ΕΛΛΗΝΙΚΗ
ΕΠΙΣΤΗΜΟΝΙΚΗ
ΕΤΑΙΡΕΙΑ
ΕΔΑΦΟΜΗΧΑΝΙΚΗΣ
& ΓΕΩΤΕΧΝΙΚΗΣ
ΜΗΧΑΝΙΚΗΣ

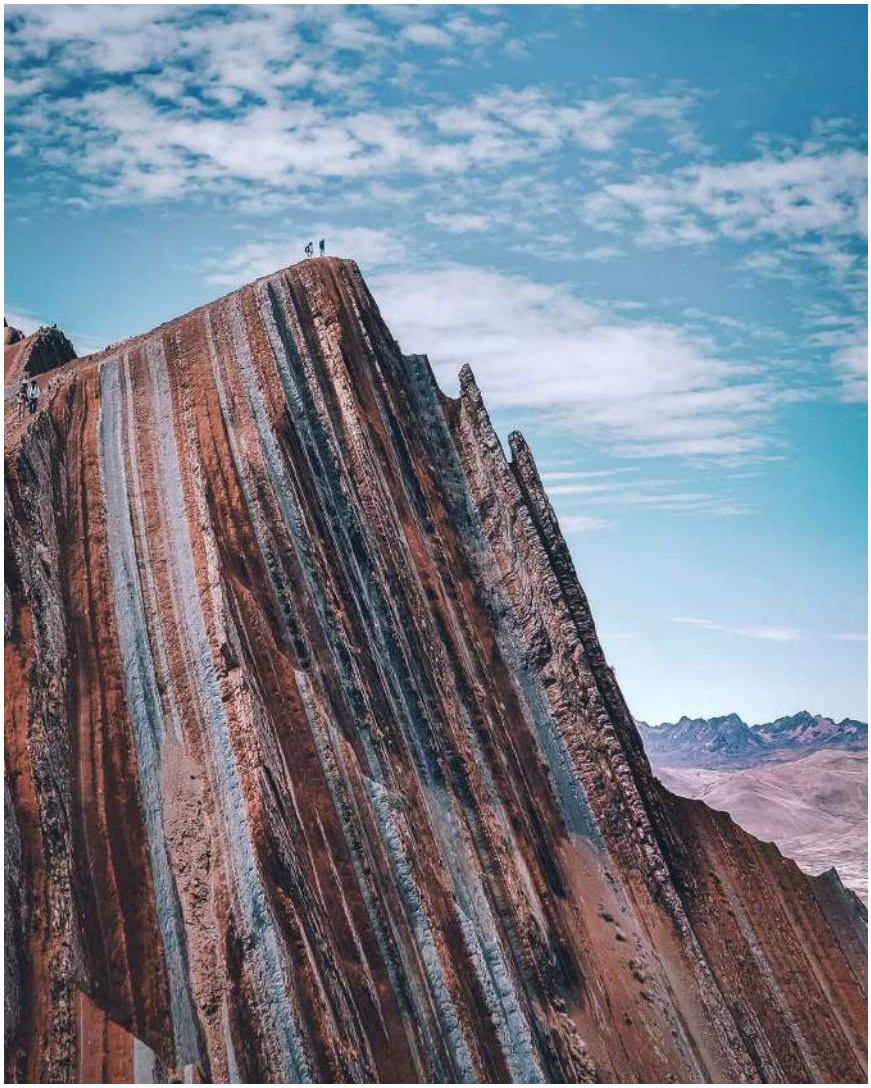
Τα Νέα της Ε Ε Ε Ε Γ Μ

140

Αρ. 140 – ΙΟΥΛΙΟΣ 2020

SIMSG ISSMGE

ISRM



Cusco, Περού

Π Ε Ρ Ι Ε Χ Ο Μ Ε Ν Α

Εκκλησάκι Αγίου Αρσενίου στην Κέρκυρα

Σπήλαιο της Μελισσάνης, Κεφαλληνία






www.hypedup.co.uk


ΑΡΘΡΑ

Fundão Mine tailings dam failure

James Hopkins and Karl Snelling, GDS Intruments

1.0 Introduction

At 3:45pm on the 5 November 2015, the 110m tall Fundão Mine Tailings Dam, located in the south-eastern Brazilian State of Minas Gerais, collapsed in a liquefaction flowslide. The failure released approximately 43M.m^3 of iron ore tailings into the environment, polluting over 600km of watercourses (Fonseca do Carmo et al, 2017) and resulting in 19 deaths.

The event was considered, at the time, to be Brazil's worst environmental disaster and has to date cost the mine's owners billions of dollars (Ridley and Lewis, 2019).

The Fundão Tailings Dam Review Panel was assembled following the collapse to investigate and determine why the Fundão Tailings Dam failed in a liquefaction flowslide.

The panel reported on its findings (Morgenstern et al, 2016) in August 2016, concluding that conditions necessary for liquefaction to occur within the dam were present prior to failure (ie loose, saturated sand tailings were present), and that lateral extrusion of slimes-rich deposits underneath sand tailings provided the mechanism to trigger the liquefaction flowslide.

This case study briefly summarises some of the many geotechnical engineering findings reported by the panel. Specifically, it focuses on aspects of the advanced laboratory testing programme conducted during the investigation, which employed an advanced cyclic direct simple shear apparatus designed and manufactured by GDS Instruments.

Readers are recommended to refer to the publicly available panel report, published by Cleary Gottlieb Steen and Hamilton, for a detailed commentary on the Fundão Tailings Dam failure. Additional information relating to ongoing environmental impacts and legal cases are available within the wider media.

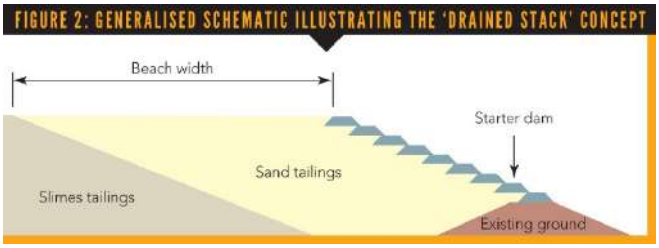
Figure 1: The Fundão Tailings Dam on the 7 July 2016, approximately eight months after failure occurred. Image courtesy of Ibama.

2.0 Fundão Mine Tailings Dam

The Fundão Mine Tailings Dam (figure 1) was constructed to retain sand and slimes tailings that were produced from the beneficiation of iron ore. Transported in slurry form, the sand tailings comprised sand and silt-sized particles, which generally allowed for rapid water drainage following their deposition.

The sands deposits were, however, typically loose and uncompacted, due to their placement by hydraulic means. The slimes tailings, also transported as a slurry, were classified as a low-plasticity clay (despite containing only a small proportion of clay minerals), which produced deposits that were more compressible and of lower permeability than the sands.

With two different material types to be retained, the initial dam design used a "drained stack" concept, as generalised in the figure 2 schematic. This concept aimed to progressively stack the sands behind a starter dam, with the slimes retained behind the sand stack, and the starter dam raised on top of the sands using upstream-style construction.



A critical condition of this design was to maintain adequate drainage within the loose, uncompacted sands, such that the sands remained unsaturated and did not become susceptible to static liquefaction. This condition was to be met through three factors: construction of a high-capacity drainage system beneath the starter dam; construction of concrete galleries (2m diameter conduits) beneath the left and right dam abutments to convey upstream surface water inflow downstream of the dam; and separation of the slimes from the sands during tailings deposition by maintaining a 200m sand beach width from the dam crest, such that downward drainage in the sands was not impeded.

Starter dam construction, including that of the high-capacity drainage system and concrete galleries, was completed in October 2008. Tailings discharge then began in April 2009. A number of problems were however encountered during dam operation and raising, prior to the November 2015 failure. These included:

- **Serious construction flaws within the high-capacity drainage system, leading to an internal erosion incident in 2009. This resulted in the high-capacity drainage system being sealed off, and a revised drainage design eventually being implemented. Importantly, more widespread saturation of the sands was accepted following failure of the high-capacity drainage system.**
- **Difficulty maintaining the 200m design sand beach width during 2011 and 2012, with the slimes getting as close as 60m from the dam crest. Importantly, this resulted in slimes being deposited in areas that were originally reserved for sands deposition.**
- **Structural failure of the concrete gallery beneath the left abutment, leading to the gallery being sealed off in 2013. Importantly, this resulted in subsequent construction of the left dam abutment being shifted to an upstream alignment, closer to (and, in fact, above) areas in which slimes had been deposited.**

It is also noted that three low-magnitude earthquakes of magnitudes from 1.8 to 2.6 occurred near the dam approximately 90 minutes prior to dam failure taking place.

3.0 Panel investigation into the dam failure

Eyewitness accounts and physical evidence confirmed that the dam collapsed in a liquefaction flowslide, initiating at the left abutment. This starting point led the panel to focus on why a liquefaction flowslide occurred, why it initiated at the left abutment and why it failed on the 5 November 2015.

To answer these questions, the panel undertook a systematic investigation, which required compilation of eyewitness interviews and dam instrumentation data, analytical and seismological studies and a virtual reconstruction of the pre-failure dam structure.

Estimation of the pre-failure engineering properties and performance of the dam materials (ie sand and slimes tailings) were a fundamental input for the virtual dam reconstruction. These estimations were largely based on subsurface field investigations and laboratory test data, the latter of which was predominantly obtained during a laboratory testing programme conducted by the Panel. This programme included advanced direct simple shear (DSS) and triaxial (TX) testing of specimens reconstituted/remoulded from shovel-excavated surface samples of sands obtained from the Dam site, as well as slimes obtained from the nearby Germano tailings impoundment.

4.0 Advanced laboratory testing programme

4.1 Monotonic and cyclic DSS testing

Figure 3: The GDS Electromechanical Dynamic Cyclic Simple Shear (EMDCSS) device

Klohn Crippen Berger (KCB) performed 15 constant volume DSS tests on sands and slimes specimens as part of the panel's advanced laboratory testing programme. This testing was undertaken using a GDS Electromechanical Dynamic Cyclic Simple Shear (EMDCSS) device (figure 3), which enables a constant specimen volume to be maintained during shearing (monotonic and/or cyclic) via a low compliance DSS device design, active height control and physical lateral restraint via a stack of low-friction retaining rings (alternatively, a wire-reinforced rubber membrane may also be used). The tests were performed as per the ASTM D 6528 test standard (ASTM, 2007).

Nine sands specimens tested by KCB within the GDS EMDCSS device were nominally 70mm diameter and were consolidated to between 150kPa to 600kPa vertical effective stress. Of the five cyclically-sheared specimens, two had an initial shear stress bias applied during the consolidation stage (17.5% and 35% of the vertical effective consolidation stress respectively). Cyclic loadings were applied at a frequency of 0.1Hz, with applied cyclic stress ratios (CSR) guided by site response analyses conducted by the panel.

Six slimes specimens tested by KCB within the GDS EMDCSS device were also nominally 70mm diameter and were consolidated across the same vertical effective stress range as applied during testing of the sands. Of the three specimens that were cyclically-sheared, one had an initial shear stress bias applied during consolidation (17.5% of the vertical effective consolidation stress), while one had cyclic loading applied following monotonic shearing to 20% shear strain.

Data gained from the constant volume monotonic DSS tests produced estimations of peak undrained strength ratio (ie peak horizontal shear stress divided by vertical effective consolidation stress) in the range of 0.12 to 0.14 for the sands, and 0.16 to 0.17 for the slimes. It is noted that the sands specimens were estimated to have post-consolidation void ratios ranging from 1.04 to 0.93, while the slimes specimens estimated to have void ratios ranging from 0.99 to 0.91. All specimens demonstrated strain softening behaviour (ie a small to significant reduction in shear stress) when the soil was strained beyond the peak shear stress.

Data recorded during the constant volume cyclic DSS tests showed that cyclic loadings representative of the low-magnitude earthquake shaking that preceded the dam failure did not produce significant excess pore pressure build-up or shear strains. For example, applied CSR values of 0.01 tended to result in maximum shear strains of 0.01% being recorded within sand and slimes specimens after 30 loading cycles, while a CSR equal to 0.004 was estimated to be representative of an 84th percentile ground motion at a depth of 58m below the dam crest (near the base of sand tailings). Applied CSRs were subsequently increased during the cyclic DSS tests, where the CSR was raised to 0.05, and then 0.1.

4.2 Triaxial testing

An extensive series of drained and undrained triaxial (TX) tests was conducted on sands specimens by KCB during the advanced laboratory testing programme. A total of 21 tests were performed by applying strain-controlled compression to isotropically and anisotropically consolidated specimens under drained and undrained conditions, with results used to estimate strength parameters (eg, an effective friction angle of 33°), as well as critical state line (CSL) and dilatancy parameters. These parameters subsequently formed an integral component of stability and deformation analyses conducted as part of the panel's investigation.

Nine additional drained TX tests, termed "extrusion collapse" tests, were also performed to investigate the possible initiation of liquefaction in the sands via a lateral extrusion mechanism. The mechanism is described further in the conclusions section of this document).

To conduct these tests, specimens were firstly anisotropically consolidated, after which a specially-designed stress path was followed wherein the mean effective stress (ie specimen confinement) was decreased while the deviator stress was either kept constant or increased. As the stress state of a test

specimen neared the CSL, rapid specimen collapse was typically observed. This testing essentially replicated the manner in which the sands within the dam failed.

It is noted that the TX apparatus used for performing "extrusion collapse" testing is a modified TX system. The modifications are required to achieve the stress-control necessary to generate rapid specimen failure. GDS can provide TX devices specifically configured for "extrusion collapse" testing, wherein a velocity-controlled triaxial load frame receives direct feedback from a triaxial load cell via a Digital Remote Feedback Module (DigiRFM). The direct feedback can significantly increase the responsiveness of the triaxial load frame, enabling fast axial compression to be applied as rapid specimen collapse initiates under drained conditions.

Undrained TX tests were also performed on slimes specimens obtained from field sampling, however the results from these tests were not used by the panel.

4.3 Other advanced laboratory testing

One direct shear test, one oedometer test, and two bender element tests were conducted on sands specimens to provide additional strength, compressibility and permeability, and small-strain shear modulus estimates for the sands. One oedometer test, one large-strain consolidation test, and one settlement test were conducted on slimes specimens to provide compressibility, coefficient of consolidation, permeability, and settlement rate estimates for the slimes. Please refer to Appendix D of the panel's report for further details regarding these laboratory tests.

5.0 Insights from the advanced laboratory testing programme

The panel's advanced laboratory testing programme provided a number of important insights into the overall behaviour of the sands and slimes, as well as estimates for fundamental engineering parameters, which assisted the panel in determining why the dam failure initiated at the left abutment on the 5 November 2015.

Cyclic direct simple shear testing of sands specimens within a GDS EMDCSS device showed that significant excess pore pressures and shear strains did not develop when representative low-magnitude earthquake loadings were applied. This enabled the panel to conclude that the earthquakes which preceded the dam collapse did not induce liquefaction within the sands, ruling out a potential failure mechanism. The panel did however note that the earthquakes likely accelerated the dam failure.

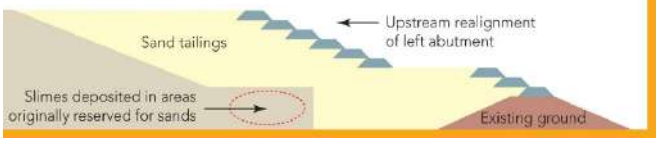
Drained "extrusion collapse" triaxial testing of sands specimens replicated the rapid collapse that was observed to have occurred during the dam failure, helping the Panel to confirm that a lateral extrusion mechanism ultimately triggered the liquefaction flowslide. Standard drained and undrained triaxial tests also provided strength, critical state, and dilatancy parameter estimates for the sands for use in stability and deformation analyses.

Oedometer testing of a slimes specimen provided data to inform the consolidation and permeability parameters adopted as part of the panel's modelling of the consolidation behaviour of slimes underlying the dam's left abutment.

6.0 Conclusions reached by the panel

The panel's investigation ultimately concluded that the dam failed because a lateral extrusion mechanism triggered liquefaction within loose, saturated sands located at the left abutment. This mechanism, in which slimes-rich deposits located beneath the sands (figure 4) deformed laterally (ie were extruded) when compressed under the load from the increasingly tall dam, forced the sands above to undergo a progressive reduction in horizontal stress (ie a reduction in confinement) and effectively loosen. This process eventually resulted in the sands reaching an unstable stress state, at which point liquefaction was triggered and the dam breached. Modelling conducted by the panel suggested this state of instability was expected to be reached at approximately the dam height present on the 5 November 2015, helping to explain why the dam failed when it did.

FIGURE 4: GENERALISED SCHEMATIC ILLUSTRATING HOW UPSTREAM REALIGNMENT OF THE LEFT DAM ABUTMENT, COMBINED WITH ENCROACHMENT OF SLIMES INTO AREAS ORIGINALLY RESERVED FOR SANDS, COULD RESULT IN THE LEFT DAM ABUTMENT BEING CONSTRUCTED ABOVE SLIMES-RICH DEPOSITS



Conditions necessary for a lateral extrusion mechanism to develop at the left dam abutment and initiate the liquefaction flowslide were effectively created by problems encountered during construction, operation and raising of the dam, specifically:

- **Loose, uncompacted sands became susceptible to liquefaction through being saturated, which occurred due to inadequate drainage conditions. This issue is unlikely to have arisen had the original high-capacity drainage system remained operative throughout dam operation.**
- **A lateral extrusion mechanism was able to develop because the abutment was realigned upstream and subsequently constructed above slimes-rich deposits. This realignment is unlikely to have been required had the underlying concrete gallery not experienced structural failure, and significant slimes-rich deposits are unlikely to have been present at the realigned abutment location had the 200m design beach width been maintained throughout tailings deposition.**

7.0 Summary

The Fundão Tailings Dam was determined to have failed on the 5 November 2015 in a liquefaction flowslide, initiated by the lateral extrusion of slimes-rich deposits underlying loose, saturated sand tailings.

The Fundão Tailings Dam Review Panel reached this conclusion following a systematic investigation which, amid many other analyses, incorporated the advanced laboratory testing of sands and slimes specimens within a GDS Electromechanical Dynamic Cyclic Simple Shear device.

This case study demonstrates the insights advanced laboratory testing programmes can provide when examining the behaviour and potential failure mechanisms of tailings materials during forensic investigations, as well as how a chain of unintended events and deviations from original design can result in the catastrophic failure of a dam structure.

Disclaimer

This case study has been prepared solely by GDS Instruments following its review and interpretation of a publicly

available technical report. This case study has not been reviewed by third parties and does not constitute technical advice of any sort.

References

ASTM (2007). Standard Test Method for Consolidated Undrained Direct Simple Shear Testing of Cohesive Soils, ASTM D6528-07 ASTM International

Fonseca do Carmo, Fl; Kamino, L H Y; Tobias Junior, R; Christina de Campos, I; Fonseca do Carmo, Fe; Silvino, G; Xavier de Castro, K J d S; Mauro, M L; Rodrigues, N U A; Miranda, M P d S; Pinto, C E F, (2017). Fundão tailings dam failures: the environment tragedy of the largest technological disaster of Brazilian mining in global context Perspectives in Ecology and Conservation, 15, p145-151

Morgenstern, N R; Vick, S G; Viotti, C B; Watts, B D, (2016). Fundão Tailings Dam Review Panel, Report on the Immediate Causes of the Failure of the Fundão Dam 25 August 2016 Cleary Gottlieb Steen and Hamilton

Ridley, K; Lewis, B, (2019). BHP faces $5bn claim over 2015 Brazil dam failure

(Claire Smith / GROUND ENGINEERING, Technical Note, 12 February, 2020, https://www.geplus.co.uk/features/technical-note-fundao-mine-tailings-dam-failure-12-02-2020/)

Slide3 and RS2 : The Tools of Choice for Back-Analysis of an Open Pit Mine Highwall Failure

Rocscience Slide3 and RS2 are widely known for their reliable and robust limit equilibrium and finite element slope stability analysis . It comes as no surprise, then, that they were the tools of choice for J.M. Kabuya et. al. in a paper presenting a numerical back-analysis of a highwall slope failure that occurred in an open pit mine in Canada.

The highwall was over 125 m high and 200 m wide, with the overall slope angle being 44°. The instability was detected by slope stability radar resulting in a multi-bench failure consisting of approximately 3,000,000 t of rock.

The Methodology

The methodology of the back-analysis consisted of three steps:

Step 1 – Base case models were developed and analysed using Slide3.

Step 2 – Iterative calibration of the base case model reproduced the observed failure characteristics.

Step 3 – Finite element back-analysis using RS2 to verify the results of Slide3.

The Inputs

Several data sources and assumptions were used in the preparation of the base (pre-calibration) modeling inputs for the slope failure back-analysis:

Geological Model

The mine geological block model was used as the basis for developing 3D geology solids to be used for the back-analysis modeling. These 3D solid files were clipped to the area of interest for Slide3 import and sectioned for use in RS2. Figure 1 depicts the geometrical model, including the geological model, used in the initial iteration of the base case model.

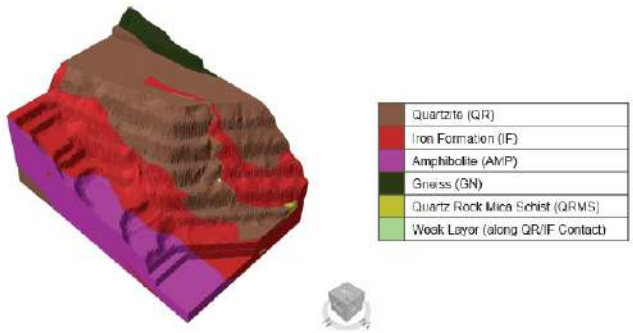


Figure 1. Geometrical model including the geological model

Geotechnical Model

A previous geotechnical characterization for the open pit as well as data presented specific to the highwall failure location were used for the base case modeling.

Rock mass strength – Base case rock mass strength and quality parameters for the five lithological rock units that were present in the southeast area of the open pit studied, were sourced from reported 35th percentile strength parameters used for 2D limit equilibrium analyses by Piteau Associates Engineering Ltd. (2016), as shown in Table 1 and were used as the input parameters for the base case finite element and limit equilibrium numerical models.

Lithology	Unit weight (kg/m³)	Intact rock strength (MPa)	RMR_{76}/GSI	Mi
Amphibolite	3,066	93	71	11
Gneiss	2,835	56	65	23
Iron formation	3,583	150	73	25
Quartzite	2,651	258	78	33
Quartz rock mica schist	2,674	113	70	12

Table 1. Hoek-Brown rock mass strength parameters

Orientations of discontinuities - Structural data was collected from photogrammetry mapping of the highwall. Figure 2 presents a stereonet representative of the discontinuity sets and orientations. Discontinuities along foliation in the region of the failure were typically moderately to steeply dipping, with strike near-parallel to the northwest-facing pit wall (FL-1B, FL-1C, and FL-1A). Cross joints oriented orthogonally to the foliation were also present (JN Set 1A/1B, BD-1).

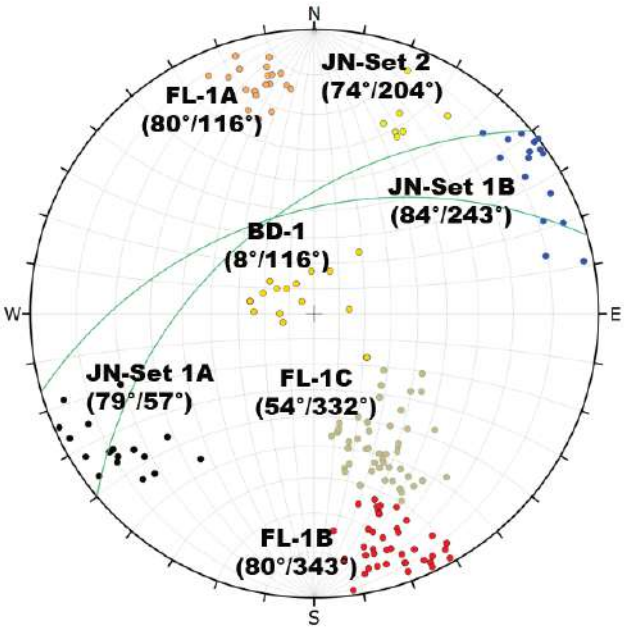


Figure 2. Structural interpretations of the southeast region of the open pit mine (Kabuya & Henriquez 2017)

Shear strength along discontinuities – For back-analysis modeling of the highwall failure, where photos indicated highly persistent foliation discontinuities, strengths based on 5% rock bridging were assumed for the orientations of bedding joints and other joints in the base case models. These strength parameters are summarized in Table 2 for discontinuities in AMP, IF, and QR.

Lithology	Discontinuity type	Cohesion (kPa)	Friction angle (°)	Residual cohesion (kPa)	Residual friction angle (°)
Amphibolite	Fault	–	22.6	–	18.0
	Bedding joint (foliation)	128	33.6	0	27.0
	Joint	–	39.1	–	33.0
Iron formation	Fault	–	24.3	–	20.0
	Bedding joint (foliation)	154	35.0	0	29.0
	Joint	–	40.3	–	34.0
Quartzite	Fault	–	25.4	–	20.0
	Bedding joint (foliation)	283	35.9	0	30.0
	Joint	–	41.1	–	34.0

Table 2. Mohr-Coulomb shear strength based on lithology and discontinuity type (5% rock bridging adapted from Piteau Associates Engineering Ltd. 2016)

Slide3 Limit Equilibrium Back-Analysis

Slide3 was the primary tool for back-analyzing the open pit highwall failure. The potential sliding mass is divided into vertical columns for analysis. An overall FOS for the sliding mass is calculated based on the forces and moments acting on each column, and this calculation is performed iteratively to search for the most critical potential failure surface, i.e., the slip surface with the lowest overall FOS.

Slide3 Model Development

The base case Slide3 model was developed progressively, beginning with an assumption of homogenous isotropic rock units and incrementally introducing anisotropic strength and discrete structures based on the input parameter assumptions. Complexity was added gradually to the models to understand the effects of each assumption on the stability analysis. In all cases, reported minimum FOSs were determined using the Janbu simplified force-equilibrium method and Cuckoo Search for ellipsoidal surfaces followed by surface altering optimization (SAO).

Base model (V1) – The geometrical model, including the geological model used in the initial iteration of the base case model, is depicted in Figure 1. The results of the isotropic rock mass model indicated that the slope was stable (minimum FOS = 6.5), suggesting that the estimated rock mass strengths alone do not effectively simulate the directional weakness that can control stability when persistent discontinuities are aligned with a direction of potential sliding. Nonetheless, the geometry of the lowest FOS slip surface did match well with the observed extents of the failure detected by the mine's GroundProbe slope monitoring radar, as shown in Figure 3a.

Anisotropic strength added (V2) – With the aim of reducing the slope FOS and to better represent the directionally-dependent strength of the jointed rock mass, anisotropic strength windows representative of the average orientation of Foliation 1B and 1C (67°/338°) and joint sets JN-1A (79°/57°) and JN-1B (84°/243°) were added to all rock units in the model, which resulted in a reduced slope FOS of 4.8. When anisotropic strengths representative of JN-2 (74°/204°) and BD-1 (8°/116°) were also added, FOS was further reduced to approximately 2.7 (Figure 3b).

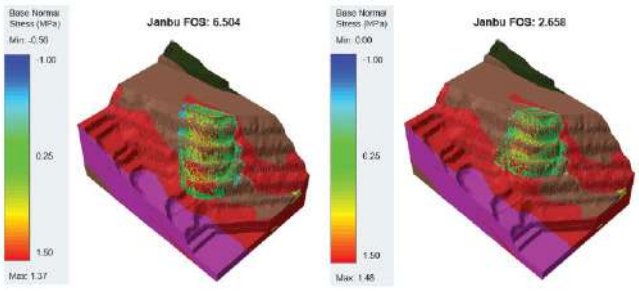


Figure 3. Critical slip surface: (a) V1 model, (b) V2 model

Elevation-dependent foliation (V3) – To further define the foliation structure present in the immediate area of the highwall instability, and in an attempt to adjust the predicted failure geometry, separate structural regimes were defined for the upper and lower slopes in the failure area. Figure 4a depicts two sections within the V3 limit equilibrium model, denoted by the colour variation in QR. Analysis of the V3 model did not significantly alter the predicted failure geometry from V2 and indicated a slightly increased critical FOS (3.1). Despite this, the V3 model was considered the best estimate of the geometric and structural features of the highwall failure.

Slide3 Model Calibration

A calibration of strength parameters and groundwater conditions was performed on the V3 model to reduce the estimated FOS to approximately 1.0 and to match the observed extents of failure and interpreted mechanisms of failure. To do so, variations of parameters related to shear strengths, discontinuities, and groundwater conditions were tested.

Results of the tests produced a model with a minimum slope FOS of 0.97 for a failure surface that slides along the weakened QR-IF contact, exiting the slope at a minimum toe elevation of approximately 642 m, exploiting the weakened BD-1 joint set at the toe. Figure 4b shows an image of this failure surface. The same model, run without the influence of groundwater, indicated a slope FOS of 1.3. Equivalent models run using the 2015 and 2017 pit topography surfaces produced FOS values of 8.2 and 1.2 under wet conditions, respectively.

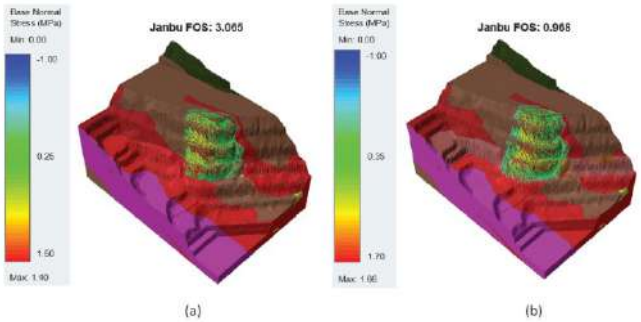


Figure 4. Critical slip surface: (a) V3 model, (b) Calibrated Slide3 model

RS2 Finite Element Back-Analysis

A section through the highwall failure mass was analyzed in RS2 to verify the results of the Slide3 modeling exercise and to explore the possibility of failure mechanisms not simulated in Slide3's limit equilibrium calculation.

In RS2, the stability of a slope is quantified using the shear strength reduction (SSR) method. With this approach, the shear strength of the simulated rock mass and joints is incrementally reduced until instability occurs. The factor by which the strengths must be reduced to cause the instability, called the critical strength reduction factor (SRF), is analogous to an FOS calculated in Slide3. Critical SRF values were obtained for numerous variations of the RS2 model, mostly targeted at evaluating the influence of BD-1 strength parameters below 646 m elevation, groundwater conditions, and strain softening assumptions. Selected cases are presented in Table 3.

RS2			SLIDE3
Case	**BD-1 joints**	**Critical SRF**	**FoS**
No strain softening, dry conditions	No BD-1 joints	4.9	4.8
	Strong BD-1 ubiquitous joints (40° friction, zero cohesion)	2.6	2.7
	Weak BD-1 ubiquitous joints (30° friction, zero cohesion)	2.1	1.3
Strain softening, dry–wet conditions	Strong BD-1 joints (40° peak friction, 34° residual friction, zero cohesion)	1.7–1.4	1.11
	Slightly weakened BD-1 joints (35° peak friction, 29° residual friction, zero cohesion)	1.5–1.2	1.04
	Weak BD-1 joints (30° peak friction, 24° residual friction, zero cohesion)	1.2–0.95	0.97

Table 3. Factor of safety (FOS) and critical strength reduction factor (SRF) values

Figure 5 depicts the critical SRF state of the RS2 case 10 final model showing contours of maximum shear strain. The con-

tact between QR and IF forms a significant portion of the upper failure surface and the sub-horizontal BD-1 joint set forms the lower portion of the failure surface. Figure 6 depicts the critical SRF state of the RS2 case 10 final model showing contours of total displacement.

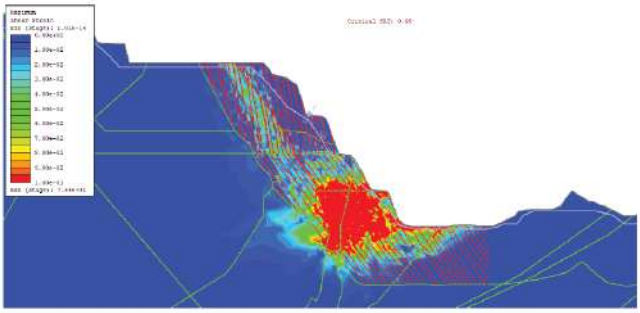


Figure 5. Critical strength reduction factor for RS2 case 10 final model (maximum shear strain)

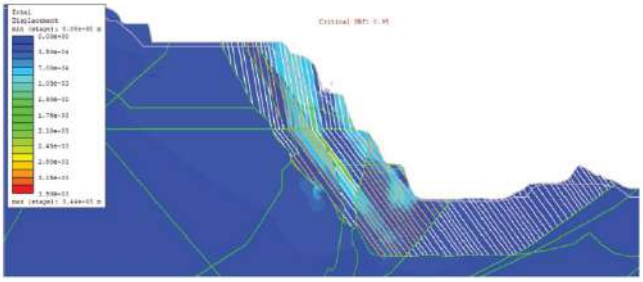


Figure 6. Critical strength reduction factor for RS2 case 10 final model (total displacement)

Conclusion

The results of this simple calibration study were judged to reproduce the observed failure mechanism satisfactorily and may be referenced for future geotechnical design analyses for the open pit studied as well as other mine pits of a similar magnitude or where similar geotechnical conditions or features exist. In addition, the back-analysis highlights that understanding the geological variability associated with complex structural environments requires an excellent understanding of the orebody genesis and the regional geologic environment.

Reference

J.M. Kabuya, R. Simon, J. Carvalho, and D. Haviland. Numerical back-analysis of highwall instability in an open pit: a case study. Slope Stability 2020 - PM Dight (ed.). Australian Centre for Geomechanics, Perth, ISBN 978-0-9876389-7-7. https://papers.acg.uwa.edu.au/p/2025_62_Kabuya/.

(RocNews July'20, https://www.rocscience.com/about/news-events/slide3-and-rs2-the-tools-of-choice-for-back-analysis-of-an-open-pit-mine-highwall-failure)

3D Modelling of Underground Excavations

The principal objective of this article is to outline how RS3, the 3D numerical modelling software based on the finite element method (FEM), and EX3, the recently released overhaul of Examine3D, complement each other in the analysis and design of underground excavations for civil engineering and mining applications. The article targets practicing geotechnical engineers and engineering geologists who need to model underground excavations. Many of these professionals possess a firm understanding of geotechnical engineering, particularly the physical behaviour of geological materials. What many of them lack is highly specialized numerical modelling skills. Practicing geotechnical engineers are also typically constrained by tight project timelines and limited budgets; they often need to obtain answer questions over a short time.

The relatively simple, inexpensive, and fast-computing EX3, can be used by practitioners to study the effects of excavation on stresses and displacements of geological material and major geological discontinuities such as faults. EX3 is well suited for elastic analysis involving large extents and irregular geometries (which is particularly true of mining). Parts of the discussion will detail the types of problems that EX3 can analyze and the program's advantages and limitations. The article will also describe the power of RS3 and how that can be combined with EX3 to facilitate good geotechnical engineering.

The article is laid out as follows:

- First introduces readers to underground geomechanics problems and why numerical modelling tools are essential for problem-solving in everyday engineering of underground excavations
- Provides a brief overview of numerical methods for underground excavation analysis, shows the classes to which RS3 and EX3 belong, and the programs' advantages and limitations
- Discusses the problems caused by excavating near or across major geological structures such as faults
- Outlines types of underground excavation analysis and design problems that EX3 and RS3 can address, and insights that engineers can gain using both software, and
- Summarizes the attractiveness of both software.

Numerical Methods for Geomechanics

Different types of soil and rock failure mechanisms, ranging from the simple to the very complex, can occur with underground excavation under the combined influence of geology, in situ stress and mining/geotechnical conditions (including excavation geometries and layout). It is best to study these problems with numerical modelling software tools.

The purpose of all numerical modelling in rock engineering is to analyze the behaviour of geological media and structures under excavation and other loading conditions. Numerical methods aim at producing 'acceptably accurate' solutions to complex geomechanics problems by dividing domains into equivalent systems of smaller, interconnected elements and determining approximate solutions. By necessity, models incompletely represent the real world. However, they allow us to investigate the responses and characteristics of geotechnical structures/excavations and anticipate how they will behave under different conditions.

Numerical methods attempt to satisfy several theoretical geotechnical requirements, including

- Realistic material stress-strain responses and their related parameters
- Boundary conditions that realistically simulate real-world conditions
- Excavation geometry and layouts
- Construction sequence
- Interactions between support and surrounding ground, and
- Consideration of pore water pressures

With recent advances in computing, numerical methods are enjoying increasing use in the solution of three-dimensional problems.

Numerical modelling can help engineers and engineering geologists gain valuable insights into potential failure modes and areas in which these are likely to occur. This aspect enables geotechnical professionals to develop designs and solutions. Numerical modelling tools help geotechnical professionals rationally compare design alternatives and identify those requiring more detailed analysis. (This is one of the critical ways in which EX3 and RS3 complement each other and help engineers optimize the use of time and budgetary resources.)

Numerical tools are particularly useful for undertaking parametric and sensitivity analyses. They help engineers and geologists appreciate the uncertainty and risks associated with design choices.

The numerical methods can be classified into the following three main categories:

- Continuum methods
- Discontinuum methods, and
- Hybrid continuum/discontinuum methods.

Continuum methods assume that the continuity of all points in a problem domain is always preserved. As a result, even when discretized into elements, these methods ensure continuity between the elements. Discontinuum methods treat individual elements as being separate but interacting with each other. Whereas continuum methods focus on the deformations of a system, discontinuous methods typically target the rigid body motions (usually large movements) of individual elements.

The most popular continuum methods are the Finite Element Method (FEM), Finite Difference Method (FDM) and Boundary Element Method (BEM). The most widely used discontinuum methods are the Discrete Element Method (DEM) and Discontinuous Deformation Analysis (DDA).

The FEM is the numerical method most widely applied to a wide range of problems in soil and rock. It can accommodate geometries of geotechnical structures, complex loading paths, and nonlinear behaviour of soils and rocks, among many other important aspects. However, models are typically

larger, require more computing power and take longer to compute. RS3 is a full 3D FEM implementation.

As the name suggests, the boundary element method (BEM) 'discretizes' (or divides into elements) the boundaries in a problem domain. Boundaries include geometric entities such as excavation surfaces, discontinuities, and material interfaces, for multi-material problems. Because the BEM discretizes only boundaries, model sizes are typically much smaller and compute times faster. However, it is not as generalized as the FEM. EX3 is a BEM program.

The next sub-section will briefly describe key features of the BEM and FEM.

The Boundary Element Method

There are two types of BEMs – direct boundary element methods and indirect boundary element methods. The direct boundary element method solves directly for unknown stresses and/or displacements from specified boundary conditions. Direct boundary element methods are constrained to simple problems such as half space problems in civil engineering.

The indirect boundary element method uses fictitious stresses on boundaries to first calculate the stress conditions on the boundaries and then applies separate relationships to find boundary displacements. For underground excavations, the indirect boundary element method (fictitious stress method) is widely used. 3D (Examine 3D, Curran & Corkum, 1993) and 2D (Examine 2D, Curran & Corkum, 1994) boundary element programs were used in this research.

Under the class of indirect BEMs, there is a method known as the Displacement Discontinuity Method (DDM). It is well suied to the modelling of tabular orebodies, excavations, and major geological structures such as faults.

With most numerical methods, far-field stress and displacement conditions must be approximated in some way. This is typically done by truncating the problem domain at some distance beyond the zone of influence of the excavation and fixing the outer boundaries. The BEM captures excavation influence into infinity, i.e. far-field stresses are not influenced by the creation of excavations. Consequently, for problems involving linear elastic, homogeneous material domains, the BEM offers a major advantage of correctly modelling far-field boundary conditions, and confining discretization errors to problem boundaries. It ensures that stresses and displacements vary continuously throughout the problem domain, and problems compute much more rapidly than other numerical methods.

The ability to inherently model far-field stress conditions can be disadvantageous in the solution of problems involving different geological units of finite extents. For such problems, the BEM requires special numerical techniques. These are implemented in EX3 and allow the program to be applied to multi-material problems.

The Finite Element Method

The FEM originated in the early 1940s from the solution of complex elasticity and structural analysis problems in civil and aeronautical engineering. The FEM develops systems of algebraic equations that approximate solutions for partial differential equations. It accomplishes this by subdividing a problem domain into smaller, simpler components – elements.

The FEM can be applied to a very broad range of geotechnical engineering problems that require calculation of stresses, displacements, pore pressures and forces in support elements. In many cases, what limits the FEM's application are factors such as computational resources, time, acquisition of appropriate input data and not inherent limitations of the method. The method can account for complex in situ stress conditions, linear and nonlinear stress-strain behaviour, multiple materials and support systems, excavation and construction sequences, groundwater conditions, and mix of boundary conditions, among other factors.

3D Numerical Modelling

In the past, when there were no easy-to-use three-dimensional analysis tools, engineers simplified all problems to two dimensions. Sometimes they did so using questionable assumptions. Today, the availability of software tools such as EX3 and RS3, truly three-dimensional aspects, such as excavation layout and sequencing, can be readily modelled. These software tools can also model the localized and mine-wide influence of major geological structures (such as faults, shear zones and dykes) on excavations. For example, numerical modelling software can help engineers and geologists to determine excavation conditions under which faults can slip and sometimes induce seismic events.

Input Parameters for Numerical Modelling

From the above discussions, inputs for numerical analysis of underground excavations include the following:

- In situ stress states (principal stress magnitudes and orientation)
- Excavation geometry, layout and sequence
- Strength and deformation characteristics of rock mass units, faults and other large-scale geological structures
- Strength, deformation and mode of action of support systems or elements
- Location and orientation of faults relative to excavations (whether they daylight/intersect or are simply situated close to excavations)
- Number of faults, and
- Water pressures

RS3 takes all of the above into account. EX3 accounts for most except for pore pressures and the influence of structural support elements.

What are the effects of faults on underground excavations?

It is not uncommon for orebodies to occur within or near geological discontinuities such as faults, shear zones and intrusions. Civil engineering infrastructure such as power caverns and tunnels also regularly encounter major geological structures. When major discontinuities lie within rock mass volumes influenced by excavation, stress redistributions can strongly depart from classic continuum mechanics and must be studied closely. Modelling of the interactions between excavations and faults, particularly at mine-wide scale, is a key challenge in the geomechanics of underground excavations. As a result, this section of the article will discuss details of these interactions.

Slip and separation of geological structures that daylight into excavations can generate stress relaxation, a major cause of excavation instability. In mining, for example, relaxation occurs in hanging walls. Relaxation typically allows the formation of gravity-induced failures (falls of ground) and significantly influences ore dilution. Faults also act as free surfaces that help create rock wedges and facilitate wedge

movements. Differences in the strength and deformation characteristics between fault materials and adjacent rock mass units also contribute to the redistribution of stresses and displacements with excavation.

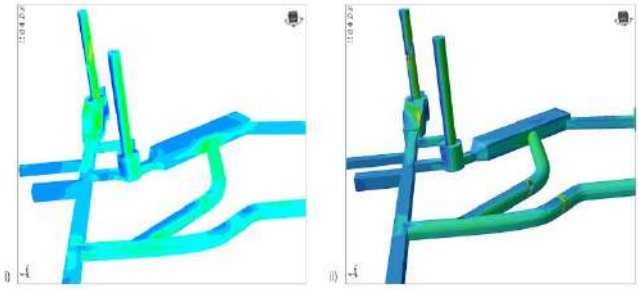
When a fault does not intersect an excavation but lies close to it, slip along the fault can concentrate stresses in the rock mass volume between the excavation and the fault. In high stress environments (such as those encountered in deep mining or tunnelling through high mountains), this stress concentration can lead to rockbursts.

It can be seen from the above discussions that the degree to which faults influence excavation stability is determined by excavation geometry, locations of faults relative to excavations, in situ stresses, and the strength and deformation characteristics of the rock mass units and faults.

RS3 and EX3 can efficiently model excavation-fault interactions. EX3 is the preferred tool when trying to understand the influence of mine-wide excavations on fault behaviour due to the method's use of surface discretization only. RS3, on the other hand, is better suited to understanding the details of excavation-fault interactions, resulting redistributions and the design of support for such areas.

Combination of EX3 and RS3 in Practice

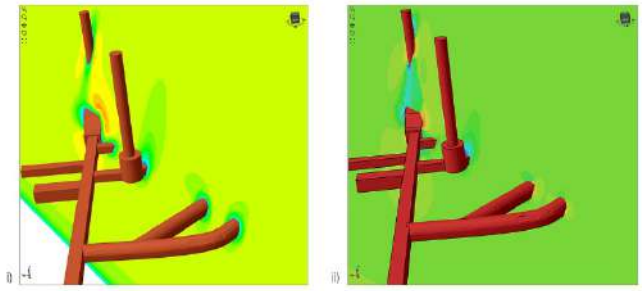
EX3 combines the DDM with the conventional indirect BEM. As a result, although EX3 models only elastic material behaviour, it can capture the inelastic effects of separation and slip of large-scale discontinuities on stress redistributions around excavations. If such analysis with EX3 indicates zones of inelastic response that are relatively large compared to the dimensions of excavations, it may be necessary to undertake more detailed studies into these effects using RS3. However, even in such cases, surprisingly useful engineering insights can be established using the simpler approaches of EX3.



Contours of major principal stresses around the excavations as viewed in (i) RS3 and (ii) EX3. Note the stress concentrations on both plots where the fault intersects the excavations.

For the above reasons, in large-scale problems Rocscience recommends that EX3 elastic analysis precede more sophisticated RS3 analysis. EX3 allows for quick, inexpensive exploration of the effects of varying design controls such as excavation dimensions, shape, location, orientation and sequence. Once key understanding has been gained, RS3 can be deployed to model inelastic material behaviour, groundwater effects, and to design support elements such as bolts, liners.

For smaller scale excavations such as those encountered in civil engineering, both EX3 and RS3 can again be used to assess the stability of rock masses immediately adjacent to excavations, including when fault intersect the excavation or pass close by the excavation. Typical examples are found in the excavation of tunnels and power caverns. Again, EX3 offers the advantage of rapid computing of simple elastic material response. The simple-to-use EX3 elastic stress-strain analysis tool can be used to estimate fault-slip potential of faults. EX3 can be used to estimate the location and size of excavation disturbance zone based on in situ stresses, strength and deformation properties of rock masses and discontinuities, and the layout and geometries of excavations.



Contours of normal stress on the fault as viewed in (i) RS3 and (ii) EX3.

Elastic analysis based on a linear relationship between stress and strain ignores peak and post-peak strength behaviour and can significantly overestimate calculated stresses, strains and kinetic energies. RS3 can be employed to evaluate the 'true' magnitudes of stresses and extents of failure zones. It can also be used to assess the interactions between support elements and the ground being supported.

Both EX3 and RS3 can be powerful in assessing potential pillar behaviour and evaluating different strategies and tactics (such as backfill support) for minimizing negative impacts of stress redistribution from excavation.

Concluding Remarks

Considerable understanding into the behaviour of rock masses and major geological structures due to excavation (both mining and civil) can be gained using numerical modelling tools, including EX3 and RS3. EX3 combines speed and simplicity, making it useful for generating preliminary insights into stress problems, and analyzing large-scale underground mines and tunnels. It is very helpful in studying interactions between different excavations, and between excavations and geological structures. RS3, on the other hand, is more powerful and versatile in handling a broad range of geotechnical inputs and problems, including complex material, soil-structure interactions and support behaviours.

Although EX3 and RS3 do not in themselves solve problems, they offer the tools for tackling your practical, engineering challenges. The two software help you to manage the challenge of appropriately balancing accuracy with costs such as available time, computational resources and budgetary constraints.

(RocNews July'20,
https://www.rocscience.com/about/news-events/3d-modelling-of-undergroud-excavations-with-ex3-and-rs3)

Tunnel Vision: Europe's New Urban Pathways and Metro Stations

Urban connections define modern cities. From public transportation to walking and cycling paths, mobility has the potential to enrich urban life. In Europe, planners and designers have a long history of working through city connections to integrate with existing historic fabrics and make room for contemporary transport solutions.

Taking a closer look at Europe's metro stations and new urban networks, it's quickly apparent that there is a significant investment in "hubs of mobility" that work together for different types of transportation. Bringing together mixed-use architecture and public space, these projects are made for better operations management and to promote density. The following designs look at urban pathways and metro stations built within the last ten years, projects made to reimagine how we move over, under, and around our cities.

Széll Kálmán Square / Építész Stúdió + Lépték-Terv

The project was the refurbishment of one of Budapest's busiest downtown transport hubs and one of the most visited public squares. Due to the strict order of tramlines and roads, the main architectural and landscaping goal was to clean up and rationalize the inner parts, making the square a pedestrian priority public space with as many green areas as possible.

Rotterdam Central Station / West 8 + Benthem Crouwel Architects + MVSA Architects

Rotterdam Central Station is one of the most important transport hubs in The Netherlands. With 110,000 passengers a day the public transport terminal has as many travelers as Amsterdam Airport Schiphol. In addition to the European network of the High Speed Train (HST), Rotterdam Central is also connected to the light rail system, RandstadRail.

Cuyperspassage / Benthem Crouwel Architects

Cuyperspassage is the name of the new tunnel at Amsterdam Central Station that connects the city and the waters of the IJ-river. Since the end of 2015 it has been used by large numbers of cyclists, some 15,000 daily, and pedestrians 24 hours a day. The tunnel is clad on one side by nearly 80,000 Delft Blue tiles: a true Dutch spectacle at a central spot in Amsterdam.

Delft City Hall and Train Station / Mecanoo

From the outset, Mecanoo's idea was to design a station that makes it clear to visitors that they have arrived in Delft. The station, in combination with the new city hall, sits atop a new train tunnel built in place of the old concrete viaduct that divided the city in two since 1965. Coming up the escalators, the ceiling with the historic map of Delft unfolds.

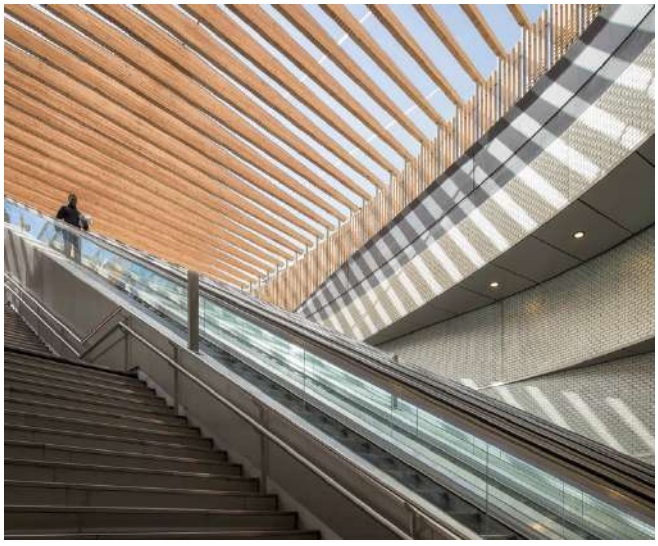
Løren Metro Station / Arne Henriksen Arkitekter + MDH Arkitekter

The neighbourhood of Løren, a former industrial area and military camp, has in recent years emerged as a new, attractive residential district. As a further development of the area a new metro station was planned. The station is located 27 meters underground and accessed by stairs, escalators or lifts from the two entrances.

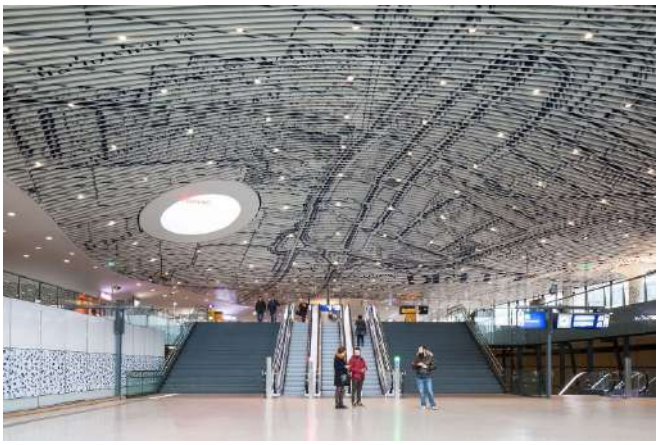
Zürich Main Station / Dürig AG

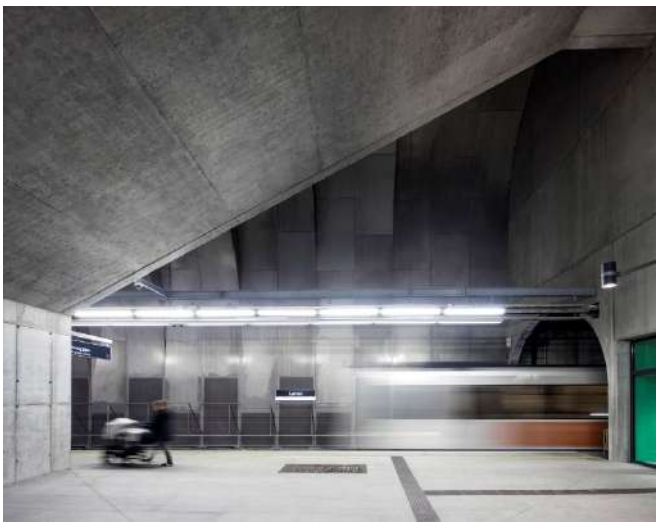
The new underground Löwenstrasse transit station forms the centrepiece of the cross-city rail link. With its four railway tracks and two platforms it is situated below tracks 4 to 9 of the upper central station. The east end of the platform is aligned underneath the transverse hall of the historical main station, after which the tunnel descends beneath the River Limmat towards Oerlikon.

Porte Marguerite de Navarre / 169 architecture



This temporary project for a metro station follows the initiative of the city of Paris that aims to promote the use and reuse of bio-sourced materials. Elioth and 169-architecture defined several principles for the realization of this project in order to limit its carbon impact and encourage the use of short supply chains.





(Eric Baldwin / arch daily, July 16, 2020, https://www.arch-daily.com/943863/tunnel-vision-europes-new-urban-path-ways-and-metro-stations)

modus architects' ring road project in south tyrol includes sculptural concrete portals

since 2015, modus architects — the firm led by matteo scagnol and sandy attia — has been developing a infrastructural landscape project in northern italy. the masterplan comprises a series of connected, largely underground roads that reduce traffic volume and provide an alternate route around the south tyrol cities of bressanone (brixen) and varna (vahrn). the brief called for a series of interventions along its entire length, including: tunnel portals, retaining walls, acoustic barriers, service substations, mechanical structures, ventilation chimneys, and various signage elements.

modus architects began the project by seeking to minimize the environmental impact of the elements above ground in order to express both an architectural and technical quality. secondly, these elements, and those below ground, were conceptualized into a unified, consequential design approach, and were calibrated to accommodate the particularities of the immediate site conditions. lastly, the bressanone and varna tracts were pulled together into one continuum whereby the two townships are no longer conceived as distinct contexts but as two parts of a greater whole.

the tunnels' sculptural portals have been conceived as expressive figures that emerge from the buried, unseen networks of roads. the concrete used for the new addition is made of excavation materials drawn from the ongoing construction site of the 64-kilometer-long (40 mile) 'brenner base tunnel' traversing below the alps from innsbruck (austria) to fortezza (italy). together with exposed concrete, larch wooden acoustic barrier walls, and weathering steel ventilation chimneys, the portals mark the threshold between below and above ground.

***'civil engineering projects provide a unique opportunity to bring together the different scales — and at times jarring specificities — of infrastructure, landscape, architecture and urban decorum,'* explains sandy attia, co-founder of modus architects.** *'the ring road project underlines the reciprocity of these disciplines as a singular design challenge, not just given the environmental and economic impact of these projects, but also as a model for small cities grappling with questions of mobility, heritage and placemaking.'*

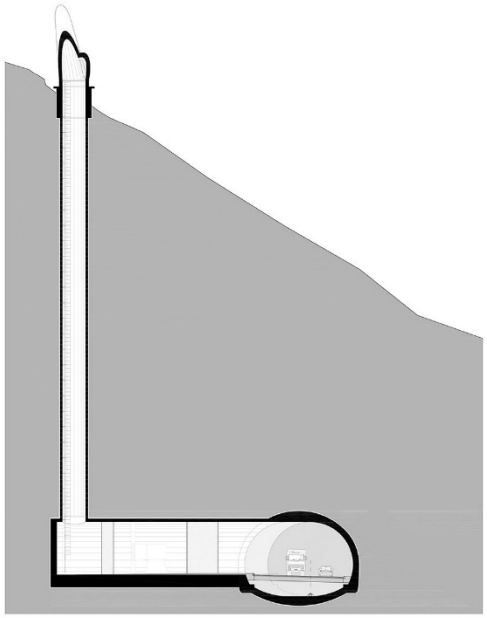
the other half of the founding duo, matteo scagnol continues: *'the role architects play in large infrastructural projects has been increasingly marginalized over the past few decades in italy: the country's remarkable density and stratification of historical and natural contexts present unique and pressing challenges that the public administration needs to address. the ring road in south tyrol is borne of deliberate, decision-making processes that comprehend the importance of design at every scale and as such created the conditions necessary for a cross-disciplinary collaboration to occur.'*

chimney construction

chimney construction

chimney construction

chimney construction



chimney section

project info:

name: central juncture of bressanone-varna ring road
location: bressanone (bolzano, italy)
architect: **modus architects** (sandy attia, matteo scagnol)
client: department of infrastructure and mobility of the autonomous province of bolzano
design phase: 2015-2017
construction phase: 2017-2020
completion: end of june 2020

civil and structural engineering, construction management: ing. mario valdemarin
engineering team: ing. mario valdemarin, ing. dieter schölzhorn, EUT energie und umwelttechnik GmbH, bergmeister GmbH, geoconsulting int.
underground and geotechnical consultant: ing. mario valdemarin, ing. dieter schölzhorn
geological consultant: geol. alfred psenner, geol. icilio starni
technological systems consultant: studio tema srl (p.i. mattia betti)
project manager: provincia autonoma di bolzano, dott. ing. umberto simone
general contractor: PAC s.p.a in ati with wipptaler bau AG and beton eisack GmbH
length: 500m /1,640 ft (central juncture tunnel); 5km / 3 miles (completed ring road); 8km / 5 miles (full length of the ring road)
materials: exposed concrete, leca-beton (structural light concrete with leca expanded clay aggregates), cor-ten steel, larch wood

(philip stevens / designboom, jul. 15, 2020, https://www.designboom.com/architecture/modus-architects-ring-road-south-tyrol-sculptural-concrete-portals-07-15-2020)

Let's Boogie in a new tunnel

The new Victory Boogie Woogie Tunnel will be the most sustainable tunnel in the Netherlands.

The road surfaces have been paved with asphalt

The new tunnel connection being opened in The Hague is claimed to be the most sustainable tunnel in the Netherlands.

The tunnel gets its rather unusual name from an artwork by Dutch painter Piet Mondrian, the Victory Boogie Woogie.

The construction of the new tunnel project is being headed by BAM Infra, which is meeting tough environmental constraints set by the Netherlands Government. The Rotterdamsebaan project, as it is known, involves building the new road for the City of The Hague, which includes the construction of the tunnel.

The project to build this new road and tunnel connection is necessary to tackle the heavy traffic congestion in the area. At present, vehicles travelling to and from The Hague rely on a number of routes, one of which is the Utrechtsebaan (A12). This carries around 40% of the traffic entering and leaving the city and has suffered from severe congestion, particularly at peak periods. The traffic congestion also affects residential areas such as Rijswijk and Voorburg in The Hague as well as surrounding areas.

The massive cutting shield for the TBM had to be moved by barge

However, opening the Rotterdamsebaan link, measuring around 4km in all, will help to address the traffic problem. It will make The Hague and the area surrounding it more accessible according to the project partners.

The Rotterdamsebaan will connect the A4 and A13 highways, as well as the city's central ring road. It runs from the Ypenburg interchange, entering a cutting in the Vlietzone and then going underground close to the car park at Drievliet. The underground section of the Rotterdamsebaan runs under the Westvlietweg, Voorburg-West, the Forum Hadriani archaeological site and the Binckhorst harbour. The road then re-emerges at Binckhorst by the Zonweg, where it links with the Binckhorstlaan and the Mercuriusweg. The tunnel has been designed for vehicles to travel at speeds of up to 70km/h.

BAM Infra is building the Rotterdamsebaan road project at a cost of some €301 million. The link will includes two 450m-long ramps, 650m of cut and cover tunnel and the dual tunnel sections that have been bored with the help of a massive TBM.

A key improvement will be the reduction in heavy vehicles using minor roads in the area. Overall, the opening of the road and tunnel stretch will help to distribute vehicle traffic more evenly, while reducing vehicle movements on minor roads as well as for the existing (and overloaded) Utrechtsebaan. For drivers, the congestion problem will be reduced significantly and journey times will be shorter. From a safety perspective, a better distribution of the vehicle traffic to the new tunnel will reduce risks for vulnerable road users such as cyclists and pedestrians along the minor roads.

Under construction

The tender process was from 2014 to 2015, with BAM Infra winning the deal and commencing its preparatory work in 2015. Conventional earthmoving techniques were used to remove material for the ramp sections and the cut and cover tunnel stretches.

The massive Herrenknecht TBM was named the Catherina-Amalia, after the Dutch princess in line to be the next Queen

The bored tunnel sections were driven using a tunnel boring machine (TBM) built by German specialist Herrenknecht. For the project the TBM was named the Catherina-Amalia.

The machine was equipped with a mixed shield with a diameter of 11.34m, driving both of the 1.6km-long twin tubes within a 12-month period. However, the work was challenging, not the least of which was due to the facts that the site area was cramped and that the team had to ensure traffic flow continued during construction.

The project partners, however, had experience of the conditions, having previously carried out tunnelling work in the area between 2013 and 2015. The same TBM had been used to drive the Sluiskil Tunnel between Goes and Ghent, which opened to traffic in May 2015. This link also features twin tubes and measures around 1.6km in length, while it was

built to reduce the congestion problems over the existing Sluiskil Bridge. After the TBM carried out the Sluiskil Tunnel work, the machine was returned to the Herrenknecht plant in Kehl, Germany to be refurbished and made ready for its next contract.

Work to drive the first bore of the Victory Boogie Woogie Tunnel was carried out between January and July 2018. Weighing 1,600tonnes and measuring 80m long, the TBM then had to be disassembled and moved into position for the second drive. Although complex, this process was carried out within schedule and the TBM was then able to bore the second tube, having started with this portion of the work in September 2018. The TBM used was named for the work and finished its second drive on the 10th of January 2019 to complete its work for the Victory Boogie Woogie Tunnel.

In all, the 80m-long TBM excavated over 330,872m3 of material and at the deepest point, the tunnels are 31m below ground. Driving the Victory Boogie Woogie Tunnel, the TBM proved highly productive and Herrenknecht said that the machine was able to achieve advance rates of up to 30m/day at one point during its second drive.

The two tunnels both feature three pumping systems under the road to collect rainwater entering, which is then discharged - image © courtesy of Frank Jansen

As with the Sluiskil Tunnel, the ground conditions for the Victory Boogie Woogie Tunnel proved difficult, featuring sand, silt and clogging-prone clay.

However, the previous experience with the Sluiskill Tunnel meant that the TBM could be configured specifically to cope with the conditions. It was fitted with an open cutting face, featuring direct material transport from the centre as well as a specially adapted slurry circuit.

Once the twin tube link had been driven, the sides of the Victory Boogie Woogie Tunnel were supported using precast segments. One of the tunnels has 818 complete ring sections while the other has 820 ring sections. Each ring itself is made up of eight components, so the longer of the tunnels features 6,650 of these precast units while the other tunnel has 6,544 of the components. When the lining work had been completed, it allowed the roadbed to be built featuring two lanes in either tube. In addition, cross tunnel connections were constructed at 250m intervals to link the twin tubes, intended to boost safety as well as provide maintenance access.

The roadway for both tunnels has been constructed on a concrete bed with an asphalt running surface, allowing a maximum height clearance of 4.7m.

Clean route

The project has had to meet tough environmental requirements and for this reason, a number of sustainable solutions are being utilised for the tunnel. The impact of work to build the project has been reduced by minimising construction traffic movements as well as by building a temporary road link.

The visual impact of the portal in the Vlietzone has been taken into account, with its design intended to 'fit in with the green landscape of the area'.

The environmental solutions include the installation of solar panels that provide all of the electrical power needed for the control room of the tunnel. Low energy LED lighting is used, reducing the power required and also minimising the need for long-term maintenance, given the longevity of the units. The systems also include a fine dust reduction system (FDRS) using filters installed at the tunnel portals to optimise the air quality within the link. The tunnel builders have fitted the FDRS to address the issue of particulates within the tunnel.

Installing the last section of the 100m-long pedestrian bridge at Drievliet - image © courtesy of Frank Jansen

Meanwhile, the road surfaces are utilising a special LEAB grade of asphalt that features the use of RAP. Pumps are also installed inside the tunnel to remove rainwater, with this being passed through to the local sewer system for safe disposal.

Other sustainability measures used during the construction process have included the use of cleaner fuel grades onsite and the installation of sound diffraction equipment to minimise traffic noise transmission.

Lifting and Shifting

A huge challenge for the project came in the shape of the massive TBM itself. Because of the TBM's sheer scale Sarens, a specialist in lifting and shifting, was brought in to move the machine. This was a key role for the entire tunnel boring operation and Sarens carried out the work on behalf of its client Combinatie Rotterdamsebaan.

Together with Herrenknecht, the firm was tasked with the initial transport and assembly of the TBM to the construction site. The firm needed to carry the TBM in 50 separate sections from the Herrenknecht factory in Germany to the site in the Netherlands, with the heaviest piece weighing some 130tonnes and measuring 5.7m wide by 4.4m high.

When the components arrived, the team started to assemble the TBM as well as the crawler crane needed for the initial lift. However, the space available for crane operation was limited so Sarens opted to use its LR1350-1 crane for its capacity and ability to manoeuvre in the tight space.

Due to the constricted working area, some parts of the tunnel boring machine had to be first assembled close to the

launching shaft and then transported using self-propelled mobile transporters (SPMTs) to the crawler crane for the lift. The crew also used a second mobile crane for the installation of the back-up trailer.

Using a crew of 10 members at a time, Sarens carried out the lifts for the cutting head, 120tonne steel cylinder, and 70tonne pump station, which required two mobile cranes working in tandem.

Sarens also then had to transport the TBM components back to the launch shaft after it had been used to drive the first bore. After the TBM carried out boring of the second tunnel, Sarens once again disassembled the machine and transported it away from the site.

However, the second phase of the project in particular, to move the TBM back to the launch shaft after the first tunnel had been bored, was not without its challenges.

One of these challenges was that the last part of the TBM to be disassembled was also the first part required for reassembly. To ensure that the reassembly work did not affect the project timeline, the team from Sarens had to plan the entire transfer operation carefully to ensure each specific task was correctly scheduled.

The actual size of the TBM was itself a challenge. While most of the TBM's components were of a size that meant they could be moved by road, six were simply too large and heavy for this option. Instead, these sections had to be transferred using an SPMT as well as a barge.

The large SPMT featured no less than 24 axles, while the barge measured 45m long by 7m across the beam. Sarens also used a number of other large items of equipment to move the TBM components. These included a 350tonne capacity LR1350-1 crawler crane, a 700tonne capacity AC700 all-terrain crane, and two mobile cranes: an LTM1400-7.1 and an LTM1130-5.1.

The TBM's cutting shield featured a diameter of 11.8m and its size meant that it was simply too wide to be moved along the roads or over bridges in the area. As a result, Sarens set up a support system that would allow the shield to be raised vertically. The crew then used the support system to lift the cutting shield in one piece, first to transfer it from the SPMTs to the barge, and then from the barge, back onto the SPMTs.

The barge had to make three trips along the canal to move the largest components. It was docked next to where a crane with a capacity of 700tonnes was located on a public road. The crane then transferred parts from the barge to the SPMTs for onward transport.

(WORLD HIGHWAYS / Road Structures, July 7, 2020, https://www.worldhighways.com/wh10/feature/lets-boogie-new-tunnel)

ΝΕΑ ΑΠΟ ΤΙΣ ΕΛΛΗΝΙΚΕΣ ΚΑΙ ΔΙΕΘΝΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΝΩΣΕΙΣ

International Society for Soil Mechanics and Geotechnical Engineering

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

1. Recent Webinars

- Prof Mark Jaksa: 2nd John Burland Lecture: Reflections on Some Contemporary Aspects of Geotechnical Engineering Education - From Critical State to Virtual Immersion
- Prof. Rodrigo Salgado: Forks in the Road: Rethinking Modeling Decisions that Defined Teaching and Practice of Geotechnical Engineering
- Prof. Susan A. Ambrose: Prior Knowledge, Learning and Common Instructional Practices Grounded in Evidence
- Prof. Luciano Picarelli: The Classification of Landslides in Soils in a Mechanical Perspective.
- Prof. Fumio Tatsuoka: Geosynthetics-Reinforced Soil Structures - Developments from Walls to Bridges.

2. Bright Spark Lecture Award at Sydney ICSMGE 2021

The deadline for Bright Spark Lecture Award nominations has been extended to 1 August 2020. Two award recipients will be given the opportunity to give a keynote lecture at the 20th ICSMGE. More information can be found here.

3. Corporate Associates Presidential Group:

The May 2020 update of Corporate Associates' varied and exciting activities around the world can be found here https://www.issmge.org/corporate-associates/corporate-associates-presidential-group. Why and how to join as a Corporate Associate are detailed in https://www.issmge.org/corporate-associates/why-how-to-join.

4. Bulletin

The latest edition of the ISSMGE Bulletin (Volume 14, Issue 2, June 2020) is available from the website https://www.issmge.org/publications/issmge-bulletin/vol-14-issue-3-june2020

5. ISSMGE Online Library – Open Access

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

- 1st (2007) and 7th (2019) International Symposium on Geotechnical Safety and Risk
- 10th International Symposium on Field Measurements in Geomechanics (FMGM2018)
- 25th European Young Geotechnical Engineers Conference

6. ISSMGE Foundation

The next deadline for receipt of applications for awards from the ISSMGE Foundation is the 30th September 2020. Click **here** for further information on the ISSMGE Foundation.

7. Conferences

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

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

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

ISSMGE Events

SECOND VIETNAM SYMPOSIUM ON ADVANCES IN OFFSHORE ENGINEERING - 22-04-2021 - 24-04-2021
Ho Chi Minh City University of Technology, Ho Chi Minh City, Vietnam; English; Organiser: Association of Vietnamese Scientists and Experts; Ho Chi Minh City University of Technology; Contact person: Dinh Hong DOAN; Email: vsoe2021@sciencesconf.org; Website: https://vsoe2021.sciencesconf.org/;

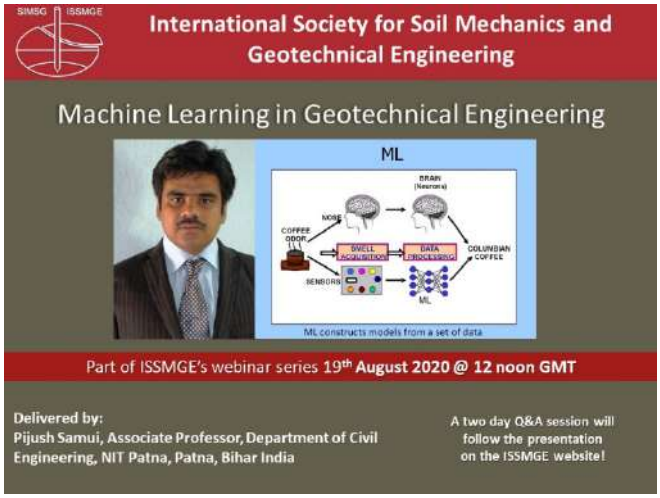
XI CONGRESO CHILENO DE GEOTECNIA - 22-11-2021 - 24-11-2021
Universidad de Talca, Chile; Language: Spanish; Organiser: Chilean Geotechnical Society; Contact person: Macarena Tugas; Email: coordinadorasochige@gmail.com; Website: http://www.sochige.cl

5TH INTERNATIONAL SYMPOSIUM ON CONE PENETRATION TESTING (CPT'22) - 08-06-2022 - 10-06-2022
Centro Congressi CNR, Bologna Italy; Language: English; Organiser: Italian Geotechnical Society (AGI) and University of Bologna (endorsed by TC102); Contact person: Susanna Antonielli (AGI), Prof. Guido Gottardi (University of Bologna); Email: guido.gottardi2@unibo.it;

Machine Learning in Geotechnical Engineering

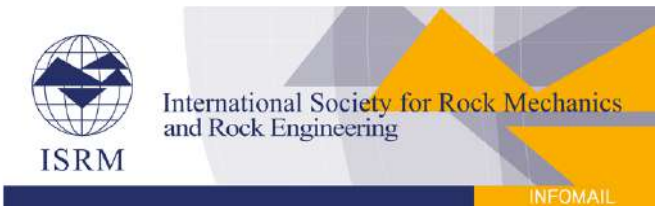
Presenter: Prof. Pijush Samui
Launching Date & Time: August 19 2020 12:00pm GMT

https://www.issmge.org/education/recorded-webinars/machine-learning-in-geotechnical-engineering



ISO 18674 Part 4 Measurement of pore water pressure: Piezometers is published
https://www.issmge.org/news/iso-18674-part-4-measurement-of-pore-water-pressure-piezometers-is-published

There is a new ISO Standard for the measurement of pore water pressure by piezometers. In it you will find recommendations for guidance on types of piezometers and how to install them. The standard can be purchased from https://shop.bsigroup.com/ProductDetail?pid=000000000030374989



The ISRM 2020 International Symposium - EUROCK2020 was cancelled

Dear ISRM members and Rock Mechanics colleagues,

The ISRM regrets to announce that the 2020 ISRM International Symposium - EUROCK2020 was cancelled. This was a difficult decision taken by the EUROCK2020 Organizing Committee in constant dialogue with the ISRM. In view of the current COVID-19 pandemic and of the strong restrictions to travelling, this became an inevitable and also a wise decision. Their cancellation message is copied below.

The ISRM meetings programmed for the days before EUROCK2020 have also been cancelled. The Council, Board and Commissions meetings will take place as video-conferences during October. The ISRM National Groups and the Commission chairs have already been informed about this.

The Organizing Committee and the ISRM agreed that the papers presented to EUROCK2020 will be published in the OnePetro.org platform, subject to the authors' consent.

The ISRM would like to show its deep appreciation for the work of the Organizing Committee of EUROCK2020 and of the Norwegian Group for Rock Mechanics (the ISRM National Group for Norway), who did everything they could to go ahead with the Organization of EUROCK2020.

We wish all of you good health. Stay safe.

Luís Lamas

Secretary General, ISRM

EUROCK2020 was cancelled

In the last couple of weeks, we have unfortunately experienced an increase in infections both in Norway, and abroad, leading the Norwegian government to impose stricter restrictions on international travel, only allowing travelers coming to Norway from a few European countries. This, in turn, leaves us with no other option than to cancel EUROCK 2020, as most of our presenters, invited speakers and delegates will not be allowed to enter Norway without a two-week quarantine period.

We have long hoped to avoid this lamentable situation, and it is not with a light heart we have made this decision. Rest assured that we, together with the ISRM, have tried our best to make EUROCK 2020 happen. A physical conference is simply not technically nor economically feasible in the given pandemic situation. We do also find that it is best and safest not to promote international travel for the time being.

We deeply apologize the inconvenience the cancellation will cause for many of our delegates, presenters, invited speakers, partners and colleagues. All participants will get their participation fee back, minus a minor (approx. EUR 35) fee to cover the cost associated with the transfer, this in accordance with the conditions announced during the online registration. Participants paying accommodation through our website will get a full refund of these payments.

We have more than 200 peer-reviewed conference papers ready for publishing, and we do intend to publish the proceedings through OnePetro.org, in collaboration with the ISRM. All authors will be contacted shortly by us, asking for their consent to publish their papers.

The EUROCK 2020 Organizing Committee.

http://www.eurock2020.com/

ITA Announcement WTC

Status of WTC 2020 Refunds

Following the cancellation of the physical WTC 2020 in Kuala Lumpur, Malaysia, ITA and the Institution of Engineers, Malaysia (IEM) issued a joint statement indicating IEM's refund commitment. ITA was not a party to any of the payments made to IEM, however ITA's Executive Council (ExCo) created a task force to review IEM's financial position and to urge IEM to offer the largest refund possible. The joint statement commits IEM to refund around 70% of funds received. Based on its task force review, ITA maintains its position that IEM should increase its level of refund. In the spirit of transparency to our constituents, ITA has invited Malaysia to present their financial accounts at the virtual General Assembly in September and explain the basis for the level of refund being offered.

IEM has now apparently sent two notices that have made the refund conditional to additional processes; one includes a sign off that refunds will be accepted in full, in effect waiving any further action on behalf of the participants/exhibitors/sponsors, and another requiring authors to create and provide to IEM a presentation video. Neither notice was sent with ITA knowledge or approval.

ITA encourages IEM to stand behind its refund commitment without condition.

ITA encourages the tunnelling industry to support IEM's virtual WTC 2020 event.

Moving Forward

While the pandemic was beyond everyone's control, ITA is examining options to mitigate the risk of similar financial losses from WTC events occurring again. At the upcoming General Assembly, ITA's ExCo will propose revisions to how future WTC events are organized, including ITA taking a stronger role in planning and financial control. WTC events are the pre-eminent global tunnelling industry event to share knowledge, ideas, experiences, and services, which is the core of ITA's mission. ITA intends to exit the COVID-19 pandemic stronger than before, including financial controls that protect its WTC contributors and participants.

ITA is an association of Member Nations and welcomes feedback from its members and our industry partners regarding the above issues. We will continue to provide updates as our recovery process, lessons learned, and actions advance.

ITA - IEM JOINT ANNOUNCEMENT
WTC 2020 Kuala Lumpur, Malaysia
11 – 17 SEPTEMBER 2020 DIGITAL WTC2020

ITA and IEM hereby jointly announce that WTC2020 in Kuala Lumpur, Malaysia scheduled from 11th to 17thSeptember 2020 will be moved to a fully digital platform due to the impacts of COVID-19, including border restrictions and health risks associated with international travel and the assembly of large meetings.

IEM commits to refund 70% of monies already paid to WTC2020 by sponsors, exhibitors and registered participants and 100% refund for the charges paid by registered participants for side events such as Gala dinner, site visits etc. This refund includes about 8.5% from ITA by waiving all of its entitlements as agreed by ITA.

The digital WTC2020 is currently in preparation at no extra cost for those already registered and all sponsors, exhibitors and registrants would be notified of the format for the digital event soon by the Organizing Committee of WTC2020. A digital book of proceedings will also be made available to all registrants. The dates for the digital WTC2020 remain unchanged from 11th to 17th September 2020.

We know that this disruption of events saddens you as much as us. We look forward to the tunnelling community safely meeting again to discuss the issues that mobilize our industry and inspire our world.

Professor Jinxiu (Jenny) Yan
ITA President 2019-2022

Ir. David Lai Kong Phooi
Chairman, IEM Training Centre Sdn Bhd
President, The Institution of Engineers, Malaysia

Young Members Group

Time-Dependent Deformations of Shafts and Tunnels in the Greater Toronto Area

BTSYM and Tunnelling Association of Canada Young Members will be delivering a joint lecture, titled "**Time-Dependent Deformations of Shafts and Tunnels in the Greater Toronto Area**" at 1800 BST [UTC+1] on 16th July 2020.

Further details will be made available in due course, however please make a note of the YouTube Live link https://youtu.be/YQC-JcluyGU

TCAym continue to deliver monthly webinars during these times.

The details of their next webinar is as follows,

Title: Gardiner Expressway Replacement Tunnel Project

Presenters: Primo Noegroho, Miguel Pestana, Abirathan Rajmohan, and Jan Scheele

Overview:

The Gardiner Expressway is a major access route that connects users to the Toronto downtown area and other major highways.

The expressway was constructed in 1965 but has since reached the end of its useful lifespan: maintenance costs

have increased to the point where it is no longer feasible to maintain.

Additionally, it acts as an obstruction to the waterfront area, occupies valuable land, and can no longer handle the traffic volume in the GTA.

For our fourth-year design project, we have proposed replacing the existing elevated expressway with an underground tunnel to fulfill and improve on the Gardiner's role as a major expressway for Toronto.

The scope of this project includes selection of an optimal tunnel alignment and tunnel excavation method, design of a typical tunnel section using RS2 by Rocscience (a finite element analysis software), and a cost estimate.

Please sign up here to receive the streaming link

You can also follow TACym for further updates at:

Facebook : @TACyoungmembers

Instagram: @tac_young_members

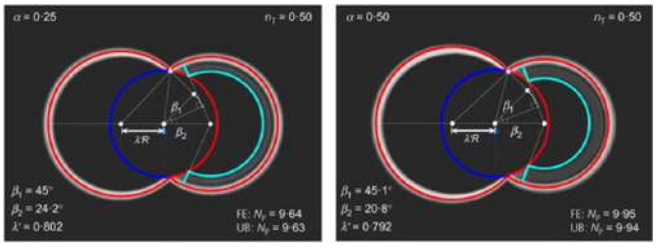
ice Publishing

Geotechnical engineering update

FREE TO READ

Embedded foundations under complex loading

This new themed issue of *Géotechnique* is based around the performance of foundations under complex loading. The papers included in this issue reflect a range of themes and have extended outside the confines of classic embedded foundations to include bridge abutments and plate anchor performance as well.



Read now

***Géotechnique Letters* Editors' picks**

We have collected together specially selected best papers from past volumes of *Géotechnique Letters*. All of the papers are free for you to read.

Read them all

More free to read

Asymptotic state boundaries and peak states in barodesy for clay

Development of a fault simulator for soils under large vertical stress in a centrifuge

Observations during suction bucket installation in sand

Search all our content

CALL FOR PAPERS

Find the right place for your work

Writing a paper is a great way to share your work more widely. Our open themed issue call for proposals include:

Gas transport in porous media and performance of capping system

Application of Smart Sensors in Geoenvironmental Monitoring

View them all

NEWS

2020 Impact Factors

We are pleased to announce continued growth in the impact factors of our journals.

This year 15 journals saw increases in their score. Here we look at some of the highlights.

Find out more

Underground cities

The London Underground may have been built in the 1860s but there's evidence of underground cities dating back millennia. We take a look at how underground spaces are made and might be used in the future

Read more

Connect with us safely

Are you interested in physical modelling in geotechnics? You can engage with the community in our LinkedIn group

Join us

BOOKS

Offer excludes books not yet published, as well as contracts and titles from other publishers. See website for other terms and conditions.

Browse the sale

The British Dam Society

The Toddbrook Reservoir Incident
(Webinar, 6 July 2020)

In August 2019, Toddbrook Reservoir in north-west England was affected by two storm events in quick succession, resulting in damage to the auxiliary spillway, located on the main earth embankment dam. The concrete lining to the auxiliary spillway was damaged and erosion of the underlying dam shoulder material occurred, prompting fears of a dam breach.

An emergency evacuation of approximately 1500 persons from the downstream town of Whaley Bridge was completed. Multi-agency services were mobilised and the scour hole was infilled through use of a helicopter. Stream diversion and pumping works were initiated to empty the reservoir. Almost a week after the incident was declared, the residents were permitted to return to their homes.

There are 4 videos that you can view in a playlist. These are:

- **The History of Toddbrook Reservoir, David Brown, Principal Reservoir Engineer, Canal & River Trust**
  David Brown presents a history of the Toddbrook Reservoir and explains the events leading to the construction of the auxiliary spillway structure which failed in August 2019.

- **Pump Deployment, Eddie Quinn , Director, Kier**
  In this presentation, the planning and deployment of multiple pump sets to drain Toddbrook Reservoir is explained. In combination with other measures, the pump sets nearemptied the reservoir in six days.

- **Grouting the Void, Dr Steve Ovington, Director, On-Site**
  This presentation explains how the aggregate bag work lifted into the void in the auxiliary spillway was supplemented by cementitious grout and expanding foam works to form the temporary repair to the Toddbrook dam.

- **Impact on the community, Chris Wilman Whaley Bridge resident**
  Chris Wilman, a resident of Whaley Bridge, explains the impact of the Toddbrook incident on the residents of the town, many of whom were evacuated for their safety.

The seminar was delivered in 2 sessions.

Session 1

- Incident identification and first steps
- Day 1: Inspecting engineer mobilisation and initial response actions
- Days 2-6: Monitoring, surveillance and river diversion improvements
- Filling the Void
- Incident command and multi-agency co-ordination

- Incident closure

Session 2

- Interim improvements and the future of Toddbrook Reservoir
- CRT incident investigation
- Government Independent Review - investigation
- Government Independent Review – summary and recommendations

https://www.ice.org.uk/eventarchive/the-toddbrook-reservoir-incident-london?_ccCt=_DSIcRURSTkcjJo9W_XlFdN89tfDWnoh-tUVgBQi9Fgwz0hEsulvLV7BLdDPXGoSX

ΠΡΟΣΕΧΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΚΔΗΛΩΣΕΙΣ

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

Seismological Society of America - The *Bulletin of the Seismological Society of America* (BSSA) solicits papers for a Special Section on Fault Displacement and Near-Source Ground Motion Models. Please address questions about scientific issues to Luis A. Dalguer at luis.dalguer@alumni.ethz.ch or to Thomas Pratt, BSSA Editor-in-Chief, at bssaeditor@seismosoc.org. Submission-related questions should be addressed to Betty Schiefelbein, Manuscript Coordinator, at bssamss@seismosoc.org. https://www.seismosoc.org/publications/bssa/bssa-call-for-papers-special-section-on-fault-displacement-and-near-source-ground-motion-models/

3rd International Conference on Geotechnical Engineering (ICGE – Colombo -2020), 10 - 11 August 2020, Colombo, Sri Lanka, http://icgecolombo.org/2020/index.php

WTC 2020 ITA-AITES World Tunnel Conference, September 2020, Kuala Lumpur, Malaysia, www.wtc2020.my
ITA and IEM hereby jointly announce that WTC2020 in Kuala Lumpur, Malaysia scheduled from 11th to 17th September 2020 will be moved to a fully digital platform due to the impacts of COVID19, including border restrictions and health risks associated with international travel and the assembly of large meetings.

RTG²EE - Recent Trends in Geotechnical and Geo-Environmental Engineering and Education, Online Conference, 10 – 11 September 2020, Bali, Indonesia, https://rtgee.org

ACE 2020 14th International Congress on Advances in Civil Engineering, 16-18 September 2020, Istanbul, Turkey, www.ace2020.org/en

Fourth International DAM WORLD Conference, 21-25th September 2020, Lisbon, Portugal, https://dw2020.lnec.pt

Cities on Volcanoes 11 - Volcanoes and Society: environment, health and hazards, 25-30 September 2020, Heraklion, Crete, https://pcoconvin.eventsair.com/volcanoes11

EUROCK 2020 Hard Rock Excavation and Support, 12-14 October 2020, Trondheim, Norway, www.eurock2020.com

E-UNSAT 2020 4th European Conference on Unsaturated Soils - Unsaturated Horizons, 19 to 21 October 2020, Lisbon, Portugal, https://eunsat2020.tecnico.ulisboa.pt

GEO-EXPO 2020 Scientific and Expert Conference, 22-23 October 2020, Prijedor, Bosnia and Herzegovina www.geotehnika.ba

HYDRO 2020 Strategies for future progress, 24-28 October 2020, Strasbourg, France, www.hydropower-dams.com/hydro-2020

GeoAmericas2020 4th Pan American Conference on Geosynthetics, 26-29 October 2020, Rio de Janeiro, Brazil, www.geoamericas2020.com

5th Symposium of the Macedonian Association for Geotechnics, 29-31 October 2020, Ohrid, North Macedonia, mag@gf.ukim.edu.mk

3rd Conference of the Arabian Journal of Geosciences (CAJG), 2-5 November 2020, Sousse, Tunisia, https://cajg.org

5TH World Landslide Forum Implementation and Monitoring the USDR-ICL Sendai Partnerships 2015-2015, 2-6 November 2020, Kyoto, Japan, http://wlf5.iplhq.org

Fourth GeoMEast©2020 International Underground Structures Conference (IUSC), 8-12 November 2020, Cairo, Egypt, http://underground.geomeast.org

CouFrac 2020 - International Conference on Coupled Processes in Fractured Geological Media: Observation, Modeling, and Application, November 11-13, 2020, Seoul, Korea, http://coufrac2020.org

10th International Conference on Scour and Erosion (ICSE-10), November 15-18, 2020, Arlington, Virginia, USA, www.engr.psu.edu/xiao/ICSE-10 Call for abstract.pdf

88th ICOLD Annual Meeting & Symposium on Sustainable Development of Dams and River Basins, 28-November to 3-December 2020, New Delhi, India, https://www.icold2020.org

ATS 2020 AUSTRALASIAN TUNNELLING CONFERENCE

Nov 29 – Dec 2, 2020, Melbourne, Australia
https://www.ats2020.com.au

The Australasian Tunnelling Conference (ATS2020), our premier industry event, will be held in Melbourne 29th Nov – 2nd Dec 2020.The conference is a great opportunity for individuals to take time out from their day-to-day to learn from and reflect on the many advances made by the industry. It is a great opportunity to meet, explain, question, listen, and indeed advertise. The conference program and activities are shaping up to be a major national, regional and international event. The Organising Committee is planning for a wide variety of technical presentations and workshops, as well as the largest industry trade exhibition that Australian tunnelling has ever seen. We have secured the Melbourne Convention and Exhibition Centre (MCEC) at South Wharf in Melbourne, a world-renowned modern conferencing facility, including 4,500 m^2 of event space on the ground level of the centre. This event space will provide a wide range of options to showcase the industry, including the ability to place plant and equipment, in addition to very flexible exhibition display booths, breakout zones, industry hub and refreshment areas.

The Australian Tunnelling Society (ATS), as the event's primary host, has developed a theme for the conference which is forward thinking, '2020 Vision: Innovating the next 50

years'. A lot has been achieved in the past 50 years of underground construction since the first two day symposium on Raise and Tunnel Boring in Australia, held at the University of Melbourne, Australia in 1970, which lead to the subsequent formation of the ATS. As an industry we rely upon our accumulated knowledge and experience in undertaking our work, like industries the world over, we need to consider how the world is changing and the various challenges we all face regarding sustainable development, climate change, inclusivity, more complex procurement approaches and the integration of modern technology into our work practices. The current high level of industry activities within Australasia, as well as the strong pipeline of future works, is of course very good for the tunnelling industry, but it has also created significant challenges, not the least around workforce resourcing and training, and developing core competencies, which is an area that the ATS and other industry groups are well aware of and are seeking to manage. Therefore, the theme for ATS2020 is one that places a strong emphasis on the future direction of our industry as well as celebrating all the remarkable achievements to date.

Prospective attendees at ATS2020 may already be benefitting from the current high level of tunnelling activity within Australasia or may be potential new entrants to this dynamic industry and exploring new prospects associated with the strong pipeline of future works, which we are leveraging off in our planning for the event. We are confident that ATS2020 will be a major industry drawcard and will be broadly supported across all industry sectors. The ATS, our colleagues in New Zealand, the NZTS, along with the conference Organising Committee invite your organisation to participate as a sponsor, exhibitor or delegate at this significant industry event.

ATS2020 Technical Program

The ATS2020 Technical program is shaping up to be a mix of high-quality presentations in-line with our conference theme '2020 Vision: Innovating the next 50 years'.

The organising committee has been delighted by the quality and quantity of abstracts that they received towards the end of last year, in a reflection of the very healthy state of tunnelling in this region, our technical program paper submissions were nearly 4 times oversubscribed.

This has seen the committee undertake a detailed assessment process to reduce the numbers down to fit into our 3-day event and to provide a diverse range of high quality presentations across all aspects of our industry.

This process means that many deserving abstract submissions will not be accepted for oral presentation. We thank everyone who submitted an abstract and if you were one of the many who were not accepted we thank you for your understanding of our need to reduce the numbers.

We all know that ATS Tunnelling Conferences generate a successful mix of high quality technical presentations with great networking and social opportunities, and are a great chance to catch up with your industry colleagues – the 2020 event promises to be no different! The theme for the conference is *'2020 Vision – Innovating the next 50 years'* and the committee has identified several technical streams to be presented at the conference.

- Innovative Construction
- Future Proofing through Project Development and Delivery
- Environmental Assessment, Stakeholder Engagement, and Community Impact and Placemaking
- Major Projects – Case Studies
- Challenges for Ground Support and Permanent Lining
- World Best Practice in Health, Safety, Risk, Training and Education
- Growth in Digital Engineering, Instrumentation and Tunnel Data Systems
- Improvements in Tunnel Ventilation and Fire Life Safety
- Sustainable Tunnel Operations, Maintenance and Rehabilitation
- Tunnelling in Australia – the last 50 years
- Young Members – the future of our industry

CONTACT

For all enquiries please contact

ATS2020 Event Manager
Louise Telford
(Elle Conference & Event Specialists)

- +61 425 328 069
- louise@elleevents.com.au

ASIA 2020 Eighth International Conference and Exhibition on Water Resources and Renewable Energy Development in Asia, 8-10 December 2020, Kuala Lumpur, Malaysia, www.hydropower-dams.com/asia-2020

6th ICFGE 2020 Forensic Geotechnical Engineering & Geo-Disaster Documentation, December 10-12, 2020 IIT Delhi, India, http://tc302-issmge.com

27th European Young Geotechnical Engineers Conference and Geogames, 17 – 19 December 2020, Moscow, Russia, https://t.me/EYGEC2020

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

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

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

Nordic Geotechnical Meeting Urban Geotechnics, 18-20 January 20210, Helsinki, Finland, www.ril.fi/en/events/ngm-2020.html

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

XIII International Symposium on Landslides - Landslides and Sustainable Development, 21-26 February 2021, Cartagena, Colombia, www.scg.org.co/xiii-isl

2021 GEOASIA7 - 7th Asian Regional Conference on International Geosynthetics Society, March 1-4, 2021, Taipei, Taiwan, www.geoasia7.org

3rd International Symposium on Coupled Phenomena in Environmental Geotechnics, 17 – 19 March 2021, Kyoto, Japan, https://cpeg2020.org

ICEGT-2020 2nd International Conference on Energy Geotechnics, 28-31 March 2021, La Jolla, California, USA, https://icegt-2020.eng.ucsd.edu/home

International Conference on Challenges and Achievements in Geotechnical Engineering
31.03.2021 – 02.04.2021, Tirana, Albania

Organiser: Albanian Geotechnical Society
Contact person: Erdi Myftaraga
Phone: +355699336911
Email: emy@greengeotechnics.com

EUROENGEO 3RD EUROPEAN REGIONAL CONFERENCE OF IAEG, 8 - 12 April 2021, Athens, Greece, www.euroengeo2020.org

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

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

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

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

WTC 2021 World Tunnel Congress 2021 - Underground solutions for a world in change, 16-19 May 2021, Copenhagen, Denmark, www.wtc2021.dk

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

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

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

Joint meeting of ISSMGE TC201 and TC210, ICOLD TC E and TC LE "Dams and Levees: Particle Movements – Case Studies, Experiments, Theory", June, 2020, Budapest, Hungary, www.isc6-budapest.com

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

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

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

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

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

2nd ICPE 2021 The Second International Conference on Pressin Engineering, 19-21 June 2021, Kochi, Japan, https://icpeipa.org/

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

IS-Cambridge 2020 10th International Symposium on Geotechnical Aspects of Underground Construction in Soft Ground, 28 June to 01 July 2021, Cambridge, United Kingdom, www.is-cambridge2020.eng.cam.ac.uk

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Eurock 2022

Rock and Fracture Mechanics in Rock Engineering and Mining
13÷17 June 2022, Helsinki, Finland

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

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

9th International Congress on Environmental Geotechnics

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

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

Contact Information

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

5th International Symposium on Cone Penetration Testing (CPT'22)
26-29 June 2022, Bologna, Italy

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

Contact person: Susanna Antonielli (AGI), Prof. Guido Gottardi (University of Bologna)

Email: guido.gottardi2@unibo.it
Email: agi@associazionegeotecnica.it

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

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

15th ISRM

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

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

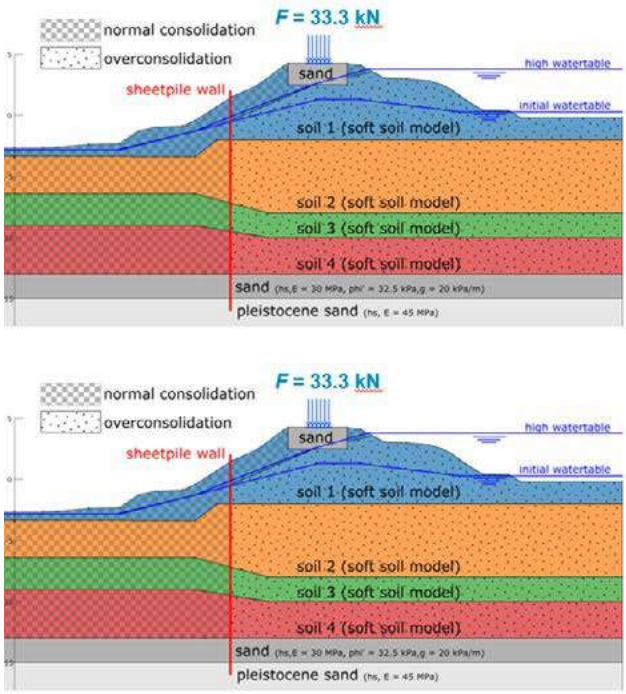
ΕΝΔΙΑΦΕΡΟΝΤΑ ΓΕΩΤΕΧΝΙΚΑ ΝΕΑ

Fast reliability analysis for complex geotechnical models

Probabilistic models need to be made more efficient in order to keep up with time-consuming, state-of-the-art, geotechnical models including finite element models (FEM). Furthermore, probabilistic analysis is being used more and more to optimise designs or demonstrate compliance with safety standards.

However, traditional methods for reliability analysis do not work well with state-of-the art geotechnical models because of excessive computing times (Monte Carlo) or inaccuracy (First-Order Reliability Method - FORM). Deltares and Delft University of Technology therefore developed the ERRAGA toolbox (Efficient Reliability Analysis for Geotechnical Applications).

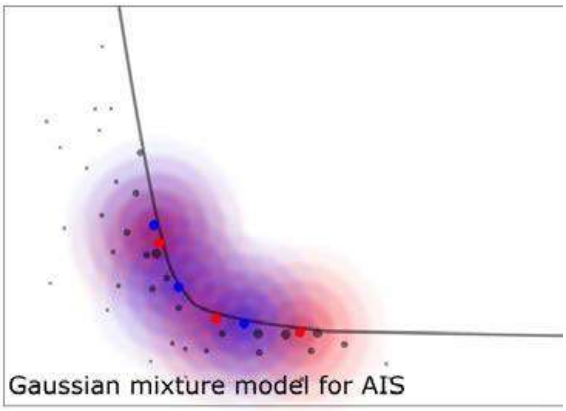
The ERRAGA project involved the development of a Python toolkit specifically for the challenges typically encountered in geotechnical practice with FEM models for low failure probabilities. These geotechnical models have many variables and typically take minutes or hours to run for one model evaluation. Highly non-linear and noisy behaviour can also be expected.



Example of a Finite Element Model, Plaxis, that is used to compute the probability of the maximum bending moment in a sheet pile in a dike being exceeded.

ERRAGA met these challenges by using meta-modelling in combination with machine learning techniques. A meta-model is a simpler, faster model that is trained to replace a more complex model in order to save computational time while maintaining reasonable accuracy. This is done by using a limited number of random model evaluations and smart interpolation between the computed points. An example is the use of a limited number of geotechnical model evaluations (represented by points and determined by varying the tangent of the friction angle) to construct two meta-models of the resulting bending moment in the sheet pile (represented by lines) that are used to predict when the limit state (maximum allowable bending moment M_{max}) is exceeded.

Interpolation in ERRAGA draws on Gaussian Mixture Modelling and Kriging algorithms that incorporate machine learning and correlation patterns in the interpolation. The reliability analysis can be performed very quickly with the meta-model. The ERRAGA Python toolkit is used in combination with the Deltares Probabilistic ToolKit (PTK) for the probabilistic computations and to couple it efficiently with external geotechnical models. An example of the interpolation based on Gaussian Mixture Modelling for the AIS (Automatic Identification System) is also illustrated. The dots are the model evaluations that are used to determine the meta-model (line). The shaded blue and red areas show the zones of influence of individual points using this method. This approach reduces the number of model evaluations required to around 100, a lot lower than in traditional methods.



ERRAGA example of interpolation between samples using Gaussian Mixture Modelling for AIS

ERRAGA therefore brings the practical application of probabilistic analysis for challenging geotechnical models one step closer. More verification and application to cases will be needed to demonstrate its applicability further.

Further reading:

van den Eijnden, A.P., T. Schweckendiek, M.A.Hicks (2020). Metamodelling for geotechnical reliability analysis with noisy and incomplete models. Revision submitted to Structural Safety

Contact

Timo Schweckendiek Timo.Schweckendiek@deltares.nl
Rob Brinkman Rob.Brinkman@deltares.nl

Deltares R&D Highlights 2020, p. **40,** R&D Highlights 2020 (https://bit.ly/30wNj4T)

Earthquakes trigger landslides. Can landslides also trigger earthquakes?

Southern Taiwan was hit by thousands of landslides after Typhoon Morakot in 2009.

When the deadliest typhoon to hit Taiwan in modern history struck the island in 2009, it dumped 3 meters of rain in as many days, triggering thousands of landslides. But what surprised scientists was the slew of earthquakes that followed Typhoon Morakot's landfall. Now, a new study suggests why they occurred: The landslides scraped away so much soil and rock that Earth's crust, newly lightened, buckled in new ways.

"In previous cases most people only considered that earthquakes could trigger landslides," says Zhigang Peng, a seismologist at the Georgia Institute of Technology who was not involved in the research.

Roughly 10,000 landslides struck Taiwan in the days following Typhoon Morakot, heaving 1.2 cubic kilometers of soil and rocks down hillsides. Over time, rivers carried much of the debris away. That permanently flushed the landscape of hundreds of millions of tons of sediment—equivalent to scraping 3 centimeters off the entire surface of Taiwan, says Philippe Steer, a geoscientist at the University of Rennes 1 in France.

That tectonic shift might have affected seismic activity, Steer and his colleagues hypothesized, so they mined a catalog of more than 340,000 earthquakes that occurred in Taiwan between 1995 and 2015. In areas affected by Typhoon Morakot–related landslides, the researchers found a threefold increase in the earthquake rate immediately following the storm, they report today in *Scientific Reports*. They also found an uptick in the proportion of small earthquakes after the storm. Seismic activity in those areas remained higher than normal for roughly 2.5 years, the team noted.

They say the increase can be explained by the removal of hundreds of millions of tons of sediment, which likely caused Earth's crust near Taiwan to flex slightly upward. That motion would have altered stresses within the crust, potentially unclamping faults that were already near the point of rupturing, the researchers surmised.

That makes sense, Peng says. "It's not the landslide itself. The subsequent erosion process generates stress."

This isn't the first time researchers have linked erosion to earthquake behavior. In 2010, scientists suggested the tendency for large earthquakes to occur in the New Madrid region in the central United States is due to thousands of years of erosion caused by the Mississippi River. No other modern cases of erosion-induced earthquakes have been documented, but Haiti and Puerto Rico would be good places to look, Peng says, because these nations are often slammed by hurricanes and see lots of landslides.

"It's very rare to be able to observe these kinds of changes," Steer says. But because climate change could lead to more frequent extreme events, there could be more erosion—and therefore earthquakes—in our future.

(Katherine Kornei / SCIENCE - AAAS, Jul. 2, 2020, https://www.sciencemag.org/news/2020/07/earthquakes-trigger-landslides-can-landslides-also-trigger-earthquakes)

The Dawn of Hope peat slide: understanding the source area

My tweet yesterday linking to the remarkable video on Youtube by John Flynn that shows the full extent of the Dawn of Hope peat slide attracted a great deal of attention. One of the aspects of landslides that I enjoy the most is that, 30 years into my professional career, I still find slides that cause surprise. This is one, without doubt.

https://www.youtube.com/watch?v=ttJsyGSBPcc&feature=emb_logo

The video provides a source to toe record of the landslide, but of course it is the source area that has generated the most interest. I can only speculate on what is going on here – others will investigate it properly, and I will post their findings when published if possible. On Twitter some suggested that this might be a lateral spread that transitioned into a flow slide. I would speculate that this is unlikely. This image shows the lower part of the source area, and the transition zone into the channelised flow:-

The lower part of the source area of the Dawn of Hope peat slide. Still from a Youtube video posted by John Flynn.

I would hypothesise that the slide initiated here as a bog burst and then retrogressed to create the extraordinary landform seen in the upper reaches of the source area:-

The upper part of the source area of the Dawn of Hope peat slide. Still from a Youtube video posted by John Flynn.

These are extensional landforms, which have generated because there was space vacated by the initial bog burst. The line of trees, mostly intact and upright, following the drainage line, is remarkable. It shows that the failure has propagated up the channel, and that in the channel itself mobility is quite high. The peat adjacent to the channel has failed, but with much lower mobility.

To understand landslides in peat there are a few important aspects to consider:-

1. Peat is a predominantly organic material, with some clay and silt and a very large amount of pore space. This means that it has an unusually low density compared with other geomaterials. A typical density for peat is about 400 kg per cubic metre – less than half of that of water – so rafts of peat can literally float.
2. The peat itself has low compressive strength, but is quite strong in tension. This is because the body of the peat consists of organic fibres. This may be the reason that the blocks have remained intact.
3. Failure in peat slides very often occurs at the boundary between the peat and the underlying substrate. I think there is some evidence that this is the case here.

So, my hypothesis would be that the extreme rainfall, perhaps aided by piping in the peat, led to very high pore water levels in lower part of the topographic depression shown in the first image. This failed to generate a bog burst, and a large amount of degraded organic material vacated the depression and entered the channel. It clearly entrained considerable amount of material from within the channel, and of course the structure of the peat was rapidly lost in the turbulent flow, creating a slurry with high mobility.

Back in the source area, the now vacated depression allowed failure of the adjacent blocks. Failure propagated upwards through the depression, aided by the high pore water pressures. But of course these materials are highly permeable, so failure also induced rapid drainage, especially away from the channels. Thus, the pore water pressures at the base of the blocks quite rapidly declined, leaving the peat rafts stranded.

The video also shows the areas of inundation (there is more than one) downstream:-

One of the inundated areas from the Dawn of Hope peat slide. Still from a Youtube video posted by John Flynn.

The level of damage here is undoubtedly high.

(Dave Petley / AGU – THE LANDSLIDE BLOG, 3 July 2020, https://blogs.agu.org/landslideblog/2020/07/03/dawn-of-hope-peat-slide-2)

Japan to build dam entirely with robots

The Obayashi Corporation, one of the five largest construction companies in Japan, is building a dam almost entirely with robots, addressing the industry's labor shortage and aging workforce, according to a report on the Nikkei Asian Review website.

The dam project is located in the Mie Prefecture, in the southeast corner of Japan’s main island.

The 84-meter-high structure is slated for completion in March 2023.

Obayashi will be testing a variety of robotic and automation technologies in its construction.

Obayashi has developed automated equipment to stack concrete layers to form a dam.

To further streamline the process, a plant has been built near the site to mix sand and gravel with cement to make concrete.

Building a dam requires knowledge and skill developed through years of experience. Obayashi's automated system is expected to be a game-changer in dam construction, as well as in other applications.

"By transferring expert techniques to machines, we're able to analyze what was once implicit knowledge," said Akira Naito, head of Obayashi's dam technology unit.

Every process for constructing the 334-meter-wide dam will involve some form of automation. That includes the initial work of establishing the foundation, and pouring concrete to form the body.

The dam's body is built in layers by pouring concrete into 15-meter square partitions. Tower cranes that pour the concrete are controlled remotely by office computers, which also monitor the positioning of the partitions and the progress of construction.

Humans will man the cranes for safety reasons, but the machines are self-operating.

Building a dam is an intricate endeavor that requires all crevices to be sealed to prevent breaches. Concrete surfaces need to be processed so they are tightly stacked on one another.

Layers that are uneven are usually brushed down by human professionals until they are flat. Obayashi has developed machines that handle the brushing. The frequency of the cyclical brushing and the pressure on the surface are automatically controlled.

As poured concrete builds up, the forms used to give it structure need to be raised to keep unset concrete from leaking out. Normally, multiple skilled workers in heavy machinery operate in tandem to gradually lift the forms, calling out to each other to coordinate their movements.

Obayashi has developed a robot to handle this task, allowing for humans to be cut out of the picture entirely.

Surprisingly, Obayashi says all of its futuristic solutions have only increased productivity by about 10%, since it still needs to have people on-site ready to jump in should things go wrong. The company plans to acquire more know-how so it can eventually reduce the amount of manpower it needs.

"Eventually, we may be able to cut building time by 30%," said Naito.

Other Japanese contractors are also working on automation. Kajima has developed self-driving bulldozers and dump trucks so construction can continue 24 hours a day. It has automated the lifting of concrete forms, which it used at a dam construction site in Hokkaido for the first time.

Dam construction is especially conducive to automation, since it involves a lot of repetition and tends to happen on sprawling sites far from population centers, meaning there is less risk of automated equipment hitting bystanders or other machinery.

Japan's construction industry is aging quickly, with 35% of all workers now 55 or older, according to the Japan Federation of Construction Contractors. Companies are scrambling to build robots based on workers' expertise before they retire. The companies also hope that new technology could dispel negative stereotypes of the industry among younger generations, encouraging more people to work in construction.

UNM – United News of Bangladesh, July 25, 2020,
(http://unb.com.bd/category/Tech/japan-to-build-dam-entirely-with-robots/55134)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΣΕΙΣΜΟΙ

Mexico City building during the recent M7.1 earthquake

https://www.facebook.com/EngineerInfo168/videos/1141340159566699/

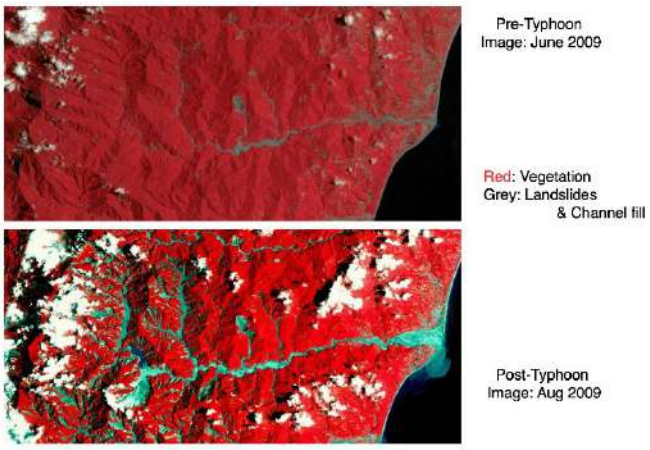
Notice how this building under construction in Mexico City moves during the earthquake this week (7.1 on the Ritcher scale). Structure of armed concrete aporticated and with walls as a resistant earthquake system.

Notice how this building under construction in Mexico City moves during the earthquake this week (7.1 on the Ritcher scale). Structure of armed concrete aporticated and with walls as a resistant earthquake system.

Link: https://t.me/joinchat/IENuHxtenb8_dDPbAWvAUA

A typhoon changed earthquake patterns, study shows

The Earth's crust is under constant stress. Every now and then this stress is discharged in heavy earthquakes, mostly caused by the slow movement of Earth's crustal plates. There is, however, another influencing factor that has received little attention so far: intensive erosion can temporarily change the earthquake activity (seismicity) of a region significantly. This has now been shown for Taiwan by researchers from the GFZ German Research Centre for Geosciences in cooperation with international colleagues. They report on this in the journal *Scientific Reports*.



Images from a satellite (LANDSAT) show massive erosion after the typhoon Morakot hit Taiwan. This influenced seismicity in the affected regions. Credit: NASA/LANDSAT

The island in the western Pacific Ocean is anyway one of the most tectonically active regions in the world, as the Philippine Sea Plate collides with the edge of the Asian continent. 11 years ago, Typhoon Morakot reached the coast of Taiwan. This tropical cyclone is considered one of the worst in Taiwan's recorded history.

Within only three days in August 2009, three thousand liters of rain fell per square meter. As a comparison, Berlin and Brandenburg receive an average of around 550 liters per square meter in one year. The water mass caused catastrophic flooding and widespread landslides. More than 600 people died and the immediate economic damage amounted to the equivalent of around 3 billion euros.

The international team led by Philippe Steer of the University of Rennes, France, evaluated the earthquakes following this erosion event statistically. They showed that there were significantly more small-magnitude and shallow earthquakes during the 2.5 years after typhoon Morakot than before, and that this change occurred only in the area showing extensive erosion. GFZ researcher and senior author Niels Hovius says: "We explain this change in seismicity by an increase in crustal stresses at shallow depth, less than 15 kilometers, in conjunction with surface erosion." The numerous landslides have moved enormous loads, and rivers have transported the material from the devastated regions. "The progressive removal of these loads changes the state of the stress in the upper part of the Earth's crust to such an extent that there are more earthquakes on thrust faults," explains Hovius.

Due to massive erosion after the typhoon Morakot the patterns of earthquakes changed for a time. Credit: Philippe Steer, Geosciences, Rennes, France

So-called active mountain ranges, such as those found in Taiwan, are characterized by 'thrust faults' underground, where one unit of rocks moves up and over another unit. The rock breaks when the stress becomes too great. Usually it is the continuous pressure of the moving and interlocking crustal plates that causes faults to move. The resulting earthquakes in turn often cause landslides and massively increased erosion. The work of the GFZ researchers and their colleagues now shows for the first time that the reverse is also possible: massive erosion influences seismicity—and does so in a geological instant. Hovius notes, "Surface processes and tectonics are connected in the blink of an eye." The researcher continues, "Earthquakes are among the most dangerous and destructive natural hazards. Better understanding earthquake triggering by tectonics and by external processes is crucial for a more realistic assessment of earthquake hazards, especially in densely populated regions."

(Helmholtz Association of German Research Centres / PHYS ORG, July 2, 2020, https://phys.org/news/2020-07-typhoon-earthquake-patterns.html)

Earthquake statistics changed by typhoon-driven erosion

Philippe Steer, Louise Jeandet, Nadaya Cubas, Odin Marc, Patrick Meunier, Martine Simoes, Rodolphe Cattin, J. Bruce H. Shyu, Maxime Mouyen, Wen-Tzong Liang, Thomas Theunissen, Shou-Hao Chiang & Niels Hovius

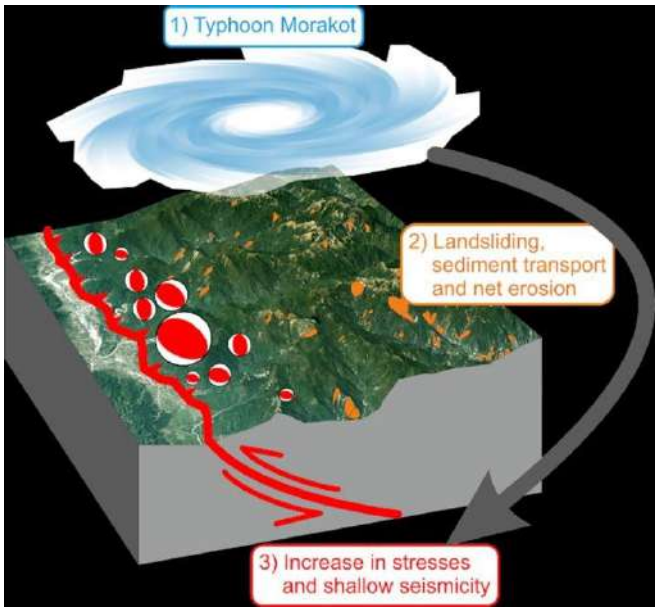
Scientific Reports **volume 10**, Article number: 10899 (2020) Cite this article

Abstract

Tectonics and climate-driven surface processes govern the evolution of Earth's surface topography. Topographic change in turn influences lithospheric deformation, but the elementary scale at which this feedback can be effective is unclear. Here we show that it operates in a single weather-driven erosion event. In 2009, typhoon Morakot delivered ~ 3 m of precipitation in southern Taiwan, causing exceptional landsliding and erosion. This event was followed by a step increase in the shallow (< 15 km depth) earthquake frequency lasting at least 2.5 years. Also, the scaling of earthquake magnitude and frequency underwent a sudden increase in the area where mass wasting was most intense. These observations suggest that the progressive removal of landslide debris by rivers from southern Taiwan has acted to increase the crustal stress rate to the extent that earthquake activity was demonstrably affected. Our study offers the first evidence of the impact of a single weather-driven erosion event on tectonics.

https://www.nature.com/articles/s41598-020-67865-y

Earthquakes triggered by landslides



Earthquake patterns changes in Taiwain after the impact of typhoon Morakot.

It is widely known that earthquakes can trigger disastrous landslides but, what about the opposite? Can landslides trigger earthquakes?

Earthquakes are triggering factors that can activate slope instabilities known as co-seismic landslides. Those slides are caused by inertial forces and may vary in size and shape. Usually, the ground failure is quick and sudden, a fact that makes co-seismic landslides hazardous for human civilization. The impact of an earthquake in a given slope is dependent on the energy that arrives at the site which is mainly controlled by the magnitude of the quake, the epicentral distance, the topography amplification and the stratigraphy.

A new research endeavor conducted by scientists in the GFZ German Research Centre for Geosciences and other colleagues, comes to answer the opposite question. The study was published in Scientific Reports.

The research was driven by a series of earthquakes that struck Taiwan 11 years ago. "In 2009, typhoon Morakot delivered ~ 3 m of precipitation in southern Taiwan, causing exceptional landsliding and erosion," the study reports.

Those earthquakes occurred after heavy rainfalls hit the island triggering numerous landslides. Scientists estimate that 1.2 km^3 soil and rock material was displaced as a result of around 100,000 landslides. This amount is equivalent to 4,800,000 Olympic size swimming pools.

Taiwan is a region that experiences earthquakes, however, by analyzing 20 years of data and 340,000 seismic shocks that occurred in the region, scientists found that the areas affected by the aforementioned landslides were impacted by far more earthquakes than normal. The seismic activity was recorded instantly after the rainfalls and landslides struck and persisted for about 2.5 years.

Researchers interpret this response as a result of the soil and rock mass removal that caused a slight upward displacement to the Earth's crust locally. Inferentially, there were stress alterations within the crust, a fact that may have caused faults to rupture, triggering earthquakes. "These observations suggest that the progressive removal of landslide debris by rivers from southern Taiwan has acted to increase the crustal stress rate to the extent that earthquake activity was demonstrably affected," the study mentions.

The authors of the study point out that it's not the landslides (the sudden movement of the ground downwards), that trigger those earthquakes but the redistribution of the material through the area which leads to the internal stresses' changes. For this reason, it is better to characterize these phenomena as erosion-induced earthquakes.

The knowledge of these geologic processes is currently limited since similar events are relatively rare and have not been widely documented. Nevertheless, the team suggests that future research potential is high since erosion-induced earthquakes will occur more frequently as a result of extreme weather phenomena caused by climate change.

Sources: Science, Phys

(geoengineer, Jul, 02, 2020 https://www.geoengineer.org/news/earthquakes-triggered-by-landslides

Seismologists find slow earthquakes in Cascadia predictable

Seismologists at Caltech analyzed 10 years' worth of slow-slip events that result from episodic fault slip, like regular earthquakes, but only produce barely perceptible quakes in the Cascadia region of the Pacific Northwest. They found that this particular type of seismic event is deterministic and could be predictable--days or weeks in advance.

"Deterministic chaotic systems, despite the name, do have some predictability. This study is a proof of concept to show that friction at the natural scale behaves like a chaotic system, and consequently has some degree of predictability," said lead author Adriano Gualandi.

Slow-slip events were first noted about 20 years ago by geoscientists tracking imperceptible shifts in the Earth with GPS. Such events happen when tectonic plates grind slowly against each other, like a slow-moving earthquake.

A slow-slip event that takes place over the course of weeks may release the same amount of energy as an M7.0 quake for one minute.

However, since these tremors release energy slowly, the deformation they cause is on the scale of millimeters, despite impacting areas that may be thousands of square kilometers away.

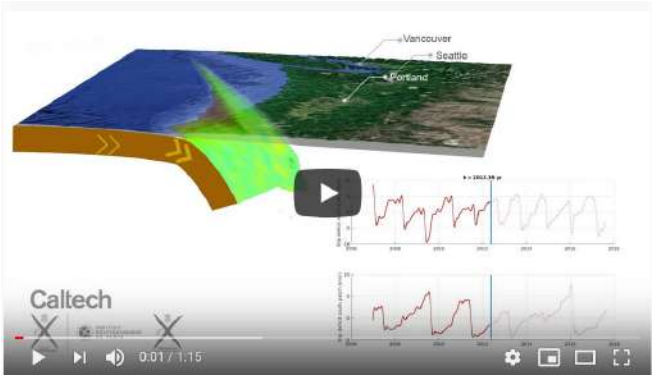
Slow-slip events were only discovered when GPS technology was improved to the point that it could detect the slow shifts. Such events do not occur along every fault and have only been spotted in a few locations so far, including the Pacific Northwest, Mexico, New Zealand, and Japan.

In a short time frame of around a decade, seismologists using high-end GPS equipment can observe the cycle repeat itself several times.

It also represents a 'forced non-linear dynamical system.' The motion of the tectonic plates is the force driving the system, while the friction between the plates makes the system non-linear.

Despite the fact that both the motion and friction can be starting conditions of the system, how much strain under has a major impact on long-term results. Not knowing those exact starting conditions is one of the probable reasons that the overall system is unpredictable in the long run.

However, a study of the fault slip history can show how often and for how long similar patterns recurred over time. The team was able to assess the predictability horizon time of slow-slip events this way.



Slow-Slip Earthquakes

https://www.youtube.com/watch?time_continue=1&v=ALwV40HCzk8&feature=emb_logo

"This result is very encouraging. It shows that we are on the right track and, if we manage to get more precise data, we could attempt some real-time prediction experiments for slow earthquakes," Gualandi added.

Gualandi likens the probable prediction of a slow-slip event to the current science of weather forecasting, which also involves predictions about a chaotic and complex process.

"We already know that approximately every 12 to 14 months there will be a new slow earthquake, but we do not know exactly when it will happen."

"What we have shown is that it seems to be possible to determine when the fault will slip some days before it happens, similar to the way the weather can be forecast fairly accurately a couple of days in advance."

One major question is whether the findings can translate to the regular earthquakes that endanger lives and properties. Last year, Gualandi and colleagues reported evidence that slow-slip earthquakes are a good analog for more destructive seismic events.

"If the analogy that we're drawing between slow earthquakes and regular earthquakes is correct, then regular earthquakes are predictable," said co-author Jean-Philippe Avouac.

"But even if regular earthquakes are deterministic, the predictability horizon may be very short, possibly on the order of a few seconds, which may be of limited utility. We don't know yet."

Reference

"The predictable chaos of slow earthquakes" - Gualandi, A. et al. - Science Advances - DOI: 10.1126/sciadv.aaz5548

Abstract

Slow earthquakes, like regular earthquakes, result from unstable frictional slip. They produce little slip and can therefore repeat frequently. We assess their predictability using the slip history of the Cascadia subduction between 2007 and 2017, during which slow earthquakes have repeatedly ruptured multiple segments. We characterize the system dynamics using embedding theory and extreme value theory. The analysis reveals a low-dimensional (<5) nonlinear chaotic system rather than a stochastic system. We calculate properties of the underlying attractor like its correlation and instantaneous dimension, instantaneous persistence, and metric entropy. We infer that the system has a predictability horizon of the order of days weeks. For the better resolved segments, the onset of large slip events can be correctly forecasted by high values of the instantaneous dimension. Longer-term deterministic prediction seems intrinsically impossible. Regular earthquakes might similarly be predictable but with a limited predictable horizon of the order of their durations.

(Julie Celestial / THE WATCHERS, July 11, 2020, https://watchers.news/2020/07/11/seismologists-find-slow-earthquakes-in-cascadia-predictable/)

Researchers develop equations for earthquake forecasting

2020 Elazığ earthquake: one of the deadliest quakes this year

A group of researchers at the Lyell Centre in Edinburgh formulated a way to use math formulas to help forecast earthquakes. The team describes translating the movement of a particular type of rock to mathematical equations, leading to the development of a predictive formula.

For decades, scientists have been trying to figure out a way to forecast when a major earthquake will occur. In this new endeavor, researchers took math as another approach to the problem. They started their efforts with evidence that particular types of rock play a major role in earthquakes. The rocks make up a group called phyllosilicates and they form in plates or sheets.

Earthquakes happen when such rocks slide against each other, the theory suggests. The researchers emphasized that frictional strength is a critical factor in such slippage. It is the force needed to push one of the sheets against another sheet.

Frictional strength is something that can be calculated, so for them to come up with useful calculations, the researchers analyzed many samples of phyllosilicates and the ways in which they interact with one another, under various conditions.

The team used what they learned to formulate equations that would describe such behavior, deep underground where they could not be tested directly. They factored in other variables as well, such as humidity levels, fault movements, and the speed at which the ground can move in fault areas.

After much effort with the equations, the researchers developed a formula that they believe can be applied in real-world situations to forecast when an earthquake might happen in a certain location.

The group noted that their formula is still a work in progress, and scientists are still working out how phyllosilicates behave under different scenarios. For instance, phyllosilicates can actually stand in the way of earthquakes occurring in some unusual places.

Reference

"Postseismic deformation following the 2015 Mw7.8 Gorkha (Nepal) earthquake: new GPS data, kinematic and dynamic models, and the roles of afterslip and viscoelastic relaxation" - Liu-Zeng, J. et al. - Journal of Geophysical Research: Solid Earth - https://doi.org/10.1029/2020JB019852

Abstract

We report Global Positioning System (GPS) measurements of postseismic deformation following the 2015 Mw7.8 Gorkha (Nepal) earthquake, including previously unpublished data from 13 continuous GPS stations installed in southern Tibet shortly after the earthquake. We use variational Bayesian Independent Component Analysis (vbICA) to extract the signal of postseismic deformation from the GPS timeseries, revealing a broad displacement field extending >150 km northward from the rupture. Kinematic inversions and dynamic forward models show that these displacements could have been produced solely by afterslip on the Main Himalayan Thrust (MHT) but would require a broad distribution of afterslip extending similarly far north. This would require the constitutive parameter (a − b) σ to decrease northward on the MHT to ≤0.05 MPa (an extreme sensitivity of creep rate to stress change) and seems unlikely in light of the low interseismic coupling and high midcrustal temperatures beneath southern Tibet. We conclude that the northward reach of postseismic deformation more likely results from distributed viscoelastic relaxation, possibly in a midcrustal shear zone extending northward from the seismogenic MHT. Assuming a shear zone 5-20 km thick, we estimate an effective shear-zone viscosity of ~3 · 1016 − 3 · 1017 Pa · s over the first 1.12 postseismic years. Near-field deformation can be more plausibly explained by afterslip itself and implies (a − b) σ ~ 0.5-1 MPa, consistent with other afterslip studies. This near-field afterslip by itself would have re-increased the Coulomb stress by ≥0.05 MPa over >30% of the Gorkha rupture zone in the first postseismic year, and deformation further north would have compounded this reloading.

(Julie Celestial / THE WATCHERS, July 19, 2020, https://watchers.news/2020/07/19/researchers-develop-equations-for-earthquake-forecasting/)

COVID-19 lockdown causes 50% global reduction in human-linked Earth vibrations

The lack of human activity during lockdown caused human-linked vibrations in the Earth to drop by an average of 50% between March and May 2020.

This quiet period, likely caused by the total global effect of social distancing measures, closure of services and industry, and drops in tourism and travel, is the longest and most pronounced quiet period of seismic noise in recorded history.

Our study uniquely highlights just how much human activities impact the solid Earth, and could let us see more clearly than ever what differentiates human and natural noise. Dr Stephen Hicks Department of Earth Science and Engineering

The new research, led by the Royal Observatory of Belgium and five other institutions around the world including Imperial College London, showed that the dampening of 'seismic noise' caused by humans was more pronounced in more densely populated areas.

The relative quietness allowed researchers to listen in to previously concealed earthquake signals, and could help us differentiate between human and natural seismic noise more clearly than ever before.

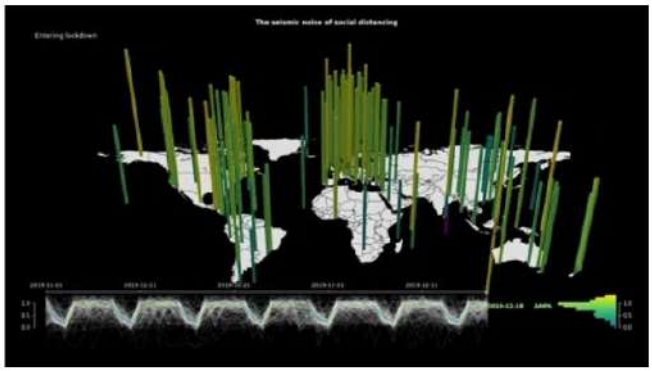
Co-author Dr Stephen Hicks, from Imperial's Department of Earth Science and Engineering, said: "This quiet period is the longest and largest dampening of human-caused seismic noise since we started monitoring the Earth in detail using vast monitoring networks of seismometers.

"Our study uniquely highlights just how much human activities impact the solid Earth, and could let us see more clearly than ever what differentiates human and natural noise."

The paper is published today in *Science*.

Anthropause

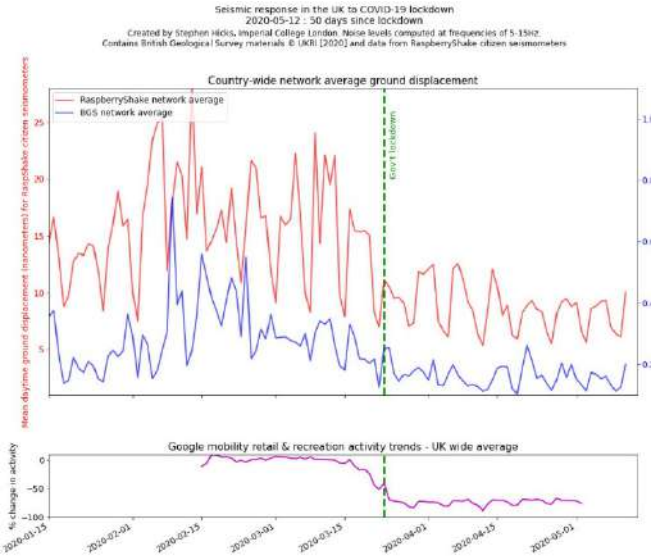
Measured by instruments called seismometers, seismic noise is caused by vibrations within the Earth, which travel like waves. The waves can be triggered by earthquakes, volcanoes, and bombs - but also by daily human activity like travel and industry.



https://giphy.com/gifs/imperialcollege-earth-covid-19-pandemic-kFIfZV2ovNY4SftrSm

Although 2020 has not seen a reduction in earthquakes, the drop in human-caused seismic noise is unprecedented. The strongest drops were found in urban areas, but the study also found signatures of the lockdown on sensors buried hundreds of metres underground and in more remote areas.

Human-generated noise usually dampens during quiet periods like over the Christmas/New Year period and Chinese New Year, and during weekends and overnight. However, the drop in vibrations caused by COVID-19 lockdown measures eclipse even those seen during these periods.



Drop in UK seismic activity and recreation/retail activity, pre- and post-lockdown

Some researchers are dubbing this drop in anthropogenic (human-caused) noise and pollution the 'anthropause'.

Dr Hicks said: "This is the first global study of the impact of the coronavirus anthropause on the solid Earth beneath our feet."

To gather the data, researchers looked at seismic data from a global network of 268 seismic stations in 117 countries and found significant noise reductions compared to before any lockdown at 185 of those stations. Beginning in China in late January 2020, and followed by Europe and the rest of the world in March to April 2020, researchers tracked the 'wave' of quietening between March and May as worldwide lockdown measures took hold.

With increasing urbanisation and growing global populations, more people will be living in geologically hazardous areas. It will therefore become more important than ever to differentiate between natural and human-caused noise Dr Thomas Lecocq Royal Observatory of Belgium

The largest drops in vibrations were seen in the most densely populated areas, like Singapore and New York City, but drops were also seen in remote areas like Germany's Black Forest and Rundu in Namibia.

Citizen-owned seismometers, which tend to measure more localised noise, noted large drops around universities and schools around Cornwall, UK and Boston, USA – a drop in noise 20 per cent larger than seen during school holidays.

Countries like Barbados, where lockdown coincided with the tourist season, saw a 50 per cent decrease in noise. This coincided with flight data that suggested tourists returned home in the weeks before official lockdown.

Listening in

Over the past few decades, seismic noise has gradually increased as economies and populations have grown.

The drastic changes to daily life caused by the pandemic have provided a unique opportunity to study their environmental impacts, such as reductions in emissions and pollution in the atmosphere. The changes have also given us the opportunity to listen in to the Earth's natural vibrations without the distortions of human input.

A citizen seismometer known as a 'Raspberry Shake'

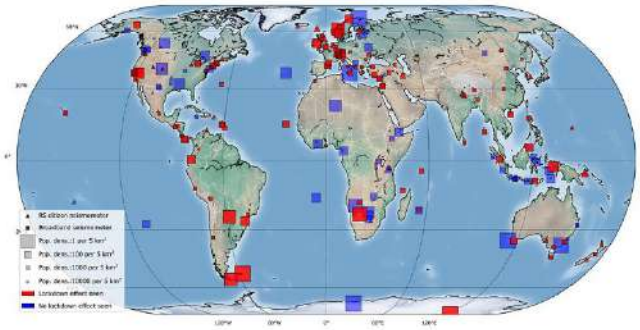
The study reports the first evidence that previously concealed earthquake signals, especially during daytime, appeared much clearer on seismometers in urban areas during lockdown.

The researchers say the lockdown quietening could also help them differentiate between human-caused noise and natural signals that might warn of upcoming natural disasters.

Lead author Dr Thomas Lecocq from the Royal Observatory of Belgium said: "With increasing urbanisation and growing global populations, more people will be living in geologically hazardous areas. It will therefore become more important than ever to differentiate between natural and human-caused noise so that we can 'listen in' and better monitor the ground movements beneath our feet. This study could help to kick-start this new field of study."

The study's authors hope that their work will spawn further research on the seismic lockdown, as well as finding previously hidden signals from earthquakes and volcanoes.

Dr Hicks said: "The lockdowns caused by the coronavirus pandemic may have given us a glimmer of insight into how human and natural noise interacts with the Earth. We hope this insight will spawn new studies that help us listen better to the Earth and understand natural signals we would otherwise have missed."



268 seismometers (red) in 117 countries detected a drop on seismic noise.

"Global quieting of high-frequency seismic noise due to COVID-19 pandemic lockdown measures" by Thomas Lecocq et al., published Thursday 23 July 2020 in *Science*

(Caroline Brogan / Imperial College Communications and Public Affairs, 23 July 2020, https://www.imperial.ac.uk/news/200454/covid-19-lockdown-causes-50-global-reduction)

Science News *from research organizations*

COVID-19 lockdown caused 50 percent global reduction in human-linked Earth vibrations

Date: July 23, 2020

Source: Imperial College London

Summary: The lack of human activity during lockdown caused human-linked vibrations in the Earth to drop by an average of 50 percent between March and May 2020.

Story Source:

Materials provided by **Imperial College London**. Original written by Caroline Brogan. *Note: Content may be edited for style and length.*

Journal Reference:

1. Thomas Lecocq, Stephen P. Hicks, Koen Van Noten, Kasper van Wijk, Paula Koelemeijer, Raphael S. M. De Plaen, Frédérick Massin, Gregor Hillers, Robert E. Anthony, Maria-Theresia Apoloner, Mario Arroyo-Solórzano, Jelle D. Assink, Pinar Büyükakpınar, Andrea Cannata, Flavio Cannavo, Sebastian Carrasco, Corentin Caudron, Esteban J. Chaves, David G. Cornwell, David Craig, Olivier F. C. den Ouden, Jordi Diaz, Stefanie Donner, Christos P. Evangelidis, Läslo Evers, Benoit Fauville, Gonzalo A. Fernandez, Dimitrios Giannopoulos, Steven J. Gibbons, Társilo Girona, Bogdan Grecu, Marc Grunberg, György Hetényi, Anna Horleston, Adolfo Inza, Jessica C. E. Irving, Mohammadreza Jamalreyhani, Alan Kafka, Mathijs R. Koymans, Celeste R. Labedz, Eric Larose, Nathaniel J. Lindsey, Mika McKinnon, Tobias Megies, Meghan S. Miller, William Minarik, Louis Moresi, Víctor H. Márquez-Ramírez, Martin Möllhoff, Ian M. Nesbitt, Shankho Niyogi, Javier Ojeda, Adrien Oth, Simon Proud, Jay Pulli, Lise Retailleau, Annukka E. Rintamäki, Claudio Satriano, Martha K. Savage, Shahar Shani-Kadmiel, Reinoud Sleeman, Efthimios Sokos, Klaus Stammler, Alexander E. Stott, Shiba Subedi, Mathilde B. Sørensen, Taka'aki Taira, Mar Tapia, Fatih Turhan, Ben van der Pluijm, Mark Vanstone, Jerome Vergne, Tommi A. T. Vuorinen, Tristram Warren, Joachim Wassermann, Han Xiao. **Global quieting of high-frequency seismic noise due to COVID-19 pandemic lockdown measures**. *Science*, July 23, 2020; DOI: 10.1126/science.abd2438

(ScienceDaily, 23 July 2020, https://www.sciencedaily.com/releases/2020/07/200723143728.htm)

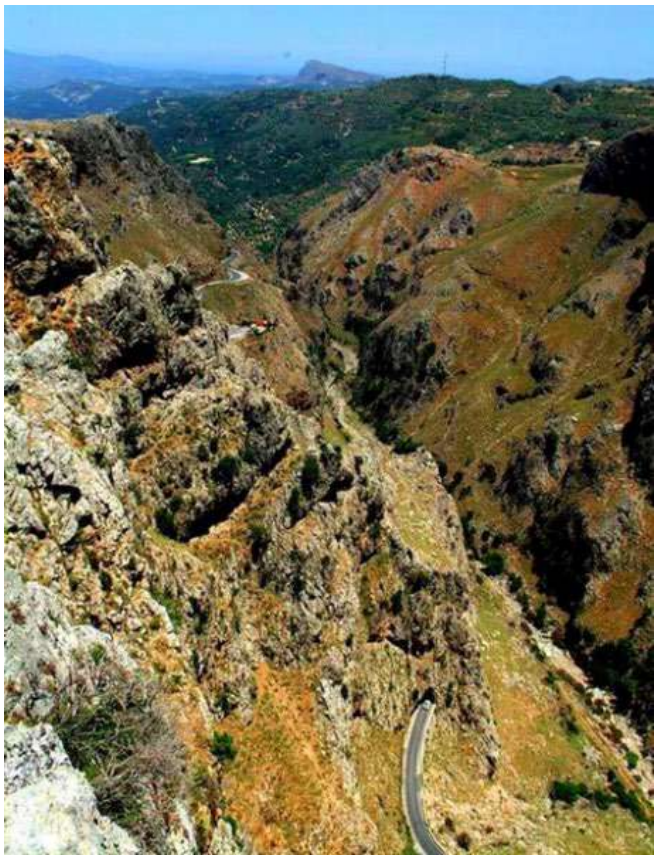
ΕΝΔΙΑΦΕΡΟΝΤΑ - ΓΕΩΛΟΓΙΑ

Τοπολιανό φαράγγι: Ο Τάλως και οι Νεράιδες

Στην Περιφερειακή Ενότητα Χανίων, νότια από την κωμόπολη του Κισσάμου, την έδρα του ομώνυμου δήμου, βρίσκεται ένα εξαίρετο μνημείο της φύσης, το Τοπολιανό φαράγγι

Το μεγαλοπρεπές Τοπολιανό φαράγγι)

Στην **Περιφερειακή Ενότητα Χανίων**, νοτιοανατολικά από την κωμόπολη του **Κισσάμου**, την έδρα του ομώνυμου δήμου, βρίσκεται ένα εξαίρετο μνημείο της φύσης, το **Τοπολιανό φαράγγι**.



Η στενή και βαθιά αυτή χαράδρα εκτείνεται από τα **Τοπόλια**, χωριό με παραδοσιακό χρώμα, χτισμένο σε γραφική κοιλάδα, έως τον **Κουτσοματάδο** (Κατσοματάδο), ακολουθώντας διαδρομή παράλληλη με την επαρχιακή οδό που οδηγεί στην περιοχή των Εννέα Χωριών (Έλος, Κεφάλι κ.ά.) και, μακρύτερα, στο μαγευτικό Ελαφονήσι.

Το μεγαλοπρεπές, άγριας φυσικής ομορφιάς Τοπολιανό φαράγγι, μήκους περίπου 1.500 μέτρων, έχει πλούσια χλωρίδα, με σπάνια και ενδημικά είδη φυτών.

Οι απόκρημνες πλαγιές του φαραγγιού, με ουκ ολίγες σπηλαιώδεις κοιλότητες, ορθώνονται επιβλητικές, σε ύψος εκατοντάδων μέτρων.

Ιδιαίτερο ενδιαφέρον παρουσιάζει το **σπήλαιο της Αγίας Σοφίας** με τον ομώνυμο ναό και σταλαγμίτες. Στο σπήλαιο έχουν βρεθεί θραύσματα αγγείων που χρονολογούνται από τους Νεολιθικούς έως τους Ρωμαϊκούς Χρόνους.

Σε πλαγιά του φαραγγιού των Τοπολίων βρίσκεται η ομώνυμη σήραγγα.

Η μυθολογική παράδοση θέλει το Τοπολιανό φαράγγι να είναι ο τόπος όπου κατοικούσαν **Νεράιδες (Νύμφες)**, αλλά και αναπαυόταν ο **Τάλως**, ο φημισμένος χάλκινος γίγαντας της Κρήτης, απολαμβάνοντας το χορό και τα τραγούδια των Νεράιδων.

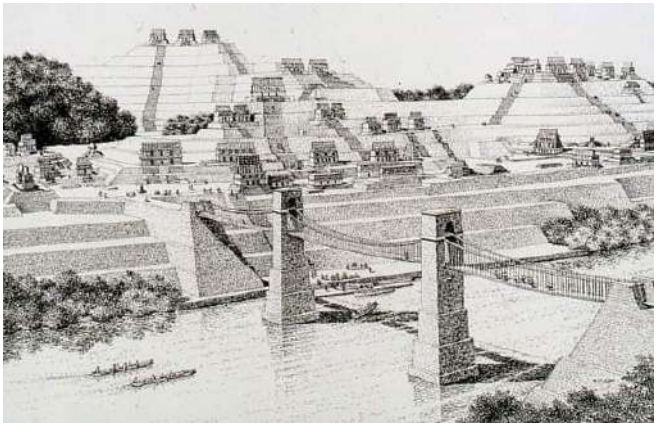
Ο Τάλως, δημιούργημα του **Ηφαίστου**, ήταν ο έμψυχος κολοσσιαίος χάλκινος ανδριάντας που είχε δωρίσει στο **βασιλιά Μίνωα** ο θεός του πυρός, για να φυλάσσει την Κρήτη και να προστατεύει τις ακτές της από τους ξένους.

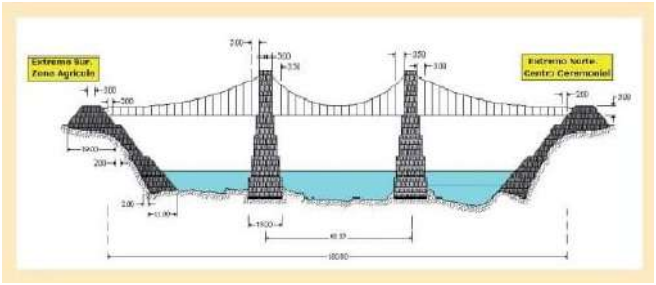
Ο θρυλικός γίγαντας, που πηγαινοερχόταν καθημερινά από τη μια άκρη του νησιού ως την άλλη, για να μην επιτρέψει στους ξένους να πατήσουν σε κρητικό έδαφος, φονεύτηκε από τη **Μήδεια**, όταν θέλησε να εμποδίσει την αποβίβαση των **Αργοναυτών** στην Κρήτη.

(Βαγγέλης Στεργιόπουλος / in.gr, 16 Ιουλίου 2019, https://www.in.gr/2019/07/16/plus/diakopes/the-experts-way/topoliano-faraggi-o-talos-kai-oi-neraides/)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΛΟΙΠΑ

Γέφυρα Yaxchilan, Μεξικό





Η παλαιότερη κρεμαστή γέφυρα στον κόσμο χρονολογείται από τον 7ο αιώνα, χτίστηκε στο Yaxchilan και διατηρήθηκε για περισσότερα από 700 χρόνια. Είχε μήκος άνω των 100m και διέσχιζε τον ποταμό Osumacinta. Η σχετική αναφορά έγινε από τον αρχαιολόγο και μηχανικό James A. O'Kon στο βιβλίο του «The Lost Secrets of Maya».

Περισσότερες πληροφορίες:
http://www.smie.org.mx/SMIE_Articulos/co/co_12/te_09/ar_03.pdf

El puente colgante mas antiguo del mundo y el de mayor longitud en su tipo que perduro por más de 700 años data del siglo VII construido en Yaxchilán. Media mas de 100 metros de largo atravesaba el rio Osumacinta y unia el centro ceremonial (lado de Mexicano) con el resto de la población y los cultivos (lado Guatemalteco).

Esto planteado por el arqueólogo e ingeniero James A. O'Kon en su libro "The Lost Secrets of Maya".

210,000-year-old human skull in Greece is the oldest found outside Africa

Two skulls found in a Grecian cave paint a surprising portrait of who lived there hundreds of thousands of years ago. One fragmentary skull has been dated to 210,000 years ago, and researchers believe that it is the earliest evidence of modern humans living in Eurasia, according to a new study. The other, more complete skull belonged to a Neanderthal who lived 170,000 years ago.

Finding both in the same cave illustrates that multiple early migrations out of Africa, rather than a single event, helped early humans spread, according to the researchers. Southeast Europe is considered to be one of those major migration corridors out of Africa.

The study was published in the journal Nature on Wednesday.

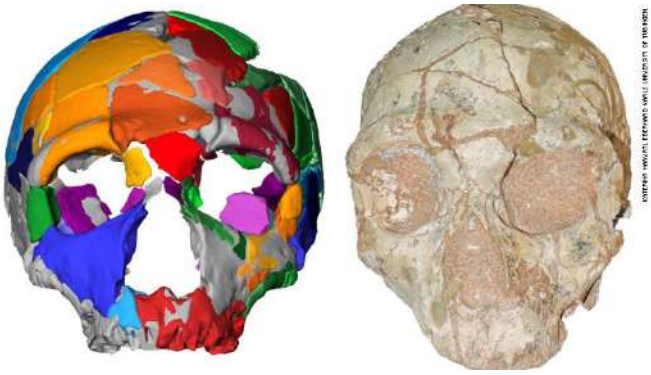
Both skulls were found in a block of breccia, or broken fragments of rock and fossil cemented together, wedged high between the walls of the Apidima Cave in southern Greece. The skulls were discovered in 1978, when the National and Kapodistrian University of Athens was conducting research.

The breccia was dated to between 100,000 and 190,000 years old at the time. The skulls were not removed from the breccia and remained at the museum. Given the fragmentary nature of the skulls, they were difficult to remove and clean, though that eventually happened in the 1990s.

Apidima 1 was in pieces, and Apidima 2, the most complete skull belonging to the Neanderthal, was distorted. At the time, researchers focused on the latter. It had all of the characteristics of a Neanderthal, like a thick and rounded brow ridge.

Researcher Katerina Harvati and her colleagues, who focus on reevaluating the existing fossil record with cutting-edge dating techniques, were invited to study the Apidima fossils.

They scanned the fossils and created 3D reconstructions of them. The shape of each skull was compared with those of other species from the fossil record.



The Apidima 2 skull, right, and its reconstruction. Apidima 2 shows a suite of features characteristic of Neanderthals, indicating that it belongs to the Neanderthal lineage.

Apidima 2, which is essentially just the facial region of a skull without the lower jaw, matched yet again as a Neanderthal skull, despite its distortion.

Apidima 1, just the back of a skull, was fragmented but not distorted, so the researchers were able to use mirroring to re-create it.

The researchers were surprised to find all of the signatures of an early member of the Homo sapiens family in the Apidima 1 skull. The rounded back is just like a modern human's; Neanderthals have a bulge at the back of the skull that almost resembles a hair bun.

The oldest known fossils of early humans were found at Jebel Irhoud in Morocco, dating to 315,000 years ago. But the Jebel

Irhoud fossils display more primitive features than Apidima 1.

Apidima 1 is now the oldest known European modern human fossil, 160,000 years older than previous discoveries.

The researchers also used uranium-series dating to determine the ages of each skull, putting Apidima 1 at 210,000 years old and Apidima 2 at 170,000 years old. Previously, it had been assumed they would both be the same age, given that they were found in the same breccia and only the breccia was initially dated.

But the cave system where they were found allowed for the remains of humans and animals from different time periods to accumulate.

The cave is reachable only by water now. At the time when modern humans and Neanderthals lived there separately, sea levels were lower. The cave overlooked a coastal plain that was probably perfect for hunting, while the cave itself provided shelter. Southern Greece would have been attractive during glacial times, offering a milder climate, the researchers said.

Given the fact that the modern human skull is older than the Neanderthal skull, which was unexpected, researchers believe that a group of modern humans lived in the area but didn't thrive. Climactic events or competition from Neanderthals caused them to die off, leaving no genetic trace behind in the population. Without further evidence, it's difficult to know what happened to them.

Then, Neanderthals lived in the area. And about 40,000 years ago, the last of the Neanderthals died off, and modern humans thrived.

Previous discoveries of early modern human fossils in Israel, dated between 90,000 and 194,000 years ago, could also represent populations that failed to thrive after leaving Africa.

Many questions remain for the researchers. They want to know the underlying cause for the early migrations, if there were technological advancements that allowed for those migrations and why some of the modern human populations didn't persist in the areas where they migrated.

They were also unable to recover DNA from the skulls but will analyze ancient proteins that could be preserved in the fossil, a method known as palaeoproteomics.

(Ashley Strickland / CNN, July 10, 2019, https://edition.cnn.com/2019/07/10/world/early-human-skulls-greece-scn/index.html)

Apidima Cave fossils provide earliest evidence of *Homo sapiens* in Eurasia

Katerina Harvati, Carolin Röding, Abel M. Bosman, Fotios A. Karakostis, Rainer Grün, Chris Stringer, Panagiotis Karkanas, Nicholas C. Thompson, Vassilis Koutoulidis, Lia A. Moulopoulos, Vassilis G. Gorgoulis & Mirsini Kouloukoussa

Nature **volume 571**, pages 500–504 (2019)

Abstract

Two fossilized human crania (Apidima 1 and Apidima 2) from Apidima Cave, southern Greece, were discovered in the late 1970s but have remained enigmatic owing to their incomplete nature, taphonomic distortion and lack of archaeological context and chronology. Here we virtually reconstruct both crania, provide detailed comparative descriptions and analyses, and date them using U-series radiometric methods. Apidima 2 dates to more than 170 thousand years ago and has a Neanderthal-like morphological pattern. By contrast, Apidima 1 dates to more than 210 thousand years ago and presents a mixture of modern human and primitive features. These results suggest that two late Middle Pleistocene human groups were present at this site—an early *Homo sapiens* population, followed by a Neanderthal population. Our findings support multiple dispersals of early modern humans out of Africa, and highlight the complex demographic processes that characterized Pleistocene human evolution and modern human presence in southeast Europe.

https://www.nature.com/articles/s41586-019-1376-z

Ancient Greeks may have built 'disability ramps' on some temples

"The ancient Greek world was not some progressive utopia, but we do see some interesting solutions" for the disabled.

A digital rendering of the fourth-century B.C. Temple of Asklepios at Epidaurus (right). Notice the ramp on the temple's east side.

The ancient Greeks didn't construct temples just for able-bodied people; this ancient society purposefully built ramps at some of its temples — especially at healing sanctuaries — so that people with disabilities could access the sites, a new study suggests.

Some of these ramps date back to before the fourth century B.C., and they were likely used by other people with limited mobility as well, including the elderly, pregnant and very young, said study researcher Debby Sneed, a lecturer of classics at California State University, Long Beach.

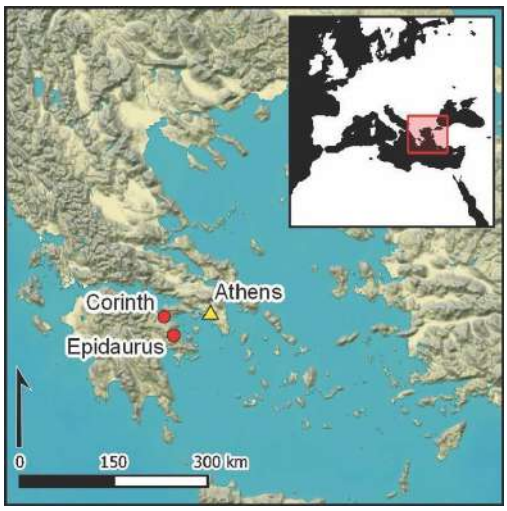
"It seems clear that the most reasonable explanation for [these] ramps is that they were intended to help mobility-impaired visitors access the spaces that they needed to experience religious healing," Sneed told Live Science in an email. "This shouldn't surprise us, really: The Greeks built these spaces for disabled people, and they built the spaces so that their target visitor could access them."

Until now, archaeologists had largely neglected to study ramps in ancient Greece, Sneed said. She took an interest in these sloping surfaces while doing a project on disability accommodations in ancient Greece. Her research showed that the disabled were acknowledged and cared for, at least partly, in ancient Greece.

A digital reconstruction of the fourth-century B.C. tholos (circular "beehive" structure) of the Sanctuary of Asklepios at Epidaurus.

For instance, in the fourth century B.C. in Athens, "the city provided a regular maintenance payment for adult male citizens who were disabled and could not support themselves because of their disability," Sneed said. "We know about this payment primarily because we have a speech, delivered by a man who says he walks with the aid of two crutches." This man had been accused of welfare fraud, so he was "defending both his disability and his inability to support himself because of it," Sneed said.

Despite these maintenance payments, "I want to be clear that the ancient Greek world was not some progressive utopia, but we do see some interesting solutions," Sneed noted.



These ancient Greek cities had healing sanctuaries with ramps that were likely meant for the disabled.

A man leaning on a crooked staff or crutch (left) says goodbye to a warrior on this red-figure amphora, which is attributed to the Matsch Painter, circa. 480 B.C.

This black-and-white photo shows a ramp on the north side of the Sanctuary of Asklepios at Corinth.

A fifth-century B.C. frieze of the Parthenon in Athens showing the disabled god Hephaestus with a crutch tucked under his right arm.

These legs and feet were votive offerings to the healing god Asclepius. People would have offered these limbs to Asclepius, asking him to heal the limb or body part in question.

More votive offerings for the healing god Asclepius.

As part of her research, Sneed looked at ancient Greek healing sanctuaries, which were destinations for people seeking treatments or cures for both permanent and temporary health conditions, including eyesight problems, troubles conceiving, pregnancy issues, nefarious poisonings, leg and arm injuries, and developmental issues in children (one man, for example, brought his nonverbal child to a healing sanctuary in search of a cure, Sneed said). Then, she realized that many healing sanctuaries had one thing in common: ramps.

"I was familiar with ramps, but most religious (non-healing) sanctuaries have just one ramp, maybe two," she said. "When I looked at the most important healing sanctuary in Greece, the Sanctuary of Asclepius at Epidaurus, I found that there were at least 11 permanent stone ramps that provided access to nine different structures," once renovations for the building began in 370 B.C.

Installing ramps required extra money, resources and space, so they were likely built to serve a much-needed purpose, she said.

Multipurpose ramps?

Previously, scholars tended to attribute ramps found in ancient Greece as a conduit for sacrificial animals, dedication ceremonies to the gods that involved heavy objects or construction. "[But] these explanations are not satisfactory," Sneed said. "In the first place, sacrificial animals only rarely went into temples: They were slaughtered on a ramp outside of the temple and had no reason to be led inside."

Secondly, temples did have dedications to the gods, but buildings whose dedications involved heavy materials (called treasuries) never had ramps, so ramps could not have been used for this purpose, Sneed said. Finally, the Greeks used cranes and other hoists during construction, not ramps.

"So, given that these traditional explanations don't really work, and the ramps show up much more often in contexts where we know there were a lot of disabled people, the likeliest explanation is that the ramps were built with the needs of disabled people in mind," Sneed said. That said, it's possible these ramps served multiple purposes, she said, just as today's ramps are used by people in wheelchairs, travelers pulling suitcases, bicyclists and parents pushing baby strollers.

The study's argument is a compelling one, said Mark Wilson Jones, a professor of architecture at the University of Bath in England, and the author of "Origins of Classical Architecture: Temples, Orders, and Gifts to the Gods in Ancient Greece" (Yale University Press, 2014), who was not involved with the research.

"Although there may be some other uses for the ramps, the point of the article is well made especially as regards healing sanctuaries," Wilson Jones told Live Science.

However, while ramps were popular at healing sacularies, they were still relatively rare in ancient Greece. One survey of doric-column temples found ramps at fewer than 20 of them. Of these, most temples have just one ramp leading to the main building, which makes the 11 ramps at the healing Sanctuary of Asclepius at Epidaurus all the more extraordinary.

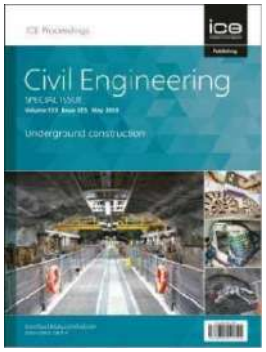
Given these small numbers, "it would be necessary to have a bigger sample group in order to have some statistical grounding to the findings," that healing sanctuaries tend to have ramps that were likely built for the disabled, Wilson Jones said.

Sneed noted that her research shows how important it is for the field to include a diversity of scientists. Perhaps one reason the ramps in ancient Greece had never been assessed for serving the disabled is because "many archaeologists are not physically disabled (or don't identify as physically disabled), so they aren't regularly thinking about issues of access in the course of their daily lives," she said.

The study was published online today (July 21) in the journal Antiquity.

(Laura Geggel - Associate Editor / LIVESCIENCE, July 21, 2020, https://www.livescience.com/ancient-greek-temples-disability-ramps.html)

ΝΕΕΣ ΕΚΔΟΣΕΙΣ ΣΤΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΠΙΣΤΗΜΕΣ



Civil Engineering
Special Issue:
Underground Construction

Editor: Simon Fullalove

ICE (The Institution of Civil Engineers) has announced the publication of its first Special Issue of 2020 dedicated to exploring the potential of underground construction. The latest in a growing number of publications on the subject, it also reflects a renaissance of interest in underground space as a sustainable form of urban development. This latest publication follows a previous ICE book published in 2018 titled 'Underground Spaces Unveiled' by Han Admiraal and Antonia Cornaro.

Recent years have seen a renaissance of interest in the enormous potential of underground development to contribute to less congested, cleaner and more sustainable cities. In addition to transport arteries, car parks and utilities, subterranean development can also accommodate facilities that take up much-needed space and do not need to be on the surface.

Factories, offices, shopping malls, waste processing facilities, libraries, cinemas, theatres, convention centres, performing arts venues, health centres and educational establishments can all potentially be located underground, unlocking much-needed land for housing and green space. Montreal, Canada has shown how successful this sort of subterranean development can be with its 'Underground City' comprising a labyrinthine network of tunnels beneath the city's central business district connecting offices, shopping centres, convention halls and arts venues. And Helsinki, Finland was the first city to develop an underground masterplan to designate space for development in areas of the urban bedrock.

Where urban development is so dense that even housing cannot be adequately provided, the solution could also lie underground. Mexico-based BNKR Arquitectura's Earthscraper concept is essentially an inverted skyscraper, a 300m-deep underground pyramid with its base at ground level. Aiming to address Mexico City's acute housing and land shortage, the 'mini-city' incorporates retail, residential and office developments.

This ICE Special Issue is unlikely to be the last publication to highlight the multiple benefits of underground construction and its contribution to greener, cleaner and more liveable cities. The technology certainly exists. But it also requires the vision, courage and will of politicians and city planners for it to materialise.

This Civil Engineering special issue is on underground construction. It explores some of the latest developments and innovations that are transforming underground construction across the world. The wide-ranging papers cover various ways in which underground spaces can meet society's future needs, and the innovations in underground construction technology that are helping to improve safety, delivery and environmental performance. The issue has been supported by the British Tunnelling Society (BTS), an Institution of Civil Engineers associated society, which celebrates its 50th anniversary in 2021. Since its first meeting in March 1971, it has since grown to become one of the world's most vibrant gatherings of professional tunnellers in the world, providing industry guidelines, codes of practice, training, conferences and advice to government on all aspects of underground construction.

(ICE Pyblishing, 08 May 2020)

ΗΛΕΚΤΡΟΝΙΚΑ ΠΕΡΙΟΔΙΚΑ

An official journal of the International Society for Soil Mechanics and Geotechnical Engineering
www.geocasehistoriesjournal.org/pub/issue/view/46

Κυκλοφόρησε το Τεύχος 4 του Τόμου 5 του του International Journal of Geoengineering Case Histories με τα παρακάτω περιεχόμενα:

Editorial, Nina Stark, Lee Wooten, Sissy Nikolaou

Geotechnical Extreme Event Site Reconnaissance in Puerto Rico after the Passage of Hurricane Maria, Francisco Silva-Tulla, Miguel A Pando

Hurricane Irma: Consequences of Intense Rainfall and Storm Surge from a Tropical Storm in North and Central Florida, Melissa E Landon, Nick W Hudyma, Radhey S Sharma

Post-2017 Hurricane Season Assessment of Civil Infrastructure Impacts on Beach and Near-Beach Environments, Stephanie Marie Smallegan, Jens Figlus, Nina Stark, Inthuorn Sasanakul, Luis G. Arboleda Monsalve, Iman Shafii, Navid Jafari, Nadarajah Ravichandran, Patrick Bassal

Scour at the Seawall in Surfside, Texas, During Hurricane Harvey (2017), Nina Stark, Iman Shafii, Navid Jafari, Nadarajah Ravichandran, Jens Figlus, Stephanie Smallegan, Patrick Bassal

Geotechnical Effects of Hurricane Harvey in the Houston, Beaumont, and Port Arthur Areas, R. Lee Wooten, Stacey Kulesza, Chadi El Mohtar, Brian Diaz, Olusola Ilupeju, Marcus Rasulo, Patrick Bassal, Ahmed Hussien, Behdad Mofarraj Kouchaki, Michael V. Little, Ahmet A. Mert, Christopher W. Nelsen

Geotechnical Effects and a 6-Year Outlook of the 2012 Hurricane Sandy in the Eastern United States, Sissy Nikolaou, Youssef M.A. Hashash, Beena Sukumaran, Aaron Sacks, Michael J. Burlingame, Chris Baxter, Aaron Bradshaw, Lee Wooten, Hugh Lacy, Cheryl Moss, Joseph A. Daraio, Thomas D. O'Rourke

Reconnaissance of the New Orleans Hurricane and Storm Damage Risk Reduction System after Hurricane Gustav, Ray Lee Wooten, P.E., Robert B. Gilbert, Ph.D., P.E., William F. Marcuson, III, Ph.D., P.E., Peter G. Nicholson, Ph.D., P.E., Leslie F. Harder, Jr., Ph.D., P.E., G.E.,

International Geosynthetics Society

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

IGS NEWSLETTER – July 2020

Helping the world understand the appropriate value and use of geosynthetics

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

- Watch: Past-President Jorge G. Zornberg Highlights Importance Of IGS Educate the Educators (EtE) Initiative READ MORE
- IGS 2020 Election Results Are In! READ MORE
- Get To Know Your Newly Elected IGS Council Members! READ MORE
- GeoAsia7 Postponement Notice READ MORE
- EuroGeo7 Gearing Up For May READ MORE
- IGS Reaches 2,000 Followers On LinkedIn READ MORE
- 5 Great Links To Love READ MORE
- XVIII Croce Lecture Delivered By Heinz Brandl – Roma, Italy 11 December 2019 READ MORE
- Calendar of Events

READ MORE AT GEOSYNTHETICSSOCIETY.ORG

ΕΚΤΕΛΕΣΤΙΚΗ ΕΠΙΤΡΟΠΗ ΕΕΕΕΓΜ (2019 – 2022)

Πρόεδρος	:	Μιχάλης ΜΠΑΡΔΑΝΗΣ, Δρ. Πολιτικός Μηχανικός, ΕΔΑΦΟΣ ΣΥΜΒΟΥΛΟΙ ΜΗΧΑΝΙΚΟΙ Α.Ε. mbardanis@edafos.gr, lab@edafos.gr
Α' Αντιπρόεδρος	:	Χρήστος ΤΣΑΤΣΑΝΙΦΟΣ, Δρ. Πολιτικός Μηχανικός, ΠΑΝΓΑΙΑ ΣΥΜΒΟΥΛΟΙ ΜΗΧΑΝΙΚΟΙ Ε.Π.Ε. editor@hssmge.gr, ctsatsanifos@pangaea.gr
Β' Αντιπρόεδρος	:	Μιχάλης ΠΑΧΑΚΗΣ, Πολιτικός Μηχανικός mpax46@otenet.gr
Γενικός Γραμματέας	:	Γιώργος ΜΠΕΛΟΚΑΣ, Δρ. Πολιτικός Μηχανικός, Επίκουρος Καθηγητής ΤΕΙ Αθήνας gbelokas@teiath.gr, gbelokas@gmail.com
Ταμίας	:	Γιώργος ΝΤΟΥΛΗΣ, Πολιτικός Μηχανικός, ΕΔΑΦΟΜΗΧΑΝΙΚΗ Α.Ε.- ΓΕΩΤΕΧΝΙΚΕΣ ΜΕΛΕΤΕΣ Α.Ε. gdoulis@edafomichaniki.gr
Έφορος	:	Γεώργιος ΓΚΑΖΕΤΑΣ, Δρ. Πολιτικός Μηχανικός, Ομότιμος Καθηγητής Ε.Μ.Π. gazetas@central.ntua.gr, gazetas50@gmail.com
Μέλη	:	Ανδρέας ΑΝΑΓΝΩΣΤΟΠΟΥΛΟΣ, Δρ. Πολιτικός Μηχανικός, Ομότιμος Καθηγητής ΕΜΠ aanagn@central.ntua.gr
		Παναγιώτης ΒΕΤΤΑΣ, Πολιτικός Μηχανικός, ΟΜΙΛΟΣ ΤΕΧΝΙΚΩΝ ΜΕΛΕΤΩΝ Α.Ε. otmate@otenet.gr
		Μαρίνα ΠΑΝΤΑΖΙΔΟΥ, Δρ. Πολιτικός Μηχανικός, Αναπληρώτρια Καθηγήτρια Ε.Μ.Π. mpanta@central.ntua.gr
Αναπληρωματικά Μέλη	:	Χρήστος ΣΤΡΑΤΑΚΟΣ, Πολιτικός Μηχανανικός, ΝΑΜΑ Α.Ε. stratakos@namalab.gr
		Βάλια ΞΕΝΑΚΗ, Δρ. Πολιτικός Μηχανικός, ΕΔΑΦΟΜΗΧΑΝΙΚΗ Α.Ε. vxenaki@edafomichaniki.gr
Εκδότης	:	Χρήστος ΤΣΑΤΣΑΝΙΦΟΣ, Δρ. Πολιτικός Μηχανικός, ΠΑΝΓΑΙΑ ΣΥΜΒΟΥΛΟΙ ΜΗΧΑΝΙΚΟΙ Ε.Π.Ε. editor@hssmge.gr, ctsatsanifos@pangaea.gr

ΕΕΕΕΓΜ

Τομέας Γεωτεχνικής
ΣΧΟΛΗ ΠΟΛΙΤΙΚΩΝ ΜΗΧΑΝΙΚΩΝ
ΕΘΝΙΚΟΥ ΜΕΤΣΟΒΙΟΥ ΠΟΛΥΤΕΧΝΕΙΟΥ
Πολυτεχνειούπολη Ζωγράφου
15780 ΖΩΓΡΑΦΟΥ

Τηλ. 210.7723434
Τοτ. 210.7723428
Ηλ-Δι. secretariat@hssmge.gr ,
geotech@central.ntua.gr
Ιστοσελίδα www.hssmge.org (υπό κατασκευή)

«ΤΑ ΝΕΑ ΤΗΣ ΕΕΕΕΓΜ» Εκδότης: Χρήστος Τσατσανίφος, τηλ. 210.6929484, τοτ. 210.6928137, ηλ-δι. ctsatsanifos@pangaea.gr, editor@hssmge.gr, info@pangaea.gr

«ΤΑ ΝΕΑ ΤΗΣ ΕΕΕΕΓΜ» «αναρτώνται» και στην ιστοσελίδα www.hssmge.gr