φέρουσα ικανότητα. Βάσει της επιλογής αυτής ο κύριος γεωτεχνικός σχεδιασμός στόχευσε στην εκτίμηση της φέρουσας ικανότητας και στην επίδραση της συνεχούς κίνησης της εδαφικής μάζας στην εντατική κατάσταση κάθε ομάδας πασσάλων.

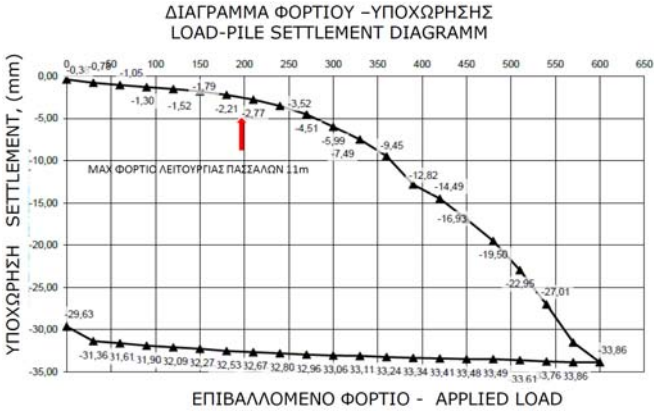
2.2. Δοκιμαστικές φορτίσεις – Φέρουσα ικανότητα πασσάλων

Προκειμένου να ξεπερασθεί η αβεβαιότητα σχετικά με τη συμπεριφορά πασσάλων μέσα στην ανομοιογενή εδαφική μάζα, πραγματοποιήθηκαν δύο δοκιμαστικές φορτίσεις μη λειτουργικών πασσάλων (Εικόνα 4). Η πρώτη δοκιμή εκτελέσθηκε σε πάσσαλο διαμέτρου 1m και μήκους 5m επί του αριστερού κλάδου. Η δεύτερη δοκιμή εκτελέσθηκε σε πάσσαλο διαμέτρου 1m και μήκους 12m σε θέση κατάντη του δεξιού κλάδου. Τα φορτία δοκιμής ήταν 3000KN και 6000KN, αντίστοιχα. Ταυτόχρονα, δίπλα στις δοκιμαστικές φορτίσεις εκτελέσθηκαν δειγματοληπτικές γεωτρήσεις για την εξακρίβωση του ακριβούς γεωτεχνικού προφίλ και την συναξιολόγηση με τις δοκιμές. Μορφώθηκαν τα διαγράμματα θλιπτικού φορτίου-υποχώρησης για πασσάλους μήκους 5m (Σχήμα 4) και 12m (Σχήμα 5) καθώς και εφελκυστικού φορτίου – ανύψωσης (ο οποίο προέκυψε από τους πασσάλους αντίδρασης, μήκους 16m). Στο Σχήμα 6 παρουσιάζεται το επιτρεπόμενο φορτίο υπολογισμένο με βάση τον EC-7, για διάφορα μήκη πασσάλων εφαρμόζοντας τη μεθοδολογία υπολογισμού του DIN4014, για χαλαρά μη συνεκτικά υλικά (q_s=12MPa). Στο ίδιο σχήμα εμφανίζονται τα μέγιστα αξονικά φορτία για τυπικά μήκη πασσάλων που χρησιμοποιήθηκαν, καθώς και το φορτίο της δοκιμαστικής φόρτισης το οποίο αντιστοιχεί στη θεωρητική υποχώρηση για το επιτρεπόμενο φορτίο, όπως αυτό εκτιμήθηκε κατά EC-7. Με βάση αυτήν την επεξεργασία επιλέχθηκαν κατ' αρχήν τα μήκη των πασσάλων σε κάθε βάθρο συναξιολογώντας τη θέση του υποβάθρου και τα φορτία από την ανωδομή, διατηρώντας ένα ικανοποιητικό περιθώριο ασφαλείας τόσο από την πραγματική συμπεριφορά των πασσάλων όσο και τα θεωρητικά όρια του EC-7. Στη συνέχεια τα μήκη βελτιστοποιήθηκαν με βάση τους ελέγχους λόγω των επιβεβλημένων μετακινήσεων από την ολισθαίνουσα μάζα, λαμβάνοντας ταυτόχρονα υπόψη διάφορες υποθέσεις εργασίας τοπικών αστοχιών κατάντη του δεξιού κλάδου.

Εικόνα 4. Δοκιμαστική φόρτιση πασσάλων



Σχήμα 4. Διάγραμμα φορτίου υποχώρησης για πάσσαλο μήκους 5m

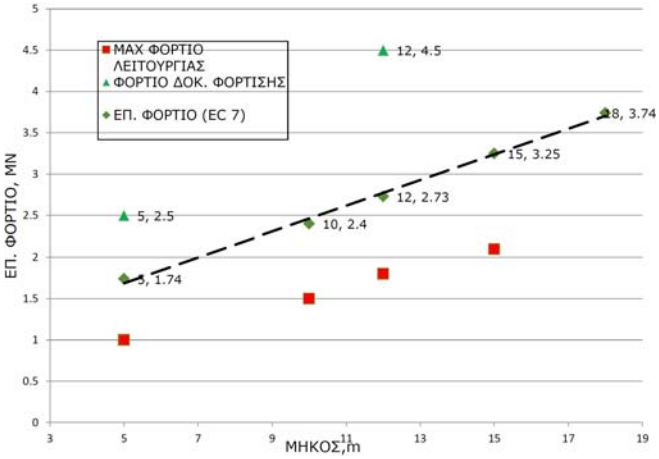


Σχήμα 5. Διάγραμμα φορτίου υποχώρησης για πάσσαλο μήκους 12m

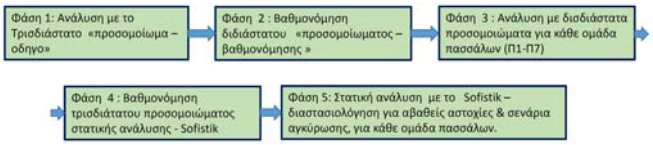
3. Γεωτεχνική και στατική προσομοίωση ομάδας πασσάλων μέσα στην ολισθαίνουσα μάζα

3.1. Φάσεις διερεύνησης

Το σύνολο των φάσεων της γεωτεχνικής και στατικής διερεύνησης των έργων αλλά και της τελικής διαστασιολόγησης παρουσιάζεται συνοπτικά στο Σχήμα 7.



Σχήμα 6. Μέγιστο επιτρεπόμενο φορτίο για διάφορα μήκη πασσάλων



Σχήμα 7. Φάσεις διερεύνησης

Πιο αναλυτικά η μεθοδολογία που ακολουθήθηκε παρουσιάζεται παρακάτω.

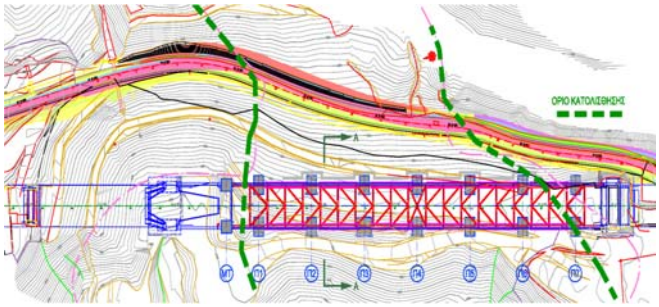
3.2. Περιγραφή μεθοδολογίας γεωτεχνικής προσομοίωσης

Προκειμένου να εκτιμηθεί η επιρροή των κινήσεων της κατολίσθησης επιλέχθηκε να διερευνηθεί η κεντρική περιοχή αυτής, μεταξύ των πύργων Π2 και Π3, η οποία θεωρήθηκε και η δυσμενέστερη από πλευράς έντασης της κινηματικής δραστηριότητας. Το υπό μελέτη πρόβλημα είχε έντονα τριδιάστατο χαρακτήρα εξαιτίας της απόστασης μεταξύ των πύργων και κατ' επέκταση των βάθρων θεμελίωσης κατά μήκος της γέφυρας. Η κύρια συνιστώσα της εδαφικής μετακίνησης ήταν περίπου εγκάρσια ως προς το διαμήκη άξονα της γέφυρας. Για την περιοχή αυτή πραγματοποιήθηκαν λεπτομερέστατες τρισδιάστατες αναλύσεις, σε μια αντιπροσωπευτική διατομή, με τελικό στόχο να υπολογισθούν τα εξής:

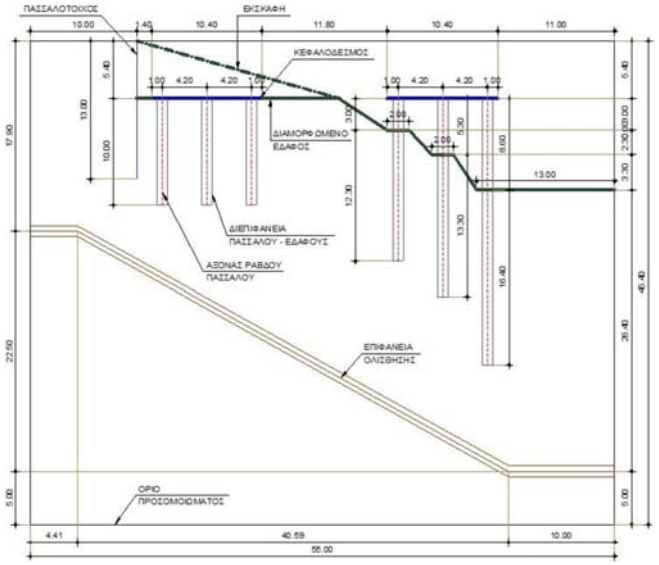
α. Η κινηματική συμπεριφορά της πασσαλομάδας υπό την δράση των εδαφικών μετακινήσεων.
β. Η καταπόνηση επί των δομικών στοιχείων (πάσσαλοι, κεφαλόδεσμοι), εξαιτίας αποκλειστικά των γεωτεχνικών δράσεων.

Το προσομοίωμα που δημιουργήθηκε στα πλαίσια των αναλύσεων αυτών αποτέλεσε το «προσομοίωμα – οδηγό». Από την εφαρμογή τριδιάστατων γεωτεχνικών αναλύσεων (με τα λογισμικό ABAQUS), προέκυψε η εκτίμηση των αναπτυσσόμενων μετατοπίσεων για το «προσομοίωμα – οδηγό», καθώς και των εντατικών μεγεθών των δομικών στοιχείων. Ουσιαστικά το «προσομοίωμα – οδηγός» παρείχε μία ποιοτική εκτίμηση της συμπεριφοράς αυτού του ιδιόμορφου έργου θεμελίωσης για το οποίο δεν ήταν δυνατόν να υιοθετηθούν παραδοχές και μεθοδολογία από τη βιβλιογραφία. Η διατομή που χρησιμοποιήθηκε για το προσομοίωμα φαίνεται στο Σχήμα 8.

Προκειμένου το προηγούμενο βήμα του σύνθετου και χρονοβόρου προσομοιώματος να χρησιμοποιηθεί παραγωγικά, πραγματοποιήθηκαν διδιάστατες γεωτεχνικές αναλύσεις (PLAXIS), στις οποίες προσομοιώνεται με ακρίβεια, η επιφάνεια του εδάφους με βάση τα τοπογραφικά δεδομένα και οι επαφές των γεωλογικών σχηματισμών με βάση τις γεωτεχνικές τομές σε κάθε θέση πύργου. Αυτό έγινε εφικτό μετά από προσεκτική βαθμονόμηση των δύο προσομοιωμάτων, συγκρίνοντας τα αποτελέσματα των διδιάστατων αναλύσεων με αυτά των τριδιάστατων αναλύσεων για το «προσομοίωμα – οδηγό». Βασικός στόχος της βαθμονόμησης ήταν η εκτίμηση της ισοδύναμης δυσκαμψίας των δομικών στοιχείων του διδιάστατου προσομοιώματος. Το βήμα αυτό προσέφερε υποστήριξη για την διαστασιολόγηση της θεμελίωσης, παρέχοντας σε κάθε θέση, (α) την εκτίμηση της αύξησης των εντατικών μεγεθών λόγω της συνεχούς μετακίνησης των μαζών , (β) την εκτίμηση των ωθήσεων επί της ομάδας (γ) την εκτίμηση των χαρακτηριστικών ελαστικής στήριξης (ελατήρια) στη βάση κάθε πασσάλου λαμβάνοντας υπόψη τη θέση του βραχώδους υποβάθρου σε κάθε πύργο. Τα προηγούμενα βήματα χρησιμοποιήθηκαν τελικά στη στατική μελέτη – διαστασιολόγηση των δομικών στοιχείων χρησιμοποιώντας το λογισμικό SOFiSTiK, το οποίο με την σειρά του, πριν μπει στη γραμμή παραγωγής, βαθμονομήθηκε με βάση το ABAQUS για το «προσομοίωμα – οδηγό».



(α)



(β)

Σχήμα 8. Γεωμετρία «προσομοιώματος – οδηγού» (α) Κάτοψη, (β) Εγκάρσια τομή Α-Α

3.3. Τριδιάστατες αναλύσεις με το λογισμικό ABAQUS

Τα εδαφικά υλικά προσομοιώνονται με τριδιάστατα εξαπλευρικά οκτακομβικά πεπερασμένα στοιχεία ελαστοπλαστικής συμπεριφοράς με βάση το κριτήριο αστοχίας Mohr-Coulomb, οι πάσσαλοι με τριδιάστατα γραμμικά στοιχεία δοκού ελαστικής συμπεριφοράς, ενώ η οπή που σχηματίζεται στο έδαφος λόγω της διατομής των πασσάλων πληρώνεται με εξαπλευρικά οκτακομβικά πεπερασμένα στοιχεία, στα οποία αντιστοιχείται μηδενικό μέτρο ελαστικότητας. Ο κεφαλόδεσμος και ο ανάντη τοίχος αντιστήριξης προσομοιώνεται με τετραπλευρικά τετρακομβικά στοιχεία κελύφους ελαστικής συμπεριφοράς.

Εξαιτίας του εξαιρετικά μεγάλου προσομοιώματος και του απαιτούμενου χρόνου υπολογισμού και δεδομένου ότι το επίπεδο που είναι εγκάρσιο στη διεύθυνση της γέφυρας αποτελεί επίπεδο συμμετρίας για τα γεωμετρικά και γεωτεχνικά στοιχεία του προσομοιώματος, επιλέχθηκε να κατασκευαστεί το μισό μόνο προσομοίωμα. Η επιλογή των διαστάσεων του

προσομοιώματος, των συνοριακών συνθηκών και της διαδικασίας υπολογισμών βασίστηκε στη μεθοδολογία που προτείνεται από τους Kourkoulis et al. 2011 and 2012. Τα στάδια των αριθμητικών αναλύσεων ήταν τα ακόλουθα:

Στάδιο 1: Γεωστατική κατάσταση με οριζόντια επιφάνεια εδάφους.

Στάδιο 2: Αφαίρεση γεωυλικού για τη διαμόρφωση της υφιστάμενης τοπογραφίας.

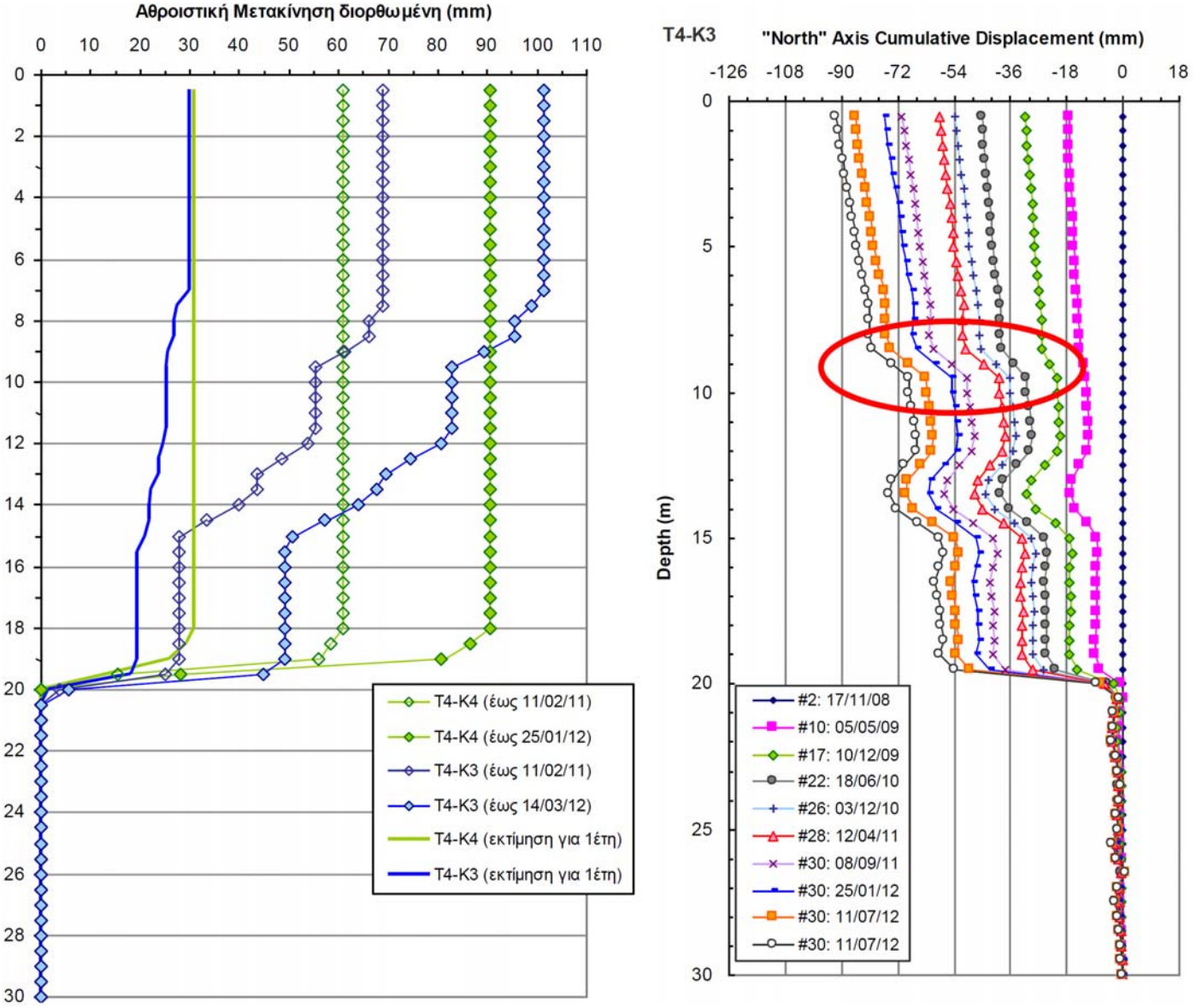
Στάδιο 3: Προσομοίωση της εκσκαφής στο επίπεδο της κεφαλής των πασσάλων και ενεργοποίηση των πεπερασμένων στοιχείων κελύφους του ανάντη τοίχου αντιστήριξης.

Στάδιο 4: Αφαίρεση των πεπερασμένων στοιχείων εδάφους εντός της οπής των πασσάλων και ενεργοποίηση των πεπερασμένων στοιχείων μηδενικής δυσκαμψίας και των στοιχείων δοκού.

Στάδιο 5: Ενεργοποίηση των κεφαλόδεσμων

Στάδιο 6: Επιβολή των φορτίσεων από τους πύργους

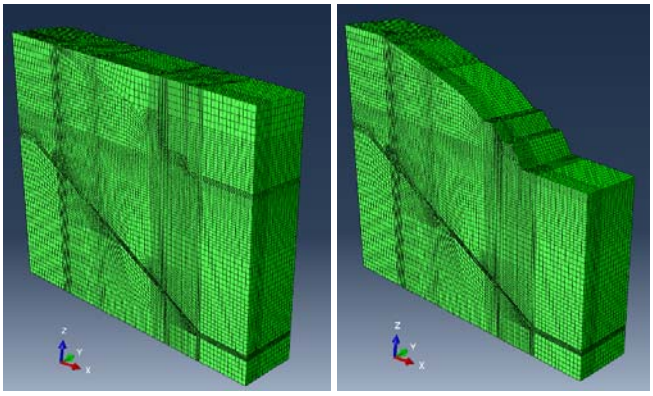
Στάδιο 7: Επιβολή οριζόντιας μετακίνησης 6cm στις τρεις από τις τέσσερις παρειές του προσομοιώματος (εκτός από την παρειά επί του επιπέδου συμμετρίας). Οι επιβαλλόμενες οριζόντιες μετακινήσεις βασίζονται στις πραγματικές καταγραφές των κλισιομέτρων T4-K3 και T4-K4 (Σχήμα 9) (Κ. Σεφέρογλου και Φ. Χρυσοχοΐδης, 2016). Εφαρμόσθηκε μετακίνηση σχεδιασμού 6cm λαμβάνοντας υπόψη διάρκεια κατασκευής του τόξου 2 έτη (μετακίνηση 3cm/έτος).



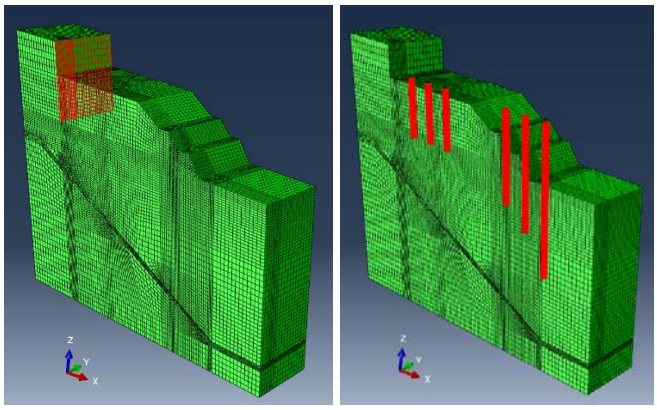
Σχήμα 9. Μορφή επιβεβλημένων μετακινήσεων με βάση τις πραγματικές μετρήσεις στη θέση του έργου

Εικόνες από το προσομοίωμα για τα διάφορα στάδια αναλύσεων δίνονται στο Σχήμα 10, ενώ στο Σχήμα 11 δίνεται η κατανομή των επιβαλλόμενων οριζόντιων μετατοπίσεων εγκάρσια στη διεύθυνση της γέφυρας λόγω των μετακινήσεων της εδαφικής μάζας που αντιστοιχούν στο Στάδιο 7 των αναλύσεων. Στην κατάντη πασσαλομάδα παρατηρούνται τα δυσμενέστερα εντατικά μεγέθη, λόγω της μορφολογίας του εδάφους που οδηγεί σε μεγαλύτερο ελεύθερο ύψος πασσάλων. Τα αποτελέσματα αυτά χρησιμοποιήθηκαν για σύγκριση με τις άλλες δύο προσεγγίσεις (PLAXIS και SOFISTIK) και τη βαθμονόμηση των παραδοχών τους. Ενδεικτικά στο Σχήμα 12 δίνονται τα διαγράμματα των αξονικών δυνάμεων στους πασσάλους του δεξιού κλάδου για το Στάδια 6 και 7. Αντίστοιχα διαγράμματα καμπτικών ροπών απεικονίζονται στο Σχήμα 13, ενώ η αύξηση των μετακινήσεων στους κατάντη πασσάλους από το Στάδιο 6 στο 7 δίνεται στο Σχήμα 14. Από τις αναλύσεις παρατηρήθηκε μία ομοιόμορφη μετακίνηση της εδαφικής μάζας πάνω από την επιφάνεια ολίσθησης λόγω

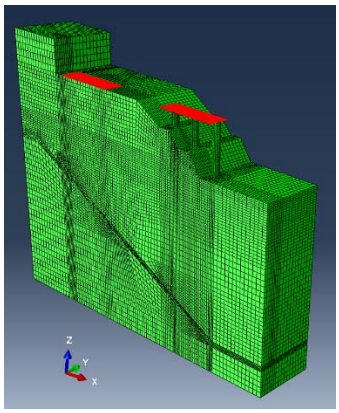
της εξέλιξης των εδαφικών μετακινήσεων, δίχως σαφή διαφοροποίηση των αποτελεσμάτων γύρω από την ομάδα πασσάλων. Αυτό οδήγησε στο συμπέρασμα πως η κίνηση της θεμελίωσης ήταν κυρίως μεταφορική, δίχως διαφορικές συνιστώσες, με αποτέλεσμα η πρόσθετη ένταση λόγω αυτών των μετακινήσεων να ήταν μικρή. Επομένως, βάσει του προτεινόμενου σχεδιασμού, δεν υπάρχει σημαντική επιβάρυνση των εντατικών μεγεθών εξαιτίας των συνεχιζόμενων μετακινήσεων της εδαφικής μάζας. Η εκτίμηση αυτή οδήγησε στην αντίληψη ότι ακόμη και η ταυτόχρονη επίδραση της διαμήκους συνιστώσας της μετακίνησης (προφανώς η κατολίσθηση είχε και διαμήκη συνιστώσα ως προς τη γέφυρα), δεν θα είχε σημαντική επίδραση στα εντατικά μεγέθη της θεμελίωσης των πύργων, τουλάχιστον για ένα προσωρινό έργο.



Στάδιο 1 Στάδιο 2

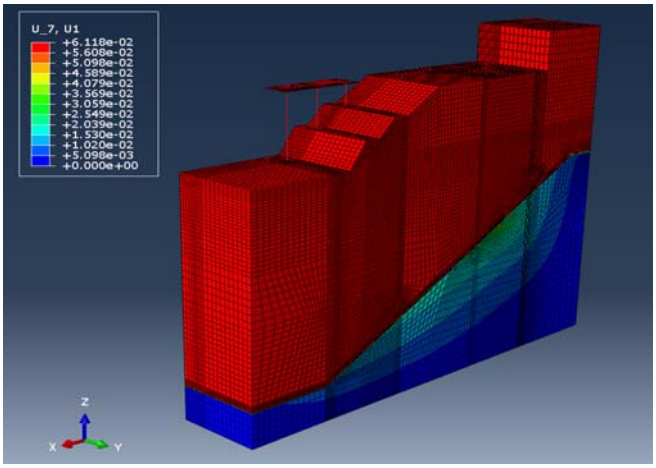


Στάδιο 3 Στάδιο 4

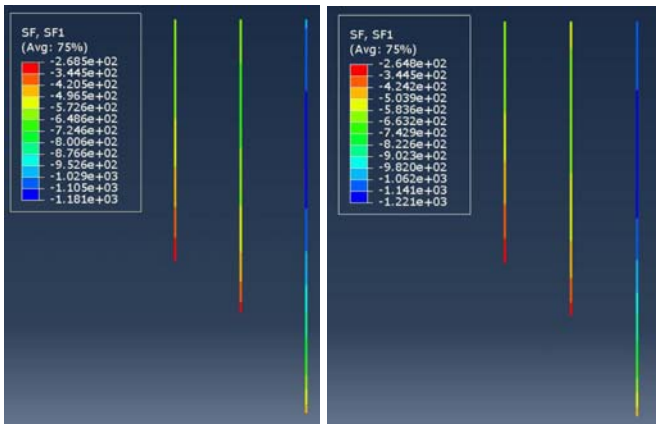


Στάδιο 5

Σχήμα 10. Αριθμητικό προσομοίωμα – οδηγός στο λογισμικό ABAQUS, Στάδια 1-5.

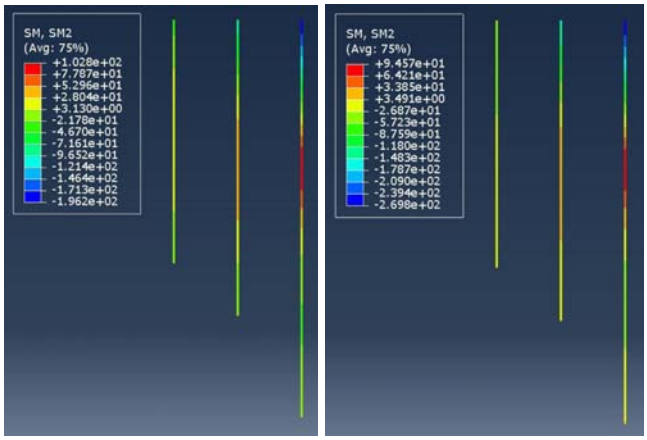


Σχήμα 11. Κατανομή οριζόντιων μετατοπίσεων εγκάρσια στη διεύθυνση της γέφυρας λόγω των μετακινήσεων της εδαφικής μάζας (Στάδιο 7)



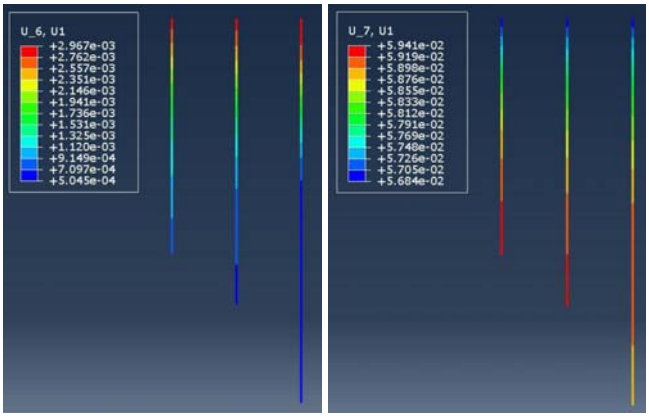
(α) (β)

Σχήμα 12. Κατανομή αξονικών δυνάμεων στους πασσάλους του δεξιού κλάδου (α) Στάδιο 6, (β) Στάδιο 7



(α) (β)

Σχήμα 13. Κατανομή καμπτικών ροπών περί τον διαμήκη άξονα της γέφυρας στους πασσάλους του δεξιού κλάδου (α) Στάδιο 6, (β) Στάδιο 7



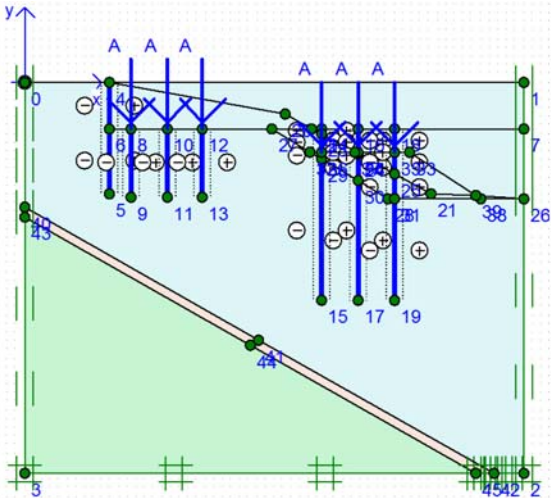
(α) (β)

Σχήμα 14. Κατανομή οριζόντιων εγκάρσιων μετατοπίσεων στους πασσάλους του δεξιού κλάδου (α) Στάδιο 6, (β) Στάδιο 7

3.4. Διδιάστατες αναλύσεις με το λογισμικό PLAXIS

Η ιδιαίτερη γεωμετρία του βραχώδους υποβάθρου με τις έντονες κλίσεις, αλλά και οι διαφορές της επιφανειακής μορφολογίας από θέση σε θέση βάθρου, κατέστησαν αναγκαία τη μελέτη της θεμελίωσης σε κάθε θέση χωριστά. Το τριδιάστατο γεωτεχνικό προσομοίωμα, το οποίο χρησιμοποιήθηκε για την εξαγωγή γενικών συμπερασμάτων και τη χάραξη των βασικών κατευθύνσεων στην επιλογή της θεμελίωσης, ήταν πολύ χρονοβόρο ως προς τη διαμόρφωση προσομοιωμάτων, την εκτέλεση αναλύσεων και την εξαγωγή αποτελεσμάτων. Συνεπώς κρίθηκε μη αποδοτικός ο έλεγχος κάθε περιοχής με χρήση τριδιάστατων γεωτεχνικών προσομοιωμάτων. Γι' αυτό το λόγο χρησιμοποιήθηκε το πρόγραμμα PLAXIS, εκτελώντας διδιάστατες αναλύσεις για όλες τις διατομές του έργου. Η μεθοδολογία μετάβασης από το λεπτομερές τρισδιάστατο προσομοίωμα, στο απλοποιητικό διδιάστατο για κάθε θέση περιλάμβανε μία ενδιάμεση φάση βαθμονόμησης με τη χρήση ενός «προσομοιώματος – βαθμονόμησης» που αντιστοιχούσε στο «προσομοίωμα – οδηγό».

Στην ενδιάμεση αυτή φάση ελέγχθηκε η ακρίβεια των παραδοχών της ανάλυσης, συγκρίνοντας τα αποτελέσματα του PLAXIS για το «προσομοίωμα – βαθμονόμησης» με τα αντίστοιχα του ABAQUS (εντατικά μεγέθη και μετατοπίσεις) για το «προσομοίωμα – οδηγό». Προκειμένου να ξεπερασθεί το πρόβλημα της θεώρησης των πασσάλων στο αριθμητικό προσομοίωμα ως απειρομήκες διάφραγμα κατανεμημένης δυσκαμψίας έγινε βαθμονόμηση με βάση τα αποτελέσματα του τρισδιάστατου προσομοιώματος. Στο Σχήμα 15 παρουσιάζεται το προσομοίωμα που χρησιμοποιήθηκε για την βαθμονόμηση των αναλύσεων.



Σχήμα 15. «Προσομοίωμα – βαθμονόμησης» για το λογισμικό PLAXIS

Η γεωμετρία σχεδιάστηκε ακριβώς όμοια με την γεωμετρία του τριδιάστατου «προσομοιώματος – οδηγού», ενώ οι πάσσαλοι σχεδιάστηκαν ως στοιχεία με ισοδύναμη δυσκαμψία και δυστένεια με τους 2 πασσάλους κάθε σειράς. Ως προς τις φάσεις εκσκαφής, τις γεωτεχνικές παραμέτρους αλλά και τη γεωμετρία των εκσκαφών το προσομοίωμα βασίστηκε στις παραδοχές που έγιναν στο τριδιάστατο μοντέλο. Ταυτόχρονα, στη θεμελίωση ασκήθηκε φόρτιση ισοδύναμη με αυτή που λαμβάνεται στο ABAQUS, ενώ στα σύνορα του μοντέλου αλλά και στην επιφάνεια ολίσθησης θεωρήθηκε επιβαλλόμενη οριζόντια μετατόπιση ίση με 6cm. Τα στάδια αναλύσεων που ελήφθησαν υπόψη είναι τα παρακάτω:

Στάδιο 1: Γεωστατικές συνθήκες

Στάδιο 2: Εκσκαφή και κατασκευή ανάντη πασσαλοτοίχων

Στάδιο 3: Κατασκευή συστήματος θεμελίωσης (κεφαλόδεσμος και πάσσαλοι θεμελίωσης)

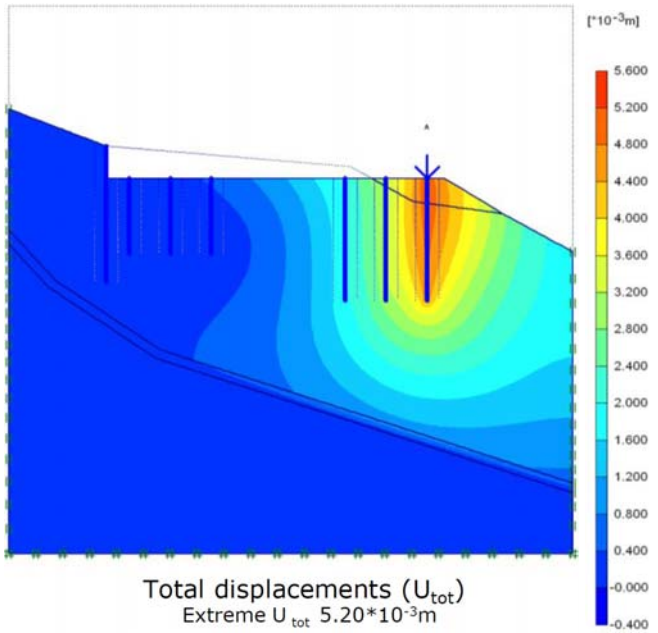
Στάδιο 4: Εφαρμογή εξωτερικών φορτίων στους κεφαλοδέσμους

Στάδιο 5: Εφαρμογή επιβαλλόμενης μετακίνησης 6cm (προσομοίωση μετακίνησης λόγω κατολίσθησης)

Με βάση τα αποτελέσματα των αναλύσεων επαληθεύτηκε πως η μέθοδος διδιάστατης ανάλυσης, με τις παραδοχές που έγιναν, συνέκλινε ικανοποιητικά με τα αντίστοιχα αποτελέσματα της τριδιάστατης ανάλυσης. Συγκεκριμένα, και στις δυο προσεγγίσεις οι αναπτυσσόμενες παραμορφώσεις, τόσο μετά την επιβολή των εξωτερικών φορτίων, όσο και στο στάδιο επιβολής της επιβαλλόμενης μετακίνησης, ήταν παρόμοιες. Ταυτόχρονα, τα εντατικά μεγέθη που αναπτύσσονταν ήταν αντίστοιχα ως κατανομή και τιμές με τα αποτελέσματα που είχαν εξαχθεί από την τριδιάστατη ανάλυση με το πρόγραμμα ABAQUS.

Η διαστασιολόγηση των πασσάλων της θεμελίωσης των πύργων έγινε με το λογισμικό SOFiSTiK. Ωστόσο, με το συγκεκριμένο λογισμικό δεν υπήρχε η δυνατότητα άμεσης προσομοίωσης της γεωμετρίας της επιφάνειας και του κεκλιμένου βραχώδους υποβάθρου. Αντίθετα μπορούσε να ληφθεί υπόψη έμμεσα μέσω της χρήσης διαφορετικών ελαστικών σταθερών στήριξης στους πασσάλους σε κάθε θέση. Ο υπολογισμός των ελαστικών αυτών σταθερών στήριξης έγινε επίσης με χρήση του διδιάστατου προσομοιώματος. Μετά τη βαθμονόμηση, πραγματοποιήθηκαν αναλύσεις σε κάθε θέση ώστε να υποστηριχθεί το επόμενο και τελικό στάδιο της στατικής μελέτης της ομάδας πασσάλων. Έτσι, σε κάθε θέση βάθρου προσομοιώθηκε η επιφάνεια του εδάφους και η γεωμετρία του υποβάθρου, οι εκσκαφές και η κατασκευή των πασσάλων. Στη συνέχεια επιβλήθηκε σε κάθε πάσσαλο ισοδύναμο φορτίο P=1000kN και υπολογίστηκε η κατακόρυφη μετακίνηση του πασσάλου v_z, απ' όπου προκύπτει η κατακόρυφη ελαστική σταθερά του πασσάλου ως $K=P/v_z$ με την οποία πραγματοποιήθηκαν οι υπολογισμοί στο πρόγραμμα SOFiSTiK. Ενδεικτικά στο Σχήμα 16 δίνεται διάγραμμα κατακόρυφης μετακίνησης για τον κατάντη πάσσαλο του πύργου Π5.

Παράλληλα, για να προσδιοριστεί το μέγεθος των ωθήσεων γαιών που αναπτύσσονταν επί της πασσαλομάδας του δεξιού κλάδου (λόγω της μορφολογίας του πρανούς), χρησιμοποιήθηκαν τα αποτελέσματα των ελαστοπλαστικών αναλύσεων. Για κάθε μία από τις θέσεις Π2, Π3 και Π4 υπολογίζονται για τους ανάντη πασσάλους οι οριζόντιες και κατακόρυφες τάσεις και στη συνέχεια υπολογίζεται μια μέση τιμή ενός ισοδύναμου συντελεστή ωθήσεων. Η μέση τιμή κυμαινόταν μεταξύ 0.33 και 0.47, επομένως στις στατικές αναλύσεις που πραγματοποιούνται στη συνέχεια λαμβάνεται υπόψη συντελεστής ωθήσεων ίσος με 0.50 υπέρ της ασφαλείας. Παρόμοια διερεύνηση πραγματοποιήθηκε και στη φάση εφαρμογής της επιβαλλόμενης μετακίνησης λόγω της ολίσθησης, η οποία έδωσε μικρές αποκλίσεις στα αποτελέσματα.



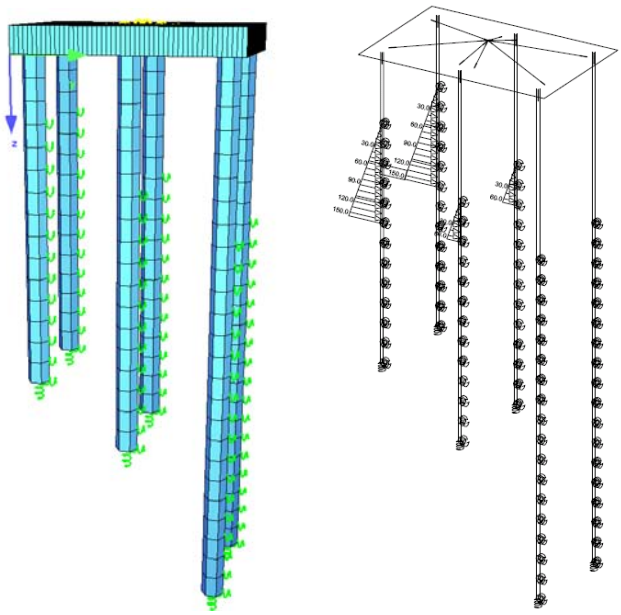
Σχήμα 16. Κατακόρυφη μετακίνηση του κατάντη πασσάλου του δεξιού κλάδου στο προσομοίωμα της θέσης Π5

3.5. Διαστασιολόγηση θεμελίωσης πύργων με το λογισμικό SOFiSTiK

Με δεδομένο ότι στη φάση αυτή το έδαφος προσομοιώνεται με ελατήρια και προκειμένου να υπάρχει συμβατότητα ως προς τη λεπτομερή γεωτεχνική ανάλυση που προηγήθηκε, δημιουργήθηκε και πάλι ένα «στατικό προσομοίωμα – βαθμονόμησης» που χρησιμοποιήθηκε για τη βαθμονόμηση των παραδοχών της στατικής επίλυσης των θεμελιώσεων των πύργων (Σχήμα 17). Η αλληλεπίδραση εδάφους-κατασκευής ελήφθη υπόψη μέσω των ωθήσεων γαιών και των οριζοντίων ελατηρίων. Για την βαθμονόμηση λαμβάνεται υπόψη το ίδιο βάρος, τα φορτία των πύργων και οι ωθήσεις γαιών με K_o=0.50. Συγκρίνοντας αυτά τα εντατικά μεγέθη με τα αντίστοιχα που προέκυψαν με το πρόγραμμα ABAQUS για την ίδια εξωτερική φόρτιση, δεν προκύπτουν σημαντικές διαφορές. Επομένως η προσέγγιση με το SOFISTIK ήταν ικανοποιητική και χρησιμοποιήθηκε για τις περαιτέρω αναλύσεις, όλων των διατομών, για το σύνολο των εξωτερικών φορτίσεων και του σεισμού, λαμβάνοντας υπόψη μειωμένη σεισμική επιτάχυνση, λόγω του προσωρινού χαρακτήρα του έργου (0.08g). Στους πύργους Π2Δ έως Π5Δ επιβλήθηκε ως προσθετη καταπόνηση, η μετακίνηση των 15mm στο ανώτερο τμήμα του πασσάλου για την προσομοίωση πιθανής αβαθούς αστοχίας (βλ. §0). Τα μέγιστα εντατικά μεγέθη που αναπτύσσονται στην κορυφή των πασσάλων των θεμελιώσεων των πύργων Π2Δ έως Π5Δ, όπου και απαιτούνται οι μεγαλύτεροι διαμήκεις οπλισμοί, συγκρίνονται με τα αντίστοιχα εντατικά μεγέθη που υπολογίστηκαν με το PLAXIS λαμβάνοντας υπόψη και την επιβαλλόμενη μετακίνηση στο ανώτερο τμήμα της εδαφικής μάζας ίση με 6cm και με φορά προς τα κατάντη. Από τη σύγκριση προέκυψε το συμπέρασμα ότι η μετατόπιση της εδαφικής μάζας δεν προκαλεί μεταβολές μεγαλύτερες από 2.5% στις αξονικές δυνάμεις, οι οποίες μπορούν να αγνοηθούν, και 6% στις καμπτικές ροπές. Επομένως, στους πασσάλους των πύργων αυτών θεωρήθηκε μία προσαύξηση του απαιτούμενου διαμήκους οπλισμού κατά 10%.

3.6. Επίδραση αβαθών τοπικών ολισθήσεων

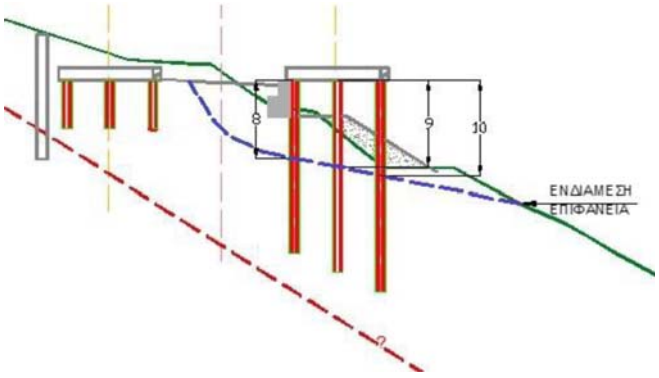
Ο κίνδυνος από την πιθανότητα εκδήλωσης αβαθών τοπικών μετακινήσεων εξαιτίας εσωτερικών επιφανειών ολίσθησης, δεν ήταν αμελητέος. Όπως φαίνεται στο διάγραμμα του κλισιομέτρου Τ4-Κ3 (Σχήμα 9) υπάρχουν τέτοιες ενδείξεις για βάθη γύρω στα 10m, γεγονός που οδήγησε στην υιοθέτηση μιας ακόμη υπόθεσης εργασίας για έλεγχο. Η προσομοίωση για τον έλεγχο αυτής της υπόθεσης έγινε για κάθε βάθρο



(α) (β)

Σχήμα 17. (α) Προσομοίωμα για τη βαθμονόμηση παραδοχών με το SOFISTIK (β) Φόρτιση ωθήσεων γαιών

του δεξιού κλάδου που βρίσκεται κοντά στο φρύδι του πρανούς, με την επιβολή ομοιόμορφου διαγράμματος μετακίνησης ίσου με 15mm σε όλους τους πασσάλους των πύργων, το οποίο εφαρμόζεται καθ' ύψος της ζώνης της αβαθούς ολίσθησης. Με βάση αυτές τις υποθέσεις και τις μετρήσεις κυρίως στην περιοχή του Π4, υιοθετήθηκαν επιφάνειες ολίσθησης για τις θέσεις Π2Δ – Π5Δ. Ενδεικτικά στο Σχήμα 18 δίνεται μία τέτοια θεώρηση.



Σχήμα 18. Χαρακτηριστική μορφή θέσης αβαθούς επιφάνειας αστοχίας στον πύργο Π2

3.7. Πρόβλεψη εγκάρσιας αγκύρωσης βάθρων

Για να αντιμετωπισθεί μια ακραία δυσμενέστερη δράση από εξαιρετικές μετακινήσεις προβλέφθηκε η δυνατότητα αγκύρωσης των κεφαλοδέσμων του δεξιού κλάδου, είτε στον αντίστοιχο του αριστερού, είτε με αγκύρια στο βραχώδες υπόβαθρο του αριστερού κλάδου. Η τοποθέτηση των αγκυρίων θα γινόταν εφόσον οι οριζόντιες εγκάρσιες μετακινήσεις των κεφαλοδέσμων υπερέβαιναν τις προβλέψεις και τις ανοχές της ανωδομής στη φάση ανέγερσης των τόξων. Ενδεικτικά, στον πύργο Π2Δ, οι θέσεις των αγκυρώσεων φαίνονται στην Εικόνα 5. Ωστόσο, η τελική εξέλιξη των μετακινήσεων στο χρονικό διάστημα ανέγερσης του τόξου ήταν μέσα στα όρια των μετακινήσεων σχεδιασμού και δεν χρειάσθηκε ενεργοποίηση τέτοιου σεναρίου ανάγκης, το οποίο βέβαια (σύμφωνα με την εξαντλητική αξιολόγηση της συμπεριφοράς της κατολίσθησης) εκτιμήθηκε ότι θα χρειαζόταν μόνο εφόσον η αφαψίδωση του τόξου και η ανεξαρτητοποίηση από την στηριξη των πύργων, καθυστερούσαν πολύ.

Εικόνα 5. Θέσεις προβλεπόμενης εγκάρσιας αγκύρωσης κεφαλοδέσμου Π2Δ

4. Σύνοψη

Στο άρθρο αυτό περιγράφηκε η μεθοδολογία που ακολουθήθηκε για τη γεωτεχνική και στατική μελέτη των θεμελιώσεων των πύργων που χρησιμοποιήθηκαν για την ανέγερση των τόξων και του καταστρώματος της γέφυρας στην Τσακώνα, οι οποίοι θεμελιώθηκαν στην ενεργό κατολίσθηση της περιοχής. Η ιδιομορφία των έργων ήταν ο καθοριστικός παράγοντας που οδήγησε σε χρήση πολλαπλών φάσεων ανάλυσης για την προσέγγιση της συμπεριφοράς των προσωρινών βαθιών θεμελιώσεων και γεφυρών. Όμως αυτή η υπερπροσπάθεια απέδειξε άλλη μια φορά ότι η συνεργασία γεωτεχνικών και δομοστατικών μηχανικών είναι κάτι παραπάνω από απλή εκτίμηση «σταθερών ελατηρίων», και φέρουσας ικανότητας μεμονωμένου πασσάλου. Υπάρχει αναγκαιότητα πραγματικής ομάδας, καθημερινής τριβής και ανάδρασης ώστε να σχεδιάζεται το έργο αποτελεσματικά.

5. Ευχαριστίες

Ο σχεδιασμός του έργου στη φάση κατασκευής της γέφυρας και η ανταπόκριση στην πρόκληση της θεμελίωσης σημαντικών έργων αλλά και της προσωρινής έδρασης της Εθνικής Οδού, στο σώμα μιας ευρύτατης ενεργού κατολίσθησης, ήταν έργο ομαδικής εργασίας των στελεχών της εταιρείας «ΟΔΟΤΕΧΝΙΚΗ Ε.Π.Ε.». Συγκεκριμένα εργάσθηκαν, οι Κ. Σεφέρογλου, Πολ. Μηχ, Γ. Προυντζόπουλος, Δρ. Πολ. Μηχ., Π. Φορτσάκης, Δρ. Πολ. Μηχ., Κ. Νίκας, Πολ. Μηχ., Ι. Βασιλοπούλου, Δρ. Πολ. Μηχ., Φ. Χρυσοχοΐδης, Τεχν. Γεωλόγος, Γ. Σκάρπα, Τεχν. Μηχ. και Κ. Σταμούλη, Σχεδιάστρια. Δεν μπορεί να μην αναφερθεί η έμπειρη άποψη του Ξεν. Μποτόπουλου Πολ. Μηχ., ο οποίος πάντοτε στήριζε με απλές αλλά πρακτικές απόψεις την δουλειά των νεοτέρων. Τέλος αξίζει να αναφερθεί η συμβουλευτική υποστήριξη του Καθ. Ι. Αναστασόπουλου, Δρ. Πολ. Μηχ. Και του Κων. Τζιβάκου, Πολ. Μηχ. πάνω στη βελτιστοποίηση και εφαρμογή του κώδικα ABAQUS.

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Surveying a Tunnel Using an ROV

Bob Clarke and Rick Fletcher

A short section of the headrace tunnel at the La Higuera Power Station in Chile collapsed in August 2010, forcing a 20 month repair outage. As part of those repairs, the owners installed sensors that provide real-time monitoring of geotechnical parameters within the tunnel. For a more comprehensive overview, power production is halted to deploy a remotely operated vehicle (ROV) to scan the entire tunnel.

With a combination of new technologies and the innovative application of existing ones, the owner is able to monitor the tunnel without dewatering, minimizing lost energy production and preventing the development of stresses that are induced on tunnel linings when they are dewatered. This article describes the ROV systems used to inspect the tunnel and provides examples of the products the owner uses to manage this valuable generating asset.

Introduction

La Higuera is a 155 MW run-of-river project in the Andes Mountains on the Tinguiririca River in Chile. The project is managed by Tinguiririca Energia, which is co-owned by Pacific Hydro and SN Power. Construction of the project was completed in 2009.

Water comes from two intakes on the Tinguiririca and Azufre rivers, as well as from the 155 MW La Confluencia hydroelectric project, also owned by Tinguiririca Energia and located immediately upstream. Both rivers are glacier fed and contain high levels of suspended sediment. The water flows into a small reregulation pond, then into an 18 km-long headrace tunnel, and finally through a surface penstock to a powerhouse with two Francis turbine-generator units.

The geology of the area includes volcanic andesites, breccias and tuffs that contain swelling minerals that react with water from the tunnel and expand, exerting pressures of up to 1.7 MPa (powdered sample) that could result in cracking, bulging and eventual collapse of the tunnel lining system. The headrace tunnel was constructed using drill and blast techniques from 10 different fronts. Most of the tunnel was supported with shotcrete and bolts and features a roller compacted-concrete (RCC) floor.

In August 2010, a 20 m-long section of the tunnel collapsed. The collapsed area was sealed off and a 260 m-long bypass was constructed to reinstate water flow. As a result of a complete inspection of the tunnel, areas that showed distress or a high swelling potential were reinforced with a combination of Norwegian girders, cast in place concrete, bolting and shotcrete as required.

The tunnel was refilled in May 2013 and has operated successfully since then, with dewatering conducted in July 2014 to verify the performance and condition, perform basic maintenance (cleaning of the rock trap) and install additional sensors for monitoring of the tunnel lining.

Monitoring of tunnel condition

Tinguiririca Energía wished to monitor condition of the repaired tunnel to ensure it would operate without incident. Dewatering the tunnel to do this would not only lead to significant lost electricity production but also cause reversal of water pressure on the tunnel, with the potential for inducing damage to the lining.

To provide real-time and ongoing monitoring of tunnel condition, Tinguiririca Energía implemented a series of measures, including:

- Installation of geotechnical instrumentation (fiber-optic extensometers, vibrating wire piezometers and crackmeters, and Brillouin optical time domain reflectometry (BOTDR) fiber-optic strain measurement);
- Installation of pressure transducers to measure head losses and trigger an alarm if the losses exceeded a predetermined range;
- Turbidity measurements at the intake and discharge of the water, along with allowances for the transit time of water in the tunnel, to trigger an alarm if there is an unusual or unexplainable differential in measurements; and
- Periodic inspection of the tunnel using an ROV to check for rock falls, swelling of the rock mass and condition of the rock trap.

This has allowed the tunnel to remain in a pressurized state and minimize outage times while collecting adequate data for the tunnel's condition assessment.

Objectives of ROV inspection

The ROV inspection was to target three key components for the condition assessment:

- General tunnel condition;
- Deformation of the tunnel perimeter due to the presence of swelling minerals in the rock mass; and
- Detection of any cracking, displacements, or separations in the tunnel lining.

The general inspection was to provide information including identification and quantification of any debris or rock fallouts, accumulations of sediment and condition of the rock trap. To facilitate locating the ROV within the tunnel, angled metal plates were installed on the left wall at 500 m intervals and surveyed in.

To determine potential deformation of the tunnel perimeter, before watering up of the tunnel and after the repair work was completed, a georeferenced lidar (laser imaging, detection and ranging) survey was completed, generating a point cloud with a precision of ±2 mm. Because one of the data sets collected using the ROV was to generate a similar point cloud, this would allow for a comparison between the two point clouds to determine any deformations in the tunnel surfaces.

In anticipation of potential deformations and cracking of the liner, it was desired that the ROV would also be able to pick up any of these types of features. It was recognized that hairline cracks would not create a sonar shadow, and only if the cracks opened up to more than 10 mm or resulted in a physical displacement from one side of the crack to the other would these be visible.

ROV inspection

ROVs, unmanned robotic systems controlled by a human operator, are typically tethered by a cable that incorporates conductors for power and telemetry and strength members bundled by a protective jacket. This configuration provides power from a surface supply, real-time control of the vehicle, and immediate feedback and relay of data from the machine. Development of them for internal inspections of tunnels and pipelines has produced a cost-effective alternative to dewatering tunnels for condition assessment surveys.

The client representative and experts are able to view data from the ROV in real-time and are able to make a reasona-

ble condition assessment based on the sensory feedback. Sensors typically include video systems for visual feedback and usually one or more sonar systems for navigation and metrology. Depending on the vehicle, a wide variety of other more exotic sensors can also be integrated, such as underwater laser systems, point measurement velocimeters, hydrophones, chemical sensors and physical sampling devices.

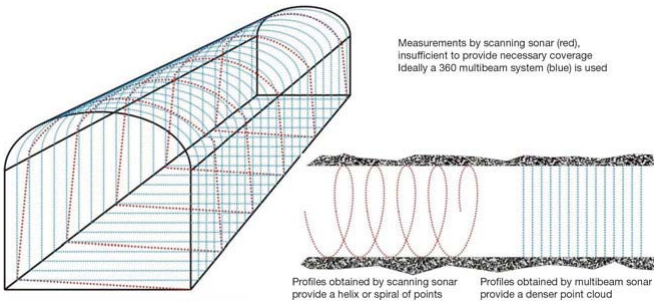
Vehicle development

ROVs use sonar systems to make underwater measurements. For measuring tunnel diameter, a scanning sonar system is commonly used. The sonar emits a narrow sound pulse and measures the time it takes to travel from the transducer, bounce off a target and come back to the transducer. This measurement of time is translated into distance using the speed of sound in the water. A scanning sonar makes this measurement multiple times at discrete angular intervals to cover a complete 360 degrees.

The best use of this application requires stabilizing the vehicle so that the measurements are accurate. Even if high-end motion sensors are incorporated onto the vehicle and the ROV flown down the center of the tunnel, the resulting cork-screw in the data results in sparse coverage.

A multibeam sonar system emits multiple sonar pulses simultaneously, with each beam acquiring a single measurement (see Figure 1). This makes all the measurements in that sample, or ping, accurate with respect to each other. Multibeam sonar is normally used for making depth measurements in open bodies of water and has a "field of view" that is typically about 120 degrees wide. By using three systems, it was conceivable to obtain 360 degrees of coverage of the tunnel.

Figure 1 - Scanning and Multibeam Comparison



Different data is acquired using a scanning profile sonar and multibeam data acquisition. This figure shows the data collected by the two while traveling through a tunnel.

ASI selected the Reson 7125 multibeam system because it had a good track record and had previously been operated as a dual-head system, although never configured to operate with three heads. The manufacturer was also a provider of the data acquisition and processing software, making it a "one-stop-shop" for development of this sensor package into one that could be applied in the tunnel.

To detect small targets, another type of sonar system was required. A scanning image sonar acquires a two-dimensional image of its target area using a fan-shaped acoustic pulse that is swept across the area of interest, generating an almost photographic image.

Again, an accurate image requires time and stabilization of the ROV and sonar while the acoustic pulse is stepped across the area of interest. In recent years, sonars identified as 2D sonars, acoustic cameras or multibeam imaging sonars have become more popular for use as navigation tools on ROVs. The multibeam imaging sonar uses multiple beams fired simultaneously to create an image over a field of view that can be updated several times per second, rendering an image stream representative of a video.

ASI used multiple BlueView 2D imaging sonars to cover the invert and tunnel walls. By rotating the sonar 90 degrees and mounting it angled to the side, coverage of the walls could be achieved.

The middle sonar was mounted on a tilt tray so that it could be used to image the crown if needed. Three heads had never been operated simultaneously before and never in such a confined space as a tunnel.

The combination of sonars would transmit a significant amount of data, so a telemetry system that could handle a high volume of data at high speed was essential. ASI selected the Forum Sub-Atlantic Mohican ROV. The new technologies to support the data requirements as well as improved systems' reliability made this selection essential for successful development of a new-generation tunnel inspection ROV.

At Reson's facilities in Goleta, Calif., USA, ASI conducted initial testing with the three multibeam heads, the three BlueView systems, a scanning Tritech Seaking sonar that was standard to the ROV, and an acoustic Doppler current profiler (ADCP). This latter sensor is integral to the inertial navigation system that would be required to accurately track the ROV - there is no GPS signal in a tunnel, especially one filled with water.

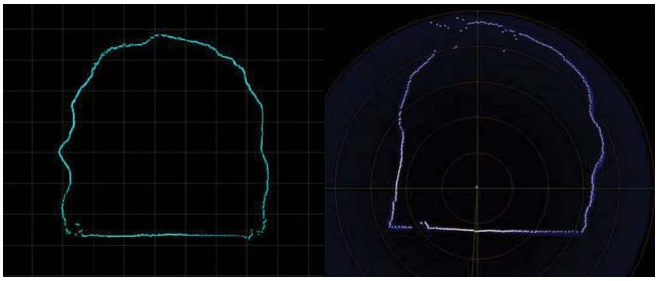
All of these sensors are acoustic based. From all suppliers, this required new software simply to trigger the multiple systems, then consideration had to be given to possible interference between the units. This was equivalent to a group of musicians tuning their instruments at the same time in a room with no sound absorption; echoes and multipath artifacts resulted in a significant amount of "noise" or stray signals being picked up by the sensors, initially resulting in poor-quality data.

With a combination of synchronization, directionality and adjustments of frequency, the multiple systems were eventually configured to provide good quality data without interference.

System performance

The system was first deployed into the Tinguiririca tunnel that is located immediately upstream and is part of the La Confluencia project (both tunnels carry the same name). Technical issues prevented all of the multibeam systems working consistently, but the overall operation and collection of data proved the concept. The inspection results provided additional details on an anomaly that was identified in an earlier inspection, conducted by ASI with its Falcon ROV that was fitted with a scanning profile and BlueView sonar systems. A small relief target was identified with the scanning profile sonar - a coincidence considering the scan came around at just the right time to catch the feature (see Figure 2).

Figure 2 - Small Feature Identified



A small feature with a raised profile is present on the bottom left side of the invert. The images show how it was identified with scanning profile sonar (left) and multibeam sonar (right) on subsequent inspection.

The benefit of the multibeam system is that it can collect several thousand points within a small area that better defines surfaces. The follow-up inspection captured not just the one instance of the raised target but completed the full model of the area so that the feature could be put into context with its surroundings (see Figure 3).

Figure 3 - 3D Model of Feature

A 3D model of the tunnel location in Figure 2 was rendered from multibeam point cloud data. The left image is a view from inside a lined section out to the main tunnel. The right image is downstream of the lined section and shows the raised feature adjacent to the wall.

The feature of interest had length, so it was unlikely to be a rock. A few months after the inspection, the tunnel was dewatered during a routine maintenance outage. Arrangements were made to conduct a drive through the tunnel to locate targets that had been seen in sonar images and compare them with actual features. The target of interest modeled by the sonar systems was identified as pipes that were installed through the lined section. They allow water to drain from the tunnel on the upstream side of the lined section (see Figure 4).

Figure 4 - Feature Identified Visually

These photos of the downstream end of the lined section shows pipes that provide a bypass for water when the tunnel is dewatered to drain water from the upstream side of the lined section. This was the feature identified in Figures 2 and 3.

Another common observation was noted as "linear feature." Without knowing the exact nature of these items, they could not be labeled as cracks or joints. During the drive through, the joints between consecutive pours of the RCC on the tunnel invert were ignored until it was realized they were the "linear features" identified in the sonar images.

Conclusions

The system has been used to make three runs at La Higuera and two at La Confluencia. The system always collected information of value, and during operation in March 2014 where both the La Confluencia and La Higuera tunnels were inspected, the system performed without issue.

The continual improvement and application of remote technologies to asset management projects can help reduce overall inspection costs, eliminate the risk to inspection personnel and eliminate structural risks associated with dewatering a tunnel. The level of detail that can be obtained, even in zero visibility water, can be used to detect small isolated rocks or debris so that intervention can be planned in advance rather than in an emergency response. The ROV will continue to be used to provide assurances to all stakeholders that the tunnel can be effectively monitored without the need to dewater.

Bob Clarke, P.Eng., is senior operations manager of ASI Group Ltd. Rick Fletcher, now retired, was executive manager, engineering (Chile) with Pacific Hydro Chile SA at the time the work discussed in the article was performed.

(Hydroworld, 04.01.2016,
http://www.hydroworld.com/articles/print/volume-24/issue-2/features/surveying-a-tunnel-using-an-rov.html)

Trends in Dam Safety

Michael F. Rogers

Dam safety is an aging concern of the profession, making it critical for us to keep this topic at the forefront of conflicting priorities for owners, regulators and the worldwide engineering community. Lessons are being learned around the globe, some tragically, that must be communicated and shared to maintain our highest priorities of protecting and serving the public with some of the most important infrastructure facilities in the world. With even the smallest dam comes great responsibility to prioritize safety, minimize risk and never become complacent, recognizing that all man-made structures have a useful service life that must be understood and respected, even to decommissioning when that service life is complete.

Dealing with El Nino

The current "monster" El Nino weather pattern in the Pacific Ocean has serious implications for dams in North America, and for the state of California in particular. Most of the western U.S. has been experiencing drought conditions over the past four years, with California suffering the most significant impacts. Most of the state has been classified as experiencing "extreme" to "exceptional" drought since 2014. Recent large storms have begun to make a dent in the state's water deficit, but still reservoirs remain far from filled.

Being confident this weather would bring significant drought relief over the winter of 2015-2016, we did a lot of work in 2015 that involved looking at all aspects of dam safety for several important dams in southern California. It was vital to determine what owners of reservoirs and dams needed to do to get ready for possible sudden increases in water inflow. There was a significant push to make sure the dams were ready for the anticipated extreme operating change in terms of both equipment (such as the radial gates and low level outlets) and instrumentation.

Bear Valley Dam is a 92-foot-high multiple barrel arch dam in southern California. Work to ensure the spillway gates were ready to operate was required in the event of a large rainfall event from El Nino.

This anticipated weather pattern provides a great opportunity to get a good assessment of the performance of dams and dam safety equipment. Some reservoirs hadn't experienced water levels this low since they were initially filled, decades earlier, and there was potential that these reservoirs would be completely filled in just one season. With that anticipated large range of reservoir levels, it was important to verify the instrumentation was ready to go (e.g. verifying piezometers were performing correctly and the potential effects of uplift on concrete dams).

We performed this type of work at Bear Valley Dam. Located on Bear Creek, a tributary of the Santa Ana River, Bear Valley Dam forms the famous Big Bear Lake in the San Bernadino Mountains of southern California. Last fall, the water level in this reservoir was 13 feet down from normal pool, the lowest the reservoir has been in more than a decade. With a large watershed (38 square miles) relative to the available storage in the reservoir, there was potential that water levels could reach the top of the dam with just one or two large storms. Thus we worked with the dam owner, Big Bear Municipal Water District (BBMWD), to make sure their spillway gates were ready and they had an operational plan ready to implement.

To provide context as to why this is important and relevant, a dam failed in the Midwest last year because one of its radial gates didn't operate when storms came. As a result, the embankment dam got overtopped and failed. This was a situation where the dam would probably have survived the large flooding event if the owner had been able to operate that gate.

At dams where gates have sat a long time without operating, it is vital to make sure they are ready to go before major storm events. Dams like Shasta and Oroville in northern California are examples of situations where large gates have sat idle for five to eight years. The California Department of Water Resources and U.S. Department of Interior's Bureau of Reclamation spent considerable time this last fall exercising those gates and making sure they were ready to go. As a result, the risks to the projects have been minimized by addressing theoretical potential failure modes (PFM) association with non- or mis-operation of critical spillway gates.

Gaging hydrology

The Big Bear project provides another dam safety lesson in today's market. Water is a valuable commodity in California, so it can't be wasted. At Big Bear Lake, the local economy depends on tourist recreation that comes from high lake levels in the summer. Thus BBMWD must always gauge how much the reservoir level will rise when these rain storms occur across their watershed, in an attempt to balance water releases and storage while avoiding overtopping the dam.

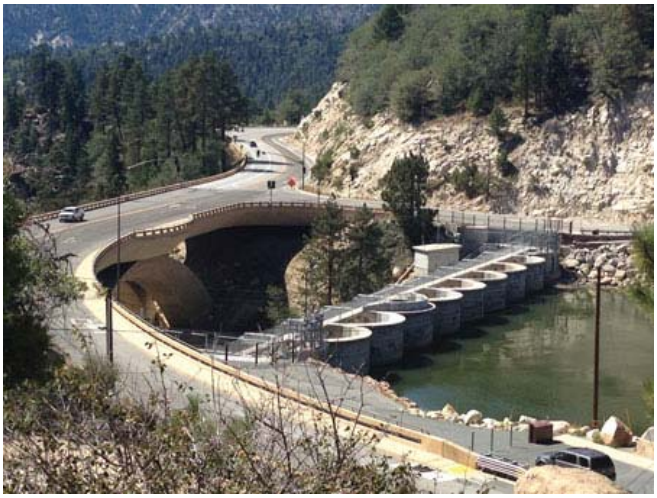
Determining the hydrology of watersheds is difficult because you are trying to make educated guesses: With a particular amount of rainfall or snow/snowmelt, how much will run off and how much will be absorbed? What impact will that have on the reservoir level? Typically there is not a lot of instrumentation installed around watersheds and this makes it difficult to tie precipitation events to rising water levels in the reservoir. BBMWD took this opportunity to augment its database of weather data using regional data from the nearby airport and ski parks. When faced with predicted large storms, they need to draw the reservoir down to prevent overtopping the dam. District General Manager Mike Stephenson says, "That's a delicate process. You don't want to release any more water than you have to because it is so valuable. But you also have to balance that [keeping water in the reservoir] with keeping the dam safe." With the right instrumentation in the right location, you can better hone in on best answers for operating the dam and reservoir in these extreme situations.

Hazard analysis

With regard to "cool" newer things that are going on in the practice of dam safety, the idea of risk assessment and probable maximum floods (PMF) for high-hazard dams is an important aspect. We see more dam owners wanting to use risk assessment concepts that utilize extreme hydrologic and seismic events (i.e., PMFs and maximum credible earthquakes) to prioritize dam safety budgets and focus dam safety improvements on those projects where they can

maximize the return on their investments for protection of the dam and residents downstream. A lot of work is being done in the industry to identify good assessments of risk for these projects, especially for owners with multiple projects or a portfolio of dams. Examples of this include Southern California Edison, Reclamation, the U.S. Army Corps of Engineers, and Pacific Gas & Electric for their west coast inventory of high-hazard projects.

Owners of these high-hazard projects will tell you there is always a need for regular updates and maintenance. When looking at dam safety, we are trying to find those projects that have the most immediate need for reducing risk by investing money in a targeted fashion to address the highest risk-effective areas. With regard to what most owners are looking for these days in projects to take on, they want to know how they can reduce overall project and portfolio risks to industry-acceptable levels. I believe that the dams profession - owners, regulators and engineering consultants - is doing a very good job in this respect. A lot of that work is being led by the federal government, primarily the Corps and Reclamation with their risk assessment methodologies. Overall, this work is making the industry more robust with regard to risk-informed decision making, thus leading to safer projects and safer populations who are at risk downstream of dams.



This upstream view of Bear Valley Dam shows the level of the reservoir, which was 13 feet down from normal pool last fall, the lowest the reservoir has been in more than a decade.

In my role at the International Commission on Large Dams (ICOLD), I'm seeing a lot of international interest in this approach, particularly the risk assessment using a PFM approach to dam safety to increase the safety of projects all around the world. The PFM approach of looking broadly at project-specific characteristics and situations when prioritizing dam safety investments will likely be the worldwide standard for the current and next generations of dam professionals.

The average age of our more than 84,000 dams in the U.S. is about 55 years. Any person 55 years old (or older) will tell you that at this age, you need to get regular check-ups for your health. Dams are no different. However, owners of a lot of these projects haven't taken a fresh look at dam safety, including hydrology, since the 1970s or 1980s. We know watersheds change, along with our science of prediction for large precipitation events. The focus in previous updates to PMF studies had been the probable maximum precipitation part, the meteorology part, and not so much the changing watershed part. Updating the watershed characteristics for development, for runoff, and actually putting some measuring gages in the watershed area around the reservoir for validation of assumptions, which can be connected by remote telemetry, allows you to get that data in real time to control centers for assessment and monitoring. That data can be used to predict what's going to happen in the reservoir, allowing an optimized operation for safety of the dam and downstream residents and property.

Proper instrumentation

Speaking of my international work, both with MWH and ICOLD, I have seen some innovative applications of proper watershed monitoring in China. China Three Gorges Corporation (CTGC) is building projects in China and around the world, and part of the work CTGC is doing on big rivers with cascades of dams and hydro plants is getting good instrumentation installed in the upper reaches of watersheds so they can predict flows and are prepared in real time for these flooding situations. Mountains and watersheds in China are almost completely fed by runoff. They need to know, to a high degree of accuracy, what's coming down the river along a particular cascade. I've seen some of the state-of-the-practice work being done by CTGC in this regard, including work in ICOLD on a new bulletin by the Technical Committee on Integrated Operation of Hydropower Stations and Reservoirs.

The Chinese dam engineers and builders are in a great position, and we're in a position to learn from them, because of the sheer number and size of dams and hydro projects they are building. Hydro developers from China, including CTGC, are leading developers of large projects in Africa and South America. We are talking about a lot of technology being developed for large projects in China and bringing this to projects around the world.

Dealing with aging structures

A common question from dam owner clients is about the remaining useful service life of their structures and equipment. Many projects in the U.S. were built 50 to 100 years ago and have surpassed their design life. Owners ask, "If I have a concrete or embankment dam, what do I need to do to get another 50 to 100 years out of my project?" For well-maintained projects, not a lot needs to be done. It's a bit like an older model car or older house, or an aging person. You have to do some routine maintenance (or exercise), and every so often you have to do major overhauls to stay healthy and productive.

A lot of U.S. projects are ready for a major overhaul, or at least a significant check-up or review of high-risk aspects of structures. And by a major overhaul I say for concrete dams, looking at deterioration over time, particularly in areas susceptible to freeze-thaw damage and how much of the concrete remains to carry original design loads. They may need an overhaul to remove deteriorated concrete, bridges or spillway piers. Thinner concrete structures are usually more susceptible to material losses through deterioration. In some cases, projects may be ready for an overhaul to completely replace them or remove them completely from service. Over the next decade or so, owners will need to decide if the cost and benefit of maintaining an aging dam are worth the investment to continue periodic refurbishments, possibly replace all or a portion of the structure, or decommission the project entirely.

One of the big disservices we could do as a profession is try to keep old projects, those that are reaching the end of their design life, in operation through minimal investments and not properly assessing the overall structural condition and risks of keeping those projects in service after their design life. This approach increases risk to the project, environment and downstream population and property as PFMs change and escalate with time. The ultimate risk facing many projects is structural failure, either limited or catastrophic. As time goes on, that risk of failure will slowly

increase and must be met with increasing investment and vigilance by owners.

Many of the world's dams have reached an unacceptable level in terms of risk and, unfortunately, we regularly see news reports of dam failures. As a profession, we should strive for the highest possible safety standards that minimize risk to our worldwide inventory of dams. We as owners, regulators and the engineers who are looked to for proper assessments need to be cognizant of our professional duty to keep the public safe, including replacement or removal of dams at the end of their design service lives.

Mike Rogers, PE, PMP, is vice president, principal civil engineer and senior project manager with MWH. He also is chair of the U.S. Society on Dams' Technical Committee on Concrete Dams and vice president for the Americas Region of the International Commission on Large Dams.

(HYDRO REVIEW, 01.04.2016,
http://www.hydroworld.com/articles/hr/print/volume-35/issue-3/articles/trends-in-dam-safety.html)

Investing in critical infrastructure like dams is paramount to public safety… According to the 2013 National Inventory of Dams, Rhode Island has 236 dams, 97 of which are classified as high hazard potential, wherein dam failure is probable to cause loss of human life. In West Virginia 422 dams are classified as high hazard potential. The new effort proposed in US Senate legislation makes many of these dams eligible for grant assistance to help inspect, repair and rehabilitate high-hazard dams.

… … …

σ.ε. Έχει γίνει κάποιος έλεγχος της κατάστασης των φραγμάτων στην Ελλάδα; Η ηλικία κάποιων από αυτά υπερβαίνει τα 60 χρόνια, ενώ έχουν σχεδιασθή (και κατασκευασθή) με σεισμικά φορτία πολύ μικρότερα αυτών με τα οποία σχεδιάζουμε σήμερα και, ενδεχομένως, με μικρότερες πλημμυρικές παροχές. Ιδού πεδίον δόξης λαμπρόν για την Ελληνική Επιτροπή Φραγμάτων και Ταμιευτήρων.

ΠΡΟΣΕΧΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΚΔΗΛΩΣΕΙΣ

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

19SEAGC – 2AGSSEAC Young Geotechnical Engineers Conference, 30th May 2016, Petaling Jaya, Selangor, Malaysia, seagc2016@gmail.com

19th Southeast Asian Geotechnical Conference & 2nd AGSSEA Conference Deep Excavation and Ground Improvement, 31 May – 3 June 2016, Subang Jaya, Malaysia, seagc2016@gmail.com

ISSMGE TC211 Conference Session within the framework of the 19th Southeast Asian Geotechnical Conference "GROUND IMPROVEMENT works: Recent advances in R&D, design and QC/QA"

3rd International Course on Geotechnical and Structural Monitoring
7-9 June 2016, Poppi, Tuscany, Italy
www.geotechnicalmonitoring.com/en

"After two successful editions of the International Course on Geotechnical and Structural Monitoring (held in Poppi, Tuscany, Italy in June 2014 and June 2015) that attracted more than 200 registrants from 34 countries and 32 partners, we're now working hard to organise a third edition in 2016. 25 speakers have contributed to the high professional level of the past courses and we're looking for improvements and innovation. Some new expert speakers are expected for the next edition. We plan to invite registrants to interact with us well before the start of the course, to discuss the possibility of them making presentations about new monitoring trends and about case histories and lessons learned.

After the 2015 course we had an exciting field trip to the Poggio Baldi landslide (www.landslidemonitoring.com), where 10 companies made demonstrations of their equipment. We're exploring the possibility of another field trip combined with the 2016 course."

Leading experts from all over the world will contribute with their lectures to one of the most advanced and high professional course ever organized about Geotechnical and Structural Monitoring.

In the next edition three special sessions will be dedicated to the **presentation of the new trends on geotechnical and structural monitoring, by course Partners** and in particular:

- New Trends in Contact Monitoring
- New Trends in Remote Monitoring
- New Trends in Offshore Monitoring and Data Transmission and Management (more details about this session are available here…)

Furthermore, **10 challenging Case Histories** were selected by a call for presentation dedicated to the **course participant** (more details about this session are available here…).

Several companies are expected to attend the 2016 edition of the course to show their innovative solutions equipment for geotechnical and structural monitoring (list of Partners and Exhibitors already confirmed for the 2016 Edition).

The course is intended for engineers, geologists and technicians who are involved with performance monitoring of geotechnical features of civil engineering projects, project managers and other decision-makers who are concerned with management of RISK during construction of these and other project types:

- Large and small infrastructures
- Tunnels
- Dams
- Excavations
- Excavated and natural slopes
- Building foundations
- Transportation
- Mining
- Oil and gas
- Land and water management

Topics

This is a course for practitioners, taught by practitioners with wide field experience. The emphasis is on why and how to monitor field performance.

The course will cover the following main topics:

- Basic concepts of monitoring and planning
- Contact Monitoring methods
- Remote Monitoring methods
- Vibration Monitoring
- Offshore Monitoring
- Management, analysis and interpretation of data
- Interactive sessions
- Case-histories, given by international leading experts
- Open forum

The ISSMGE is supporting the 3rd International Course on Geotechnical and Structural Monitoring.

The Field Trip will be held again at the Poggio Baldi experimental site and at the Ridracoli Dam (Santa Sofia, FC – Italy) on 10th June 2016.

During the visit to the Poggio Baldi Landslie, participants will have the opportunity to understand the geological and geomorphological processes which led to the catastrophic event of March 2010 and to take a look to the experimental monitoring site that NHAZCA set up in collaboration with the National Park "Foreste Casentinesi, Monte Falterona e Campigna"

Practical demonstrations will be also performed by international leading partners (manufacturers and expert technicians) in the geotechnical monitoring field, thus showing and providing information about the most innovative solutions for landslide monitoring (e.g. Laser Scanner, Radar Interferometry, Photogrammetry) on a real test site.

During the visit to arch-gravity dam of Ridracoli, organized thanks to the collaboration of Romagna Acque – Società delle Fonti S.p.A., the participants will have the opportunity to visit the monitoring system of the Dam and of the surrounding areas.

For more information about the event please visit www.landslidemonitoring.com

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ISL 2016 12th International Symposium on Landslides Experience, Theory, Practice, Napoli, June 12th-19th, 2016, www.isl2016.it

2ο Πανελλήνιο Συνέδριο Εξόρυξης και Εναλλακτικών Μεθόδων Διαχείρισης Αποβλήτων, 15-16 Ιουνίου 2016, Αθήνα, www.erasmus.gr/microsites/1091

(JAG-2016)
Géotechnique et emergence socio-économique des pays d'Afrique intertropicale
20-24 June 2016, Douala, Cameroun
www.8jag-cngc.org/8jag/en

Held in Cameroon in 2016 the next sitting of the General Assembly of the African Association of Laboratory of Building and Public Works (ALBTP) and the 8th African Days Geotechnics is the implementation of one of the resolutions final communiqué of the latter held on 1 July 2015 in Yamoussoukro, Ivory Coast. This scientific event to bring together for four days the representatives of eighteen countries members of the said Association namely: Cameroon, Chad, Burkina Faso, Congo, Gabon, Ivory Coast, DR Congo, Mali, Togo, Niger, Guinea Conakry, Benin, Senegal, Burundi, Ghana, Morocco, Tunisia and Equatorial Guinea.

The ALBTP is an association of organizations working in the field of building and public works. Its primary objective is to promote dialogue and exchange of experiences among its members in particular by the establishment of a data bank and the realization of publications of common interest to make the most of their scientific potential and technology. It shall hold a General Assembly once a year. On the sidelines to it, it organizes several activities including African Days Geotechnics (JAG).

The last three editions of the African Days Geotechnics (JAG) held respectively in the following countries: Congo (Brazzaville, 2013); Burkina Faso (Ouagadougou, 2014) and Ivory Coast (Yamoussoukro, 2015).

These days, among other objectives:

- Share and exchange innovative experiences geotechnical work;
- Promote and strengthen cooperation between geotechnical African practitioners of this trade.

THEMES

Les sous-thèmes proposés pour ces journées sont les suivants:

- Matériaux locaux dans les infrastructures de Génie Civil et innovations en matière de techniques routières;
- Reconnaissance des sites, construction et maintenance des barrages et autres infrastructures;
- Classification des sols en Afrique intertropicale;
- Révision des Règles Techniques de Génie Civil en Afrique intertropicale.

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BCRRA 2017 Tenth International Conference on the Bearing Capacity of Roads, Railways and Airfields, 28 –30 June 2017, Athens, Greece, www.bcrra2017.com

ICONHIC 2016 1st International Conference on Natural Hazards and Infrastructure: Protection, Design, Rehabilitation, 28-30 June 2016, Chania, Greece, http://iconhic2016.com

ICONHIC 2016 Performance-based soil-structure interaction of lifelines and infrastructure, gerolymos@gmail.com, asextos@civil.auth.gr & a.sextos@bristol.ac.uk

Conference in Honour of Michele Maugeri
01 July 2016, Catania, Italy
www.associazionegeotecnica.it

Location: University of Catania Department of Civil Engineering and Architecture (DICAR) Auditorium - Edificio della Didattica Cit, Catania, Italy

Language: English

Organizer: Italian Geotechnical Society
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4th GeoChina International Conference Sustainable Civil Infrastructures: Innovative Technologies for Severe Weathers and Climate Changes, July 25-27, 2016, Shandong, China, http://geochina2016.geoconf.org

S3: Slopes, Slides and Stabilization, August 1-3, 2016, Denver, USA, events@dfi.org

6th International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics August 1-6, 2016, Greater Noida (NCR), India, www.6icragee.com

EUROC 2016 - ISRM European Regional Symposium Rock Mechanics & Rock Engineering: From Past to the Future, 29-31 August 2016, Ürgüp-Nevşehir, Cappadocia, Turkey http://eurock2016.org

ICEGE 2016 1st International Conference on Energy Geotechnics, 29-31 August 2016, Kiel, Germany, www.iceg-2016.de

3rd ICTG – 3rd International Conference on Transportation Geotechnics 4 - 7 September 2016, Guimaraes, Portugal, www.civil.uminho.pt/3rd-ICTG2016

IAS'5 5th International Conference on Geotechnical and Geophysical Site Characterisation, 5-9 September 2016, Gold Coast, Queensland, Australia, http://www.isc5.com.au

The World Multidisciplinary Earth Sciences Symposium– WMESS 2016, 5-9 September 2016, Prague, Czech Republic www.mess-earth.org

http://eunsat2016.sciencesconf.org

Geotechnical research into the field of Unsaturated soils started in the 50's with some funding papers including Croney, Coleman and Bishop's pioneering contributions and its development started to be significant 20 years ago, following the venue of the UNSAT'95 - First International Conference on Unsaturated Soils held in Paris in 1995, as a consequence of a series of successful Conferences on Swelling soils with the last one held in Dallas (1992).

This series of conferences sponsored by the TC6/TC106 Technical Committee of ISSMGE on Unsaturated soils was afterwards followed by a series of successful Regional Conferences that started in Singapore in 2000 with the Asia-Pacific series, followed by the European one started in Durham (UK) in 2008 and, finally, the Pan-American series started in Cartagena de las Indias (Colombia) in 2013.

In the meantime, research into the behaviour of unsaturated soils expanded in a spectacular manner in terms of laboratory/in-situ investigations and conceptual/numerical modelling, aiming at solving practical engineering problems based on sound analyses of coupled multi-physics phenomena that became less mysterious thanks to the sound and deep investigations carried out all over the world in a constantly increasing number of research groups.

In this exciting context, there is no doubt that the forthcoming E-UNSAT 2016 in Paris, will attract interesting contributions and foster fruitful discussions from researchers from Europe and overseas.

The main topics of the conference are the following:

- Microstructure
- Advances in experimental methods
- Water retention and transport properties
- Mechanical behaviour
- Physical modelling
- Thermal and chemical effects
- Fundamentals
- Constitutive modelling
- Numerical modelling
- Nuclear waste disposals
- Gas storage
- Soil-vegetation-atmosphere interactions
- Foundations
- Slope stability
- Dams and dykes
- Transportation infrastructures
- Geo-environmental applications
- Case histories

Contact: eunsat2016@sciencesconf.org

ACCUUS 2016 15th World Conference Underground Urbanisation as a Prerequisite for Sustainable Development, September 12-15, 2016, http://acuus2016.com

SAHC 2016 - 10th international Conference on Structural Analysis of Historical Constructions 13-15 September 2016, Leuven, Belgium, www.sahc2016.be

Hydropower Development Europe 2016 - Flexible hydropower and pump storage generation for a safe renewable electricity system, 14 – 15 September 2016, Lyon, France, http://www.wplgroup.com/aci/event/hydropower-development-europe-2016

13 Baltic States Geotechnical Conference Historical Experiences and Challenges of Geotechnical Problems in Baltic Sea Region, 15 - 17 September 2016, Vilnius, Lithuania, http://www.13bsgc.lt

Dam Surveillance Practice
3rd Experts Seminar
18 - 23 Sep 2016, Landeck, Tyrol, Austria
www.atcold.at/de/home-1/41-2016-veranstaltungen/155-dam-surveillance-practice-2016

The Austrian National Committee on Large Dams is organizing the 3rd International Seminar on Dam Surveillance and Safety Assessment of dams.

This international seminar – the third after the successful seminar of 2005 – will deal with all the questions regarding the surveillance and safety assessment of dams. Experts will speak about the theory and practice of dam engineering, instrumentation, execution of measurements, visual inspection, data processing and safety evaluation for concrete and embankment dams. The theory will be supplemented by practical work at dam sites, which will include all aspects of site inspection. The participants will be encouraged to present their own findings and conclusions from site inspections and safety assessment. Sufficient time will be available for discussing dam surveillance matters in detail.

The seminar is tailored to persons involved in dam design, operation, surveillance as well as dam safety assessment. Renowned and specialized lecturers in this field will teach about surveillance practice for three days. Two days are dedicated to practical courses and exercises in dams to carry out measurements and performance data collection. On-site practical courses will be held in a concrete and fill dam respectively.

If you have any questions, please contact

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Please do not hesitate to contact us at secretary@atcold.at for further details.

ACE 2016 12th International Congress on Advances in Civil Engineering, 21-23 September 2016, Istanbul, Turkey, http://www.ace2016.org

International Geotechnical Engineering Conference on
Sustainability in Geotechnical Engineering Practices and Related Urban Issues
23-24 September 2016, Powai, Mumbai, India
www.igsmumbaichapter.in

International Conference on "Sustainability in Geotechnical Engineering Practices and Related Urban Issues" is jointly organised by the Indian Geotechnical Society (IGS), Indian Geotechnical Society Mumbai Chapter (IGS Mumbai Chapter) in association with International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE). This international event of ISSMGE offers a platform for worldwide geotechnical engineers, researchers and practitioners to interact and share experiences on geotechnical testing, analysis, design and construction issues. The conference will be held at Ramada Powai Hotel and Convention Centre, Mumbai, India during September 23-24, 2016. The detailed information regarding themes, speakers and registration details will be published shortly.

THEMES

The main theme of the Conference is sustainability in geotechnical engineering practices and related urban issues. Under this main theme, the following applications will be covered in the Conference.

- Cost effective foundations
- Railways and tramways and their formations
- Rigid and flexible pavements and tunnels
- Landfills and hazardous waste management
- Earth and rockfill dams and levees
- Shore and bank protection
- Offshore geotechniques
- Slopes and earth retaining structures

All these applications will include the following:

- Field and laboratory testing
- Modelling, analysis and design
- Instrumentation and monitoring
- Geo-hazarads
- Reliability studies
- Codes and standards
- Any other related topics

ADDRESS FOR CORRESPONDENCE

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EuroGeo 6 – European Regional Conference on Geosynthetics, 25 – 29 Sep 2016, Istanbul, Turkey, www.eurogeo6.org

8th Nordic Grouting Symposium State of the art – Future Development, 26-27 September 2016, Oslo, Norway, http://nordicgrouting.com

5th International Scientific Conference on Industrial and Hazardous Waste Management, 27 - 30 September 2016, Chania, Crete, Greece, http://hwm-conferences.tuc.gr

5-6 October 2016, London, United Kingdom
https://basements.geplus.co.uk

Ground Engineering is delighted to bring you the ninth annual Basements and Underground Structures conference; your best opportunity to explore the procurement, design and delivery of underground spaces.

The event is a critical gathering of leaders from major clients, main contractors, consultants, designers, specialist contractors and suppliers and essential for anyone involved in small, medium or large scale projects.

There are many great reasons to attend the event in 2016, but here are *three* you should have in mind when weighing up whether to attend:

- Exclusive networking - gain access to over 220 senior industry figures including potential clients, project partners and innovative suppliers
- Peer learning - attend technical workshops, breakfast briefings, panel discussions and case study sessions to draw out lessons from current projects across the domestic, commercial and infrastructure sectors
- Knowledge building - hear about the techniques and technologies which will be critical to the delivery of future basement projects and understand what this means for your business

Whatever the scale, location or stage of the basements you are involved in, Basements and Underground Structures gives you the industry's best opportunity to improve your knowledge and understand where future opportunities will arise.

Contact: Roland Maybank on 0203 033 2911 or email roland.maybank@emap.com

2nd International Specialized Conference on Soft Rocks – ISRM 2016 Understanding and interpreting the engineering behavior of Soft Rocks, 6-7 October 2016, Cartagena, Colombia, www.scg.org.co/?p=1634

ARMS 9, 9th Asian Rock Mechanics Symposium, ISRM Regional Symposium, 18-20 October 2016, Bali, Indonesia, http://arms9.com

SFGE 2016 Shaping the Future of Geotechnical Education International Conference on Geo-Engineering Education 20 - 22 October 2016, Minascentro, Belo Horizonte, MG, Brazil, http://cobramseg2016.com.br/index.php/sfge-sobre/?lang=en

10th ICOLD European Club Symposium & Exhibition, 25-30 October 2016, Antalya, Turkey, http://trcold.com

1st International Symposium on
Seismic Rehabilitation of Heritage Structures
30-31 October 2016, Tehran, Iran
www.srhs.ir

Topics

- Principles and Standards
- Theory of Conservation and Seismic Rehabilitation
- Valunerability Assessment
- Seismic Behavior
- New Techniques, Materials and Innovations
- Traditional Strenghthening Schemes and Methods
- Repair, Strenghthening and Reconstruction
- Structural Maintenance and Monitoring
- Earthquake Risk Management
- Case Studies

Colleagues interested in participating the symposium please apply Prof. Mehrdad Hejazi (mm.hejazi@yahoo.com)

NEMO International Conference Probing the Santorini volcano for 150 years / Διεθνές συνέδριο NEMO 150 χρόνια μελέτης ηφαιστείου της Σαντορίνης, 3-5 November 2016, Santorini, Greece, http://nemo.conferences.gr

GeoAsia 6 - 6th Asian Regional Conference on Geosynthetics 8-11 November 2016, New Delhi, India, http://seags.ait.asia/news-announcements/11704

پنجمین همایش بین‌المللی مهندسی ژئوتکنیک و مکانیک خاک
5th International Conference on
Geothechnical Engineering & Soil Mechanics

15-17 November 2016, Tehran, Iran
www.icgesm2016.ir

Established in 1971, Iranian Geotechnical Society (IGS) is one of the eldest professional engineering organizations in Iran. IGS seeks to help in a better understating of the Geotechnical Engineering field and to promote collaboration and coordination among its members, who are graduates of Geotechnical Engineering, Geological Engineering and other related fields for scientific, professional and research-based activities.

Iranian Geotechnical Society is among the eldest members of the International Society for Soil Mechanics and Geotechnical Engineering and has maintained good ties with ISSMGE.

In the line of spreading the Geotechnical Engineering knowledge, scientific and professional conferences have always been a major concern for IGS and in this regard, a number of national and 4 international successful conferences and many scientific seminars have been held.

In response to numerous requests from scientific societies and experts of the practice, the 5th International Conference on Geotechnical Engineering and Soil Mechanics (5thICGESM) will be held on November 15-17, 2016 in Tehran with association of university faculty members, researchers and experts of the practice in collaboration with different ministries and organizations of the country. One of the main objectives of this 3-day conference is to provide an opportunity for the participants to present their achievements and services and the latest technologies related to the field of Geotechnical Engineering.

Accordingly, Iranian Geotechnical Society encourages university professors and students, engineers and experts in Geotechnical Engineering and other related fields such as Engineering Geology, Mining Engineering and Geophysics, and clients who deal with Geotechnical Engineering projects, to participate in the conference and present their latest findings in the form of papers, posters or workshop in the context of the topics of the conference.

Conference Program

The main program of the conference consists of the followings:

- Keynote Lectures by National and International Distinguished Professors and Experts.
- Theme Lectures by National and International Experts and Professors on each technical topic
- Oral presentations of the selected papers
- Poster presentations of the selected papers
- Technical workshops and short courses
- Exhibition for professionals, companies and their products/services
- Technical book fair
- Technical Tours and Social programs

Conference Topics

- Laboratory Testing, Physical Modeling and Field Tests
- Soil Characterization and Constitutive Modeling in Geomechanic
- Geotechnical Engineering for Infrastructure and Transportation
- Geotechnics and Geomechanics in Petroleum Industries
- Earthquake Geotechnical Engineering
- Marine Geotechnics
- Environmental Geotechnics
- Geotechnics in Underground Space
- Ground Improvement
- Excavation in Urban Area – Challenges and Problems
- Innovative Techniques and Technologies in Geotechnical Engineering
- Lessons Learned from Case Histories

Contact Information of Secretariat

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Email: info@icgesm2016.ir

RARE 2016 Recent Advances in Rock Engineering 16-18 November 2016, Bangalore, India, www.rare2016.in

TBM DiGs Istanbul 2016 2nd International conference on "TBM DiGs in difficult grounds", 16-18 November 2016, Istanbul, Turkey, www.tbmdigsturkey.org

The 3rd International Conference on Geotechnics for Sustainable Infrastructure Development
24-25 November, Hanoi, Vietnam
www.geotechn.vn

Started from October 2011, the first international conference GEOTEC HANOI 2011 was excellently successful with about 450 attendees from 24 countries. Among the conference highlights were the six keynote-lectures given by Prof. Sven Hansbo (Sweden), Prof. Kenji Ishihara and Dr. Hiroshi Yoshida (Japan), Prof. Harry G. Poulos (Australia), Prof. Pieter A. Vermeer (Netherlands), Prof. Alain Guilloux (France).

In November 2013, the second conference GEOTEC HANOI 2013 was held with great keynote lectures by Prof. Rolf Katzenbach (Germany), Prof. Alain Guilloux (France), Prof. Fumio Tatsuoka (Japan), Prof. Kenichi Soga (UK), and Prof. Helmut Schweiger (Austria), and an honorary lecture given by Prof. Sven Hansbo from Sweden. GEOTEC HANOI 2013 was an unforgettable event with 112 papers, 500 attendees from 27 countries.

Continuing the success of the two previous events, GEOTEC HANOI 2016 conference is organized by FECON Corporation, the Vietnamese Society for Soil Mechanics and Geotechnical Engineering (VSSMGE), and the Japanese Geotechnical Society (JGS), and will be held on 24th and 25th November 2016 at JW Marriott Hotel in Hanoi. At this conference the keynote-lectures will be given by the five world leading experts: Prof. Bengt H. Fellenius from Canada, Prof. Chang-Yu Ou from Taiwan, Prof. Buddhima Indraratna from Australia, Prof. Kazuya Yasuhara from Japan and Dr. Jamie Standing from the U.K.

Conference themes

- Deep foundations
- Underground construction & tunneling
- Ground improvement for infrastructure projects
- Coastal geotechnics for climate change
- Monitoring, inspection and maintenance

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5th International Conference on Forensic Geotechnical Engineering
8-10 December 2016, Bangalore, Karnataka, India
http://5icfge.com

The International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) constituted a Technical Committee (TC) on Forensic Geotechnical Engineering (FGE) in 2005. During the first four years it was designated as TC40 and is now designated as TC302. This committee has conducted four international seminars on FGE and is now organizing the fifth conference during December 8-10, 2016 at Bengaluru, India. The theme of the event is "Forensic Geotechnical Engineering". Lessons learned from failures of different types of geotechnical structures that can be attributed to any one or more of the topics below can be highlighted. Manuscripts highlighting the failures due natural hazards, lack of codal provisions, challenges in geoenvironmental engineering and rock engineering are welcome. During the conference, the following ten topics and their role in Forensic Geotechnical Engineering will be discussed.

Forensic geotechnical engineering involves scientific, legalistic investigations and deductions to detect the causes as well as the process of distress in a structure, which are attributed to geotechnical origin. Such a critical analysis will provide answers to "what went wrong, when, where, why, how, and by whom". Cases of remedied installations, particularly those which, fall under public / or government category, where the analysis and evaluation of adopted remedial measures with regard to their effectiveness and economy may be subjected to judicial scrutiny also, fall under this purview. It also gives strong inputs to improve designs. The normally adopted standard procedures of testing, analysis, design and construction are not adequate for the forensic analysis in majority of cases. The forensic investigations involve fresh field and laboratory tests apart from collection of all available data. The test parameters and design assumptions will have to be representative of the actual conditions encountered at site. While the designs are mostly stress based, the forensic analysis has to be deformation based. The forensic geotechnical engineer (who is different than the expert witness) has to be not only thorough in his field of specialization, but also be familiar with legal procedures. This seminar highlights the principles of planning and executing a forensic investigation citing case histories.

Themes of the Conference

- Collection of Data
- Distress Characterization
- Development of Failure Hypothesis
- Diagnostic Tests
- Back Analysis
- Reliability Aspects
- Technical Shortcomings
- Legal Issues
- Observation Method of Performance Evaluation
- Case Histories

Contact

All Correspondence relating to the Symposium shall be sent to

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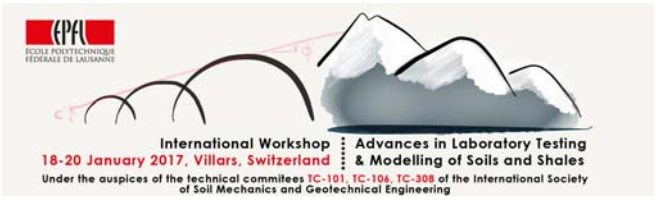
International Symposium on Submerged Floating Tunnels and Underwater Tunnel Structures (SUFTUS-2016), 16—18 December 2016, Chongqing, China, www.cmct.cn/suftus



http://atmss.epfl.ch

After the great success of the first edition of the Workshop on "Advances in Multiphysical Testing of Soils and Shales", the Laboratory for Soil Mechanics (LMS) at the EPFL is glad to announce the International Workshop on "Advances in Laboratory Testing and Modelling of Soils and Shales". The International Workshop is a 2.5 days event promoting the exchange of ideas, practices and state of the art among the major experts active in the field of laboratory testing and modelling of soils and shales. The workshop, located in the wonderful landscape of the Swiss Alps, aims at stimulating the debate on the most recent advances in experimental and modelling geomechanics.

Flashback on the first edition of the Workshop on "Advances in Multiphysical testing of Soils and Shales: http://amtss.epfl.ch

The proceedings of the workshop will be published by Springer and indexed in Scopus and SpringerLink. The authors of the most outstanding contributions will receive the opportunity of publication in a special issue of the ELSEVIER journal "GEOMECHANICS FOR ENERGY and the ENVIRONMENT".

The Workshop is organized under the auspices of the ISSMGE Technical Committees:

- TC-101 — Laboratory Stress Strength Testing of Geomaterials

- TC-106 — Unsaturated Soils
- TC-308 — Energy Geotechnics

Workshop Topics

- Non-destructive soil testing
- Microstructural imaging techniques
- Advanced laboratory testing: developments in advanced laboratory geotechnical testing, including apparatus, techniques, data acquisition and interpretation
- Cyclic and dynamic loading
- Multiphysical testing
- Thermo-hydro-chemo-mechanical behaviour of soils and shales
- Unsaturated soils
- Large scale experiments
- Constitutive modelling: prediction of the behaviour of soils and shales, multiscale approach
- Case studies: application of advanced laboratory testing in integrated site characterization studies, in ground modeling
- Other relevant topics in the field.

For any question regarding the Workshop, please contact us via e-mail: atmss@epfl.ch

ICNCGE-2017
International Conference on
New Challenges in Geotechncial Engineering
23 January 2017, Lahore, Pakistan
www.pges-pak.org/home/icncge-2017

The Pakistan Geotechnical Engineering Society (PGES) in collaboration with the National University of Computer and Emerging Sciences (FAST- NUCES) takes pleasure in announcing an International Conference on January 23, 2017 in Lahore, Pakistan.

The theme of the Conference is "NEW CHALLENGES IN GEOTECHNICAL ENGINEERING". This broad theme has been kept to attract a diversity of quality papers from around the globe. The Conference will act as a platform for exchange of technical ideas between Clients, Consultants, Contractors and Manufacturers. Outstanding keynote lectures, presentations and technical discussions will afford opportunity to explore the fast-growing new challenges in geotechnical engineering.

The City of Lahore is the cultural, entertainment and food capital of Pakistan. Lahore is the capital of the Province of Punjab and also the hub of economic activities. Lahore offers both historical and cultural attractions, including exceptional Mughal Architecture and many easily accessible cultural tours. In addition, many mega projects have recently been completed and some are underway, that give a new look to Lahore. Whether delegates are attracted to world class theatres, museums, cultural attractions, unique shopping areas, exceptional restaurants or thematic neighborhoods, Lahore's diversity of features ensures there is something for everyone.

OBJECTIVE

This Conference will provide a great opportunity to the engineers, geologists, seismologists and other professionals engaged in the field of geotechnical engineering, foundation design, construction and manufacturing, to share their expertise in the realm of Geotechnical Engineering. The Conference will help bring together the knowledge available in this field, for future guidance.

MAIN THEMES

Papers to be presented at the Conference may be related to any aspect of new challenges being faced in geotechnical engineering. The Organizing Committee suggests the following main themes:

1. Field Investigations/Testing
2. Geomatics Techniques
3. Laboratory Testing
4. Analysis and Design
5. Problematic Soils
6. Ground Improvement
7. Landslides Mitigation
8. Conservation of Archeological Sites
9. Deep Excavations
10. Hazard Zonification
11. Numerical Modeling
12. Geotechnical Construction
13. Performance and Monitoring
14. Environmental Geotechnical Engg.
15. Academia and Professional Practice
16. Case Histories
17. Any other relevant topic

All correspondence and inquiries related to the Conference should be addressed to the Secretary, Conference Organizing Committee at the following address:

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Web: http://www.pges-pak.org
Facebook: https://web.facebook.com/groups/pges.pak

AfriRock 2017, 1st African Regional Rock Mechanics Symposium, 12 – 17 February 2017, Cape Town, South Africa, www.saimm.co.za/saimm-events/upcoming-events

AFRICA 2017 - Water Storage and Hydropower Development for Africa, 14-16 March 2017, Marrakech, Morocco, www.hydropower-dams.com/AFRICA-2017.php?c_id=89

5th International Conference on the Use of EPS Geofoam Blocks in Construction Applications
22-24 May 2017, Istanbul, Turkey
www.geofoam2017.org

On behalf of the organizing committee, I am pleased to invite you to the **5th International Conference on Geofoam Blocks in Construction Applications (EPS'17)** which will be held in Istanbul, Turkey on May 22 – 24, 2017.

Geofoam researchers, consultants, molders, contractors and practitioners from all around the world will be meeting in Istanbul to discuss the recent developments and future trends of the expanded polystyrene (EPS)-block geofoam technology and its construction applications. EPS'17 will continue to contribute to the development of the geofoam applications after successful Oslo (1985), Tokyo (1996), Salt Lake City (2001) and Oslo (2011) conferences.

We are honored to dedicate the proceedings of EPS'17 to Mr. Tor Erik Frydenlund and Mr. Geir Refsdal who were the pioneers of the development of geofoam technology. They have implemented the use of geofoam as a lightweight fill material in Norway and also involve in the dissemination of the technology to other countries.

The conference program will be a combination of technical papers and group discussions regarding the use, new development and implementation of geofoam technology. The conference theme will cover but not limited to the present use of geofoam, design specifications, applications, new concepts, material properties, modeling and special topics of geofoam blocks in construction applications.

CONFERENCE THEMES

Dedication:

Papers about Tor Erik Freydlund and Geir Refsdal's achievements on the development of geofoam technology

Present use of Geofoam:

Reports by members of the International Organizing Committee on known applications, type of projects and volumes.

Expanded Polystyrene:

Chemical composition and production process
Index properties
Product control
Durability

Material properties and modeling:

Model studies
Dynamic properties
Fatigue

Design specifications:

International standards
National specifications
Seismic design

Construction applications:

Roads, Railroads and Airports
Buildings and Industrial plants
Landscaping
Settlement mitigation
Load reduction on buried culverts
Failures

New concepts and special topics:

Innovative use of Geofoam blocks
Avalanche protection
Disaster prevention - climate change
Re-use/recycling of Geofoam blocks

Organizing Secretariat

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Visit www.dekon.com.tr for more information

World Tunnel Congress 2017 Surface challenges – Underground solutions, 9 to 16 June 2017, Bergen, Norway, www.wtc2017.no

EUROCK 2017 Human Activity in Rock Masses, 13-15 June 2017, Ostrava, Czech Republic, www.eurock2017.com

BCRRA 2017 Tenth International Conference on the Bearing Capacity of Roads, Railways and Airfields, 28th to 30th June 2017, Athens, Greece, www.bcrra2017.com

GeoMEast2017, 15 - 19 July 2017, Sharm El-Sheik, Egypt, www.geomeast2017.org

3rd International Conference on Performance-based Design in Earthquake Geotechnical Engineering (PBD-III), July 16 - 19, 2017, Vancouver, Canada, http://pbdiiivancouver.com

19th International Conference on Soil Mechanics and Geotechnical Engineering, 17 - 22 September 2017, Seoul, Korea, www.icsmge2017.org

GeoAfrica 2017
3rd African Regional Conference on Geosynthetics
9 – 13 October 2017, Morocco

11th International Conference on Geosynthetics (11ICG)
16 - 20 Sep 2018, Coex, Seoul, Korea
csyoo@skku.edu

http://people-x.com/webmail/11ICG/m-e01.htm

10th Asian Rock Mechanics Symposium - ARMS10
October 2018, Singapore

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AFTES International Congress
"The value is Underground"
13-16 November 2017, Paris, France
www.aftes.asso.fr

AFTES, the French Tunnelling and Underground Space Association, is organising its 15th International Congress, to be held at the Palais des Congrès convention centre, at Porte Maillot, Paris, from 13 to 16 November 2O17.

The congress with the general theme of «The value is underground» (L'espace souterrain, notre richesse), will highlight the latent value of underground space as a means of developing our living spaces, especially if urban planning harnesses it to establish a symbiosis between ground-level and underground. It will also focus on the abundance of, and the necessity of interweaving know-how and disciplines that are crucial to providing those spaces with a sustainable life.

This topic will be explored over the first three days, in conferences focusing on the optimisation of projects and innovation as from their design phase and through to their construction and equipment with the aim of optimising the operation of actual underground structures and the services and companies they accommodate. The fourth day will be dedicated to underground urban development and the architecture of subsurface structures. A competition will also be organised for architecture and engineering students on the topic of «Underground, breathing space for the cities of tomorrow» (Le sous-sol, la respiration des villes de demain).

For the first three days, emphasis will also be placed on an exhibition reserved for professionals, bringing together all the players in the field, including project owners, developers, contractors, engineers, architects, urban planners, academics, builders, suppliers and operators. Local government representatives will play an active part in this event, against the backdrop of the launch of Grand Paris worksites which will be visited. Strong delegations from outside France are also expected, especially with the holding of the 2O17 Tunneling Awards ceremony during the Congress.

AFTES invites you to take part in this congress and to keep up-to-date with information released about this event, including notably details of its programme and logistics, on the AFTES website. You are invited to back this event as a sponsor or partner for the duration of the Congress in order to promote and showcase your activities.

We look forward to seeing you and your colleagues at this Congress which is your event.

TOPICS

Topic A

Developing underground space, value to be conquered and harnessed

Demonstrating the relevance and usefulness of a project is of paramount importance, especially when it involves developing underground spaces which call for major investments. This topic is aimed at decision-makers and designers, who are invited to explain their vision and solutions in the face of the constraints and reticence they have to overcome: integrating these structures into a complex environment, the quality of constructions, pleasantness of underground spaces created and project costeffectiveness. The following sub-topics may be covered with reference to feasibility studies, projects carried out and feedback:

- Intregrating transport infrastructure into urban settings
- Creating and offering high-quality, safe and sustainable underground spaces providing innovative solutions to site constraints
- Demonstrating the socioeconomic benefits of underground construction

Topic B

Optimising projects, bringing out tomorrow's value

This topic targets players in the design field who have the job of proposing suitable solutions to the challenges of underground construction. Project optimisation entails the study of sites (geological surveys of sites and their vicinity), design (optimisation of spaces and structures: excavation methods, supports and linings) as well as contractual and project management aspects. The specific question of overall cost is highlighted, as the vision of project owners should go further than the initial construction phase. Optimisation in keeping with a long-term vision also meets some sustainable development requirements. The following sub-topics may be covered:

- Planning projects while integrating surveys and environment-related constraints
- Optimising the design of spaces and structures
- Maximising opportunities and managing risks (risk management, insurances)
- Controlling costs with a long-term view: overall cost

Topic C

Capitalising the wealth of feedback and innovating

Contractors, urban planners, architects, project managers and project owners are invited to share their experiences, as regards their successes and also difficulties they have encountered in constructing underground structures. Special emphasis will be placed on innovative solutions. The following topics may be covered:

- Specific challenges related to underground engineering works on urban sites
- Innovative solutions for underground engineering works - Feedback on underground cities worldwide
- Architects, urban planners and engineers tackling innovation in the field of underground spaces

Topic D

Harnessing and preserving the value of underground heritage

Underground structures constitute an invaluable heritage. They must be equipped with complex systems to ensure

their safe and efficient operation. Players contributing to their maintenance and operation are invited to discuss strategies for their operation, servicing, renovation, monitoring and maintenance, as well as innovative solutions that can be implemented to monitor, improve and preserve this heritage.

- Equipping and operating underground cities
- Monitoring and maintaining underground structures
- Renovating structures and diversifying and developing their uses

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World Tunnel Congress 2018
20-26 April 2018, Dubai, United Arab Emirates

EUROCK 2018
22-26 May 2018, Saint Petersburg, Russia

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16TH EUROPEAN CONFERENCE ON
EARTHQUAKE ENGINEERING THESSALONIKI 18 - 21 JUNE 2018
www.16ecee.org

Το Ελληνικό Τμήμα Αντισεισμικής Μηχανικής βρίσκεται στην ευχάριστη θέση να πληροφορήσει τα μέλη του αναφορικά με την ανάληψη της διοργάνωσης του **16ου Ευρωπαϊκού Συνεδρίου Αντισεισμικής Μηχανικής** που θα πραγματοποιηθεί στην Ελλάδα και ειδικότερα στη **Θεσσαλονίκη** κατά το διάστημα **18-21 Ιουνίου 2018**.

Το Συνέδριο αυτό συμπίπτει με τη συμπλήρωση 40 χρόνων από τον σεισμό του 1978 που έπληξε την περιοχή της Θεσσαλονίκης και αποτέλεσε, μαζί με τους σεισμούς της Καλαμάτας και των Αθηνών που ακολούθησαν, την αφετηρία της εξέλιξης και σημαντικότατης προόδου της σεισμικής μηχανικής στη χώρα μας.

On behalf of the Hellenic Society of the European Association for Earthquake Engineering and Aristotle University of Thessaloniki, I have the great pleasure to invite you to the 16th European Conference on Earthquake Engineering (16thECEE), to be organized in Thessaloniki, Greece between 18 and 21, June, 2018.

In the light of the previous successful conferences we have committed ourselves to deliver a well-tailored and focused event of the highest scientific and organizational standards in a vibrant and friendly city renowned for its beauty, its warm hospitality and history, spanning more than 2000 years.

We are working hard to organize the conference around a breadth of state-of-the-art scientific topics. In Thessaloniki, earthquake and geotechnical engineers, geologists and seismologists from all over the world will find an excellent forum to exchange ideas, share knowledge and discuss the most recent advances in soil dynamics, structural earthquake and geotechnical engineering, up to the boundaries of geology and engineering seismology. Distinguished Invited keynote lecturers will present recent and ongoing developments, addressing unresolved issues and projecting ideas for the future. Workshops and round table discussions will also be carefully organized on selected topics of particular engineering and societal interest to broaden the horizons of the earthquake engineering community and to reinforce international cooperation links.

A varied and colorful schedule of activities will be made available to participants and accompanying persons before, during and after the conference to providing opportunities to experience the great culture, high quality touristic service and the magnificent natural beauty of Greece and Thessaloniki: a city where everything is within walking distance. You will have the chance to savour the renowned Greek hospitality, the pleasant weather and exquisite food, the beautiful nearby beaches and mountains. In a place where you find history around every corner, the unique archaeological sites and cultural events will certainly give you the opportunity to combine professional interests with a taste of the Greek way of life.

We are sure that you will find participation in 16th ECEE professionally rewarding, scientifically stimulating and personally enjoyable. We look forward to welcoming you to Thessaloniki in June 2018.

Kyriazis Pitilakis
Chairman of 16thECEE

The purpose of the Conference is to provide the perfect platform to present and discuss the recent progress in

Earthquake Engineering along with priority issues of global importance in seismic risk reduction, preparedness and management.

Topics

- Seismic Hazard, Engineering Seismology and Strong Ground Motion
- Soil Dynamics
- Site Effects and Microzonation Studies
- Geotechnical Earthquake Engineering
- Soil-Foundation-Structure Interaction
- Performance-Based Design of Structures
- Laboratory, In-Situ Testing and Structural Health Monitoring of Structures
- Large Scale Facilities for Earthquake Engineering purposes
- Seismic Design and Analysis of Reinforced Concrete Buildings
- Seismic Design and Analysis of Steel Structures
- Seismic Design and Analysis of Masonry Buildings
- Seismic Design and Analysis of Bridges
- Seismic Design and Analysis of Special Structures
- Seismic Retrofit and Strengthening of Structures
- Tsunamis and Risk Assessment of Structures and Infrastructures
- Seismic Performance and Retrofit of Historical Monuments
- Active and Passive Structural Control Systems
- Lifeline Earthquake Engineering
- Risk Assessment of Critical Buildings, Infrastructures, Utility Systems and Industrial Facilities
- Economic and Societal Models for Earthquake Loss Assessment and Mitigation
- Civil Protection and Earthquake Risk Mitigation Policies and Methodologies
- Eurocode 8 and Seismic Design Codes
- Lessons from Recent Earthquakes
- New Generation, Performance and Resilience Based Design of Structures and Systems

CONTACT

For any further questions regarding the 16thECEE please contact.
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4th International Symposium on Cone Penetration Testing
21-22 June 2018, Delft, Netherlands
www.cpt18.org

Technical Committee TC102 of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) and Delft University of Technology are pleased to announce the 4th International Symposium on Cone Penetration Testing, CPT'18. CPT'18 will be held on 21 and 22 June 2018, in Delft, the Netherlands, following the previous successful symposia in Linkoping, Sweden (1995), Huntington Beach, California (2010) and Las Vegas, Nevada (2014).

CPT'18 will focus on the solution of geotechnical challenges using the cone penetration test CPT, CPT add-on measurements and companion in-situ penetration tools (such as full flow and free fall penetrometers), with particular emphasis on practical experience and application of research findings. As CPTs play a major role in geo-engineering, CPT'18 will bring together the world's experts who are working to improve the quality and reduce the difficulties involved. The symposium will be attended by academics, researchers, consultants, practitioners, hardware/software suppliers, certifiers and students. It will be a unique opportunity for meeting people and sharing high-level knowledge.

The main themes of CPT'18 are:

1. Equipment, Testing and Procedures

   Aspects regarding equipment, testing and procedures – including both well-established and novel equipment.
2. Interpretation of Test Results

   Aspects of interpretation, from theoretical to empirical, including case histories and numerical simulation.
3. Solution of Practical Problems

   Application of test results, including onshore/offshore geohazards, foundations, embankments, slopes, tailing dams, geo-environmental and seismic design

The symposium venue at Delft University of Technology is only a short walk away from the lovely city centre of Delft, which is one of the main touristic attractions in the Netherlands. Participants are warmly recommended to extend their stay and bring families and friends.

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Questions on registration: Registration@cpt18.org
Questions on abstracts/papers: Papers@cpt18.org

UNSAT2018 The 7th International Conference on Unsaturated Soils, 3 - 5 August 2018, Hong Kong, China, www.unsat2018.org

11th International Conference on Geosynthetics (11ICG)
16 - 20 Sep 2018, Seoul, South Korea
csyoo@skku.edu

ARMS10
10th Asian Rock Mechanics Symposium
ISRM Regional Symposium
October 2018, Singapore

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14th ISRM International Congress
2019, Foz de Iguaçu, Brazil

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ISDCG 2019
7th International Symposium on
Deformation Characteristics of Geomaterials
26-28 June 2019, Strathclyde, Scotland, UK,

Organizer: TC101

The 17th European Conference on
Soil Mechanics and Geotechnical Engineering
1st - 6th September 2019, Reykjavik Iceland
www.ecsmge-2019.com

The theme of the conference embraces all aspects of geotechnical engineering. Geotechnical engineering is the foundation of current as well as future societies, which both rely on complex civil engineering infrastructures, and call for mitigation of potential geodangers posing threat to these. Geotechnical means and solutions are required to ensure infrastructure safety and sustainable development. Those means are rooted in past experiences enhanced by research and technology of today.

At great events such as the European Geotechnical Conference we should: Spread our knowledge and experience to our colleagues; Introduce innovations, research and development of techniques and equipment; Report on successful geotechnical constructions and application of geotechnical design methods, as well as, on mitigation and assessment of geohazards and more.

Such events also provide an opportunity to draw the attention of others outside the field of geotechnical engineering to the importance of what we are doing, particularly to those who, directly or indirectly, rely on our services, knowledge and experience. Investment in quality geotechnical work is required for successful and safe design, construction and operation of any infrastructure. Geotechnical engineering is the key to a safe and sustainable infrastructure and of importance for the society, economy and the environment. This must be emphasized and reported upon.

ΕΝΔΙΑΦΕΡΟΝΤΑ ΓΕΩΤΕΧΝΙΚΑ ΝΕΑ

GEER responds to the 2015 Kfarnabrakh rock-slide

GEER responds to the 2015 Kfarnabrakh rockslide, based on the message by Professor Chadi El Mohtar.

Dear Geotech Colleagues,

During the early hours of November 30th, 2015, the mountain town of Kfarnabrakh experienced a major land-slide at one of the town's rock cliffs. Kfarnabrakh is 1,150 meters above the sea level, 45 km south-east of Beirut, and about 30 km away from the Mediterranean seacoast. The landslide was well documented with multiple cellphone vid-eos captured by the local residents (check link at the end of this email) that were later used to finalize the failure mechanism. The rock cliffs are located at the north-northeast edge of the village with houses constructed within few meters of the cliff edges. Seventeen houses were evacuated and the families were provided temporary housing until the stability and safety of the sliding zone is assessed.

In response to this extreme event, a recon team sponsored by the NSF-sponsored Geotechnical Extreme Events Reconnaissance (GEER) Association and the Lebanese National Council for Scientific Research (NCSR-L) authorities, had multiple visits to the location of the landslide and collected information from the local residents on the events of the day of the failure. In addition, the team explored the area and checked for possible locations of future breakoffs. A drone was used for aerial photography acquisition and a Digital Surface Model was generated for the area of interest. Geologic and hydrogeological maps of the area were used to help understand the cause of failure. Rainfall and seismic records didn't show any major events in the days leading to the failure. The failure occurred in the C3 formation, a highly jointed chalky limestone. The C3 formation has an embedded thin layer (about 0.3-0.5m thick) of high plasticity Blue Marl clay located 20-25 m. from the top of the formation.

The GEER report is available at:
http://www.geerassociation.org/component/geer_reports/?view=geerreports&id=74&layout=default

The YouTube video of the landslide occurring can be seen at
https://www.youtube.com/watch?v=1qTtrICtT-A&feature=youtu.be

A YouTube video of the area generated from the drone images can be seen at:
https://www.youtube.com/watch?v=MPZiwozwMOs

We invite you all to take a look. Chadi El Mohtar, Grace Abou-Jaoude, Chadi Abdallah and Jacques Harb.

The news item is based on the message by Professor Chadi El Mohtar

(Geoengineer, Monday, 28 March 2016,
http://www.geoengineer.org/news-center/news/item/1380)

Airport Runway Redesign with Geosynthetic Reinforcement

In 2015, the 10-28 runway at Guadalajara International Airport in Mexico began to exhibit signs of stress fracture due to the high shear stresses placed upon it by air traffic. Runway repair was needed, but the client needed an efficient solution to minimize downtime. A long-term geosynthetic reinforcement and pavement rehabilitation solution was implemented.

Guadalajara is Mexico's second-largest city, and Miguel Hidalgo y Costilla Guadalajara International Airport is the secondest-largest cargo airport and third-busiest passenger airport in the country.

Opened in 1966, it is located 16km south of the city centre and is composed of two runways and one terminal. The site serves as a major connection airport. It hosts hubs for Aeroméxico and Volaris, which make it a primary gateway to the United States.

When the stress fraction issue was detected in the runway, the client Constructora y Pavimentadora Vise sought an immediate solution to ensure safe operations for aircraft manoeuvring.

Maccaferri de Mexico were approached to propose a suitable pavement rehabilitation solution.

Among the factors that needed to be considered included the loss of operational revenue, cost of repair or replacement, and liability of aircraft damage due to the poor or failing pavement.

The geosynthetic reinforcement solution proposed involved resurfacing the existing runway with the introduction of an asphalt interlayer reinforcement grid, MacGrid® AR. The interlayer product relieves stress concentrations in the asphalt matrix. Stress is redistributed and absorbed into the reinforcing geogrid.

Without a stress-relieving interlayer, cracks within the sub-base can quickly reflect back up into the new resurfacing layer, compromising it and reducing the anticipated service life. This reflective cracking phenomenon is countered by an asphalt reinforcing geogrid with high tensile strength and low elongation.

The existing pavement was milled and cleaned to remove surface irregularities before the 100kN and 200kN MacGrid® AR products were deployed. These were lightly rolled using appropriate equipment, before an 8 cm dense asphalt layer was placed and compacted onto it. Afterwards, a thin SMA wearing course was applied.

The geogrid solution is made from glass fibres coated in an elastomeric polymer, designed to protect the glass fibre strands during paving and to maintain cohesion with the bitumen.

The newly reinforced pavement is now able to absorb the tensile stresses caused by air traffic, mitigate rutting and increase fatigue life. The result is that the operational integrity of the airfield pavement is restored and a safe passage provided for all those who use it.

This technique enabled a reduction in the thickness of construction materials needed to maintain performance and fatigue life; not only a cost saving, but a reduction in the carbon-footprint of the solution.

(Chris Kelsey /geosynthetica.net, April 7, 2016, http://www.geosynthetica.net/airport-runway-redesign-geogrid-reinforcement)

Το πεντάστερο ξενοδοχείο που χτίζεται μέσα σε λατομείο

Θα έχει δύο υπέργειους ορόφους και... 17 υπόγειους

Η Κίνα κατέχει αναμφίβολα το προβάδισμα στην «κούρσα» του κατασκευαστικού τομέα, «σηκώνοντας« ουρανοξύστες, σπίτια, ακόμα και ολόκληρες πόλεις με ταχύτητα που εντυπωσιάζει τον κόσμο όλο.

Όπως φαίνεται οι Κινέζοι γίνονται ολοένα και πιο εφευρετικοί στον τομέα αυτό, κατασκευάζοντας τώρα ένα πεντάστερο ξενοδοχείο μέσα σε εγκαταλελειμμένο λατομείο.

Οι εργασίες βρίσκονται σε εξέλιξη για την ανέγερση του ξενοδοχείου InterContinental Shimao στο βουνό Tianmenshan στα ανατολικά.

Το συγκρότημα των 430 εκατομμυρίων ευρώ σχεδίασε η βρετανική εταιρεία Atkins και θα διαθέτει 370 δωμάτια σε 19 ορόφους. Απευθύνεται προφανώς στην κινεζική ελίτ.

Μόνο δύο από τους ορόφους θα είναι πάνω από την επιφάνεια της γης, οι υπόλοιποι 17 θα είναι υπόγειοι. Οι δύο τελευταίοι θα είναι κάτω από το νερό και θα διαθέτουν ενυδρείο, εστιατόριο και χώρους φιλοξενίας.

Το ξενοδοχείο θα έχει επίσης πισίνα και χώρο άσκησης, πολλά εστιατόρια και συνεδριακούς χώρους.

Η Atkins σχεδίασε το ξενοδοχείο με στόχο η κατασκευή να ενσωματώνεται στον περιβάλλοντα χώρο με οικολογική «πράσινη» ταράτσα όπου θα φυτευτούν πολλά δέντρα.

Η κατασκευή αναμένεται να ολοκληρωθεί το 2017 και η διαμονή θα κοστίζει από 250 ευρώ τη βραδιά.

(newsbeast, 07.04.2016, http://www.newsbeast.gr/travel/arthro/2195827/to-pentastero-xenodochio-pou-chtizete-mesa-se-latomio)

Future tracks: A tale of two technologies

This week I had the pleasure of attending two very different media events, showcasing two very different technologies. One will help transform London and the South East, while the other has implications for the entire planet. Both of them are promising big things for the future.

On Wednesday, I descended the depths of Crossrail's Fisher Street shaft to get a glimpse of how the project's central section is progressing. The Fisher Street site – located two minutes from Holborn Tube station – is Crossrail's floating track slab (FTS) construction hub. FTS will be laid at two key points beneath the capital to minimise noise and vibration; at Barbican, to protect the theatre from disturbance; and at Soho, where recording studios and arts venues will be insulated from the 30 passing trains per hour.

Having visited Crossrail's Farringdon site last year, I already had a good idea of the scale of the tunnels. But the project has progressed a great deal since the 26 miles of twin-bore shafts were completed in May 2015, and is now at a stage where one can see the finished article slowly emerging. Tunnels and stations are in the process of being fitted out with all the necessary infrastructure and systems required for the Elizabeth line to begin operating in December 2018. This includes track, ventilation, high-voltage power, signalling, communications and overhead line equipment.

The Fisher Street ventilation shaft

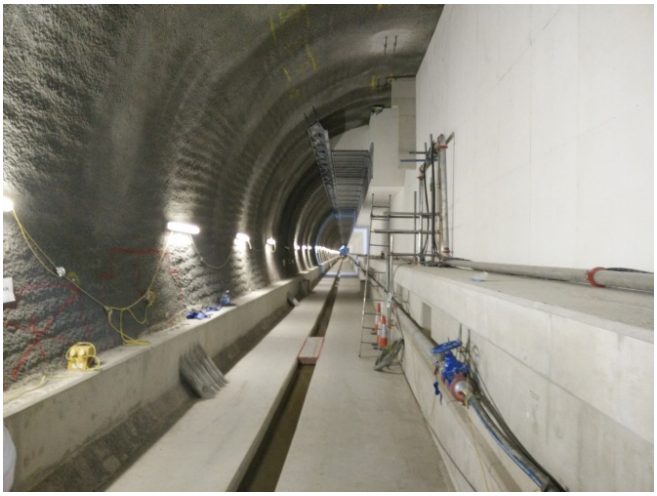
According to the Crossrail overlords, the project is now over 70 per cent complete. More than 10km of track has been laid beneath South East London, with work from the east now approaching my local area of Stepney Green. In the west, track installation started in March and is moving towards the new Paddington and Bond Street stations. All track work is due to be finished in 2017.

Over 10km of track has already been laid

Our visit brought us through the tunnels from Fisher Street towards Soho, past the recently constructed westbound Tottenham Court Road platform. While there's clearly still plenty of work to be done, it was also surprisingly thrilling

to see a key element of the Crossrail network begin to take shape. Tottenham Court Road is where Crossrail 2 will eventually intersect with the first line, and it's fascinating to envisage what the station will look like – both above and below ground – in 20 years time when both lines are operational. I recently spoke with Crossrail 2 chief Michèle Dix about that project's evolution, and the interview will appear in the forthcoming issue of *The Engineer*.

Earlier in the week I visited Imperial College London to learn about a slightly less extravagant, but no less impressive, technology project. Imperial is the UK home of Indian company Carbon Clean Solutions Limited (CCSL), which has developed a new patented solvent that it claims could transform the carbon capture industry.

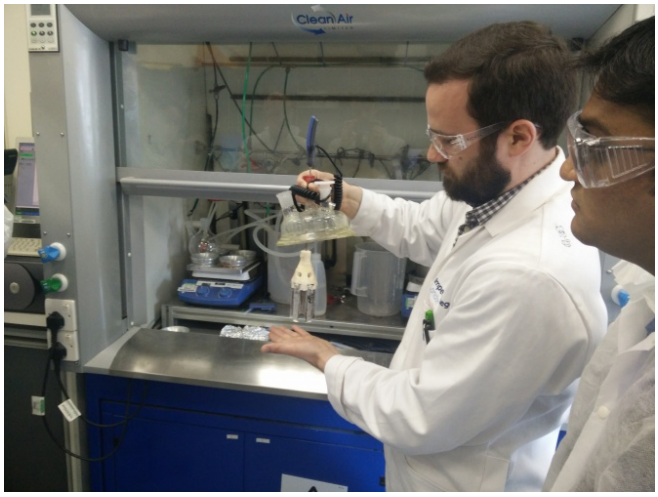


The platform at Tottenham Court Road station is beginning to take shape

Carbon capture and storage (CCS) has not had a good time in the UK of late, with Drax pulling out of the White Rose project last September, and the government scrapping its £1bn funding for CCS two months later. Decarbonisation is a vital long-term goal, but immediate investment in CCS will be crucial to remain on track for limiting global temperature rises to 2°C. This week Myles Allen, a professor of climate dynamics at Oxford University, outlined how CCS is a necessary "backstop" and the only way to bring net carbon emissions down to zero.

Imperial's working carbon capture test plant

But up until now carbon disposal has been seen as uneconomical, with large amounts of energy required to separate CO2 from the solvents used to capture it. Current CO2 capture costs around $60 per tonne. However, CCSL claims its APBS solvent could help drive this down to as little as $10 a tonne by 2018, making commercial CCS a real possibility. In November last year it began a test programme at Technology Centre Mongstad in Norway, the world's largest CO2 capture demonstration plant. CCSL says its solvent provided a 20 per cent reduction in energy costs, with eight times less solvent lost in the process and a seven times reduction in corrosion to the capture plant equipment.



CCSL says its product is 20 per cent more energy efficient than current solvents

The company is working with power and utilities operators in other countries, but CEO Aniruddha Sharma said that conversations in the UK have so far been with industrial players. For heavy industry such as cement and steel, carbon capture is the only path to cutting emissions, and CCSL's technology could help the sector avoid costly carbon taxes in the future. For now, it seems, this is an investment that the government appears reluctant to make. With Crossrail coming in at just under £15bn – and Crossrail 2 expected to cost double that – the £1bn recently axed from CCS development looks like short-sighted penny-pinching that could have far-reaching consequences.

(Andrew Wade / theengineer, 8th April 2016, http://www.theengineer.co.uk/future-tracks-a-tale-of-two-technologies/?cmpid=tenews_2191669)

VIDEO: Rockfall Protection Wall in Val d'Isère

Last year Geosynthetica profiled NAUE's rockfall protection wall design in Val d'Isère, a renowned winter sports region in Southeastern France. Now, the company has released video of the construction and finished work (https://www.youtube.com/watch?v=ZzG3s2htluk).

The geosynthetic reinforcement project enabled the Val d' Isère area, situated at 1800m above sea level, to host World Cup skiing this past winter.

The Val d'Isère Project

The lower 5m of the construction includes angles up to 79°. Four grades of geogrids were used to meet the reinforcement requirements of the differently angled sections.

The upper 7m of the wall is set at 45° (1:1). The NAUE m^3 system, diagrammed here, is designed for landslide protection and slope stability up to 50°, making it an efficient choice for the top section of the construction

For the district of La Daille, boulders had increasingly broken away from the mountainside and rolled or plunged directly onto the RD 902 main road. These geohazards occasionally fell with enough energy to reach buildings in the village. The existing rockfall-protection strategies needed to be updated.

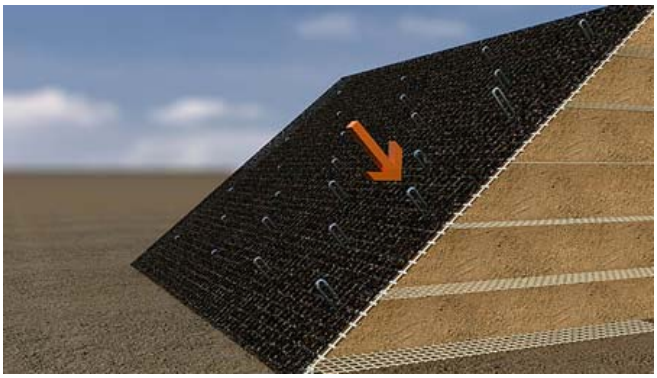
The particular challenge was to build a strong rockfall protection wall as high as possible within the limited roadside space. A steep structure was required, and it had to meet the aesthetic requirements of the resort area. The structure also needed to utilize local soils (ecological and economical benefits).

The design calculations and the execution plans for the entire construction project (with a length of 150m) were drawn up by the consultants BBG Bauberatung Geokunststoffe, Germany.

NAUE reinforcement geosynthetics were specified.

Constructing the Rockfall Protection Wall

The uphill face of the structure was given a slope angle of 65° and a maximum height of 7m. The slope facing was constructed using tires, which provided robustness against rockfall impact. Secugrid® geogrids were installed every second layer of tires, with a vertical spacing of 660mm.



On the face adjacent to the road, the wall was built to approximately 12m at its highest. The lower 5m of the structure was sloped at approximately 79°. Here, Secugrid® geogrids were laid with a vertical spacing of 680mm. The facing element consisted of two layers.

The geogrids were wrapped around and a filter nonwoven was incorporated to prevent soil erosion. In front of this, an approximately 300mm-thick stacked rock facing gave the structure the aesthetic finish the site owners requested.

Permanent shuttering made of galvanized steel mesh was used over the total facing.

The upper part of the wall, with a height of up to 7m, was executed as a steep slope with an inclination of 45° (1:1). The NAUE m^3 system ensured the stability of this steep slope through utilization of Secugrid® layers at a vertical spacing of 660mm. The vegetated surface was protected using erosion-protection mats.

Four different grades of NAUE Secugrid® were installed in Val d'Isère: Secugrid® 200/40 R6, Secugrid® 150/40 R6, Secugrid® 80/20 R6, and Secugrid® 40/20 R6.

(Chris Kelsey / geosynthetica.net, April 20, 2016, http://www.geosynthetica.net/video-rockfall-protection-wall-france)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΣΕΙΣΜΟΙ

AERIAL SURVEY
Dramatic drone footage of earthquake damage on Japan's Kyushu island

An earthquake-caused landslide in the town of Minamiaso, in the Kumamoto prefecture of southern Japan

In the past five days, a pair of powerful earthquakes and hundreds of aftershocks have rippled through Japan's Kyushu island. The first one struck on Thursday night, followed by another on Saturday morning, with magnitudes of 6.2 and 7.0, respectively. Many of the aftershocks—over a hundred—have been strong enough to damage buildings on their own.

Kyushu Island

To survey the situation, the Geospatial Information Authority of Japan deployed drones over the affected area, in part because roads and rail lines have been wiped out. It also shared some of the footage to help rescue efforts.

The most dramatic video shows the destructive force of an earthquake-caused landslide near the mountain town of Minamiaso. In it a massive column of soil and rock has wiped out a stretch of road and rail track, along with a bridge (start at the 5:15 mark to best see the damage to transportation infrastructure):
https://www.youtube.com/watch?v=C52Niq2jNdI

The rail line connects Kumamoto Station with Oita Station, and fixing it—along with the road and bridge—will obviously take a great deal of work. Bullet trains and other types of rail service, as well as flights, have been suspended in the area.

Another video patiently traces a peripheral fault line as it indiscriminately cuts through farmland, cliffs, and roads: https://www.youtube.com/watch?v=DXTAAvVB2M8

More than 40 people were killed, hundreds injured, and many thousands evacuated to shelters. Authorities have instructed more than a quarter million people to leave their homes for fear of further quakes, as some 30,000 rescue workers look for survivors trapped under collapsed homes and landslides.

Major Japanese companies reported manufacturing stoppages, among them Sony, Honda, and Toyota. Ironically, many companies set up factories in Kyushu island's Kumamoto prefecture because it's usually less prone to earthquakes (paywall).

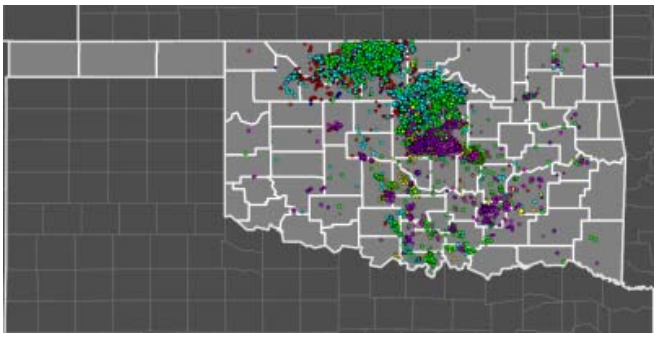
The quakes were the most powerful to hit Japan since a huge one (magnitude 9.0) struck in 2011, killing thousands and causing a tsunami that triggered a third crisis at the Fukushima nuclear plant.

http://qz.com/663944/dramatic-drone-footage-of-earthquake-damage-on-japans-kyushu-island

Visualization of Oklahoma's Induced Earthquakes

As many of us earth and atmospheric scientists already know, seismic activity in Oklahoma has increased dramati-

cally since 2009. This increase in earthquakes seems to be common knowledge. However, I was curious about some of the specific details and statistics surrounding this new phenomenon. According to the Oklahoma Geological Survey, or OGS, the northwest and central part of the state, which has historically had a low rate of seismic activity, has seen seismic activity rates jump by nearly 600% between the years 2009 – 2016 compared to the rate of activity from 2007 and earlier. I recently attended to the 22nd Annual 3D Seismic Symposium in Denver, CO, where the director of the OGS, Dr. Jeremy Boak, gave a presentation about the seismology of induced, or human caused, earthquakes in Oklahoma and how this new trend was effecting the state.



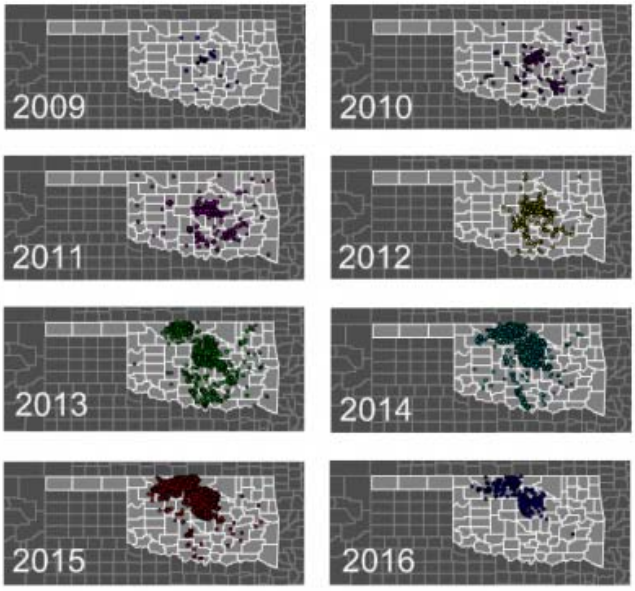
Earthquake events in Oklahoma from 2009 - present mapped in Surfer color-coded by year.

Over the past several years there has been discussion about the cause of the increase of the earthquake events, where most individuals seem to speculate that the events in Oklahoma have been caused by induced seismic activities associated with oil and gas exploration, namely fracking. According to Dr. Boak, many of the plays in central and northwest Oklahoma are deep carbonite plays that require horizontal drilling and use brine injections to increase productivity pressure. These two factors create a large amount of waste water when the oil solids are separated from the brine. The waste water has been typically disposed of deep in the strata via injection wells for permanent storage, mainly in the Arbuckle geological formation. During the presentation, Dr. Boak sites a study done by the OGS where the OGS officially acknowledged the connection between "substantially increased disposal of waste water in the Arbuckle foundation and a ~600-fold increase in the number of earthquakes of magnitude > 3.0."

Of most interest to me, personally, in Dr. Boak's discussion was not the structure where the waste water was being disposed of or how the waste water disposal and the seismic events are related to oil and gas production, but simply the sheer numbers of earthquake events alone across the state since 2009. The number of seismic events is staggering. During the presentation, Dr. Boak showed a time series map of the earthquake events in a 2 dimensional, top-down orientated animation. As a GIS enthusiast, seeing the animation made me naturally think "how could I visualize the quake data from this time period in Oklahoma using Golden Software applications?"

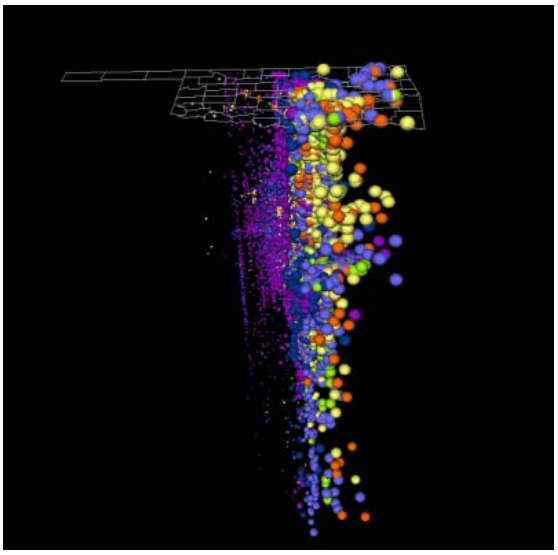
Dr. Boak mentioned a location on one of the OGS servers that contains all of the most recent earthquake event data that is downloadable, which can be found at http://www.ou.edu/content/ogs/research/earthquakes/catalogs.html. The earthquake catalog data, which was going to be a good source for my mapping project, contains a number of different attributes including the latitude and longitude of each seismic event, the depth, the date, and the magnitude of each event. This would prove to be all of the information I needed to create the visualization.

To approach the mapping project, I downloaded the earthquake catalogs in CSV format from the OGS site. In Surfer, our contouring, gridding, and surface mapping software, I decided to create a post map layer for each of the year's earthquake events and overlay them on US boundary files from the Golden Software website that contain the state and county boundaries. I then used the proportional sizing method in Surfer to make the earthquake events' point size based on the magnitude of each event. This resulted in the image above, which seems a little cluttered due to the volume of events. I wanted to generate some comparative maps that show each year's seismic events individually, so I created a new Surfer project that contains 8 different map frames, one for each year. I applied the same proportional symbology to each map frame and used the same base map layers to generate the figure below. As you can clearly see, the volume of events has been greatly increasing since 2009.



Earthquake events in Oklahoma from 2009 - present mapped in Surfer by year for comparison.

For the final portion of the mapping project, I wanted to incorporate the depth of these events by generating a 3D visualization of the earthquakes in Oklahoma. I used Voxler, our 3D modeling software, to visualize the data in true 3D space by creating a classed ScatterPlot where I based the size of each 3D sphere on the magnitude of the event. The earthquake events ranged from the surface to ~15 km deep. In the image below, you can see the most previous 8 years' worth of seismic event data together, creating a very clustered and stunning look at these events.



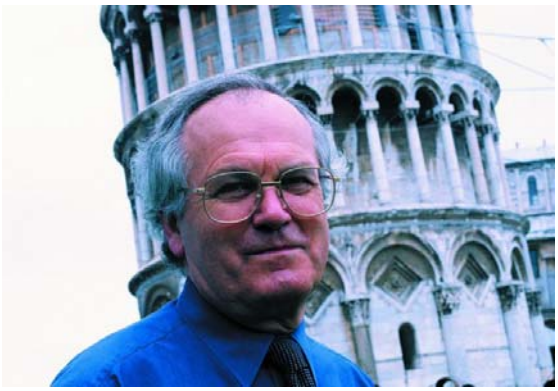
Earthquake events in Oklahoma from 2009 - present visualized in 3D using Voxler color-coded by year.

Take a look at these easy to use mapping and visualization applications for your next mapping project!

(Andrew Dudley / GOLDEN SOFTWARE, Newsletter DATAPOINTS Issue #82 April 2016, http://www.goldensoftware.com/blog/visualization-of-oklahoma-s-induced-earth-quakes?utm_source=Q2_2016&utm_medium=Email&utm_content=OKearthquakes&utm_campaign=Newsletter)

ΕΝΔΙΑΦΕΡΟΝΤΑ – ΛΟΙΠΑ

Imperial engineer recognised by American Academy



Imperial researcher John Burland, who helped to stabilise the Leaning Tower of Pisa, has been elected to the US National Academy of Engineering.

Emeritus Professor **John Burland**, from Imperial's Department of Civil and Environmental Engineering, has been elected as a Foreign Member. Election to the Academy is among the highest professional distinctions accorded to an engineer. Professor Burland was only one of 22 Foreign Members and the only UK engineer to be elected this year.

Professor Burland said: "I only just heard about the news so I am still recovering my composure. At present I feel stunned, surprised and elated! I know that extremely high standards are demanded of individuals for Foreign Membership of the Academy, so this recognition means a great deal to me. Imperial must take the credit for this honour and it is yet another indicator of what a fabulous place this is. I plan to celebrate with the department and I'll also have a family celebration as well, but I know they will make sure that I don't get too big-headed."

Professor Burland's research focuses on engineering challenges related to the interaction between the ground and structures made of masonry. He is responsible for the design of many large engineering projects such as the underground car park at the Palace of Westminster and the foundations of the Queen Elizabeth II Conference Centre.

Professor Burland was also a member of the Italian Prime Minister's Commission for stabilising the Leaning Tower of Pisa from 1990 to 2002. In addition, he was a member of the international board of consultants that advised on the stabilisation of the Metropolitan Cathedral of Mexico City from 1992 to 1998.

Professor Burland was also London Underground's expert witness for the Parliamentary Select Committees on the Jubilee Line Extension and has advised on many geotechnical aspects of that project, including ensuring the stability of the Big Ben Clock Tower.

Professor Burland will attend a ceremony in Washington on 9 October 2016 where he will be formally inducted as a Foreign Member of the National Academy of Engineering.

http://www3.imperial.ac.uk/newsandeventspggrp/imperialcollege/newssummary/news_10-2-2016-9-12-41

Dubai Plans Earth's Tallest Skyscraper, Inspired by the Hanging Gardens of Babylon

Aside from a few ancient texts, there's no conclusive proof the Hanging Gardens of Babylon (one of the seven wonders of the ancient world), actually existed. Still, Emaar Properties is building on this mythical "tall tale" as it transforms Dubai's skyline with the world's tallest skyscraper—again.

The Tower will be a centerpiece of Dubai's 2020 World Expo

The Tower, viewed from Dubai Creek Harbour

Emaar, the government-backed developer of the 2,717-foot-high Burj Khalifa (currently the world's tallest building), unveiled plans to construct "The Tower," an even taller Dubai skyscraper whose upper observation decks represent the ancient Hanging Gardens—rumored to have been among the supreme engineering marvels of its time (circa 600 BC). This 8th wonder of the world, scheduled for completion by 2018, will be a centerpiece of the vast Dubai Creek Harbour project and the city's 2020 World Expo.

Designed by Spanish-Swiss neo-futurist architect Santiago Calatrava Valls, the $1 billion glimmering skyscraper will boast at least 20-mixed use floors, a boutique hotel, panoramic restaurants, a "Pinnacle Room" with 360-degree views, VIP observation garden decks that recreate the Hanging Gardens, and rotating balconies that literally extend outside the building. The super-scraper's overall design is influenced by a lily flower and minarets, distinctive features of Islamic culture and architecture, particularly on mosques.

The super-scraper will be designed with gardens and sustainable features.

The Tower's upper observation decks are modeled after the Hanging Gardens of Babylon, one of the seven wonders of the ancient world.

Emaar Properties is redeveloping old Dubai with Dubai Harbour Creek, a community of luxury residences, trendy hotels, galleries, stores, a marina boardwalk, and The Tower.

"This project envisages an artistic achievement in itself, inspired by the idea of welcoming people, not only from Dubai and the UAE, but from the entire world," said Calatrava, who also designed the new World Trade Centre Transportation Hub in New York, Calgary Peace Bridge and the Olympic Sports Complex in Athens. "It is a symbol of an abiding belief in progress."

The project has the seal of approval from Sheikh Mohammed bin Rashid Al Maktoum, the United Arab Emirates' vice president, prime minister and ruler of Dubai. The skyscraper features a super-slim profile with a floating oval-shaped bud ascending to the top observation areas which will be highlighted as a light beacon at night. Even the structural core and tension cables disguised as the delicate veins of lily leaves (which anchor the building to the ground) will showcase dynamic lighting—including kinetic lighting effects.

The Tower will top the apex of Dubai's Burj Khalifa (currently the world's tallest skyscraper, in the background). Its observation decks will be illuminated as a night beacon.

Structural core and tension cables disguised as delicate ribbing of lily leaves anchor the building to the ground.

The Tower complex will integrate sustainability features, including green corridors and an environment-friendly tram service that connects pedestrians to various plaza access points and Dubai Creek Harbour, a 2.3-square mile waterfront development (located near the airport and a renowned wildlife sanctuary) that's two times the size of downtown Dubai.

The Tower is expected to cost approximately $1 billion. It's scheduled to be completed by 2018.

This planned redevelopment of "old Dubai" boasts Emaar-built high-end residences—Dubai Creek Residences, Creekside 18, and most recently, Harbour Views homes in The Island District, a vibrant young neighborhood. Dubai Creek Harbour also comprises a nearby marina, yacht club, event spaces, galleries, retail stores, the trendy Vida hotel, and a 2.8-mile Creek Boardwalk that envelopes The Island District. All areas will boast impressive views of future The Tower.

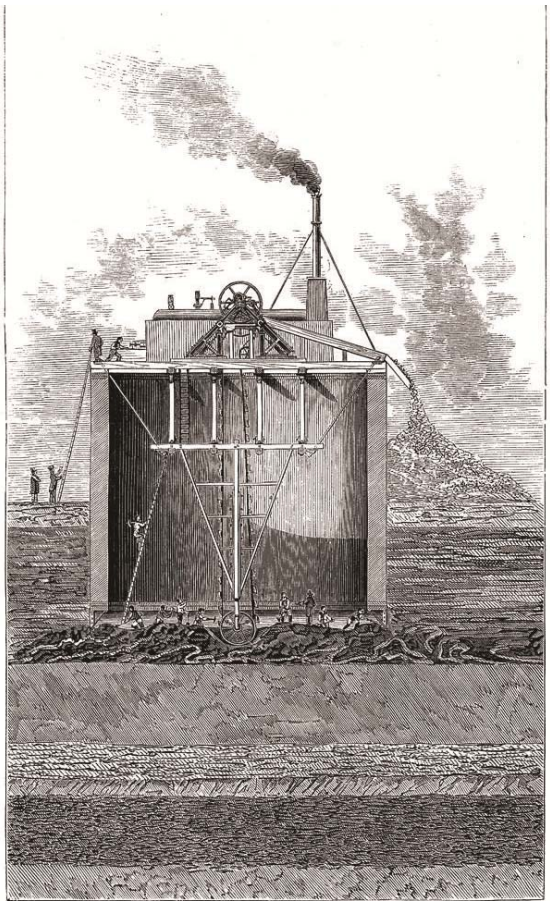
There's no official word on The Tower's final height but it will have stiff competition in the race to the clouds. The Tower's stratospheric apex will compete with its sibling Burj Khalifa (829 meters tall); Saudi Arabia's Jeddah Tower (under construction at 1,008 meters); Iraq's proposed tower "The Bride" (1,152 meters tall); "The Mile," an unattached conceptual green observation deck park (1,609 meters); and Tokyo's proposed Sky Mile Tower (1,699 meters) scheduled for completion in 2045.

(Keith Flamer / Forbes, Apr. 12, 2016, http://www.forbes.com/sites/keithflamer/2016/04/12/dubai-plans-earths-tallest-skyscraper-an-8th-world-wonder-inspired-by-hanging-gardens-of-babylon/#16f432e7295a)

A Marvel of Victorian Engineering Reopens as a Concert Venue in London

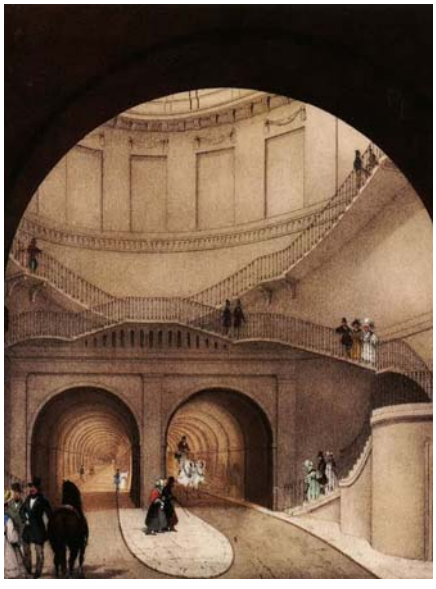
Stairs being installed in the Grand Entrance Hall, part of Isambard Kingdom Brunel's Thames Tunnel.

The influential 19th-century British mechanical and civil engineer Isambard Kingdom Brunel's Thames Tunnel in London was the first underground tunnel to be constructed successfully beneath a navigable river. Built between 1825 and 1843, it was considered a wonder of Victorian engineering, achieved using tunneling shield technology in which an iron shaft 50 feet in diameter was sunk into the banks of the Thames by its own weight as a first step in excavating the space. When the tunnel opened, the *Illustrated London News* called it the eighth wonder of the world.



Section of shaft in process of being sunk

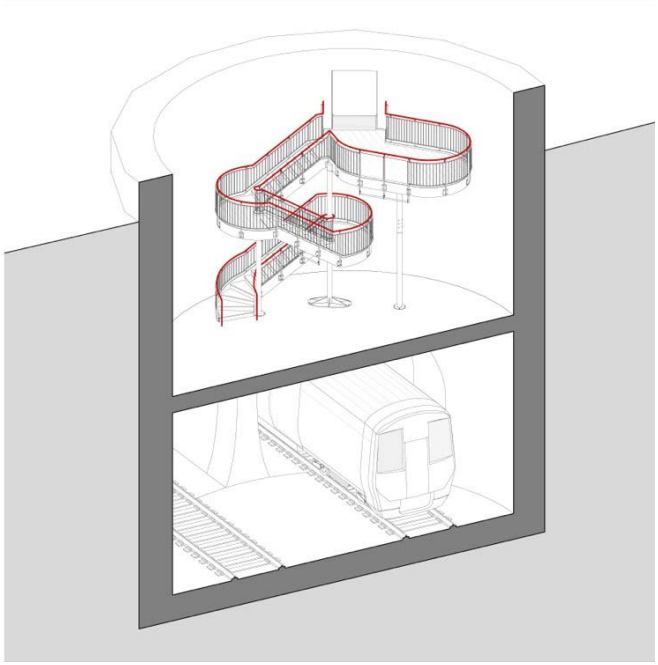
Originally designed for horse-drawn carriages, the historic tunnel became a blockbuster pedestrian thoroughfare and tourist attraction instead (and a brothel after dark) before serving as part of London's underground railway from 1869 to 2007. The tunnel is now used as part of the London Overground suburban rail network.



An illustration of the original 19th-century space.

Back in the day.

And to celebrate and raise awareness of the built legacy of Brunel and his father, Marc Isambard Brunel, who initiated the project, the historic Grand Entrance Hall of the original sinking shaft has been reopened by the nearby Brunel Museum. Once the site of underground banquets and concerts, it's being rebranded as a subterranean performance and event space that just happens to be located in the historic heart of the world's oldest underground rail network.



An illustration showing how part of the tunnel is now used for the London Overground railway network.

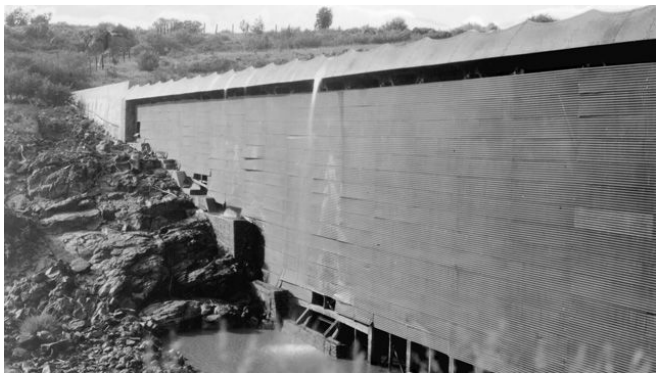
Grand Entrance Hall door.

To make the space more easily accessible to the public, the original Brunel staircase was removed, and a new door and oak and steel staircase designed by architects Tate Harmer architects has been constructed. The freestanding staircase includes a ribbon of red light along the banister that makes it look like a passageway to a rave venue, but the smoke-blackened brick walls have been left untouched.

"We wanted to celebrate the raw nature of the Victorian industrial heritage," Tate Harmer partner Jerry Tate said in a press release, "while providing the public proper access for tours and performances."

(Kristin Hohenadel / SLATE, April 20, 2016, http://www.slate.com/blogs/the_eye/2016/04/20/london_s_thames_tunnel_reopens_as_an_underground_performance_space.html)

Ashfork-Bainbridge Steel Dam, Arizona



View of the dam face in 1922

As you'll find out further into our abbreviated treasury of water-impounding structures, Arizona is a state with a decent number of major dams: Some are named after presidents (Hoover, Roosevelt and Coolidge Dams); some are supported by buttresses (Bartlett Dam) and some by canyon walls (Glen Canyon Dam); some are more famous for the reservoirs that they form (Parker Dam). And then there's Ashfork-Bainbridge Steel Dam, a historic Arizona dam that's in a league of its own.

Completed in 1898 in a far-flung corner of Coconino County, the Ashfork-Bainbridge Steel Dam is, you guessed it, constructed from steel — a wild departure from the concrete and masonry behemoths of the mid-20th century. In fact, the landmark structure, listed on the National Register of

Historic Places in 1976, was the first steel dam ever realized — and one of only two extant steel dams remaining. There was a third in Montana but it failed just a year after its completion in 1908.

The innovative but modestly sized Ashfork-Bainbridge Dam also differs from a majority of other Arizona dams in that in wasn't constructed to control river flooding, produce hydroelectricity or to supply nearby farms with water. Rather, the prefabricated-in-Wisconsin steel plate dam was commissioned by the Atchison, Topeka and Santa Fe Railway (ASTF) to impound floodwater flowing through Johnson Canyon. Blocked by the curious-looking yet totally revolutionary steel structure, floodwater then drained into a pipe that flowed to a water tower in the nearby town of Ashfork where the ATSF had established a crucial water stop for steam locomotives, which required huge amounts of water. So basically, the dam formed a reservoir in the middle of the Arizona desert that helped power trains.

(10 of America's grandest dams by Matt Hickman / mnn mother nature network, April 22, 2016, http://www.mnn.com/earth-matters/wilderness-resources/photos/10-americas-grandest-dams/ashfork-bainbridge-steel-dam-arizona#top-desktop)

The **Ashfork Bainbridge Steel Dam**, the first large steel dam in the world, and one of only three ever built in the United States, was constructed in 1898 by the Atchison, Topeka and Santa Fe Railway (ATSF) to supply water for railway operations near Ash Fork, Arizona. It is named for the town of Ash Fork, and for Francis H. Bainbridge, a civil engineer and graduate of Rensselaer Polytechnic Institute (RPI), who was an engineer for ATSF. The dam has been listed on the National Register of Historic Places since 1976.

The dam was fabricated by the Wisconsin Bridge and Iron Company and shipped to the site in pieces for erection. Construction of the dam began in 1897 and was completed March 5, 1898 at a total cost of US$63,519.

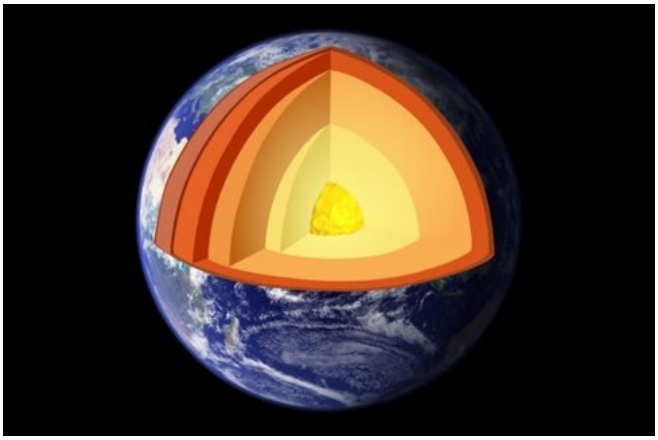
Current view of dam face

The structure gets its scalloped appearance from 24 curved 3/8 inch steel plates (alternately loose and rigid to compensate for a temperature range from 104 °F (40 °C) to minus 4 °F) that slope downstream. The central steel section is 184 feet (56 m) long, 46 feet (14 m) high, and weighs about 460,000 pounds (210,000 kg). No spillway was provided; instead, the dam was designed to withstand overtopping of 6 feet (1.8 m) of water pouring directly over its crest.

It holds about 36,000,000 US gallons (140,000,000 L) of water when full.

(Wikipedia, https://en.wikipedia.org/wiki/Ashfork-Bainbridge_Steel_Dam)

Παράξενα του χρόνου
Στο κέντρο της Γης, το ρολόι πάει 2,5 χρόνια πίσω



Το πρόσωπο της Γης είναι πιο γερασμένο από τον εσωτερικό της κόσμο

Τι ώρα είναι; Η απάντηση ποικίλλει ανάλογα με το βάθος: λόγω της Γενικής Σχετικότητας του Αϊνστάιν, το κέντρο της Γης είναι 2,5 χρόνια νεότερο από το έδαφος που πατάμε, δείχνουν οι τελευταίοι υπολογισμοί.

Όπως προέβλεψε πριν από έναν αιώνα ο Άλμπερτ Αϊνστάιν, ο χρόνος τρέχει πιο αργά όταν η δύναμη της βαρύτητας μεγαλώνει. Και αυτό σημαίνει ότι στην κορυφή ενός βουνού ο χρόνος κυλά πιο γρήγορα από ό,τι στη βάση του, αφού η απόσταση της κορυφής από το κέντρο του πλανήτη είναι μεγαλύτερη και η βαρύτητα μικρότερη.

Το φαινόμενο έχει επιβεβαιωθεί πειραματικά και πρέπει μάλιστα να λαμβάνεται υπόψη στο σύστημα GPS -ο χρόνος κυλά πιο γρήγορα για τους δορυφόρους του συστήματος, και αν αυτή η διαφορά δεν λαμβανόταν υπόψη η απόκλιση στο γεωγραφικό στίγμα θα έφτανε τα πολλά χιλιόμετρα ανά ημέρα.

Όπως επισημαίνουν οι ερευνητές της τελευταίας μελέτης, τη δεκαετία του 1960 ο αμερικανός κβαντικός φυσικός Ρίτσαρντ Φέινμαν είχε υπολογίσει ότι η χρονική απόκλιση ανάμεσα στην επιφάνεια και τον πυρήνα της Γης ήταν μία με δύο ημέρες.

Ο Δρ Ούλριχ Ούγκερχοφ του Πανεπιστημίου του Ώρχους στη Δανία είχε τη σωφροσύνη να διασταυρώσει την εκτίμηση του Φέινμαν πριν την συμπεριλάβει σε ένα σύγγραμμα που συνέτασσε για τους προπτυχιακούς φοιτητές του.

Υπολόγισε έτσι τη διαφορά στο βαρυτικό δυναμικό -ένα μετρο του έργου που παράγει η βαρύτητα μετακινώντας ένα σώμα προς τα κάτω- ανάμεσα στο κέντρο και την επιφάνεια του πλανήτη. Οι υπολογισμοί έδειξαν ότι, για κάθε δευτερόλεπτο που περνάει στην επιφάνεια, ο χρόνος στο κέντρο της Γης υπολείπεται κατά 3×10^{-10} δευτερόλεπτα.

Στα τέσσερα δισεκατομμύρια χρόνια που έχουν περάσει από τον σχηματισμό του πλανήτη, η σωρευτική διαφορά φτάνει περίπου τον ενάμισι χρόνο.

Αυτό, όμως, ισχύει μόνο αν θεωρήσει κανείς ότι η Γη είναι ομοιογενής. Στην πραγματικότητα δεν είναι, αφού ο πυρήνας του πλανήτη αποτελείται κυρίως από σίδηρο και έχει μεγαλύτερη πυκνότητα από τον μανδύα και τον φλοιό. Λαμβάνοντας υπόψη αυτούς τους παράγοντες, οι οποίοι επηρεάζουν το βαρυτικό πεδίο, ο Ούγκερχοφ καταλήγει στην εκτίμηση ότι ένα ρολόι στο κέντρο του πυρήνα θα πήγαινε 2,5 χρόνια πίσω σε σχέση με ένα ρολόι στην επιφάνεια της θάλασσας.

Στην περίπτωση του γιγάντιου Ήλιου, προσθέτει ο ερευνητής, η χρονική διαφορά ανάμεσα στο κέντρο και την επιφάνεια είναι ακόμα μεγαλύτερη, γύρω στα 40.000 χρόνια.

Παραμένει πάντως ασαφές αν ο Ρίτσαρντ Φέινμαν έκανε λάθος στις πράξεις, ή αν η εκτίμησή του μεταφέρθηκε αλλοιωμένη από «χρόνια» σε «μέρες» από άλλους επιστήμονες.

Όπως επισημαίνει ο Ούγκερχοφ στο περιοδικό New Scientist, «θα πρέπει κανείς να είναι πάντα προσεκτικός και να διασταυρώνει τα λεγόμενα ακόμα και των διάσημων ανθρώπων».

Η μελέτη του είναι διαθέσιμη στην υπηρεσία προδημοσίευσης arXiv.

(Βαγγέλης Πρατικάκης / Newsroom ΔΟΛ, 23 Απρ. 2016, http://news.in.gr/science-technology/article/?aid=1500073369&ref=newsletter)

Earth's core is two-and-a-half years younger than its crust

There's a surprise lying deep beneath your feet. Physicists have calculated that the centre of the Earth is two-and-a-half years younger than its surface, thanks to the effects of gravity as described by general relativity.

Fresher in the middle

According to Einstein's theory, your position in a gravitational field changes the rate at which you experience time passing. The idea has been rigorously tested and has an impact on GPS satellites. But the time differences involved here are normally fractions of a second, not a couple of years.

Ulrik Uggerhøj of Aarhus University in Denmark and his colleagues realised the effect would be much more pronounced for Earth after re-examining a claim made by physicist Richard Feynman in the 1960s. In a series of lectures, Feynman claimed that the difference in age between the Earth's centre and surface was about a day or two – a figure often repeated and cited in papers by other physicists, including Uggerhøj.

But when Uggerhøj recently decided to include the anecdote in an undergraduate textbook, he sat down to check the figure himself. The calculation involves working out the difference in gravitational potential – a measure of the work done by gravity in moving a mass from one location to another – between the centre and surface.

Young at heart

Plugging this difference into the equations of relativity gives a time dilation factor of around 3×10^{-10}, meaning every second at the Earth's centre ticks this much slower than it does on the surface. But since the Earth is around four billion years old, the cumulative effect of this time dilation adds up to a difference of around a year and a half.

These calculations assume a uniform density throughout the Earth, which we know isn't accurate since the core is denser than the mantle. Using a more realistic model of Earth's density, Uggerhøj's team found the difference in age is actually around two-and-a-half years.

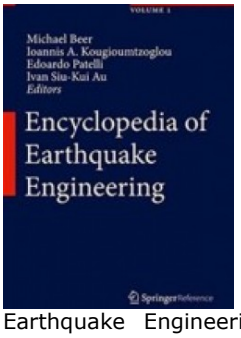
Of course, we can't confirm this number experimentally, says Uggerhøj. But general relativity has passed every test thrown at it so far, so it seems likely to be correct. And since, as far as we know, the theory operates throughout the universe, the same effect occurs for any massive body. The team calculates that the centre of the sun is around 40,000 years younger than its surface.

Uggerhøj says it is unclear whether Feynman made the error originally, or whether the transcription of his lectures somehow garbled "days" into "years", but he says it pays to take nothing for granted. "One should always be cautious and test even famous people's suggestions," he says. "I fell into the trap of not doing it, I must admit."

Reference: arxiv.org/abs/1604.05507

(Jacob Aron / New Scientist, 22 April 2016, https://www.newscientist.com/article/2085599-earths-core-is-two-and-a-half-years-younger-than-its-crust)

ΝΕΕΣ ΕΚΔΟΣΕΙΣ ΣΤΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΠΙΣΤΗΜΕΣ



Encyclopedia of Earthquake Engineering

Editors: M. Beer, I. A. Kougioumtzoglou, E. Patelli, Siu-Kui Au

The scope of the Encyclopedia of Earthquake Engineering covers the interaction between earthquake events and our engineering installations and infrastructures. It is expected to range over buildings, foundations, underground constructions, lifelines and bridges, roads, embankments, and slopes. Although a plethora of references exist in the context of treating/addressing individual earthquake engineering topics, there is no literature dealing with earthquake engineering in a comprehensive, versatile, and unified manner. In this regard, the extreme event of an earthquake has a multifaceted impact on a variety of activities. These include day-to-day operations of public and private services which have greatly increased their exposure to risk.

The Encyclopedia is designed to inform technically inclined readers about the ways in which earthquakes can affect engineering installations and infrastructures and how engineers would go about designing against, mitigating, and remediating these effects. It is also designed to provide cross-disciplinary and cross-domain information to domain experts. Specifically, the proposed work introduces a coupling between traditional topics of earthquake engineering, such as geotechnical/structural engineering, topics of broader interest such as geophysics, and topics of current and emerging value to industrial applications, such as risk management. In this regard, risk management is included in a comprehensive manner, which addresses the dimension and complexity of earthquake hazards. This elucidates the vital connection of the technical contents to the societal context. The main benefit of the Encyclopedia is its breadth of coverage to provide quick information on a substantial level to virtually all groups of readers from academia, industry, and the general population who would like to find out more in the area of earthquake engineering.

Overall, this work is a concerted effort to provide with a holistic perspective on earthquake engineering–related issues of recent currency. Its innovative, modular, and continuously updated form facilitates a potent, self-contained, and readily accessible exposition of multi/interdisciplinary elements in the broad field of earthquake engineering, thus enabling the researcher/practitioner/designer to identify links and potential future research themes in an efficient and timely manner.

(Springer, November 2015)

ΗΛΕΚΤΡΟΝΙΚΑ ΠΕΡΙΟΔΙΚΑ

http://www.issmge.org/en/resources/issmge-bulletin/795-vol-10-issue-2-april-2016

Κυκλοφόρησε το Τεύχος αρ. 2 του Τόμου 10, Απριλίου 2016 του ISSMGE Bulletin της ISSMGE με τα ακόλουθα περιεχόμενα:

- Message from the President
- Message from the Chairs of TOC and CAPG
- Research Highlights

  Geotechnical engineering laboratories, the University of Tokyo, Japan
- Major Projects

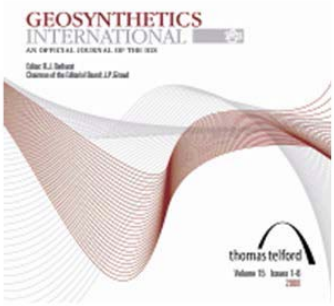
  Utilisation of deep groundwater barrier walls using soil bentonite and biopolymer slurries in geotechnical and environmental applications
- TC Report

  Joint workshop at ECSMGE, Edinburgh
- Conference Reports

  The 12th Australia New Zealand conference on Geomechanics

  The workshop of Seismic Soil Classification, Chile

  Geotechnical seminar "Reading of Gersevanov", Russia
- Event Diary
- Corporate Associates
- Foundation Donors



Content of Volume: 23, Issue: 2 (April 2016)

Laboratory study on the use of EPS-block geofoam for embankment widening, A. T. Özer

Water vapour adsorption and desorption in GCLs, M. A. Rouf, A. Bouazza, R. M. Singh, W. P. Gates and R. K. Rowe

Effects of geogrid encasement on lateral and vertical deformations of stone columns in model tests, M. Gu, M. Zhao, L. Zhang and J. Han

Shear-induced changes in smooth geomembrane surface topography at different ambient temperatures, J. D. Frost and T. Karademir

Cyclic and post-cyclic behaviour from sand–geogrid interface large-scale direct shear tests, F.-Y. Liu, P. Wang, X. Geng, J. Wang and X. Lin

Scaled model tests on influence factors of full geosynthetic-reinforced pile-supported embankments, C. Xu, S. Song and J. Han

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Κυκλοφόρησε το Τεύχος #133 του **Newsletter του Geoengineer.org** (Απριλίου 2016) με πολλές χρήσιμες πληροφορίες για όλα τα θέματα της γεωμηχανικής. Υπενθυμίζεται ότι το Newsletter εκδίδεται από τον συνάδελφο και μέλος της ΕΕΕΕΓΜ Δημήτρη Ζέκκο (secretariat@geoengineer.org).

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