Καστανιά Καλαμπάκας

Αρ. 145 – ΔΕΚΕΜΒΡΙΟΣ 2020

SIMSG ISSMGE

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ΕΔΑΦΟΜΗΧΑΝΙΚΗΣ
& ΓΕΩΤΕΧΝΙΚΗΣ
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Τα Νέα της Ε Ε Ε Ε Γ Μ

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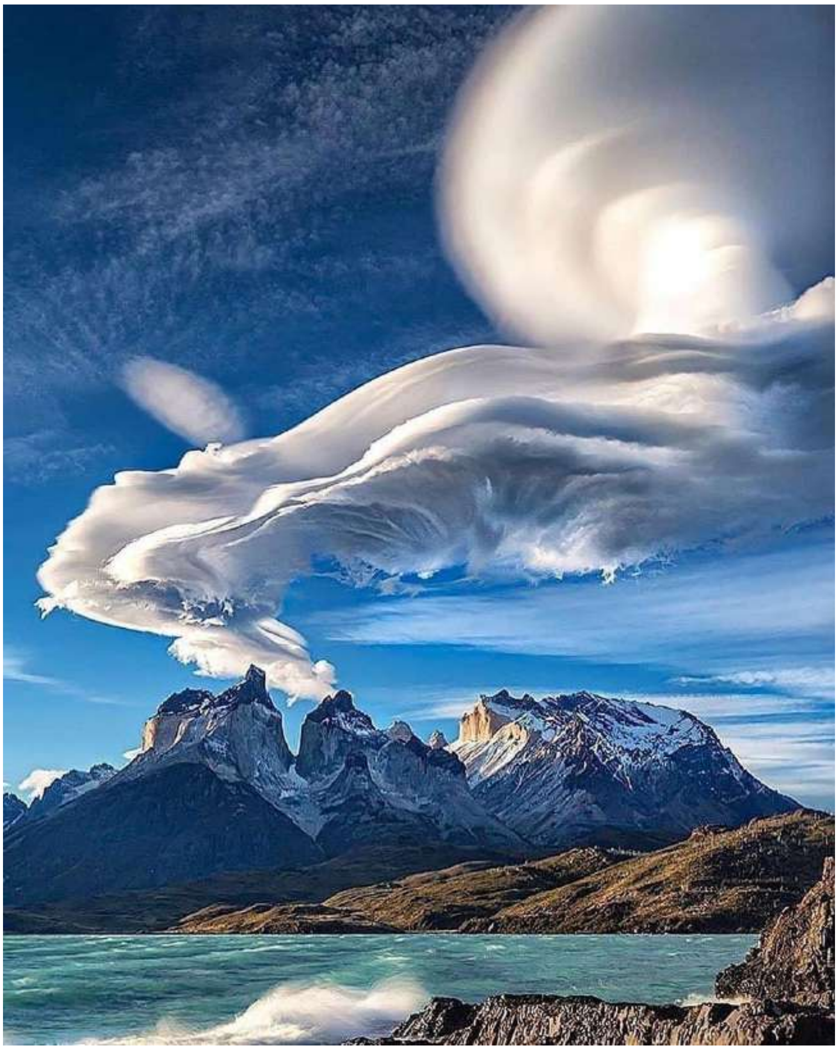


Lenticular clouds over Torres del Paine, Chilean Patagonia

Π Ε Ρ Ι Ε Χ Ο Μ Ε Ν Α

ΑΠΩΛΕΙΕΣ

Νίκος Κανταρτζής (1942 – 2020)

Το Σάββατο 28 Νοεμβρίου έφυγε από τη ζωή ο Νίκος Κανταρτζής, νικημένος από τον κορωνοϊό.

Ο Νίκος υπήρξε εξέχον-δραστήριο μέλος (μέχρι και την τελευταία στιγμή) της γεωτεχνικής μας κοινότητας και ιδρυτικό μέλος του Ελληνικού Συνδέσμου Γεωσυνθετικών και μέλος του 1[ου] Δ.Σ. του.

Ο Νίκος γεννήθηκε στο Βόλο τον Αύγουστο του 1942. Τελείωσε με άριστα τη δευτεροβάθμια εκπαίδευση στη Βαρβάκειο Πρότυπο Σχολή. Σπούδασε Πολιτικός Μηχανικός στο CARLETON / OTTAWA University του Καναδά, από όπου στη συνέχεια πήρε το Master of Engineering (MEng) στην Υδραυλική και στην Εδαφομηχανική (Hydraulics and Geotechnical Engineering), το 1972.

Μετά τις σπουδές του στον Καναδά, εργάστηκε για δύο χρόνια στην Ελληνική Εταιρεία Θεμελιώσεων ΑΕ, ως Εργοταξιάρχης και υπεύθυνος για την κατασκευή σειράς έργων θεμελιώσεων, αντιστηρίξεων και αποστραγγίσεων. Στα επόμενα 4 χρόνια τον βρίσκουμε να εργάζεται στην EDOK-ETER-MANDILAS Ltd ως Διευθύνων Μηχανικός Τμήματος Ειδικών Γεωτεχνικών / Υδραυλικών Μελετών και Κατασκευών στη Νιγηρία και στη συνέχεια στην ΕΔΟΚ ΑΕ - ΕΤΕΡ ΑΕ - ΔΟΜΙΚΑ ΕΡΓΑ ΑΕ ως συνεργοταξιάρχης κατασκευής του Κεντρικού Αγωγού Θεσσαλονίκης σε σήραγγα. Μέχρι το 1991 εργάστηκε σε διάφορα έργα στη Βόρεια Ελλάδα με έδρα τη Θεσσαλονίκη. Το 1991 βρίσκεται να εργάζεται σαν Ειδικός Μηχανικός στη Δημοκρατία του Μάλι για το πρόγραμμα επιδιόρθωσης – βελτίωσης υδροαρδευτικών έργων του Οργανισμού του Νίγηρα και του προγράμματος ρυζιού Segou.

Από το 1987 και για περισσότερα από 15 χρόνια, συμμετείχε στη ΔΗΛΕΑ ΕΠΕ σαν εταίρος / ειδικός σύμβουλος μελετών επιλογής και εφαρμογής ειδικών υλικών (γεωυφασμάτων, γεωπλεγμάτων κλπ) για μεγάλα αναπτυξιακά έργα. Ταυτόχρονα, εργάστηκε ως Γεωτεχνικός Μηχανικός αρχικά και ως Τεχνικός Σύμβουλος στη συνέχεια, στην εταιρεία «ΕΞΑΡΧΟΥ ΝΙΚΟΛΟΠΟΥΛΟΣ ΜΠΕΝΣΑΣΣΩΝ, ΣΥΜΒΟΥΛΟΙ ΜΗΧΑΝΙΚΟΙ Ε.Π.Ε. (ΕΝΜ ΕΠΕ)» & ENB Consulting Engineers Overseas Ltd, όπου συμμετείχε σε διάφορες μελέτες και επιβλέψεις γεωτεχνικών και υδραυλικών έργων στην Ελλάδα, στην Αιθιοπία, στην Μαυριτανία, στο Καμερούν, στην Παλαιστίνη, στις Νήσους Κομόρες και για αρκετά χρόνια στην Αλγερία. Την περίοδο αυτή προσέφερε υπηρεσίες και στην Κοινοπραξία ΟΔΟΣΗΡΑΓΓΕΣ, Τεχνικό Σύμβουλο της ΕΥΔΕ Οδικών Σηράγγων και Υπογείων Έργων του τότε Υπουργείου Δημοσίων Έργων.

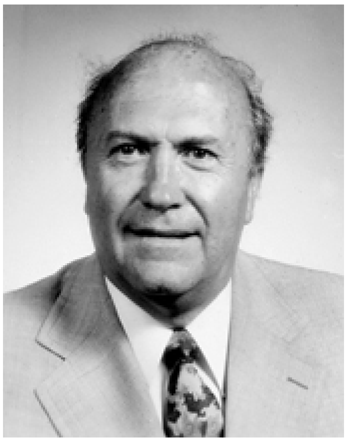
Ήταν μέλος της International Geosynthetics Society (IGS), του Engineering Institute of Canada - Canadian Geotechnical Society (EIC-CGS), της American Society of Civil Engineers (ASCE).

Ήταν παντρεμένος με την Ηρώ και είχε δύο γιούς τον Ανδρέα και το Γιάννη.

Τον αγαπημένο μου θείο Νίκο ή σκέτο Νίκο, όπως ήθελε να τον αποκαλώ, θα τον θυμάμαι πάντα σαν έναν πάρα πολύ δραστήριο άνθρωπο και παθιασμένο με τη δουλειά του μηχανικό, που γύρισε δουλεύοντας σχεδόν όλο τον κόσμο, που βοηθούσε και στήριζε τους νέους μηχανικούς, και που τόσο άδικα έφυγε για τη γειτονιά των αγγέλων.

Δρ. Χριστίνα Κανταρτζή

Jean Aubouin (1928 – 2020)



Αγαπητές και αγαπητοί Συνάδελφοι

με ιδιαίτερη λύπη σας γνωστοποιώ την απώλεια του διαπρεπούς Γεωεπιστήμονα Jean Aubouin (92 ετών).

Ο Jean Aubouin συνέβαλε καθοριστικά στη γνώση της Γεωλογίας του Ελλαδικού χώρου και παρήγαγε ένα τεράστιο πρωτοπόρο για την εποχή του επιστημονικό έργο σε πολλές περιοχές του κόσμου.

Ήταν Πρόεδρος της Ακαδημίας του Παρισιού, Επίτιμος Καθηγητής του Εθνικού και Καποδιστριακού Πανεπιστημίου Αθηνών και έτυχε σημαντικών διακρίσεων σε διεθνές επίπεδο.

Με εκτίμηση,

Δρ Ευθύμης Λέκκας

ΣΕΙΣΜΟΣ ΣΑΜΟΥ - ΣΜΥΡΝΗΣ

National & Kapodistrian University of Athens

Post Graduate Program
Environmental, Disaster & Crises Management Strategies

Scientific Report
The October 30, 2020, Mw=6.9, Samos [Eastern Aegean Sea, Greece] EQ: Preparedness and Emergency Response for Effective Disaster Management

Ο σεισμός μεγέθους Mw 6.9 που εκδηλώθηκε την 30η Οκτωβρίου 2020 βόρεια της Σάμου προκάλεσε δεκάδες ανθρώπινες απώλειες και είχε σημαντικές επιπτώσεις σε υποδομές και κατασκευές, καθώς και σε κοινωνικό και οικονομικό επίπεδο στην Ελλάδα και στην Τουρκία.

Μετά το σεισμό, οι ελληνικές αρχές έθεσαν σε εφαρμογή το μηχανισμό διαχείρισης κρίσης, πραγματοποιώντας τη μεγαλύτερη κινητοποίηση από τότε που ολοκληρώθηκε και τέθηκε σε ισχύ το σχέδιο "Εγκέλαδος" για την Αντιμετώπιση Εκτάκτων Αναγκών και Άμεσης/Βραχείας Διαχείρισης των Συνεπειών από την Εκδήλωση Σεισμών.

Η έκθεση είναι ειδική έκδοση του "**NEWSLETTER OF ENVIRONMENTAL, DISASTER, AND CRISIS MANAGEMENT STRATEGIES**" και παρουσιάζει εισαγωγικά το σύστημα Πολιτικής Προστασίας στην Ελλάδα και το Σχέδιο "Εγκέλαδος" και επικεντρώνεται στις δράσεις, που πραγματοποιήθηκαν κατά την έκτακτη ανάγκη που διαμορφώθηκε από την εκδήλωση του σεισμού και των γεωδυναμικών θαλάσσιων κυμάτων (tsunami).

Διαπιστώνεται ο υψηλού επιπέδου δομημένος σχεδιασμός της πολιτικής διαχείρισης καταστροφών και κρίσεων στην Ελλάδα.

Η έκθεση είναι αποτέλεσμα συνεργασίας του ΠΜΣ "Στρατηγικές Διαχείρισης Περιβάλλοντος, Καταστροφών και Κρίσεων" του Εθνικού και Καποδιστριακού Πανεπιστημίου Αθηνών και του Οργανισμού Αντισεισμικού Σχεδιασμού και Προστασίας και είναι διαθέσιμη εδώ.

Τι αποκάλυψε η χαρτογράφηση στα ανοιχτά της Σάμου για το υποθαλάσσιο ρήγμα

Διήρκησε επτά ημέρες και χαρτογραφήθηκαν συνολικά 1.478 km²

Λεπτομερής υδρογραφική αποτύπωση και χαρτογράφηση της περιοχής της θάλασσας της Σάμου αλλά και μεγάλου τμήματος του Ικάριου πελάγους πραγματοποιήθηκε με αφορμή των καταστροφικό σεισμό που έπληξε στο τέλος του Οκτωβρίου το νησί. **Η ωκεανογραφική αποστολή διήρκησε επτά ημέρες και χαρτογραφήθηκαν συνολικά 1.478 km²**.

Η υλοποίηση της εν λόγω αποστολής από το ΓΕΝ έγινε με αφορμή τον καταστροφικό σεισμό της 30ης Οκτωβρίου που έπληξε τη Σάμο, μετά από έγκριση του ΥΕΘΑ και σχετικό αίτημα του ΕΚΠΑ και τη σύμφωνη γνώμη του ΓΕΕΘΑ.

Την ερευνητική εργασία με θέμα «ΟΛΟΚΛΗΡΩΜΕΝΗ ΚΑΙ ΛΕΠΤΟΜΕΡΗΣ ΒΥΘΟΜΕΤΡΙΚΗ ΜΕΛΕΤΗ ΤΟΥ ΘΑΛΑΣΣΙΟΥ ΧΩΡΟΥ ΒΟΡΕΙΑ ΤΗΣ ΣΑΜΟΥ-ΙΚΑΡΙΑΣ ΜΕΣΩ ΝΕΩΝ ΕΞΕΛΙΓΜΕΝΩΝ ΣΥΣΤΗΜΑΤΩΝ & ΤΕΧΝΙΚΩΝ ΕΡΕΥΝΑΣ ΚΑΙ ΔΙΑΣΚΟΠΗΣΗΣ» διεκπεραίωσαν η Υδρογραφική υπηρεσία (ΥΥ) με το υδρογραφικό-ωκεανογραφικό(Υ/Γ- ΩΚ)«ΝΑΥΤΙΛΟΣ» σε συνεργασία με το τμήμα Γεωλογίας και Γεωπεριβάλλοντος του Εθνικού και Καποδιστριακού Πανεπιστημίου Αθηνών (ΕΚΠΑ).

Την ειδική ομάδα αποτελούσαν, όπως μεταδίδει το Αθηναϊκό Πρακτορείο Ειδήσεων, επιστημονικό προσωπικό της ΥΥ και του ΕΚΠΑ, με επικεφαλής την αναπληρώτρια καθηγήτρια του τμήματος Γεωλογίας, κ. Παρασκευή Νομικού, με σκοπό τη λεπτομερή υδρογραφική αποτύπωση και χαρτογράφηση της περιοχής της θάλασσας της Σάμου, αλλά και μεγάλου τμήματος του Ικάριου πελάγους.

Όπως ανακοινώθηκε από το ΓΕΝ, τα δεδομένα που συλλέχθηκαν από το Υ/Γ-ΩΚ ΝΑΥΤΙΛΟΣ θα τύχουν επεξεργασίας για την κατασκευή βαθυμετρικού χάρτη υψηλής ανάλυσης, αλλά και τη δημιουργία υποθαλάσσιου μορφοτεκτονικού χάρτη στον οποίο θα παρουσιάζονται όλα τα γεωμορφολογικά χαρακτηριστικά του πυθμένα σε συνδυασμό με την τεκτονική της περιοχής.

Με τη βοήθεια των δεδομένων αναμένεται επίσης, να κατανοηθεί το δυναμικό όλων των ενεργών ρηγμάτων στην περιοχή σε συνδυασμό με τα χερσαία δεδομένα.

Όπως δήλωσε στο Αθηναϊκό - Μακεδονικό Πρακτορείο Ειδήσεων η κα Νομικού, «η συμβολή της ΥΥ στην εκτέλεση του ωκεανογραφικού πλόα στις δύσκολες συνθήκες της πανδημίας Covid-19 ήταν καθοριστική για να συλλεχθούν επιστημονικά δεδομένα σε μία από τις σεισμικότερες περιοχές του Αιγαίου. Είναι σημαντικό να τονίσουμε το υψηλό επίπεδο φιλοξενίας σε πλοίο του Πολεμικού Ναυτικού και ειδικότερα σε περίοδο πανδημίας, που είχε ως αποτέλεσμα την ολοκλήρωση της αποστολής με ασφάλεια. Είναι αξιοσημείωτο το γεγονός ότι η εξαιρετική συνεργασία ΠΝ και ΕΚΠΑ στο πεδίο οδήγησε στην άμεση συλλογή βαθυμετρικών δεδομένων στην περιοχή Σάμου-Ικαρίας, σε χρονικό διάστημα μόλις ενός μήνα από την εκδήλωση του σεισμού».

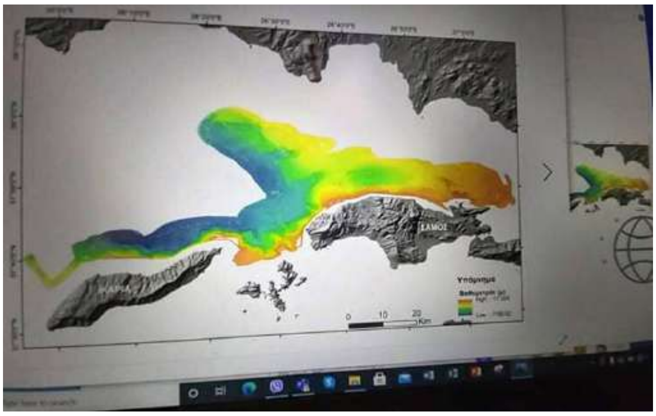
Την ομάδα εκτέλεσης του έργου αποτέλεσαν το πλήρωμα του ΩΚ-Υ/Γ «Ναυτίλου» με κυβερνήτη τον πλωτάρχη Χρήστο Βλαχογιάννη (ΠΝ), η αναπλ. καθηγήτρια του ΕΚΠΑ, Παρασκευή Νομικού, η υποψήφια διδάκτωρ του ΕΚΠΑ, Δ. Λαμπρίδου και ο πλωτάρχης του ΠΝ, Δ. Λίτσας (υπεύθυνος του Υ/Γ Συνεργείου της ΥΥ).

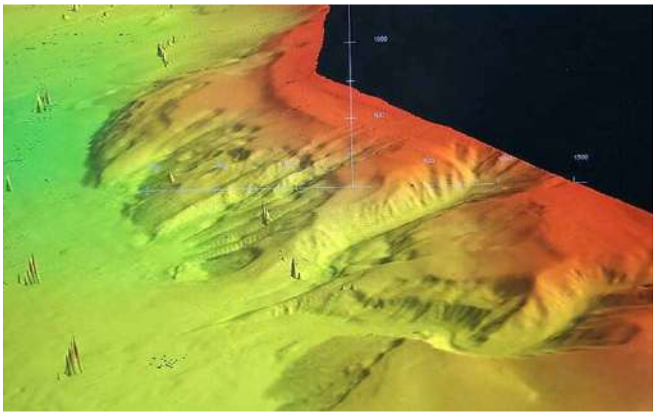
Όπως δήλωσε στο ΑΠΕ-ΜΠΕ η κα Νομικού, «η ωκεανογραφική αποστολή πραγματοποιήθηκε σε επτά μέρες και χαρτογραφήθηκαν συνολικά 1.478 τετραγωνικά χιλιόμετρα. **Το κύριο υποθαλάσσιο ρήγμα βόρεια της Σάμου έχει συνολικό μήκος 37 χιλιομέτρων, με κύρια διεύθυνση αρχικά ΔΒΔ-ΑΝΑ και στη συνέχεια Α-Δ και κλίση προς τα βόρεια. Το ίχνος του ρήγματος εντοπίστηκε σε βάθη από 230 μέχρι και 670 μέτρων και σε απόσταση τριών ως επτά χιλιομέτρων από τις βόρειες ακτές της Σάμου**».

Ανέφερε ακόμη ότι «το μεγαλύτερο βάθος της επιμηκυμένης λεκάνης της θάλασσας της Σάμου είναι 689 μέτρα. Εντυπωσιακά υποθαλάσσια φαράγγια με μήκος μέχρι και 2,7 χιλιόμετρα επικρατούν κατά μήκος των βόρειων ακτών της Σάμου, ενώ εντοπίστηκαν δύο μεγάλες υποθαλάσσιες κατολισθήσεις πλάτους 1,3 και 0,8 χλμ. στο θαλάσσιο χώρο βόρεια από το Καρλόβασι.

Χαρτογραφήθηκε επίσης το ανατολικό περιθώριο του Ικάριου Πελάγους - το όριο της θάλασσας της Σάμου - που οροθετείται από την ενεργή ρηξιγενή ζώνη με διεύθυνση ΒΒΔ-ΝΝΑ και μήκος 34 χλμ., που έχει μέτριες μορφολογικές κλίσεις και το οποίο διακόπτεται από δύο εντυπωσιακές κατολισθήσεις μεγάλης έκτασης. Στην ευρύτερη περιοχή έχουν παρατηρηθεί πολλοί μετασεισμοί σε συνέχεια του κύριου σεισμού».

Όπως έδειξε η έρευνα, ο πυθμένας στη δυτική πλευρά της Σάμου παρουσιάζει μεγάλες μορφολογικές κλίσεις λόγω της ύπαρξης ενεργού ρήγματος με διεύθυνση ΒΑ-ΝΔ, που αποτελεί και το ΝΑ περιθώριο του Ικάριου Πελάγους και διακόπτεται από εντυπωσιακά υποθαλάσσια φαράγγια με διεύθυνση από ΝΑ προς ΒΔ μήκους 12 και 9,6 χλμ. αντίστοιχα. Χαρτογραφήθηκε επίσης η βόρεια πλευρά της Ικαρίας (νότιο περιθώριο του Ικάριου πελάγους), η οποία παρουσιάζει απότομες μορφολογικές κλίσεις λόγω της ύπαρξης ρηγμάτων με διεύθυνση ΒΑ-ΝΔ και Α-Δ και μήκος 18 και 16 χλμ. αντίστοιχα.





Με τα δεδομένα που συλλέχθηκαν, θα γίνει η κατασκευή ενός βαθυμετρικού χάρτη υψηλής ανάλυσης και η δημιουργία ενός υποθαλάσσιου μορφοτεκτονικού χάρτη, στον οποίο θα παρουσιάζονται όλα τα γεωμορφολογικά χαρακτηριστικά του πυθμένα, σε συνδυασμό με την τεκτονική της περιοχής. Τέτοιοι χάρτες έχουν ήδη κατασκευαστεί από την ερευνητική ομάδα του ΕΚΠΑ για το Βόρειο Αιγαίο, τη λεκάνη της Σκύρου, τη λεκάνη της Αμοργού, τη Σαντορίνη, την Κω και τη Νίσυρο. Θεωρούνται απαραίτητοι, σύμφωνα με την κα Νομικού, για όλο το Αιγαίο αλλά και το Ιόνιο Πέλαγος για την καταγραφή και εκτίμηση των υποθαλάσσιων γεωκινδύνων (σεισμοί, κατολισθήσεις, τσουνάμι κλπ).

(newsbeast, 08.12.2020, https://www.newsbeast.gr/greece/arthro/6895300/ti-apokalypse-i-chartografisi-sta-anoichta-tis-samoy-gia-to-ypothalassio-rigma)

ΑΡΘΡΑ

Συμβολή γεωφυσικών μεθόδων στην αξιόπιστη εκτίμηση της Vs30

Παπαδόπουλος Γ., Φίκος Η., Βαργεμέζης Γ. και Θεοδουλίδης Ν.

Περίληψη

Είναι πλέον κοινά αποδεκτό ότι κατά τη διάρκεια ενός σεισμικού γεγονότος η σεισμική κίνηση επηρεάζεται σε σημαντικό βαθμό από τις τοπικές εδαφικές συνθήκες. Συνεπώς, είναι απαραίτητη η γνώση της γεωφυσικής δομής των επιφανειακών σχηματισμών, δηλαδή οι ταχύτητες διάδοσης των σεισμικών κυμάτων, η πυκνότητα, οι ελαστικές σταθερές κλπ. Για το χαρακτηρισμό των τοπικών εδαφικών συνθηκών σύμφωνα με τον Ευροκώδικα EC8, απαιτείται η εκτίμηση της μέσης ταχύτητας των εγκαρσίων σεισμικών κυμάτων στα πρώτα 30m (Vs30), ή η αντίστοιχη Vsz από την επιφάνεια μέχρι ένα συγκεκριμένο βάθος, z, όταν αυτό είναι μικρότερο ή μεγαλύτερο των 30m. Στην εργασία αυτή παρουσιάζεται προσπάθεια εκτίμησης της Vs30 στην θέση του σεισμολογικού σταθμού του Α.Π.Θ. στην πόλη της Θεσσαλονίκης, με τη συνδυαστική εφαρμογή γεωφυσικών μεθόδων χαμηλού κόστους, όπως είναι η τεχνική ειδικών δικτύων σεισμογράφων για την καταγραφή περιβαλλοντικού θορύβου, η πολυκαναλική ανάλυση επιφανειακών κυμάτων (M.A.S.W.) και η τομογραφία ηλεκτρικής αντίστασης (ERT). Η αξιοπιστία των αποτελεσμάτων ελέγχεται συγκριτικά με δεδομένα από σεισμικές μετρήσεις σε γεώτρηση (DH: downhole) που έχει πραγματοποιηθεί στην περιοχή αυτή.

1. Εισαγωγή

Η σεισμική εδαφική απόκριση σε μία θέση επηρεάζεται σημαντικά από τις τοπικές γεωλογικές συνθήκες. Χαρακτηριστικό παράδειγμα για τη σπουδαιότητα των τοπικών συνθηκών αποτελεί ο σεισμός του 1985 και οι επιπτώσεις της σεισμικής δόνησης στο Mexico City εξαιτίας της ενίσχυσης που προκάλεσαν σε αυτήν οι εδαφικές συνθήκες. Η καλή γνώση της γεωλογικής και γεωτεχνικής δομής της θέσης καθώς και η γνώση του σεισμοτεκτονικού υποβάθρου και της σεισμικότητας της ευρύτερης περιοχής θεωρούνται σημαντικές παράμετροι για τη ρεαλιστική εκτίμηση της σεισμικής επικινδυνότητας στην εξεταζόμενη θέση.

1.1 Εδαφικός θόρυβος

Εδαφικός (ή περιβαλλοντικός) θόρυβος θεωρούνται οι συνεχόμενες ταλαντώσεις του εδάφους από πηγές που σχετίζονται τόσο με φυσικές διεργασίες όσο και με ανθρώπινη δραστηριότητα (Gutenberg 1958, Bonnefoy-Claudet et al. 2006). Όπως κάθε σεισμική καταγραφή έτσι και ο εδαφικός μικροθόρυβος παρέχει πληροφορίες σχετικά με την πηγή, το δρόμο διάδοσης και τις τοπικές εδαφικές συνθήκες στη θέση καταγραφής του. Η τεχνική μετρήσεων εδαφικού θορύβου με ανάπτυξη ειδικών δικτύων σεισμομέτρων (Array Technique) αποτελεί ένα πολύ χρήσιμο και ελκυστικό εργαλείο για την εκτίμηση της μονοδιάστατης δομής ταχυτήτων των εγκαρσίων κυμάτων (S-waves) σε μία περιοχή (Aki 1957, Asten 1978, Tokimatsu 1997) κυρίως επειδή το κόστος εφαρμογής συγκριτικά με τη χρήση γεωτρήσεων είναι πολύ χαμηλό αλλά και της δυνατότητας εφαρμογής της σε δομημένο περιβάλλον λόγω του παθητικού (passive method) χαρακτήρα της. Η τεχνική αυτή, μπορεί να εφαρμοσθεί εύκολα σε αστικές περιοχές καθώς δεν απαιτούνται τεχνητές σεισμικές πηγές και επιτρέπει την εξαγωγή πληροφοριών από πολύ μεγάλα βάθη, ανάλογα με τη διάμετρο του δικτύου και το συχνοτικό περιεχόμενο του εδαφικού θορύβου (Satoh et al. 2001). Μια βασική υπόθεση η οποία γίνεται είναι ότι ο εδαφικός θόρυβος αποτελείται κυρίως από επιφανειακά κύματα και ότι η υπεδάφια δομή παρουσιάζει οριζόντια διαστρωμάτωση (Tokimatsu, 1997). Σε μία τέτοια δομή, τα επιφανειακά κύματα εμφανίζουν το φαινόμενο της σκέδασης (dispersion), όπου η φαινόμενη ταχύτητα (apparent velocity) μεταβάλλεται με τη συχνότητα. Τα επιφανειακά κύματα Rayleigh και Love συνυπάρχουν στις οριζόντιες συνιστώσες, ενώ οι κατακόρυφες συνιστώσες επηρεάζονται μόνο από τα κύματα Rayleigh. Το πρώτο στάδιο της ανάλυσης δεδομένων εδαφικού θορύβου είναι η εξαγωγή της καμπύλης σκέδασης των επιφανειακών κυμάτων (διάγραμμα ταχύτητας φάσης – συχνότητας) με τη μέθοδο της υψηλής ανάλυσης συχνότητας – κυματαρίθμου (high resolution f-k) και το δεύτερο στάδιο η αντιστροφή της παραπάνω καμπύλης για την παραγωγή του μονοδιάστατου προφίλ ταχυτήτων εγκαρσίων κυμάτων με το βάθος. Σύμφωνα με τους Woods & Lintz (1973) η ικανότητα ενός δικτύου να εξάγει την καμπύλη σκέδασης σε επιθυμητά όρια συχνοτήτων δεν εξαρτάται μόνο από της διάμετρο του αλλά και από τη χωρική κατανομή των σεισμομέτρων και από τη συσχέτιση των κυμάτων που πρόκειται να αναλυθούν. Η μέθοδος αυτή επηρεάζεται από τη μη-μοναδικότητα της λύσης και για το λόγο αυτό οποιαδήποτε διαθέσιμη πληροφορία για τη θέση εφαρμογής πρέπει να λαμβάνεται υπόψη κατά τη διαδικασία της αντιστροφής.

1.2 Τομογραφία ειδικής ηλεκτρικής αντίστασης (ERT)

Με την εφαρμογή ηλεκτρικών μεθόδων επιδιώκεται ο καθορισμός της κατανομής των ηλεκτρικών ιδιοτήτων του υπεδάφους. Ως πηγή χρησιμοποιείται τεχνητά παραγόμενο ηλεκτρικό πεδίο στο έδαφος μέσω ενός ζεύγους ηλεκτροδίων. Σε ένα δεύτερο ζεύγος ηλεκτροδίων μετράται η διαφορά δυναμικού που προκαλείται. Η ωμική αντίσταση που υπολογίζεται σαν το πηλίκο των δύο αυτών μεγεθών χρησιμοποιείται για τον υπολογισμό της φαινόμενης ειδικής ηλεκτρικής αντίστασης (apparent resistivity). Στη συνέχεια τα ηλεκτρικά δεδομένα αντιστρέφονται για την παραγωγή μονοδιάστατων (βυθοσκόπηση) ή δισδιάστατων προφίλ κατανομής ειδικής ηλεκτρικής αντίστασης. Στην παρούσα έρευνα χρησιμοποιήθηκε η τεχνική της ηλεκτρικής τομογραφίας (ERT) για τη λήψη πληροφοριών τόσο για την κατακόρυφη όσο και την οριζόντια μεταβολή της ειδικής ηλεκτρικής αντίστασης του υπεδάφους κατά μήκος της γραμμής έρευνας.

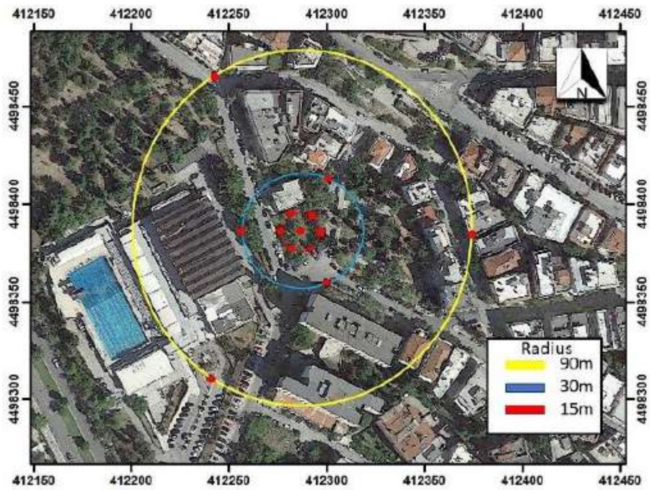
1.3 Πολυκαναλική ανάλυση επιφανειακών κυμάτων (M.A.S.W.)

Η μέθοδος M.A.S.W. εφαρμόζεται για τον προσδιορισμό της κατανομής της ταχύτητας των εγκαρσίων κυμάτων (Vs) σε μία ή σε δύο διαστάσεις (Park et al., 1999). Για την καταγραφή των δεδομένων κυμάτων Rayleigh τοποθετούνται σε μία ευθεία γεώφωνα κατακόρυφης συνιστώσας ιδιοσυχνότητας 4.5 Hz σε σταθερή απόσταση μεταξύ τους τα οποία είναι συνδεδεμένα με ψηφιακό σεισμογράφο. Για την παραγωγή των σεισμικών κυμάτων χρησιμοποιούνται διάφορες τεχνητές πηγές π.χ. σφυρί το οποίο είναι η πιο κοινή και οικονομική πηγή για σεισμικές τομές σχετικά μικρού μήκους. Μετά τη λήψη των δεδομένων, γίνεται επεξεργασία για την εξαγωγή της πειραματικής καμπύλης διασποράς η οποία αντιστρέφεται για να παραχθεί ένα μονοδιάστατο (ή και δισδιάστατο) προφίλ ταχυτήτων εγκαρσίων κυμάτων. Το βάθος διασκόπησης ορίζεται περίπου ίσο με το 1/3 το μέγιστου μήκους κύματος (λ_{max}). Όπως αναφέρθηκε παραπάνω, οι μέθοδοι κατά τις οποίες εξάγεται μία καμπύλη διασποράς των επιφανειακών κυμάτων εμπεριέχουν, κατά την αντιστροφή, το πρόβλημα της μη-μοναδικότητας της λύσης και γι' αυτό οποιαδήποτε γεωφυσική ή γεωλογική πληροφορία αφορά την περιοχή μελέτης είναι σημαντική για τον περιορισμό των τελικών αποτελεσμάτων (Foti et al., 2009).

2. Μεθοδολογία

Για τον χαρακτηρισμό των τοπικών εδαφικών συνθηκών μέσω της μέσης ταχύτητας εγκαρσίων κυμάτων των πρώτων 30m (Vs_{30}) χρησιμοποιήθηκαν μετρήσεις εδαφικού θορύβου με τη χρήση ειδικών δικτύων σεισμομέτρων σε συνδυασμό με τη σεισμική μέθοδο M.A.S.W. Επίσης πραγματοποιήθηκε και μία τομογραφία ηλεκτρικής αντίστασης με σκοπό την παραγωγή ενός προφίλ κατανομής των ηλεκτρικών αντιστάσεων στο υπέδαφος της περιοχής μελέτης το οποίο θα μας έδινε το πραγματικό, τουλάχιστον σε ότι αφορά τη γεωμετρία του, αρχικό μοντέλο. Το πλεονέκτημα της επιλεγμένης θέσης (Σεισμολογικός σταθμός Θεσσαλονίκης του ΑΠΘ) είναι η ύπαρξη γεώτρησης και μετρήσεις ταχυτήτων Vs και Vp μέσα σε αυτή, δεδομένα τα οποία χρησιμοποιήθηκαν για τη σύγκριση των τελικών αποτελεσμάτων με την πραγματική υπεδάφια δομή.

Η οργάνωση του δικτύου σεισμομέτρων πραγματοποιήθηκε με τοποθέτηση σταθμών καταγραφής σε κυκλικές διατάξεις. Η γεωμετρία των διατάξεων του δικτύου αποτελείται από τρεις νοητούς ομόκεντρους κύκλους (ερυθρή, κυανή, πράσινη καμπύλη στο Σχήμα 1), με ένα σταθμό καταγραφής στο κέντρο, έξι στην περιφέρεια του πρώτου, εσωτερικού κύκλου (κόκκινο) καμπύλη), τρεις στην περιφέρεια του δεύτερου κύκλου (μπλε) και επίσης τρεις σταθμούς καταγραφής στην περιφέρεια του εξωτερικού κύκλου (κίτρινο). Η επιλογή της διαμέτρου κάθε κύκλου καθορίζεται βάση των αναμενόμενων χαρακτηριστικών της υπεδάφιας δομής, το επιθυμητό βάθος διασκόπησης, την τιμή της ιδιοσυχνότητας των επιφανειακών στρωμάτων και τις τοπικές συνθήκες (διαθέσιμος χώρος). Τελικά, για την ανάπτυξη του δικτύου, χρησιμοποιήθηκαν συνολικά 13 θέσεις.

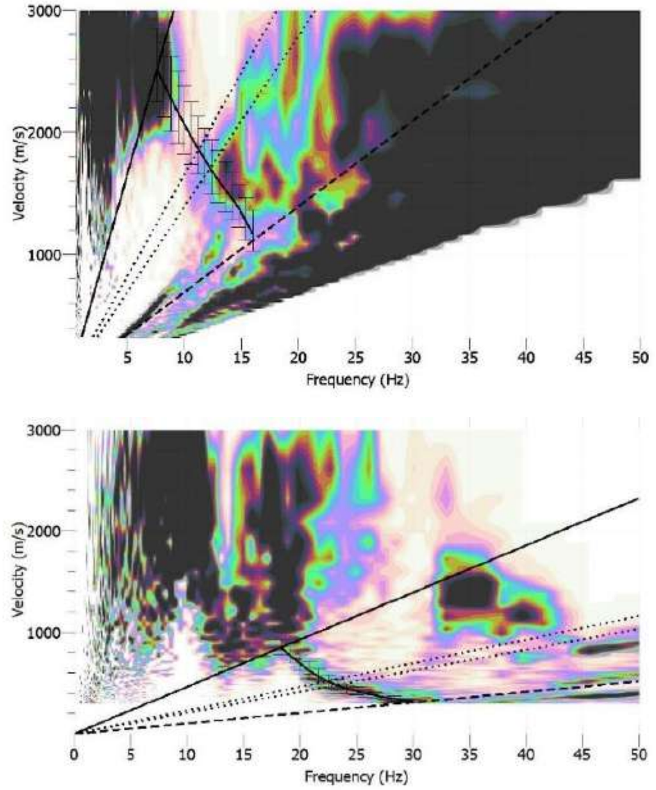


Σχήμα 1. Ανάπτυγμα ειδικού δικτύου σεισμομέτρων μέτρησης εδαφικού μικροθορύβου στην περιοχή μελέτης.

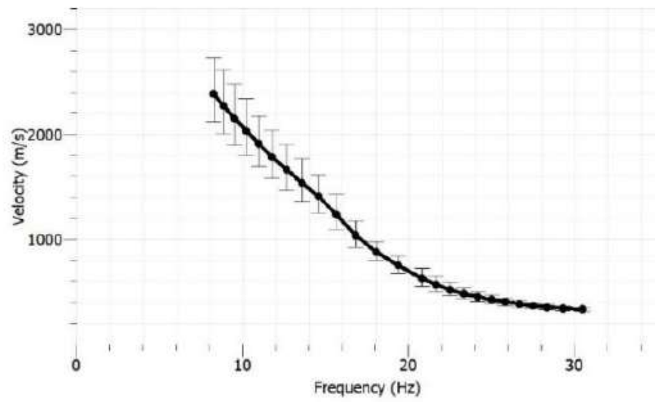
Η διάρκεια καταγραφής μικροθορύβου ήταν 4h30min για τη διάταξη 1-3-3 (εξωτερικός και ενδιάμεσος κύκλος) και 30min για τη διάταξη 1-6 (εσωτερικός κύκλος). Η επεξεργασία των δεδομένων έγινε με το λογισμικό Geopsy (Wathelet et al., 2020) και τα δεδομένα αναλύθηκαν με τη μέθοδο f-k με σκοπό την παραγωγή του διαγράμματος ταχύτητας φάσης – συχνότητας (v-f) για την επιλογή της καμπύλης σκέδασης. Τα αποτελέσματα της ανάλυσης των δεδομένων μικροθορύβου με τη μέθοδο f-k για και για τις δύο διατάξεις εμφανίζονται στο Σχήμα 2.

Οι δύο καμπύλες σκέδασης που προέκυψαν συνδυάστηκαν για την κατασκευή της συνολικής καμπύλης σκέδασης η οποία καλύπτει ένα μεγάλο εύρος συχνοτήτων (Σχήμα 3). Η καμπύλη υφίσταται εξομάλυνση (smoothing) για τη διευκόλυνση του αλγορίθμου αντιστροφής και επανεπιλογή κάποιων σημείων της (resampling).

Πριν τη διαδικασία της αντιστροφής ορίζεται ο χώρος των παραμέτρων της υπό εκτίμηση υπεδάφιας δομής. Το αρχικό μοντέλο που ορίσθηκε αποτελούνταν από δύο στρώματα που επικάθονται πάνω από ημιχώρο. Στη συγκεκριμένη θέση οι επιλογές των παραμέτρων (εύρος Vs για κάθε στρώμα και αριθμός στρωμάτων) του αρχικού μοντέλου (Σχήμα 4) βασίστηκαν σε πληροφορίες από διαθέσιμη γεώτρηση στην περιοχή.



Σχήμα 2. Διαγράμματα v-f και επιλεγμένες καμπύλες σκέδασης επιφανειακών κυμάτων για τη διάταξη 1-6 (ακτίνα 15m) - δεξιά, και για τη διάταξη 1-3-3 (30-90m) - αριστερά.

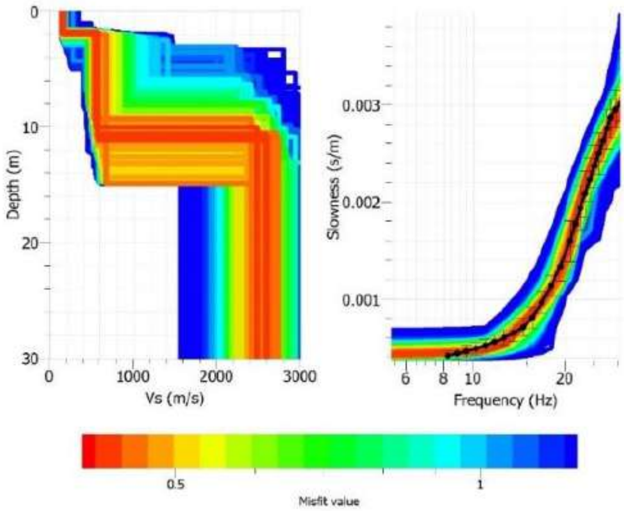


Σχήμα 3. Συνολική καμπύλη σκέδασης που προέκυψε από την σύνθεση των καμπυλών των δύο διατάξεων του δικτύου.

Η κατανομή Vs με το βάθος για τη θέση του δικτύου καθώς και οι θεωρητικές καμπύλες σκέδασης για τα παραγόμενα μοντέλα φαίνονται στο Σχήμα 5.

Στην περιοχή μελέτης πραγματοποιήθηκε και τομογραφία ηλεκτρικής αντίστασης για τον προσδιορισμό της γεωηλεκτρικής δομής στις δύο διαστάσεις. Για την μέτρηση τοποθετήθηκαν 24 ηλεκτρόδια με 2m απόσταση μεταξύ τους δημιουργώντας μια τομή 46m. Η τομή διέρχεται από τη θέση του κεντρικού σεισμομέτρου του ειδικού δικτύου σεισμομέτρων μέτρησης εδαφικού θορύβου που πραγματοποιήθηκε (Σχήμα 6). Για τη λήψη των μετρήσεων χρησιμοποιήθηκαν οι διατάξεις dipole-dipole και multigradient. Τα ηλεκτρικά δεδομένα υπόκεινται στη μαθηματική διαδικασία της αντιστροφής τα αποτελέσματα της οποίας φαίνονται στο Σχήμα 7. Στο σχήμα αυτό ο οριζόντιος άξονας περιγράφει ο μήκος πάνω στην επιφάνεια του εδάφους με την αρχή στο νοτιοανατολικό άκρο ενώ ο κατακόρυφος το βάθος. Διακρίνονται δύο κύρια χαρακτηριστικά της θέσης που ερευνήθηκε. Το πρώτο είναι η ύπαρξη, κυρίως στο νότιο τμήμα (6 – 23 μέτρο της τομής) αντιστατικών σχηματισμών πάχους περίπου 3 μέτρων που αποδίδονται σε αμμοχάλικα ενώ βαθύτερα και μέχρι τα 10 μέτρα βάθος οι αντιστάσεις μειώνονται και ερμηνεύονται σαν αποσαθρωμένος ή/και έντονα κερματισμένος γνεύσιος ή σχιστόλιθος. Το δεύτερο χαρακτηριστικό που φαίνεται είναι η παρατηρούμενη μικρή μείωση των αντιστάσεων στο βόρειο τμήμα (23 – 46 μέτρο της τομής) η οποία μπορεί να συσχετιστεί με κατά θέσεις αυξημένη υγρασία. Μια πιθανή ερμηνεία μπορεί να είναι η παρουσία μιας ρηξιγενούς ζώνης με διεύθυνση περίπου κάθετη στην τομή μας το οποίο υδροφορεί.

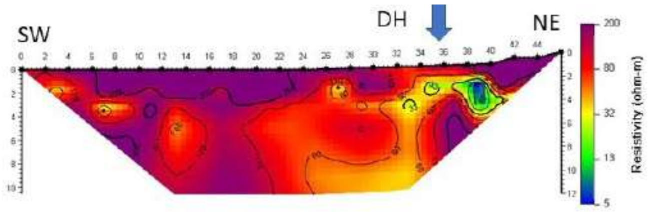
Σχήμα 4. Παράμετροι του αρχικού μοντέλου.



Σχήμα 5. Αριστερά, μεταβολή της Vs με το βάθος και δεξιά οι θεωρητικές καμπύλες σκέδασης (σε χρωματική κλίμακα). Η μαύρη γραμμή με τις τυπικές αποκλίσεις είναι η πειραματική καμπύλη σκέδασης των επιφανειακών κυμάτων.

Στην ίδια ακριβώς θέση της ERT υλοποιήθηκε η διάταξη για την εφαρμογή της μεθόδου M.A.S.W. για τον προσδιορισμό ενός μονοδιάστατου προφίλ Vs και σύγκριση του τόσο με το αποτέλεσμα των μετρήσεων μικροθορύβου όσο και με δεδομένα από την υπάρχουσα γεώτρηση. Για πρακτικούς λόγους η διάταξη έχει αντίθετη φορά (Σχήμα 6) σε σχέση με την ERT. Τοποθετήθηκαν 24 γεώφωνα με 2m απόσταση μεταξύ τους υλοποιώντας μια τομή μήκους 46m. Με τη χρήση σφυριού ως πηγή σεισμικών κυμάτων, πραγματοποιήθηκαν δύο χτυπήματα, ένα στο κέντρο της τομής (23m) και ένα 5m από το νοτιοδυτικό άκρο της τομής (-5m). Η ανάλυση των επιφανειακών κυμάτων έγινε με το λογισμικό επεξεργασίας σεισμικών κυματομορφών Seisimager.

Σχήμα 6. Γραμμή ηλεκτρικής τομογραφίας και M.A.S.W. η οποία διέρχεται από τη θέση του κεντρικού σεισμομέτρου κατά τη διεξαγωγή παθητικών μετρήσεων με την τεχνική ειδικών δικτύων σεισμομέτρων



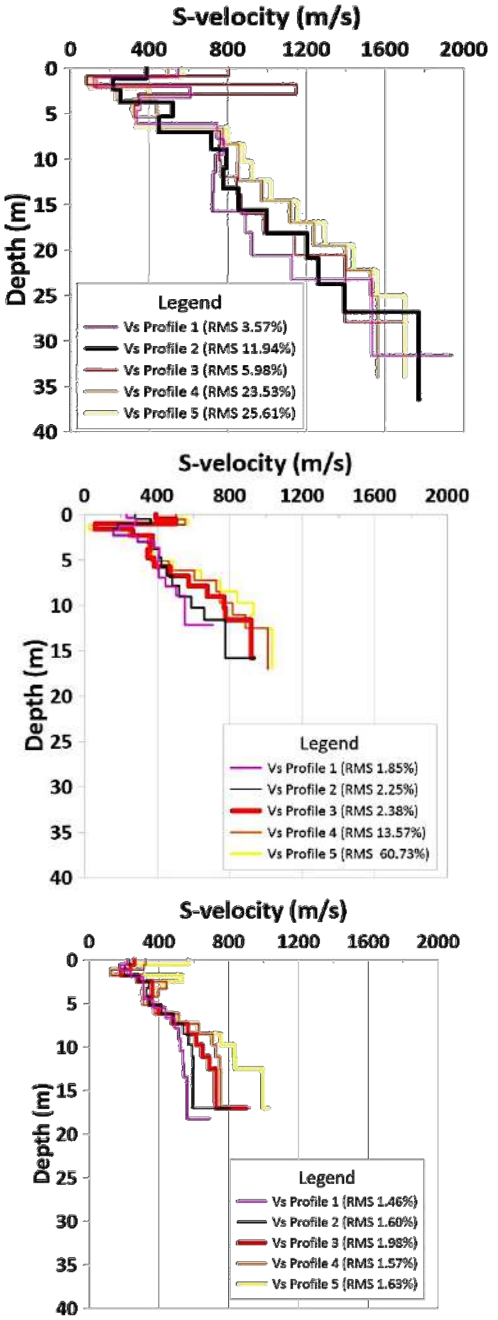
Σχήμα 7. Αποτέλεσμα αντιστροφής ηλεκτρικών δεδομένων. Στο 36m βρίσκεται η θέση της γεώτρησης

Για κάθε πηγή σεισμικών κυμάτων (χτύπημα) παράχθηκε ένα διάγραμμα v-f και έγινε η επιλογή των καμπυλών διασποράς. Η επιλογή της καμπύλης διασποράς μπορεί να γίνει σε ένα αρκετά μεγάλο εύρος φαινόμενης ταχύτητας. Για το λόγο αυτό επιλέχθηκαν περισσότερες από μία καμπύλες διασποράς για κάθε χτύπημα (shot) με σκοπό τον καθορισμό ενός εύρους φαινόμενης ταχύτητας φάσης που περιγράφει την θεμελιώδη καμπύλη διασποράς (σχήμα 8). Σε κάθε διάγραμμα βάθους – ταχυτήτων Vs του Σχήματος 8 η εντονότερη σε πάχος καμπύλη κρίθηκε ως η πλέον αντιπροσωπευτική λύση του αντίστρόφου προβλήματος.

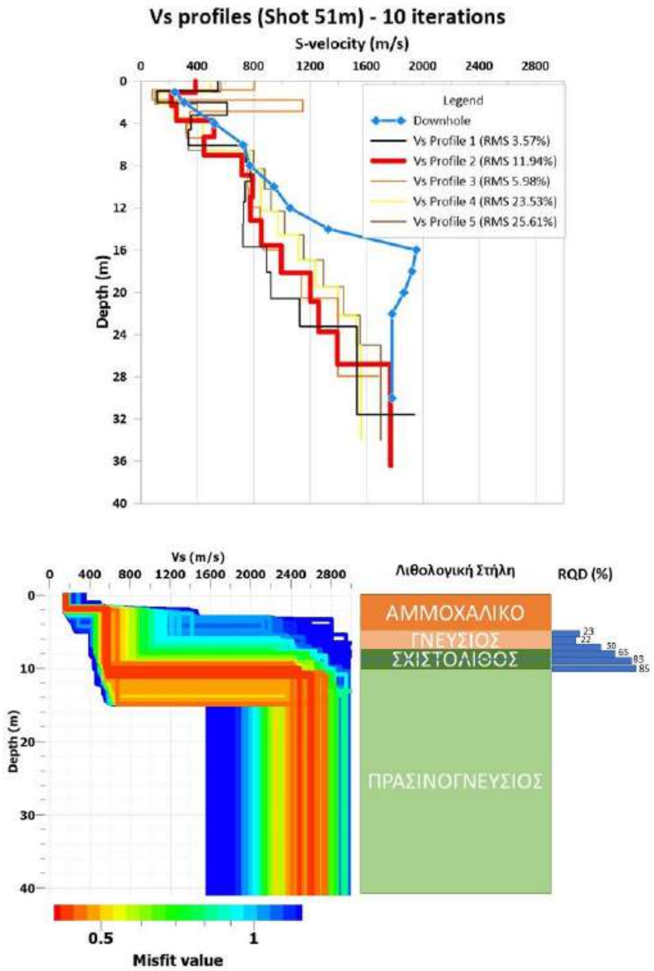
Λόγω της πλευρικής διαφοροποίησης που αναδεικνύει η ERT αποφασίστηκε η ανάλυση των κυμάτων Rayleigh που προκλήθηκαν από το χτύπημα στο μέσο της τομής (23m) να χωριστεί γεωμετρικά σε δύο μέρη με το πρώτο μέρος να αντιστοιχεί στο βόρειο τμήμα (0-23m) και το δεύτερο μέρος στο νότιο τμήμα (24-46m), εφόσον η πλευρική μεταβολή στην ERT φαίνεται να εμφανίζεται περίπου στο μέσο της τομής (Σχήμα 7). Ο διαχωρισμός αυτός προκύπτει ως πρόταση μελέτης του υπεδάφους όταν παρατηρούνται έντονες πλευρικές μεταβολές κατά την εφαρμογή της ηλεκτρικής τομογραφίας η οποία προηγείται των δύο άλλων μεθόδων.

3. Σύγκριση των αποτελεσμάτων με δεδομένα γεώτρησης

Στο σχήμα 9 παρουσιάζονται με κοινή κλίμακα βάθους και ταχυτήτων το προφίλ Vs που προέκυψε από τα δεδομένα μικροθορύβου (μέση) και η κατανομή των Vs από δεδομένα υπάρχουσας γεώτρησης (μετρήσεις downhole) μαζί με τα προφίλ που προέκυψαν από τη MASW (shot 51m) (αριστερά) καθώς και η λιθολογική στήλη της γεώτρησης (δεξιά). Τα μοντέλα με την καλύτερη προσαρμογή στην πειραματική καμπύλη διασποράς (καμπύλες με έντονο κόκκινο χρώμα) περιγράφουν σε πολύ καλό βαθμό τη λιθολογία που προκύπτει από τη γεώτρηση. Διακρίνεται ένα επιφανειακό στρώμα 2-3m με Vs= 200m/s το οποίο αντιστοιχεί σε αμμοχάλικα σύμφωνα και με τη λιθολογική στήλη. Σε βάθος 3-10m η ταχύτητα αυξάνει σημαντικά (Vs=600-800m/s). Η απότομη αυτή μεταβολή παρατηρείται και στο προφίλ Vs από τις μετρήσεις downhole και δικαιολογείται από την ύπαρξη πιο σκληρού σχηματισμού που αποτελείται από μερικώς αποσαθρωμένους λευκογνεύσιους και σχιστόλιθους (RQD: 22-23%). Περίπου στο βάθος των 11-12m εντοπίζεται πιο συμπαγής πρασινογνεύσιος (RQD: > 65%) ο οποίος παρουσιάζει μεγάλες ταχύτητες της τάξης των 2500m/s.



Σχήμα 8. Μοντέλα μεταβολής της Vs με το βάθος που προέκυψαν μετά το διαχωρισμό του δείγματος δεδομένων, από το κτύπημα στο κέντρο της τομής για το βορειότερο τμήμα αυτής **(επάνω)**, για το νοτιότερο τμήμα της **(μέσον)** και προφίλ Vs όλου του δείγματος δεδομένων από το χτύπημα στο νοτιοδυτικό άκρο (-5m) **(κάτω)**.



Σχήμα 9. Αποτελέσματα από Downhole & MASW (shot at 51m) **(επάνω)**, Αποτελέσματα ειδικού δικτύου μικροθορύβου **(κάτω αριστερά)** - Λιθολογική στήλη από γεώτρηση και RQD (%) **(κάτω δεξιά)**.

Οι παραπάνω μεταβολές των Vs διακρίνονται και στα προφίλ κατανομής ταχυτήτων που προκύπτουν από τη μέθοδο MASW. Παρατηρήθηκε όμως ότι η μέθοδος αυτή υποεκτιμά τις Vs σε σχέση με τις μεθόδους των ειδικών δικτύων και της downhole.

Στη συνέχεια υπολογίσθηκε η Vs_{30} από τα αποτελέσματα κάθε μεθόδου ξεχωριστά για να γίνει σύγκριση με τα δεδομένα από τη downhole. Ο υπολογισμός έγινε με βάση τη σχέση:

$$V_{s,30} = \frac{30}{\sum_{1,N} \frac{h_i}{v_i}}$$

όπου h_i το πάχος σε μέτρα (m) και v_i η ταχύτητα των εγκαρσίων κυμάτων κάθε στρώματος. Τα αποτελέσματα παρουσιάζονται στον παρακάτω πίνακα και όπως φαίνεται και οι 3 μέθοδοι καταλήγουν σε παραπλήσιες τιμές ταχυτήτων Vs_{30}.

Geophysical method	Vs_{30} (m/s)
MASW (Shot51)	702
Microtremor Array	806
Downhole	879

4. Συζήτηση & Συμπεράσματα

Στην εργασία αυτή προτείνεται συνδυασμός τριών γεωφυσικών μεθόδων για την αξιόπιστη εκτίμηση της V_{S30} σε αστικό περιβάλλον, με την εξής σειρά υλοποίησης. Αρχικά πραγματοποιείται τομογραφία ηλεκτρικής αντίστασης (E.R.T.) η οποία δίνει πληροφορίες σχετικά με τη γεωμετρία και την πλευρική μεταβολή των υποκείμενων σχηματισμών (π.χ. την ύπαρξη 1-D ή 2-D δομής, τον αριθμό των στρωμάτων, την ενδεχόμενη ύπαρξη κάποιας πλευρικής μεταβολής ή ρήγματος) καθώς επίσης και ποιοτικές πληροφορίες για το εδαφικό υλικό. Οι πληροφορίες που προκύπτουν από τη διεξαγωγή της E.R.T. μπορούν να χρησιμοποιηθούν για το σχεδιασμό και διεξαγωγή των μετρήσεων M.A.S.W. καθώς και της τεχνικής ειδικών δικτύων σεισμομέτρων. Στη συνέχεια, υλοποιείται η μέθοδος της πολυκαναλικής ανάλυσης επιφανειακών κυμάτων (M.A.S.W.) η οποία με ανεξάρτητο τρόπο εκτιμάει τη V_{S30} in-situ κατά μήκος της επιλεγμένης τομής. Τέλος πραγματοποιείται η τεχνική ειδικών δικτύων σεισμομέτρων με βάθος διασκόπησης, το οποίο καθορίζεται από τη ζητούμενη εκτίμηση Vs στα πρώτα 30m ή και σε μεγαλύτερα βάθη. Η τεχνική αυτή προσεγγίζει καλύτερα την τρισδιάστατη εικόνα της δομής στην εξεταζόμενη θέση (όσον αφορά τη V_{S30}) δεδομένου ότι οι πηγές περιβαλλοντικού θορύβου κατανέμονται αζιμουθιακά γύρω από αυτήν. Τέλος, οποιαδήποτε γεωλογική πληροφορία (π.χ. λιθολογική στήλη) υπάρχει διαθέσιμη στην ευρύτερη περιοχή πρέπει να λαμβάνεται υπόψη για την τελική ερμηνεία.

Στην εργασία αυτή, από την εφαρμογή των τριών μεθόδων προκύπτει ότι η θέση κατατάσσεται στην κατηγορία A του EC8. Ενδεχόμενες αποκλίσεις που εμφανίζονται όσον αφορά τη V_{S30} οφείλονται στο γεγονός ότι η τεχνική ειδικών δικτύων σεισμομέτρων αποδίδει μία τρισδιάστατη εικόνα της θέσης, η M.A.S.W. εκτιμάει τη V_{S30} κατά μήκος μιας τομής και η μέθοδος Downhole σημειακά.

Ο παραπάνω συνδυασμός μεθόδων μπορεί να υλοποιηθεί σε μια ημέρα με 3 έως 4 άτομα και συνεπώς αποτελεί μια γρήγορη, χαμηλού κόστους υποσχόμενη μεθοδολογία χαρακτηρισμού της θέσης με βάση τη V_{S30}. Είναι αυτό-ελεγχόμενη, καθώς κάθε μέθοδος προσεγγίζει τη V_{S30} με διαφορετικό τρόπο, γεγονός που προσθέτει στην αξιοπιστία της.

Ερώτημα προς διερεύνηση αποτελεί η πλευρική μεταβολή που παρατηρείται στην ERT κάτι το οποίο θα ερευνηθεί περαιτέρω με επιπλέον μετρήσεις ERT σε παρακείμενες θέσεις. Προς το παρών μια πιθανή ερμηνεία της βασισμένη και στα δύο διαφορετικά προφίλ Vs που προέκυψαν από το διαχωρισμό του δείγματος δεδομένων από το shot στο μέσο της τομής (23m) μπορεί να είναι η παρουσία μιας ζώνης ρήγματος που τέμνει με γωνία την τομή και που υδροφορεί. Ένα τέτοιο μοντέλο μπορεί να δικαιολογήσει τις χαμηλότερες αντιστάσεις στο βόρειο τμήμα ενώ παράλληλα μπορεί να δικαιολογήσει και το γεγονός πως μηχανικά συμπεριφέρεται λίγο καλύτερα από το νότιο τμήμα, το οποίο είναι εντονότερα αποσαθρωμένο.

Ένας ακόμη τρόπος για να ερευνηθεί αυτή η πλευρική μετάβαση είναι η τοποθέτηση σεισμομέτρων ανά 5m κατά μήκος της τομής και η εφαρμογή της μεθόδου HVSR για την παραγωγή του φασματικού λόγου της οριζόντιας-προς-κατακόρυφη συνιστώσα των επιφανειακών κυμάτων. Επίσης, θα ήταν ενδιαφέρον να γίνει συνδυασμός των σεισμικών δεδομένων από όλες τις μεθόδους για την παραγωγή μίας ενιαίας καμπύλης σκέδασης με τα συνολικά σφάλματά της, πριν τη διαδικασία της αντιστροφής. Τέλος, θεωρούμε πως για την καλύτερη τεκμηρίωση της μεθοδολογίας που εφαρμόσθηκε στην εργασία αυτή είναι απαραίτητη η εφαρμογή και έλεγχός της και σε άλλες θέσεις αστικού περιβάλλοντος με διαφορετικά χαρακτηριστικά υπεδάφιας δομής.

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Tunnel failure trends and risk management

Spyros Konstantis and Prof. Panos Spyridis, both Directors of Ruler Consult, delve into the statistics of tunnel failures from 1980 to 2019 and explain the importance of good design and construction practices and of risk management in minimizing the possibility of such events in the future

Every stakeholder involved in the tunnelling industry, including the construction insurance market, knows and has learned the easy, or indeed the hard way that tunnels and underground works are a risky business. These unique structures are subject to a diversity of inherent uncertainties associated with the geotechnical, hydro-geological and physical environment that surrounds them. On many occasions, the associated risks can materialize, leading to loss events with substantially high adverse impact on reinstatement cost, incurred delays (particularly when Delay in Start Up coverage is provided), reputation and third parties, to name a few. Substandard design, poor project management practices, unforeseen and unforeseeable ground conditions, aggressive project timelines leading to taking shortcuts to avoid LDs/penalties or achieving bonuses, compressed budgets and application of innovative techniques not yet fully tested and validated, are some of the factors which contribute towards an increased probability of risk materialisation and failure events. It was due to a number of such high impact losses and the consequent reluctance of the insurance market to provide coverage for underground works that led to the introduction of the Code of Practice for Risk Management of Tunnel Works in 2006 (ITIG, 2006 & 2012).

In the underground construction industry, there is currently an understanding deficit on past tunnel failures, due to the inherent human tendency to promote our own successes but avoid sharing our failures in a public forum. Lessons learned exercises and initiatives are indeed carried out but they usually take place in in-house forums or in informal discussions. This is the case primarily due to commercial sensitive information involved, such as insurance losses and delays, not being formally released to the public and the associated corporate reputational consequences. Attempts were made in the past to create a database with tunnel failures (Souza, 2010; CEDD, 2015; Konstantis, 2016). This article expands on this previous work and looks at all the significant tunnel failures which occurred between 1980 and 2019, recording the important tunnel characteristics and parameters and failure type. An effort was made to demonstrate that there are certain contributing factors that are persistently involved in tunnel failures which can be eliminated or significantly reduced in the framework of a pro-active and targeted risk engineering and management approach (Konstantis, Denney and Tillie, 2014).

Tunnel failure causes

A tunnel can fail (or succeed) due to a number of independent or interrelated reasons, with the highest contributing parameters being the level of understanding of the geotechnical/geological conditions, the design approach, the excavation method, the workmanship and the construction supervision.

A tunnel construction can be undermined by a poor level of understanding of the physical and mechanical properties of its surrounding geo-materials and the adequate identification of potentially hazardous in situ conditions and ground features, such as faults, water bearing lenses and boulders (Figure 1). A poor design, lack of expertise and experience, superficial knowledge of the ground and surrounding conditions combined with a low level of risk awareness on the designer's side, increases the risk profile of a tunnel project. The choice of a non-appropriate construction method based on incomplete knowledge of the ground conditions can lead to increased probability of failure and can have detrimental consequences in the project budget and schedule when long lead equipment need to be rescued or replaced, such as a trapped or halted TBM. Equally important, incorrect implementation of the selected construction and excavation method, poor workmanship, late and improper installation of support measures, lack of a rigorous instrumentation and monitoring plan with early warning systems and absence of advance probing and assessment techniques increase the probability of a failure event.

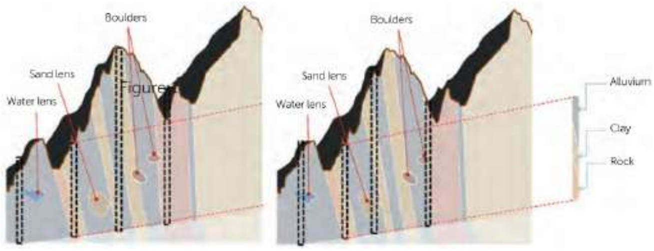

Figure 1. Illustrating the importance of adequately identifying potential hazardous conditions (Reiner 2011)

Based on available statistical data, tunnel failures and collapses can primarily be attributed to design and construction errors with design errors corresponding to 40% (Reiner, 2011) and accidents making up 20% of all failures (Spyridis and Proske, 2020). Using extensive databases and catalogues for tunnel collapses, it was assessed that the failure rate of a tunnel is in the range 10-2 to 10-3 per year (Spyridis and Proske, 2020). Hence, a robust design which ideally is independently verified by a competent and experienced third party, a well experienced and meticulous team for the construction execution and high-quality workmanship specifications and supervision would reduce the risk of failure significantly. It should however be noted that since there is no comprehensive unified tunnel design standard, each tunnel is designed to a different level of safety as set by each responsible authority.

Database and results

The generated database only looked at failures post 1980 considering that this is when modern tunnelling techniques started to be widely applied. The starting point was the work presented by IMIA 2006, MunichRe 2006, Reiner 2011, CEDD 2012 and Konstantis 2016 where a total of 68 tunnel failures were listed. Following a comprehensive literature review and search in the technical news domain, a total of 378 incidents were recorded, however for some cases very little information was available and these were discarded. Each entry into the final database included at least 3 significant parameters, resulting in a partially incomplete dataset. The parameters recorded when information was available were the following: tunnel use, failure type, failure cause, tunnel length, tunnel diameter, overburden, excavation method, geological conditions, rock/soil, stress conditions, water conditions, portal failure, third party impact, fatalities, monetary losses and schedule delays.

Figure 2 shows the pie charts for the type and excavation method of the recorded tunnel failures during construction. It can be seen that approximately three quarters of the failures occurred in rural areas (assuming that rail, road and hydro tunnels are primarily excavated in mountainous terrains), where ground investigations are usually limited, thus increasing the risk profile of the tunnel (see Figure 1). The excavation method primarily depends on the geology, the tunnel length and third-party impact considerations. Almost half of the failures are associated with NATM/SCL/SEM methods of excavation. In a broad categorization of mechanized (TBM) versus conventional excavation methods, the failure percentages are roughly one third and two thirds, respectively.

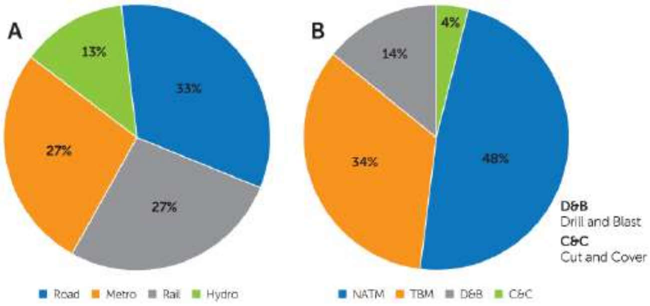

Figure 2. Type (left) and excavation technique (right) of tunnel failures during construction (Dallavalle, 2020)

Table 1 is presenting the number of incidents per excavation method and failure type.

	Number of Incidents			
	Excavation Method			
Failure Type	**C&C**	**D&B**	**NATM**	**TBM**
Face collapse	1	15	45	36
Overstressed support	2	9	30	20
Crown wedge collapse	1	2	2	2
Fire	0	0	11	3
Other	0	0	0	2

With regards to geological conditions, the split between rock and soil for failures during construction is 64% and 36%, respectively. Figure 3 shows the prevailing ground conditions in the tunnel failure cases where it can be seen that 56% occurred when excavated through four main sedimentary groups - sandstone, shale, marlstone and limestone. It is interesting to note that NATM failures occurred 44% more in rock than in soil while TBM failures occurred 8% more in soil than in rock.

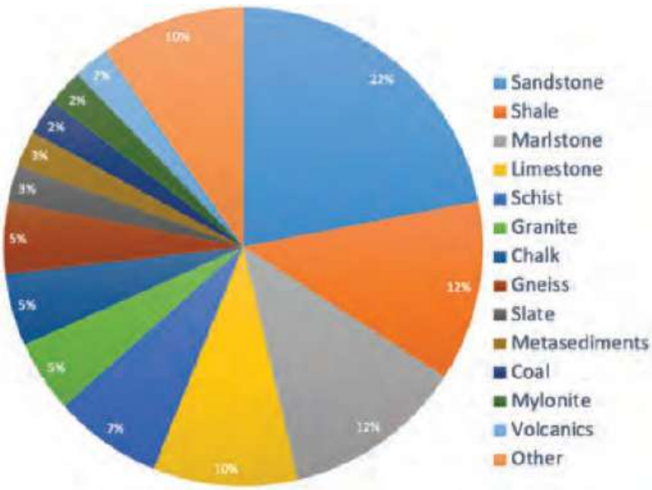

Figure 3. Prevailing ground conditions in the tunnel failure cases (Dallavalle, 2020)

With reference to the excavation area, the highest number of failures occurred for tunnels with diameter in the range of 9m to 13m for NATM tunnels, which is the typical diameter of double track metro tunnels and metro station caverns and highway tunnels, respectively. For TBM tunnels, the highest number of failures is observed for diameters in the range of 3m to 6m and 7m to 10m, which are typical for water conveyance tunnel schemes and single and double track metro tunnels, respectively. From Figure 4, it can be seen that the number of TBM failures decreases with increasing diameter, while the opposite is observed for NATM tunnels. The larger the diameter, the higher the probability of face instabilities due to the bigger exposed face area and possibly due to mixed face conditions. For the TBM case, this is counterintuitive based on the database set. Although there are less larger diameter TBMs operating worldwide in comparison to smaller diameter, a possible explanation could be that with the application and implementation of emergency response systems and equipment (such as emergency slurry pumps) and the increased risk awareness with large diameter TBMs given the higher reputational burden of such high profile projects, fewer failures are observed for larger diameters. For smaller diameter TBM tunnels, a possible explanation could be that the project teams become complacent and although proper risk management practices may be in place, these may not be strictly followed and collapses may occur due to operating in semi closed mode to achieve higher advance rate, for example, or not performing advance exploration methods, etc. For the NATM tunnels, the advancement is divided in phases as the diameter increases, however the absence of active face pressure and possible weak zones present on the face contribute to the increase of the failures as the diameter increases.

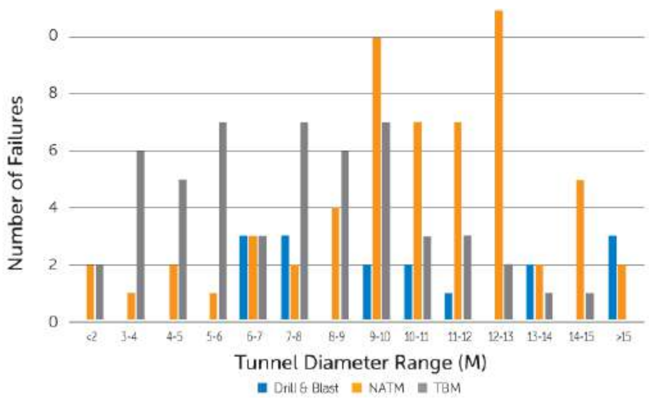

Figure 4. Number of tunnel failures per diameter range for different excavation methods

Figure 5 shows the tunnel failures distribution per overburden range for rock and soil conditions. For the soil conditions, the bulk of the failure cases are observed for overburdens up to 50m. For higher overburdens, there are usually no soil formations present and the failed cases are probably due to encountering weathered of fault zones in mountainous terrains. With regards to the failure type, face collapses are as high as 72% in metro tunnels which are the shallowest. For the rock conditions, the highest number is observed for overburdens between 20m-50m (typically soft or weathered rock conditions), 100m to 250m and more than 500m (typically stress induced failures, wedge collapses or weathered zones).

For tunnels during operation, fire and earthquake account for 82% of all the incidents, while fire is responsible for 90% of the fatalities recorded (Figure 6). It is interesting to note that no fatalities have been recorded due to earthquakes, which provides a further proof that tunnel structures are resilient to earthquake events.

Following the implementation of the Code of Practice for Risk Management of Tunnel Works in 2006, it is apparent that there is a downward trend in the number of tunnel failures which is very positive. This trend has also been identified by (Spyridis and Proske 2020), while the authors are generally aware of an – otherwise undocumented - consensus in the market that the establishment of this Code improved safety in tunnelling. Based on Ruler's experience in carrying out risk engineering surveys in infrastructure projects worldwide, the project stakeholders tend to exhibit an increased risk awareness and although in many cases they are not familiar with the Code, the implemented practices and approaches are following the spirit of the Code.

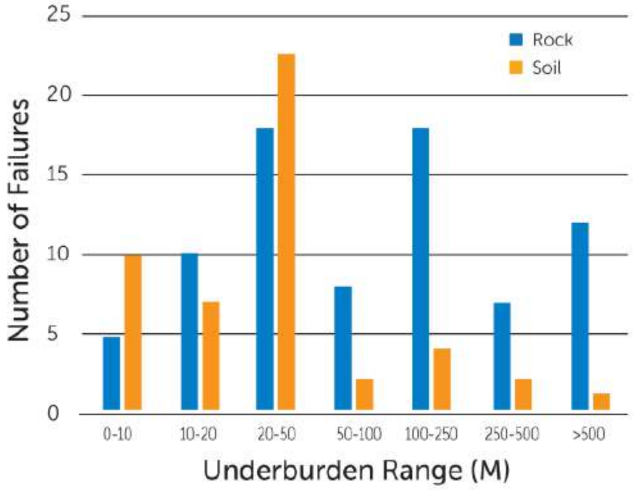

Figure 5. Number of tunnel failures per overburden range for rock and soil ground conditions

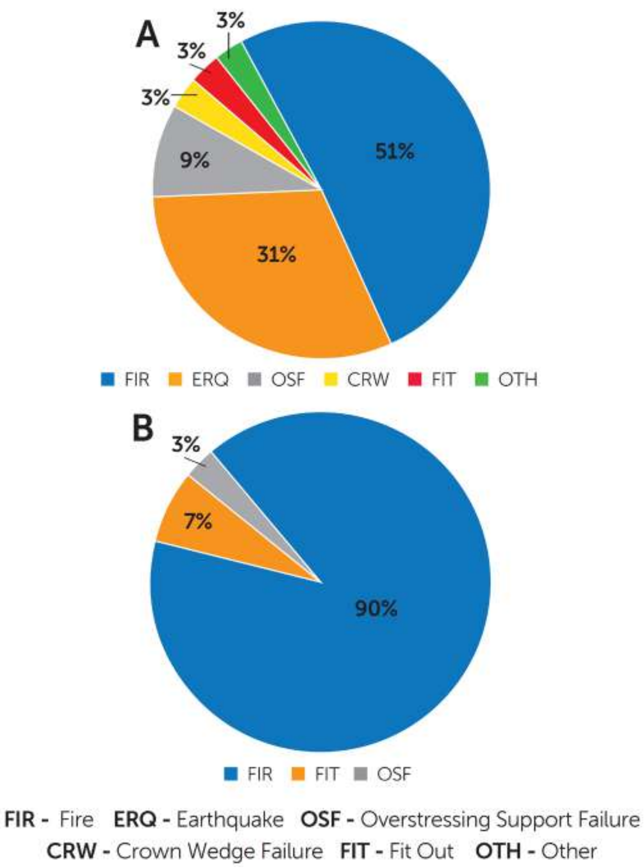

Figure 6. Failure types (left) and fatal incidents (right) during tunnel operation (Dallavalle, 2020)

Insurance losses

Given the sensitive nature of commercial information related to monetary losses and schedule delays, there is a shortfall of insurance related information on specific tunnel losses. Based on the information available in the public domain, the monetary losses and schedule delay frequency distributions were created (Konstantis, et. al, 2016).

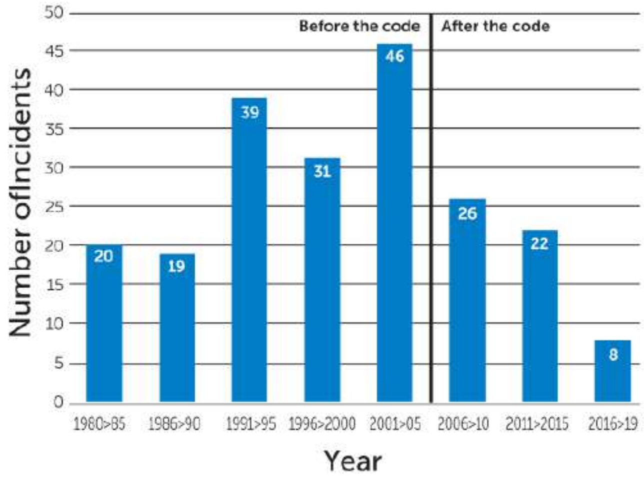

Figure 7. Number of incidents during tunnel construction per year and the impact of the Code of Practice for Risk Management of Tunnel Woks (Dallavalle, 2020)

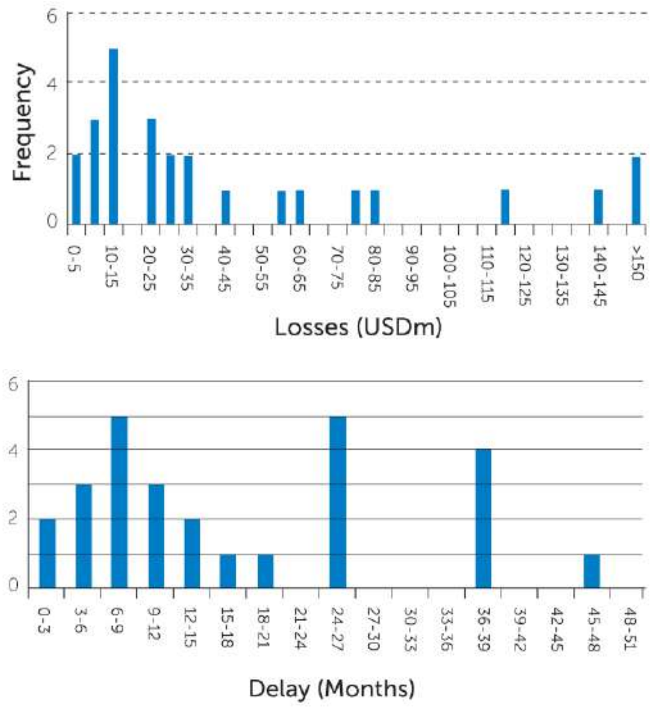

Figure 8. Frequency of insurance monetary loss (left) and schedule delays (right) due to tunnel failures (Konstantis, 2016)

Insurance losses seem to span a wide range of values, even exceeding US$150M. However, they exhibit a rather normal distribution for values up to US$50M, with a mean value of approximately US$10M to US$15M, but an elongated tail towards higher values and a peak in the range of US$100M. The bell-shaped probability density function for this distribution appears to be in good agreement with most tunnel limits in the majority of placed construction insurances policies. However, we can also identify cases with very high impact/ very low probability of occurrence. Looking at the schedule delays, there is almost a normal distribution for delays up to approximately 1 year. These values could be considered in good agreement with common practice experience. Delays up to 1 year, which correspond to one standard deviation, seem to be quite often and regular, whereas more severe ones can be considered as limited and particular cases. In addition, effort was put into identifying any potential relationship between the insurance cost and the corresponding delays that the same project has suffered. Figure 9 illustrates this, with the potential of a linear trend being established, neglecting of course the outliers and extreme cases. One interesting finding is that there are cases illustrating a very small economic loss but with significant time delays.

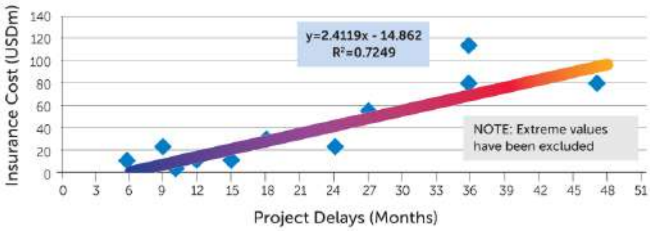

Figure 9. Insurance losses versus project delays (Konstantis, 2016)

Risk engineering management

Despite the inherent uncertainties associated with the design and construction of tunnels and underground works and the various aspects and factors with significant adversarial influence, a proactive risk engineering management attitude and probabilistic approaches (see also ITA, 2006) can efficiently contribute in reducing the size and frequency of major incidents. A higher risk reduction level is achieved when all important lessons learnt from past failures are integrated in a continuous updating process. Actions can be taken from the conceptual stage to operation, in order to mitigate, or even eliminate, construction failures and their consequences. These actions and the associated mitigation measures must be clearly documented in structured and formalized risk registers, which can also be part of the contract documents (R. Goodfellow, J. O'Carroll, S. Konstantis, 2014).

During the early and tender stages, all the available and relative information must be conveyed to the tenderers to enable a proper risk assessment and evaluation which will in turn inform accordingly the design approach and construction methodology and equipment to be used, thus reducing the probability of failure events. Equally important is the ground investigation scheme. Its extent, suitability and relevance to the individual project can be crucial in timely identifying the exact ground conditions and the existence of any major features capable of jeopardizing the safety of the works. The design stage has the dynamic to influence the risk profile of a project. A proper and well established design approach and management plan and a risk oriented philosophy is a major contributing factors and line of defence against future failures and corresponding losses. As mentioned above, design errors account for a significant percentage of the tunnel failures. In this regard, probabilistic assessments under uncertainty can provide a decision framework for design improvement and optimization (see for instance Konstantis, Spyridis and Gakis, 2016). Moving on to the construction stage, it is equally important that the design is implemented without deviations or is appropriately adjusted to the in situ conditions following a rigorous risk assessment and effective change management process. Probe drilling ahead of the tunnel face can be extremely beneficial and avert any forthcoming disaster by providing critical information on the existing conditions to be encountered.

Risk Engineering Management must encompass the above indicative and non-exhaustive elements in a structured manner, adopting a pro-active approach that spans from the conceptual and insurance pre-placement stage until the completion and handover of the project. The first step is to undertake a benchmarking exercise against the Code of Practice for Risk Management of Tunnel Works in an effort to review the risk management frameworks of the project. In addition, Risk Engineering surveys must be carried out at regular intervals with the aim to identify the ongoing risk profile of the project and ensure continuous adherence to the Code of Practice principles. In view of providing a proper and adequate insurance coverage of the tunneling works, the tunnel loss limits adopted in the Insurance Policy is a key driving element. Project hazards and associated risk scenarios and assessments must provide a realistic estimation of the Probable Maximum Loss.

The complete elimination of risks in tunnel construction is utopic. However, by implementing proper risk management practices and exhibiting a high risk awareness and attitude, we can collectively reduce both the probability of occurrence and the magnitude of consequences to acceptable levels. In this regard, communicating our failures and learning from them is a key risk mitigation measure."

Acknowledgments

The presented statistical interpretations partially rely on work by Mr. Marco Carlo Dallavalle, as part of his MSc Thesis 'Assessing the Failure Potential of Underground Works and the Impact of Delays and Costs on Insurability' at Leeds University, supervised by Ruler Consult and Dr. Chrysothemis Paraskevopolou.

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Μετά την δημοσίευση του άρθρου στο περιοδικό Tunneling Journal, ο πρόεδρος του ITIG (International Tunneling Insurance Group) επικοινώνησε με τον Σπύρο Κωνσταντή και παρείχε επανατροφοδότηση σχετικά με τα δεδομένα και τις απόψεις που περιέχονται σε αυτό με σκοπό τη βελτίωση των εξαγόμενων αποτελεσμάτων και την αποφυγή πιθανώς λανθασμένων συμπερασμάτων. Ο σχετικός διάλογος θα δημοσιευτεί σε μία από τις επόμενες εκδόσεις του περιοδικού Tunneling Journal. Παρακάτω παρατίθενται τα κύρια διευκρινιστικά σημεία:

***Ruler Consult (Spyros Konstantis)**: In our analysis we only used the publicly available data related to the recorded tunnel failure cases. We did not normalize the findings with all the constructed tunnels worldwide that did not have issues as this information does not currently exist in a comprehensive database. In the most relevant study provided by Spyridis and Proske (Revised Comparison of Tunnel Collapse Frequencies and Tunnel Failure Probabilities, 2020, in press), an estimate was made about the total number of tunnels existing worldwide, including the average tunnel length in some countries, from which the total km of driven tunnels could be roughly estimated (based on growth rate trend, etc). However the confidence level would not be high enough to draw definite conclusions, given all the uncertainties and assumptions involved. In addition, in the same study, there was no split between all the different tunnel uses to be able to estimate the relative performance of the four sectors (road, metro, rail and hydro). I believe the contribution of the ITA and the country members would significantly assist in this direction in order to acquire, for the concerned period 1980 to 2019 of the failure database, reliable data and information for the number and type of tunnels driven worldwide, including tunnel use, length, diameter, construction method, ground conditions, etc. We will then be able to normalize the data accordingly and provide a measure of the relative performance of each construction method.*

***Ruler Consult (Spyros Konstantis)**: From the literature review that was conducted in order to create the database, we recorded the geological formation which was present in the location where the tunnel failure occurred. Likewise, due to the absence of the overall relevant information for all the tunnels constructed worldwide without any issues, we did not normalize the findings. When in soil type formations (typical for low overburden), the failure mainly occurs due to the low geomechanical strength and deformability characteristics of the unit. In rock type formations (typical for higher overburden heights), the failures are usually to be attributed to the presence of weathered and weak zones, faults and local disturbed zones, bands with entrapped water under pressure, etc. From all the recorded cases, the highest percentage occurred in sandstone. Of course, this does not necessarily imply that tunneling in sandstone has by nature a higher risk profile and of course we can not linearly link failure to ground conditions when so many other variables have a significant contribution to a potential failure scenario. It could however be treated as a sign of caution that when tunneling through sandstone or similar geological formations, a higher risk awareness should be present based on the historical records.*

***Ruler Consult (Spyros Konstantis)**: With reference to Figure 4 in the article which plots the TBM diameter of the tunnel failures frequency, it was observed that the number of TBM failures decreases with increasing diameter and this is most probably due to the fact that there is a fewer number of larger diameter TBMs operating worldwide in comparison to smaller diameters. It was also pointed out that the larger the diameter, the higher the probability of face instabilities due to the bigger exposed face area and possibly due to mixed face conditions. It was emphasized that due to the much wider publicity that the large diameter TBMs are attracting and the higher financial and reputational burden in case of a failure, these larger diameter machines (often innovative indeed as they have to cross the current technological limits) receive higher attention to mitigate the identified risks. This aspect though does not guarantee that the larger diameter TBMs will be safer compared to the smaller diameter machines. The risk mitigations discussed in the paper can certainly reduce the risk profile of the larger diameter TBMs but of course more attention should be paid in these challenging and very often innovative cases.*

***Ruler Consult (Spyros Konstantis)**: The presented data does not include cases where the source of loss was ingress of external water, such as rainfall run-off and flood. We have recorded cases with notable water ingress but these are related to a local failure or a generalized collapse at or close to the face area. Losses attributed to water ingress from external sources are increasingly attracting the attention of tunnel project stakeholders as they are easily identifiable and can be sufficiently mitigated to acceptable levels with proactive risk management. In the risk surveys which Ruler Consult is conducting in various projects worldwide, we note an increased awareness trend towards mitigation of external water ingress risks, both in the temporary and permanent works. Simple measures that can be implemented include the construction of an upstand or a parapet around shafts and openings, the presence on site of emergency dewatering pumps with quick deployment time as well as deployable water barriers where a permanent installation may not be practically possible. In any case, it is essential to carry out a comprehensive flood risk management study for the considered flood return period in order to determine the appropriate threshold levels of the structures, including any freeboard as an additional safety margin, and ensure successful implementation of the flood risk control measures.*

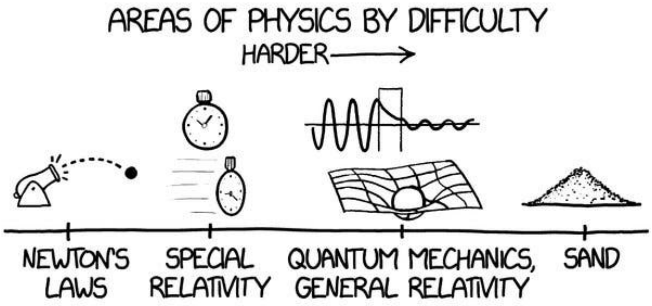
What Makes Sand Soft?

Understanding how grains flow is vital for everything from landslide prediction to agricultural processing, and scientists aren’t very good at it.

What is the softest sand in the world? Why is some sand softer than others?
— Peter S., Brooklyn

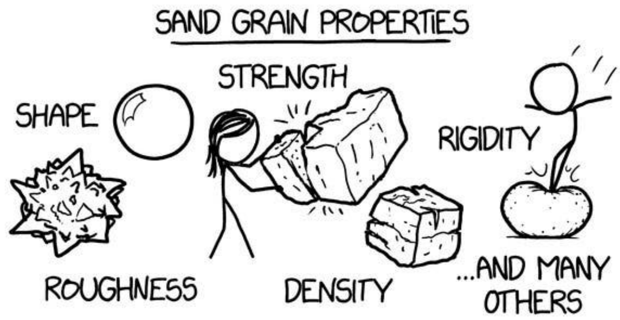
We don’t know. No one understands how sand works.

That may sound absurd, but it’s sort of true. Understanding the flow of granular materials like sand is a major unsolved problem in physics.



If you build an hourglass and fill it with sand grains with a known range of sizes and shapes, there is no formula to reliably predict how long the sand will take to flow through the hourglass, or whether it will flow at all. You have to just try it.

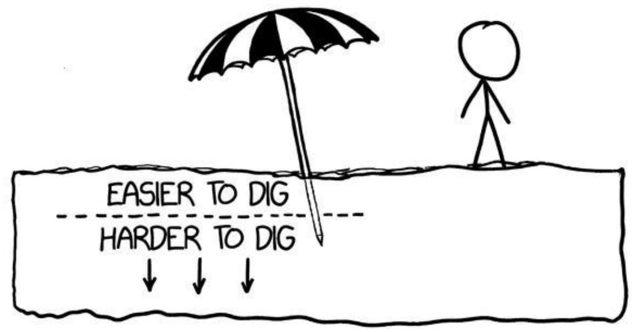
Karen Daniels, a physicist at North Carolina State University who studies sand and other granular materials — a field actually called “soft matter” — told me that sand is challenging in part because the grains have so many different properties, like size, shape, roughness and more: “One reason we don’t have a general theory is that all of these properties matter.”



But understanding individual grains is only the start. “You have to care not just about the properties of the particles, but how they’re organized,” Dr. Daniels said. Loosely packed grains might feel soft because they have room to flow around your hand, but when the same grains are packed together tightly, they don’t have room to rearrange themselves to accommodate your hand, making them feel firm. This is part of why the surface layers of beach sand feel softer than the layers underneath: the grains in the deeper layers are pressed closer together.

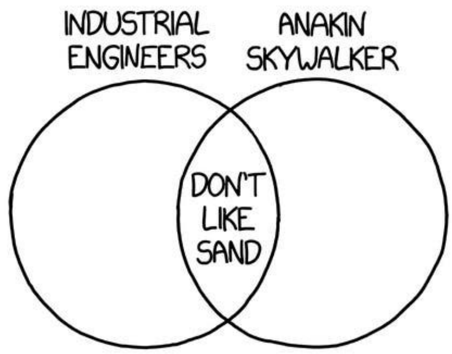
Our failure to find a general theory of sand isn’t for lack of trying. For everything from agricultural processing to landslide prediction, understanding the flow of granular materials is extremely important, and we just aren’t very good at it.

“People who work in particulate handling in chemical engineering factories can tell you that those machines spend a lot of time broken,” Dr. Daniels said. “Anyone who’s tried to fix an automatic coffee grinder knows they get stuck all the time. These are things that don’t work very well.”



Luckily, we’re not totally in the dark, and can say a few things about what makes sand softer or harder.

Sand with rounder grains usually feels softer, because the grains slide past each other more easily. Smaller grains also don’t produce the pinprick feeling of individual grains pressing into your skin. But if the grains are too small, moisture causes them to stick together, making the material feel clumpy and firm.



Dr. Daniels said that the softest granular material she had ever touched was a substance called Q-Cell, a silica powder used for filling dents in surfboards. The powder is made of hollow grains, so it feels extremely light, and the silica material stays dry, which keeps it from clumping. She compared the way it sloshes around to a bucket full of very fine, very dry beach sand.

A beach made of Q-Cell “sand” might be soft, but it wouldn’t be very pleasant. Fine, dry powders are dust, not sand, and inhaling them can be extremely hazardous to your lungs. The ideal beach sand would probably have a grain size and shape that balanced softness, dustiness, clumping and a variety of other properties that make sand soft and nice to walk on. With so many subjective factors to consider, it’s hard to say exactly what the ideal soft beach sand would be.

You’ll just need to gather some experimental data.

(Randall Munroe / The New York Times, Nov. 9, 2020, https://www.nytimes.com/2020/11/09/science/what-makes-sand-soft.html)

Fractality in Geomechanics

Gerd Gudehus

Abstract The cognition of natural soil and rock, called geomatter as it is not a simple material, is impeded by opaqueness and wild randomness so that Aristoteles' induction and Popper's demarcation of theories are seemingly insufficient. This can be attributed to critical phenomena with seismogeneous chain reactions which exhibit fractal features, leave back permanent traces and elude mathematical treatment in general. In the stable range of grain fabrics buckling force chains cause a heat-like micro-seismicity which activates redistributions and can be captured mathematically. This is no more possible for chain reactions due to a positive feedback by seismic waves and pore water diffusion, with sizes from sand-boxes to subduction zones. Successions of them can be captured probabilistically by power laws with lower and upper bounds, which should be estimated in a rational way for keeping the geotechnical risk acceptably low. For this aim one should reduce deficits and avoid defects of cognition

1 Introduction

The similarity of sand and rock can get visible at the beach (e.g. Fig. 1). It implies self-similar roughness, i.e. geometrical *fractality*. One could estimate fractal dimensions of rims, profiles and surfaces with Mandelbrot's [20] box-counting, but this is left aside as generating mechanisms elude yet mathematical treatment. I focus on internal mechanisms which are intricate enough because of their triple fractality, viz.

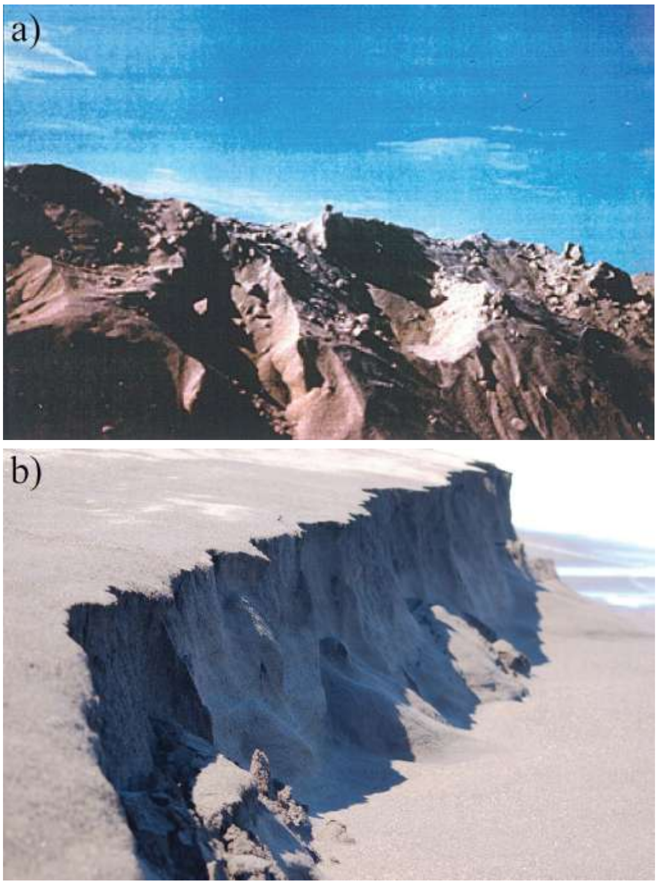


Fig. 1 Self-similarly rough sand structures of ca. 0.3m height at the beach: a) mountain ridge (photo R. Gudehus), b) cliff (photo M. Poblete)

- spatial: the solid mass m_s in a cube increases with its length d by $m_s = m_{sr} (d / d_r)^{3\alpha}$ with an exponent ca. $0.9 < \alpha < 1$ as the pore system (πόρος = passage) is geometrically fractal;
- temporal: seismic spectra tend often to $v^2 \propto 1 / f^{2\beta}$ with ca. $0.9 < \beta < 1$;
- episodic: successions of collapses with released energy E or more occur often with a number $N = N_r (E / E_r)^{-\gamma}$ and an exponent γ near 1.

This holds true approximately within lower and upper cutoffs, and the fractal exponents are not constant. Spatial and temporal distributions of geomechanical quantities may be continuous, but are not differentiable so that gradients and rates do not properly exist. Sets of events are wildly random [21] so that a single event can matter as much as the sum of all smaller ones [22]. Geomatter is not a simple material in [35] sense, and *geomechanics is no continuum mechanics*:

- the solid partial stress, spatially distributed in fractal force chains via contact flats of grains or rock fragments, is no force density in Cauchy's sense;
- rearrangements of the solid fabric are no deformations as displacements are not differentiable, and as there are no unique reference configurations except for the vicinity of solids;
- capillary effects enable metastable fractal fabrics of grains and rock fragments;
- even in a stable range constitutive relations for solid and pore fluid in the usual sense cannot strictly hold true for lack of gradients and rates;
- fractal pore systems force an anomalous diffusion of masses, energies and momentum already in the stable range;
- at the verge of stability geomatter passes through phase transitions in wildly random chain reactions;
- there are no initial states and boundaries in a classical sense.

Nevertheless there are systematic features with the aid of which geotechnical engineers can and should reduce the risk of operations. This is outlined first for the stable range of grain fabrics where a mean-field theory suffices as long as fractal relics matter little (Sec. 2), then for sand deposits with shear bands or liquefaction (Sec. 3). The outline is continued for rock from samples to subduction zones where conventional concepts fail more often (Sec. 4). I turn then to random successions of critical phenomena and to the geomechanical risk (Sec. 5), thereafter my *desiderata* refer to cognition deficits and defects (Sec. 6).

2 Sand in the stable range

Fabrics of grains, called *granular solids* by physicists, exhibit fractally distributed stress fields with force chains as no two grains are equal. At equilibrium they have a specific elastic energy w_e, depending on invariants of the elastic strain e^e_{ij} and the void ratio e, which is the potential of stress by $\sigma'_{ij} = \partial w_e = \partial \varepsilon^e_{ij}$ [11]. Deforming a fabric causes buckling of force chains in a random succession, e.g. Fig. 2.

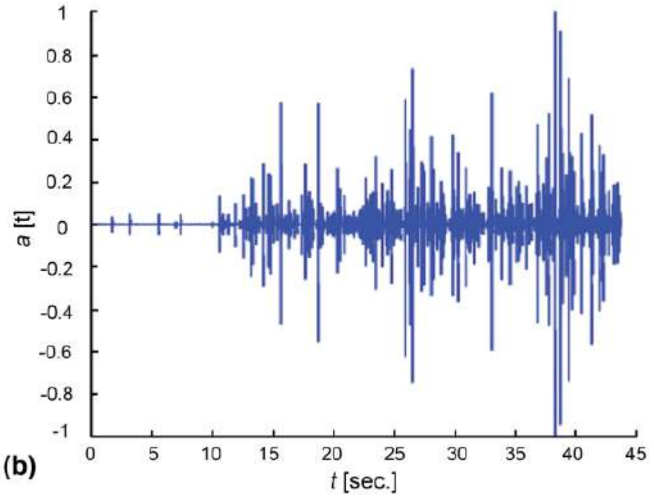


Fig. 2 a) Rubber mould enclosing corundum grains under vacuum, b) acoustic emission due to axial loading [10]

Audible collapses occur practically synchronous with the drive, i.e. the response is rate-independent, and get more marked with an increasing stress ratio. Up to a critical point each one is accompanied by a minute rearrangement, then a noisy bulging indicates an avalanche-like succession of buckling force chains so that a new equilibrium is attained only after a big rearrangement.

The *micro-seismicity*, with frequencies from an audible part up to eigenvalues of grains, is incoherent in the stable range. It goes over into heat instead of being conserved as the interaction of grains is not conservative like the one of molecules. Coming in jerks due to an imposed deformation or load, it activates rearrangements with a relaxation of elastic energy. This is missed in discrete element simulations with an artificial viscosity, whereas physicists calculated seismic energies and fluctuating parts of elastic energies at equilibrium by means of event algorithms [16]. Thus the force-roughness means a latent seismicity [3] which is waked by deformations imposed to the grain fabric.

The dynamics of granular solids is determined by elastic and micro-seismic energies which go over into heat at dislocating grain contacts. In their 'granular solid hydrodynamics' (GSH) [12] proposed a relaxation of elastic energy with a rate proportional to a granular temperature T_g by means of a factor λ, and obtained a hypoplastic relation for monotonous deformations. In a subsequent paper [6] we showed that deformations with cyclic portions cause a kind of plastic flow like in the high cycle accumulation (HCA) model by [27]. However, the differential response at reversals is always elastic as the half-life of T_g is far shorter than the pause of deformation during a reversal. Thus GSH underestimates hysteretic and cumulative effects in general, and numerical simulations with it are intricate.

I propose instead evolution equations with a hidden state variable χ named *eutaraxy* (*ευ*=favouring, *τάραξις* = disturbance) [5]. Therein $T_g\lambda$ of GSH is replaced by $\chi d\varepsilon / dt$, with an amount of stretching ε, for the relaxation of ε^e_{ij} so that its evolution is rate-independent. The evolution equation of χ has a term for driving and a second one for halting, both proportional to $d\varepsilon$=dt, with a switch function depending on the sign of $d^2\varepsilon / dt^2$. Thus χ can reach a hypoplastic limit for monotonous deformations and can approach zero for non-monotonous ones with small amplitude. Rates of fabric stress are related with the ones of ε^e_{ij} by an elastic energy w_e and a transfer factor a almost like in GSH, but w_e has a critical point at e_{max} instead of e_{min} and a depends on χ instead of T_g.

This constitutive model, named GSD-EH for brevity, captures the observed sand behavior in the stable range up to its verge with few parameters which can be determined with triaxial tests - but why and how far? The micro-seismicity – observable as crackling noise - arises in fact alongside with an imposed deformation and does not depend on σ'_{ij} and e. It activates intergranular dislocations which are aligned by ε^e_{ij}, i.e. by σ'_{ij} via w_e and a, and with a rate in proportion to the one of strain and to the propensity for micro-seismicity, i.e. to $\chi d\varepsilon = dt$. The transfer factor a is the same for motions and forces, like in a bicycle with a belt instead of a chain connecting discs instead of toothed wheels. Due to an erratic stick-slip the drive is transferred with a loss factor $0 \le a < 1$ both kinematically and statically. With driving χ grows up to a saturation value in the hypoplastic range so that it gets constant. An isochoric continuation leads to a critical state with a mean effective pressure $p'(e)$, but no more for $e \to e_{max}$ as then a granular solid collapses into a granular fluid.

Halting of an imposed deformation means a reduction of χ due to its relaxation by the dwindling $\chi d\varepsilon / dt$. The simultaneous reduction of the transfer factor a and the elastic pressure $p^e = ⅓\, \partial w_e / \partial \varepsilon^e_v$ keeps the fabric pressure $p' = (1-a)p^e$ constant, this leads to $a \propto \chi.\chi \to 0$ requires a halting deformation which is hardly achieved after a hypoplastic state. However, repeated reversals with a small amplitude lead to χ near zero so that the response gets nearly elastic, except a cumulative part like in the HCA model of [27]. Cyclic attractors - i.e. asymptotic state cycles [3] - are also captured, particularly butterfly-like ones for isochoric cyclic deformations and lenticular ones for isochoric ratchetting.

GSD-EH works at best up to the verge of convexity of we as then critical phenomena arise (Sec. 3), but no more with *relics of critical phenomena*. Those with shear bands mean fractal spatial fluctuations of the void ratio e, which are hardly ironed out by seismic actions (*σείω* = to shake) via attractors in the large [3]. Therefore wave propagations in the stable range are accompanied by an energy diffusion [7] so that power spectra tend to $v^2 \propto f^{-2a}$ with a fractal exponent a just below 1. Fractional derivatives employed in this theory are expected values of classical ones. If relics of critical phenomena are less ironed out the average χ is higher so that the subsequent response is less elastic. As initial χ-fields are unknown in general the eutaraxy in the large causes an inevitable fuzziness of predictions already in the stable range.

The pore system imposes its fractality to the *pore water* already at and near stable equilibria. As water and grain mineral are neutral with respect to changes of pore water pressure p_w the effective or solid partial pressure is $p' = p-p_w$ in case of full saturation. Thus water and solid are isochoric, and so is a grain fabric without drainage. At equilibrium the hydraulic energy height $h \equiv h_g + p_w = \gamma_w$, with geometrical height h_g and specific weight γ_w of water, is constant. Slow deviations are usually captured with Darcy's relation $v_{wi} = k_f \nabla_i h$ of seepage velocity with the hydraulic gradient. However, the thus presumed derivatives do not properly exist with a fractal pore system. Like with the wave propagation indicated above constitutive relation and mass balance of pore water should be written with fractional operators which represent expected values of classical ones in a fractal random set. Then solutions can represent an anomalous diffusion without inadequate notions like laminarity and tortuosity.

The fractality of granular pore systems matters more with *capillary effects*. In case of multiply-connected pore gas Bishop's heuristic relation for p' can still be proven with equilibrium thermodynamics [13], and the authors capture now also the capillary hysteresis. Like with full saturation the transport of pore water and gas could be modelled with fractional derivatives. If pore gas is enclosed its spatial distribution - known as fingering and gas islands - gets less regular so that fractal random sets require fractional images already at equilibrium. Capillary bridges enable grain fabrics with aggregates and macropores which are metastable for $e>e_{max}$ as they collapse into a suspension after flooding (Sec. 3).

Robust geotechnical systems enable *indifferent limit equilibria*, i.e. dissipative transitions to infinitesimally neighbored configurations with the same overall potential energy. Apart from geometrical effects as with toppling or pull-out, then limit equilibria with a realistic set of mechanisms and with ductile shear resistances τ_f are not only necessary, but also sufficient for overall stability [8]. For undrained loose water-saturated sand t f is at least the one determined by GSD-EH from critical states with $(e_{max} - e)/(e_{max}-e_{min})$ and φ_c. Drained sand has at least $\tau_f = \sigma' \tan\varphi_c$, but fabric pressures σ' can be estimated at best for slopes and retaining structures. There are no indifferent limit equilibria for piles, tunnel roofs and similarly confined configurations as pressure fields are far from statically determinate. The bound theorems of ideal plasticity fail also in case of shaking with insufficient drainage, e.g. during earthquakes or offshore.

3 Critical phenomena with sand

At the local verge of stability of a grain fabric its elastic energy is at a *saddle point* with respect to e^e_{ij}. This is a necessary condition for the loss of equilibrium, which is evident with two invariants of ε^e_{ij}, e.g. Fig. 3. Like with a sphere on the wrist of your hand there are two opposite directions with a maximal release of kinetic energy; a collapse occurs with one of them if there is no constraint. An isobarically driven grain fabric dilates then in shear bands, thus polar quantities arise with σ'_{ij}-alignment. Quasi-static simulations with hypoloastic relations, including polar degrees of freedom, yield shear band patterns which come astonishingly close to observed ones [3]. The simulated extension of a dense sand layer yields a fractally hatched shear band pattern and a warped surface, e.g. Fig. 4.

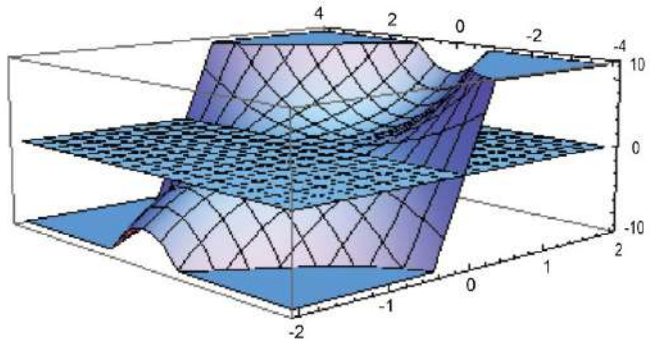


Fig. 3 Blow-up of the elastic energy versus first and second invariants of the elastic energy at a critical point with a tangential plane

This quasi-static simulation could not be continued beyond the second configuration as the equations got ill-posed. This would also happen with a polar extension of GSD-EH, whereas fictitious viscous terms would constitute a non-physical regularization. Inertial effects should be taken into account, but as yet nobody did that. Fortunately there is an evidence of kinetic effects in model tests. George Darwin [1] - second son of Charles Darwin, astronomer and mathematician - checked earth pressure theories by means of a box filled with dry flint powder (Fig. 5). Releasing a wall with hinges by a string he measured the resulting force with a spring balance up to a critical point. This was indicated by a 'hissing noise' and a sudden 'settling' after a slow 'unsettling' during the release. He asked Clerk Maxwell for advice, who stated that 'a *historical element* would enter largely into the nature of the limiting equilibrium of sand', and concluded that this would 'essentially elude mathematical treatment'.

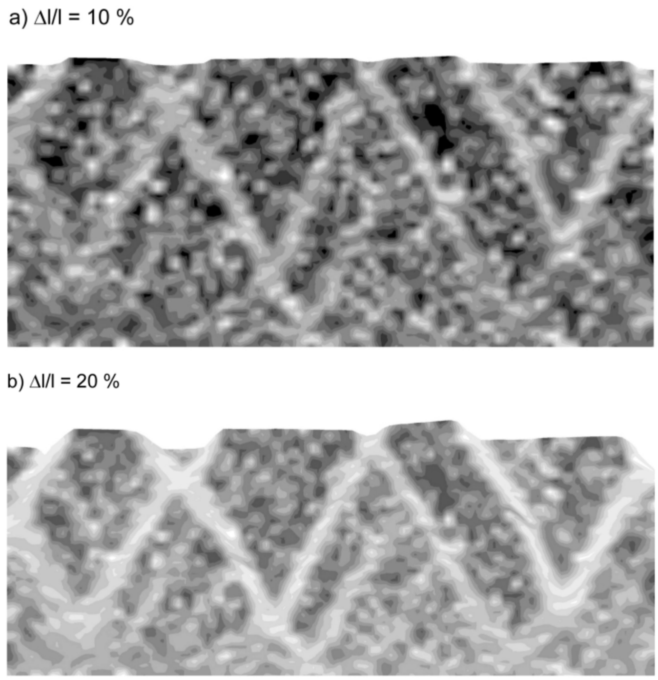


Fig. 4 Simulated quasi-static extension of an initially 10 cm long sand strip with ca. 1 mm grain size and polar quantities. State at the right boundary as at the left one with reflected orientation, configurations after 10 % (top) and 20 % extension (down), black zones dense, white bands dilated [28]

Darwin demonstrated that this 'capricious' behaviour refuted the earth pressure theories of Rankine and Boussinesq. His 'unsettling' was rediscovered by Reynolds as dilatancy, while his conclusions were ignored until present. His hissing noise indicates a coherent seismicity with frequencies of at least *ca.* $c_s / d \approx 100 m/s$ with $c_s \approx 100 m/s$ and $d \approx 0.1 m$. This arose in a contractant *chain reaction* within a Coulomb-like shear zone, where the sand got close to critical points with equal stress alignment by the release of the wall. Like with dominoes on a table with equal alignment and suitable distances pressure waves produced a positive feedback towards critical points. This occurred up to a surroundings with less uniform alignment and lower stress ratio. Thus limit stress states arose one after another, not simultaneously in a region as often assumed since Rankine's times.

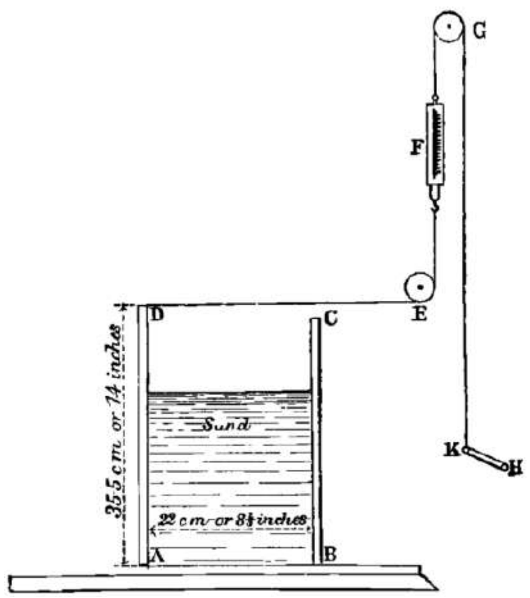


Fig. 5 Model test setup by George Darwin [1]

Model tests with dry sand in a box are irreplaceable for understanding *tectonic deformations* [23]. For sand these are localized in shear bands with stress alignment via a Mohr-Coulomb condition, and they occur similarly with faults in the lithosphere. Initial and boundary conditions in sand-box tests are debatable as the lithosphere has no onset and no walls with imposed displacements. Thus the extension of a sand layer, e.g., can produce lithosphere-like fractal patterns [37], but with lateral artefacts for lack of antimetric boundaries like in Fig. 4. Model tests with periodic boundary conditions are more adequate and yield likewise spatial fractality [31]. One could track contractant chain reactions like those in Darwin's experiments by successive location of seismic sources in a sand-box, though with an inevitable haziness because of energy diffusion [7]. Such investigations could clarify the interplay of slow and fast tectonic processes, and could foster calculation models of seismogeneous chain reactions.

Loose flooded sand deposits demonstrate that seismogeneous chain reactions are also enhanced by the *diffusion of pore water* [4]. Gas-filled macropores enable metastable grain fabrics with an average void ratio $\bar{e} > e_{max}$ which collapse into a suspension after minute disturbances. A collapse front spreads laterally by P-waves up to more than 100 m width so that surface waves arise which are registered up to 100 km away. As the pore pressure p_w attains the total pressure p in the liquefied zone p_w rises in the vicinity by the combination of seepage and compression of enclosed gas, i.e. a kind of diffusion. Thus a next collapse front arises with a progression of ca. 10 m/s, and further ones as far as the deposit is metastable. Combined with a humid cover this led to avalanches with en-échelon offsets (e.g. Fig. 6) with released energies up to ca. 109 kNm.

Fig. 6 Loose partly flooded sand deposit from lignite mining after flow slides (courtesy LMBV)

Similar technogeneous avalanches occurred in building and mining sites with released energies from about 10^4 kNm to 10^{10} kNm. Collapses of flooded sand into excavations or tunnels release smaller energies, but can also cause considerable damages. Their 'capricious' dynamics eludes again as yet mathematical treatment. Bigger avalanches of flooded granular solids with gas inclusions occurred naturally. The one triggered at the volcano Huascaran (Peru) 1962 erased a town with 20.000 inhabitants and released about 10^{14} kNm. Another one triggered at the Norwegian continental shelf about 8000 years ago (Storegga) released ca. 10^{16} kNm and produced a tsunami.

4 Critical phenomena with rock

For employing the similarity of sand and rock indicated with Fig. 1, I begin with triaxial test results by [18]. Critical points of a cemented grain fabric were attained by axial shortening or lengthening plus increase of pore water pressure p_w. If the effective radial pressure σ'_3 was higher than the tensile strength c' a *shear band pattern* arose at a Mohr-Coulomb limit, Fig. 7 above. It resembles the ones in triaxial tests with sand, and also the simulated one in Fig. 4. The few minutes required for getting a uniform p_w suit to the estimated time needed for a diffusion of pore water [3], and the permeability decreased due to the comminution in shear bands. The confined chain reaction could be tracked by locating seismic sources, also in a series of such experiments, this could help develop mathematical models for such critical phenomena.

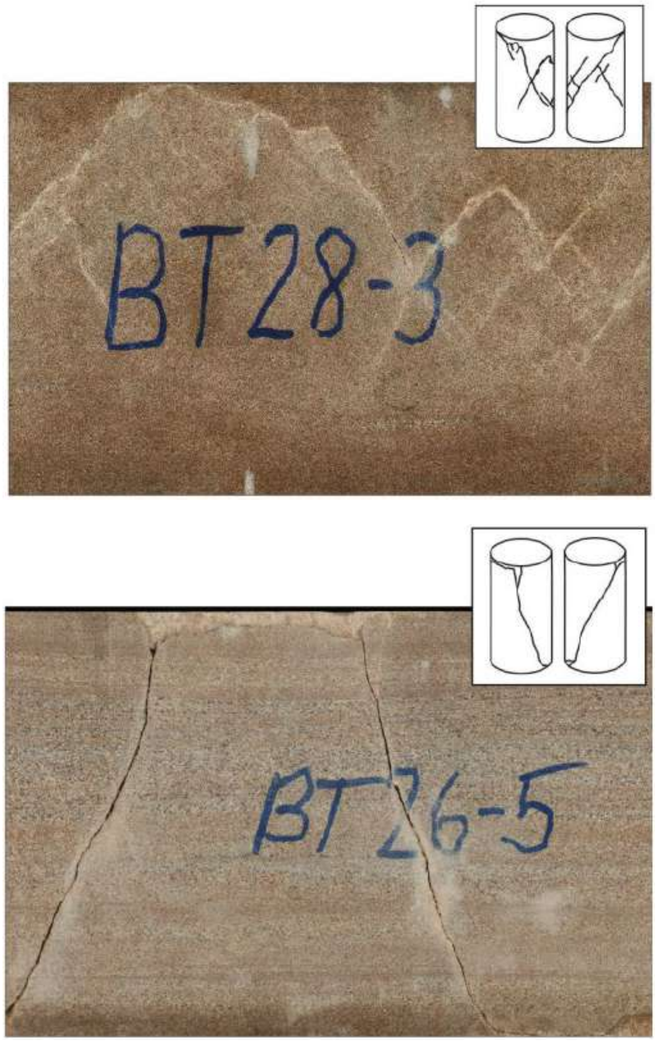


Fig. 7 Shear bands (above) and cracks (below) of water-saturated sandstone samples after triaxial tests with high or low effective radial pressure, respectively (winding-up photographs by Lempp et al 2018)

Critical points with $\sigma'_3 < c'$ led to opening cracks, e.g. Fig. 7 below, and thus to a dramatic increase of the overall permeability. This kind of *splitting or discing* by axial shortening or extension, respectively, resembles a Griffith [2] fracture, but eludes as yet mathematical treatment because of its wild randomness. The permeability with cracks is not Darcy-like as temporal and spatial derivatives do not exist, but could be calculated for the linear hydraulic range with a given pore system and boundary conditions. The evolution of crack systems is a more difficult task as the equations for the solid degenerate at critical points, and as random sets of such events should be constructed. Such an approach could help understand rock collapses *in situ* at so low depths thats cracks get wider.

Features like in Fig. 7 could also be obtained with humid sand samples at low pressures. Then condensate bridges are no more solid and brittle, but liquid and determined by the vapor pressure so that they dwindle by dilation. The potential energy has an elastic and a capillary part, and at critical points localized state variables come into play. Seismogeneous chain reactions prograde by P-waves and by diffusion of pore water, the latter also via vapor in case of humid geomatter. Like with Darwin's conclusions the loss of stability cannot be captured by conventional limit equilibria because the historical element eludes as yet mathematical treatment. A localized dilation can go over into a crack if the potential energy is at a saddle point like in Griffith's [2] theory, but with spatial and temporal fractality.

The striking similarity of small humid sand structures, e.g. those in Fig. 1, with *rock slopes and mountains* can be explained and employed without calculations. Parts of a steep slope or a cliff collapse suddenly after weathering up to a critical point. Limit equilibria - as conventionally proposed with humid sand and waterfilled cracks - may be snapshots, but are insufficient for the judgment of stability [8]. Simulations with finite elements are even more misleading if localizations including capillarity and chain reactions with seismic and hydraulic feedback are not taken into account. This holds also true with erosion and avalanches. A seismo-hydraulic monitoring could serve as early warning if collapse mechanisms are understood with the aid of model and field tests, which could lead to realistic calculation models including the ever-present fractality.

This argument can also be applied to *cavities*. The caving in of boreholes is usually investigated by means of numerical simulations with radial symmetry, but thus the wild randomness of chain reactions with an ever-present fractality is missed. Further damage can arise with erosion along boreholes if this leads to eruptions of mud, gas and/or oil. Natural eruptions from gas inclusions with excess pressure and collapses of sinkholes elude likewise mathematical treatment. The same holds true for excavated cavities, particularly with tunnelling. Limit states are not sufficient for the proof of stability because the shearing resistance is not perfectly plastic as needed for the bound theorems. Presently employed quasi-static finite element simulations require stability so that this cannot be proven with them. Temporal extrapolations of measured displacements and forces are futile as the required differentiability gets lost with the fractality of critical phenomena. Again a seismo-hydraulic monitoring could serve instead for early warning if the mechanisms are properly understood.

The fractality matters also for the identification of *seismic sources*. In classical models point sources are conceived as momentum tensors with assumed spatiotemporal distribution for getting far-field spectra, and this procedure is tentatively inverted [19]. The classical Green function for a point source can represent speeds and polarizations of wave crests so that the ray approximation is legitimate for farfields in spite of the energy diffusion due to an inherent fractality in the stable elastic range [7]. Thus momentum tensor inversions can convey at best a diffuse image of propagating dislocations. As outlined further above seismogeneous chain reactions differ from evolutions of regular cracks, and usual stick-slip models are tribologically contestable [29, 9].

A possible way out of this conceptual blockade is the transfer of findings with sand to the lithosphere, in particular to *subduction zones*. The biggest one exists under Chile, shown e.g. with a cross section near its capital in Fig. 8. The dots representing seismic sources accumulate in a rather fractal manner in three regions. The Nazca plate (d) dips with a trench (fosa) and hits the continental plate in a thrust zone (a). This may be considered as a passive Coulomb zone with a continued drive. Differently from Darwin's [1] experiments chain reactions - with positive feedback by seismic waves and pore water diffusion - arise repeatedly. The continued shearing of the oceanic plate past the continental one is no more sand-like at bigger depths (b) due to a kind of melting. There mineralogical phase transitions occur in shear bands without pores, but again in a 'capricious' succession of critical points. The horizontally compressed plate under the mountain ridge reaches critical points preferably under its rim (c) due to spreading forces.

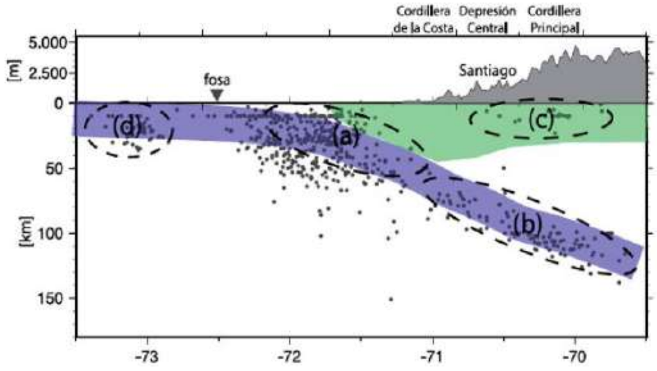


Fig. 8 Cross section of Chile with seismic sources [17]

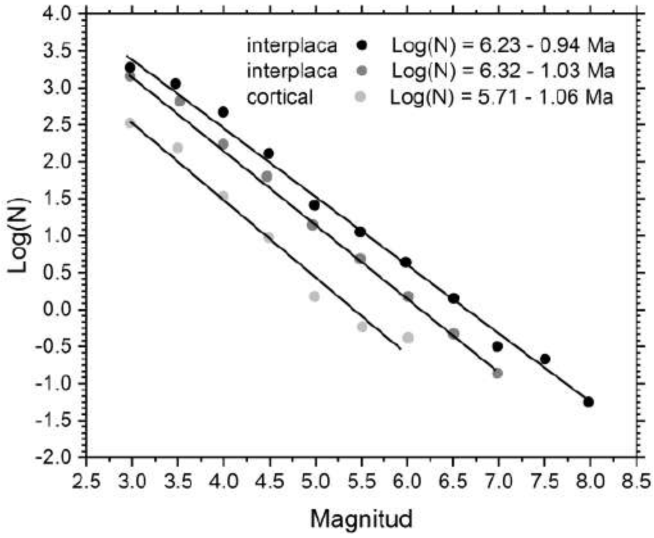


Fig. 9 Seismicity of central Chile [17]: logarithm of number of earthquakes with magnitude *M* or more. Upper line interplate (thrust), middle one intraplate (subductive shear), lower one crustal (under mountains)

5 Successions of critical phenomena and geomechanical risk

Fig. 9 depicts numbers *N* of earthquakes for the cross section of Fig. 8 which exceed a certain magnitude *M*. The regression lines confirm the *Gutenberg-Richter relation* with a negative slope or *b*-value near 1. *M* is defined as the logarithm of the energy *E* released in a seismic episode, expressed in energy units. I leave aside the determination of *E* and *M*, presuming that disputable details matter little for the sequel. One can represent the straight lines by

$$N = N_r (E/E_r)^{-b} \; ; \; E_r \leq E \leq E_m \qquad (1)$$

with a reference number N_r, a lower cutoff E_r serving also as a reference value, and an upper cutoff E_m. Normalizing *N* by N_r leads to the cumulative probability

$$P_{\geq E} = (E/E_r)^{-b} \; ; \; E_r \leq E \leq E_m \qquad (2)$$

that an earthquake releases at least the energy *E* if it happens in a region where *E* ranges from E_r to E_m. So why does (2) hold, and why with $b \approx 1$?

We consider random successions of seismic episodes with released energy *E* as *stable Lévy processes* [9]. *E* comes in jumps versus time t as the duration of an episode is far smaller than its recurrence time. Subsequent jumps have variable sizes with a wildly random [21] distribution which changes with time. This property is called 'infinite divisibility', and if the probability distribution is not changed by superimposing distributions of different observation times it is called 'stable'. Then the cumulative probability $P(\xi,\tau)$ of events with $\xi \equiv E/E_r$ or more at a dimensionless time $\tau \equiv t/t_r$ satisfies the relations

$$P(\xi,\tau) = P(a^{1/\gamma}\,\xi\,,\,\tau) \qquad (3)$$

and

$$P \propto \tau\xi^{-\gamma} \text{ for } \xi/t^{1/\gamma} > 1 \qquad (4)$$

The wild randomness means that $P(\xi,\tau)$ does not depend on the one of any previous time, which is seemingly at variance with the historical element of seismogeneous chain reactions. However, any subsequent chain reaction occurs in another site than the preceding one as this led to a stabilization so that a continued magma drive leads first other sites close to critical points. This occurs in such a way that the correlation of successive chain reactions arising at different sites gets lost.

If the lithosphere response to the magma drive is *rate-independent* (cf. Fig. 2) P is not changed if either the energy threshold E or the registration time t changes by a certain factor. This means γ=1 by (3) and (4), then the stable cumulative Lévy distribution simplifies to the Cauchy distribution

$$P(\xi,\tau) = 1 - (2/\pi)\arctan(\xi,\tau) \qquad (5)$$

Its log-log plot (Fig. 10) exhibits a kind of plateau due to $P \to 1$ for $\xi/\tau \to 0$, a bend near $\xi/\tau = 1$ and a straight line with a slope -1 right of it by (4). Expected value and variance related with (5) diverge, this cannot occur physically and is avoided with an upper cutoff, as assumed also in Fig. 10. A smooth cutoff function instead of an abrupt one widens the range of distributional stability and enables an objective scaling [32]. The convergence to a normal distribution for sums of truncated Lévy distributions is extremely slow [25].

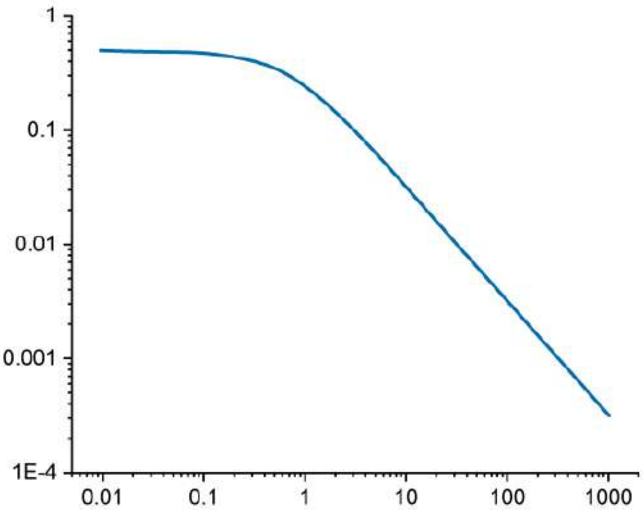


Fig. 10 Log-log plot of a stable cumulative Lévy distribution with $g = 1$. Cumulative probability P versus $x = t$, cutoffs for $x / t \to 0$ and $x / t \to \infty$

The comparison of (2) and (4) supports a stationary *Gutenberg-Richter relation* with b = 1. An upper bound E_m of released energy is determined by the biggest possible chain reaction in a considered region. It could be estimated as $E_m \approx F_m u_m$ by means of the length and depth of a thrust zone with uniform alignment, leading to a Coulomb-like resisting force F_m, and the biggest possible sudden tectonic displacement um. This leads to $E \approx 10^{18}$ kNm like for the Valdivia event 1960 with M = 9.6, the biggest earthquake ever registered. Due to their long recurrence times such events are rarely observed and hardly representative in a statistical sense. An objective lower cutoff E_r could be related with the log-log bend of an observed distribution near $\xi / \tau = 1$ (cf. Fig. 10). It is inevitably hazy as the theoretical bend is smooth, which corresponds to indiscernible events of a background noise.

b = 1 is legitimate if the tectonic conditions are stationary and the lithosphere responds to them without delay, whereas thermally activated dislocations and changing tectonic conditions lead to an *instationary Gutenberg-Richter relation*. Stable Lévy distributions with γ above or below 1 can be approximated by series expansions [24]. With $\gamma \neq 1$ the cumulative probability can again be approximated by (2) due to (4), while it tends to 1 for $(E/E_r) / (t/t_r)^{1/\gamma} \to 0$. Thus the total of released energies beyond a certain E does not grow with the same factor as the registration time. The substitute distribution (2) requires therefore time-dependent bounds E_r and E_m, and the reference number N_r in (1) is no more proportional to the velocity of the magma drive and the registration time.

The Gutenberg-Richter relation with $b \approx 1$ is empirically well established so that it can be used for the validation of stable Lévy processes with γ around 1. Seismically less active regions are left aside as the events constitute a kind of noise which cannot as clearly be related with tectonic mechanisms as with subduction zones. There are *other successions of geomechanical chain reactions* which are seismogeneous and wildly random so that the theory of stable Lévy processes can be of use. Their size, given by the released and dissipated energy, ranges again from a rather diffuse lower cutoff to an upper one which is several orders of magnitudes bigger. This holds true also for collapses of and eruptions from natural cavities, slope collapses from rock falls to avalanches, rupture of retaining structures for excavations and slopes, toppling of high-rise buildings and offshore structures, and combinations of such cases.

A common feature of such mechanisms is an ever-present spatial and temporal fractality, and the impossibility to capture them with presently used computer models. For quantifying the related geomechanical risk R, i.e. the expected value of damage D, probabilities of such events and the exposition of men and objects to them is needed. In the simplest rational approach the probability density derived from (2) with $b = \gamma = 1$, and the ansatz $D = VE$ with a constant vulnerability V, leads to the expected value

$$R \equiv \bar{D} = V\,E_r\,\ln(E_m / E_r) \qquad (6)$$

and with $E_m \gg E_r$ to the variation coeffient

$$V_D = V_E = \sqrt{(E_m / E_r)} / \ln(E_m / E_r) \qquad (7)$$

An insurance fee is obtained from R by adding an amount for administration and risk of the insurer. The latter is higher than with normal distributions as the law of big numbers works only for at least $n = V_D$ cases [25]. The need of keeping V low and of confining the worst case with $D = VE_m$ is trivial. Less evident is the control of the lower bound E_m so that, alongside with the expenses for reducing it and V, the overall expenses are minimal.

This scheme enables the construction of *fractal random sets* with a minimal number of scenarios. The episodic fractal exponent is γ =1 if the geomechanical systems reacts to a drive - from excavation and erosion to tectonic shift - within a time which is several orders of magnitude shorter than the recurrence time. $\gamma > 1$ is adequate if thermally activated relaxation reduces the propensity for chain reactions, e.g. in zones of slow thrust, and the opposite holds true e.g. for excavations in ground with soft mineral. $\gamma < 1$ is also adequate in case of hydraulically activated softening or erosion, and if the damage increases by a delay of remedies.

Systematic estimates of $\gamma \neq 1$ are beyond the present reach, so one should first focus on the cutoffs for $\gamma = 1$. The lower one provides an objective scaling by (6) and works as a kind of background noise which can trigger chain reactions. The expected value of released energy $\bar{E} = E_r \ln(E_m / E_r)$ refers to cases where a trigger with E_r is imposed, while the number of events equals the one of such triggers. The vulnerability V depends on exposition, sheltering and monitoring with an erratic component which is but indirectly related with the complexity of geomatter. A paramount objective of geomechanics is the realistic estimation of upper cutoffs E_m or worst cases. As stated further above they cannot be captured by quasi-static computer models as these require stability for being feasible. It is indispensable to take into account inertial effects for modelling seismogeneous chain reactions. Numerical models could be checked and improved by means of sand-box tests with location of seismic sources.

The *eutaraxy in the large* is a bigger challenge. As outlined in Sec. 2 the eutaraxy which has been captured mathematically represents the force-roughness of grain fabrics in the stable range, i.e. the propensity for an incoherent micro-seismicity due to imposed deformations. This works heuristically as long as relics of former critical phenomena are sufficiently ironed out, but precisely speaking this is a contradiction in terms. Force-roughness means fractal spatial fluctuations so that classical intensive and extensive quantities are objectionable. The postulate of locality for simple materials [35] gets invalid with critical phenomena as then correlation lengths diverge. Thermodynamic critical phenomena yield already fractality, but seismogeneous chain reactions are more intricate as geomatter conserves traces of former critical phenomena as long as they are not swept out - this is Maxwell's historical element. For lack of ergodicity there is a *configurational entropy* which differs from the entropy by Boltzmann and Shannon as fluctuations are rather Lévythan Gauss-like.

6 Conclusion

The objective of research is to reduce *cognition deficits*. This requires induction (*επαγωγή*) in Aristoteles' sense, i.e. hypotheses and logic with empirically limited validity. Popper [30] calls theories nets thrown out for catching parts of reality, emphasizes their refutability and proposes a probabilistic frame for random phenomena. Geomatter is a complex part of reality as it is less continuous than classical solids and fluids, and as its opaqueness impedes observations. In TA ΦΥΣΙΚΑ Aristoteles mentions that a heap of fragments does not react to an action (*ενέργεια*) like continuous matter. Műller [26] calls natural rock a discontinuum and points to the self-similarity of crack patterns, Mandelbrot [20] stresses the fractality of earthquakes and the intricacy of Lévy's theory, Turcotte [36] doubts the 'self-organized criticaliy' with cellular automata, Wu and Aki [38] and Shapiro [33] tried to relate wave scattering with the geometrical fractality of geomatter, Tarasov [34] proposed a fractional hydrodynamics for fissured rock. So I am standing on the shoulders of giants in Newton's sense, but their diversity is sometimes frustrating.

My list of contra-continuum arguments (Sec. 1) appears likewise frustrating – so what should and could be done? Maxwell's historical element is a commonplace in geosciences, but does it elude the mathematical treatment of limit equilibria for ever? Small deviations from stable equilibria of solid and pore water with fractality can be captured with the fractional calculus, but how do fractal pore systems evolve? And how to manage the risk even if cumulative probabilities can be captured with truncated power laws or stable Lévy distributions? Briefly speaking: how to cope with the ever-present fractality in geomechanics for research and practice? One may speak of a new paradigma, but there is no easy answer. Before working out calculation models one should realize how the stability of geomechanical systems gets lost in chain reactions with fractality before, during and after them. Single events should be observed in boxes with sand - dry and water-saturated - and seismometers, and simulated numerically with seismic waves and pore water diffusion. Polar quantities and initial fluctuations should be taken into account. Systematic variations of initial and boundary conditions should reveal expected values and variances of chain reactions, and more generally a data set which is indispensable for developing fractional images of fractal random sets. The range between mild and wild randomness [20, 21] is wide and yet hardly explored.

Capillary effects, fracture and erosion including fractality could also be clarified by means of sand-box tests. Kadanoff [14] doubted hydrodynamic theories for sand, Jiang and Liu [12] presented a promising one, I replace their 'hydro' by means of a 'eutaraxy'. Both models cannot yet capture critical phenomena with growing fractality, but extensions should be attempted alongside with sand-box tests. As long as there is no general energetics for fractal phenomena this procedure is inevitably heuristic, but what counts is always the strength of hypotheses. Model experiments with sand and structures can also help to understand the robustness of geotechnical systems, i.e. the ability of harmless redistributions in case of inevitable extreme actions. Model tests with sensitive systems and location of prograding seismic sources could help to clarify not only tectonic evolutions, but also early warning systems for geotechnical operations.

An objective of psychology is to reveal cognition defects. Kahnemann [15] showed that human beings - including scientists and engineers - tend to see patterns even if there are none in reality, and are weak in estimating probabilities even of simple events. No wonder therefore that in geomechanics

- the illusion of limit stress fields and rigid sliding blocks survived until present;
- geotechnical systems with varying arrangement are confused with structures for which the degrees of freedom do not change;
- the probability of failure is considered as sufficiently low by means of safety factors although the then required robustness is not given in general;
- finite element simulations are used for the assessment of stability although the latter is needed for making the former feasible;
- observational methods are used for maintaining stability even if the employed extrapolation gets impossible due to the temporal fractality of stability losses;
- quasi-static finite and discrete element simulations are made with a fictitious viscous damping so that crucial seismic effects are excluded;
- cellular automata are employed for getting look-alikes instead of realistic images of successive events;
- after disasters mysterious anomalies are invented instead of real mechanisms in order to avoid liability suits.

Instead of thus producing or accepting 'alternative realities' and 'fake news' one should go on with Aristoteles' induction by means of an open-minded discourse like in his peripatetic school.

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Liquefaction Software using CPT data

Kostas Lontzetidis(*)

Twenty years ago, I had to prepare a report for a gas project, where a pipe was crossing a stream in northern Greece. The geotechnical data available were only CPTs, using the Begemann mechanical cone, where the cone resistance and the skin friction recorded every 20cm.

The soil materials encountered along the pipe route, were mainly medium dense sands and the ground water table measured at a shallow depth. Although the seismicity in the area of the project was not high, the importance level of the project was high enough to obtain quite significant design accelerations.

At that time, the typical in-situ test used as input for the liquefaction analysis, was the Standard Penetration Test. Since there were only CPT data available, I thought that I could complete the liquefaction analysis, by correlating/converting the CPT to SPT data (averaging cone resistance values for each soil layer encountered) and using the graph from Seed et al. 1985 in Figure 1.

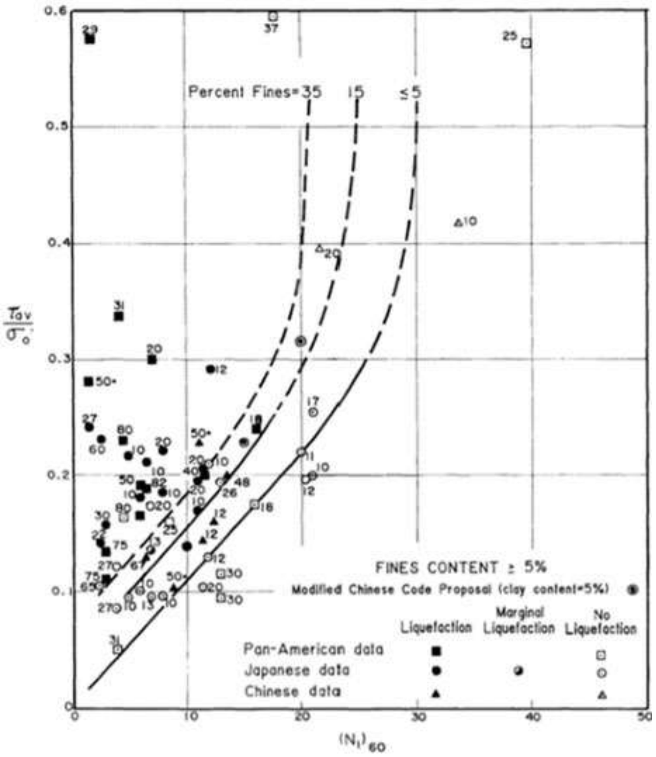

Figure 1. SPT Clean Sand Base Curve for Magnitude 7.5 Earthquakes with data from liquefaction case histories (modified from Seed et al. 1985).

During the process of liquefaction analysis, I felt that the bulk of the CPT data were underutilized in the analysis, and perhaps the results were overestimating or underestimating the liquefaction potential. I then started a methodical search in literature to find more about CPT & liquefaction and utilize CPT data as much as possible. One of the papers that I came across, was from Robertson & Campanella 1985. In this paper, there was a graph presenting a zone on the CPT classification chart, developed by Douglas and Olsen 1981, in which the soil material within this zone was considered susceptible to liquefaction (Zone A in Figure 2). This designated zone was developed by the work from Douglas 1982 and experience gained at the University of British Columbia (UBC).

Instantly, I thought that this graph could be used as a screening tool in the process for the calculation of the liquefaction potential, where the soils would be only considered liquefiable, if they were within the A zone. This screening tool became later the first step in the liquefaction analysis process that was finally concluded.

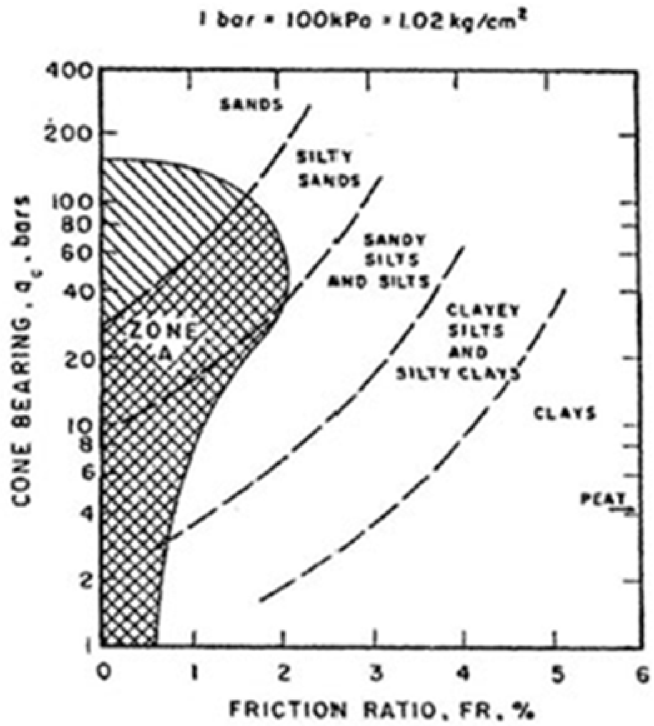

Figure 2. Soil Classification Chart for CPT showing proposed zone of liquefiable soils (Robertson & Campanella 1985)

Now there was one more thing missing in order to complete the liquefaction analysis, and this was how to quantify the severity of liquefaction. How to assess if there is a risk of liquefaction at a site, where only certain points at certain random depths appear to be liquefiable. This was something that a team from Japan (Iwasaki et al. 1978) had been working on already, for more than 10 years, where a method to calculate the liquefaction potential was proposed. In 1982 Iwasaki et al., used the term Liquefaction Potential Index (LPI) to quantify the severity of liquefaction. LPI uses the F (factor of Safety) from liquefaction triggering as well as a depth-based weighting function W(z) and was defined as shown in Figure 3.

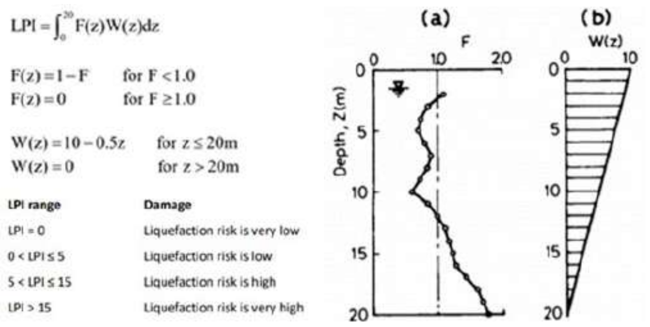

Figure 3. Equations to calculate the Liquefaction Potential Index (LPI) according to Iwasaki, et al. 1982.

The LPI parameter assumes that the severity of liquefaction manifestation is proportional to the thickness of a liquefied layer, the amount by which FS is less than 1.0, and the proximity of the layer to the ground surface. The LPI parameter assumes that each liquefying soil layer contributes to some extent to the damage potential at the ground surface.

After the whole process had been concluded, the first spreadsheet was created including all the afore mentioned checks and analyses and is given in Figure 4. Please bear in mind that at that time the input data included apart from the CPT, the ground water table, the seismic acceleration, the earthquake magnitude, and the soil parameter.

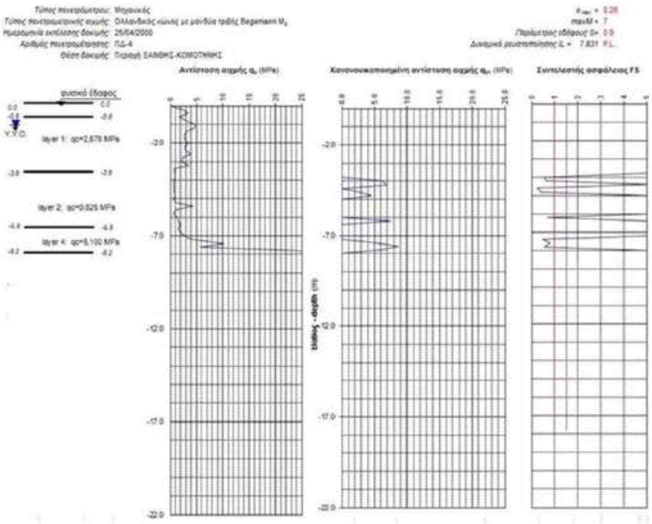

Figure 4. Liquefaction analysis results using CPT data

About three years later, in 2003, John Ioannides (Geologismiki) developed the first version of LiqIT, a software where the liquefaction potential using SPT and CPT data could be calculated. In 2007 John and I went to USA to meet Peter Robertson. With Peter's mentoring and help as well the support from Gregg Drilling the Cliq (Geologismiki) software was born. A dedicated software to perform liquefaction analysis using CPT data. Soon, CLiq became popular in many places and now the software is well known all over the world, having more than 2,000 users over 73 countries.

Below is a figure showing the output from the Cliq ver. 3.0.3.2 software using the same data as the one in Figure 4.

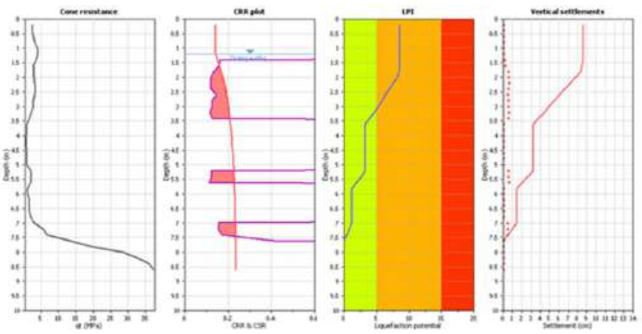

Figure 5. Liquefaction analysis results using CLiq and the CPT data shown in Figure 4.

Over the years many factors have been added in the liquefaction analysis (aging factor, transition zones, weighting factor etc) but the basic concept remains the same for simplified liquefaction assessment procedures. Although I think that the simplified liquefaction assessment is good for a first screening regarding liquefaction, we should consider using a bit more advanced tools to assess liquefaction in case that the importance level of the structure is high or the consequences from liquefaction are significant. As discussed by Cubrinovski 2019, many influencing factors are always in play resulting in a unique combination of contributions, for a given site and earthquake excitation. Unweaving this complexity and identifying key factors that govern the liquefaction response and associated damage should therefore be the principal target in the engineering assessment of liquefaction.

I would like to thank George Mavridis for providing the spreadsheet to manipulate and present CPT data, Gregg Drilling for "The Trip", Peter Robertson for mentoring me for many years, and John Ioannides for the lovely journey working together on ideas to develop software for geotechnical engineers.

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2020 Medicane Ianos

Event Date : 09-17-2020
Location: Greece
Report Date : 12-05-2020
Event Category: Storm
Report Number: GEER-068
DOI: doi.org/10.18118/G6MT1T
Event Latitude: 39.3632674
Event Longitude: 21.9217243

Team: Dimitrios Zekkos (zekkos@berkeley.edu) & George Zalachoris

Collaborators: Alvertos Antonios E., Amatya Pukar M., Blunts Parker, Dafis Stavros, Farmakis Ioannis, Ganas Athanassios, Hille Madeline, Kalimogiannis Vassilis, Karagiannidis Athanasios, Karantanellis Efstratios, Khan Sana, Kirshbaum Dalia, Kourkoulis Rallis, Kotroni Vasiliki, Ktenidou Olga - Joan, Lagouvardos Kostas, Loli Marianna, Makrinikas Antonios, Marinos Vassilis, Manousakis John, Nikas Konstantinos, Panousis Dimitris, Papathanassiou George, Saroglou Charalampos, Simopoulos Asterios, Stanley Thomas, Tsavalas Alexandros, Valkaniotis Sotiris

Summary: Perishable data web map: https://elxis-group.com/GEER-MedicaneIanos-FieldMap/

On September 17-20 2020 Medicane Ianos impacted Greece. The Medicane was associated with significant wind speeds, and precipitation. The amount of precipitation during a duration of about ~48 hrs was among the highest recorded in certain areas and exceeded in certain areas the mean annual precipitation. The extent of the affected area was very large and encompassed the western, central and southern Greece, all the way south to the island of Crete. The Ionian islands and the areas around Karditsa and Lamia in Central Greece were particularly affected. Field deployments to collect perishable field performance data were supported by remote sensing tools and geospatial data analysis. The GEER team used optical and radar satellite imagery to generate a broad assessment of the conditions, and also data-mined social media to identify sites of particular interest. On the ground, conventional site characterization tools were supplemented by Unmanned Aerial Vehicles to generate three dimensional models of target areas and sites. During field deployment, data collected in the field were uploaded on a shared Box folder and were projected on a web-based GIS map the next morning to facilitate collaboration among teams. The amount of precipitation resulted in a wide variety of landsliding that included (a) landslides involving soils and fractured and weathered rocks, (b) rockslides, rockfalls and structurally controlled rock failures, as well as (c) debris flows. Just in the areas to the west of Karditsa, around Lake Plastiras, more than 1,400 landslides were mapped using satellite imagery, and some of them were documented in the field, although access in the mountainous areas affected data collection. In Cephalonia, one of a few major debris flows, a rare occurrence on the island, devastated the community of Assos. Extensive flooding was also observed throughout the affected areas nationwide. Lower-elevation areas were flooded, and portions of the town of Karditsa and surrounding communities became completely submerged. The amount of water compromised, in numerous areas, the road and railroad network by washing out roads or railroad lines, damaging the embankments that supported the pavements or disrupting their functionality by landslide debris. Particularly pronounced was the damage to many bridges, ranging from minor damages (such as movement) to complete collapse, due to foundation scour, or "push-over" by debris. Riverbanks and levees were also overtopped and scoured. The extent of the affected area by Medicane Ianos far exceeds the extent of affected areas by other natural disasters such as earthquakes or precipitation events. The diversity of damage observed also raises the need for community-level resiliency considerations, particularly in light of what appears to be a potentially new "norm" of more intense and larger precipitation events, such as this medicane. To that end, this report contributes to the condition assessment and perishable data collection from Medicane Ianos that can support engineers and community leaders in being prepared for future events. It also forms the basis for subsequent phases of investigation to better understand the causes of the recorded damage and the contributing factors.

File Upload : Medicane Ianos 2020 GEER Report

The work of the GEER Association, in general, is based upon work supported in part by the National Science Foundation through the Geotechnical Engineering Program under Grant No. CMMI-1266418. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the NSF. The GEER Association is made possible by the vision and support of the NSF Geotechnical Engineering Program Directors: Dr. Richard Fragaszy and the late Dr. Cliff Astill. GEER members also donate their time, talent, and resources to collect time-sensitive field observations of the effects of extreme events.

http://www.geerassociation.org/component/geer_reports/?view=geerreports&id=95&layout=build

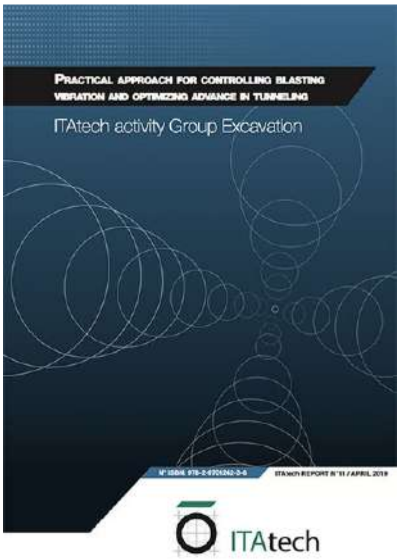
Being part of the team of experts of the Geotechnical Extreme Events Reconnaissance (GEER) Mission for Medicane Ianos was really great. Many thanks to Dimitrios Zekkos for leading and Georgios Zalachoris, Ph.D. for his support. I want to thank my PhD student Vasilis Kallimogiannis and team members Athina Tsirogianni, Eleni Pavlopoulou and Antonios Makrynikas. We, as a team, mapped more than 50 landslides of all types in the affected area of Karditsa and deployed just a few days after the event. Have a look at the selection of the most impressive landslides we mapped.

You can download the full report here:
https://lnkd.in/d8mphRE

Harry Saroglou

Controlling blast vibrations

Strict vibration limits often restrict the use of drill+blast excavation in vibration sensitive environments. However, good planning of controlled blasting can often accommodate such restrictions. In a guideline produced by the ITAtech Committee Excavation Group and published by the ITA, International Tunnelling and Underground Space Association, describes practical suggestions of how to utilize vibration measurement in the design of drill charge hole patterns and detonation control.



Download a copy of the guideline https://about.ita-aites.org/wg-committees/itatech/publications/1703/practical-approach-for-controlling-blasting-vibration-and-optimizing-advance-in-tunneling

Due to the complexity of geology, forecasting vibration propagation for a given drill+blast project can be difficult. Multiple factors are described in the guideline that can affect the propagation of vibration waves including:

- receptor distance from the blast
- rock mass properties, the ability to conduct and absorb the vibration
- changes in rock mass which can cause bending and reflection of vibration waves
- rock mass fracturing and orientation towards the vibration waves
- change of water content or temperature, such as in moraine or frosted soil

Environment and nearby structures define the allowed vibration limits, which are usually set by authorities taking into account factors including:

- the type and age of structures
- use of structures with strict limits for hospitals and scientific facilities
- the prevailing geology
- construction materials of structures and basement type
- the reliability of the as-built data of structures

The total amount of explosives for each drill+blast round of excavation is calculated as a mass per each charge, as this is typically the minimum amount of momentary kilos that can be blasted. Modern detonator systems offer extensive possibilities for the delay timing of the blast, with the more material that blasts per ignition level, the more vibration that will be generated. The tendency therefore is to limit the amount of explosives per ignition level. The momentary reporting of blast vibrations is based on defining hole charges and detonation delays in the blast round plan.

Measurement systems play a vital role in vibration control with triaxial seismograph sensors attached at critical locations where peak particle velocity (PPV) limit-values have been designated. Sensors are connected wirelessly to a web-server and record data when they detect vibration levels above a deigned trigger level. Vibrations are recorded in speeds of mm/sec, amplitude in mm, acceleration in m/s2 and frequency as 1/s. This data is recorded in the x-, y- and z- axes directions with web-server data analysis producing vibration reports together with possible overshoot comparisons.

Based on the vibration analysis the charges, detonation control and location of the holes in the drill plan can be adjusted to improve production and limit the need for shortening the round length or introducing partial face blast rounds.

If vibration data is examined against the momentary design (against time-kilos- graph), the correlation between vibration data and the designed hole charge blasting can be found. This will not only express the PPV-value of the round blasted, but the data is also available for detailed study. When the absolute value of vibration data amplitude is scaled to generally match the blasted kilos, the remaining deviations between these two values can be observed (Fig 1). An overshoot might be due to too large a momentary design or incorrect selection of the detonators or misfire in some of the previous charge holes. The overshoot holes can be pinpointed based on the timing value to indicate where the drilling and blasting plan can be adjusted.

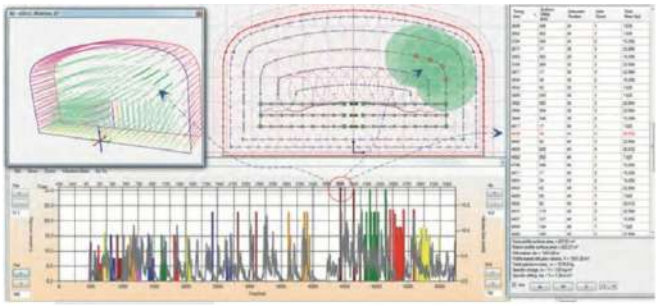


Fig 1. Example of momentary design and scaled vibration level [mm/sec] where both overshoots and delayed detonation can be detected

A more predictable vibration of the blast can increase drill+blast excavation progress. Some key points that the ITA guideline suggests to keep in mind include the following.

- Reducing the maximum instantaneous charge (MIC) tends to increase the number of holes required in the face.
- Smaller charge hole diameter increases typically increases the partial charge blasting reliability of emulsion explosives.
- Smaller charges increase the profile quality, assuming a good drill plan, of top quality drilling and controlled detonation.
- Smaller charges reduce the blasting damage zone.
- Better quality can reduce the amount of shotcrete required for primary lining and support purposes.
- Better profile quality reduces scaling time and can increase safety.
- Conversely, increasing the number of holes increases the cost of drilling with the additional use of explosives and detonators.

The ITAtech document is produced as an initiative for establishing a common interface between vibration measurement systems and drill+blast design programs to help all parties control blast vibration in a cost-effective way. Download a pdf copy of the ***Practical approach for controlling blasting vibration*** guideline produced by the ITAtech Committee Excavation Group of the ITA.

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- Explosives for blasting in civil excavations – *TunnelTalk,* November 2020
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(*TunnelTalk* reporting, 17 Dec 2020, https://www.tunneltalk.com/Focus-Drill-Blast-Dec2020-Guideline-for-controlling-blast-vibrations.php)

Explosives for blasting in civil excavations

Michael Rispin, Vice President, Underground, Dyno Nobel Americas with contributors **John MacGregor**, **Justin Banks** and **Tristan Worsey**, Dyno Nobel Inc

While mechanical excavation has moved forward dramatically in the last 50 years and now forms a greater portion of civil underground construction, explosives and blasting nonetheless remain an essential method for breaking rock and advancing excavations. **Michael Rispin** and his colleagues explain advances in the art of applying explosives in the civil excavation industry.

There are three primary applications for explosives in tunneling: for tunnel headings, cavern excavations and shaft sinking. Accordingly, blasting is applied horizontally, vertically and in all orientations. Aside from applying experience, principles and engineering to the application of explosives in blasting, safety is paramount. Misapplication, error or carelessness can have catastrophic results. Explosives and blasting knowledge today are highly advanced and the safety focus is all-prevailing.

Charged face initiated for a blast round

The application of explosives is subject to all jurisdictional and regulatory considerations. These can be applicable to the country, state, province or territory, and county or city in which the work is carried out. There are also occupational health regulations and governing rules of the owner under whose auspices the excavation is being advanced. Many contractors have their own, overarching rules concerning blasting and must, therefore, be aware specifically of the transportation, storage and application regulations to which adherence must be assured. There will almost certainly be licensing requirements specifically for the blaster-in-charge and those under that person's command. Most contracts will define the regulations of which the contractor must be aware.

It is critically important to treat blasting holistically. Blast design is always a function of the rock being excavated, the orientation of the excavation, the explosives and initiation systems being used, and, perhaps most importantly in a vast majority of civil works, the location of the project that will govern environmental factors including ground vibration, airblast and dust generation.

Drilling is an interdependent factor with the explosives in the success of the blast. To obtain optimal results, the fragmentation of the broken rock and ground control implications are to be considered in the design and adjusted through measurement and observational engineering as the excavation progresses. For security and efficiency reasons, the logistics of getting the explosives to the worksite and to the working face must be considered.

Plastic and paper wrapped Dyno Nobel emulsion

Dynamite, the nitroglycerin-based explosive, was the dominant explosive used until the latter half of the 20th Century. Ammonium nitrate fuel oil, or anfo, began to be seen in civil work in the 1970s with watergels and emulsions starting to appear in the 1980s. The advantages of these technologies range from less impact sensitivity, lower cost, and reduction of the risk of unwanted propagation during blasting, to beneficial velocities of detonation as emulsion technology has become fine-tuned. For those who have suffered from nitroglycerin headaches when handling or being in the vicinity of dynamite, the alternative technologies are a blessing.

These alternate technologies have some trade-offs. Lower bulk strengths require higher powder factors to achieve the same useful work at detonation and the number of required charge holes tend to increase, driving up drilling costs. Nor were all explosives created equally. Dead pressing, whereby explosives in a charge hole may be rendered insensitive due to the explosives in an adjacent charge hole detonating before them, became an issue to be reckoned with. The industry, through much experience and study and the application of technologies, including microballoon strength, secondary salts, emulsifiers, and ingredient mix variants, has dramatically improved the explosives resulting in the robust products of today.

DynoMiner Advance emulsion loading unit

Anfo, while cost attractive, has the detraction of being water soluble, resulting in the risk of high concentrations of nitrates in tunnel and groundwater outflow that can shut down jobs either temporarily or permanently. When applying packaged explosives to blasting in civil works, emulsions are the products most selected. For specific applications and challenges, dynamite still has a significant place in the industry. Where a specification is tight and revolves around limitation of mass per delay, dynamite, as the most energetic explosive available, may be the best or necessary choice. In challenging conditions, such as fragmented rock or water-bearing strata, its high energy, proven reliability and ruggedness, can dramatically reduce the risk of poor blast results. This combination of performance characteristics remains relevant today.

Titan 7000 sensitised emulsion

DynoMiner APS loading unit

In recent times, there has been an evolution from packaged to bulk explosives, especially for larger excavations. The advantages can be significant. Eliminating packaging reduces costs, there are reduced logistics costs, speedier loading rates, a reduction of manual aspects of the loading process, and more efficient filling of the available charge hole space. While anfo and watergels may also be applied in bulk, emulsions are now the preferred technology.

Solid density control, more stable emulsifiers and water-ring pumping technology whereby an annulus of water around the explosive to facilitate the flow of emulsion in the charge hose, have made re-pumpable emulsion possible, which is of primary importance from a logistics point of view. The ability to pump or blow the emulsion more than once is critical for most underground excavation projects. The application of bulk emulsions can reduce the loading cycle in a heading by sometimes up to 75% with hydraulic pumping units operating at capacities of up to 90kg/min.

When using bulk explosives, the reduction in packaging costs is partially offset by the need for investment in bulk loading equipment. However, on an all-in basis, given the right size and logistical and dimensional parameters, bulk products are less costly than the packaged explosive alternatives. Emulsions in bulk offer added flexibility. They may be:

- applied hydraulically or pneumatically;
- sensitized in different manners with solid or gas additives, or a combination of both;
- delivered to site as an oxidizer and sensitized at point of loading into an explosive, thereby eliminating some explosives handling restrictions or costs in storage or transportation,
- density-modified at point of loading, lending the option of flexibility to loading different charge holes at different strengths;
- used to fill the charge hole for blasting efficiency or, alternatively, string loaded thereby decoupling perimeter charge holes, for example, to reduce over-excavation.

Most bulk emulsion manufacturers specify the equipment and control systems which go with the various formulations. The companies either manufacture the loading equipment themselves or specify the use of a third-party manufacturer which produces specified equipment under license. For safety reasons, Dyno Nobel does not allow its bulk emulsions to be pumped through equipment other than those it recommends.

A tagger and blast initiator command set for a wired electronic initiation system

In choosing the right combination of bulk emulsion and loading equipment, a variety of factors must be considered. The choice of thicker formulations for hydraulic loading versus thinner formulations for pneumatic loading defines the viscosity specification of the explosive.

Hydraulic loading tends to be more robust, faster, and amenable to application technologies, including:

- using longer and smaller diameter hoses for loading, hose pushing and retraction;
- metering of loaded explosive;
- computer control of the loading process;
- gassing, or sensitizing the explosive by introducing trace chemicals at time of loading to create microscopic voids in the explosive matrix; and
- string loading.

With proper procurement and correct maintenance, hydraulic systems bring ease-of-use but require a higher level of training.

Pneumatic loading tends to demand less expensive equipment, simpler operation and may be more suited to smaller workspaces. The carrier required for heavier hydraulic loading equipment is avoided with skid-mounted units, and sling-mounted loading equipment for shaft work, where available.

Given these advantages, pneumatic equipment is often selected for testing or approval work. At the same time, shorter hose runs only are typical and metering options are limited. Pressure vessel pneumatic technology is favored primarily for shaft work but is suitable also for horizontal applications. It is uncomplicated, with limited moving parts and can facilitate a rapid loading rate, particularly on a crowded benching excavation. Using specifically formulated bulk emulsions, loading rates dramatically reduce the loading time of down and horizontal charge holes compared with packaged explosives. Uphole loading is not possible with emulsions, but this is rarely a limitation in civil applications.

Solid sensitization requires the incorporation of solid microballoons of glass or plastic into the explosive at point of manufacture. Sensitization using the gassing method requires greater care in equipment set-up, maintenance and training, but offers cost benefits when viewed holistically. Because the explosive is being modified at point of loading, minimum diameter and maximum density must be carefully monitored in order to ensure optimum blast results. The setup of the equipment and the skill of the operator is key.

String loading, or decoupled charging, involves reducing the energy dissipated by the detonation of explosives in a non-fully circumferentially loaded charge hole. Less explosive goes into the individual hole and its effect, beyond the unloaded perimeter of the charge hole, is reduced. This lends itself well to the loading of perimeter holes to control overbreak.

DigiShot Plus 4G tagger

DigiShot Plus 4G coil

Initiation systems

Many in the industry during the 1980s and before will remember loading holes with safety fuse and hooking up faces with igniter cord. While this was an important development at the time of its inception, safety fuse today belies its name. Thankfully, the civil excavation industry has now progressed through electric and nonelectric detonators to the state-of-the-art electronic detonators of today, which can be either wired-electric or shock tube nonelectric.

The accuracy available with today's technology takes a lot of guesswork out of blasting, offering:

- Secure blast design: making available
  - A guaranteed single hole per delay and
  - Lower vibrations
- More reliable and controlled perimeter and cushion blasting; to
  - Reduced back break and damage of the rock beyond the excavation perimeter,
  - Limiting over-excavated material to be removed
  - Reducing overbreak
- Greater excavation scales per blast under tighter restrictions;
- An ability to verify the integrity of the initiation system up to the point of detonation; and
- Reduced inventory and procurement concerns.

This technology comes with a higher unit cost but considering the scope of a blasting operation, the benefits significantly outweigh the cost. The wired electronic technology typically involves a steeper learning curve but once mastered is applied as second nature. Wired electronic detonators can come with pre-set timing or can be programmed while loading or at any time prior to detonation.

EZshot LP shock tube initiated electronic detonator

The nonelectric electronic detonators, with timing set at the point of manufacture, provide high accuracy with ease of application. These detonators are applied identically to traditional pyrotechnic nonelectric detonators and a variety of configurations, either avoiding or requiring compatible detonating cord, are available.

Nonelectric detonator

When using the less sensitive explosives of today, particularly bulk explosives, the energy needed to set off an efficient detonation typically exceeds the detonator alone. This requires the use of boosters to ensure steady state velocity of explosive detonation. Boosters also minimize the likelihood of unwanted blast gasses being generated by sub-standard detonation and provide an additional level of dead press protection to electronic detonators. These boosters are typically manufactured of rigid high explosive and are affixed to the detonator prior to loading into the charge hole and being surrounded by explosive.

In the future, fully wireless initiation systems will be economically and technologically available for the diameters of charge holes typically applied in civil underground projects. These are in selected use today in the mining industry and further development is required before expected widespread application in civil work.

A set of Stinger boosters

Blast design

There are many aspects to consider in the design and application of explosives and blasting, including the design of the charge hole drilling patterns. These include:

- Fragmentation
- Perimeter control
- Ground vibration
- Airblast
- Size of excavation
- Cost

These cannot be assessed in isolation and must be evaluated holistically, particularly in urban environments, or in close proximity to other infrastructure where the environmental knock-on effects of ground vibration, airblast and noise can be paramount. Ground vibration and airblast complaints in residential areas can threaten shutdown of job sites or lawsuits. Residual blast gasses are at best a nuisance and at worst a risk to health and can also threaten job shutdowns and litigation. Avoiding damage to nearby structures from blasting is a prime driver in blast design considerations.

There is no substitute for training and experience when it comes to blasting design. Blasters, independent consultants and explosives manufacturer-based consultants rely heavily on these. There exists also a variety of technological tools that complement this expertise and knowledge, by providing measured parameters which can be integrated into blast planning, either at the outset or as part of the observational and applied engineering refinements as a project progresses. Some tools to consider for design implementation in the field and for troubleshooting issues, include:

- Seismographs and accelerometers
- Drillhole deviation measurement devices
- 3D excavation scanning
- Drillhole cameras
- Velocity of detonation recorders

The application of these technologies minimizes the need for guesswork, can provide valuable data with which to analyze challenges, and can be essential in avoiding complications from negative environmental aspects of the excavation.

Project interaction

Each civil excavation project comes with its own set of challenges and opportunities from an explosives and blasting perspective, with senior managers from the project owner, design, construction manager, contractor and Explosives supplier involved in the decision making. It is advisable to seek supplier consultation in the design, bidding, pre-planning and value engineering phases, as well as during the actual drilling and blasting operation itself. Suppliers, with their blasting expertise and product knowledge, can also be helpful in meetings up to and including the project owner. Blast evaluation, troubleshooting and fine tuning are all part of the observational engineering process.

Much knowledge and many tools exist to assist in the design of blast excavations and their implementation. Product technologies and delivery systems are highly advanced today and when specified correctly, are used safely and effectively in excavating shafts, tunnels and caverns. Blasting is carried out every day around the civil construction world, driving excavations forward while minimizing environmental effects and disruption to neighbors or surrounding infrastructure. Highly trained and experienced staff are available for consultation on what will work best for each project, considering the many different factors to be considered.

References

- Intelligent solutions for drill+blast operations – *TunnelTalk,* February 2017
- Jumbos drive Malaysia's rail connector – *TunnelTalk,* January 2011
- Fast-track drill+blast in Canada – *TunnelTalk,* April 2010
- Drill+blast planning of deep sewage tunnels in Hong Kong – *TunnelTalk,* May 2009
- Record drill+blast work in Norway – *TunnelTalk,* January 2009

(05 Nov 2020, https://www.tunneltalk.com/Focus-Drill-Blast-Oct2020-Explosives-for-blasting-in-civil-excavations.php)

Artificial intelligence improving drill+blast processes

Pekka Nieminen, Director Tunnelling, Sandvik

Pioneering work towards developing automated drilling jumbos began back in 1985 by the drill rig manufacturer Tamrock of Finland, which was later acquired by Sandvik. During that time it was seen that instrumented rigs, starting with the Tamrock three-boom data jumbos, were able to increase drill+blast quality and decrease the cost of large-scale rock excavation. Over the years, requirements have increased and more features have been added. **Pekka Nieminen** of Sandvik explains that the evolution continues today with the iSURE® Intelligent Sandvik Underground Rock Excavation software, a computer program for drill+blast process control for iSERIES rigs.

Successful drill+blast operations consist of four essential elements: safety, quality, cost and schedule. In order to assist in achieving these operational necessities, Sandvik has continued development of its drill+blast design software iSURE®. The computer program works seamlessly with the Sandvik iSERIES jumbos and associated equipment. The system assures operational efficiency and productivity by producing all the data needed to design and optimise the drill+blast cycle with data collection tools on the rigs and provide accurate analysis functionality. With its user focused features, Sandvik iSURE® has been designed to deliver the best results by capitalizing on the accuracy of the rigs to make drill+blast more accurate and thereby improving work cycles and processes.

Amongst its design attributes, iSURE® 8.0, the latest version of the program, has a wizard-functionality tool that enables the selection of ready-made drilling templates for charge hole plan creation. The template-based plan generation tool takes into account rock blastability, heading profile quality, the allowed excavation damage zone (EDZ) and the explosives being used. Plans created, based on these templates, are readily editable to incorporate drill+blast feedback while being optimized to suit the prevailing rock conditions. This produces an effectively controlled blast that results in good blasting pull out while restricting the fracture zone and resulting in greater rock strength around the excavated tunnel.

Applying artificial intelligence software and systems for optimizing drill+blast excavation of rock

Knowing what has happened

Key to producing the benefits is the combination of rig accuracy and optimized drill+blast plans. The data collection by the rig and its analysis by iSURE® delivers feedback for process improvement. The system is developed to work in conjunction with Sandvik instrumented iSERIES drill rigs that log the round drilling operation to a detailed level. The on-board computers of all Sandvik drill rigs are able to plot the location of the drill holes as recorded in the pre-programmed drill plan and in the project coordinate systems. The rigs can be navigated accurately, based on the defined heading alignment making it possible to express drilled hole coordinates globally and coordinate with the system and plot as-built. Hole start and end points are also assessed to reveal if the holes that have been drilled according to the drill plan. This computer control also allows action to be taken to correct any discrepancies.

Among the many features that iSURE® adds to the process, is the data logging of 19 different measured-while-drilling parameters at 2cm intervals during the drilling of each drilled hole. The recorded data can be examined on a per hole basis, or as a 3D round view (Fig 1). The data can also be presented as a histogram report of the penetration rates for the applied drilling power and flushing sufficiency or disturbances during drilling, both in general terms and for each boom.

Other functional and operational features that are collected for each round and boom include measures for percussion, power pack, drilled meters and net penetration, as well as average and gross drilling capacity. This provides valuable feedback that helps to fine-tune the rig behaviour and use. The program further assists in the analysis of data collected along the heading progress to build a trend of various key performance indicators.

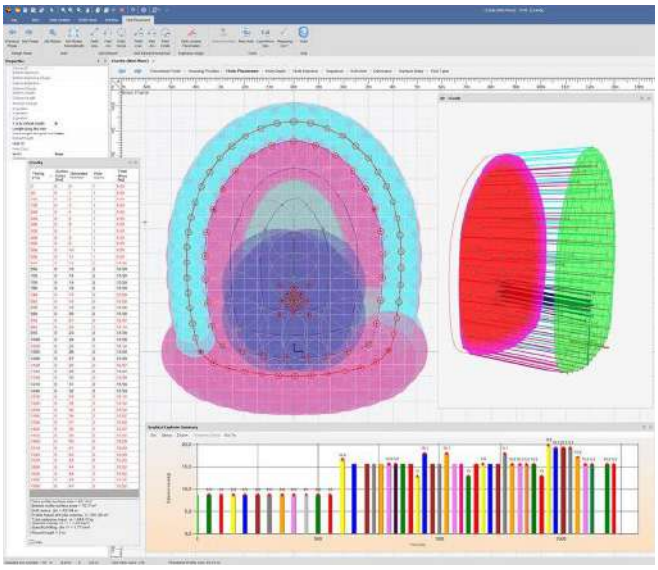
After hole drilling is completed and the holes are charged and blasted, iSURE® has the ability to compare consecutive rounds to calculate the achieved pull out in different areas of the face. This information, as a form of a heat map, can then be superimposed on top of the drilling plan of the heading to indicate where to improve the plan for pull out. No extra parameters need to be measured to provide this information as functionality is based on recording the realised start and end points of each charge hole in the face. Using the drill holes more efficiently to achieve a good pull out results in savings both in excavation schedule and project cost.

Vibration, profile and geological analysis

Through its data recording and analysis abilities, the iSURE system can utilise measured vibration data in order to more accurately control the blasting generated vibrations within defined limits for monitoring environmental limitation factors including vibration and the impact of drill+blast excavations on nearby structures in an urban environment. Based on systematic vibration measurement data and permitted peak particle velocity information, analysis feedback can be used to adjust and define the charges, detonation control and location of the holes in the drill plan to meet project permits as necessary. With control of the blasting process to meet necessary vibration restrictions, more tunnel meters/day can be achieved, as shortening the round length or reducing the face into partial blastings might be avoided.

iSURE® further provides an interface to import vibration data from third party systems and enable the utilisation of this data in connection with momentary design. This facilitates the pinpointing of any holes that generated excessive vibration. For detonation design, iSURE® supports impulse detonator timings of different manufacturers as well as impulse detonators supplemented by surface delay units to increase the usage possibilities of detonators, and free timing settings for electronic detonators.

In an extension of the iSURE® system, drill rigs can be equipped with on board profile scanners to provide an optional toolset for geological analysis and a tunnel profile 3D scanning system. Based on the data generated by iSURE 3D SCAN, the iSURE® 8.0 can create a 3D view visualisation of under and overbreak and a 2D view for drill+blast design optimization, together with volume calculation of realized and theoretical profile under and overbreak. With these details, the drilling rig operator is assisted in drilling additional holes in the correct locations to remove any existing underbreak if it exists.



iSURE® software turns recorded data of measured-while-drilling parameters into graphical 3D and histogram information for improving the drill+blast process as a whole

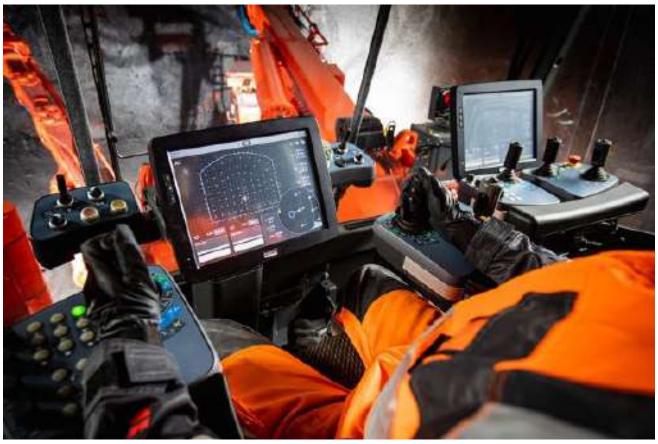
For further assistance of the drill+blast operations, iSERIES drill rigs can be equipped with the optional iSURE GEO system, which decodes geological parameters based on hole drilling data. Drilling resistance factors for example will measure MPa rock strength, as well as indicators of rock mass fracture and assessment of rock classification. The GEO option used by iSURE® 8.0 enables the viewing and extrapolation of this data in 2D and 3D views. The system is designed as a geological toolbox acting as a complementary subsystem to assist geologists in their daily work through providing a key source of information.

Accurate plans, controlled blasting and immediate analysis and feedback on the rock conditions will lead to increased pull out of estimates up to 97%, based on the proper use of iSURE and iSERIES drill rigs. With optimum blasting control, scaling time might also be reduced by up to 45 min/round. An optimum pull out also creates a better face for the next round of drilling, a reduced damage zone from the subsequent blast, as well as producing a better environment for rock bolting, and the automated production of drilling plans while ensuring that there are fewer interruptions in the operation.

Empowering the process

In effect, the information provided by iSURE® will also indicate if rig adjustment is needed or if rig misuse is suspected. It shows the change in rock mass drillability, records drill steel consumption, maps face shape after blasting and scaling, operator deviation from the plan while drilling, and, based on scanner data, defines the profile and calculates production volume. All is available at the fingertips of rig operators and operation designers, resulting in improved production and information that can be assessed and built upon to empower the drill+blast process.

Any software is only as good as the drill rig it serves and based on customer focused feedback, iSURE® capabilities on the advanced Sandvik iSERIES rigs constitute a powerful tool that enables the sharing of project data between different group members to achieve the best drill+blast operation possible. iSURE® 8.0 software is available in four versions: Basic, Plus, Premium and Pro to meet the objectives and aims of drill+blast contractors and their contract clients.



Operators dashboard in the cab of a modern iSERIES drill rig

Improvement and development of the iSURE® artificial technology system is continually progressing in Sandvik. Updated versions of the software packages are planned annually based on knowledge and experience sharing with customers and drill+blast professionals globally. The next step will be iSURE 8.1 focusing on more data driven productivity to provide customers with extended production reports to optimize the drill+blast cycle and covering the whole fleet of face drilling rigs. The upgraded iSURE 8.1 systems are to be available to the marketplace in January 2021.

References

- Improved drill bits and units from Sandvik – *TunnelTalk,* November 2016
- Speeding up excavation rates in Hong Kong – *TunnelTalk,* October 2015
- Sandvik jumbos on rail duty in Turkey – *TunnelTalk,* August 2013
- Fast-track drill+blast in Canada – *TunnelTalk,* April 2010
- Record drill+blast work in Norway – *TunnelTalk,* January 2009

(26 Nov 2020, https://www.tunneltalk.com/Focus-Drill-Blast-Nov2020-Artificial-intelligence-applied-to-the-rock-drilling-process.php)

ΝΕΑ ΑΠΟ ΤΙΣ ΕΛΛΗΝΙΚΕΣ ΚΑΙ ΔΙΕΘΝΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΝΩΣΕΙΣ

Ελληνική Επιτροπή Τεχνικής Γεωλογίας
Διάλεξη Δρ. Νικολάου Δεπούντη

Η ΕΕΤΓ διοργάνωσε διάλεξη του Δρ. Νικολάου Δεπούντη, Επίκουρου Καθηγητή του Τμήματος Γεωλογίας του Πανεπιστημίου Πατρών, την Πέμπτη 17.12.2020 και ώρα 18:30, στην Ηλεκτρονική Αίθουσα με σύνδεσμο: https://centralntua.webex.com/centralntua/j.php?MTID=m4162a1b434a7cd91751d45b5753f6de6 με θέμα:

"**Ανάπτυξη συστημάτων καταγραφής και παρακολούθησης κατολισθητικών κινήσεων και αξιοποίησή τους στην πρόγνωση των αστοχιών. Εφαρμογή στον οικισμό Μετσόβου της Περιφέρειας Ηπείρου**".

Περίληψη Διάλεξης

Οι κατολισθήσεις αποτελούν έναν από τους μεγαλύτερους γεωλογικούς κινδύνους (geohazards) και προκαλούν σημαντικές καταστροφές σε κατοικημένες περιοχές και έργα υποδομής. Σύμφωνα με το *Centre for Research on the Epidemiology of Disasters (CRED – United Nations Office for Disaster Risk Reduction)* κατά την τελευταία εικοσαετία οι κατολισθήσεις αποτελούν την 4η κατά σειρά «σπουδαιότητας» φυσική καταστροφή παγκοσμίως σε αριθμό συμβάντων (5.2% επί του συνόλου) με 18,414 ανθρώπινα θύματα και κόστος της τάξης των 8 δις $. Στην Ελλάδα και ειδικότερα στη Δυτική Ελλάδα, έχουν συμβεί τα τελευταία χρόνια πολλές και μεγάλες κατολισθήσεις, οι οποίες προκάλεσαν εκτεταμένες καταστροφές σε οικισμούς και στο οδικό δίκτυο. Στην Ελλάδα η μέχρι σήμερα εμπειρία έχει δείξει ότι:

α) η πρόγνωση κατολισθήσεων είναι ανύπαρκτη, ο δε βαθμός αντιμετώπισης ανεπαρκής και

β) δεν υφίσταται συστηματική παρακολούθηση ακόμα και 'γνωστών' ενεργών κατολισθήσεων

Με σκοπό την ολοκληρωμένη καταγραφή και παρακολούθηση των κατολισθήσεων που λαμβάνουν χώρα σε μια πυκνοκατοικημένη περιοχή, εγκαταστάθηκε για πρώτη φορά στην Ελλάδα, ένα ολοκληρωμένο σύστημα καταγραφής και παρακολούθησης κατολισθητικών κινήσεων. Το σύστημα εγκαταστάθηκε στον οικισμό Μετσόβου και χρηματοδοτήθηκε από το Ε. Π. Ήπειρος 2014-2020. Περιλαμβάνει γεωδαιτικούς σταθμούς, σκεδαστές για δορυφορικές λήψεις, μόνιμα αποκλισιόμετρα και κλισιόμετρα, μετεωρολογικό σταθμό και αξιοποιεί τις δυνατότητες που δίνουν τα UAV και οι μετρήσεις στο πεδίο. Το σύστημα καταγράφει και αποθηκεύει δεδομένα από τα εγκατεστημένα όργανα και εμφανίζει σε πραγματικό ή σχεδόν πραγματικό χρόνο το ρυθμό της εδαφικής παραμόρφωσης, με τελικό στόχο την βραχυπρόθεσμη αξιοποίησή του ως σύστημα έγκαιρης πρόγνωσης εκδήλωσης των κατολισθήσεων.

Συνοπτικό Βιογραφικό Σημείωμα Ομιλητού

Ο Δρ. Νικόλαος Δεπούντης είναι Επίκουρος Καθηγητής Τεχνικής Γεωλογίας του Τμήματος Γεωλογίας του Πανεπιστημίου Πατρών, ειδικός εμπειρογνώμων στον τομέα της γεωτεχνικής στην Ευρωπαϊκή Ομοσπονδία Γεωλόγων, με διδακτορικές σπουδές στη Γεωπεριβαλλοντική Μηχανική, στο Πανεπιστήμιο του Κάρντιφ Ουαλίας. Μέλος του εργαστηρίου Τεχνικής Γεωλογίας Πανεπιστημίου Πατρών https://engeolab.gr/.

Διαθέτει σημαντική ερευνητική και εργασιακή εμπειρία στο αντικείμενο των κατολισθήσεων (ενόργανη παρακολούθηση, εκτίμηση επικινδυνότητας, σχεδιασμός έργων αποκατάστασης) και της γεωτεχνικής των εδαφών και πετρωμάτων. Έχει συνεχή εγχώρια και διεθνή συμμετοχή σε αντίστοιχα έργα και προγράμματα, είτε ως επιστημονικός υπεύθυνος είτε ως μέλος ερευνητικής ομάδας και έχει δημοσιεύσει σαράντα εργασίες σε διεθνή περιοδικά, κεφάλαια βιβλίων και πρακτικά συνεδρίων.

International Society for Soil Mechanics and Geotechnical Engineering

ISSMGE News & Information Circular December 2020
https://www.issmge.org/news/issmge-news-and-information-circular-december-2020

1. 20ICSMGE- IMPORTANT NOTICE

Due to the ongoing pandemic, the conference organisers have taken the difficult decision to postpone the conference until Feb-April 2022. The final date will be confirmed in the next circular.

2. TERZAGHI ORATION – News from the ISSMGE President Charles Ng

I am very pleased to announce that Professor Antonio Gens from the Universitat Politècnica de Catalunya in Spain has been selected Terzaghi Orat20ICSMGE in Sydney. Professor Gens was selected from a pool of 16 outstanding nominations including 5 former Rankine Lecturers. After reviewing the abstracts of proposed case histories including photographs submitted by 6 finalists and consultation among some distinguished peers in our Society, I had the privilege to select Professor Gens to be our next Orator although the decision was extremely difficult since we had so many outstanding candidates. I am absolutely confident that Professor Gens will deliver an excellent lecture in Sydney. Please join me in congratulating Professor Gens.

3. BRIGHT SPARK LECTURES - 20ICSMGE

The YMPG in collaboration with the Local Organising Committee for the ICSMGE would like to announce the winners of the

Bright Spark Lecture Award to two very distinguished engineers: Dr. Ashani Ranathunga (Sri Lanka) and Dr. Brendon Bradley (New Zealand). They are both invited to give keynote lectures at the 20ICSMGE in Sydney.

For the full article, please refer to the News Bulletin, October 2020, page 30 (https://www.issmge.org/publications/issmge-bulletin/vol-14-issue-5-october-2020)

4. TC - NOMINATIONS

These TCs are actively seeking nominations for members from the Member Societies. Please make sure that your Member Society representative is aware of your interest in joining either of these Committees.

TC107 – Tropical Residual Soils
TC214 - Foundation Engineering for Difficult Soft Soil Conditions.

5. WEBINARS

The following webinar was recently added to the ISSMGE educational resources available from the website:

- Prof. Pijusch Samui: Machine Learning in Geotechnical Engineering

6. ISFOG 2020 – Proceedings now available

The proceedings for ISFOG 2020 (a specialist conference on offshore geotechnics held under the auspices of TC209) have just been released. The conference itself has been postponed to late 2021, but the decision was taken to make the proceedings available this time - to ensure the material comes out in a timely fashion, and to honour the commitment of authors to the conference. The link to purchase the proceedings is at https://www.isfog2020.org/proceedings. The cost is USD150.00 and will be deducted from the cost of your conference registration. Registration will open to the public in June 2021. Registrants will be contacted closer to that date and given instructions on how to obtain credit for the purchase of the proceedings.

7. BULLETIN

The latest edition of the ISSMGE Bulletin (Volume 14, Issue 5, October 2020) is available from the website https://www.issmge.org/publications/issmge-bulletin/vol-14-issue-5-october-2020

8. ISSMGE ONLINE LIBRARY - OPEN ACCESS

The ISSMGE Online library (https://www.issmge.org/publications/online-library) is in continuous development – please note the following additions/updates:

- All Proceedings from Australia New Zealand Conferences on Geomechanics

9. ISSMGE FOUNDATION

The next deadline for receipt of applications for awards from the ISSMGE Foundation is the 31st January 2021. Click here for further information on the ISSMGE Foundation.

10. CONFERENCES AND EVENTS

For a listing of all ISSMGE and ISSMGE supported conferences, and full information on all events, including deadlines, please go to the Events page at https://www.issmge.org/events. However, for updated information concerning possible changes due to the coronavirus outbreak (i.e. postponements, cancellations, change of deadlines, etc), please refer to that specific event's website.

As might be expected, many events have been rescheduled and we update the Events page whenever we are advised of changes.

The following are events that have been added since the previous Circular:

ISSMGE Events

INTERNATIONAL WEBINAR SERIES ON FORENSIC GEOTECHNICAL ENGINEERING - 10-12-2020 - 13-12-2020

Webex online platform, Bangalore, India; Language: English; Organiser: ISSMGE TC302; Contact person: Dasaka S Murty; Address: Department of Civil Engineering; Phone: 91-9869607604; Email: dasaka.iitb@gmail.com; Website: http://tc302-issmge.com - pre-registration is mandatory for all participants at the following link: https://kaksha.webex.com/kaksha/j.php?MTID=mbc70d0fbf9a06a3b5df0bd37d08f9e92

ISSMGE TC WORKSHOP ON SCOUR AND EROSION - 16-12-2020 - 17-12-2020

Online, Visakhapatnam, India , Language: English; Organizer: Indian Geotechnical Society and Andhra University, Visakhapatnam; Contact person: Prof. C.N.V. Satyanarayana Reddy; Address: Andhra University College of Engineering; Phone: 919849100310; Email: igc2020vizag@gmail.com; Website: http://www.igc2020vizag.com;

XIII INTERNATIONAL SYMPOSIUM ON LANDSLIDES - 22-02-2021 - 26-02-2021

Virtual, Bogotá, Colombia; Language: English; Organiser: JTC1; Contact person: Ing Alvaro González García; Address: Carrera 57 No 172-44; Phone: +57-315410049, Email: ajgonzg@gmail.com; Website: http://www.scg.org.co/xiii-isl/; Email: scgeotecnia1@gmail.com

SECOND INTERNATIONAL CONFERENCE ON GEOTECHNICAL ENGINEERING-IRAQ 2021 - 05-04-2021 - 06-04-2021

Akre/ Duhok/Iraq, Language: English; Organiser: Iraqi Scientific Society of Soil Mechanics and Foundation Engineering; Contact person: Mahdi O Karkush; Address: University of Baghdad, Aljadriah, Baghdad; Phone: 009647801058893; Email: mahdi_karkush@coeng.uobaghdad.edu.iq; Website: http://ocs.uobaghdad.edu.iq/index.php/icgeotecheng/icgte

11TH INTERNATIONAL CONFERENCE ON STRESS WAVE THEORY AND DESIGN AND TESTING METHODS FOR DEEP FOUNDATIONS - 20-09-2022 - 23-09-2022

De Doelen, Rotterdam, The Netherlands,; Language: English; Organiser: Royal Netherlands Society of Engineers (KIVI); Contact person: Angelique van Tongeren, Address: Prinsessegracht 23, Phone: +31(0)70-3919890, Email: SW2022@kivi.nl; Website: https://www.kivi.nl/afdelingen/geotechniek/stress-wave-conference-2022

All Proceedings from the Australian New Zealand Conferences on Geomechanics available in open access!

The Innovation and Development Committee of the ISSMGE is pleased to announce that through the initiative of the Australian Geomechanics Society (AGS) and the New Zealand Geotechnical Society (NZGS), 1850 papers from the Australia

New Zealand Conferences on Geomechanics, are now available in the online library here:

https://www.issmge.org/publications/online-library

The database includes the proceedings from all 13 Australian New Zealand Conferences on Geomechanics, held from 1971 up to 2019, and can be searched by theme, title and authors! More specifically, it includes:

1^{st} Australia New Zealand Conference on Geomechanics (Melbourne, 1971): 81 papers

2^{nd} Australia New Zealand Conference on Geomechanics (Brisbane, 1975): 62 papers

3^{rd} Australia New Zealand Conference on Geomechanics (Wellington, 1980): 110 papers

4^{th} Australia New Zealand Conference on Geomechanics (Perth, 1984): 129 papers

5^{th} Australia New Zealand Conference on Geomechanics (Sydney, 1988): 114 papers

6^{th} Australia New Zealand Conference on Geomechanics (Christchurch, 1992): 104 papers

7^{th} Australia New Zealand Conference on Geomechanics (Adelaide, 1996): 154 papers

8^{th} Australia New Zealand Conference on Geomechanics (Hobart, 1999): 129 papers

9^{th} Australia New Zealand Conference on Geomechanics (Auckland, 2004): 127 papers

10^{th} Australia New Zealand Conference on Geomechanics (Brisbane, 2007): 203 papers

11^{th} Australia New Zealand Conference on Geomechanics (Melbourne, 2012): 277 papers

12^{th} Australia New Zealand Conference on Geomechanics (Wellington, 2015): 159 papers

13^{th} Australia New Zealand Conference on Geomechanics (Perth, 2019): 201 papers

Detailed acknowledgements for all 13 Australian New Zealand Conferences on Geomechanics and bibliographical details for referencing can be found at the ISSMGE Online Library Acknowledgements section.

ΟΣ ΣΟ

ISRM
International Society for Rock Mechanics and Rock Engineering

32nd ISRM online lecture by Prof. Antonio Samaniego on 17 December 2020

For the 32nd ISRM Online Lecture the ISRM invited Prof. Antonio Samaniego. The title of the lecture is "Empirical Design Methods in Underground Mining". The lecture was broadcasted on the 17th December at 10 A.M. GMT.

Dr. Samaniego is a civil and mining engineer with over 40 years of experience. He obtained a BSc in Civil Engineering from the Catholic University of Peru; a BSc in Mining Engineering from University College Cardiff; and an MSc and PhD in Rock Mechanics from the Royal School of Mines of Imperial College London.

In 1985, Dr. Samaniego co-founded SVS Ingenieros, which merged with SRK Consulting (Peru) SA in 2011. As Practice Leader, he assesses mining method design; rock support; slope stability; mine planning; tailings deposit design; and due diligence. Dr. Samaniego has worked on more than 150 civil engineering and mining projects in Latin America.

Dr. Samaniego was President of the Institute of Engineers of Peru (IIMP) in 2014- 2016 as well as Vice President for South America of ISRM in 2011-2015. He is member of the SME, CIM, IIMP and SPEG; Fellow Member of IOM3; and CEng. Dr. Samaniego is a principal lecturer at the Catholic University of Peru and a post-graduate thesis advisor. Dr Samaniego has authored technical publications and has been speaker at different Peruvian and international conferences.

The lecture will remain online so that those unable to attend at this time will be able to do it later. As usual, the attendees will be able to ask questions to the lecturer by e-mail during the subsequent five days. All online lectures are available from **this page**.

News

www.isrm.net/noticias/?tipo=1&todas=1&show=info

New ISRM course on "Prevention methods for Landslides in Rock Masses" by Prof. Zhong-qi YUE 2020-12-28

1st International Youth Scientists Forum for Discontinuous Deformation Analysis (IYSF-DDA) 2020-12-19

First announcement for IYSF-DDA

32nd ISRM Online Lecture is now online 2020-12-17

The 32nd Online Lecture with the title "Empirical Design Methods in Underground Mining" by Professor Antonio Samaniego is now online at the ISRM website

Tsinghua University Seminar Series on Rock Mechanics, 11-18 December 2020-12-10

Tsinghua University is organizing a seminar series on Rock Mechanics, 11-18 December 2020.

ΟΣ ΣΟ

Dear ITACET Foundation followers,

We are pleased to announce that in February 2021 we will be starting a monthly **Online Lunchtime Lecture Series!**

Every **2nd Tuesday** of the month we will be hosting short lectures on different subjects with the aim to keep all those in the field abreast of new ideas and technologies, and to provide training on important subjects. We want to make tunnelling and underground space education accessible to everyone and we believe that online training such as this is a way to do that.

The series is organised by the ITACET Foundation in close coordination with the ITA-CET Committee and ITA. It will bring together top professionals from the ITA's Working Groups and Committees, as well as industry representatives and project owners.

The first session will be on **Tuesday 9th February** on the subject of Conventional tunnelling and **new blasting technologies** and includes a dedicated time for questions too! The session will last approximately 1 hour and is therefore designed to be participated in during your lunch break, or as a quick bite-size session depending on your time zone! Following on from this on the 9th March and the 13th April will be lectures on Construction contracts and Health & Safety respectively.

We would be extremely happy if you were numerous in joining us for these online sessions, so please don't hesitate to share the news with any friends or colleagues that you think might be interested.

Registration for the sessions will be required, but the first three sessions will be free! After this, we'll be asking a small token amount. The link to register each month will be on the ITACET Foundation website, on the 'Forthcoming sessions' page: https://www.itacet.org/sessions/forthcoming and you'll also find the link on the ITACET Foundation LinkedIn page and posts.

We look forward to seeing you online in February! And if you have any questions in the meantime, please don't hesitate to reach out to the ITACET secretariat: secretariat@itacet.org.

BTS December Live Webinar: Tideway Update

Andy Alder, Tideway Programme Director, gave an update on the Tideway Project, current progress and the approaches being used on Thursday, 10th December 2020.

This was followed by presentations from those working at three of the numerous Tideway worksites. These gave an appreciation of the scale and range of tunnelling and civil engineering activities taking place, and explained some of the technical challenges that have been overcome. Robbie Quinn presented the Barn Elms shaft and pipejack, Oscar Hueso Cuberos and Mikel Martinez Goirigolzarri presented the Hyperbaric TBM interventions and Shannon O'Keeffe presented the East Main Tunnel TBM delivery and launch.

Streaming Link: BTS December Meeting : Tideway Update - YouTube

UC Berkeley 2-Day Short Course
New Technologies for Geotechnical Infrastructure Sensing and Monitoring
January 22-23, 2021
Instructed Online

Dear alumni and friends of the UC Berkeley Geosystems program,

On January 22-23, 2021, UC Berkeley Faculty of the Geosystems group and collaborators, are offering a 2-day short course on "**New Technologies for Geotechnical Infrastructure Sensing and Monitoring**". The course will provide a review of some of the latest technologies that are about to, or are already impacting the way we maintain, monitor, or operate geo-infrastructure and the way we manage risk. Technologies to be discussed are sensor-equipped Unmanned Aerial Vehicles (or drones), 3D model creation using optical (Structure-from-Motion) imagery and LiDAR, infrared sensing, Synthetic Aperture Radar (SAR), wireless sensing fundamentals, ShapeArray Accelerometers and distributed sensing using fiber optics.

The instructors (Zekkos, Soga, Kayen, Johnson) have significant experience on the technologies presented and will outline the principles of operation and the advantages and disadvantages, as well as share examples of projects where these technologies have been successfully implemented with the intent to support professionals in selecting the right monitoring technologies that are needed for a range of geo-infrastructure applications.

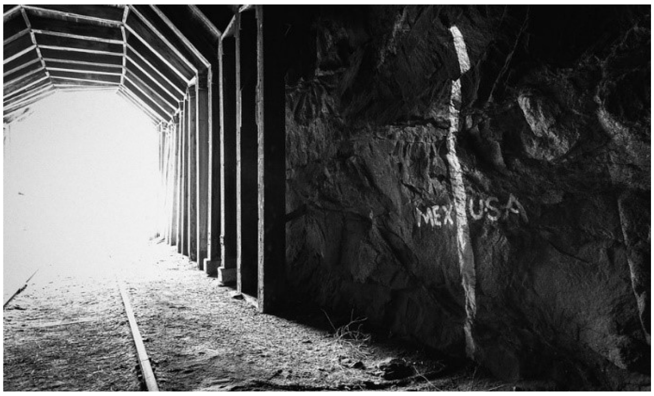
Due to COVID, the course will be offered online this year, but can also accommodate participants in all time zones by making the recorded lectures available online.

More information, and registration, for this course can be found here: https://www.geoengfdn.org/

If you have any questions, feel free to contact Dimitrios Zekkos at zekkos@berkeley.edu.

ΠΡΟΣΦΟΡΕΣ - ΠΡΟΚΗΡΥΞΕΙΣ ΘΕΣΕΩΝ ΓΙΑ ΓΕΩΤΕΧΝΙΚΟΥΣ ΜΗΧΑΝΙΚΟΥΣ

School of Sociology, Politics and International Studies (SPAIS)



Hidden Tunnels: tunneling as political resistance

PhD Research Project: Invitation to Interview

The aim of this research project is to consider how tunnels can be used by people to hide from state authorities. The knowledge and expertise required to construct or refurbish hidden tunnels cannot be acquired in isolation, and relies upon networks of information and learning which cross international borders and political ideologies. To this end, this research project would consider subterranean spaces of the occupied territories of the Gaza strip and the West Bank, tunnels under the US-Mexico border, tunnels under the Berlin Wall during the Soviet occupation of East Germany, and those used by environmental activists here in the UK. Other such tunnels are those used at Cu Chi during the Vietnam war, the Island of Pilau in World War 2, as well as resistance fighters in the Netherlands and in Odessa, Ukraine.

The intention of the project is to interview people (especially tunnel engineers) who are linked to the planning, construction and application of tunneling in a variety of environments, and authorities and agencies whose responsibilities include the detection and securing of subterranean spaces. The aim is to develop a deeper understanding of the risks and challenges secret tunneling creates, and the possibilities alternative expressions of exilic spaces provide.

As a (new) member of the British Tunneling Society, I would value the opportunity to learn more about the unique field of civil engineering which tunneling engineers inhabit, especially the challenges and solutions around keeping tunneling 'hidden' from the surface.

If you would be willing to help us non-specialists in our research via an anonymous on-line interview, please feel free to contact me at any stage.

Thank you.

Mr Timothy Duroux
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ΠΡΟΣΕΧΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΚΔΗΛΩΣΕΙΣ

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

Λόγω της πανδημίας του κορωνοϊού, υπάρχουν αλλαγές είτε στον τρόπο διεξαγωγής των συνεδρίων (με φυσική παρουσία ή virtual), είτε των ημερομηνιών διεξαγωγής κάποιων συνεδρίων. Συνιστάται να ελέγχετε την ημερομηνία διεξαγωγής απ' ευθείας στον ιστότοπο του συνεδρίου.

Postponed ISGPEG 2020 International Conference on Innovative Solutions for Geotechnical Problems in Honour of Prof. Erol Guler, 2021, Istanbul, Turkey, www.isgpeg2020.org/en

Online 14th Baltic Sea Geotechnical Conference 2020 Future Challenges for Geotechnical Engineering, 18-20 January 2021, Helsinki, Finland, www.ril.fi/en/events/bsgc-2020.html

Online Nordic Geotechnical Meeting Urban Geotechnics, 18-20 January 2021, Helsinki, Finland, www.ril.fi/en/events/ngm-2020.html

Virtual 17th World Conference ACUUS2020 Deep Inspirations, 3-4 February 2021, www.ril.fi/en/events/acuus-2020.html

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3rd International Tunnelling Forum
03.02.2021 - 04.02.2021, Poland, On-line
https://en.kongresdrogowy.pl/konferencja/115-3rd-international-tunneling-forum

It has already become a tradition that the series of conferences of the Polish Road Congress begins each year with a Forum devoted to the construction and operation of tunnels. After two editions of the Polish Tunnel Forum, in 2021 the event has a new name - the 3rd International Tunneling Forum. This emphasizes its scope, presenting the experiences of different countries and the number of participants that is expanding every year. The growing position of the Tunneling Forum is confirmed with the endorsement by the International Tunnelling and Underground Space Association ITA-AITES. The honorary patronage was also taken by the General Director of National Roads and Motorways.

This time, due to the restrictions caused by the pandemic, instead of Wrocław, we kindly invite you to an on-line conference. During the conference, design, execution and hardware solutions in tunneling construction will be presented, based on examples of specific projects implemented in various countries and in Poland. It will be an overview of the different technologies used in tunnel construction, depending on the location and geological conditions. The second basic thematic block will be experiences from the functioning of the existing tunnels in terms of ensuring safety. They are mainly about fire safety and the related providing of proper ventilation.

Provisional agenda

- Inaugural Session I
- Session II: Tunnel construction technologies
- Session III: Underwater Tunnels
- Session IV: Factors affecting safety in tunnels
- Session V: Construction and operation of tunnels

Contact

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www.kongresdrogowy.pl

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Virtual XIII International Symposium on Landslides - Landslides and Sustainable Development, 22-26 February 2021, Colombia, www.scg.org.co/xiii-isl

ICOLD-CIGB 2020 NEW DELHI Sustainable Development of Dams and River Basins, 24-27th February 2021, New Delhi, India, https://icold2020.org (physical and virtual)

International Conference on Challenges and Achievements in Geotechnical Engineering, 31.03.2021 – 02.04.2021, Tirana, Albania, Erdi Myftaraga, emy@greengeotechnics.com

Second International Conference on Geotechnical Engineering - Iraq 2021, 5-6 April 2021, Akre (Aqrah), Duhok, Iraq, http://ocs.uobaghdad.edu.iq/index.php/icgeotecheng/icgte

Virtual Rocscience International Conference on Numerical Modelling "The Evolution of Geotech: 25 Years of Innovation", April 20th - 21st, 2021, www.rocscience.com/learning/rocscience-conference

2nd Vietnam Symposium on Advances in Offshore Engineering – Sustainable Energy & Marine Planning, 22-24 April 2021, Ho Chi Minh City, Vietnam, https://vsoe2021.sciences-conf.org

16th International Conference of the International Association for Computer Methods and Advances in Geomechanics – IACMAG - CHALLENGES and INNOVATIONS in GEOMECHANICS, 03-05-2021, Torino, Italy, www.symposium.it/en/events/2020/16th-international-conference-of-iacmag?navbar=1

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9th International Symposium on Geomechanics
3 - 6 May, 2021, Medellin, Colombia

Organizer: Sociedad Colombiana de Geotecnia and Universidad Nacional de Colombia

Telephone: + 57 4 425 5146

E-mail: gaalzate@unal.edu.co

ATS 2020 AUSTRALASIA TUNNELLING CONFERENCE, 10th – 13th May 2021, Melbourne, Australia, www.ats2020.com.au

EUROGEO WARSAW 2020 7th European Geosynthetics Congress, 16-19 May 2021, Warsaw, Poland, www.eurogeo7.org

TISOLS Tenth International Symposium on Land Subsidence, Living with Subsidence, 17-21 May 2021, Delft - Gouda, the Netherlands, www.tisols2020.org/tisols2020

7th International Conference on Industrial and Hazardous Waste Management 18 - 21 May, 2021, Chania, Crete, Greece, http://hwm-conferences.tuc.gr

Virtual 2020 CHICAGO ICTG International Conference on Transportation Geotechnics, May 23 - 26, 2021, Chicago, Illinois, USA, http://conferences.illinois.edu/ICTG2020

Fifth International Conference on New Developments in Soil Mechanics and Geotechnical Engineering, 27 – 29 May 2021, Nicosia, Northern Cyprus https://zm2020.neu.edu.tr/

2021 ICOLD MARSEILLE - ICOLD 27th Congress - 89th Annual Meeting Sharing Water: Multipurpose of Reservoirs and Innovations, 4 - 11 June 2021, Marseille, France, https://cigb-icold2021.fr/en/

International Airfield and Highway Pavements Conference, June 6-9, 2021, Austin, Texas, USA, www.pavementsconference.org

MSL 2021 The 1st Mediterranean Symposium on Landslides SLOPE STABILITY PROBLEMS IN STIFF CLAYS AND FLYSCH FORMATIONS, 7-9 June 2021, Naples, Italy, https://medsymplandslides.wixsite.com/msl2021

9th International Conference on Computational Methods for Coupled Problems in Science and Engineering (COUPLED PROBLEMS 2021), 13-16 June 2021, Sardinia, Italy, coupledproblems_sec@cimne.upc.edu

Rapid Excavation and Tunneling Conference RETC2021, June 13-16, 2021, Las Vegas, Nevada, USA, www.retc.org

Cities on Volcanoes 11 - Volcanoes and Society: environment, health and hazards, 14-18 June 2021, Heraklion, Crete, https://pcoconvin.eventsair.com/volcanoes11

Joint meeting of ISSMGE TC201 and TC210, ICOLD TC E and TC LE "Dams and Levees: Particle Movements – Case Studies, Experiments, Theory", June 16-19, 2021, Budapest, Hungary, www.isc6-budapest.com

6th International Conference on Geotechnical and Geophysical Site Characterization "Toward synergy at site characterisation", June 16-19, 2021, Budapest, Hungary, www.isc6-budapest.com

EGRWSE 2020 - 3rd International Conference on Environmental Geotechnology, Recycled Waste Materials and Sustainable Engineering, 17-19 June 2021, Izmir, Turkey, www.egrwse2020.com

2nd ICPE 2021 The Second International Conference on Press-in Engineering, 19-21 June 2021, Kochi, Japan, https://icpe-ipa.org/

DFNE 2021 3rd International Conference on Discrete Fracture Network Engineering (in conjunction with ARMA 2021), June 23-25, Houston, Texas, USA, www.dfne2021.org

1st International Conference on Sustainability in Geotechnical Engineering, ICSGE, 27-30 June 2021, Lisboa, Portugal, http://icsge.lnec.pt/#

ICONHIC2021: THE STEP FORWARD - 3rd International Conference on Natural Hazards & Infrastructure, 22 – 24 June 2021, Athens, GREECE, https://iconhic.com/2021

DFI Deep Mixing, 5-8 July 2020, TBD, Gdansk, Poland, www.dfi.org/DM2020

II International Seminar "Tailings and Waste Rock Disposal", July 12 – 14, 2021, Lima, Peru, www.geoingenieria.org.pe

7th ICRAGEE International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, 12-17 July 2021, Bengaluru, India, http://7icragee.org

AFRICA 2021 Water Storage and Hydropower Development for Africa, 13-15 July 2021, Lake Victoria, Uganda, www.hydropower-dams.com/africa-2021

GEOCHINA 2021 - 6th GeoChina International Conference Civil & Transportation Infrastructures: From Engineering to Smart & Green Life Cycle Solution, July 19 to 21, 2021, NanChang, China, http://geochina2021.geoconf.org

PanAm Unsat 2021 3rd Pan-American Conference on Unsaturated Soils, 25-28 July 2021, Rio de Janeiro, Brazil, https://panamunsat2021.com

ACE 2020 14th International Congress on Advances in Civil Engineering, September 2021, Istanbul, Turkey, www.ace2020.org/en

XVIth International Congress AFTES 2021 Underground, a space for innovation, 6 to 8 September 2021, www.aftes2020.com

COMPLAS 2021 XVI International Conference on Computational Plasticity, Fundamentals and Applications, 7-10 September 2021, Barcelona, Spain, https://congress.cimne.com/complas2021/frontal/default.asp

RMEGV 2021 - 5th International Workshop on Rock Mechanics and Engineering Geology in Volcanic Fields, 9÷11 September 2021, Fukuoka, Japan, https://ec-convention.com/rmegv2021

SYDNEY 7iYGEC 2021 7th International Young Geotechnical Engineers Conference A Geotechnical Discovery Down Under, 10-12 September 2021, Sydney, Australia, http://icsmge2021.org/7iygec

SYDNEY ICSMGE 2021 20th International Conference on Soil Mechanics and Geotechnical Engineering, 12-17 September 2021, Sydney, Australia, www.icsgme2021.org

International Conference on Textile Composites and Inflatable Structures (MEMBRANES 2021), 13-15 September 2021, Munich, Germany, https://congress.cimne.com/membranes2021/frontal/default.asp

37th General Assembly of the European Seismological Commission, 19-24 September 2021, Corfu, Greece, www.escgreece2020.eu

EUROCK TORINO 2021 - ISRM European Rock Mechanics Symposium Rock Mechanics and Rock Engineering from theory to practice, 20-25 September 2021, Torino, Italy, http://eurock2021.com

This British Tunnelling Society "BTS 2020" Conference and Exhibition, Sept 30th - Oct 1st, 2021, London, United Kingdom, www.btsconference.com

Virtual EUROENGEO 3RD EUROPEAN REGIONAL CONFERENCE OF IAEG, 7 - 10 October 2021, Athens, Greece, www.euroengeo2020.org

10th International Conference on Scour and Erosion (ICSE-10), October 17-20, 2021, Arlington, Virginia, USA, www.engr.psu.edu/xiao/ICSE-10 Call for abstract.pdf

3rd International Symposium on Coupled Phenomena in Environmental Geotechnics, 20-22 October 2021, Kyoto, Japan, https://cpeg2020.org

ARMS11 11th Asian Rock Mechanics Symposium, Challenges and Opportunities in Rock Mechanics, 21-25 October 2021, Beijing, China, www.arms11.com

Roles of hydro in the global recovery
25-27 October 2021, Strasbourg, France
www.hydropower-dams.com/hydro-2021

MISSION AND SCOPE

The focus of the conference will be on the impact of hydropower worldwide, and optimizing its ongoing contribution to progress and development, particularly in the post-pandemic recovery period. Major renewable energy policy drivers, such as the AU, IRENA, IEA, the EU and the IFIs have agreed that there will be a need for vast amounts of new hydro and pumped- storage, in the move to achieve a more sustainable future, with a greater share of all renewable energy sources, but especially hydropower.

The French hydropower and dam industry welcomes the event, and the extensive experience of supporting organizations EDF and CNR, both within France and abroad, will be well reflected in the programme, and on the study tours.

CONFERENCE TOPICS

Future developments
The role of hydro in the post-COVID recovery
Hydropower integrated with other RE systems
Identifying development opportunities
Planning and design, including planning tools
Artificial intelligence and computer learning
The need for flexible grid systems

Transboundary projects
Project structuring and financing
Joint research and planning for cross-border schemes
Responsibilities for safety and hazard risk
Environmental aspects of transboundary projects
Viewpoints from the development banks
Technical issues, including transmission lines

Project financing and structuring
Investment trends and long-term opportunities
Attracting private finance
The shift from BOOT to PPPs
Company, project and country risk management
Concession agreements
Legal, contractual and insurance issues
Valuing full economic benefits and liabilities

Dealing with hazards and risk
Adapting management to address challenge of a pandemic
Experience with climate adaptation strategies
Climate-resilient infrastructure and projects
Challenges of seismicity, landslides, extreme floods and GLOFs
Warning systems, exclusion mapping and evacuation plans

Civil engineering
New approaches to design and construction
Refurbishment and retrofitting of civil works
Materials for dams
Challenging sites (geological conditions, remote access, extreme climate, etc)
Tunnels and underground works

Safety and risk
Dam and hydro plant safety; design aspects and monitoring systems
Cyber security
Learning from incidents and failures
Public safety around water infrastructure
Electronic and physical security of gates and spillways
Gate operation (including hot and cold climatic conditions)

Pumped storage
The role of pumped storage for intermittent energy sources
Technical developments in pumped storage
Ancillary benefits of pumped storage
Innovative pumped-storage projects

Hydraulic and electrical machinery
Research and development
Modelling and testing
Machinery design and safety
Smart systems to improve efficiency
Hydro plant operation
Powerplant monitoring and control
Operation and maintenance
Retrofitting and upgrading
Timely refurbishment

Environmental and social aspects
Strategic integration of environmental, social and governance aspects
Designing environmental mitigation measures
Environmental enhancements during upgrades
Innovative solutions for fish protection and passage
Greenhouse gas emissions accounting
Resettlement programmes
Post-implementation socio-economic assessments
The role of hydro in livelihood improvement/poverty alleviation

Small hydropower
Small hydro potential and benefits
Rural electrification schemes
Innovative small hydro technology

Marine energy: wave and tidal power

Capacity building and training
Capacity building needs, and developing local expertise
Succession planning and opportunities for young professionals
Training programmes
Viewpoints from young engineers

Sedimentation management
Hydraulic research and modelling
Monitoring sedimentation
Sediment removal systems
Design solutions for siltation and erosion
Catchment area management
Young professionals' research in sedimentation

If you have any questions about submitting an abstract or the technical programme, please contact us at: Hydro2021@hydropower-dams.com. You can also register to receive updates on our activities via our website: www.hydropower-dams.com

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EURO:TUN 2021 Computational Methods and Information Models in Tunneling, October 27th - 29th, 2021, Bochum, Germany, http://eurotun2021.rub.de

Emerging Technologies and Applications for Green Infrastructure, 28-29 October 2021, Ha Long, Vietnam, https://cigos2021.sciencesconf.org

5TH World Landslide Forum Implementation and Monitoring the USDR-ICL Sendai Partnerships 2015-2015, 2-6 November 2021, Kyoto, Japan, http://wlf5.iplhq.org

ISFOG 2020 4th International Symposium on Frontiers in Offshore Geotechnics, 8 – 11 November 2021, Austin, United States, www.isfog2020.org

2021 GEOASIA7 - 7th Asian Regional Conference on International Geosynthetics Society, November 22-26, 2021, Taipei, Taiwan, www.geoasia7.org

ICGE – Colombo – 2020 3rd International Conference in Geotechnical Engineering, 6-7 December 2021, Colombo, Sri Lanka, http://icgecolombo.org/2020/index.php

GeoAfrica 2021 - 4th African Regional Conference on Geosynthetics Geosynthetics in Sustainable Infrastructures and Mega Projects, 21-24 February 2022, Cairo, Egypt, https://geoafrica2021.org

ICEGT-2020 2nd International Conference on Energy Geotechnics, 10-13 April 2022, La Jolla, California, USA, https://icegt-2020.eng.ucsd.edu/home

WTC 2022 World Tunnel Congress 2022 - Underground solutions for a world in change, 22-28 April 2022, Copenhagen, Denmark, www.wtc2021.dk

LARMS 2021 – IX Latin American Rock Mechanics Symposium Challenges in rock mechanics: towards a sustainable development of infrastructure, 15 – 18 May 2022, Asuncion, Paraguay, https://larms2021.com

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CPT'22

5th International Symposium on Cone Penetration Testing

8-10 June 2022, Bologna, Italy

The Italian Geotechnical Society (AGI) and the University of Bologna are pleased to announce the 5th International Symposium on Cone Penetration Testing, CPT'22, to be held in Bologna, Italy, on June 8-10, 2022. CPT'22, organized under the auspices of the ISSMGE Technical Committee TC102, follows the successful symposia held in Delft, The Netherlands (2018), Las Vegas, Nevada USA (2014), Huntington Beach, California USA (2010) and Linköping, Sweden (1995).

As tradition of the CPT events, which foster a lively debate on recent advancements on cone penetration testing, the Symposium aims at providing Researchers, Practitioners and Contractors with a unique opportunity of sharing up-to-date knowledge in equipment, testing procedures, data interpretation and related applications, as well as discussing emerging solutions and new ideas with the largest gathering of world's experts, academics and non-academics, working in the broad and dynamic area of CPTs.

Organizer

Italian Geotechnical Society (AGI) and University of Bologna (endorsed by TC102)

Contact Information

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Prof. Guido Gottardi (University of Bologna)

Email: guido.gottardi2@unibo.it,
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3rd European Conference on Earthquake Engineering and Seismology (3ECEES), 19-24 June 2022, Bucharest, Romania, https://3ecees.ro

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9th International Congress on Environmental Geotechnics
Highlighting the role of Environmental Geotechnics in Addressing Global Grand Challenges
26-29 June 2022, Chania, Crete island, Greece
www.iceg2022.org

The 9th International Congress on Environmental Geotechnics is part of the well established series of ICEG. This conference will be held on an outstanding resort in the town of Chania of the island of Crete in Greece. The theme of the conference is "Highlighting the role of Environmental Geotechnics in Addressing Global Grand Challenges" and will highlight the leadership role of Geoenvironmental Engineers play on tackling our society's grand challenges.

Contact Information

- Contact person: Dr. Rallis Kourkoulis
- Email: rallisko@grid-engineers.com

IS-Cambridge 2020 10th International Symposium on Geotechnical Aspects of Underground Construction in Soft Ground, 27 - 29 June 2022, Cambridge, United Kingdom, www.is-cambridge2020.eng.cam.ac.uk

UNSAT2022
8th International Conference on Unsaturated Soils
June or September 2022, Milos island, Greece

Eurock 2022

Rock and Fracture Mechanics in Rock Engineering and Mining
12÷15 September 2022, Helsinki, Finland
www.ril.fi/en/events/eurock-2022.html

Themes

- Rock mass Characterization
- Geophysics in rock mechanics
- Mechanics of rock joints
- Jointed rock mass behaviour
- Rock support, probability based design
- Rock stress measurements
- Constitutive modelling of rock
- Rock drilling
- Blast induced fractures
- Rock engineering and mining education
- Geological disposal of spent nuclear fuel
- Recent advances in rock mechanics research
- Field and laboratory investigations
- Case studies

Contact Person: Lauri Uotinen
E-mail: lauri.uotinen@aalto.fi

6th Australasian Ground Control in Mining Conference – AusRock 2022
17 – 19 September 2022, Melbourne, Australia

Organizer: UNSW Sydney, AusIMM
Contact Person: Ismet Cambulat
E-mail: icambulat@unsw.edu.au

XII ICG - 12th International Conference on Geosynthetics, September 18 – 22, 2022, Rome, Italy, www.12icg-roma.org

28th European Young Geotechnical Engineers Conference and Geogames, 17 – 19 September 2022, Moscow, Russia, https://www.eygec28.com/?

11th International Conference on Stress Wave Theory and Design and Testing Methods for Deep Foundations, 20 - 23 September 2022, De Doelen, Rotterdam, The Netherlands, https://www.kivi.nl/afdelingen/geotechniek/stress-wave-conference-2022

88th ICOLD Annual Meeting & Symposium on Sustainable Development of Dams and River Basins, April 2023, New Delhi, India, https://www.icold2020.org

15th ISRM

International Congress in Rock Mechanics
9÷14 October 2023, Salzburg, Austria

Contact Person: Prof. Wulf Schubert
E-mail: salzburg@oegg.at

Gamsberg mine in South Africa: when is a landslide a geotechnical failure?

Gamsberg mine is a comparatively new open cast pit in the Northern Cape, South Africa. Operated by Vedanta Zinc International, it currently produces 400,000 tonnes of ore per month. Once full production capacity is reached Gamsberg is expected to produce 4 000,000 tonnes of ore and 250,000 tonnes of zinc-in-concentrate per year. The current reserve and resource is 214 million tonnes, and operations are estimated to last about 30 years.

On 17 November at about 1:15 am Gamsberg suffered what its owners are describing as a "geotechnical failure" that was sufficiently large to require that the company release a formal statement. The failure occurred in a high wall excavation known at a part of the mine known as the South Pit. At the time of the failure there were ten members of staff at the bottom of the pit. Eight were rescued, but it appears that the other two were killed.

The failure is sufficiently large that it is clearly visible on the daily Planet Labs imagery. The images below show the South Pit; the left image was captured on 14 November, before the landslide, and the image on the right was captured after the event on 17 November.

Planet Labs imagery showing the Gamsberg mine before the failure (left, collected on 14 November 2020) and after (right, collected on 17 November 2020).

This image provides an overview of the landslide itself:

An overview of the landslide at Gamsberg mine. Image posted anomalously to Reddit.

Whilst this image shows the damage caused by the landslide:-

The damage caused by the landslide at Gamsberg mine. Image posted anomalously to Reddit.

There is very little additional information about this very large mining landslide. The impact on the workers in the mine and to the equipment above suggests that it might not have been anticipated. As high wall mines often have sophisticated monitoring of their slopes, it is increasingly unusual for the operators to be taken by surprise by such events.

Reference and acknowledgement

Planet Team (2020). Planet Application Program Interface: In Space for Life on Earth. San Francisco, CA. https://www.planet.com/

(Dave Petley / THE LANDSLIDE BLOG, 2 December 2020, https://blogs.agu.org/landslideblog/2020/12/02/gramsberg-1)

Haines, Alaska: a major landslide leaves people missing

Heavy rainfall this week triggered landslides around the town of Haines in Alaska, causing extensive damage. Around 200 mm fell on Tuesday and Wednesday, with the additional effect of melting snow pack. Heavy rain on snow is a scenario that he previously proven to be effective in generating failures.

The largest failure appears to have occurred at the Beach Road residential area close to the town of Haines. The image below of the landslide has been published by Alaska Public Media. It seems that four houses were destroyed:-

The landslide in Haines, Alaska on Wednesday, Dec. 2.

The landslide in Haines, Alaska on Wednesday, Dec. 2.

This is clearly a major rockslide. Note the shattered timber at the foot of the landslide. Whilst initial reports indicated that six people might be missing in this landslide, most of those have now been accounted for. However, two people, the residents of one of the houses destroyed, remain missing. If they were in the property at the time of the landslide then the prospects are bleak.

This looks to be a relatively deep-seated rock slope failure high up on the slope, with entrainment of material along the length of the slope to the water. The timber is extremely shattered, suggesting an energetic failure. Most of the debris appears to be under the water. Some images show pieces of destroyed timber houses floating in the water.

Other landslides have been reported, most notably at the Macaulay Salmon Hatchery in Juneau, where a water pipeline supplying the hatchery was destroyed by a slip. As the site was without a source of freshwater, the staff at the hatchery have been forced into destroying their stock of young chinook salmon and rainbow trout, which would have been released in the spring, as well as many of the young coho salmon.

Acknowledgement

Many thanks to a number of people who contacted me directly or via Twitter about this slide. I have drawn heavily on the links that you sent.

(Dave Petley / THE LANDSLIDE BLOG, 4 December 2020, https://blogs.agu.org/landslideblog/2020/12/04/haines-1)

Mindu in Tibet: detecting precursors of an imminent landslide

With the possible exception of some landslides triggered by earthquakes, large slope failures generally develop strain (movement) prior to failure. The failure process involves the progressive deformation of the slope – a shear surface may form in the base of the landslide, tension cracks form, lateral scarps develop, etc. A classic case is the Barry Arm landslide in Alaska, where movement on the slope has led to the development of very large tension cracks. There is strong evidence that over time the rate of movement increases as failure approaches. This increase in deformation is the basis of various methods of prediction of the time of failure (with success in some circumstances).

One challenge of course is to use this knowledge to identify and monitor slopes that might be undergoing failure. The holy grail is to have a remote monitoring system that collects data at a regional or national scale and then identifies slopes that are actively deforming. InSAR provides one potential basis for this, and national scale deformation maps are now available, but identifying correctly slopes that might be dangerous requires more work and a better understanding.

Another approach, applicable for individual landslides at the moment, is to use imaged correlation approaches from optical satellite imagery. In this approach, pairs of images are compared. Perhaps surprisingly, image processing can allows deformations on the scale of 3 to 10% of a pixel to be detected. The Sentinel-2 satellites have an image resolution of about 10 metres, so deformation of less than a metre can be measured.

In an open access paper in the journal *Natural Hazards and Earth System Sciences*, Yang *et al.* (2020) have used image processing of Sentinel-2 imagery to examine the movement through time of a developing failure near to the town of Mindu in Tibet. This is a large area of slope deformation – this is the Google earth image collected in 2011 for example:-

A Google Earth image of the landslide near to Mindu in Tibet

The location of this landslide is 30.582, 98.925. Whilst there is little in the way of the landslide, clearly a major rock slope failure at this site near to Mindu would potentially block the river, creating a substantial hazard downstream.

The image processing by Yang *et al.* (2020) has demonstrated that this landslide is actively deforming. Perhaps most interestingly, between November 2015 and November 2018 the slope showed less than 2 metres of movement. However, between 2018 and 209 the slope moved over 6 metres. The research team were able to then look at a larger number of images in this more rapid movement period, finding that in the rainy season (summer and autumn) the movement rate accelerated.

This study demonstrates that processing of optical satellite imagery can allow high quality monitoring of dangerous slopes to be undertaken. It is another step along the way towards the goal of high quality early warning systems for slopes in high mountain areas.

Reference

Yang, W., Liu, L., and Shi, P. 2020. Detecting precursors of an imminent landslide along the Jinsha River. *Natural Hazards and Earth System Sciences*, **20**, 3215–3224, https://doi.org/10.5194/nhess-20-3215-2020.

(Dave Petley / THE LANDSLIDE BLOG, 10 December 2020, https://blogs.agu.org/landslideblog/2020/12/10/mindu-1)

Detecting precursors of an imminent landslide along the Jinsha River

Wentao Yang, Lianyou Liu, and Peijun Shi

Abstract

Landslides are major hazards that may pose serious threats to mountain communities. Even landslides in remote mountains could have non-negligible impacts on populous regions by blocking large rivers and forming dam-breached mega floods. Usually, there are slope deformations before major landslides occur, and detecting precursors such as slope movement before major landslides is important for preventing possible disasters. In this work, we applied multi-temporal optical remote sensing images (Landsat 7 and Sentinel-2) and an image correlation method to detect subpixel slope deformations of a slope near the town of Mindu in the Tibet Autonomous Region. This slope is located on the right bank of the Jinsha River, ~80 km downstream from the famous Baige landslide. We used a DEM-derived aspect to restrain background noise in image correlation results. We found the slope remained stable from November 2015 to November 2018 and moved significantly from November 2018. We used more data to analyse slope movement in 2019 and found retrogressive slope movements with increasingly large deformations near the riverbank. We also analysed spatial–temporal patterns of the slope deformation from October 2018 to February 2020 and found seasonal variations in slope deformations. Only the foot of the slope moved in dry seasons, whereas the entire slope was activated in rainy seasons. Until 24 August 2019, the size of the slope with displacements larger than 3 m was similar to that of the Baige landslide. However, the river width at the foot of this slope is much narrower than the river width at the foot of the Baige landslide. We speculate it may continue to slide down and threaten the Jinsha River. Further modelling works should be carried out to check if the imminent landslide could dam the Jinsha River and measures should be taken to mitigate possible dam breach flood disasters. This work illustrates the potential of using optical remote sensing to monitor slope deformations over remote mountain regions.

How to cite.

Yang, W., Liu, L., and Shi, P.: Detecting precursors of an imminent landslide along the Jinsha River, Nat. Hazards Earth Syst. Sci., 20, 3215–3224, https://doi.org/10.5194/nhess-20-3215-2020, 2020.

Nat. Hazards Earth Syst. Sci., 20, 3215–3224, 2020 https://doi.org/10.5194/nhess-20-3215-2020

https://nhess.copernicus.org/articles/20/3215/2020/

Large landslides cause major damage in Seyðisfjörður, Iceland

A series of landslides have been reported in the town of Seyðisfjörður, Iceland, causing major damage to at least 10 houses and electrical poles. A red alert phase has been in effect in the area since December 15, 2020, with fears that more houses would be lost in the slips, while residents nearby Eskifjörður had to be evacuated as well due to the hazards. The landslips occurred following days of heavy rain-- meteorologists said the precipitation from December 14 to 18 was the most recorded during a five-day period in the country.

On Friday, December 18, residents in the town were evacuated after a large landslide damaged at least 10 houses. Local reports said only first responders, meteorologists, reporters, and electrical repair team has been allowed in the area.

Around 700 people reside in the town, and some of them stayed with friends, relatives, or at hotels in nearby communities.

Kristín Björg Ólafsdóttir, a climate specialist at the Icelandic Met Office told Iceland Monitor that up to 570 mm (22 inches) of rain fell in the town from December 14 to 18-- the most recorded in a five-day period in Iceland. By comparison, the average yearly precipitation in Reykjavik is 860 mm (34 inches).

Seyðisfjörður Landslide Aftermath - New Drone Footage
https://www.youtube.com/watch?v=YmjoZ7JRJ3I&feature=emb_logo

"All of us are very grateful that no lives were lost," said Hildur Þórisdóttir, former president of the Seyðisfjörður town council. "Amid this whole disaster, that is a miracle."

Town in Iceland evacuated after mudslide hits - BBC News
https://www.youtube.com/watch?v=0VLVZ7TzrKA&feature=emb_logo

The Department of Civil Protection and Emergency Management issued a red alert phase for the area on Tuesday, December 15.

"I fear this isn't over yet, and that we'll lose more houses," Hildur added. "It is clear that an enormous amount of water has accumulated in the mountains."

Landslide hits an Icelandic Town - Unique Footage
https://www.youtube.com/watch?v=2mr_amZQQhw&feature=emb_logo

"A great deal of work is ahead, cleaning, and rebuilding. At the same time, people show incredible solidarity. Seyðisfjörður is a community of residents who love living there. The people were resilient already, and I hope that resilience will carry them through this terrible shock."

As the risk of further landslides remains, residents in parts of nearby Eskifjörður had to be evacuated. Mountainsides remain saturated with rainwater, and fissures in an old road above the town were reported to have grown wider.

(Julie Celestial / THE WATCHERS, December 21, 2020, https://watchers.news/2020/12/21/iceland-landslide-december-2020)

Faroe Islands: Inside the undersea tunnel network

The Faroe Islands are set to open an under-sea roundabout following more than three years of construction.

The underwater tunnels connect the islands of Streymoy and Eysturoy in a network some 6.8 miles (11km) long. The network is scheduled to open on 19 December.

The tunnel network will come as a relief to residents, cutting down the travel time between the capital Torshavn and Runavik, from an hour and 14 minutes to just 16 minutes.

The lowest point of the tunnel network is 187m (613ft) below sea level.

The Faroe Islands, a series of 18 islets in the North Atlantic located halfway between Iceland and Norway, constitute an autonomous region of Denmark.

In order to ensure the safety of those using the tunnel, the steepest incline is no more than a 5% gradient, the company behind the tunnels confirmed.

A test-run involving emergency services is scheduled for 17 December, according to local media.

The roundabout in the middle of the network will contain artwork by Faroese artist Trondur Patursson. The art will comprise sculptures and light effects.

Those using the tunnels will be required to pay a toll fee. Local.fo, a Faroese news website, reports that passenger cars will have to pay 75 Danish Krona (£9.10) one way.

Locals can sign up to a subscription which makes it cheaper.

According to contractors NCC, the tunnels are the biggest infrastructure investment ever made on the Faroe Islands.

Another tunnel is currently under construction, connecting the islands of Sandoy and Streymoy.

(BBC, 4 December, https://www.bbc.com/news/world-europe-55195390)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΓΕΩΛΟΓΙΑ

Weathering, Erosion, and Deposition Song

This song compliments "The Rock Cycle Rock" and focuses on the processes that change Earth's surface; weathering, erosion, and deposition. It explains how water, wind, and ice are chief agents of these changes that happen constantly. Often these changes are slow, but they are happening nonetheless. Use this song with upper elementary and middle school learners.

https://www.youtube.com/watch?v=6_e5CGBZXZs

Jerry Hull School Songs and Science

Αλιεύθηκε από την συνάδελφο Κατερίνα Ζιωτοπούλου Katerina Ziotopoulou @KaterinaZiot, Επίκουρη Καθηγήτρια στο University of California, Davis, η οποία τιτίβισε «Just found this gem. Will it be featured in my @ucdaviscee ECI 171 soil mechanics winter quarter Week 1? Yes, yes it will.»

Crowley Lake Columns
Mono County, California

Eons old volcanic activity created one of the most stunning rock formations in the United States.

Hundreds of thousands of years in the past when the Long Valley Caldera was created by violent volcanic action, the ultra hot lava flows created California’s Bishop Tuff tableland range, an otherworldly length of stony waves and columns.

The giant plateau formation sits in one of the world’s most interesting volcanic areas. Over 767,000 years in the past a massive volcanic eruption sent rivers of lava cascading over the surrounding desert which had just been covered by falling ash. As the colossal torrents of lava washed over the built up ash it baked the ash to a layer of stone in an instant.

Now after millennia of erosion from wind and water the bottom layer and the top layer of cooled lava can be clearly seen, taking the form of rocky waves bisected by a dividing line. In certain sections along the tuff, the stone has turned into bulbous columns known as “degassing pipes” creating a veritable forest of oddly shaped stone. The Bishop Tuff also sits near the equally alien Mono Lake where the only traces of non-carbon-based life were discovered.

https://www.atlasobscura.com/places/crowley-lake-columns

Massive supercontinent will form hundreds of millions of years from now

Converging continents could reshape global climate.

The supercontinent Pangaea dominated Earth's surface until about 200 million years ago.

Supercontinents — giant landmasses made up of multiple continents — could emerge again on Earth 200 million years from now, and where they form on the globe could drastically affect our planet's climate.

Scientists recently modeled this "deep future" view of Earth with a supercontinent makeover, presenting their findings Dec. 8 at the annual meeting of the American Geophysical Union (AGU), held online this year. They explored two scenarios: In the first, around 200 million years in the future, nearly all continents push into the Northern Hemisphere, with Antarctica left all alone in the Southern Hemisphere; in the second scenario, about 250 million years in the future, a supercontinent forms around the equator and extends into Northern and Southern Hemispheres.

For both, the researchers calculated the impact on global climate based upon the supercontinents' topography. They were surprised to find that when continents were pushed together in the north and the terrain was mountainous, global temperatures were significantly colder than in the other models. Such an outcome could herald a deep freeze unlike any in Earth's past, lasting at least 100 million years, scientists reported at AGU.

Earth's continents didn't always look the way they do today. Over the past 3 billion years or so, the planet has cycled through multiple periods where continents first crowded together to form immense supercontinents and then broke apart, according to lead study author Michael Way, a physical scientist at the NASA Goddard Institute for Space Studies in New York.

Earth’s many ancient continents – The first half-billion years of Erath science were gnarly.

The most recent supercontinent (relatively speaking) was Pangaea, which existed from about 300 million to 200 million years ago and included what is now Africa, Europe, North America and South America. Before Pangaea was the supercontinent Rodinia, which existed from 900 million to 700 million years ago, and prior to that was Nuna, which formed 1.6 billion years ago and broke apart 1.4 billion years ago, Live Science previously reported.

Another team of scientists had previously modeled supercontinents of the far distant future. The supercontinent they dubbed "Aurica" would coalesce in 250 million years from continents collecting around the equator, while "Amasia" would come together around the North Pole. For the new study, Way and his team took the Aurica and Amasia landmasses and different topographies — highly mountainous; flat and close to sea level; or mostly flat but with some mountains — and plugged them into a circulation model called ROCKE-3D, Way told Live Science.

Simulations show possible land configurations for supercontinents in a "far future" Earth. (Image credit: M.J. Way, H.S. Davies, Joao Duarte, J.A.M. Green)

In addition to plate tectonics, other parameters informed the models' calculations for deep future Earths, based on how Earth changes over time. For example, 250 million years from now, Earth will spin just a little slower than it does today, which the model took into account, Way explained.

"Earth's rotation rate is slowing down over time — if you move 250 million years into the future, the day length increases by about 30 minutes, so we put that into the model to see if that had an effect," Way said. Solar luminosity will also slightly increase in 250 million years, "because the sun is gradually getting brighter through time," he said. "We put that into the model also, so we increased the amount of radiation the planet sees."

The most unexpected result in their models was that global temperatures were colder by nearly 7.2 degrees Fahrenheit (4 degrees Celsius) in a world with a mountainous Amasia supercontinent in the Northern Hemisphere. This was mostly because of a strong ice albedo feedback. Snow and ice in this northern supercontinent at high latitudes created permanent cover over land during the summer and winter months, "and that tends to keep the surface temperature a couple of degrees colder than in all the other scenarios," Way said.

By comparison, in models of a less mountainous Amasia, lakes and inland seas were able to form. They transported atmospheric heat northward from the equator, seasonally melting snow and ice so that the land wouldn't be permanently frozen.

On Earth today, ocean circulation carries heat to far northern regions, traveling around Greenland and through the Bering Strait. But when a supercontinent forms and those avenues close, "then you can't transport that warm ocean heat from lower latitudes or southern summer up north to melt and keep things warm," Way said.

Earth's more recent ice ages lasted for tens of thousands of years. But the formation of Amasia could usher in an ice age that would be significantly longer.

"In this case, we're talking about 100 million years, 150 million years," Way said.

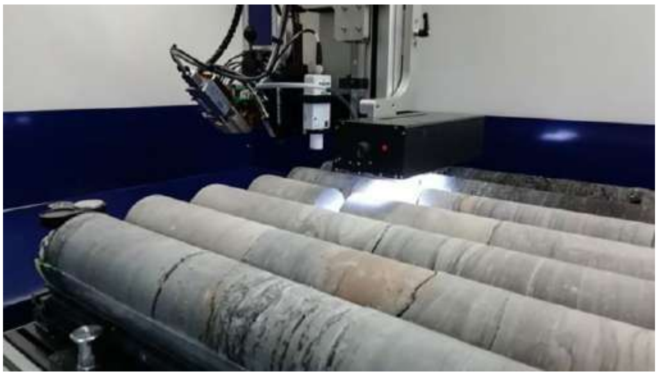
What might that mean for life on Earth? As tropical lowlands vanish, so too would the incredible biodiversity that they support. However, new species could emerge that would be adapted to survive in extremely cold environments, like they did during earlier ice ages.

"When you give evolution enough time, it finds a way to fill every ecological niche in some way," Way said. And in a situation such as this, where exceptional cold would dominate the planet for 100 million years or more, "that's a long time for evolution to work," he said.

(Mindy Weisberger - Senior Writer / LIVESCIENCE, 14.12.2020, https://www.livescience.com/agu-future-earth-supercontinent-climate.html)

Underground observatory to show scientists what lies beneath the Earth's surface

The compound in Glasgow is home to 12 boreholes which are between 16 to 199 metres deep.



Scientists will be able to use scanning equipment at the Glasgow Observatory

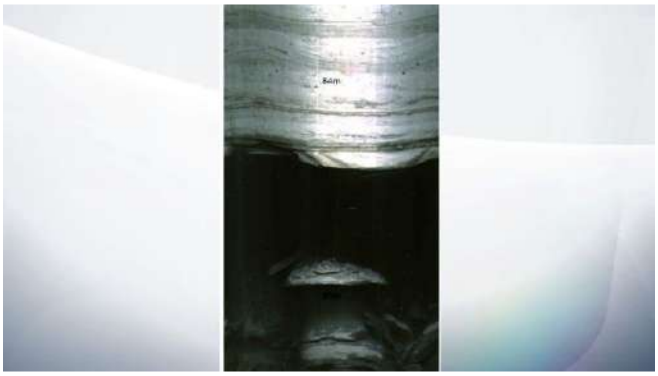
An underground observatory in Glasgow will give scientists from around the world a chance to look at what lies beneath the surface of the Earth.

The Glasgow Observatory is made up of 12 boreholes beneath manhole covers within a fenced compound.

Each one is 16 to 199 metres deep and fitted with 319 state-of-the-art sensors to help better understand the subsurface.

A virtual event will mark the official opening of the site, with scientists around the world being invited to apply to use it from March 2021 - in line with coronavirus restrictions.

The team behind the facility suggest it will help decarbonise UK energy supply and achieve the country's goal of net zero emissions by 2050.



An image taken from the facility shows what scientists will see beneath the surface

Dr Karen Hanghoj, executive director of the British Geological Survey, said: "The Glasgow Observatory builds on the city's industrial past.

"The data from Glasgow's abandoned mines will help us understand the processes and impacts of a mine water heat source and potential heat store as a sustainable way of heating homes and businesses in our cities.

"Over the next 15 years, the network of boreholes will monitor any changes in the properties of the environment below the surface, and help close the knowledge gap we have on mine water heat energy and heat storage.

"While today is the official opening, the Glasgow Observatory has been supplying scientists with open access data since drilling began in 2018.

"There is no other publicly-funded observatory like this in the world, and it is very fitting that it is located in Glasgow, which will host Cop26 next year."

A second observatory is planned for another site in Cheshire.

The equipment at the site will be available to scientists from all over the world

Professor Sir Duncan Wingham, executive chairman of the Natural Environment Research Council, said: "The Glasgow Observatory is the first of our UK observatories that will create a high-resolution understanding of the underground system, providing a breakthrough in our knowledge of what lies beneath us.

"Heat from mine water is one form of geothermal energy, and it has great potential to help the UK decarbonise its heat supply and meet net zero targets."

Professor Dame Anne Glover, president of the Royal Society of Edinburgh, also said: "It makes sense that the UK's first geoenergy observatory is in Glasgow, given Scotland's geology is world famous.

"With the government's target of achieving net zero emissions by 2050, emerging low carbon technologies may offer the best solutions to shaping future energy policy.

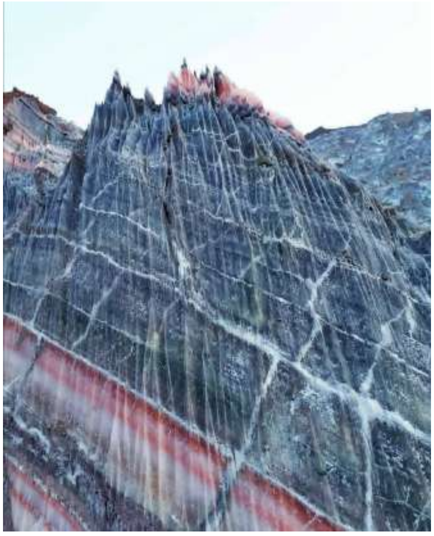
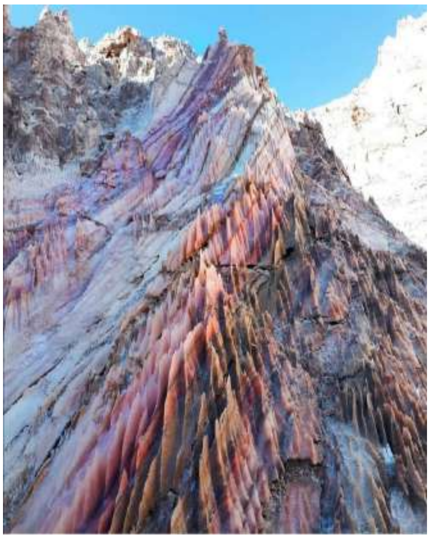
"This observatory will be absolutely key for scientists to advance the study of renewable energy and is a great example of how Scotland is leading the way in energy innovation and investigating the viability of alternative energy sources."

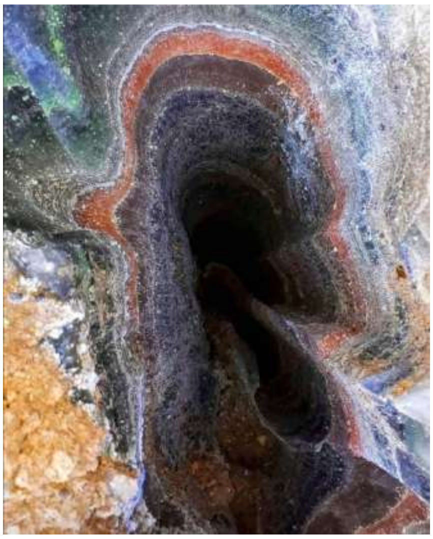
(sky news, Monday 7 December 2020, https://news.sky.com/story/underground-observatory-to-show-scientists-what-lies-beneath-the-earths-surface-12153869)

Salt Rocks, Iran







Ελληνική πρωτιά σε διεθνή διαγωνισμό σπηλαιοφωτογραφίας

Έλληνας διδάκτορας γεωλογίας του ΑΠΘ κέρδισε με φωτογραφία του σπηλαίου Αγγίτη

Η φωτογραφία του Χρήστου Πέννου που απέσπασε την πρώτη θέση στις προτιμήσεις του κοινού

Με μια φωτογραφία στην οποία «αιχμαλώτισε» μαζί με φίλους του που κρατούσαν φλασιέρες, μια φωτεινή στιγμή από ένα σημείο του κατασκότεινου σπηλαίου Αγγίτη (Μααρά), διδάκτορας γεωλογίας του ΑΠΘ απέσπασε την πρώτη θέση στις προτιμήσεις του κοινού, σε διεθνή διαγωνισμό σπηλαιοφωτογραφίας.

«Δεν είμαι φωτογράφος, είμαι γεωλόγος», δήλωσε ο Χρήστος Πέννος, ο οποίος εργάζεται ως επισκέπτης Καθηγητής στο Πανεπιστήμιο του Μπέργκεν, στη Νορβηγία. Μάλιστα, από το 2014 οπότε και μετακόμισε στη Νορβηγία, ξεκίνησε την έρευνά του για το σπήλαιο του πηγών Αγγίτη καθώς και την έρευνα σε σπήλαια του Αρκτικού κύκλου, με στόχο τις αλλαγές του γήινου ανάγλυφου και τις παλαιοκλιματικές μεταβολές.

Σταλακτίτες στο σπήλαιο Αγγίτη

«Έχω διαπιστώσει στις μελέτες μου, δραματική μείωση των παγοαποθέσεων σε σπήλαια, λόγω της κλιματικής αλλαγής που επιφέρει αύξηση των βροχοπτώσεων. Αυτό έχει ως αποτέλεσμα να χάνουμε σημαντικά αρχεία που αφορούν παλαιοκλιματικές πληροφορίες», αναφέρει. Η φωτογραφία του, που βραβεύτηκε ανάμεσα σε περίπου 350 συμμετοχές, υποβλήθηκε στο διεθνή διαγωνισμό σπηλαιοφωτογραφίας, με διοργανωτές το Slovak Museum of Nature Protection and Speleology, το Slovak Speleological Society, το Slovak Caves Administration και τον δήμο Liptovský Mikuláš της Σλοβακίας.

«Η λήψη έγινε το καλοκαίρι του 2020 κατά την επίσκεψή μου στο σπήλαιο μαζί με τους σπηλαιοεξερευνητές Γιώργο Σωτηριάδη, Σταύρο Ζαχαριάδη και Αργύρη Μανώλα. Η δουλειά ήταν ομαδική αφού το σπήλαιο δεν έχει καθόλου φως και χρειάστηκε η συνεργασία όλων μας για να βγάλουμε τις φωτογραφίες. Τοποθετηθήκαμε δηλαδή σε συγκεκριμένες θέσεις με φλασιέρες, υπολογίζοντας τις σκιές και το φως και βγάλαμε τη φωτογραφία με τη φιγούρα του Γιώργου Σωτηριάδη μέσα στο σπήλαιο προκειμένου να πετύχουμε την καλύτερη κατανόηση του μεγέθους του σπηλαίου», εξήγησε ο κ. Πέννος, προσθέτοντας ότι όλοι τους είναι και μέλη του σπηλαιολογικού συλλόγου Πρωτέας Θεσσαλονίκης.

Η επίσκεψη, το καλοκαίρι, στο σπήλαιο των πηγών Αγγίτη που είναι το μεγαλύτερο σε μήκος σπήλαιο στην Ελλάδα (περίπου 10 χιλιόμετρα), έγινε προκειμένου ο κ. Πέννος να καταγράψει τις ενδείξεις από αισθητήρες που έχει τοποθετήσει στον χώρο για να συλλέγει διάφορα στοιχεία στο πλαίσιο της έρευνάς του.

Το μεγαλύτερο ποτάμιο σπήλαιο στην Ελλάδα

Το σπήλαιο πηγών Αγγίτη (Μααράς) τοποθετείται βόρεια της υδρολογικής λεκάνης Δράμας, που περιβάλλεται από τα όρη Φαλακρό, Μενοίκιο, Παγγαίο και Σύμβολο. Βρίσκεται 25 χλμ. βορειοδυτικά της Δράμας και 500μ. από τον οικισμό Αγγίτης του Δήμου Προσοτσάνης. Θεωρείται μέχρι στιγμής το μεγαλύτερο ποτάμιο σπήλαιο στην Ελλάδα, με μήκος περί τα 15 χιλιόμετρα, εκ των οποίων τα 12,5 περίπου έχουν χαρτογραφηθεί.

Η ιδιαιτερότητα του έγκειται στο γεγονός ότι στο δάπεδό του κυλάει ο ποταμός Αγγίτης. Ο πλούσιος διάκοσμός του περιλαμβάνει τεράστιους σταλακτίτες. Το σπήλαιο είναι επισκέψιμο σε μήκος 500 μέτρων ενώ συνολικά εκτείνεται σε μήκος άνω των 12 χιλιομέτρων. Εντυπωσιακή είναι η έξοδος του ποταμού μέσα από το βουνό. Στον υπόγειο ποταμό του σπηλαίου καταλήγουν μεταξύ άλλων, τα νερά του λεκανοπεδίου του Κάτω Νευροκοπίου.

Το τμήμα του σπηλαίου που έχει εξερευνηθεί φθάνει τα 7.800 μ. ενώ περιλαμβάνει συνολικά 10.200 μ. στοών. Έτσι, αποτελεί το μεγαλύτερο σπήλαιο στην Ελλάδα καθώς το γνωστό μέχρι σήμερα τμήμα είναι 5.278 μ. σε ευθεία. Επίσης, είναι το δεύτερο μεγαλύτερο σε μήκος διαδρομών σπήλαιο στην Ελλάδα (πρώτο το Σπήλαιο Δυρού με 12.000 μ.).

Είναι γνωστό και με το όνομα σπήλαιο Μααρά, η ετυμολογία του οποίου είναι είτε από τα αραβικά και σημαίνει μικρό σπήλαιο είτε από τα εβραϊκά που σημαίνει νερό από το βουνό.

Ένα πολύ μικρό τμήμα του σπηλαίου στην έξοδο του ποταμού ήταν γνωστό από την αρχαιότητα. Στην περιοχή έχουν βρεθεί πολλά αρχαιολογικά ευρήματα καθώς και ένας χαυλιόδοντας από μαμούθ, που φυλάσσονται στο Αρχαιολογικό Μουσείο Δράμας.

Σπήλαιο πηγών Αγγίτη

Στο σπήλαιο έχουν βρεθεί επίσης μοναδικά είδη ψαριών, όπως η μπριάνα και το τυλινάρι σε βάθη 6.500 μέτρων, καθώς και ένα μοναδικό είδος ημιδιάφανης πετροκαραβίδας Austropotamobius torrentium σε βάθος 7.100 μέτρων. Στο σπήλαιο έχει αναφερθεί η ύπαρξη διάφανων ψαριών.

Το σπήλαιο βρίσκεται στο Δήμο Προσοτσάνης Δράμας και είναι προσβάσιμο από τη Δράμα, την Καβάλα και τη Θεσσαλονίκη. Έχει αξιοποιηθεί και είναι επισκέψιμο από το 2001.

(Πέμπτη, 12 Νοεμβρίου 2020, https://www.naftemporiki.gr/story/1655658/elliniki-protia-se-diethni-diagonismo-spilaiofotografias)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΛΟΙΠΑ

The Bosco Verticale

The Bosco Verticale / Vertical Forest high-rise complex in Milan, Italy. The plant life, which is said to equal 3 hectares of forests (20,000 sq m), not only moderates the tempera-ture in summer and winter but also converts as much as 30 tonnes of CO2 each year. On top of that, it filters out dust particles, protects the residents from noise pollution and creates a microhabitat for insects and birds.

From Wikipedia:

"The building itself is self-sufficient by using renewable energy from solar panels and filtered waste water to sustain the buildings' plant life. These green technology systems reduce the overall waste and carbon footprint of the towers. Lead designer Stefano Boeri stated, "It's very important to completely change how these new cities are developing. Urban forestation is one of the biggest issues for me in that context. That means parks, it means gardens, but it also means having buildings with trees."

The design was tested in a wind tunnel to ensure the trees would not topple from gusts of wind.[11] Botanists and horticulturalists were consulted by the engineering team to ensure that the structure could bear the load imposed by the plants.

Growing underground

How Bluebird Network got a data center - and how it expanded

What makes someone look at a mine and see an ideal spot for a data center? In the case of Bluebird Network's underground facility in Springfield Missouri, the story goes back at least 20 years. Bluebird's general manager Todd Murren told us the history.

In 1946, the Griesemer Stone Company began mining limestone from beneath the city of Springfield. The "room and pillar" method left huge empty underground halls. By the 1960s, Griesemer was offering warehouse space in these vast caverns.

In the 1980s, the city of Springfield got its own telecoms firm, SpringNet, when the community-owned utility decided to roll out broadband. At SpringNet, Murren began looking at the idea of setting up a secure data center in the 1990s, and eventually realized the ideal site was 85 feet below him, in Griesemer's combined mine-and-warehouse, now renamed Springfield Underground.

"You can't find anywhere else with the same level of protection," he told *DCD*. "Some people look at the mine and feel scared or think it's a bit ominous, but human beings have been looking to caves for protection since the beginning. We wanted something that would be safe from dangers that most data centers faced."

Missouri is prone to tornados, and a data center underground is one way to stay safe, but moving to a once-working mine brings other concerns. "When you're underground in a mine you may want to check that you're not building next to a TNT factory. We set up a seismograph back before we even built the data center because we're dealing with hard drives and the last thing you want to do is shake them.

An air shaft inside Bluebird underground

"But we found no problems. I've been there when they detonated explosives in the mine, there's nothing quite like it," he said. "Of course, I was a safe distance away." Limestone is structured like a rocky sponge, he explained. It can absorb shock and is flexible enough to dissipate energy.

Explosives and data centers don't mix

SpringNet bought space in the mine, and soon began construction - with some of the work already done for them: "The walls, floor, and roof are already built for you." The low ambient temperatures reduced the cooling bill, and expansion was never an issue as there's almost unlimited space to expand into.

Originally, the data center was only going to be partially in the mine, with auxiliary systems such as generators kept above ground. But then 9/11 happened.

"It caused us to pause and rethink some of the design features. The mine offers some very reliable natural disaster reinforcements, but unnatural events caused us to rethink them. That pretty much brought the project to a halt."

Suddenly, SpringNet became very aware of the damage a plane could do. The redesign brought all of the data center's surface assets, generators, and mechanical cooling systems underground. "Cooling and power," Murren said. "They're much like our critical organs in the human body. Our heart and lungs are protected under our ribcage. So, our redesign after September 11 brought those elements underground."

With the rethink, work began in earnest to get the system ready for a launch in 2003.

"It took about three years," Murren said. "Three years to properly prepare the place, smooth out the walls, and install ventilation and the electrical equipment. We had to come up with a whole design philosophy and kept on making changes because of the challenges we faced."

Before Murren and his team ever moved in, the company that operated the mine was contracted to prepare the space. Once enough room had been made, level floors were laid with concrete.

Of course, the underground roads into the facility weren't exactly smooth, so most of the heavy equipment brought into the mine had to be dismantled or shipped in on special trucks equipped with suspension controls, and specialists who knew how to navigate tight spaces were brought in to help.

"We had to remove two old generators and bring in three new ones. As with most generators, these things are brought to the job site on a semi-truck. In normal circumstances, a crane could be used, but when you are in a mine, with only 25 feet of space to the ceiling, you can't use a 100-foot crane. Getting that generator off a truck and getting it into place was a challenge," Murren added. "We had to do a certain amount of dismantling."

Another problem was the fuel for the backup generators, a potential fire hazard in the enclosed space: "When we started, we had to store around 3,000 gallons of fuel and now we're storing around 12,000. When you bring those underground in a mine right next to critical operations, you've brought a risk that you normally don't have in a [surface] data center."

Moving from above ground to below ground

Generators also have to breathe: when they're turned on, gases such as carbon monoxide and carbon dioxide are released. The mine is essentially an enclosed environment, so those generators needed sufficient ventilation.

By 2014, SpringNet had a thriving underground business, with 84 tenants including regional healthcare providers, but the telco wanted to invest in fiber, so it sold the data center to local telecom provider Bluebird Network.

Mining ceased in 2015, just one year after Bluebird took over, and the new owners embarked on an upgrade process, backed by tax incentives from the State - Murren stayed on.

Bluebird has expanded the space in three phases, with help from Schneider Electric's data center team. In 2016, it added 4,000 sq ft. In 2018, it kicked off another 4,700 sq ft expansion, and a third one adding some 7,000 sq ft was begun in 2019, leading to an eventual site with some 30,000 sq ft.

If any more space is needed, it's no problem as the mine still has some five million square feet of tunnels and caverns.

The expansion meant increasing the number of UPS systems, cooling systems, and generators. This last addition meant something more had to be done with the exhaust. Poisoning the workforce was not part of the plan.

"Part of the work on the mine was addressing the exhaust and getting rid of it. The first thing we do is scrub it, getting it as clean as we can, and then get it out of the mine." Until the expansion, the underground complex's regular ventilation systems could do the job, but for the expansion, Bluebird drilled a hole, 65 feet deep and 13-feet-wide, to act as a chimney for exhaust gases and hot air from the chillers.

During intense lightning storms, something Missouri faces quite often, electrical spikes were discovered. These 'anomalies,' as Murren calls them, led to the realization that the data center's grounding system wasn't good enough.

"So, since buildings up on the surface get to ground themselves by digging down; what do you think you can do when you're underground?"

The team decided it would be best to dig 340 feet down into Springfield's water table. It may sound strange, but limestone is an insulator and the company needed to find a good conductor to dissipate the voltage.

"So, we grounded ourselves to the water table. There are many wonderful properties to stone, one being you can't electrify it, but the issue is you want something conductible when you want to ground electricity."

Modernization can be a challenge to any building, but underground it's a major challenge. Bluebird Underground is Murren's pride and joy and he's proud to have seen it through all these stages.

"It's a blessing in disguise. Because now, anything can be going on, above, and has zero impact on the resiliency of this data center."

(Alex Alley / DCD, November 19, 2020, https://www.datacenterdynamics.com/en/analysis/growing-underground/)

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This We Call Love

SHE said: "tell me something beautiful"

HE replied: $(\partial + M)\ N_o = 0$

This is Paul Dirac's equation, and it's the most beautiful of all physics. It describes the phenomenon of quantum intertwining, which states that "if two systems interact with each other for a certain period of time then separate, we can describe them as two different systems, but in a subtle way, they become a unique system.

What happens to one continues to affect the other, even within miles or light years. It's quantum intertwining or quantum connection. Two particles that, at one point or another, are still in some way linked.

No matter the distance between the two, even if they are at opposite extreme of the universe. The connection between them is instant.

It's the same thing that happens between two people, a bond that only living beings can experience.

This is how this relationship works. THIS WE CALL LOVE.

$$(\partial + \mathrm{m})\ \mathrm{N}^{\circ} = \mathrm{o}$$

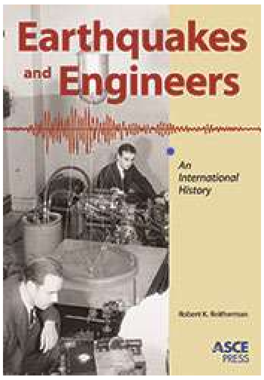
Paul Dirac

Below is the expanded or full form of the equation as Paul Dirac presented it. Terms can be regrouped to produce the above in symbolic form.

Note: In the right-hand side i stands for the imaginary number i = square root of (-1) which is one of the most brilliant inventions of mathematics.

$$\left(\beta mc^2 + c\sum_{n=1}^{3}\alpha_n p_n\right)\psi(x,t) = i\hbar\frac{\partial\psi(x,t)}{\partial t}$$

ΝΕΕΣ ΕΚΔΟΣΕΙΣ ΣΤΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΠΙΣΤΗΜΕΣ



Earthquakes and Engineers: An International History

Robert K. Reitherman, M.Arch.

Earthquakes and Engineers: An International History is the first comprehensive treatment of the engineering techniques devised around the world to address seismic problems. Beginning in ancient times, threading through the Renaissance, and continuing into the latter half of the 20th century, Reitherman traces the evolution of humankind's understanding of the cause and characteristics of earthquakes and the develop-ment of methods to design structures that resist seismic shocks. This book examines the responses not only of structural engineers, but also of geotechnical engineers, architects, and planners. International efforts in such countries as Japan, China, India, Chile, Turkey, Italy, and the United States are placed in the broader social, technological, and economic contexts of their eras.

This highly readable book is an essential reference for civil engineers who work on projects in seismic regions. For researchers in the field of the history of science and technology, the book presents original source material and an extensive list of references. Written in a straightforward style that is accessible to nonengineers, it will also be valuable to architects, planners, officials, and social scientists.

(ASCE Press, 2012)

ΗΛΕΚΤΡΟΝΙΚΑ ΠΕΡΙΟΔΙΚΑ

ASSOCIATION INTERNATIONALE DES TUNNELS ET DE L'ESPACE SOUTERRAIN AITES | ITA INTERNATIONAL TUNNELLING AND UNDERGROUND SPACE ASSOCIATION

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Κυκλοφόρησε το Τεύχος #72 (Δεκεμβρίου 2020) των ITA News με τα παρακάτω περιεχόμενα:

MESSAGE FROM JINXIU (JENNY) YAN, ITA PRESIDENT

Dear ITA colleagues,

2021 is around the corner, and 2020 will become history soon. On behalf of ITA, I would like to take this opportunity to thank you all for your strong support and joint efforts in this challenging 2020.

We are now living in a fast-changing world. Like other international organizations, ITA is facing new circumstances and new challenges. Especially, this year, due to the pandemic of Covid-19, our lives and ITA activities are being significantly affected. Thanks to advanced digital platforms, we have been able to meet and work together even in this difficult time. Actually, with your strong support and joint efforts, we have moved successfully all our conferences and meetings to digital platforms including the 46th GA, the WTC2020, ITA Awards 2020 and implemented actively our tasks related to governance and outreach.

The value of ITA as an association is that it provides a unique platform for all its members to share experience and wisdom, and work together for the good of ITA and the industry. Only by joint efforts, can we be the leading organization and serve well all ITA members, thus moving our industry forward as a whole.

The upcoming year 2021 is important for ITA in terms of changes, including the new WTC rules for better WTCs in the future, monthly digital webinars for more frequent technical exchanges, an underground space forum for further sharing the importance of the underground to a sustainable society, and communication and cooperation with banks and investors and other international organizations for promoting better use of tunnelling and underground space worldwide. All of these efforts are aimed at creating together a better and more prosperous ITA and industry in the future!

I wish you all a healthy, happy and prosperous New Year!

- WTC 2021: event rescheduled to 2022 Read more
- 2020 ITA TUNNELLING AWARDS: WINNERS ANNOUNCED Read more
- Webinar on 11 November - Moving beyond the obvious – Recording now available Read more
- ITA helds a virtual 46th general assembly Read more
- WTC 2020 moved to virtual event Read more
- Webinar 'How cool is underground space' attended by over 150 participants Read more
- World Tunnel Day 2020:24hr online meet-up Read more
- ITA-CET will organize monthly "online lunchtime lecture series" Read more
- ITA Member Nations report 2019 Read more
- Successful webinar on Expanding underground, Knowledge & Passion to Make a Positive Impact on the world Read more
- The year we lost three of our pioneering greats Read more
- Celebration of the 30th anniversary of CBT Read more
- Enjoy reading the latest ITA-CET newsletter Read more

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igs International Geosynthetics Society

Κυκλοφόρησε το IGS Newsletter της International Geosynthetics Society με τα παρακάτω περιεχόμενα:

IGS NEWSLETTER – December 2020

Helping the world understand the appropriate value and use of geosynthetics

https://www.geosyntheticssociety.org/newsletters/

- Focus On Resilience For 12th ICG READ MORE
- Best Papers of 2019 Announced! Geotextiles and Geomembranes: Best Papers 2019, Geosynthetics International: Best Papers 2019
- The Giroud Lecture – A Speaker's Perspective READ MORE
- Keynote Speakers Return For EuroGeo7 READ MORE
- IGS Chile Collaborates With GSI READ MORE
- 10 Questions with... Ian Fraser READ MORE Pietro Rimoldi READ MORE Preston Kendall READ MORE
- IGS Chapter Focus: Greecet READ MORE
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- IGS Sets Plans For 2021 READ MORE
- Sustainability eBook Now In: Chinese!
- Calendar of Events

READ MORE AT GEOSYNTHETICSSOCIETY.ORG

www.icevirtuallibrary.com/toc/jgein/27/6

Κυκλοφόρησε το Τεύχος 6 του Τόμου 27 (Δεκεμβρίου 2020) του Geosynthetics International της International Geosynthetics Society με τα παρακάτω περιεχόμενα:

www.sciencedirect.com/journal/geotextiles-and-geomembranes/vol/48/issue/6

Κυκλοφόρησε το Τεύχος 6 του Τόμου 48 (Δεκεμβρίου 2020) του Geotextiles and Geomembrabes της International Geosynthetics Society με τα παρακάτω περιεχόμενα:

Regular Articles

Effect of added polymer on the desiccation and healing of a geosynthetic clay liner subject to thermal gradients, Bowei Yu, Abbas El-Zein, R. Kerry Rowe, Pages 928-939

Load sharing characteristics of rigid facing walls with geogrid reinforced railway subgrade during and after construction, Ung Jin Kim, Dae Sang Kim, Pages 940-949

Irrigated composite liner designs for fast hydration and prevention of thermal desiccation of geosynthetics clay liners, Bowei Yu, Abbas El-Zein, Pages 950-961

Shear strength and failure mechanism of needle-punched geosynthetic clay liner, Shi-Jin Feng, Ji-Yun Chang, Hong-Xin Chen, Yang Shen, Jia-Liang Shi, Pages 962-972

Suction and crack propagation in GCLs subjected to drying and wetting in $CaCl_2$-solutions, Wolfgang Lieske, Florian Christ, Wiebke Baille, Gemmina Di Emidio, Torsten Wichtmann, Pages 973-982

Technical Notes

Characterization of geogrid mechanical and chemical properties from a thirty-six year old mechanically-stabilized earth wall, Ben Leshchinsky, Ryan Berg, Willie Liew, Morgan Kawakami-Selin, ... Mark Wayne, Pages 793-801

Case history on failure of a 67 M tall reinforced soil slope, Ryan R. Berg, James G. Collin, Thomas P. Taylor, Chester F. Watts, Pages 802-811

Ultimate bearing capacity of strip footing resting on soil bed strengthened by wraparound geosynthetic reinforcement technique, Muhammad Nouman Amjad Raja, Sanjay Kumar Shukla, Pages 867-874

Analyzing the deformation and failure of geosynthetic-encased granular soil in the triaxial stress condition, Fei Song, Yangtao Jin, Huabei Liu, Jie Liu, Pages 886-896

Evaluation of silt curtain in the reduction of suspended solids, Eduardo Paniguel Oliveira, Rafael Brito de Moura, Caio Pompeu Cavalieri, Rafael de Oliveira Tiezzi, Pages 983-988

ΕΚΤΕΛΕΣΤΙΚΗ ΕΠΙΤΡΟΠΗ ΕΕΕΕΓΜ (2019 – 2022)

ΕΕΕΕΓΜ

Τομέας Γεωτεχνικής
ΣΧΟΛΗ ΠΟΛΙΤΙΚΩΝ ΜΗΧΑΝΙΚΩΝ
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