INTERNATIONAL SYMPOSIUM
PRESERVATION OF MONUMENTS & HISTORIC SITES
SEPTEMBER 2026 | ATHENS, GREECE
ATHENS TC301

ΕΛΛΗΝΙΚΗ ΕΠΙΣΤΗΜΟΝΙΚΗ ΕΤΑΙΡΕΙΑ ΕΔΑΦΟΜΗΧΑΝΙΚΗΣ & ΓΕΩΤΕΧΝΙΚΗΣ ΜΗΧΑΝΙΚΗΣ

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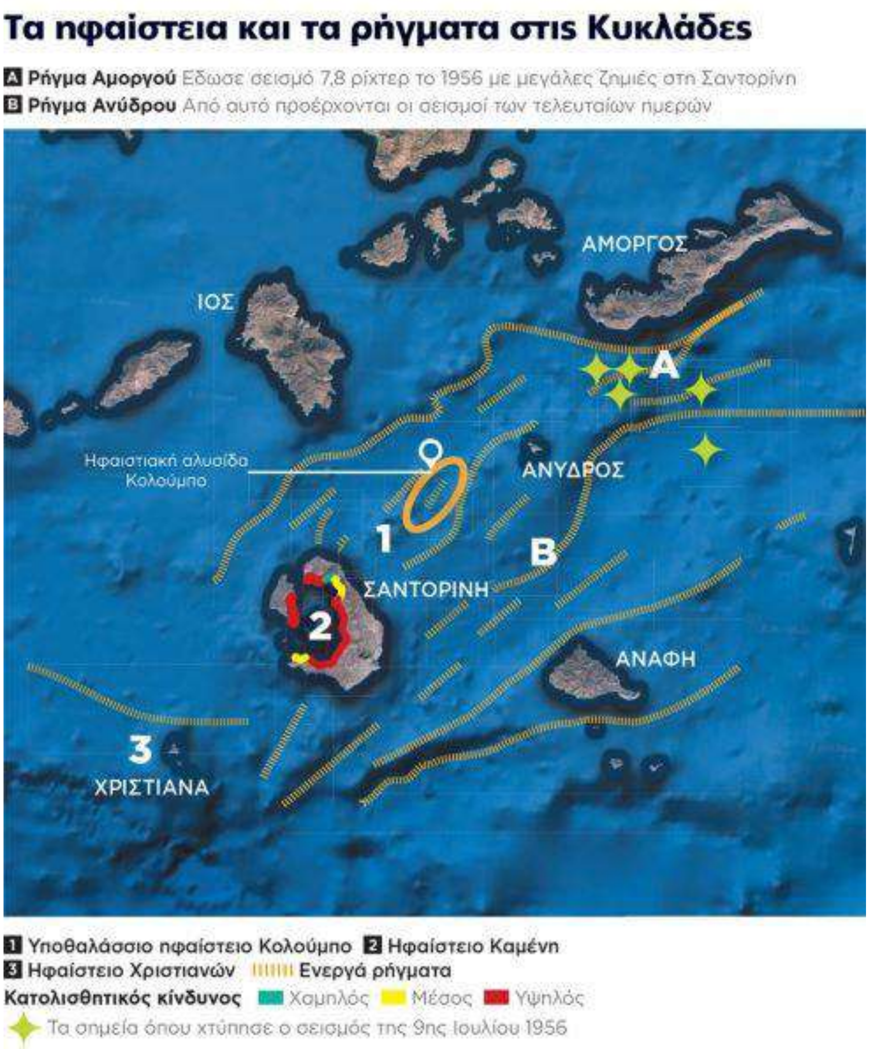

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ATHENS 2026 TC301

4th INTERNATIONAL SYMPOSIUM ON

GEOTECHNICAL ENGINEERING FOR THE PRESERVATION OF MONUMENTS AND HISTORIC SITES

24-26 SEPTEMBER 2026

NATIONAL HELLENIC RESEARCH FOUNDATION
ATHENS, GREECE

IMPORTANT DATES

31 MAY 2025
Abstract Submission

30 NOV 2025
Deadline for Early Bird Fee

30 NOV 2025
Full Paper Submission

28 FEB 2026
Final Paper Acceptance

MARCH 2026
Authors Registration Deadline

The Hellenic Society for Soil Mechanics and Geotechnical Engineering (HSSMGE) is pleased to invite you to participate in the 4th International Symposium on Geotechnical Engineering for the Preservation of Monuments and Historic Sites, which will be held on September 2026 in Athens, Greece.

CONFERENCE THEMES

- Conservation Principles
- Historical Geotechnical Engineering
- Diagnosis: Understanding and Investigating Monuments
- Analysis, Modeling and Risk Assessment
- Geotechnical Aspects of Monumental Restoration / Preservation
- Climate Change and Protection of Monuments from Natural Hazards
- Urban Development Impact on Monumets
- Case Histories: Examples & Lessons Learned
- Special Session on the Acropolis of Athens

CALL FOR ABSTRACTS

We invite the submission of abstracts that fit the conference themes.
The deadline for Abstract Submission is 31 March 2025.

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Σεισμικά σενάρια και χάρτες κατανομής της εκτιμώμενης μέγιστης εδαφικής επιτάχυνσης (PGA), κατά τη διάρκεια της πρόσφατης σεισμικής ακολουθίας στην περιοχή μεταξύ Σαντορίνης - Αμοργού

Θεοδουλίδης Νίκος, Σεισμολόγος - Δντής Ερευνών
Γρένδας Ιωάννης, Σεισμολόγος – Μεταδιδακτορικός Ερευνητής
Ινστιτούτο Τεχνικής Σεισμολογίας & Αντισεισμικών Κατασκευών (ΙΤΣΑΚ – ΟΑΣΠ)

1. Εισαγωγή

Στις 24 Ιανουαρίου 2025, ξεκίνησε μια σεισμική ακολουθία ΒΑ της Σαντορίνης της οποίας τα επίκεντρα μετατοπίσθηκαν από ΝΔ προς ΒΑ, δηλαδή, προς το νησί της Αμοργού. Εν τέλει μέσα στο πρώτο δεκαήμερο του Φεβρουαρίου περιορίσθηκαν γύρω από το μικρό νησί της Ανύδρου, μεταξύ Σαντορίνης και Αμοργού. Η ακριβής χωρο-χρονική κατανομή των σεισμών της ακολουθίας μπορεί να αναζητηθεί στα σεισμολογικά κέντρα της χώρας (Γεωδυναμικό Ινστιτούτο ΕΑΑ: http://bbnet.gein.noa.gr/HL/seismicity/real-time-seismicity/last-24-hours και Σεισμολογικός Σταθμό του ΑΠΘ: https://seismo.auth.gr/en/current-seismicity). Οι μεγαλύτεροι σε μέγεθος σεισμοί, 4.0 ≤ M ≤ 5.3 της ακολουθίας περιορίσθηκαν γύρω από την Άνυδρο. Οι μεγαλύτεροι σεισμοί M ≥5.0 έδωσαν μηχανισμό γένεσης κανονικού ρήγματος (https://seismo.auth.gr/en/focal-mechanisms), με μικρή έως αμελητέα οριζόντια συνιστώσα κίνησης.

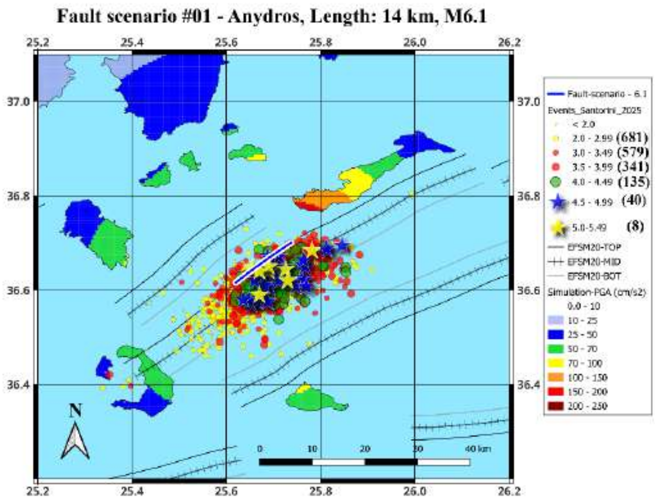
2. Δεδομένα και Μεθοδολογία

Για να εκτιμηθεί η ισχυρή εδαφική δόνηση σε περίπτωση μεγαλύτερου σεισμού (με M≥6.0) στην υπό διέγερση περιοχή της υπό εξέλιξη σεισμικής ακολουθίας, ή και στο ρήγμα της Αμοργού-Σαντορίνης, όπως αυτό δίνεται στην Ευρωπαϊκή Βάση Ρηγμάτων (EFSM20: https://seismofaults.eu), επιλέχθηκαν πιλοτικά τρία σενάρια διάρρηξης τμημάτων ή του συνολικού ρήγματος της Αμοργού-Σαντορίνης. Τα τρία αυτά σενάρια σε καμία περίπτωση δεν αφορούν σε πρόγνωση μεγέθους σεισμού, αλλά χρησιμοποιούνται με μοναδικό σκοπό την εκτίμηση της μέγιστης τιμής της εδαφικής επιτάχυνσης (Peak Ground Acceleration, PGA) της ισχυρής δόνησης, σε περίπτωση μεγαλύτερου σεισμού (M≥6.0) από εκείνους που έχουν συμβεί μεταξύ 01/01/2025 και 11/02/2025. Η επιλογή των παρακάτω σεισμικών σεναρίων είναι ενδεικτική μεταξύ πολλών άλλων που θα μπορούσαν επίσης να προταθούν.

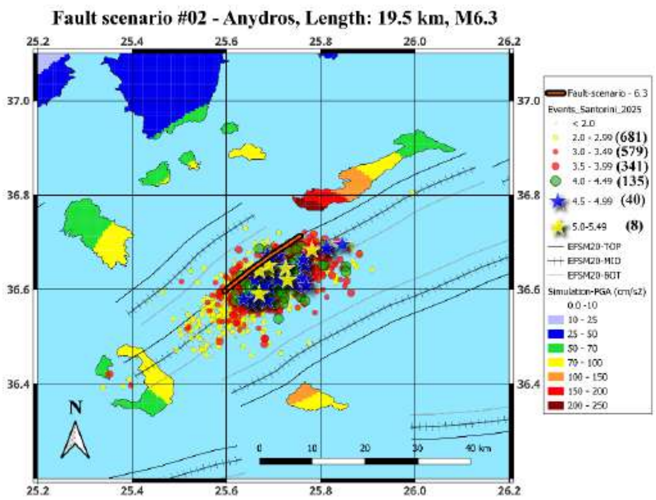
Ως σενάριο No#1 (Σχήμα 1), θεωρήθηκε εκείνο το τμήμα του ρήγματος στο οποίο έχουν συγκεντρωθεί οι μεγαλύτεροι σεισμοί, 4.0 ≤ M ≤ 5.3, της ακολουθίας κατά τις πρώτες έντεκα ημέρες του Φεβρουαρίου και βρίσκεται γύρω από το νησί της Ανύδρου. Αυτό το τμήμα έχει μήκος της τάξης των 14 km και με βάση τη σχέση του μήκους ρήγματος με το μέγεθος του σεισμού των Papazachos et al. (2004), αντιστοιχεί σε σεισμό μεγέθους M6.0, ενώ βάσει των Wells & Coppersmith, (1994), αντιστοιχεί σε σεισμό μεγέθους 6.1

Ως σενάριο No#2 (**Σχήμα 2**), θεωρήθηκε ένα μεγαλύτερο τμήμα από αυτό του σεναρίου N0#1, μήκους 19.5km, επίσης εκατέρωθεν του νησιού της Ανύδρου, στο οποίο έχουν συγκεντρωθεί οι μεγαλύτεροι σεισμοί μεγέθους: 3.0 ≤ M ≤ 5.3 Το ρήγμα αυτό με βάση την εργασία των Papazachos et al. (2004) καθώς και εκείνης των Wells & Coppersmith (1994) αντιστοιχεί σε σεισμό μεγέθους M6.3.

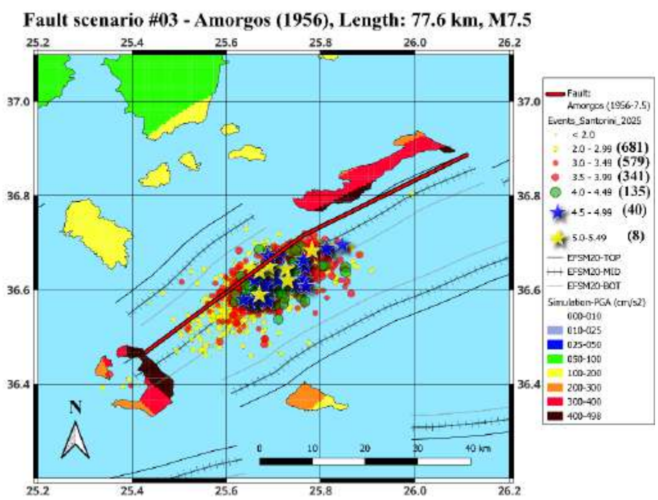
Τέλος, ως «ακραίο» σενάριο No#3 (**Σχήμα 3**), θεωρήθηκε ολόκληρο το ρήγμα της Αμοργού-Σαντορίνης, μήκους ~78km το οποίο αντιστοιχεί σε σεισμό μεγέθους M7.5, δηλαδή παρόμοιο με τον καταστροφικό σεισμό του Ιουλίου του 1956 (Papazachos and Papazachou 1997).



Σχήμα 1. Σενάριο σεισμικού ρήγματος No#1. Earthquake epicenters 1/1/2025 -11/2/2025 (NOA-Geodynamic Institute & Seismological Station AUTh



Σχήμα 2. Σενάριο σεισμικού ρήγματος No#2. Earthquake epicenters 1/1/2025 -11/2/2025 (NOA-Geodynamic Institute & Seismological Station AUTh



Σχήμα 3. Σενάριο σεισμικού ρήγματος No#3. Earthquake epicenters 1/1/2025 -11/2/2025 (NOA-Geodynamic Institute & Seismological Station AUTh

Για την προσομοίωση των τριών παραπάνω σεναρίων χρησιμοποιήθηκαν οι πρόσφατα δημοσιευμένες σχέσεις απόσβεσης για τον Ελληνικό χώρο (GMM: Ground Motion Model) των Boore et al. (2021) για εδαφικές συνθήκες «βράχου», που αντιστοιχεί σε μέση ταχύτητα των εγκαρσίων κυμάτων στα επιφανειακά 30 m, Vs30 = 760 m/sec.

Το λογισμικό υπολογισμού των μεγίστων εδαφικών επιταχύνσεων (PGA) στον ευρύτερο χώρο των σεισμικών ρηγμάτων, είναι το REDAS: Rapid Earthquake Damage Assessment System (Papatheodorou et al. 2023, Theodoulidis et al. 2024).

3. Αποτελέσματα και Συζήτηση

Στην περίπτωση του Σεναρίου Νο1# οι μεγαλύτερες τιμές της PGA σε εδαφικές συνθήκες βράχου (Vs30 = 760 m/sec) εκτιμώνται στο ΝΔ τμήμα της Αμοργού και προσεγγίζουν το 0.20 g (20% της επιτάχυνσης της βαρύτητας) και μειώνονται σταδιακά προς το ΒΑ τμήμα του νησιού σε 0.025 g. Στο κεντρικό και βόρειο τμήμα της Σαντορίνης οι τιμές της PGA για τις ίδιες εδαφικές συνθήκες βράχου κυμαίνονται σε σχετικά χαμηλά επίπεδα (0.05 g < PGA < 0.07 g), ενώ στο νότιο τμήμα καθώς και στο νησί της Θηρασιάς οι αντίστοιχες τιμές της PGA κυμαίνονται σε ακόμη χαμηλότερα μεταξύ 0.025 g και 0.05 g. Επιπλέον, οι τιμές της PGA στο νησί της Ανάφης, στην κεντρική και νότια Ίο καθώς και στα νησιά μεταξύ Ίου και Νάξου, κυμαίνονται, για τις ίδιες εδαφικές συνθήκες βράχου, μεταξύ 0.05 g και 0.07g, ενώ στην βόρεια Ίο, οι τιμές είναι χαμηλές (<0.07 g).

Στην περίπτωση του Σεναρίου Νο2# οι μεγαλύτερες τιμές της PGA για εδαφικές συνθήκες βράχου (Vs30 = 760 m/sec) εκτιμώνται στο νοτιοδυτικό τμήμα της Αμοργού (0.15 g-0.25 g), καθώς και στο κεντρικό της τμήμα (0.10 g-0.15 g). Επίσης στην Αμοργό οι εκτιμώμενες τιμές PGA ελαττώνονται προς τα βορειοανατολικά και κυμαίνονται μεταξύ 0.05 g-0.10 g. Αντίστοιχες τιμές της PGA (0.05 g-0.10 g) εκτιμώνται για το νησί της Σαντορίνης, μειούμενες από τα βορειοανατολικά προς τα νοτιοδυτικά και προς το νησί της Θηρασιάς. Παρόμοιες τιμές της PGA 0.05 g-0.10 g εκτιμώνται επίσης για το νησί της Ίου, μειούμενες από τα νότια προς τα βόρεια, καθώς και στα νησιά ανάμεσα στην Ίο και την Νάξο.

Στην περίπτωση του «ακραίου» Σεναρίου Νο3#, εκτιμώνται υψηλές τιμές PGA σε εδαφικές συνθήκες βράχου (Vs30 = 760 m/sec), μεταξύ 0.4 g και 0.5 g, στο κεντρικό και βόρειο τμήμα της Σαντορίνης καθώς και στα νοτιοδυτικά παράλια της Αμοργού. Στα υπόλοιπα τμήματα των δύο νησιών εμφανίζονται μειωμένες σχετικά τιμές της PGA, οι οποίες ωστόσο συνεχίζουν να είναι σχετικά υψηλές μεταξύ 0.3 g και 0.4 g. Μεγάλες σχετικά τιμές της PGA, μεταξύ 0.2 g και 0.3g, εμφανίζονται επίσης στην κεντρική και βόρεια Ανάφη καθώς και στην δυτική Θηρασιά, ενώ μειούμενες τιμές μέχρι τα 0.1 g εμφανίζονται στην νότια Ανάφη, την Ίο, τα Κουφονήσια, καθώς και στο νοτιότερο τμήμα της Νάξου.

Τονίζεται ότι οι παραπάνω τιμές PGA αναφέρονται σε εδαφικές συνθήκες «βράχου». Σε περιπτώσεις σκληρών ή μαλακών εδαφικών επιφανειακών σχηματισμών αυτές ενδέχεται να επαυξηθούν κατά 20% – 50% ανάλογα με το επίπεδο της PGA στο «βράχο» (Boore et al. 2021). Ωστόσο μια τέτοια εκτίμηση είναι χονδροειδής, χρειάζεται ειδικές μελέτες εδαφικής απόκρισης και ξεφεύγει του στόχου του παρόντος σύντομου άρθρου.

Τα αποτελέσματα των εδαφικών τιμών PGA μπορούν να χρησιμοποιηθούν τόσο για συγκρίσεις με αποτελέσματα από διαφορετικές μεθοδολογίες προσομοίωσης της ισχυρής σεισμικής κίνησης στην περιοχή μελέτης, όσο και σε εκτιμήσεις σεισμικής διακινδύνευσης του δομημένου περιβάλλοντος και του κινδύνου κατολισθήσεων, ιδίως στη Σαντορίνη.

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20 Years Ago a Tsunami Killed 230,000 People. We Can Do Better Now.

Costas Synolakis

Credit...Paolo Pellegrin/Magnum Photos

On Dec. 26, 2004, one of the largest recorded earthquakes struck off the Indonesian island of Sumatra, heaving a piece of seafloor roughly the length of California about 36 feet sideways and 16 feet up. Some 6,000 aftershocks followed.

The tsunami that rose from this great shifting of tectonic plates reached over 115 feet in some places and ultimately killed about 230,000 people in Indonesia, Thailand, Sri Lanka, India, the Maldives and East Africa. If there had been a natural hazards misery index, it would have registered off the scale.

About one in 28,000 people on Earth perished that day because governments were ill equipped to warn residents and visitors about the coming wave and guide them to safe evacuation routes. India failed to warn people on its eastern coast even after the tsunami wreaked havoc in the Andaman Islands, hours before striking the mainland. In Phuket, Thailand, tourists who were mesmerized by the sudden withdrawal of water roamed the exposed seafloor and then were caught unaware by the rushing water. In the Maldives, men asked women and children to stay indoors, where they could not escape the flooding. The men climbed trees and onto roofs when they heard the roar, leading to a lopsided death toll.

Today people around the world are far likelier to receive a timely warning to evacuate a giant, dangerous wave. But as a Dec. 5 earthquake and (tiny) tsunami off Northern California showed, we can't rely on just seismic information to generate warnings. That recent tsunami was only about two inches high by the time it reached the coast, but millions of people received a warning, triggering some to evacuate unnecessarily. A lot of the confusion would have been avoided if there had been more specific information for different locales, and this is entirely possible to provide.

In the 20 years since the Indian Ocean calamity, the Pacific Tsunami Warning Center started providing warning services to Indian Ocean countries. Scientists identified other high-risk zones around the world and modeled potential tsunamis. The National Oceanic and Atmospheric Administration, in conjunction with the United Nations, began training Indian Ocean scientists, emergency managers and sometimes even politicians in how to perform hazard assessment studies, do public outreach and produce inundation maps for evacuation planning and signage. The objective was to eventually provide targeted warnings and then update such warnings as new data comes in.

Before 2004, the Pacific had the only six tsunamographs in the world — buoys anchored to the deep ocean that detect tsunamis and transmit the information to satellites, which in turn transmit to tsunami warning centers. Now there are about 60 in the Pacific and the Caribbean and about 10 in the Indian Ocean. There are none in the Mediterranean.

In Northern California this month, a tsunami warning was issued for a coastal zone stretching about 600 miles along the Pacific Ocean within five minutes of the earthquake. Local authorities also activated the Wireless Emergency Alert system, and an estimated five million people from the San Francisco Bay Area to the central Oregon coast got phone alerts advising them of the tsunami threat. Unlike during the wildfires that burned the town of Paradise, Calif., in 2018 and the town of Lahaina on Maui, Hawaii, in 2023, people received the message whether they had social media accounts or not.

The problem was that the warning did not provide flood depth estimates or information on how quickly the water levels were expected to rise and then fall in different locales along the coast. The warning centers and California did not have the technology to do so and had no choice but to err on the side of caution.

With better technology, we could further shorten the time between the event and when the warning goes out — and make warnings more specific to various sites, instead of blanketing a large area.

More tsunamographs and seafloor seismometers are essential, and machine learning could provide worst-case estimates of inundation, moments after shaking ends, leading to targeted warnings and effective evacuations of at-risk areas. People need to know how much time they have to evacuate, where to go and how to refer to signage to get them there.

Worldwide, tsunami preparedness still varies, too. A real outlier is the Mediterranean, where there is substantial risk of up to two large events per century. In the Aegean Sea, where there are over 200 inhabited islands and tens of millions of tourists every year, only about 10 tidal gauges are transmitting data.

Tens of millions of euros have been spent in the Mediterranean to try to calculate tsunami probabilities, but only a small fraction of that has been spent to improve onshore preparedness. In the United States and its territories, there are 200 tsunami-ready locales, a designation that asks communities to have evacuation maps, signage and sustained public education efforts. But there are only five in the Mediterranean. The only silver lining is that Wireless Emergency Alerts are rapidly becoming common in Southern European countries — sadly, though, not in North Africa.

Site-specific warnings are technologically feasible everywhere. And there is no excuse for not having evacuation maps and signage for tsunamis. National and international organizations such as the National Oceanic and Atmospheric Administration, the Joint Research Center of the European Commission and the World Meteorological Organization need to work together to develop a warning system that has been rigorously tested, to protect residents and visitors.

Until then, if you are near a beach and feel a tremor that lasts over 15 seconds or you observe unusual shoreline motions that resemble a fast-rising or fast-receding tide, you should not wait for an official warning. You should follow tsunami evacuation signs or move immediately to an elevation of at least 50 feet above the waterline and wait there until an all-clear. That way people, no matter where they are, can avoid the fate of the 230,000 in 2004.

Costas Synolakis is a professor of engineering at the University of Southern California.

https://www.nytimes.com/2024/12/26/opinion/california-tsunami-warnings.html)

Ο Κώστας Συνολάκης είναι τακτικό μέλος της Ακαδημίας Αθηνών από το 2016.

Late, great engineers

JOHN FOWLER: MASTERMIND OF THE LONDON UNDERGROUND

One of the great Victorians, Sir John Fowler is best remembered for two feats of engineering separated by a quarter of a century: London's Metropolitan Railway and the Forth Bridge.

Nick Smith

Nobody can look at the Forth Bridge without being aware that it is great not only in size but in conception. It is a mighty work of engineering and it is also a work of art.' So wrote Trystan Edwards of Sir John Fowler's magnum opus in the Structural Engineer in 1925. But, warned the noted architect and town planner, in comparison with the Forth Bridge, 'his other engineering achievements seem necessarily somewhat dwarfed.' And yet these others were immense, including Fowler's landmark work as chief engineer on the first underground railway – London's Metropolitan Railway from Farringdon to Paddington – as well as much of what now makes up London Underground's Circle Line.

(Image: Alamy)

Fowler also consulted on many other railways and bridges both in the UK and overseas, as well as proposing the ill-starred fireless locomotive, built by Robert Stephenson and Company. Such was his influence on the so-called age of 'railway mania'– the second half of the nineteenth century during which £3bn was invested in railway building – that on his death in the twilight of the century, the Institution of Civil Engineers proclaimed in its 1899 obituary that Fowler had been 'one of the most eminent of engineers whose names are associated with the great material progress effected during the Victorian era'. In response to Fowler amassing a colossal personal wealth from his endeavours – for his work on the Metropolitan Railway alone he was paid £152,000 (£17.1 million today) – the industrialist Sir Edward Watkin commented acidly that 'no engineer in the world was so highly paid'.

John Fowler was born in 1817 at Wadsley Hall, Yorkshire, described in The Life of Sir John Fowler, Engineer (1900) by Thomas MacKay as 'the birthplace of one who played an important part in the economic revolution which was then pending'. It was the age of steam power and spinning machines – a mere decade since the appearance of the first public passenger railway – and one that would be dominated by Brunel and Bazalgette, with Fowler's name ranking alongside. MacKay notes that while Fowler's family was connected to the 'vanishing order of things', and while his land-surveying father could resist 'the unsolved problems of the industrial system', his son 'threw himself into the stream of new industry'. Sent to be privately educated at Whitley Hall, by his own admission he was an outstanding pupil: 'I was fairly quick in elementary scholarship, and in mental arithmetic was decidedly beyond the average of boys and men; a gift which was of great convenience and value in after life.'

On finishing school Fowler trained as an engineer under the Sheffield contractor John Towlerton Leather, assisting with the construction of the Redmires and Crooke's Moore reservoirs. He also worked with Leather's uncle on the Aire and Calder Navigation canalisation project, as well as with early steam locomotive builder John Urpeth Rastrick. Following a period of consulting in the Yorkshire area he relocated to London in 1844, joined the Institution of Mechanical Engineers and in 1849 became one of the first members of the Institution of Civil Engineers. In the 1860s he would become the latter's youngest president.

The first of Fowler's great projects originated in 1853 when he was appointed chief engineer of the capital's Metropolitan Railway. It was to present a challenge that drew heavily on Fowler's self-reliance. While supporters of the scheme saw the opportunity to make history with an underground railway, there was public doubt over the feasibility of the project. The directors were constantly being told, writes Fowler's obituarist, that 'they had embarked their money and that of the shareholders in an impossible enterprise'. In a cascading set of objections, 'engineers of eminence assured them they could never make the railway', or if they did 'it wouldn't work', and if it worked 'nobody would travel by it'.

Painting by Percy William Justyn showing construction of the Metropolitan Railway, the world's first underground railway

All of which apparently meant little to Fowler: 'At such times the directors would say to Mr. Fowler, "We depend on you, and as long as you tell us you have confidence we shall go on." It was a heavy load to put on the shoulders of a man who had already sufficient to attend to in combating the physical difficulties of the affair. Yet Mr. Fowler never flinched. He had made up his mind that the railway could be constructed and that it would answer its purpose.' And so the shallow cut-and-cover trenches were created beneath New Road, with tunnels and cuttings beside Farringdon Road. It took a decade to complete, but on 10 January 1863 the line opened with gas-lit wooden carriages pulled by steam locomotives. As John R Day and John Reed's The Story of London's Underground confirms, the world's first passenger-carrying designated underground railway was now functioning, and would continue to serve, after many extensions and upgrades, for seven decades until 1933.

Realising the quantities of smoke and steam emitted by conventional locomotives would cause environmental problems in underground railway scenarios, Fowler set about designing a fireless steam locomotive. The idea was to use exhaust condensing techniques in combination with large quantities of fire bricks that would retain sufficient heat to generate steam when the train was in covered sections. Trials were held on the Great Western Railway in 1861 and in London the following year, during which pressure problems were identified – the first trial almost resulted in the prototype exploding – and the scheme was abandoned. The locomotive was sold, and the whole episode – which was an acute embarrassment to Fowler – was quietly forgotten. By the end of the century 'Fowler's Ghost', as it had been dubbed by The Railway Magazine, had been scrapped.

Fowler was undeniably better at building bridges than he was steam engines, and during his career he designed several. His first railway bridge (also the first of its kind to cross the River Thames) was the Victoria Railway Bridge (now called Grosvenor Bridge), connecting Battersea to Pimlico and built between 1859 and 1860 to carry two tracks into Victoria Station. This was followed by the 13-arch Dollis Brook Via-duct – the highest point on the London Underground above ground level – for the Edgeware, Highgate and London Railway. There were also two Severn railway cast iron arch crossings – the Victoria and Albert Edward bridges – which are both in use today.

During this period of domestic bridge building he also consulted overseas on engineering projects in North America, Europe, Australia and North Africa. In the late 1860s he travelled to Egypt where he worked on a number of projects for the Khedive, including a railway to Khartoum in Sudan that was not completed until after Fowler's death. While working in the region, Fowler undertook a survey of Upper Nile Valley resulting in accurate maps that were to prove invaluable in the 1884-85 Nile Expedition to relieve Major-General Gordon at the Siege of Khartoum. In recognition of his cartographical efforts, in 1885 Fowler was made Commander of the Order of Saint Michael and Saint George.

Arguably the jewel in Fowler's engineering crown was the Forth Bridge, now one of Scotland's most recognizable landmarks. A steel cantilever construction designed by Fowler and Benjamin Baker, construction started in 1882, and it was opened on 4 March 1890 by the future Edward VII. At the time, it had the longest single cantilever span (521m x 2) of any bridge in existence, and has since only been eclipsed by the Pont de Québec (549m) completed in 1917. As Fowler's ICE obituary states: 'It was not only far larger than any railway bridge previously built, but it was of a very novel design. It was commenced with the full consciousness that its execution bristled with unknown difficulties, which would have to be met and conquered as they made themselves evident. Yet Sir John Fowler was satisfied that the project was feasible, and he did not doubt that he and his colleagues would be quite able to accomplish it. In this instance he was fortunate to have clients who had a perfect belief in his powers, and who could command the required capital.'

The Forth Bridge

Accolades followed. Fowler was created Baronet Fowler of Braemor, and along with Baker received an honorary degree from the University of Edinburgh in recognition of his engineering contribution to the Forth Bridge. In 1892, the French Academy of Sciences doubled the purse for their Poncelet Prize before jointly awarding it to Fowler and Baker. And although he continued to consult, the bridge was to be his swansong, after which he spent much of his time deerstalking on his vast Scottish estate.

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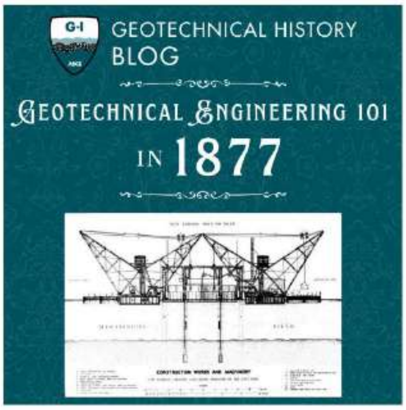
Review of
An elementary course of civil engineering (Wheeler, 1877), Chapters 11 and 12

Michael Bennett, P.E., M.ASCE (Gannett Fleming Tran-Systems, Audubon, PA)



The 1870s were a boom time for infrastructure construction in the United States. As the nation turned 100, technical advances in civil engineering and materials science mixed with a healthy helping of American optimism meant that projects long dismissed as pipe dreams were finally getting underway. In New York, Manhattanites and Brooklynites watched in amazement from their then-separate cities as construction slowly but steadily progressed on the East River (now Brooklyn) Bridge. Residents of St. Louis were similarly awestruck as crews there built the St. Louis (now Eads) Bridge across the mighty Mississippi. Americans from coast to coast could track the construction progress of both behemoths in real time through general and engineering publications made readily available by railroad postal service, and even quicker updates could come over the telegraph wires running alongside tracks. (The wires also started crackling with other signals once Alexander Graham Bell invented the telephone in 1876.)

IMAGE 1: Col. Junius B. Wheeler, USA, in civilian clothes. *Source: Find a Grave (2005).*

Major, later Colonel, Junius Wheeler followed both projects with acute interest, as he taught civil and military engineering at the US Military Academy in the 1870s. He had joined the Army during the Mexican War and had won several decorations before attending West Point and graduating in 1855. When the Civil War erupted, Wheeler, a North Carolinian, had stayed loyal to the Union and had once more served with distinction. After the war, he became a professor at his alma mater and authored several textbooks, including 1877's *An elementary course of civil engineering*. Wheeler wrote the 24-chapter work for West Point cadets, but civil engineering professors at civilian universities soon began using it as well. Wheeler devoted Chapter 11 of his text to foundations built on land and Chapter 12 to those constructed in or under water, and he prominently discussed the Brooklyn and Eads Bridges (Parramore 1996, Wheeler 1877).

The seeds of future geotechnical innovations are sown throughout Wheeler's chapters on foundations. He instructed his cadets to investigate sites during design using test pits, along with auger borings for more critical structures, and recommended performing static load tests on bedrock if it were encountered. For construction, Wheeler suggested dealing with saturated soils using underdrains – anticipating the principle of effective stress by nearly half a century – and noted that engineers could stabilize foundation excavations in soft soils by compacting sand into them. Wheeler, in a line that would fit neatly into any modern geotechnical report, advised that the sand be "spread in layers of about nine inches in thickness [with] each layer well rammed before the next is spread." He also observed that engineers could handle soft soils during construction using mat foundations, long piles driven to firm strata, or short piles driven for densifying the soft layer (Wheeler 1877).

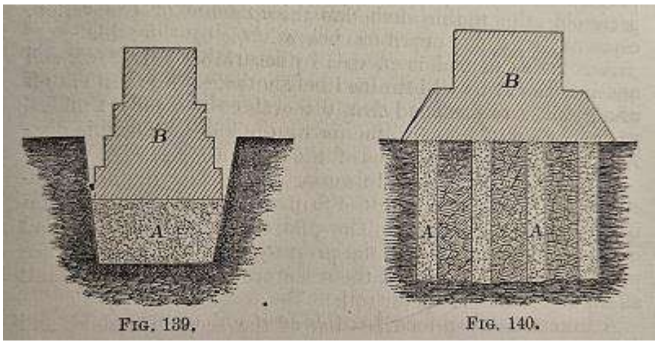


IMAGE 2: Ground improvement schematics shown in Wheeler's book for replacing unsuitable native soils with sand (A) to support foundations (B). *Source: Wheeler (1877).*

Still, plenty has changed in civil engineering since Rutherford Hayes was president, and Wheeler's book reflected some then-common fallacies in the field. For instance, he proposed a three-group soil classification system:

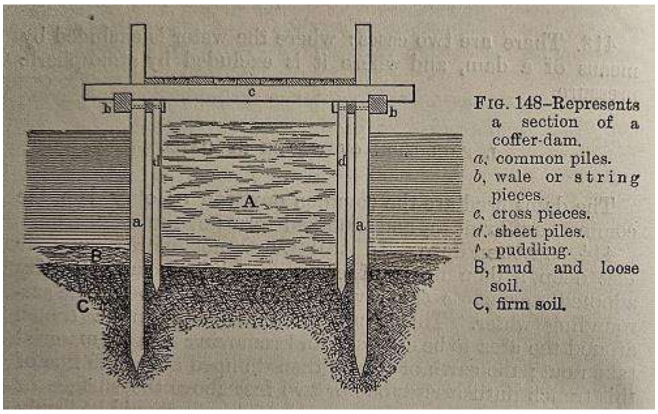
1. First-class soils that were firm and uninfluenced by groundwater, such as rock and gravels;

2. Second-class soils that were firm but affected by groundwater, such as sands and clays;

3. Third-class soils that were soft, such as peats.

While the system never caught on, its flaws – most notably lumping sands and clays into the same grouping – are apparent. Similarly, Wheeler's suggestion that wooden piles could be made from any timber available near a site failed to account for some woods being stronger or less rot-prone than others. Nor was he correct that it was "not probable" that the cast- and wrought-iron piles coming into vogue by 1877 would "ever supersede those made of wood." Yet even many of Wheeler's errors represented steps in the right direction. His soil classification system, imperfect though it was, represented an earnest attempt at solving a tough problem. Similarly, Wheeler recommended an early dynamic formula for estimating pile capacity but added the caveat – ignored by most Gilded Age civil engineers – that "the manner of driving piles, and the extent to which they may be forced into the subsoil, will depend on local circumstances." The wave equation analysis of piles (WEAP) would only appear in 1960, but Wheeler clearly recognized the inaccuracies of the "one size fits all" approach inherent in dynamic formulas (Wheeler 1877). (See Hool and Kinne (1923), Sec. 3, Pt. B.)

Wheeler's technical acumen shone through most clearly in his detailed sections on cofferdams and pneumatic caissons. By the late 1870s, cofferdams were increasingly being built of sheet piles, as their modern counterparts almost always are. However, most were still constructed of two rows of timber piles connected using cross-bracing and sheet piles. The interior spaces formed by these piles, cross-braces, and sheet piles resembled coffers, the small boxes then often used to store valuables (hence the phrase "filling one's coffers"). The structure was thus called a "coffer-dam," as Wheeler spelled it, and the hyphen was eventually dropped. Per Wheeler, the coffers were typically filled with a material known as "puddling," a mixture of clay with sand or gravel (Wheeler 1877).



MAGE 3: Cross-section of a typical timber cofferdam of the mid-Victorian Era. *Source: Wheeler (1877).*

Wheeler went into more detail on pneumatic caissons than on any other foundation engineering topic. The term *caisson* comes from the French word for "box" or "chest," as Wheeler likely knew; the US Army already used the term for its artillery ammunition lockers (as in "those caissons go rolling along"). The construction of a pneumatic caisson in a waterway begins with floating a large timber or iron structure out to the desired construction site of, for instance, a bridge pier. The structure is partitioned vertically in two; its lower half is the working chamber, while its upper half is the caisson proper. When the pneumatic caisson is in position, the working chamber is carefully filled with water and masonry is placed atop the caisson. The structure thus gradually sinks to the bottom of the waterway; guide piles or cofferdams may be installed to keep it sinking in the correct location (LOC 2025 A, Wheeler 1877).

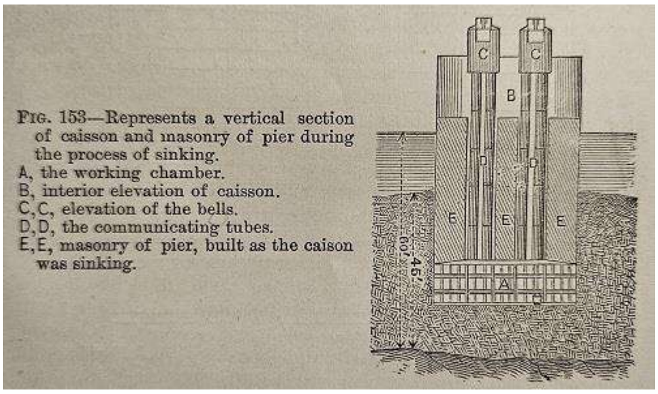


IMAGE 4: Cross-section of a typical pneumatic caisson of the mid-Victorian Era. *Source: Wheeler (1877).*

Once the pneumatic caisson rests securely upon the bottom of the waterway, water is pumped from the working chamber and replaced with compressed air. Workers then enter the chamber through pressure-regulating airlocks and access shafts in the caisson, remove the chamber floor, and excavate material from beneath the structure. The material may be removed via extraction shafts in the caisson or may be stockpiled in the working chamber. Additional tubes run through the caisson to supply compressed air and communications channels to the chamber. The compressed air both maintains a healthy atmosphere in the chamber and regulates the rate at which the caisson descends, and its exhaust vents can also be used to suction excavated material out of the chamber. Finally, the pneumatic caisson reaches its completed depth when the chamber is excavated to a suitable stratum. The compressed air is then pumped out and the chamber is backfilled with concrete, stockpiled material, or a combination thereof (Jackson 2001, McCullough 1972, Wheeler 1877).

Wheeler's book is 472 pages long, which left him little space to cover the entirety of civil engineering, let alone the Brooklyn and Eads Bridges. Thus, his spending several pages on each project, albeit at a general level, indicates that he took a keen interest in them. One particularly intriguing note Wheeler shared on the Eads Bridge was that "the health of the workmen was greatly affected by the high degree of compression of the air in which they had to work … and several lost their lives in consequence." He quickly continued from this jarring observation to his next point, but it naturally rouses a reader's curiosity about the rest of the story regarding the geotechnical construction of the bridges' pneumatic caissons. Fortunately, other sources flesh out Wheeler's cursory accounts of how they were built (Wheeler 1877).

By the mid-1800s, St. Louis was a frontier town no longer. As the US had steadily pushed westward, the Mound City had become a midwestern hub of people, commerce, and industry. However, St. Louis – unlike its emerging rival, Chicago – still lacked a grand entrance. The mighty Mississippi River brought travel and trade to the young metropolis but also forced those from east of the city to enter on slow ferries that were often bedeviled by low water and the river freezing. The ferries and commercial ships caught fire and sank so often that they presented an economic opportunity, and native St. Louisan James Eads took advantage. Starting as a teen, he taught himself engineering, and he eventually launched a successful business salvaging sunken goods and ships from the Mississippi. During the Civil War, Eads built vaunted gunboats for the Union Navy. His salvage activities and wartime work made him many powerful friends in local and national business and politics. Thus, people listened when he began making the case in the mid-1860s that St. Louis needed a railroad bridge across the Mississippi to maintain its comercial prominence in the midwest US (Jackson 2001, PBS 2000).

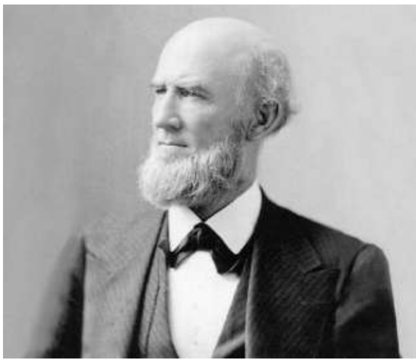


IMAGE 5: James B. Eads, pioneering US civil engineer. *Source: PBS (2000).*

Not everyone considered Eads's idea sound, including one detractor who lambasted it as "entirely unsafe and impracticable." Despite the naysayers, though, Eads's robust self-confidence – or, as his critics saw it, unbearable arrogance – carried him forward, and he drafted a three-span design involving two piers smack in the middle of the Mississippi channel. Eads initially planned to use cofferdams for the piers' foundations, a risky proposition at best in the turbulent, sediment-laden Mississippi. However, he changed his mind during a trip to Europe after witnessing the installation of pneumatic caissons in France. Captivated, Eads subsequently spoke with several British civil engineers well-versed in the technology and learned it had been in use for nearly 20 years. He decided it was time to bring pneumatic caissons across the Atlantic and, upon returning to the US, drafted plans for them for his bridge (Jackson 2001, PBS 2000).

Eads's design called for pneumatic caissons on a scale far beyond anything tried in Europe. The working chamber for the eastern pier would measure 82 feet by 60 feet; that of the western pier, 82 feet by 48 feet. The chambers themselves would measure 9 feet high and would be made of thick oak beams covered with plate iron. The caissons would be similarly massive; the eastern one would measure 50 feet by 35 feet and would be built of cast iron 3/8 of an inch thick. The structures would be kept in place during sinking using timber guide piles and would each be held level by 10 suspension screws along their sides measuring 20 feet long. Eads's crews began sinking the eastern pier caisson in October 1869 and its western counterpart in January 1870. As the caissons sank through the Mississippi's 35-foot channel, masons placed and cemented layers of stone atop them, gradually building the piers and sinking the structures. Ironworkers toiling alongside the masons bolted sheet iron plates onto the caissons' sides to keep the masons' work as waterproofed as possible (Jackson 2001, Wheeler 1877).

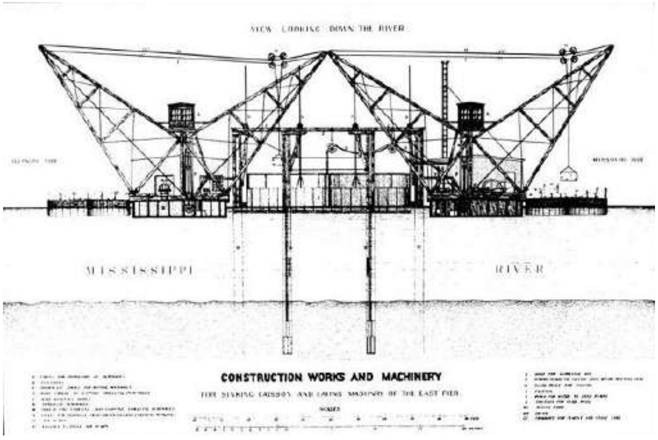


IMAGE 6: Diagram of caisson sinking for the eastern pier of the St. Louis/Eads Bridge, profile view. *Source: Woodward (1881).*

Eads's crews took just three weeks to sink each pneumatic caisson to the bed of the Mississippi. The working chambers were then pumped out and the excavators began their digging. Most material was removed from the chambers using suction pumps Eads himself had devised. Larger debris was brought up through the airlocks, while the crews stockpiled stones and bricks in the chambers for their eventual refilling. The chambers' tight confines meant that excavation was performed largely by hand, and conditions were not for the faint of heart. The chambers were perpetually warm and humid, and condensation dripped constantly from their roofs. Many workers doffed their shirts in vain attempts to beat the heat, and the resulting scent was nearly unbearable, especially when mingled with the odors of burning lamps and river-bottom detritus. The flickering, smoky lights that illuminated the chambers cast long shadows all around and gave everyone, as one observer put it, the "feeling of having descended into the underworld." The chambers' interiors gradually became covered with a grimy ooze of water and mud. Many of the St. Louis workers would likely have agreed with a mechanic in the Brooklyn Bridge's working chambers that "one might, if of a poetic temperament, get a realizing sense of Dante's inferno" from the scene (Jackson 2001, McCullough 1972).

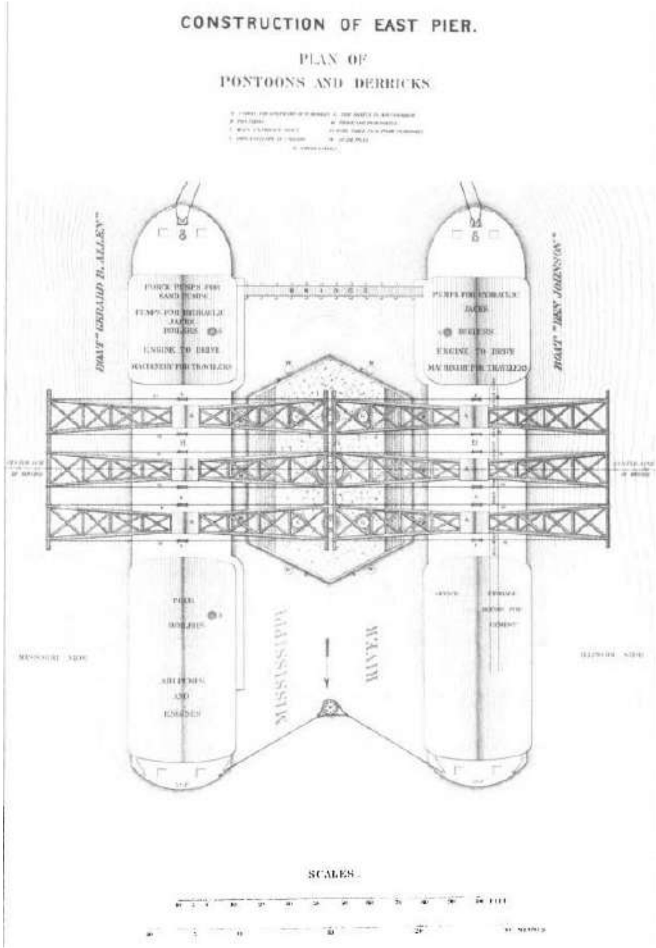


IMAGE 7: Diagram of caisson sinking for the eastern pier of the St. Louis/Eads Bridge, overhead view. *Source: Woodward (1881).*

Far more serious problems soon appeared in the Eads Bridge working chambers. They started innocuously, as Eads's men noticed that their voices were shrill there. The compressed air was constricting their vocal cords, which was harmless by itself but foreshadowed worse. Roughly 40 feet below the river bottom, laborers in the eastern chamber began experiencing stomach cramps and temporary paralysis in their legs. Affected workers walked in a crouch as they grappled with their discomfort, which their peers jocularly tagged the "Grecian bend" after a popular fashion trend. Soon, though, the symptoms worsened and the laughter stopped. As the eastern chamber reached 60 feet below the Mississippi River's bed, workers were hit with bouts of joint, back, and head pain and paralysis of the arms. By the time the 65-foot mark was reached, cases of the mysterious affliction were starting to require hospitalization. Laborers, engineers, doctors, and even James Eads were puzzled, if not terrified, by the condition and had no idea how to handle it (Jackson 2001, McCullough 1972).

A century and a half on, the nature of the excavators' illness, now known as decompression sickness, is as straightforward as it is sorrowful. The condition is explained by Henry's Law, the principle of chemistry dictating that the amount of gas dissolved in a solution is directly proportional to its partial pressure over the solution. As the working chambers had descended, the pressure of the compressed air within them had steadily risen, increasing the quantities of gases – particularly nitrogen – dissolved in the workers' blood-streams. Then, when the laborers left the chambers after each day's work, the rapid decrease in atmospheric pressure they experienced led the dissolved nitrogen in their blood-streams to bubble rapidly out of solution. It was agonizing when it happened in the muscles and joints and frequently deadly when it occurred in the brain. The condition – soon renamed "caisson disease" or, as it remains known, "the bends" – killed six excavators in two weeks in March 1870, and it took 12 lives overall by the time both pneumatic caissons were finished (Jackson 2001, McCullough 1972).

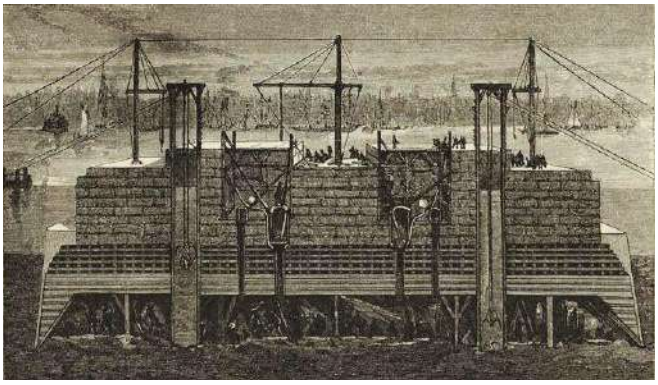


IMAGE 8: Laborers excavate the working chambers of the East River/Brooklyn Bridge in a scene much like those at the St. Louis/Eads Bridge. *Source: Maher (2016).*

Victorian employers often viewed worker safety callously, but James Eads's unorthodox opinions benefitted his laborers in this regard. His first contribution to their safety came even before excavation in the working chambers began. Prior to Eads's bridge, most pneumatic caissons had their airlocks at the tops of their access shafts. Eads recognized that this setup posed several dangers. For one thing, it meant the airlocks had to repeatedly be removed and reinstalled as the chambers descended and the access shafts were lengthened. Widespread decompression sickness among workers, far exceeding that which happened, was likely if a rapid evacuation were needed while the airlock was not in place. Another likely hazard was that all the compressed air could escape from the chamber if it abruptly dropped and the airlock was out of position. Accordingly, Eads designed an access shaft with an airlock at its bottom, immediately adjacent to the chamber. The threat of decompression sickness remained, and air pressure within the shafts themselves was now uncontrolled, but Eads's innovation still represented a big step forward for safety in pneumatic caisson construction. In August 1871, he successfully patented his design (Eads 1871, Jackson 2001).

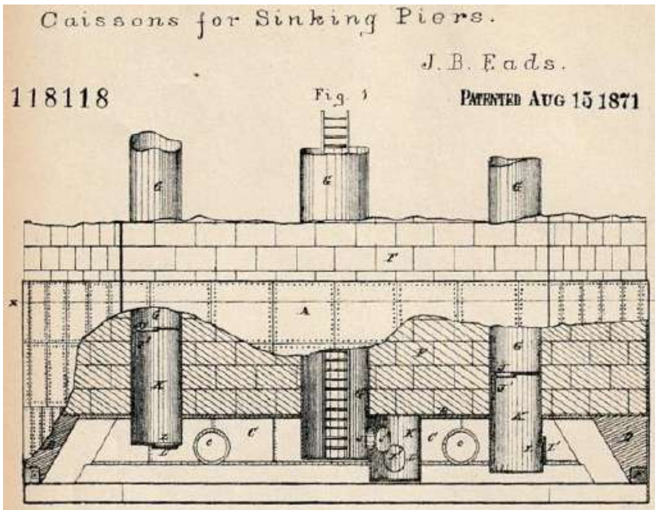


IMAGE 9: James Eads's 1871 patent for an improved airlock for pneumatic caissons. *Source: Eads (1871).*

Eads intervened to keep his laborers in the working chambers safe again when cases of decompression sickness began disabling or killing them. He brought his family physician, Dr. Alphonse Jaminet, to the site and even took him into one of the chambers. Jaminet emerged with a severe case of decompression sickness himself but fully recovered in several days, and his experience gave him unique insight into the condition. He autopsied several victims and noted that a number of them had not eaten prior to their final shifts, while others had been heavy drinkers. Eads and Jaminet eventually set rules that the laborers could work no longer than an hour at a time in the chambers and that they had to take 15 to 20 minutes to climb the access shaft stairs on their way out. The precautions were in hindsight insufficient, and workers eager to hurry home or to the nearest pub often ignored them, but they were medically sound. The impact of Jaminet's instructions is difficult to assess, but in all likelihood, they prevented the impacts of decompression sickness at the Eads Bridge from being even worse (Jackson 2001).

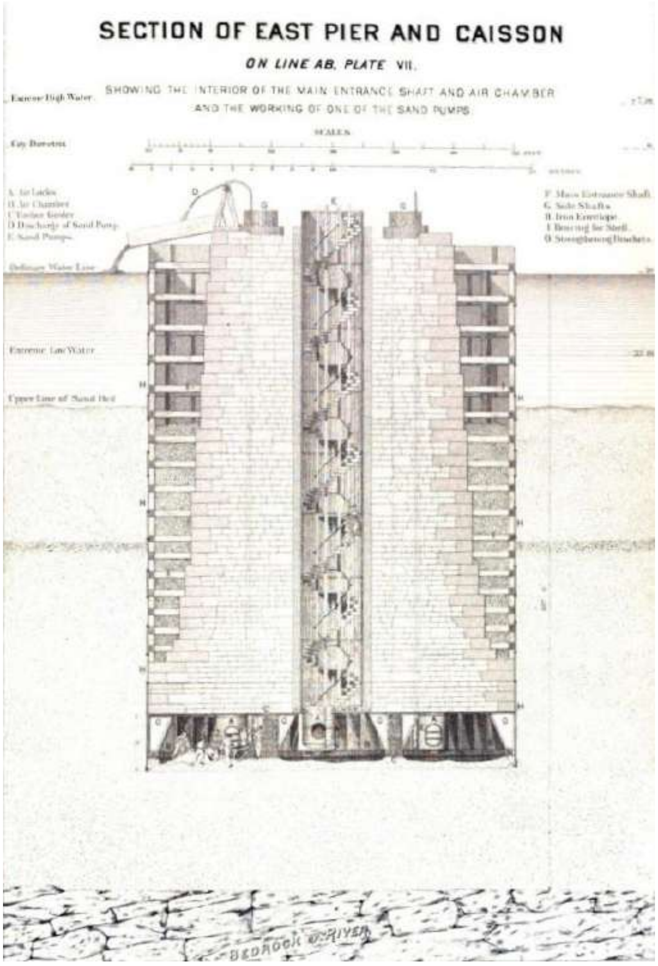


IMAGE 10: Diagram of the east pier and caisson of the St. Louis/Eads Bridge as it neared completion in early 1870. *Source: Woodward (1881).*

One factor that definitely curtailed the health impacts of decompression sickness on James Eads's bridge was when in the project lifecycle it became problematic. Most of the worst cases of "the bends" struck those in the bridge's working chambers only after the chambers had already been excavated to bedrock and were being backfilled with concrete and masonry. The eastern pier's pneumatic caisson reached bedrock 68 feet below the Mississippi River's bed (103 feet below its surface) in February 1870, and the western pier's caisson followed suit in May 1870 at 51 feet below the river bottom (86 feet below the water line). Reaching bedrock vindicated Eads's belief in his caissons and brought him a moment of geotechnical triumph as well. His salvaging days had shown him the Mississippi's power to scour, and he decided that nothing short of bedrock would make a satisfactory bearing layer for his caissons. Eads was vindicated when the bedrock encountered in the chambers showed clear signs of scour.

Four more years of arduous construction challenges followed the laborers successfully backfilling both chambers, but the piers represented a huge milestone en route to Eads triumphantly opening his bridge on Independence Day 1874, and he had proven the worth of pneumatic caissons to American civil engineers in the process (Jackson 2001, Wheeler 1877).

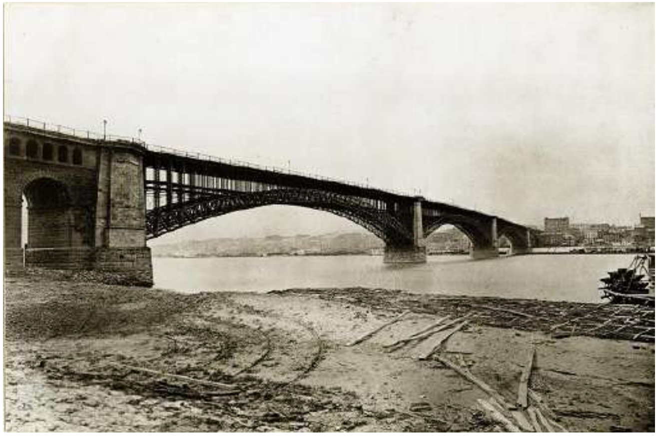


IMAGE 11: The St. Louis/Eads Bridge in the late 1800s. Source: Jackson (2001).

IMAGE 12: The St. Louis/Eads Bridge as it appears today. *Source: SLPR (2016).*

John Roebling, the chief designer of the Brooklyn Bridge, had needed no persuasion from Eads about the merits of pneumatic caissons. Unlike the self-taught Eads, Roebling had studied engineering at a university in his native Prussia before immigrating to the US and working on a variety of projects, including the Allegheny Portage Railroad (see Johnstown Flood, Part 1). In fact, Roebling had decided to use pneumatic caissons in his bridge well before Eads first considered the idea. Alas, in 1869, just after Roebling had completed his designs, he died of tetanus. Into his role on the project stepped his son, 32-year-old Washington Roebling. He also had a university education in engineering, in his case from RPI. Moreover, he – like Junius Wheeler – had distinguished himself in the Civil War, rising from private to lieutenant colonel as he saw combat with Union forces in six major battles and campaigns. It was Roebling who had turned the tide at Gettysburg by noticing Confederate forces surging toward Little Round Top and persuading his commanding officer to rush Union troops to its summit. Finally, he had the singular advantage of being John Roebling's son and having worked alongside him on several projects. The younger Roebling thus had unsurpassed insight into exactly how his father had envisioned construction proceeding on the Brooklyn Bridge (McCullough 1972, NPS 2024).

Early in 1870, as the pneumatic caissons of the Eads Bridge were completed, assembly began for the Brooklyn caisson of

IMAGE 13: Lt. Col. Washington Roebling as he looked during construction of the East River/Brooklyn Bridge. *Source: McCullough (1972).*

Roebling's bridge. That April, Washington Roebling spent two days in St. Louis visiting Eads's bridge site. Eads meticulously reviewed his project plans with Roebling and even took him down into the working chambers. Roebling appears to have taken careful notice of everything he saw, particularly the airlocks. He had already located those for the Brooklyn caisson atop the working chamber, but when the Manhattan caisson was built a year later, he shifted them to the chamber's interior in line with Eads's design. (Eads noticed this modifycation and sued Roebling – although his patent was still pending – and eventually got Roebling to settle the case.) If Roebling's airlock designs weren't original, though, his caisson designs sure were. The working chamber of the Brooklyn caisson would measure 168 feet by 102 feet, and that of its Manhattan counterpart would be 172 feet by 102 feet. The two chambers, triple the size of Eads's, could each cover half a city block. Work in Roebling's chambers would be illuminated not by flickering, foul-smelling oil lamps and candles but by far brighter and cleaner calcium carbide lamps, also known – in an expression that has outlived them – as "limelights" (McCullough 1972, Wheeler 1877).

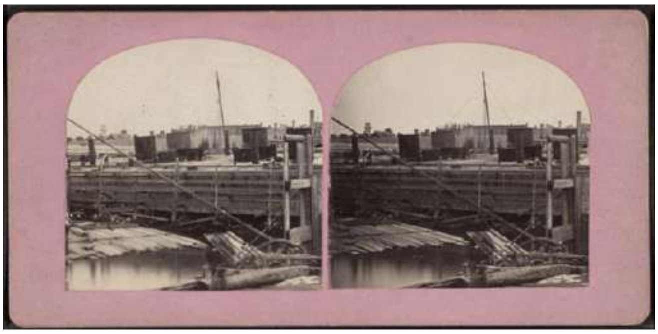


IMAGE 14: Stereograph of the Manhattan caisson of the East River/Brooklyn Bridge during its construction. *Source: NYPL (2015).*

Washington Roebling's crews sank the Brooklyn caisson of the Brooklyn Bridge in May 1870, shortly after their chief engineer returned from St. Louis. Even as the pneumatic caisson slipped beneath the East River, it was already an engineering marvel. It was made of interlocking layers of heavy timber and cast iron that tapered in thickness from 9 feet at the structure's roofline (the roof itself was 15 feet thick) to 8 inches at its base. This created a wedge to help the caisson advance as its workers excavated underlying material within the 9 foot, 6-inch-high working chamber, which was fortified with sturdy timber partitions. Roebling was acutely aware of the damage shipworms could cause his caisson, so he had its lumber caulked with oakum and soaked with hot tar, pine sap, and varnish. His caisson also had another key advantage over its St. Louis rivals. While Eads had placed his bridge's caissons in the center of the Mississippi River channel, Roebling placed those of the Brooklyn Bridge much closer to the East River's banks. Thus, the notorious East River tides only restricted the excavation schedule to low tide for about a month, after which work rapidly picked up steam (McCullough 1972, Wheeler 1877).

Washington Roebling was likely chagrined that the accelerating work on the Brooklyn caisson did not necessarily accelerate its descent. The excavators soon found that the underlying soil was strewn with boulders left over from Ice Age glaciation. These were particularly tough to extract from beneath the working chamber's edges and partition beams. The need to remove the boulders while keeping the pneumatic caisson descending uniformly slowed work to a literal crawl. During one stretch, the Brooklyn caisson was descending less than 6 inches per week. Eventually, though, Roebling and the crews figured out that when a boulder was encountered, they could use oak blocks to jack an edge or partition against *terra firma* beneath it. The laborers could then excavate the boulders either manually or with carefully controlled blasting. This innovation allowed work on the caisson to proceed apace, which proved critical when a fire damaged the working chamber's roof and forced months of painstaking repairs. The chamber reached bedrock 45 feet below high tide in early 1871 and was successfully backfilled and completed by that March. Assistant engineer Francis Collingwood, for whom ASCE later named its Collingwood Prize, estimated that the skin friction on the Brooklyn caisson came out to about 900 pounds per square foot (Collingwood 1874, McCullough 1972).

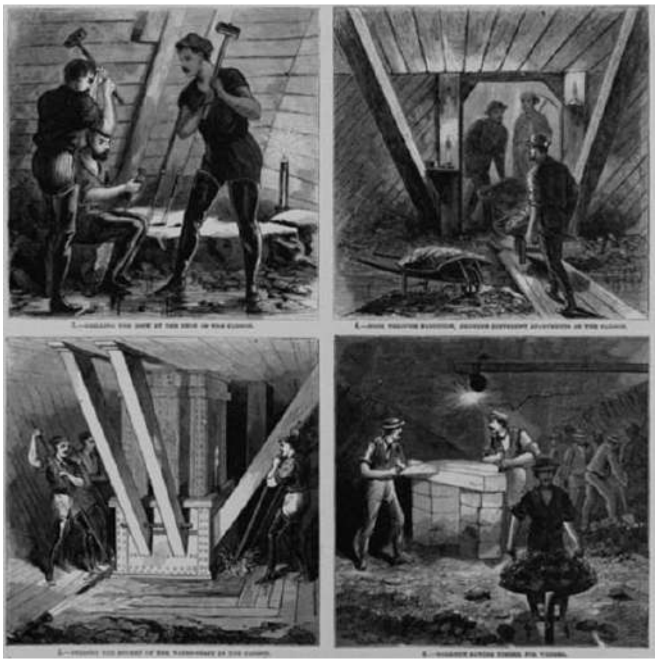
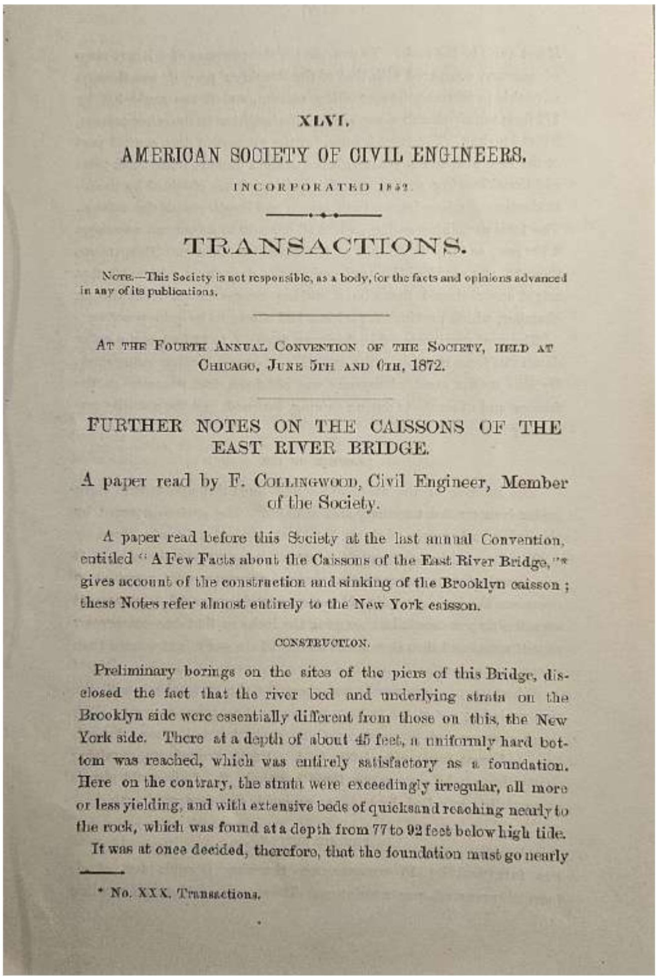


IMAGE 15: Scenes from the Brooklyn caisson of the East River/Brooklyn Bridge, October 1870. Workers are shown drilling rock for blasting (UL), hauling material through doors in the partitions (UR), removing material through the extraction shafts (LL), and cutting blocks for jacking and boulder removal (LR). *Source: LOC (2025 B).*

Washington Roebling's laborers began sinking the Manhattan caisson of the Brooklyn Bridge in September 1871. This pneumatic caisson was an engineering improvement over its Brooklyn predecessor in several ways. The Manhattan caisson featured a more robust anti-shipworm protective coating; its wooden exterior was slathered with a mixture of coal tar, rosin, and cement, which in turn was covered with soldered tin, which was itself covered in creosote-drenched pine. Its timber roof was an astonishing 22 feet thick, nearly 50% thicker than that of the already hefty Brooklyn caisson. The Manhattan caisson also featured a fireproof interior sheath of plate iron, more air compressors and extraction shafts, improved communications tubes, and (to James Eads's chagrin) airlocks immediately adjacent to the working chamber. Work on the Manhattan caisson initially went far more smoothly than that of the Brooklyn caisson, and the only obstacle at first was digging through several feet of putrid garbage from a former municipal dump. The sinking initially progressed downward at 6 to 11 inches daily, which Roebling likely found reassuring. He knew from preliminary soil borings that bedrock on the Manhattan side was roughly 40 feet deeper than on the Brooklyn side, which had driven his decision to give the Manhattan caisson a thicker roof (Collingwood 1874, McCullough 1972).

Ironically, the ease of sinking the Manhattan caisson led directly to the attacks of decompression sickness for which the Brooklyn Bridge's construction has long been infamous. As the pneumatic caisson steadily sank, its 13 air compressors (compared to 6 for the Brooklyn caisson) pumped 3 cubic feet of pressurized air per stroke into the working chamber. This air and the pressure difference to which it exposed Roebling's excavators upon exiting the chamber soon caused them the same maladies that had befallen Eads's men. The Brooklyn Bridge laborers' initial amusement at having high-pitched voices in the chamber and being unable to blow out candles there (due to the air's elevated oxygen content) quickly faded when several of them began suffering from joint pain, paralyzed limbs, and digestive tract woes. The breakdown in Roebling's professional relationship with Eads probably stymied the sharing of information about the ailments that had now tormented both sets of caisson laborers, which in turn likely impeded medical treatment of the ill-nesses among the New York workers. However, this stove-piped approach to problem-solving reflected the perspective among US civil engineers in the Gilded Age that, as one historian noted, "minding one's own business was considered among the basic rules of business." The geotechnical papers then appearing in the *Transactions of ASCE* reflected this philosophy, as most were case studies rather than examinations of particular technical principles (Collingwood 1874, McCullough 1972).

At any rate, Washington Roebling soon concluded, as James Eads had, that medical intervention was needed to address decompression sickness among his workers. Unlike Eads, he appreciated this firsthand, having had a nasty case himself after battling the Brooklyn caisson fire in late 1870. (Its lingering effects ultimately confined him to home for most of the bridge project, but he gradually recovered his health.) In January 1872, as the Manhattan caisson continued descending toward bedrock and the excavators' health woes multiplied, Roebling brought ear and eye specialist Dr. Andrew Smith onto the project as a medical officer. Smith promptly gave each caisson worker a physical exam and allowed only those he deemed fit back into the working chamber. When laborers came down with decompression sickness, he had them hospitalized and had their doctors send careful records of their cases. Smith could not figure out the precise cause of the malady but knew it was more easily prevented than cured and used his meticulous observations to compile health rules for the excavators. These included not to enter the caisson without eating, to exercise for an hour after exiting it, or to drink alcohol. Smith also observed, as did Francis Collingwood, that "most of the sick … were fleshy men, of full or large size." Modern medicine supports Smith's conclusions that adipose tissue (which readily stores nitrogen), alcohol consumption, and overexertion too soon after depressurizing all exacerbate decompression sickness (Collingwood 1874, Jackson 2001, McCullough 1972).



XLVI.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INCORPORATED 1852.

TRANSACTIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

AT THE FOURTH ANNUAL CONVENTION OF THE SOCIETY, HELD AT CHICAGO, JUNE 5TH AND 6TH, 1872.

FURTHER NOTES ON THE CAISSONS OF THE EAST RIVER BRIDGE.

A paper read by F. COLLINGWOOD, Civil Engineer, Member of the Society.

A paper read before this Society at the last annual Convention, entitled "A Few Facts about the Caissons of the East River Bridge,"* gives account of the construction and sinking of the Brooklyn caisson; these Notes refer almost entirely to the New York caisson.

CONSTRUCTION.

Preliminary borings on the sites of the piers of this Bridge, disclosed the fact that the river bed and underlying strata on the Brooklyn side were essentially different from those on this, the New York side. There at a depth of about 45 feet, a uniformly hard bottom was reached, which was entirely satisfactory as a foundation. Here on the contrary, the strata were exceedingly irregular, all more or less yielding, and with extensive beds of quicksand reaching nearly to the rock, which was found at a depth from 77 to 92 feet below high tide.

It was at once decided, therefore, that the foundation must go nearly

* No. XXX, Transactions.

IMAGE 16: 1874 paper in the Transactions of ASCE by Francis Collingwood, assistant engineer of the East River/Brooklyn Bridge, on the construction of the Manhattan caisson. *Source: Author.*

The continued descent of the Manhattan caisson was, of course, what was most exacerbating the ailments of the crew. Three men died of decompression sickness in early 1872, and many others had milder cases that left them badly shaken long after they had recovered. A turning point came at a depth of 67 feet below high tide, when Collingwood had the crews take several test borings within the working chamber. These revealed that bedrock lay at least 10 to 13 feet below the chamber beneath a glacial till layer of cemented sand interspersed with boulders. Collingwood had observed anthropogenic debris in the excavated material, including brick and pottery fragments and even a sheep bone, as far down as 65 feet. The borings thus convinced him and Roebling that they had finally reached material undisturbed by either tidal or human activity. Furthermore, Roebling estimated that excavating through this material to bedrock would take another year and cost $500,000 ($12.9 million in 2025) and 100 workers' lives. He concluded that the very dense glacial till would be more than strong enough to bear the immense weight of the bridge tower and decided excavation could be halted. In mid-May 1872, the crews stopped work at 78 feet, 6 inches below high tide in the East River. The working chamber was filled by July, and Roebling's geotechnical gamble was vindicated as the Manhattan tower was built and remained stable without noticeable settlement. Dr. Smith then returned to private practice, but shortly thereafter drew upon his Brooklyn Bridge experiences to propose a decompression chamber for making pneumatic caisson work safer. His chamber bears a striking resemblance to those used by scuba divers 150 years later (Collingwood 1874, McCullough 1972, Webster 2025).

IMAGE 17: View from Brooklyn of the towers of the East River/Brooklyn Bridge nearing completion, mid-1870s. *Source: AP (2023).*

IMAGE 18: The Brooklyn Bridge as it appears today by night. *Source: Abbiati (2023).*

Junius Wheeler's excellent summation of the construction of the Eads and Brooklyn Bridge caissons in *An elementary course of civil engineering* opens the door to two fascinating stories of Victorian geotechnical history, or geo-history. That said, any solid study of geo-history must consider how its human dimension complements the profession's technical evolution. A few notes scribbled into one copy of Wheeler's textbook by its original owner ably underscore this. The book's front endpaper is inscribed, in crisp Palmer penmanship, "Lewis J.H. Grossart, Allentown, PA, Sep. 9, 1884, L.U. '86." Grossart, an 1886 Lehigh University graduate, was in 1885 among the seven students inducted in the inaugural class of the engineering honor society Tau Beta Pi. His abundant annotations in his copy of Wheeler's textbook suggest that he studied it diligently. Grossart's subsequent 60-year career mainly involved municipal engineering in Pennsylvania's Lehigh Valley for the towns and cities of Bethlehem, Allentown, and Hellertown. Notably, his role as a municipal engineer looked quite different from its modern equivalent. A

1914 news account on Grossart noted that his "wide experience" included plenty "in the construction of foundations for bridges, buildings, and machinery," for which Chapters 11 and 12 of Wheeler's book presumably prepared him well (Hur 1886, Whelan 1990).

IMAGE 19: Lewis J.H. Grossart as a Lehigh University student. *Source: LU (2025).*

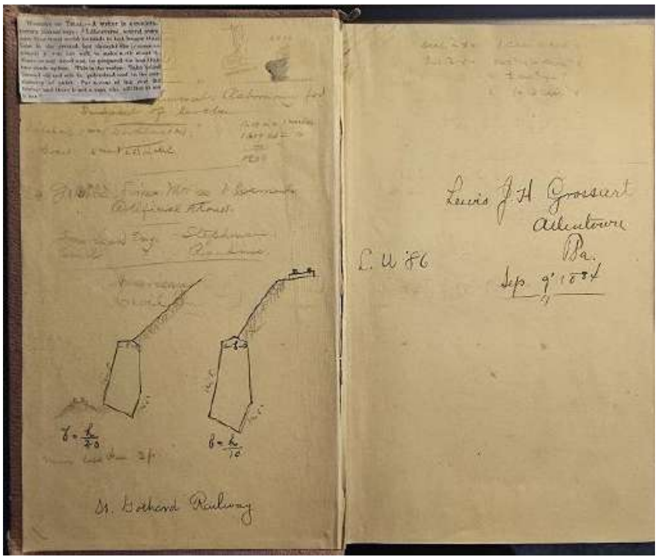


IMAGE 20: The inside front cover of Grossart's copy of Wheeler's textbook. *Source: Author.*

Equally fascinating is a short article on timber pile preservation that young Grossart taped into the front cover of his copy of Wheeler's book. Its provenance is unknown, but internet archives indicate that the blurb appeared in multiple publications in the 1880s. Ads for Ulster hats and cashmere clothes are visible on the back of the article, suggesting it came from a newspaper rather than one of the staid engineering periodicals of the day. The press clipping reviewed how timber piles could be preserved using a coating of boiled linseed oil mixed with pulverized coal. The efficacy of this treatment compared to current preservatives for timber piles, such as creosote or chromated copper arsenate, remains open to speculation, as do the relative impacts on groundwater of timber piles treated with the older and newer methods. Such questions, coming 150 years after Wheeler published *An elementary course of civil engineering* and 75 years after Lewis Grossart drew up his final blueprint, provide an excellent reminder of the value of studying geo-history.

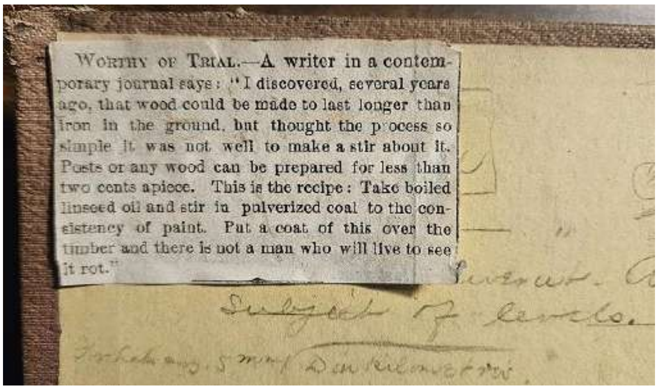

WORTHY OF TRIAL.—A writer in a contemporary journal says: "I discovered, several years ago, that wood could be made to last longer than iron in the ground, but thought the process so simple it was not well to make a stir about it. Posts or any wood can be prepared for less than two cents apiece. This is the recipe: Take boiled linseed oil and stir in pulverized coal to the consistency of paint. Put a coat of this over the timber and there is not a man who will live to see it rot."

IMAGE 21: An 1880s press clipping on timber pile preservation in Lewis Grossart's copy of Wheeler (1877), flanked by Grossart's annotations. *Source: Author.*

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Sebastian Lobo-Guerrero, Ph.D., P.E., BC.GE, F.ASCE (A.G.E.S., Inc.: Canonsburg, PA), the author's former colleague, reviewed the entry's technical content. Thomas Kennedy (Geopier: Davidson, NC), the author's Virginia Tech classmate, co-authored a 2021 version of the entry posted on an independent webpage. James Martinson, E.I.T. (Atkinson Construction: Lynchburg, VA), and Andria Zaia (National Museum of Industrial History: Bethlehem, PA) provided valuable leads on sources for the article. Angela Saade, P.E., M.ASCE (Gannett Fleming TranSystems, Audubon, PA), an experienced scuba diver and the author's colleague and Virginia Tech classmate, answered questions about decompression sickness.

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Contributing to landslide risk mitigation over longer terms in Cameroon through a multiscale and multifactorial approach

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1. Motivation

Landslide consequences at a small scale may often be regarded as insignificant since the area affected is left to the detriment of other terrains. However, the repetitive nature of landslide events leads over time to the reduction of areas exploitable by the population. They occupy other hilly lands, formerly forested or not, but stable. Abusive exploitation combined with natural factors exposes these surfaces to new and more destructive landslides added to the reactivation of old ones. The multiscale approach will consist of producing preliminary landslide inventory and susceptibility maps of the entire Cameroon region. Then more detailed investigation will be carried out in the regions marked by a higher probability of landslides occurrence.

The multifactorial approach will integrate climatic data, soil geomechanical parameters and geoenvironmental factors to generate detailed landslide susceptibility maps as initiated in a test area at the western flank of Mount Oku, located at the western flank of the hazardous Cameroon volcanic line by Djukem et al. (2020). This research will help identify lower landslide hazard zones that may fit better for human activities. The final landslides predisposition model will be a suitable tool for correcting site selection and planning, respecting sustainable development, saving lives, and involving individual landowners in Cameroon.

2. Efficiency of the multiscale approach

The simultaneous production of regional and detailed inventtory and susceptibility maps of Cameroon will provide an overview of landslide susceptibility and risk in the region. This investigation will combine remote sensing techniques with statistical and physically based landslide susceptibility modeling methods. Areas of high susceptibility will be highlighted for detailed investigation, similar to that of Mount Oku, to capture landslide patterns and elucidate their mechanisms. The results of the detailed investigation will be used to gradually improve the accuracy of the regional maps.

3. Background of the study: efficiency of the multifactorial approach

Djukem et al. (2020) have shown the importance of integrating soil geomechanical parameters and geo-environmental factors in landslide susceptibility models, taking the western flank of Mount Oku as the study area (Figure 1). Soil geomechanical properties allow for the characterization of soil behavior from a small scale (grain) to a landslide scale.

Land exploitation, combined with heavy rainfall and slope steepness frequently causes landslides in mountainous regions, such as Mount Oku. Geo-environmental factors used in our investigation include lithology, elevation, slope angle and aspect, land use, curvature, and proximity to rivers and roads; while soil geotechnical properties investigated include soil porosity, particle and bulk density, water content, grain sizes, Atterberg limits, methylene blue value, friction angle, and cohesion.

We explored a novel approach to integrate these geo-environmental and soil geomechanical parameters in a landslide susceptibility model. Membership values were assigned to each soil property class, using the fuzzy membership method. The information value method allowed for computing the weight value of geo-environmental factor classes. From the soil geomechanical membership values and the geo-environmental factor weights, three landslide predisposition models were produced, two separate models and one combined model. The model with only soil properties tended to underrate unstable and stable areas, the model combining soil properties and geo-environmental factors allowed for a more precise identification of stability conditions. The geo-environmental factors model and the model combining geo-environmental factors and soil properties displayed predictive powers of 80 and 93%, respectively. It can be concluded that the spatial analysis of soil geomechanical properties can play a major role in the detection of landslide prone areas.

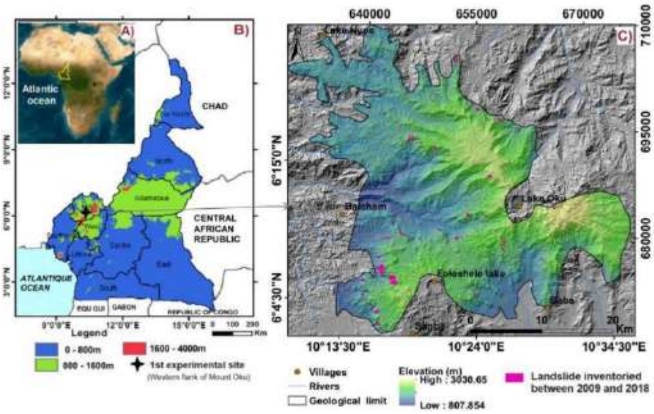

Figure 1 Localization of the study area:(A) on the world imagery map provided by Esri Geographic information system company; (B) on the Cameroon elevation map; (C) an enlargement showing the western flank of Mount Oku elevation, rivers, and landslides.

3. Conclusion

The approach we propose could form the basis for the establishment of a long-term landslide monitoring system. This will finally make it possible to anticipate the occurrence of these landslides and to take measures not only after they have caused irreparable damage, but to anticipate them and limit their damage. This could also be a basis of an establishment of a specific national landslide management plan.

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IAEG Connector E-News, YEG-Article-5-09/2024

Method and Apparatus for Tunneling by Melting

Inventor

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United States Patent

Armstrong et al.

[15] **3,693,731**

[45] **Sept. 26, 1972**

[54] **METHOD AND APPARATUS FOR TUNNELING BY MELTING**

[72] Inventors: **Dale E. Armstrong**, Santa Fe; **Berthus B. McInteer; Robert L. Mills; Robert M. Potter; Eugene S. Robinson; John C. Rowley; Morton C. Smith**, all of Los Alamos, N. Mex.

[73] Assignee: **The United States of America as represented by the United States Atomic Energy Commission**

[22] Filed: **Jan. 8, 1971**

[21] Appl. No.: **104,872**

[52] **U.S. Cl.** **175/11**, 175/16, 175/19

[51] **Int. Cl.** **E21c 21/00**

[58] **Field of Search** 175/11–16

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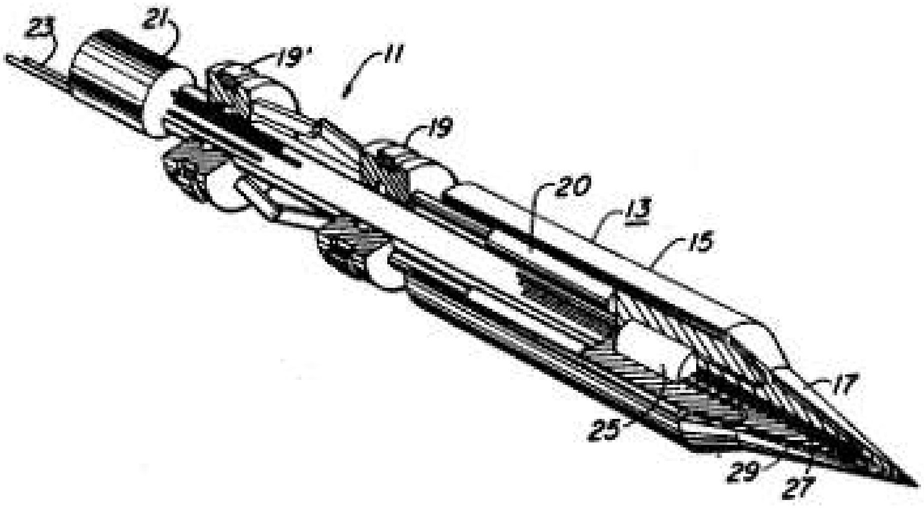
Primary Examiner—Marvin A. Champion
Assistant Examiner—Richard E. Favreau
Attorney—Roland A. Anderson

[57] **ABSTRACT**

A machine and method for drilling bore holes and tunnels by melting in which a housing is provided for supporting a heat source and a heated end portion and in which the necessary melting heat is delivered to the walls of the end portion at a rate sufficient to melt rock and during operation of which the molten material may be disposed adjacent the boring zone in cracks in the rock and as a vitreous wall lining of the tunnel so formed. The heat source can be electrical or nuclear but for deep drilling is preferably a nuclear reactor.

6 Claims, 7 Drawing Figures



https://patentimages.storage.googleapis.com/d4/77/07/cdf3f7ded50238/US3693731.pdf

METHOD AND APPARATUS FOR TUNNELING BY MELTING

The invention described herein was made in the course of, or under, a contract with the U. S. ATOMIC ENERGY COMMISSION. It relates generally to a method and apparatus for drilling, tunneling and shaft-sinking in rock with particular advantage at hitherto inaccessible depths.

This invention provides a rapid versatile economical method of deep-earth excavation, tunneling and shaft-sinking which offers solutions to ecological problems, acquiring natural resources presently inaccessible and access to an enormous reservoir of natural heat energy. These valuable subterranean sources include natural minerals and hydrocarbons, fresh water and clean geothermal heat energy.

The accessibility of these resources at the present time is limited by the technical and economic difficulties of producing large long holes in the hard rocks of the earth's crust and mantle. The available tools and techniques for relatively shallow drilling, boring, shaft-sinking, tunneling and mining in rock are highly developed and in the environments in which they have evolved they are adequately effective and efficient. However, their efficiencies and feasibility of use decrease rapidly and their costs rise in proportion, as their application is extended to greater depths, harder rocks, and higher rock temperatures and pressures. Among presently available tools for penetrating rock, only the rotary drill appears to be capable of penetrating the earth to depths greater than four to five kilometers at an economically useful rate and at such depths it is limited to producing holes no larger than about one-half meter in diameter. It is unlikely that existing methods can be used to explore or excavate the earth to depths greater than about 12 to 15 kilometers.

The present invention uses the basic apparatus and method disclosed in U.S. Pat. No. 3,357,505 and in Los Alamos Scientific Laboratory of the University of California Report No. LA-3243 (1965) entitled "Rock Melting as a Drilling Technique." The rock-melting drill so disclosed is effective in penetrating basalt and other igneous rocks at usefully high rates and with moderate power consumption. For example, igneous rocks melt at about 1,200°C and in being heated from ambient temperature such as 20°C to just above their melting ranges require about 4,300 joules of energy per cubic centimeter compared with the energy requirement of 2,000 to 3,000 joules per cubic centimeter for rotary drilling in igneous rocks.

In the existing rock melting devices of the prior art, a major difficulty which limited performance was that of delivering a sufficiently large heat flux to the melting face of the drill or penetrator. The development of the heat pipe alleviates this problem in that the use of heat pipes enables the transfer of heat energy from a compact heat source to the extended melting surface of the penetrator at rates high enough to maintain the surface above the melting temperature of the rock.

The extrapolation of a mechanism useful for forming large holes in the earth in accordance with the present invention uses the combination of a refractory rock-melting tool, an in situ heat source preferably a small nuclear reactor and an exceedingly efficient heat transfer mechanism such as a system of heat pipes to convey heat from the source to the walls of the drilling tool.

The construction and operation of heat pipes is disclosed in Los Alamos Scientific Laboratory Reports No. LA-4221-MS (1969) and No. LA-3585-MS (1966) and in IEEE Trans., *ED*-16, 717 (1969). Essentially, a heat pipe is an elongated gas-tight cavity which contains a suitable liquid and its vapor. The heat-pipe cavity is lined with a capillary structure which transports the working liquid continuously from the cool end to the heat source end. At the heat source end or evaporator the liquid is continuously evaporated so that the interior space of the heat pipe is kept filled with vapor diffusing toward the slightly cooler condenser end. At the condenser end it deposits its heat of vaporization and returns by the wick to continue the cycle.

The heat pipe has the ability to convey heat energy of remarkably large amounts with only small temperature differences between the hot and cool (relatively) ends. This is in contrast with the heat transfer capabilities of solid or liquid thermal conductors which require hundreds of degrees of temperature gradient per centimeter of length to transfer heat at equivalent rates.

In the case of the rock melting drill of the present invention in which the penetrator face must be maintained at about 1,500°K (1,227°C) for extended operational periods and the heat source is many centimeters away, the heat pipe is the practical heat energy transfer mechanism.

It was found in the utilization of the rock melting tool of U.S. Pat. No. 3,357,505 that the rock being bored usually cracked due to thermal stresses. The present invention makes use of such cracks and in fact enhances their production by the addition of mechanical pressure in order that the material being melted can be disposed of in the cracks and on the tunnel or bore hole walls.

It is a prime objective of the present invention to provide an apparatus and method for drilling tunnels or bore holes in rock of a size and/or depth which exceeds prior art methods.

Another objective is to provide drilling apparatus which is capable of boring holes and tunnels in rock and which disposes of the excavated material adjacent the drilling position as a bore hole lining.

Still another objective is to provide an apparatus and method for tunneling in rock in which a rock melting technique is utilized and in which the source of heat is provided at the drilling position.

Another objective is to provide an apparatus and method for the drilling of rock at great depths or distances by remote control.

Still another object is to provide a rock drilling method which applies heat and pressure to the earth's rock formation to hydrostatically fracture and melt the rock and dispose of the excavated material by lateral extrusion.

Another objective is to provide an apparatus and method for producing a vitreous lining on the wall of a hole in rock or in other earth materials such as sand.

The above and other objects and advantages of the invention will become apparent from the following description of a preferred and certain alternate embodiments thereof, and from the drawings in which:

FIG. 1 is an isometric view partly in section using a nuclear reactor for power.

FIG. 2 is a vertical fragmentary detail of the rock drill housing and rock penetrator.

FIG. 3 is a cross section of a nuclear reactor suitable for use in the rock melting drill.

FIG. 4 is a longitudinal cross section of a nuclear reactor heat generator adapted for remote control.

FIG. 5 is a fragmentary view of an electrical heat source.

FIG. 6 is a plan view of a field drilling facility.

FIG. 7 is a rock drill adapted to extraordinary deep drilling.

Referring to FIG. 1, an embodiment is shown of a rock melting drill designated generally by numeral 11. The drill comprises a hollow housing 13 comprising a uniform cross section portion 15 and a nose portion 17 which may have any shape but is preferably tapered to a point and which hereinafter is termed "penetrator," a pair of thruster mechanisms 19—19', a control and guidance component 21 and utility supply lines 23. The prime energy source 26 may be the nuclear reactor 25 or an electrical heating mechanism such as shown in FIG. 5. Connected in heat transferring relation to the heat source are heat pipes 27.

Referring to FIG. 2, the manner in which the condensers 29 of heat pipes 27 are coupled to the penetrator is shown. Each heat pipe so coupled is terminated in flat enlarged condenser section 29. The condenser sections are in tight thermal coupling with the interior of wall 31 of penetrator 17 as by clamping or welding.

Nuclear reactor 25 comprises essentially a core 30 shown in FIG. 3 and an insulation shield and armor covering 33. A heat coupling element 34 containing a liquid metal such as molten tin is supported in the reactor and is thermally coupled to the evaporator ends of the heat pipes 27.

The heat pipe 27 is shown as composed of end-to-end coupled heat pipe sections. The reason for this becomes apparent from further consideration of the heat pipe characteristics. For an operating temperature in the range of from 1,400° to 1,800°K (1,127° to 1,527°C) the heat-pipe container is a gas-tight refractory metal tube or shell. The preferable appropriate working fluid is lithium. Lithium heat pipes made of niobium-1percent zirconium alloys have been operated at temperatures up to 1,600°K (1,327°C) for several thousand hours. Other materials such as alloys like tantalum-10 percent tungsten are capable of operation to as high a temperature as 2,100°K (1,827°C).

The heat pipe as an individual working element has limited lift of the working fluid by capillary action. In the rock melting drill the heat source may be supported several meters above the penetrator 17. The lithium heat pipe cannot effectively transport the working fluid vertically against the force of gravity a distance much in excess of one meter. However, as many heat pipe sections (each a complete heat pipe unit) can be connected in series as the total distance requires and, as shown in FIG. 2, a plurality of heat pipe sections or units constitute each heat transfer heat pipe from the heat coupler 34 to the penetrator wall 31.

A tunneling speed of 100 meters per day is well within the heat transfer capabilities of the heat pipe. This speed of tunneling requires approximately 500 watts per square centimeter of penetrator work surface. At 1,400°K a lithium heat pipe can readily transport 10 kilowatts per square centimeter of vapor passage cross-sectional area and at 1,800°K the capacity is increased by a factor of more than five. Thus, each square centimeter of vapor passage can supply heat to at least 30 square centimeters of penetrator surface.

The heat source for the rock-melting drill to the present invention can be electrical or nuclear. The nuclear reactor as the prime source of energy is preferred for very deep or very fast tunneling. Nuclear reactors of appropriate size and capability are available for the purpose. Reactors whose core contains about 40 volume percent heat pipes with a heat generating capacity of from 100 kW to 10 MW thermal power output have a core size ranging from 18 cm diameter and 25 cm long to 1 meter diameter and 1 meter length.

A cross section of a suitable nuclear reactor is shown in FIG. 3 and it is similar to those developed for space nuclear and propulsion purposes. The core 30 comprises fuel elements 41 each of which has a hollow cavity 43 to accommodate a heat pipe evaporator end. Control rods 45 provide adjustability of heat energy generated to equal heat energy consumed in the penetrator and energy demand of accessory equipment. The reactor core is surrounded with thermal blanket and nuclear shield 49 which in turn is protected by a heavy metal shield 51 and exterior armor 53. The core 30 and elements 49, 51 and 53 constitute one practical assembly for the component 33 shown in FIG. 2.

The combination of the nuclear reactor with the heat pipes, remote control devices and coolant is explained with reference to FIG. 4. The nuclear reactor has a diametric cross section as shown in FIG. 3 except that in part the heavy metal shield 51 and armor 53 are combined into a water-cooled solid tungsten casing 55. Massive metal cage 56 provides for support of the reactor core 29 and shielding and support for devices which are connected thereto. As shown in FIG. 6, the rock drill may be connected by drill stem 66 which encloses and extends the cables, pipes and electrical conductors to above-ground control and supply facilities 61 and 63. The cooling water is admitted to pipe ducts in contact with or in the armor to cool the reactor as needed. The position of the control rod is remotely controlled by control drive motor 63. The reactor is provided with usual fail safe control system such as spring 64 conventional reactor control type. In this embodiment the inlet and exhaust water pipes, the electrical supply cables and the main suspension cable form the main cabling or umbilical cord between the control truck and the drill.

An electrical heat source instead of a nuclear reactor is shown in FIG. 5. The electrical resistance 28 is in tight thermal contact with heat pipe 27 and is energized by electrical cables 32 leading to the earth's surface. Otherwise the penetrator is similar to the nuclear energized embodiment.

With respect to any technique for drilling holes in the earth the material removed to make the hole must be disposed of. In small holes such as shallow water wells in porous soils it has long been the technique to simply drive the material radially outward into the surrounding earth. In drilling larger holes or tunnels the problem of disposal grows rapidly, at least with the square power of the diameter of the hole. With respect to large holes such as one meter or larger, the technique of sideways disposal of solid debris is not feasible even in porous soils. In solid rock this technique has hitherto not been feasible for holes of any diameter. In accordance with the present invention the debris may be disposed of as melted rock both as a lining for the hole and as a dispersal in cracks produced in the surrounding rock. The rock-melting drill is of a shape and is propelled under sufficient pressure to produce and extend cracks in solid rock radially around the bore by means of hydrostatic pressure developed in the molten rock ahead of the advancing rock drill penetrator. All melt not used in glass-lining the bore is forced into the cracks where it freezes and remains.

The ability of the rock melting drill to provide a vitreous lining for the bore hole in rock or in other earth material such as sand, whether consolidated or unconsolidated in the original condition is a meritoreous advance in the art. Such a lining eliminates, in most cases, the expensive and cumbersome problem of debris elimination and at the same time achieves the advantage of a casing type of bore hole liner. Such a molded in situ casing serves a number of functions such as preventing escape of material from within the hole, preventing ingress of unwanted materials from without the hole, reducing resistance to passage of materials or objects through the hole, and providing wall support against forces developed within or without the hole.

The feasibility of cracking subterranean rock by pressure has been established, particularly in oilfield experience by hydrofracturing. The forces involved and methods of fracturing by water pressure are discussed in publications, for example, E. Harrison et al., "The Mechanics of Fracture Induction and Extrusion," Pet. Trans. AIME, 201, 252 (1954) and M. K. Hubbert et al., "Mechanics of Hydraulic Fracturing," Pet. Trans. AIME 210, 133 (1957). However the use of melted rock as the fluid through which pressure is transmitted is novel with this invention.

The rock-melting drill of the present invention provides advantages over rock fracturing by pressure alone in that the heat induced in surrounding rock provides an effective cracking force. Most rocks are good thermal insulators. The effect of an abrupt change in surface temperature or of a heat flux suddenly applied to a rock surface will in general penetrate slowly. For example, the heat properties of the material surrounding a cylindrical hole 2 meters in diameter in granite have been discussed in the literature by L. F. Ingersoll et al., "Heat Conduction—With Engineering, Geological, and Other Applications," 1954 University of Wisconsin Press. In brief, the pertinent data are: thermal conductivity = $\lambda = 0.0065$ cal/cm-sec-°C; specific heat = $c_p = 0.19$ cal/g-°C; density = $\rho = 2.7$ g/cm³; and thermal diffusivity = $D = 0.0127$ cm²/sec.

The surface temperature of the hole, T_s is rapidly raised from 100°C to about 1,100°C which is approximately the melting temperature of granite. To determine the temperature of the surrounding rock as a function of time and of dimensionless radial distance r/a from the hole, the parameter of interest is the non-dimensional Fourier number $F_0 = (D/a^2)t$. The specific origin of this mathematical approach is D. J. Schneider, "Temperature Response Charts," John Wiley & Sons, New York 1963.

For the rock properties above given, $F_o = 1.26 \times 10^{-4}\, t$ where t is in seconds. In one hour the thermal wave has migrated about one hole radius from the hole wall. For the thermal wave to migrate 10 hole radii would take about 40 days. These results indicate that the thermal perturbation in the earth caused by passage of a rock-melting penetrator is extremely local in nature.

The thermal insulating properties of rock are favorable characteristics for limiting the energy consumed in boring and in creating stresses in the rock for creating cracks. Since the thermal perturbations are restricted to very thin layers adjacent to rock surfaces, the thermal stresses generated in the zone of perturbation are easily estimated. The magnitude of the thermal stress can be derived from the relation

$$\sigma_{th} \cong \frac{\bar{a}E}{(1-\nu)}(T_s - T_a)$$

where

σ_{th} = thermal stress, kg/cm²
$\bar{a}$ = mean coefficient of thermal expansion, °C⁻¹
E = elastic modulus, kg/cm²
ν = Poisson's ratio
T_a = ambient temperature of undisturbed rock mass, °C
T_s = ambient temperature of the rock surface, °C

By substituting typical rock properties of $\bar{a} = 8 \times 10^{-6}$ °C⁻¹; $E = 10^6$ kg/cm² and $\nu = 0.2$, the above relation becomes

$$\sigma_{th} \cong 10(T_0 - T_s) = \pm 10\Delta T.$$

Since the tensile strengths of rocks are between 40 and 100 kg/cm², a temperature decrease of 4° to 10°C in the zone adjacent the hole creates sufficient thermal stress to cause tensile cracking.

The operation of the rock-melting penetrator may be facilitated by the fact that the cracks started by thermal stress can be extended by lithofracture through the mechanism of high interface pressures produced by the thrust of a spear-shaped penetrator. Numerous data are in the public domain pertinent to the basic facts of fracturing, for example, the M. K. Hubbert et al. and the E. Harrison et al. publications in the AIME Transactions above identified. Treatment of the crack extension behavior of rocks pressurized hydraulically has been made by R. J. Sun, "Theoretical Size of Hydraulically Induced Fractures and Corresponding Uplift in an Idealized Medium," Journal of Geophysics Research, 74, 5995 (1969). Specifically, it was demonstrated that the cracks formed from a hole 10 cm in diameter extended outward to distances of 50 to 60 meters, i.e., crack depths were 500 to 600 times the hole diameter.

The volume of cracks of several different geometries, formed in granite, are shown in the following table:

CALCULATED DIMENSIONS AND VOLUMES OF CRACKS FORMED IN GRANITE

Crack Radius, L_r, m	Crack Width, cm	Crack Volume, U, m³	Net pressure, ΔP kg/cm²	(lb/in.²)
5	0.2	0.11	165	(2,300)
10	0.5	1.05	200	(2,800)
20	1.0	8.0	200	(2,800)
50	1.0	52.0	80	(1,150)
100	2.0	420.0	80	(1,150)

The data given show that lower pressures are required to form very long thin cracks than to form short, wide ones and that the long thin cracks have unexpectedly large volumes. For comparison: a 1-meter length of a hole 2 meters in diameter has a volume of only 3.14 m^3.

As seen from the foregoing, the device of the present invention works best when sufficient penetrator pressure is used to force the melted excavated material into the adjacent rock. Under the requisite pressure, the hot spear-shaped penetrator is forced against the rock and a thin film of glass-like melt forms over its hot surface. This fluid serves as a viscous pressure-transmitting medium to convert the axial thrust of the penetrator into uniformly distributed hydrostatic pressure on the wall of the hole. Stresses in the rock are very high at the tip of the penetrator and initiate cracking of the rock. The melted rock is forced into the cracks wherein heat is given up to the crack surfaces and freezes as a glass at some distance from the penetrator and serves to prop the crack open. If the flow of molten rock is prematurely stopped by the plugging of the cracks due to freezing, the walls of the bore hole are again subjected to large lateral hydrostatic forces and either the old cracks are enlarged or new cracks form to accept the molten rock.

The rate of advance of the rock-melting penetrator is governed by the rate at which the rock is melted, and this is controlled by the power delivered to the penetrator surface. Cracking of the solid rock and rate of outflow of the melted rock depend upon the thrust applied to the penetrator.

The pressure may either be obtained by a pusher pipe or rod 66 made up of connected drill pipe segments and extending to the surface as shown in FIG. 6 or it can be a bore hole lock-on type of a type well known in the prior art such as schematically shown in FIG. 1. The double compression lock-on device in general comprises two cylindrical thrusters 19 and 19' each being driven radially by hydraulic cylinders. Pusher hydraulic cylinders 20 with their hydraulic rams provide the prime mover force between the rock drill body and the lock-on thrusters 19. The thrust force needed for boring a two-meter diameter hole or tunnel is in the neighborhood of 15 million pounds or roughly eight thousand tons. Six 14-inch hydraulic cylinders pressurized at 20,000 psi provide 18 million pounds of available controllable thrust which is more than adequate. The self-contained rock melter of FIG. 1 lends itself to remote-control operation.

The rock-melting penetrator of this invention is particularly applicable to drilling at depths totally inaccessible with previously available drilling techniques. Such deep drilling is exceedingly useful not only in the obtainment of data from beneath the earth's crust but also to tap essentially limitless geothermal energy. For example, beneath the Colorado plateau, the Mohorovicic discontinuity is at the anomalously shallow depth of about 30,000 meters which is well within reach of the embodiment of FIGS. 6 and 7. At this depth the normal geothermal gradient of 20°C/km results in a rock temperature of about 600°C and the overburden pressure is about 145,000 psi. The rock drill of the type shown in FIG. 7 wherein drill stem connects the rock drill to the surface is applicable because a coolant fluid circulation system is provided through the drill stem. Coolant passage 71 is provided in the rock-drill body and is connected via pump 77 to porous metal wall 79. The fluid which exudes from the porous wall chills and strengthens the glass lining of the shaft and thermally protects the rock drill.

It is intended that at depths feasible to the operation, the FIG. 1 rock-melting drill will be guided by remote control. The feasibility of deep-hole radio control is provided by M. Dolukhanov, "Underground Propagation of Radio Waves," Radio (Moscow) 1970. (English translation by Joint Publications Research Service, Publication No. JPRS 49894 (1970).

The foregoing description of preferred embodiments deals with nuclear reactor prime mover devices. It is within the contemplation of this invention that any other adequate heat generator may be used such as one which is electrical in nature. Accordingly, it will be apparent that numerous departures from the details shown may be made within the spirit and scope of this invention and it is, therefore, understood that the invention is limited only by the scope of the following claims.

What we claim is:

1. Earth drilling apparatus for drilling bore holes and tunnels in rock by melting a path for itself comprising an elongated hollow drill housing having a first hollow portion and a second hollow portion, a heat source supported in said first hollow portion having a temperature of not less than about 1,100°C, heat pipe chains for thermally coupling the heat source to the interior surface of the walls of the said second hollow portion, each of said heat pipes comprising a plurality of thermally coupled heat pipe sections, each of the heat pipe sections having an evaporator end and a condenser end, and being coupled with the condenser end of a preceding heat pipe being adjacent the evaporator end of the next succeeding heat pipe, the initial evaporator of each of the heat pipe chains is supported in close thermal contact with the heat source and the terminal condenser of each heat pipe chain is affixed in tight thermal conductive relation to the interior wall of the said second hollow portion, and propulsion means supported by the said first hollow portion for translating the drilling apparatus in the direction of elongation.

2. The apparatus of claim 1 in which the propulsion means is a double thruster bore hole lock-on mechanism and means for operating the double thruster comprising a source of hydraulic fluid under pressure and hydraulic rams supported in the drill housing first portion.

3. The apparatus of claim 1 in which the walls of the housing second portion converge toward the forward end whereby molten rock is distributed laterally against the bore hole walls to in situ form a vitreous casing thereon.

4. The apparatus of claim 1 in which the propulsion means is a drill pipe stem made up of standard drill pipe segments and having a length coextensive with the bore hole plus one additional pipe segment or a portion thereof, said drill pipe stem being connected at one end to the rearward end of the drill housing first section and extending out of the bore hole at its other end, whereby said drill stem is adapted to forcefully urge the rock drill forward by its own weight and by force applied to said other end.

5. The apparatus of claim 4 in which the walls of the heat source and drill first section are water cooled, water transmission means, hydraulic pressure hoses and electrical power transmitting conductors being housed and supported in the drill stem.

6. The apparatus of claim 5 in combination with a surface facility, said surface facility comprising electrical generating means, electrical signaling means, water coolant storage and pumping means and vertical force generating means, electrical conducting means connecting the electrical generating means to the electrical power transmitting conductors, coupling means for coupling the signaling means to the rock drill, and hoses connected between the coolant pumping and storage means and the rock drill water transmission means for circulating water through the heat source armor and drill body first section for cooling the same and conveying the heat thereby obtained to the surface facility.

* * * * *

PATENTED SEP 26 1972 3,693,731

SHEET 1 OF 4

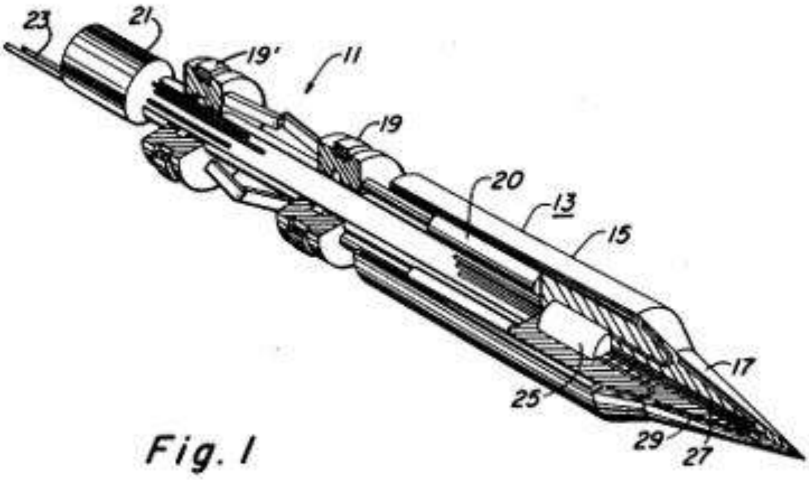


Fig. 1

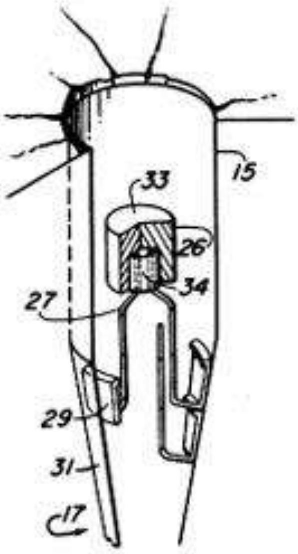


Fig. 2

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BY Roland A. Anderson
Attorney

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SHEET 2 OF 4

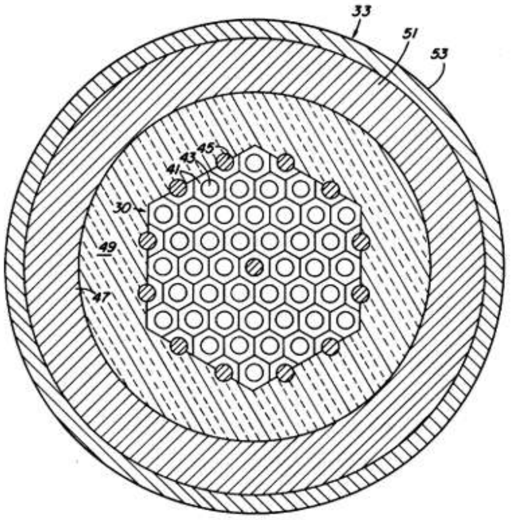

Fig. 3

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PATENTED SEP 26 1972 3,693,731

SHEET 3 OF 4

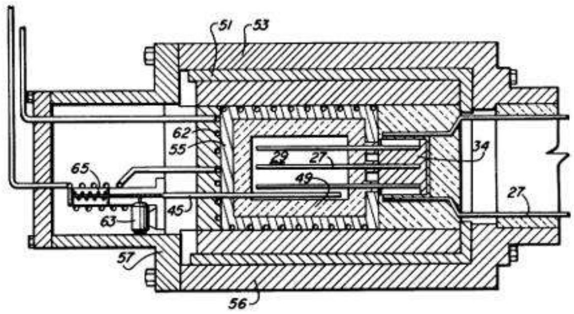

Fig. 4

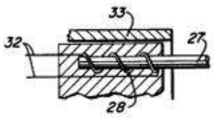

Fig. 5

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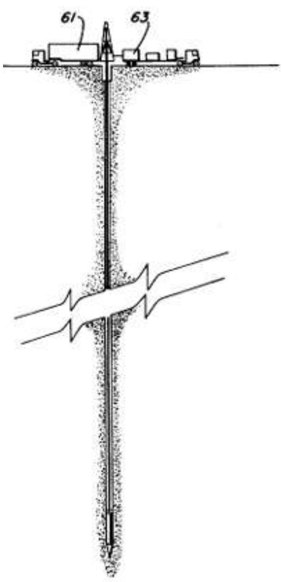
PATENTED SEP 26 1972 3,693,731

SHEET 4 OF 4



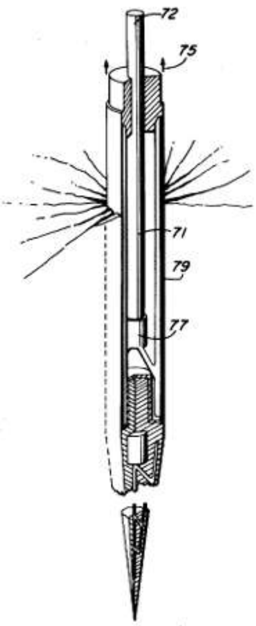


Fig. 6

Fig. 7

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Robert L. Mills, Robert M. Potter,
Eugene S. Robinson, John C. Rowley,
Morton C. Smith

BY

ΝΕΑ ΑΠΟ ΤΙΣ ΕΛΛΗΝΙΚΕΣ ΚΑΙ ΔΙΕΘΝΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΝΩΣΕΙΣ

International Society for Soil Mechanics and Geotechnical Engineering

ISSMGE News
www.issmge.org/news

January 16 Webinar by Prof. Valocchi on Groundwater & Transport Interactive Models

Marina Pantazidou / TC306 / 09-01-2025

On **Thursday, January 16, 2025, at 15:00 UTC**, **Professor Albert Valocchi will talk about "User-Friendly Interactive Models for Groundwater Education Still Useful After 25 years!**", as part of the International Webinar Series on Geoenvironmental Engineering, Sustainability, and Resiliency. The webinar is supported by three ISSMGE committees, TC306 (Geo-Education) and TC103 (Numerical Modeling), the joint task force of which initiated Prof. Valocchi's invitation, and TC215 (Environmental Geotechnics), which supports the webinar series.

The suite of the Interactive Models for Groundwater Flow and Solute Transport is available at http://hydrolab.illinois.edu/gw_applets/ and **has been maintained for 25 years, a rare feat for an educational software.**

The author of this news item has used the Interactive Models in her Environmental Geotechnics course for over 15 years and is grateful to Prof. Valocchi for enriching the course.

Register (free) for this webinar (and others in the series: there is one more webinar with education topic on March 20, 2025) at:

https://uic.zoom.us/meeting/register/tZUpdeqsrDgoE9JGBwjrAYs1M5KlSPajt2yG

Webinar TC103+TC306

Francesca Ceccato / TC103 / 09-01-2025

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https://uic.zoom.us/meeting/register/tZUpdeqsrDgoE9JGBwjrAYs1M5KlSPajt2yG

PANAMGEO 2024 Course Presentations

Alessandro Mandolini / TC212 / 14-01-2025

Presentations of TC212 Workshop at PANAMGEO 2024 in La Serena (Chile) held on 12th November 2024 are now available at:

https://www.issmge.org/filemanager/article/1339/PANAMGEO_2024_Course.rar

HTC DISCOVERER REPORT COMPETITION, 2025

ISSMGE IT Administrator / Time Capsule Project / 14-01-2025

Individual members of the ISSMGE are invited to participate in the HTC project by preparing a discoverer report for placement on the HTC website. The purpose of the discoverer report is to shine a spotlight on the chosen HTC contribution (s) placed on the HTC website or parts thereof, and bring the HTC contributions to the attention of readers. The discoverers report can be a brief note, video, audio, or other form that can be stored on the HTC website and shared online. Further details on the discoverer reports, and several discoverers reports already in place on the HTC website, can be found on https://htc.issmge.org/discovery.

The ISSMGE has made available a cash pool of **£3,000** for an HTC Discoverer Report Competition in 2025. Criteria for the ranking of discoverer reports include clarity, overall quality, originality, the attractiveness of the discoverer report, demonstrated understanding of the HTC contribution, the display of the discoverers insights on the past, present and future of the geotechnical community, and other aspects. Discoverer reports already in place and those placed in 2025 on the HTC website will be assessed by a panel led by HTC Discovery Subcommittee (https://htc.issmge.org/what-is-htc), for the award of prizes in 2026, from the £3,000 cash pool as follows:

- **1 award of first prize, £1,000,**
- **2 awards of second prize, £500 each, and**
- **5 awards of third prize, £200 each**.

Notes

1. Discoverers can update/refresh their discoverer reports on the HTC website throughout 2025
2. Discoverers can choose **not** to participate in the competition by written notice to the HTC team
3. Discoverers from the HTC team are not eligible to be considered for the award of prizes.

If you have any questions, please contact the HTC team at https://htc.issmge.org/contact

Celebrating the International Day of Education: the role of Geo-engineering education

Michele Calvello / TC306 / 24-01-2025

On the occasion of the International Day of Education, January 24, the Technical Committee 306 on Geo-Engineering Education emphasizes the crucial role university education plays in advancing the state of knowledge within the geotechnical engineering field. In this day, we encourage all stakeholders in this community to support initiatives that promote access to quality education. This year's theme, "AI and education: Preserving human agency in a world of automation," specifically highlights the urgency and the importance of equipping individuals with adequate knowledge to properly understand and influence rapidly evolving technological advancements.

On this day, we encourage educators, students, and professionals to engage in collaborative efforts that may develop innovative teaching methods and overall enhance the geotechnical education state of practice. By fostering a deep understanding of soil mechanics and geotechnical engineering, future engineers are empowered to design and implement innovative solutions that ensure the safety and sustainability of engineering projects and to address complex challenges in today's rapidly changing environment.

TC306 is committed to promoting excellence in university education and providing resources and support to educators and students alike. Through conferences, workshops, and online resources, our technical committee aims to create a vibrant and collaborative community of geotechnical engineering educators. For more information on these activities and initiatives, please visit the TC306 web page on the ISSMGE portal.

Happy International Day of Education!

Proceedings from the 4th Asia-Pacific Conference on Physical Modelling in Geotechnics available in open access

ISSMGE IT Administrator / TC104 / 28-01-2025

The Innovation and Development Committee of ISSMGE is pleased to announce that through the initiative of Prof. Tarek Abdoun, and the Technical Committee on Physical Modelling (TC104) of the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE), the 42 papers from the proceedings of the 4th Asia-Pacific Conference on Physical Modelling in Geotechnics (ACPMG2024) are available in the online library:

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

The abstracts and papers of the proceedings were reviewed through ISSMGEs Conference Review Platform, which is part of its cyber-infrastructure aiming to support open access.

The conference took place in Abu Dhabi, United Arab Emirates from December 11th to December 13th.

☙ ❧

International Society for Rock Mechanics and Rock Engineering

ISRM

News

https://www.isrm.net

Presidential election for the 2027-2031 term of office - two candidates were nominated 2025-01-16

The candidates are Pinnaduwa Kulatilake, nominated by Sri Lanka and Sérgio Fontoura, nominated by Brazil, Argentina, Mexico and Paraguay.

The election of the ISRM President for the term of office 2027-2031 is scheduled for 16 June 2015 during the ISRM Council meeting in Trondheim, Norway. The President-elect will join the Board immediately and officially take office after the ISRM International Congress in 2027, held in Seoul, Korea.

In addition to their nomination documents, the candidates were asked to submit videos outlining their backgrounds and objectives.

Clich here to read the nomination documents and to watch the videos on the ISRM website.

☙ ❧

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

Scooped by ITA-AITES #129, 14 January 2025

HS2 update: Progress on deep tunnel drives and earthworks | UK

DTL extension to Sungei Kadut to open in 2035, including new MRT station near Yew Tee Village | Singapore

World's deepest tunnel: €21 billion project underway 392 meters below sea level | Norway

World's longest expressway tunnel completed in NW China's Xinjiang

Tunnel boring machine en route to Trojena from Germany | saudi Arabia

Construction of Dhaka's first underground metro rail in full swing | Bangladesh

Rise in tunnelling and anchoring patents to transform mining operations

[Tende tunnel reopening: Major France-Italy route set to resume after 10 years]

[AKTOR's 4th TBM started boring within the Apaţa-Caţa section of the Brasov-Sighisoara railway | Romania]

[London's new Silvertown Tunnel set to open | UK]

BRITISH TUNNELLING SOCIETY YOUNG MEMBERS

Recording of December 2024 Lecture

Overcoming challenges in horizontal directional drilling

https://www.youtube.com/watch?v=EhTPgd5cewI&list=PLvvb8Hld3_aW7VtG_VpxFmRGCzn6RKIGY&index=3

January Lecture

World's Longest tunnel constructed by a single TBM: Young Engineer's story so far

Thursday, 30 January 2025
[in-person] Institution of Civil Engineers, One Great George Street, Westminster, London SW1P 3AA
This lecture can be watched online (Zoom Link)

Event Information:

This event provides a glimpse into the journeys of young engineers as they navigate the challenges and triumphs of the tunnelling industry, specifically through their work at the Woodsmith Project in the UK. The talk will delve into the world record-breaking longest tunnel using a single TBM in 2023. Each speaker will share their personal experiences, reflecting on the skills they've developed, the obstacles they faced and valuable lessons they learned along the way.

Speakers:

Aleesya Latifi *Design Engineer, Strabag UK*

Megan Ackers *Surveyor, Strabag UK*

Patrick Chow *Senior Tunnel Engineer, Strabag UK*

Justin Chow *Senior Tunnel Engineer, Strabag UK*

INTERNATIONAL GEOSYNTHETICS SOCIETY

www.geosyntheticssociety.org

News

Dates For Your Diary – 2025 January 7, 2025

Prepare for another busy year of discovery, discussion and development with the IGS's 2025 global geosynthetics conference programme. Save the dates below, and register now **Read More »**

Could You Host EuroGeo9? January 8, 2025

The search is on for the next IGS Chapter to host one of Europe's flagship geosynthetics conferences. Expressions of interest are now being sought to **Read More »**

Don't Miss GeoAsia8 Papers Deadline – And More! January 13, 2025

The window for submitting extended abstracts or full papers for the next 8th Asian Conference on Geosynthetics (GeoAsia8) closes soon. Submissions must be made by **Read More »**

IGS Expertise Shared At South America Chapter Events January 14, 2025

Geosynthetics in the IGS's Pan-American region were further championed with two recent IGS Ambassadors Program visits. Expert practitioners from the IGS spoke at events hosted **Read More »**

10 Questions With… Amir Shahkolahi January 22, 2025

The IGS Asian Regional Activities Committee (RAC) recently welcomed a new Chair. Here, Amir Shahkolahi shares what he's been working on since taking up the **Read More »**

IGS Diversity Task Force Gains Committee Status January 27, 2025

An IGS working group committed to improving inclusion and equity in the Society and wider geosynthetics industry has been upgraded into a Committee. Approval for **Read More »**

Workshop Spotlights Sustainability In Transport Geotechnics January 31, 2025

Sustainable approaches to tackling pavement and railway projects with geosynthetics were explored at a IGS workshop during the 5th International Conference on Transportation Geotechnics (ICTG). **Read More »**

News
www.britishgeotech.org/news

Call for entries for the BGA Case Histories Award 01.01.2025

Deadline for submissions is 31 January 2025. The objective of the award is to encourage and recognise the importance of exchange of exemplary geotechnical knowledge and experience of the performance of constructed works for the benefit of the geotechnical profession https://www.britishgeotech.org/call-for-entries-for-the-bga-case-histories-award-2025/

Call for Submissions for BGA Medal 2024 01.01.2025

Deadline for Submissions is 31 January 2025. The BGA Medal is awarded annually to a paper written by a BGA member (or members) for "meritorious contributions to geotechnical science or practice". https://www.britishgeotech.org/call-for-submissions-for-bga-medal-2024/

Call for Entries for the BGA 2024 Masters Dissertation Prize 01.01.2025

Deadline for submissions is 31 January 2025. The Masters Dissertation Prize is a prize of £500 awarded annually by the BGA for the best Masters' degree dissertation on a geotechnical topic. https://www.britishgeotech.org/call-for-entries-for-the-bga-2024-masters-dissertation-prize-2/

Proposal for the BGA to become an incorporated charity 07.01.2025

Proposal for the BGA to become an incorporated charity, the BGA welcomes comments from BGA members by 31 January 2025 https://www.britishgeotech.org/proposal-for-the-bga-to-become-an-incorporated-charity/

Fin Jardine 07.01.2025

The BGA is very sad to report that Finlay (Fin) Jardine passed away over the Christmas period https://www.britishgeotech.org/fin-jardine/

Finalists Announced for the 56th Cooling Prize Competition 2025 11.01.2025

The British Geotechnical Association (BGA) is pleased to announce the finalists for the 2025 Cooling Prize Competition to be hosted by the Yorkshire Geotechnical Group in Leeds on 11 February 2025. https://www.britishgeotech.org/finalists-announced-for-the-56th-cooling-prize-competition-2025/

BGA Knowledge Support Fund – Applications Welcome All Year Round 12.01.2025

The BGA is delighted to announce that our Knowledge Support Fund Award submission deadlines have been removed, and applications are welcome all year round. https://www.britishgeotech.org/bga-knowledge-support-fund-applications-welcome-all-year-round/

The Rankine Dinner student lottery is open for registration 15.01.2025

The BGA is pleased to announce a new scheme whereby a limited number of free student places will be made available for the Rankine Dinner, held after the Rankine Lecture. Applications close: Midnight on 14 February 2025. https://www.britishgeotech.org/the-rankine-dinner-student-lottery-is-open-for-registration/

The January/February 2025 issue of Ground Engineering is available on line 16.01.2025

The January/February 2025 issue of Ground Engineering is available on line. Online access to Ground Engineering (GE) is included in BGA subscriptions https://www.britishgeotech.org/the-january-february-2025-issue-of-ground-engineering-is-available-on-line/

Gerwyn Price 21.01.2025

The BGA is sad to announce that Gerwyn Price, formerly of the BRE Geotechnics Division, and Founder and Director of the I&M firm, CMCS, has died at his home in Wales, aged 87. https://www.britishgeotech.org/gerwyn-price/

Professor Andrew Schofield 28.01.2025

The BGA is sad to announce the death on the 27th January 2025 of Emeritus Professor Andrew Schofield FRS FREng at the age of 94. https://www.britishgeotech.org/professor-andrew-schofield/

News
www.geoinstitute.org/news

Former ASCE president honored with 2025 Karl Terzaghi Award 2/12/2024

ASCE has honored **Jean-Louis Briaud**, Ph.D., P.E., BC.GE, Pres.21.ASCE, with the 2025 **Karl Terzaghi Award** for his outstanding contributions to the fundamental understanding of soil erosion, foundation engineering design and construction, and development of pressuremeter testing.

Briaud is a pioneering figure in geotechnical engineering, with a career spanning 50 years marked by significant contributions to soil mechanics and erosion control. His innovative work in pressuremeter testing, particularly the development of the TEXAM device, revolutionized in situ soil testing by offering simpler yet effective methods for assessing soil properties. This technology has been widely adopted globally, influencing foundation design and construction practices.

In the realm of soil erosion, Briaud's invention of the Erosion Function Apparatus (EFA) stands out. The EFA has become a fundamental tool in studying and mitigating soil erosion, particularly in critical applications like bridge scour, levee overtopping, and cliff erosion. Briaud's methodologies for calculating scour depth at bridges are incorporated into the Federal Highway Administration's design guidelines, showcasing the practical impact of his research.

Beyond his technical contributions, he has demonstrated exceptional leadership and service to the profession, holding presidential roles in prestigious organizations such as the Geo-Institute and the International Society for Soil Mechanics and Geotechnical Engineering. His dedication to education and mentorship has shaped the careers of many geotechnical engineers who are now leaders in academia and industry. His prolific output of influential publications and his numerous international awards underscore his profound impact on geotechnical engineering. Briaud's work exemplifies the spirit of the Karl Terzaghi Award, honoring innovative research and its application to real-world engineering challenges.

The Karl Terzaghi Award is presented for outstanding contributions to knowledge in the fields of soil mechanics, subsurface and earthwork engineering, and subsurface and earthwork construction.

https://www.asce.org/publications-and-news/civil-engineering-source/article/2024/12/02/former-asce-president-honored-with-2025-karl-terzaghi-award

ΔΙΑΚΡΙΣΕΙΣ ΕΛΛΗΝΩΝ ΓΕΩΤΕΧΝΙΚΩΝ ΜΗΧΑΝΙΚΩΝ

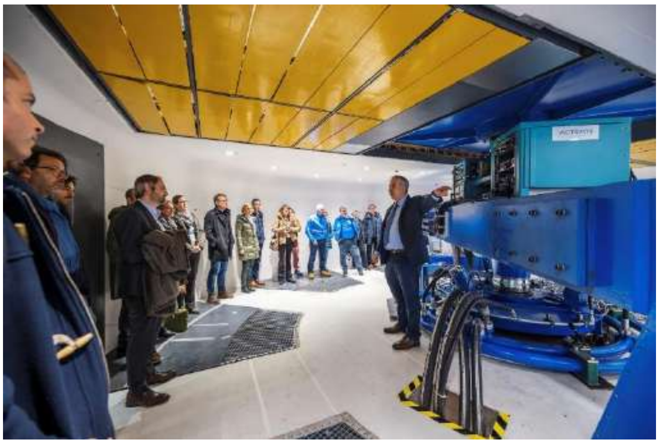
Professor Ioannis Anastasopoulos
Chair of the Institute for Geotechnical Engineering
ETH Zurich

After a long 7-year journey, on Friday 17th January 2025 (marking the 30th anniversary of the 1995 Great Hanshin Earthquake) the Inauguration event of the ETH Zurich Geotechnical Centrifuge Centre (GCC) took place in the Hönggerberg campus. The event included:

- Opening addresses by Prof. Dr. Ulrich Weidmann (Vice President for Infrastructure and Sustainability) and Prof. Dr. Alexander Puzrin (Head of Institute for Geotechnical Engineering)
- Presentation of the GCC by Prof. Dr. Ioannis Anastasopoulos
- Short presentations of first experimental results by research teams that used the facility in the last 1.5 years
- A test flight (broadcasted to the lecture room)
- Guided tours of the GCC

We would like to thank all participants for their active involvement, making it a successful event!

A video recording of the event is available in our YouTube channel: https://lnkd.in/exzepNmi



ETHZ Geotechnical Centrifuge Center Inauguration event
https://www.youtube.com/watch?v=JoR3jzx3XXg

(ETH Chair of Geotechnical Engineering, 31 January 2025)

I am very proud for the noble, enormous accomplishment by my dear friend Ioannis Anastasopoulos, and deeply honoured by his kind invitation to attend the inauguration of a breath-taking facility.

ETH of Zurich, and more specifically its Geotechnical Department headed by Yannis, demonstrated the largest -in terms of combined capacity in G's times load- centrifuge in Europe; and of the greatest worldwide.

A new era is marked in terms of possibilities on testing soil behaviour, interaction with constructed facilities under earthquake and developed dynamic phenomena, and so on, at reasonable cost, and sufficient real-scale approximation.

A notable contribution to the science / research fields and, eventually, humanity.

I take with me all insights, utilizing these in the development path systematically attended to by our company. Truly proud, thank you John for honouring me with a strong, long-lasting friendship which counts by now 30 years! Warm, sincere congrats to all contributors and faculty and researchers in ETH.

https://lnkd.in/djy8a53u

(Dimitris Katsochis • Senior Manager/Transportation Executive, 18.01.2025)

Spinning for science

Planning and building Europe's largest capacity geotechnical centrifuge took seven years. Now, after one and a half years of operation, its official inauguration is finally being celebrated at the Hönggerberg campus. And it's no coincidence that this is happening in mid-January.

Measuring nine metres across and with a capacity of 500 gtonnes, the ETH Zurich geotechnical centrifuge has the biggest capacity in Europe. (Image: Ioannis Anastasopoulos / ETH Zürich)

In brief

- Europe's largest capacity geotechnical centrifuge is being inaugurated at the Hönggerberg campus.
- The centrifuge is able to accelerate models so quickly that they are subjected to up to two hundred and fifty times the Earth's gravity.
- This piece of equipment makes a vital contribution to research on infrastructure exposed to the forces of nature.

A giant metal door leads to a bright, circular underground room. This is home to the crowning glory of the Geotechnical Centrifuge Center (GCC): the blue beam centrifuge, measuring a total of some nine metres. Constructing this research facility was no mean feat – but the builders rose to the challenge. To prevent interference with highly sensitive measurements in laboratories surrounding the GCC, the centrifuge chamber is vibration-isolated and rests on four steel spring units. Europe's largest-capacity centrifuge has been operational and delivering research data since June 2023, but now ETH Zurich is celebrating this extraordinary piece of infrastructure on a very special date.

This is a day that Ioannis Anastasopoulos, Professor of Geotechnical Engineering and Head of the Department of Civil, Environmental and Geomatic Engineering at ETH Zurich, has been anticipating for a long time. It's no coincidence that the inauguration of the centrifuge falls precisely on 17 January 2025. While Anastasopoulos didn't want to turn up to this ceremony empty-handed, preferring instead to have some first research results to present, this date is of great personal significance to him. It is the 30th anniversary of the 1995 Great Hanshin Earthquake, which devastated the city of Kobe in Japan. At the time of the disaster, Anastasopoulos was a civil engineering student. The event was instrumental to his future career, as it led to the decision to dedicate himself to geotechnical earthquake engineering.

He and his team use the centrifuge to conduct research into how buildings and civil engineering structures, including their foundations and the underlying soil, behave when exposed to the various forces of nature. To do this, they create reduced-scale models and place them at one end of the spinning beam centrifuge. The models are then accelerated so strongly that the g-forces acting on them multiply. In this process, the models are exposed to forces of up to 100 g – in other words, one hundred times the Earth's gravitational force. Scaleddown models of the ground cannot accurately represent reality, as the stresses in the ground are much smaller than those in real life, which affects the properties of the tested soil material. The increased gravitational field of the centrifuge multiplies the developing stresses in the model, reflecting real-life conditions, making this the only way to achieve realistic results.

Giving new life to an old centrifuge

While this may look like ultra-modern research infrastructure, it in fact already has a few stories to tell from its past life. ETH made the conscious decision not to acquire a new centrifuge, but rather to buy a centrifuge from Ruhr University Bochum that had been decommissioned. Although a complete overhaul was needed and new parts had to be fitted, this approach only cost around one-quarter as much as purchasing a new centrifuge of the same capacity.

Professor Ioannis Anastasopoulos and his laboratory manager, Ralf Herzog, on the Krupp centrifuge, stored in Kreuztal, Germany. (Image: Ioannis Anastasopoulos / ETH Zürich)

Refurbishing and modernising a centrifuge of this size is a daunting task. The refurbishment was performed in parallel to the construction of the facility at Hönggerberg. Both were delayed by the Covid pandemic and resulting supply-chain disturbances. But despite all these challenges, the centrifuge was put into operation just one year later than originally planned. For Anastasopoulos, this was a resounding success: "At times, we weren't sure when the centrifuge would actually be up and running, and quite a few projects depend on it. So we are happy to be able to produce some first experimental results."

A whirlwind of activity

The new "old" centrifuge has been in action for some eighteen months and is operating at full capacity. It is generally used to conduct one to three tests per week. Anastasopoulos is supported by a team of 10-15 researchers and technicians, all working to ensure that experiments can be conducted and that the centrifuge functions properly.

The frequency of the experiments depends on the complexity of the model being tested. Preparing the model takes up most of the time, because the structural and geotechnical conditions have to be reproduced as realistically as possible. Thanks to the additional g-forces generated by this extraordinary centrifuge, effects that take years to manifest in the real world can be simulated in a matter of just a few hours.

Wind farms, bridges, Brienz and Leimbach

The centrifuge can be put to a multitude of uses. One example of research currently being conducted at the GCC is related to the foundations of offshore wind turbines, which are crucial for the transition to renewable energy. Far out at sea, wind turbines are exposed to all kinds of natural hazards. Exposed to storms and earthquakes, such structures are prone to tilting, which calls for our improved understanding of their mechanical response. An inclination of just 0.5 degrees can damage the mechanical systems and greatly reduce the service life of a wind farm.

Markus Iten, a centrifuge technician, makes the final preparations before testing a model of a monopile supporting an offshore wind turbine. (Image: Ioannis Anastasopoulos / ETH Zürich)

Offshore wind farms are a rare sight in Switzerland, but the same can't be said for bridges. The country certainly has its fair share of them. Their vast majority (over 90%) were built before the '90s, are of merely "basic" seismic design and are in need of a seismic retrofit. Moreover, existing bridges need to be widened to accommodate increasing mobility volumes. While a bridge pier retrofit is relatively straightforward, foundation strengthening can be challenging, costly and time-consuming. This is especially true of pile groups, which are commonly used for bridges. This is where the research work of Anastasopoulos and his team comes into play: "Our centrifuge tests are vital to the safety of our transportation infrastructure. The centrifuge experiments can lead us to develop innovative solutions that minimise our carbon footprint and the cost of a foundation retrofit, while improving seismic safety."

In the canton of Graubünden, the entire village of Brienz is under threat from ground movements, while the Leimbach area of Zurich is constantly moving due to a slow creeping landslide. Here, the centrifuge could help us to better understand the causes of failure and the processes that lead to such massive movements, contributing to the quantification of risk for the affected population.

With such diverse research topics and areas of application, it's clear that the centrifuge has a busy future ahead.

(Noe Lüthi, Media Relations, Corporate Communications / ETH, 17.01.2025, https://ethz.ch/en/news-and-events/eth-news/news/2025/01/spinning-for-science.html)

ΠΡΟΣΕΧΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΚΔΗΛΩΣΕΙΣ

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

We are pleased to announce that the 2025 Pre-Rankine seminar on March 19th will honour our former colleague Dr. Angus Skinner. Details will shortly be finalized, but we can confirm Prof. Jamie Standing will chair the event and reflect on Angus' contributions. Other presenters include Cacin PY Wong, Catherine O'Sullivan, Hight David, Minna Karstunen, Sam Steiner, and Truong Le. This event will be followed by the 2025 British Geotechnical Association Rankine Lecture by Prof. Kenichi Soga. The seminar is co-sponsored by TC105-ISSMGE and the British Geotechnical Association

Geotechnical Engineering • Administrator at Imperial College London, 15 January 2025

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Earthquake & Geotechnical Engineering, 1° Ρουμανο-Ελληνικό Σεμινάριο επί Σεισμικής και Γεωτεχνικής Μηχανικής, 27 Μαρτίου 2025, Βουκουρέστι, Ρουμανία

ROCSCIENCE INTERNATIONAL CONFERENCE 2025, April 6-8, 2025, Sydney, Australia, www.rocscience.com/events/rocscience-international-conference-2025

4th International Conference on TRANSDISCIPLINARY MULTISPECTRAL MODELLING AND COOPERATION FOR THE PRESERVATION OF CULTURAL HERITAGE Addressing World Challenges, 7-9 April 2025, Athens, Greece, https://www.tmm-ch.com

International Conference on Advances in Structural And Geotechnical Engineering (ICASGE'25), 14 - 17 April 2025, Hurghada, Egypt https://icasge.conferences.ekb.eg

Ground Engineering Piling and Foundations 2025, 22 April 2025, Lonfon, United Kingdom https://piling.geplus.co.uk/GEPI2025/en/page/home

World Tunnel Congress 2025 "Tunnelling into a sustainable future – methods and technologies", 9-15 May 2025, Stockholm, Sweden, www.wtc2025.se

GEOTECHNICS REIMAGINED, May 21-23, 2025, Bruges, Belgium, https://dfi-events.org/dfi-effc25

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www.icold-cigb2025.com

The 28th ICOLD Congress & 93rd Annual Meeting will take place from May 16th to 23rd, 2025, in Chengdu, China. On behalf of the organizing committee and the Ministry of Water Resources of the People's Republic of China, I sincerely invite colleagues and organizations from the international dam industry to participate in this academic event with the theme of "Common Challenges, Shared Future, Better Dams", to jointly promote scientific innovation, technological progress and high-quality development of the dam industry.

Reservoirs and dams are critical foundation for water security. They buttress flood control and drought relief, water resources regulation and storage, water ecosystems and environment restoration, clean energy supply, and climate change actions. Guided by China's central water governance principles of prioritizing water conservation, balancing spatial distribution, taking systematic approaches, and promoting government-market synergy, the Ministry of Water Resources of the People's Republic of China attaches great importance to the construction and operation management of reservoirs and dams. Their roles are indispensable in the basin-scale flood control engineering systems, the national water network and the ecological restoration in rivers and lakes. Therefore, China will continue to improve the scientific construction, efficient operation, intelligent management, and safety protection of reservoirs and dams so that they can generate comprehensive economic, social, ecological, and safety benefits.

ICOLD Congress is the most professional and influential academic conference in the international dam society, with the purpose of advocating the international community to work together to strengthen multilateral cooperation and exchanges, and jointly promoting "Better dams for a better world". Chengdu congress will provide diverse opportunities to promote the international technical cooperation in the field of dams and reservoirs to a new level, and also play a critical role in promoting dam technology in the world. With all my confidence, it will be a grand meeting for participants from all member countries to sum up the past and look forward to the future.

Congress Questions

Full papers for the 28th ICOLD Congress will be organized by National Committees. The questions for the Congress are the following:

Question 108: Dams and reservoirs for climate change adaptation

1. Dams for Pumped Storage: specific features, design, examples of implementation
2. Off-river dams for water storage and flood protection
3. Offshore dams and tidal power plants
4. Dams for recharge of aquifers and other new concepts
5. Floating solar on dam reservoirs - opportunities and risks

Question 109: Dams and levees fit for the future

1. Management of an aging portfolio of dams in terms of operation, maintenance and rehabilitation, including risk-based approaches
2. Safety during construction and rehabilitation
3. Special case for small dams and levees
4. Impact of contracting practices on dam safety (e.g. private sector involvement, EPC contracts)
5. Increasingly difficult sites - dams and their new challenges
6. Need for global capacity building

Question 110: Safety of dams and levees facing extreme hydrological events

1. Assessment of extreme events (e.g. floods, droughts, typhoons/hurricanes, glacial lake outburst floods) in the context of climate change, accounting for uncertainty
2. Assessment for the safety of structures for extreme floods; management options(e.g. increasing dam height, spillway capacity, reservoir operation)
3. Flood forecasting, hydraulic management of multiple projects within river systems
4. Reassessment of the flood data and mitigation e.g. fuse devices, overflow resistance, controlled breach formation, warning and evacuation, crisis and emergency management

Question 111: Earthquake performance and safety of dams

1. Static, seismic and post-seismic monitoring of dams
2. Feedback from earthquake failures, including tailings dams and levees
3. Importance of multiple features of earthquake hazard (e.g. ground shaking, surface fault movements, mass movements)
4. Seismic design and performance criteria for dam structure, reservoir rim and impacted area
5. Earthquake safety evaluation of all types of dams and safety-critical elements (e.g. spillways, low-level outlets)

Technical Topics

T1: Precautionary management of dams and river basin under climate change

Considering the changes in hydrological conditions due to climate change and the increasing frequency of extreme weather events, the following aspects related to safety of reservoir dams and river basin will be discussed:

- Evaluation of the flood control standards and improvement of structural design for reservoir dams
- Real-time hydrological monitoring and forecasting warning technologies
- New requirements and adjustment of operation and dispatching
- Risk assessment and emergency plan
- Innovation and state-of-the-art technologies for small dams and small reservoirs

T2: Multifunctional development of dams and reservoirs

Regarding the new requirements for reservoir dams, such as regional economic development and ecological environment improvement, the following aspects will be discussed:

- The ecological compensation of reservoir dams, including downstream river channel shaping and ecological restoration through reservoir dispatching
- The multifunction of downstream urban water supply, shipping, leisure tourism, and etc.
- The technologies for new functional changes and engineering renovations of built reservoirs and dams.
- Changes in operation and upgrading technologies for existing reservoir dams
- Decision tools and technological innovations for the multifunctional operation and dispatching

T3: Technologies for dam design and construction under complex (extreme) conditions

Focus on dam design and construction techniques under complex geological conditions, strong earthquake zones or high-altitude conditions, the following aspects will be discussed:

- The technologies for geological exploration, foundation or high slope treatment
- Research on dam materials
- Innovation in dam structure design
- Construction technologies and new equipment in complex conditions

T4: Digital technology applied in dams and digital river basins

Focus on the digital technology application in design, construction, operation and maintenance of dams, the following aspects will be discussed:

- Digital design technologies, including BIM design
- Intelligent construction control system and self-driven equipment
- Intelligent operation, detection, maintenance technologies
- Remote sensing prediction and forecasting of rainfall-flood, simulation of flood scenarios, and their application in intelligent dispatching of river basins
- Digital twin dam or river basin: applications and typical cases

T5: The role of dams in achieving the goal of reducing carbon dioxide emissions

Focus on the role of dams in energy transition and achieving the goal of reducing carbon dioxide emissions, case experience and study results sharing will be included with following aspects:

- Function of hydropower in new power systems

- The regulatory role of hydropower to wind/solar energy volatility
- Spatial time complementarity of different renewable energies
- Changes of reservoir dispatching modes and technological innovation
- Pumped Storage Power Stations and development prospect

Secretariat of ICOLD 2025 Congress
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Website: www.icold-cigb2025.com

ISFOG 2025 5th International Symposium on Frontiers in Offshore Geotechnics, June 9-13, 2025, Nantes, France, https://isfog2025.univ-gustave-eiffel.fr

GeoAsia - 8th Asian Conference on Geosynthetics, 10-13 June 2025, Brisbane, Australia, https://geoasia8.org

EGRWSE-2025 6th International Conference on Environmental Geotechnology, Recycled Waste Materials and Sustainable Engineering, June 11-14, 2025, Vigo, Spain, https://egrwse2025.webs.uvigo.es/

EUROCK 2025 - ISRM European Rock Mechanics Symposium Expanding the underground space - future development of the subsurface - an ISRM Regional Symposium, 16-20 June 2025, Trondheim, Norway, https://eurock2025.com

3rd International Conference on Energy Geotechnics – Implementing the Energy Transition, 17-20 June 2025, Paris, France, Kamelia Atefi-Monfared, catefi@yorku.ca

5ICGE & 3ICESE 5th International Conference on Geotechnical Engineering-Iraq & 3rd International Conference on Engineering Science & Energy, 1–3 July 2025, 3 July 2025, Komar University, Sulymaniyah, Iraq, https://icge.tech

6th International Conference GEE2025: Charting the path toward the future Geotechnical Engineering Education, July 2-4 2025, Nancy, France, https://gee2025.sciencesconf.org/

The Fifth International Conference and Exhibition on Water Storage and Hydropower Development for Africa
8-10 July 2025, Accra, Ghana
www.hydropower-dams.com

Africa continues to be the region of the world with the greatest need for more clean renewable energy, multipurpose reservoirs, infrastructure that is resilient to climate change, and capacity building to help exploit the vast potential available. At least 36 African nations have annual per capita electricity consumption of less than 500 kWh, according to World Bank data; for several countries it is less than 100 kWh. It is well recognised globally that this has to change.

Conference Themes

The topics below represent a broad range of themes that we aim to cover at the conference, but they are not final session titles, which will be determined later, depending on the level of interest in the various subjects. If you would like to suggest a related topic not listed below, please feel free to do so, and it can be considered for a session, or incorporated in a workshop.

Future plans for water resources and hydro development in Africa …

Addressing risk and project financing …

Climate, environment and social aspects …

Civil engineering: innovation and challenges

- Innovations in dam engineering
- Safety of dams, spillways, gates and powerplants
- Monitoring and surveillance systems
- Design of flood discharge works
- Hydrological monitoring of rainfall and runoff
- Sedimentation of reservoirs and irrigation canals
- Upgrading of dams and associated structures
- Complicated construction and challenging sites
- Materials for dams
- Dealing with AAR and ASR

Multipurpose schemes …

Hydropower, large and small: the role, benefits and technology …

Conference team, Aqua~Media International:
africa2025@hydropower-dams.com

Aqua~Media International Ltd, PO Box 285, Wallington, Surrey SM6 6AN, UK. Tel: +44 20 8773 7244

ISGSR2025 9th International Symposium for Geotechnical Safety and Risk, 24th – 27th August 2025, Oslo, Norway, www.isgsr2025.com

Giz2025.org 6th International Conference on GIS and Geoinformation Zoning for Disaster Mitigation (GIZ), August 28-30, Almaty, Kazakhstan, https://giz2025.org

UNSAT2025 5th European Conference on Unsaturated Soils, 1 to 3 September 2025, Lisbon, Portugal, https://eunsat2025.tecnico.ulisboa.pt

Symposium International pour le 70ème anniversaire du pressiomètre / International Symposium for the 70th Anniversary of the Pressuremeter, 2nd to 5th of September 2025, LUXEMBOURG, https://isp8-pressio2025.com

TKZ2025 XXI Technical Dam Control International Conference, 09-12 September 2025, Chorzów, Poland https://tkz.is.pw.edu.pl/en/

EUROGEO Technical Challenges and Environmental Imperatives for the 21st Century, 15-18 September 2025, Lille, France, https://eurogeo8.org

TRANSOILCOLD 2025 7th International Symposium on Transportation Soil Engineering in Cold Regions, September 17-20, 2025, Incheon, Korea, www.transoilcold2025.org

2025 AIGTAS IWLSC 3rd International Workshop on Landslides in Sensitive Clays, September 28th to October 2nd, 2025, Quebec, Canada www.iwlsc2025.ca

https://www.geplus.co.uk/news/ground-engineering-to-launch-geotech-2025-conference-where-innovation-meets-opportunity-16-01-2025

As the construction and infrastructure industries face growing challenges – from sustainability demands and climate resilience to increasingly complex projects – **geotechnical engineering is playing a pivotal role in finding solutions**. Technologies such as smart sensors, real-time data analytics, automated monitoring systems, and machine learning are revolutionising how geotechnical professionals operate.

GeoTech is designed to be the premier platform for exploring these advances and fostering collaboration among engineers, contractors, consultants, clients and technology providers. **This event is not only about showcasing achievements but also about creating a forward-thinking space where ideas turn into action, and innovation becomes reality.**

Event enquiries

Lydia Katsipi 020 3953 2657, lydia.katsipi@emap.com

GEOTECH ASIA 2025 - GEOVADIS: The Future of Geotechnical Engineering, October 7th to 10th, 2025, Goa, India, https://www.geotechasia.org

fOMLIG3 FLORENCE 2025 Third Workshop on the Future of Machine Learning in Geotechnics "Ethics and intelligences for a geotechnical Renaissance", October 15-17, 2025, Florence, Italy https://fomlig2025.com

Urban GeoEngineering 5th AsRTC6 "Urban GeoEngineering" Symposium, 23rd & 24th of October 2025, Taipei, Taiwan, www.asrtc6urbangeoengineering2025.com/index.html

17th International Conference on Geotechnical Engineering 8th International Symposium on Geohazards, December 4-5, 2025, Lahore, Pakistan, https://17icge-8isg.com

PMGEC LEBANON 2025

Pan Mediterranean
Geotechnical Engineering Conference
25 - 28 March 2026, Phoenicia Beirut IHG, Lebanon
https://pmgec-leb.com

The Lebanese Geotechnical Engineering Society (LGES) is pleased and honored to invite you to the Inaugural Pan Mediterranean Geotechnical Engineering Conference (PMGEC) to be held in Beirut, Lebanon between the 25th and the 28th of March 2026. Save the dates on your calendar!

This new series of conferences launched by the current president of ISSMGE, Dr. Marc Ballouz, has been an idea among geo-professionals from the Mediterranean countries for years and has now become reality. The pan-mediterranean geotechnical engineering conference would be hosted every 4 years by a Mediterranean country under the auspices of the ISSMGE.

The inaugural PMGEC in Lebanon will provide an exceptional opportunity to foster professional growth, knowledge exchange, and collaboration within the geo-engineering community around the Mediterranean as well as from all around the world. Expect top Keynote lecturers, advanced technical sessions, and exciting panel discussions that will showcase the rich history in geotechnical engineering research, design and practice across the Mediterranean. We cant wait to show you our country.

Overlooking the Mediterranean Sea, exuding majesty and grandeur, the conference venue at the historical Inter-Continental Phoenicia Beirut, stands proudly at the heart of Lebanon's capital city. Its only a few minutes from the city's Downtown business district, across from the famous Saint George beach resort with its pools where we will be having our gala dinner. The beach walk promenade by the Zaitouna bay and marina is right there, with dozens of exquisite restaurants along the bay and in downtown. where Mediterranean and international cuisines awaits you , not to forget major shopping areas nearby with the ease of grabbing cheap taxis. In April, the weather is best for outdoor activities, like eco tourism , visit archaeological sites , and enjoy the Mediterranean sunshine. In addition, as a bonus, Beirut nightlife is the best in the world (according to CNN). The conference location is perfect for a memorable family trip and we are keen to give you an extremely technically striking but also incredibly enjoyable experience.

1st PMGEC Promotion by ISSMGE President Marc Ballouz:

https://www.youtube.com/watch?v=d9GVCuPeXSU

LANDSLIDES 2026 Landslide Geo-Education and Risk (LaGER), 27 April - 1 May 2026, Queenstown, New Zealand http://landsliderisk.nz

ITA-AITES WTC 2026 Montréal

https://wtc2026.ca

On behalf of the Canadian Tunnelling Association and the 2026 World Tunnel Congress Organizing Committee, I'm pleased to extend my warmest greetings and invite you to take part in this not-to-be-missed event, which will take place from May 15 to 21, 2026, in Montreal, Quebec, Canada.

Montreal is an island at the confluence of the St. Lawrence and Ottawa rivers. Steeped in history yet at the same time a dynamic technological crossroads, Montreal holds THE top spot as a host city for international congresses in America, for many reasons: its legendary safety, its cultural dynamism (more than 30 languages are spoken here), its world-renowned gastronomy, not to mention underground Montreal and its 33 km-long pedestrian network.

The event will be held at the Palais des congrès de Montréal, one of the world's most renowned convention and exhibition centers, thanks to its event technologies, ultramodern spaces and exceptional organization services. The site features a vast exhibition area showcasing new technologies, original products and services related to underground construction. The exhibition, technical program and state-of-the-art conference setting will encourage interaction and the exchange of ideas.

The conference theme, "Connecting communities through underground infrastructure", addresses the vital role the tunnelling industry plays in connecting our communities through underground infrastructure. This enables the industry to build underground networks of transportation, water and sanitation, utilities and energy that cross, connect and unite cities, regions and continents.

WTC 2026 aims to bring together our international community of tunneling practitioners to share their experience and knowledge to make our projects safer, more economical, more resilient and more sustainable. It will not only generate considerable benefits for the tunnelling industry in Montreal, the province of Quebec and Canada as a whole, but will also promote Canadian expertise.

The scientific program, technical sessions and social activities will enable delegates to participate in exchanges, acquire new knowledge and establish new contacts with professionals from all over the world.

21st International Conference on Soil Mechanics and Geotechnical Engineering Geotechnical Challenges in a Changing Environment, 14 – 19 June 2026, Vienna, Austria, www.icsmge2026.org/en

Eurock 2026
Risk Management in Rock Engineering - an ISRM Regional Symposium
14-19 June 2026, Skopje, Republic North Macedonia

Contact Person Name

Prof. Milorad Jovanovski

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ISFMG 2026 12th International Symposium on Field Monitoring in Geomechanics, 06 -10 August 2026, Indian Institute of Technology Indore, India, https://sites.google.com/view/isfmg2026/home

International Conference on
Advances and Innovations in Soft Soil Engineering 2026
24-26 August 2026, Delft, Netherlands

As global land development expands into coastal regions, offshore reclamation areas, and wetlands, the geotechnical challenges posed by soft soils are becoming more critical. These soils, including highly sensitive clays, marine silty clays, organic soils, peats, loose sands, and dredged soils, are known for their high compressibility, water content, and complex mechanical properties, making construction projects in such areas problematic. To address these challenges, soft soil engineering is evolving with innovative technologies and approaches.

This conference, organised under the auspices of the ISSMGE Technical Committee 214 on "Foundation Engineering for Difficult Soft Soil Conditions", will showcase the latest developments in testing, modelling, monitoring and construction and improvement techniques for soft soils. It will provide a platform for researchers, engineers, and industry professionals to exchange expertise and discuss how these innovations can be applied to address modern construction challenges in soft soil environments.

Contact Information

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X Latin American Congress on Rock Mechanics
26 - 28 Aug, 2026, Brsasilia, Brazil

Contact Person: Marcos Massao Futai, Brazilian Committe of Rock Mechanics

13th International Conference on Geosynthetics (13 ICG)
13-17 September 2026, Montréal, Canada
www.13icg-montreal.org

The 13th International Conference on Geosynthetics (ICG) 2026, hosted by the North American Chapter of the International Geosynthetics Society (**IGS-NA**), is themed "Legacy, Evolution & Revolution in Geosynthetics." The theme reflects the many transitions occurring in the field, in our shared responsibility to climate and society, and in how we respond to the challenges and opportunities presented to us by these transitions.

The **13th International Conference on Geosynthetics (13 ICG)** will bring together more than 1,000 leading civil engineers, researchers, regulators, material manufacturers, and sustainability and climate change experts for days of technical exchange, best practice sharing, and commercial development around geosynthetic materials in **Sustainability, Transportation Infrastructure, Climate Change Response, Mining, Energy, Environmental Protection,** and more.

Topics

T1 – Sustainability with Geosynthetics
T2 – Geosynthetics Properties and Testing
T3 – Soil-Geosynthetic Interaction
T4 – Durability and Long-Term Performance
T5 – Reinforced Walls and Slopes
T6 – Reinforced Embankments, GEC, Piles and Shallow Foundations
T7 – Seismic Design with Geosynthetics
T8 – Unpaved and Paved Roads
T9 – Geosynthetics in Roads, Railways and Airfields
T10 – Landfills and Remediation of Contaminated Sites
T11 – Filtration and Drainage
T12 – Erosion Control and Coastal Applications
T13 – Hydraulic Applications: Canals, Reservoirs and Dams
T14 – New Technologies for Advancing Geosynthetic Understanding
T15 – Exemplary Designs & Case Histories
T17 – Energy and Mining Applications
T18 – Tunnels and Underground Constructions
T19 – Geosynthetics in Extreme Environments of Service
T20 – Microplastics
T21 – Climate Change / Carbon Footprint
T22 – Innovative Design
T23 – Probabilistic Geosynthetic Design
T24 – Machine Learning and Artificial Intelligence
T25 – Circularity in Geosynthetics: Recycling and Use of Recycled Plastics
T26 – Use of Non-Synthetic Polymers and Fibers
T27 – Software for Civil Design with Geosynthetics

International Symposium Preservation of Monuments & Historic Sitew, 16 – 18 September 2026, Athens, Greece https://tc301-athens.com

6th International Conference on Information Technology in Geo-Engineering JTC2 Conference
13-16 October 2026, Oslo, Norway

The 6th International Conference on Information Technology in Geo-Engineering (6th ICITG) will be an arena to discuss all topics related to the ongoing digital transformation in Geo-Engineering. Case studies of IT in Geo-Engineering, integration of digital systems (Scan2BIM, BIM2FEM, etc.), benchmark datasets, information modelling, monitoring technology and artificial intelligence are some of the key topics of the 6th ICITG. It is organized under the auspices of the Joint Technical Committee 2 (JTC2) on "Representation of Geo-Engineering Data" of the Federation of International Geo-Engineering Societies (FedIGS).

Contact: Joint Technical Committee 2 (JTC2), Norwegian Geotechnical Institute, Graz University of Technology, georg.erharter@ngi.no

International Conference on Performance-Based Design in Earthquake Geotechnical Engineering
November 4th to 6th, 2026, Puerto Varas, Chile
www.pbd-v-chile.com

On behalf of the Chilean Organizing Committee, it is my honor to invite you to the INTERNATIONAL CONFERENCE ON PERFORMANCE-BASED DESIGN IN EARTHQUAKE GEOTECHNICAL ENGINEERING, to be held in the charming city of Puerto Varas from November 4th to 6th, 2026. This event is a unique opportunity for industry leaders, experts, and enthusiasts to gather, share knowledge, and shape the future of the earthquake geotechnical engineering sector.

Conference Theme

One of the pressing needs in geotechnical earthquake engineering is the development of performance-based design (PBD) principles. These principles, already in use for the seismic design of structures under strong earthquakes and other infrastructure under different hazards, are rapidly evolving. Practical and reliable performance-based designs in geotechnical engineering are not just theoretical but necessary for a wide range of civil engineering projects.

TOPICS

1. Case histories on site effects, embankments and slopes, earth and tailings dams, surface fault rupture, MSWLF performance, and other geohazards.
2. Underground structures and soil-structure interaction, including shallow foundations and pile foundations.
3. Soil investigation with field and laboratory testing for performance-based design.
4. Dynamic characterization and modeling of soils for performance-based design.
5. Numerical analyses for performance-based design.
6. Methodology of performance-based design.
7. Recent developments in PBD codes.
8. Advances in soil liquefaction.

ARMS14
14th Asian Rock Mechanics Symposium - ARMS14, an ISRM Regional Symposium
22-26 November 2026, Fukuoka, Japan

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16th International Congress on Rock Mechanics
Rock Mechanics and Rock Engineering Across the Borders
17-23 October 2027, Seoul, Korea

Scope

The scope of the Congress will cover both conventional and emerging topics in broadly-defined rock mechanics and rock engineering. The themes of the Congress include but not be limited to the following areas:

- Fundamental rock mechanics
- Laboratory and field testing and physical modeling of rock mass
- Analytical and numerical methods in rock mechanics and rock engineering
- Underground excavations in civil and mining engineering
- Slope stability for rock engineering
- Rock mechanics for environmental impact
- Sustainable development for energy and mineral resources
- Petroleum geomechanics
- Rock dynamics
- Coupled processes in rock mass
- Underground storage for petroleum, gas, CO2 and radioactive waste
- Rock mechanics for renewable energy resources
- Geomechanics for sustainable development of energy and mineral resources
- New frontiers & innovations of rock mechanics
- Artificial Intelligence, IoT, Big data and Mobile (AICBM) applications in rock mechanics
- Smart Mining and Digital Oil field for rock mechanics
- Rock Engineering as an appropriate technology
- Geomechanics and Rock Engineering for Official Development Assistance (ODA) program
- Rock mechanics as an interdisciplinary science and engineering
- Future of rock mechanics and geomechanics

Our motto for the congress is "Rock Mechanics and Rock Engineering Across the Borders". This logo embodies the interdisciplinary nature of rock mechanics and challenges of ISRM across all countries and generations.

XIXth European Conference on Soil Mechanics and Geotechnical Engineering
"Connecting Continents Through Geotechnical Innovations"
04-08 September 2028, Istanbul, Turkey

Conference Topics

01 Modelling and Experimental Assessment of Geomaterials

02 Geohazards, Earthquakes and Risk Mitigation

03 Development of Resilient and Sustainable Geosystems

04 Geotechnical Construction and Soil Improvement

05 Geotechnical Engineering of Multiscale Observations, Sensors and Monitoring

06 Energy Geotechnologies

07 Technological Innovation

08 Geo Education, Standards And Codes

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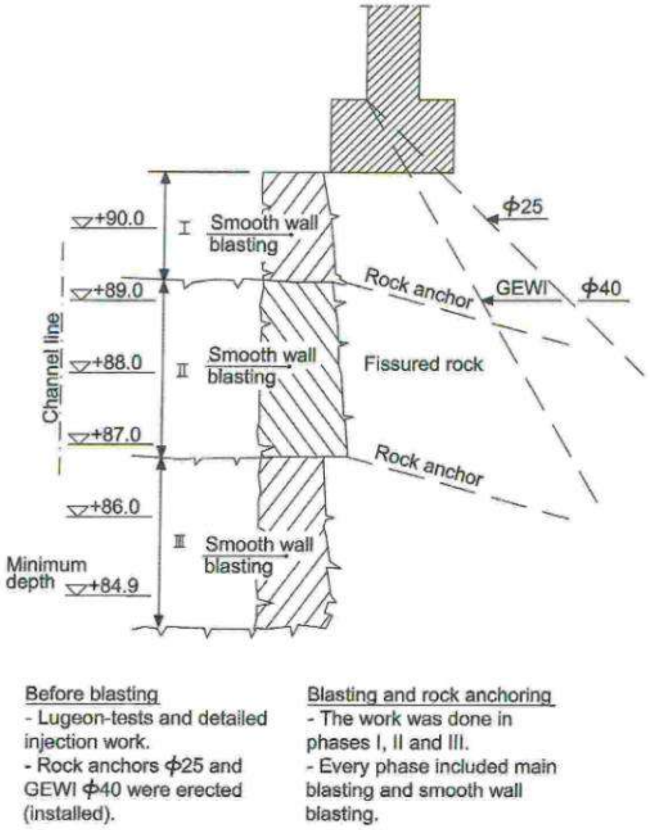
ΕΝΔΙΑΦΕΡΟΝΤΑ ΓΕΩΤΕΧΝΙΚΑ ΝΕΑ

Juankoski Channel
Ενδιαφέρον έργο υποθεμελίωσης γέφυρας

Juankoski: end of blasting process below bridge



Juankoski: blasting and rock strengthening underneath the bridge footing

Fig.: 2: Juankoski: built lock and part of the channel

(from Kari Avellan and Tarmo NUUinen "The Tahko Water Route; Juankoski and Karjalankoski Canals and Locks", PIANC Magazine No. 135, Aptil 2009, pp. 21-26, https://kareg.com/The Tahko water route.pdf)

ꙮ ꙮ

Έτοιμο το οδικό τούνελ των 22 χιλιομέτρων - Πού κατασκευάστηκε το έργο μαμούθ, ποιες περιοχές ενώνει

Tianshan Shengli tunnel

Σάρκα και οστά έλαβε η νέα μεγάλη κινεζική οδική σήραγγα η οποία, σύμφωνα με τα διεθνή ΜΜΕ, αποτελεί το μακρύτερο τούνελ ταχείας κυκλοφορίας στον κόσμο.

Την κατασκευή της **μεγαλύτερης οδικής σήραγγας ταχείας κυκλοφορίας στον κόσμο** ολοκλήρωσε τη Δευτέρα 30 Δεκεμβρίου η **Κίνα**, σηματοδοτώντας ένα σημαντικό ορόσημο σε επίπεδο υποδομών.

Το τούνελ, υπό την ονομασία "**Tianshan Shengli"** βρίσκεται στην Αυτόνομη Περιοχή των Ουιγούρων του Σιντζιάνγκ και μόλις παραδοθεί στην κυκλοφορία θα μειώσει τον χρόνο διέλευσης μέσα από την οροσειρά Τιεν Σαν από **3 ώρες** σε περίπου **20 λεπτά.**

Η σήραγγα θα **ενισχύσει θεαματικά τη συνδεσιμότητα** μεταξύ του βόρειου και νότιου Σιντζιάνγκ και θα επιτρέψει στην ευρύτερη περιοχή, που είναι στρατηγικής σημασίας για τον νέο Δρόμο του Μεταξιού, να διευρύνει περαιτέρω τη συνεργασία της με τις χώρες της Ευρασίας, όπως δήλωσε η τοπική κυβέρνηση.

Οι **εργασίες** διάνοιξης εκκίνησαν τον Απρίλιο του **2020**, με την κατασκευαστική ομάδα να καλείται γρήγορα να ξεπεράσει πλήθος δυσκολιών, όπως ήταν το **μέσο υψόμετρο** κατασκευής που ξεπερνούσε τα **3.000 μέτρα,** αλλά και οι **πολύπλοκες γεωλογικές συνθήκες.**

Η σήραγγα αποτελεί κρίσιμο κομμάτι του μήκους 319.72 χλμ. αυτοκινητοδρόμου **Urumqi-Yuli Expressway** και θα έχει καθοριστική συνδρομή στη μείωση του ταξιδιού μεταξύ των δύο τοποθεσιών σε 3, από 7 ώρες.

Ήταν η πρώτη φορά που χρησιμοποιήθηκε μηχάνημα διάνοιξης σηραγγών (tunnel boring machine) για την κατασκευή οδικής σήραγγας στην Κίνα, την ίδια ώρα που η χρήση ορισμένων σύγχρονων τεχνολογιών επέτρεψε στον εργολάβο να μειώσει τον χρόνο κατασκευής από 10 χρόνια σε μόλις 4. Το όνομα "Shengli" σημαίνει «νίκη», ενώ συνολικά **εργάστηκαν πάνω από 3.000 άνθρωποι.**

Σύμφωνα με τον Yang Dongdong, μέλος της κατασκευαστικής ομάδας, όσοι ενεπλάκησαν στη δημιουργία του τούνελ κατάφεραν να αντιμετωπίσουν πληθώρα δύσκολων περιστατικών όπως καταρρεύσεις τοίχων και εισροές νερού.

Από τη μεριά της, η κυβέρνηση επισήμανε ότι όλα τα **μηχανήματα** που επιστρατεύτηκαν για την αντιμετώπιση των «πρωτοφανών προκλήσεων» **αναπτύχθηκαν εντός της χώρας** γεγονός που επέτρεψε στην Κίνα να «σπάσει το τεχνολογικό μονοπώλιο των ξένων χωρών και να ηγηθεί σε επίπεδο καινοτομίας».

(CAR & MOTOR TEAM, 02 Jan 2025, https://www.carandmotor.gr/nea/etoimo-odiko-toynel-22-hiliometron-poy-kataskeyastike)

ΩΣ ΣΩ

Interesting Deep Excavation

This 1973 deep excavation from Les Halles in Paris, France, shows a few interesting things:

The walls consist of reinforced concrete diaphragm panels supported by lower drilled cases to bedrock. Most likely, the panels stopped where the bedrock started, and the caissons continued further down.

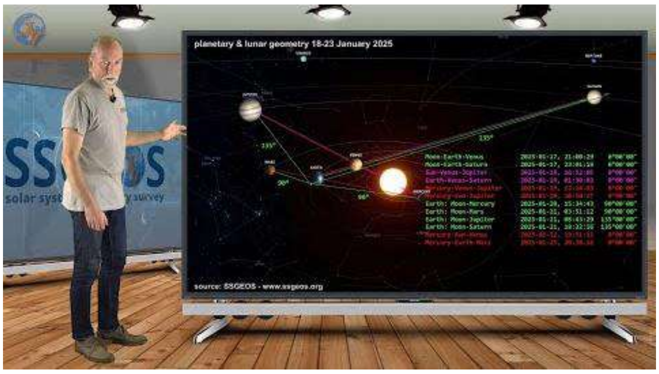
The panels appear to be laterally braced with two levels of ground anchors but only one anchor per panel (a detail that is avoided today).

(Dimitrios Konstantakos / LINKEDIN, Jan. 11, 2025)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΣΕΙΣΜΟΙ & ΑΝΤΙΣΕΙΣΜΙΚΗ ΜΗΧΑΝΙΚΗ

Seismologist warns about possible major earthquake in Middle East by February 2025

Dutch seismologist Frank Hoogerbeets is warning about a potential upcoming earthquake in the Middle East reaching a magnitude of 7.8 or higher.



Frank Hoogerbeets, a Dutch seismologist known for his previous prediction of an earthquake in Turkey, warned of a potential major earthquake in the Middle East.

A planetary alignment involving Mercury, Earth, Mars, and other planets on February 24 could result in seismic activity, with the possibility of an earthquake reaching a magnitude of 7.8 or higher, according to Hoogerbeets.

"It is not unthinkable that it could happen in the coming timeframe. I'm not saying that it will happen, but there is the potential. And these atmospheric anomalies are pretty close," Hoogerbeets stressed on increased risks in regions such as eastern Turkey and Iran, where earthquakes of 6 to 7 magnitude are possible.

Israeli earthquake experts recommend relying on established geological data rather than speculative or astrological methods for earthquake preparedness despite these predictions.

Hoogerbeets works for the Solar System Geometry Survey (SSGEOS) in the Netherlands and became well-known in 2023 after his prediction of an earthquake in Turkey went viral. The SSGEOS is a research institute for monitoring geometry between celestial bodies related to seismic activity.

"Sooner or later, there will be a magnitude 7.5 earthquake in this region (South-Central Turkey, Jordan, Syria, Lebanon)," Hoogerbeets said in a previous statement on X/Twitter.

"As I stated earlier, sooner or later this would happen in this region, similar to the years 115 and 526. These earthquakes are always preceded by critical planetary geometry, as we had on 4 – 5 February," he reacted to the earthquake after his prediction went viral.

References:

[1] Dutch seismologist warns of potential earthquake in Middle East – THE JERUSALEM POST – January 21, 2025

(Rishika Yadav / THE WATCHERS, Thursday, January 23, 2025, https://watchers.news/2025/01/23/seismologist-warns-about-possible-major-earthquake-in-middle-east-by-february-2025)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΓΕΩΛΟΓΙΑ

Pamukkale: Turkey's 'cotton castle' of white limestone that inspired an ancient cult

The Pamukkale travertines are limestone slopes and thermal water pools that have attracted visitors since before the days of Ancient Greece, when the spa town of Hierapolis was founded at the top.

The Pamukkale travertines are situated in southwestern Turkey. (Image credit: murat4art/Getty Images)

QUICK FACTS

Name: Travertines of Pamukkale
Location: Denizli province, southwest Turkey
Coordinates: 37.92387293371705, 29.123346443836517
Why it's incredible: Despite their snowy appearance, the travertines hold boiling thermal water.

Pamukkale is a town in Turkey that's famous for its dazzling travertine terraces and thermal water pools. The name, which means "cotton castle" in Turkish, hints at the height and snow-white color of the landmark, which stands in stark contrast to the surrounding arid plain.

Travertine is a type of rock made mostly of calcium carbonate that is deposited from mineral-rich spring water. Pamukkale is home to hot springs that bubble up at the top of a 660-foot-tall (200 meters) cliff overlooking the town. The water drips down over the mountainside, coating the rocks in calcium carbonate that has accumulated over millennia to form a white limestone crust.

The travertines of Pamukkale have grown so thick, they resemble a small glacier from above and afar.

Pamukkale's travertines may look like a winter wonderland, but they're situated in a warm, sun-kissed part of southwestern Turkey.

The water flowing down the slopes is also warm — between 66 and 135 degrees Fahrenheit (19 to 57 degrees Celsius), according to NASA's Earth Observatory — and can reach boiling temperatures. It collects in basins that have formed within the terraced slopes, creating natural hot tubs and infinity pools. These cascade into each other, with stalactites and other limestone formations growing along ledges up to 20 feet (6 m) tall where water has dripped down for thousands of years.

Pamukkale is listed as a UNESCO World Heritage Site, but the listing highlights far more than the site's effervescent bathing pools. The travertines have drawn visitors since antiquity, with the ancient Greeks, in particular, building thermal baths, monuments and a complex system of canals to bring the spring water to nearby villages and fields.

The Attalid kings of Pergamon — an ancient Greek state that ruled large parts of Asia Minor during the Hellenistic period — established a thermal spa town called Hierapolis near the travertines in the second century B.C., the ruins of which still exist today and are also listed by UNESCO. Previously, the site hosted an ancient cult, according to the U.N. agency.

Hierapolis reached its heyday in the second and third centuries A.D., after the ancient Romans took over and rebuilt the town following an earthquake. Remains dating back to Greco-Roman rule and the later Byzantine period include several baths, a monumental arch, a theater, a necropolis, a nymphaeum (a monument dedicated to water nymphs) and temple ruins.

Notably, some of these monuments, like the Temple of Apollo, stood on top of a geological fault that likely leaked noxious gases into the space between their walls, according to UNESCO.

The ruins at Pamukkale are generally well preserved, but huge numbers of visitors threaten the integrity of the site, according to UNESCO. An area where tourists can swim between ancient columns and marble decorations that collapsed after an earthquake in the seventh century is particularly vulnerable.

(Sascha Pare / LIVESCIENCE, Jan. 24, 2025, https://www.livescience.com/planet-earth/geology/pamukkale-turkeys-cotton-castle-of-white-limestone-that-inspired-an-ancient-cult)

Incredible photo from Brazil sent by Geologist Alvaro Rodrigues dos Santos

Cut slope in saprolitic soils from São Roque Group of Proterozoic metassediments — phyllites, quartz-phyllites, metasiltites, various schists, quartzites and metalimestones. The Project is at the Catarina Airport, São Roque City, São Paulo State — Brazil. Many thanks to Erik Wunder for organizing the sending in of this incredible photo!

IAEG Connector E-News, 15.01.2025

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΛΟΙΠΑ

1960s bridge in Brazil collapses after locals raise concerns about cracks

The collapsed Juscelino Kubitschek Bridge in Brazil (Image: REUTERS/Mauricio Marinho)

At least 12 people have died and five more are still missing after a reinforced concrete bridge in Brazil collapse while vehicles were crossing.

Four trucks, three cars and three motorcycles are believed to have been on the Juscelino Kubitschek Bridge between Tocantins and Maranhão states when it gave way last week, according to the Brazilian Navy.

The bridge, inaugurated in 1960, was 533 meters long and is located on the BR-226 highway, which connects Belém with Brasilia.

The collapsed Juscelino Kubitschek Bridge in Brazil (Image: REUTERS/Mauricio Marinho)

It gave way on 22 December and a search for victims started shortly afterwards.

One of the trucks was carrying sulfuric acid, prompting fears of water contamination.

A local councillor reportedly recorded the start of the bridge's collapse, having gone to the bridge to draw attention to cracks that had started to appear.

The collapsed Juscelino Kubitschek Bridge in Brazil (Image: REUTERS/Mauricio Marinho)

(Reuters and Neil Gerrard, 02 January 2025, https://www.constructionbriefing.com/news/1960s-bridge-in-brazil-collapses-while-vehicles-crossing/8049495.article)

Τρία καινοτόμα πρότζεκτ στην Ευρώπη δείχνουν τον τρόπο που κατασκευάζονται οι γέφυρες του μέλλοντος

Στην Ευρώπη βρίσκονται μερικές από τις πιο εμβληματικές γέφυρες στον κόσμο, ηλικίας κάποιων δεκαετιών.

Η New Sotra Bridge με πλήρως ψηφιακό σχεδιασμό στη Νορβηγία. Πηγή: Norconsult/News

Στην Ευρώπη βρίσκονται μερικές από τις πιο εμβληματικές γέφυρες στον κόσμο, ηλικίας κάποιων δεκαετιών. Πώς, όμως, έχει εξελιχθεί από τότε ο τρόπος κατασκευής τους που θα διασφαλίζει ότι η επόμενη γενιά γεφυρών θα μπορέσει να αντέξει τη δοκιμασία του χρόνου;

Η ζήτηση και η ανάγκη για προηγμένες υποδομές που θα βελτιώνουν τη συνδεσιμότητα και την οικονομική ανάπτυξη έχουν κάνει, τα τελευταία χρόνια, την Ευρώπη, κόμβο για την ανάπτυξη έργων νέων γεφυρών, όπως παρατηρεί το Construction Briefing. Τα νέα αυτά πρότζεκτ συχνά περιλαμβάνουν πολύπλοκα τεχνικά επιτεύγματα, μεγάλους προϋπολογισμούς και τεχνολογίες αιχμής.

Κορυφαίο παράδειγμα καινοτομίας αποτελεί το έργο New Sotra Bridge, στη Νορβηγία, το οποίο αναφέρεται ως το μεγαλύτερο έργο γέφυρας με πλήρως ψηφιακό σχεδιασμό. Η γέφυρα αποτελεί τμήμα της Εθνικής Οδού 555 Sotrasambandet, που συνδέει το νησί Sotra με το Μπέργκεν, τη δεύτερη μεγαλύτερη πόλη της Νορβηγίας. Στόχος είναι να βελτιώσει τη μεταφορική ικανότητα καθώς θα υποστηρίζει την κυκλοφορία πεζών και ποδηλατών, ενώ θα διευκολύνει τις εξαγωγές ψαριών, πετρελαίου και φυσικού αερίου.

Το έργο, προϋπολογισμού 1,74 δισ. ευρώ, είναι μία από τις μεγαλύτερες συμβάσεις για έργα υποδομής στην Ευρώπη και εκτελείται ως Σύμπραξη Δημόσιου και Ιδιωτικού Τομέα (ΣΔΙΤ). Τον Σεπτέμβριο του 2021, η Sotra Link (κοινοπραξία αποτελούμενη από τον ιταλικό εργολάβο Webuild, την ισπανική FCC Construcción και την κορεατική εταιρεία SK E&C) ανέλαβε τη σύμβαση και η Norconsult ξεκίνησε τον λεπτομερή σχεδιασμό για την περιοχή 08 New Sotra Bridge, μία από τις 11 υποεργολαβίες του έργου. Η γέφυρα σχεδιάστηκε ως κρεμαστή κατασκευή τεσσάρων λωρίδων με ενσωματωμένο πεζοδρόμιο, ενώ τόσο στον σχεδιασμό όσο και στην κατασκευή ακολουθήθηκαν ψηφιακές διαδικασίες.

Η Norconsult ανέπτυξε νέες ψηφιακές μεθόδους και επιλεγμένα εργαλεία για να διασφαλίσει τον αποτελεσματικό σχεδιασμό και την κατασκευή του πολύπλοκου έργου, το οποίο περιλαμβάνει, μόνο για τη New Sotra Bridge, περίπου ένα εκατομμύριο αντικείμενα και 60 εκατομμύρια σημεία δεδομένων.

Το έργο της New Sotra Bridge αναμένεται να αποτελέσει τον πιλότο για τα ψηφιακά έργα υποδομής, αξιοποιώντας προηγμένα ψηφιακά εργαλεία και βιώσιμες λύσεις για τον εξορθολογισμό του σχεδιασμού και της κατασκευής υποδομών μεγάλης κλίμακας στην Ευρώπη.

Ο Thomas Ostgulen, υπεύθυνος BIM και υπεύθυνος ανάπτυξης για τις γέφυρες στη Norconsult, περιγράφει τη σημασία της αυστηρής διαχείρισης πληροφοριών στο έργο της New Sotra Bridge. «Πρόκειται για ένα έργο BIM επιπέδου 3 και έχουμε πολύ υψηλές απαιτήσεις για τα μοντέλα και τις πληροφορίες», εξηγεί.

Η Norconsult ανέπτυξε το δικό της αυτοματοποιημένο σύστημα επικύρωσης για να διασφαλίσει ότι κάθε ενημέρωση του μοντέλου ευθυγραμμίζεται με τις απαιτούμενες ιδιότητες, τη σωστή μορφοποίηση και τις επιτρεπόμενες τιμές.

Ιδιαίτερο ενδιαφέρον παρουσιάζουν οι γλωσσικές και πολιτισμικές προκλήσεις που χρειάστηκε να αντιμετωπιστούν, σύμφωνα με τον Ostgulen καθώς η συμβατική απαίτηση είναι να παρέχονται όλα τα επίσημα έγγραφα στα νορβηγικά. Δεδομένου ότι τα περισσότερα μέλη της ομάδας της προέρχονται από χώρες εκτός Νορβηγίας, η Norconsult ενσωμάτωσε στο μοντέλο του έργου υποστήριξη σε δύο γλώσσες – τόσο στα νορβηγικά όσο και στα αγγλικά.

Η προσέγγιση αυτή μειώνει τα γλωσσικά και πολιτισμικά εμπόδια και εξασφαλίζει ότι τόσο οι τοπικές όσο και οι διεθνείς ομάδες μπορούν να συνεργάζονται αποτελεσματικότερα. Όπως σημειώνει ο ίδιος: «το μοντέλο μάς δίνει τη δυνατότητα να σπάσουμε τα γλωσσικά εμπόδια, καθώς περιλαμβάνει τόσο τα νορβηγικά όσο και τα αγγλικά, καθώς και τα πολιτιστικά εμπόδια, καθώς ακολουθούνται τα πρότυπα ISO και όχι οι εθνικές κατευθυντήριες γραμμές», γεγονός που βοηθά επίσης την επικοινωνία με υπεργολάβους από την τοπική περιοχή, οι οποίοι μπορεί να μην έχουν εμπειρία σε ψηφιακά έργα μεγάλης κλίμακας.

Με τη χρήση του BIM, το έργο αντιμετώπισε τα περισσότερα ζητήματα πριν φτάσουν στο εργοτάξιο, εξοικονομώντας χρόνο και περιορίζοντας την πιθανότητα κατασκευαστικών σφαλμάτων. Ζητήματα που προηγουμένως θα μπορούσαν να οδηγήσουν σε δαπανηρές καθυστερήσεις εντοπίστηκαν έγκαιρα και βελτιώθηκαν για μια πιο αποτελεσματική και ποιοτικότερη διαδικασία κατασκευής.

Ο Eirik Wie Furunes, επικεφαλής του τμήματος σχεδιασμού γεφυρών της Norconsult, υπογραμμίζει τη σημασία της υποστήριξης της κυβέρνησης και του πελάτη για την επίτευξη ενός έργου σε τόσο υψηλό επίπεδο ψηφιακής εξειδίκευσης. Υπογραμμίζει, παράλληλα, την αξία των πελατών που «πιστεύουν στο σύστημα» και κατανοούν ότι αυτή η επένδυση σε ψηφιακές διαδικασίες παρέχει προστιθέμενη αξία μακροπρόθεσμα.

Ο ίδιος παρατήρησε ότι η προσέγγιση της Νορβηγίας για την ψηφιοποίηση στις κατασκευές είναι μοναδική, ενώ ανέφερε την εμπειρία που είχε σε συνέδριο στις ΗΠΑ, όπου αμερικανικές εταιρείες σχεδιασμού τον ρώτησαν γιατί δεν μπορούσαν να πείσουν τους πελάτες τους να υποστηρίξουν το ίδιο επίπεδο ψηφιακής προόδου που παρατηρείται στη Νορβηγία. Ο Furunes το απέδωσε αυτό στη στρατηγική ψηφιοποίησης της Νορβηγίας, η οποία επιβάλλεται από τις αρχές μέσω δεσμευτικών συμβάσεων.

Σιδηροδρομικές γέφυρες

Στο Ηνωμένο Βασίλειο, η δυναμική του σιδηροδρομικού έργου του High Speed 2, ανακάμπτει μετά από μία περίοδο που είχε σταματήσει, ωστόσο, το εκτεταμένο πρόγραμμα μεταφορών θα βασίζεται σε μεγάλο βαθμό στις συνδέσεις γεφυρών σε όλη την έκταση των 225 χιλιομέτρων.

Λόγω των μεταφορικών αναγκών του κοινού, δεν μπορούν να κατασκευαστούν όλες οι γέφυρες επί τόπου, όπως συνέβη στην περίπτωση διάβασης μήκους 84 μέτρων στο Μπέρμιγχαμ της Αγγλίας, που ονομάζεται γέφυρα Aston Church Road.

Η πεζογέφυρα Aston Church Road κατασκευάστηκε σε οικόπεδο δίπλα στην υπάρχουσα σιδηροδρομική γραμμή και στη συνέχεια μεταφέρθηκε στη θέση της. Πηγή: HS2

Η κοινοπραξία της βρετανικής εταιρείας Balfour Beatty και της γαλλικής Vinci, ζήτησε τη βοήθεια της Mammoet, ειδικής στις βαριές ανυψώσεις και μεταφορές. Ο Ολλανδός εργολάβος χρησιμοποίησε δύο αυτοκινούμενα σπονδυλωτά μεταφορικά μέσα 128 τροχών για να μεταφέρει τη γέφυρα από χάλυβα και σκυρόδεμα βάρους 1.600 τόνων στη μόνιμη θέση της.

Ο Dan Binns, διευθυντής έργου της Balfour Beatty Vinci, δήλωσε ότι η μέθοδος χρησιμοποιήθηκε για να μειωθούν οι επιπτώσεις στις συνεχιζόμενες σιδηροδρομικές μετακινήσεις. «Επιλέξαμε σκόπιμα να μετακινήσουμε τη γέφυρα με τροχούς, ώστε να μπορεί να κατασκευαστεί πρώτα εκτός σύνδεσης και στη συνέχεια να μετακινηθεί μέσα σε μόλις πέντε ώρες, μειώνοντας σημαντικά τις επιπτώσεις για τους επιβάτες του τρένου».

Στο σημείο εγκατάστασης, τα συνεργεία κατασκεύασαν μια πλατφόρμα 9.000 m2 και 62 πασσάλους για τη στήριξη των κατασκευών από σκυρόδεμα. Χρειάστηκαν περίπου πέντε ώρες ολονύκτιας εργασίας για να μετακινηθεί και να στερεωθεί η γέφυρα πάνω από την υπάρχουσα γραμμή Μπέρμιγχαμ-Ντέρμπι, η οποία θα αποτελέσει μέρος του μελλοντικού HS2.

Σύμφωνα με τον διευθυντή του έργου η επιχείρηση έγινε ακόμα πιο δύσκολη καθώς η γέφυρα έπρεπε να οδηγηθεί πάνω από τέσσερις υφιστάμενες γραμμές του σιδηροδρομικού δικτύου, απαιτώντας χρόνια ακριβούς σχεδιασμού και προετοιμασίας.

Περίπου 4.000 m3 σκυροδέματος και 490 τόνοι οπλισμένου χάλυβα χρησιμοποιήθηκαν σύμφωνα με την Balfour Beatty.

Κατά τη διάρκεια του επόμενου έτους, τα συνεργεία θα αποσυναρμολογήσουν την παλιά Aston Church Road για να δημιουργήσουν περισσότερο χώρο για τα μελλοντικά τρένα HS2.

Βιώσιμη κατασκευή γεφυρών

Ενώ η καινοτομία αποτελεί βασικό στοιχείο για την κατασκευή σύγχρονων γεφυρών, η βιωσιμότητα στην κατασκευή είναι επίσης ζωτικής σημασίας για την ενίσχυση της δομικής μακροζωίας των μεγάλων γεφυρών της Ευρώπης και την ελαχιστοποίηση των περιβαλλοντικών επιπτώσεων.

Με την ενσωμάτωση βιώσιμων πρακτικών, οι μηχανικοί διασφαλίζουν ότι οι γέφυρες κατασκευάζονται για να διαρκέσουν, μειώνοντας την ανάγκη για συχνές επισκευές ή αντικαταστάσεις που καταναλώνουν πρόσθετους πόρους και παράγουν απόβλητα.

Τα βιώσιμα υλικά και οι μέθοδοι κατασκευής χαμηλού αντίκτυπου μπορούν να μειώσουν σημαντικά το περιβαλλοντικό αποτύπωμα των νέων έργων υποδομής, από τη μείωση των εκπομπών διοξειδίου του άνθρακα κατά τη διάρκεια της κατασκευής έως τη διατήρηση των τοπικών οικοσυστημάτων και των υδάτινων οδών.

Ο Cameron Archer-Jones, συνεργάτης της ομάδας συμβούλων μηχανικών COWI, εξηγεί την προσέγγιση της εταιρείας του για την ενσωμάτωση βιώσιμων πρακτικών στη μηχανική των γεφυρών, υπό την καθοδήγηση μηχανικού.

Περιγράφει πώς η διαδικασία διαχείρισης των εκπομπών διοξειδίου του άνθρακα αποτελεί βασικό συστατικό κάθε έργου και όχι εξωτερική προσθήκη. «Το θέμα μας», λέει ο Archer-Jones, «είναι ότι πρέπει να γίνεται από το σωστό άτομο στην ομάδα. Στην COWI, οι ίδιοι οι μηχανικοί διεξάγουν τις αξιολογήσεις άνθρακα, εντοπίζοντας άμεσα τις ευκαιρίες για τη μείωση του αποτυπώματος άνθρακα του έργου. Αυτό επιτρέπει στους μηχανικούς να εντοπίζουν πιθανή εξοικονόμηση άνθρακα νωρίς στη διαδικασία σχεδιασμού, οδηγώντας σε απτές μειώσεις που επηρεάζουν τη συνολική βιωσιμότητα του έργου».

Το σύστημα που αναπτύχθηκε σε συνεργασία με το Ινστιτούτο Δομικών Μηχανικών (IStructE), στο Λονδίνο και διαθέτει μια βάση δεδομένων με σχεδόν 150 γέφυρες και τους επιτρέπει να συγκρίνουν κάθε σχεδιασμό, να παρακολουθούν τις βελτιώσεις και να θέτουν υψηλότερα πρότυπα για κάθε νέο έργο.

Ο David MacKenzie, πρόεδρος του COWIfonden, προσθέτει ότι η επίτευξη βιώσιμων λύσεων απαιτεί στενή συνεργασία με τους πελάτες, καθώς πολλοί είναι πρόθυμοι να υποστηρίξουν φιλικές προς το περιβάλλον πρακτικές, αλλά δεν γνωρίζουν από πού να ξεκινήσουν.

((Έρη Δρίβα / economix, 4 Ιανουάριος 2025, https://www.economix.gr/2025/01/04/tria-kainotoma-protzekt-stin-evropi-deichnoun-ton-tropo-pou-kataskevazontai-oi-gefyres-tou-mellontos/)

Sweden just turned the humble water tower into art

The country is swapping out aging water infrastructure with towers that look like sculptures.

The Swedish city of Varberg found out the hard way that it needed a new water tower. The local water system sprang a leak, and the city had to tap into its backup water supply, about 525,000 gallons stored in a utilitarian UFO-shaped concrete water tower near the center of town. But the volume of water inside that tower, built in the 1960s, was not enough to meet the demands of a city that has seen its population nearly triple to 35,000 over the past 60 years. The water company eventually fixed its leak, and taps started flowing again, but the city knew it needed a better vessel for water security.

[Photo: Joacim Winqvist/courtesy White Arkitekter]

That's how Varberg, a coastal city south of Gothenburg, built what may be the world's most stunning water tower. Cast in stark concrete and perched atop a small hill, the water tower has the unusual form of a long and narrow rectangle propped up on nine slender pillars. Scalloped along its lengths with subtle curves that recall waves of the nearby coast, the water tower is a radical departure from the bulbous and cylindrical tanks found in cities around the world.

[Photo: Anna Kristinsdóttir/@annakristinz/courtesy White Arkitekter]

Designed by the Scandinavian architecture firm White Arkitekter, the tower for Varberg has reinvented the water tower typology in the face of new demands and through new technology.

The tower has been operational since late 2024, but its design dates back to 2018, shortly after the city's water system malfunctioned. The city and the water utility had calculated that the existing water tower had a capacity far below the city's need, so they commissioned the construction of a new facility with five times the volume, more than 2.5 million gallons. "They also saw the potential of the site they chose, which was very close to the highway, for creating a landmark structure could really signal the town's position," says White Arkitekter's Per Hultcrantz, the project's lead architect. "They could have just went with a regular water tower, but they decided to create an architectural competition."

The competition's design brief called for much more than a simple utilitarian structure. Hultcrantz says the stipulations included the expected water capacity and safety considerations, but also that the new tower should become a landmark, communicating creativity, slenderness, comfort, and strength.

[Photo: Anna Kristinsdóttir/@annakristinz/courtesy White Arkitekter]

[Photo: Anna Kristinsdóttir/@annakristinz/courtesy White Arkitekter]

Hydrology and water pressure dictate many of the parameters of a water tower's design, which is why many (but not all) appear to be lollipops, large bulbs of steel or concrete stacked on a spindle. Hultcrantz says the proposed site of Varberg's new tower and its required capacity and pressure meant that its tank would have to be about 26 feet in height. Following a conventional water tower design approach would have resulted in what Hultcrantz calls a wide and flat puck. "We didn't really like that shape," he says. "We decided after two days of sketching that a long, stretched out design was the right way to go."

Now, six years later, that design is a functioning piece of urban infrastructure, as well as a new calling card for the city. Easily visible from both residential areas in town and from a major highway running alongside the city, the ribbonlike spectacle stretches 615 feet long and is only 30 feet wide.

It also runs directly over a small gravel road that leads to a popular hiking area on a cliff overlooking the sea. In line with the competition's brief, Hultcrantz says the design of the tower was slightly rotated to maintain that view and its public access, hulking like a grand gateway. "It's a nice thought that you can combine this important civic function with the also equally important recreational function," he says. "When you walk up the gravel road there, the portal motif is colossal. But I feel it's a good kind of colossal."

[Photo: Anna Kristinsdóttir/@annakristinz/courtesy White Arkitekter]

[Photo: Anna Kristinsdóttir/@annakristinz/courtesy White Arkitekter]

The tower in Varberg is also proof that water tower typology can continue to evolve. Hultcrantz says Sweden's water tower history dates back to the late 1800s, when the first water storage facilities were built out of brick and stone, like oversize barrels or the turrets of ancient castles. These stood for more than 150 years before upgrades were needed. Postwar population growth in the 1950s and '60s led to increased demand for backup water supplies across Sweden, and the increasing availability of materials like steel and concrete spurred new structural forms. "A lot of Swedish water towers are from the '60s and they all look kind of like UFOs or mushrooms," Hultcrantz says.

Population growth is again leading cities across Sweden, including Varberg, to invest in new water storage. "I think we're in the third water tower boom right now," Hultcrantz says. In addition to Varberg, Hultcrantz says other cities are launching their own design competitions for new water towers.

The UFOs and mushrooms may eventually fade from the landscape. Advanced design tools and hydrological modeling software are now making it possible for the design of these water towers to take inventive new forms. One new water tower, built in the city of Helsingborg, is shaped like a large floating ring. The Stockholm suburb of Hemmesta recently announced a sculptural vaulted tower as the winner of its own water tower design competition. The rectangular form in Varberg, it seems, may be one of a variety of new shapes to define the water towers of the future. "The whole water tower know-how is being rebuilt from the foundation again," Hultcrantz says.

(Nate Berg / FASTVOMPANY, 01-07-2025 https://www.fastcompany.com/91254456/sweden-just-turned-the-humble-water-tower-into-art)

Το σπίτι στο Λος Άντζελες που η φωτιά πέρασε και δεν ακούμπησε – Τα πυρίμαχα υλικά και το σχεδιαστικό μυστικό που το έσωσε

Εκτός από το πυρίμαχο τούβλο και τα τζάμια υψηλής αντοχής, «κλειδί» αποδείχθηκε ο σχεδιασμός της σκεπής

Μία ανάρτηση του αρχιτέκτονα **Greg Chasen** στα social media αποκάλυψε μία από τις πολλές μικρές ιστορίες που έφεραν χαμόγελα μέσα στον θρήνο για ζωές και περιουσίες από την πύρινη λαίλαπα στα προάστια του Λος Άντζελες.

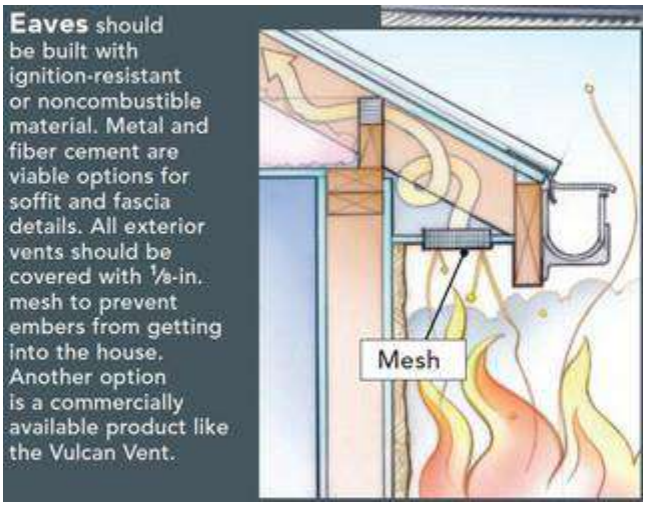
Ο αρχιτέκτονας ανέβασε φωτογραφίες από ένα σπίτι στην περιοχή του **Πάλισεϊντς** το οποίο σχεδίασε ο ίδιος, γράφοντας: **«Πραγματικά, δεν υπάρχουν λόγια – απλώς μια παράσταση τρόμου. Μερικές από τις σχεδιαστικές επιλογές που κάναμε εδώ, βοήθησαν. Ήμασταν όμως και πολύ τυχεροί».**

https://x.com/ChasenGreg/status/1877478755091767732/photo/1

Όπως αναφέρει ο Chasen, το «μυστικό» που γλίτωσε την πολυτελή κατοικία είναι το εξωτερικό υλικό την επένδυσης που δεν είναι τίποτα άλλο από ένα είδος πυρότουβλου αλλά όχι μόνο.

«Δεν υπάρχουν αεραγωγοί ή μαρκίζες και τα παράθυρα είναι από πυρίμαχο γυαλί υψηλής αντοχής. Ευτυχώς που υπήρχε και λίγο περισσότερος χώρος από τα γειτονικά σπίτια».

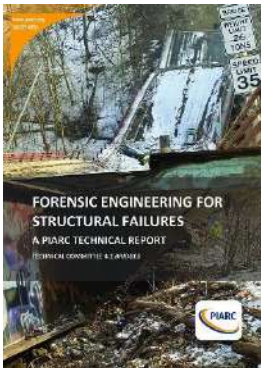
Επίσης, σύμφωνα με τον αρχιτέκτονα του σπιτιού, ένα ακόμα εξαιρετικά σημαντικό στοιχείο της πυραντοχής του κτίσματος είναι ο σχεδιασμός της κεραμοσκεπής χωρίς κενά στους προβόλους: «Οι μαρκίζες είναι ο πιο αδύναμος κρίκος όταν πρόκειται για φωτιά. Τα σπίτια μπορεί να έχουν κεραμοσκεπές "πυρίμαχες", αλλά αν οι μαρκίζες είναι εκτεθειμένες, η καυτή στάχτη μπορεί εύκολα να μπει κάτω από τη στέγη και να ανάψει το χώρο της σοφίτας. Οι περισσότεροι εργολάβοι τσιγκουνεύονται το σφράγισμα στις μαρκίζες, κάτι που θα απέτρεπε την ταχεία εξάπλωση των πυρκαγιών» λέει, ανεβάζοντας και ένα σχετικό σχέδιο.



«Έχετε μία καθαρή περίμετρο: καμία βλάστηση, εκτός από τις ζαρντινιέρες. Έχετε προβλέψει πυρίμαχη οροφή και παρακαμπτήριους. Έχετε τοίχο αντιστήριξης από πυρίμαχα τούβλα και κονίαμα. Όλα αυτά είναι καλές διασφαλίσεις κατά της πυρκαγιάς. Δεν ήταν καθόλου θέμα τύχης», σχολιάζει ένας άλλος χρήστης, και το βέβαιο είναι ότι μετά την βιβλική καταστροφή, ο τρόπος κατασκευής των κατοικιών θα αλλάξει προβλέποντας το ενδεχόμενο μίας σαρωτικής πυρκαγιάς.

(Newsroom / NEWSBEAST, 11·01·2025 https://www.newsbeast.gr/world/arthro/11987395/to-spiti-sto-los-antzeles-pou-i-fotia-perase-kai-den-akoubise-ta-pyrimacha-ylika-kai-to-schediastiko-mystiko-pou-to-esose)

ΝΕΕΣ ΕΚΔΟΣΕΙΣ ΣΤΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΠΙΣΤΗΜΕΣ



Forensic Engineering for Structural Failures - Technical Report

PIARC Technical Committee / 2020-2023 4.2 Bridges

When a bridge collapse occurs, engineers investigate the cause of collapse to identify how design, materials, workmanship, and/or overloading affected structural performance. In this meaning, forensic engineering plays an important role in improving the safety of bridges. Engineers learn from the results of forensic engineering investigations and make improvements to the requirements of design, construction, and maintenance in order to prevent these tragedies from reoccurring.

As a result, there is interest in how these tragedies are investigated and how lessons learned are identified and implemented. The engineers investigating these failures generally have two primary objectives, (1) determine the probable cause of the failure with a high level of confidence, and (2) clearly communicate that cause so that it is well understood by both the well-informed and non-technical audiences.

The objectives of this report were to provide guidance to practicing bridge engineers on the elements that make up and the factors that influence a competent forensic investigation, and on how lessons learned from a forensic investigation are identified and communicated. It is TC 4.2's expectation that this report will be used to as a reference for experienced engineers, and as an introduction to forensic engineering for a bridge engineer who has yet to participate or conduct a failure investigation.

One overarching conclusion from the information collected was that bridge failure is rare, and the circumstances associated with bridge failures are too diverse to make possible the establishment of a detailed formal process.

Recommendations were drawn from the findings and conclusions of the report. Bridge owners are recommended to maintain a comprehensive file of information on each bridge (bridge file) in their inventory, establish and maintain a centralized database of those bridge files, and to regularly archive and communicate the results of forensic engineering investigations. Understanding the broader value of the information collected, it was recommended to PIARC to continue to collect and share case studies of failure investigations.

(PIARC Ref.: 2023R18EN, 2023)

ΗΛΕΚΤΡΟΝΙΚΑ ΠΕΡΙΟΔΙΚΑ

INTERNATIONAL GEOSYNTHETICS SOCIETY

IGS NEWSLETTER – January 2025

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

Helping the world understand the appropriate value and use of geosynthetics

www.geosyntheticssociety.org/newsletters

- Gear Up for an Exciting Year of Discovery… with the IGS's 2025 global geosynthetics conference programme! Save these dates, and register now to save your space… READ MORE
- Giroud Lecturer Named As Dr. Jie Han READ MORE
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- Greek Chapter Hosts Inaugural Educate the Educators Event READ MORE
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- Businesses – Share Your Sustainability Success Stories READ MORE, SUBMIT HERE
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  - IV Romanian Conference on Geosynthetics (GeoSint 2025) READ MORE
  - GeoAsia 8 www.geoasia8.org
  - EuroGeo 8 www.eurogeo8.org
  - 13th International Conference on Geosynthetics
- Calendar of Events

☙ ❧

Highlights of the Jan/Feb Issue

Executive Director Update: A Year of Celebrations Awaits

Cover Story — Construction and Testing of Very Large Diameter Drilled Shafts for Abernethy Bridge

Happy Birthday T-Value Method

Experience-Based Design to Stabilize Cardinal Hill Slope

Load Testing for Acceptance of Shafts With Questionable Integrity: Case Studies

A Look Back: Fellenius Releases Wave Equation

Member Profile: Jewels Stover's Unique Climb to the Summit

Foundations for a Sustainable Future: Grout Spoil Desanding and Recycling During Screw Injection Pile Installation

Risk Corner: Considerations for Risk Management in Underground Projects

ΕΚΤΕΛΕΣΤΙΚΗ ΕΠΙΤΡΟΠΗ ΕΕΕΕΓΜ (2023 – 2026)

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