Σαρδηνία: Grotta di Nettuno
(Σπηλιά του Ποσειδώνα)

Αρ. 156 – ΝΟΕΜΒΡΙΟΣ 2021

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

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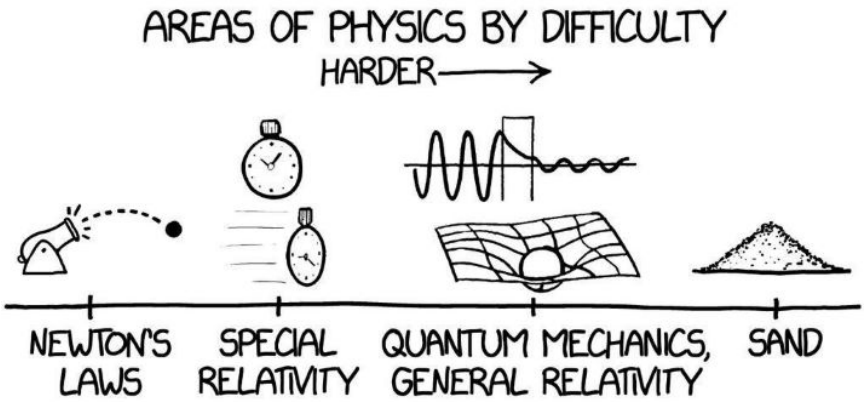
Areas of Physics by Difficulty

The New York Times three days ago on the difficulties of understanding sand: "No one understands how sand works.", ..."no formula to reliably predict"..., "You have to just try it.", ..."so many different properties, like size, shape, roughness and more", ..."and scientists aren't very good at it."



Innocent reader question leads to honest answers - and implicitly suggests **geotechnical engineers are the brightest people on the planet**: https://www.ny-times.com/2020/11/09/science/what-makes-sand-soft.html

Π Ε Ρ Ι Ε Χ Ο Μ Ε Ν Α

Earthquake-Induced Landscape Dynamics
https://slidenz.net

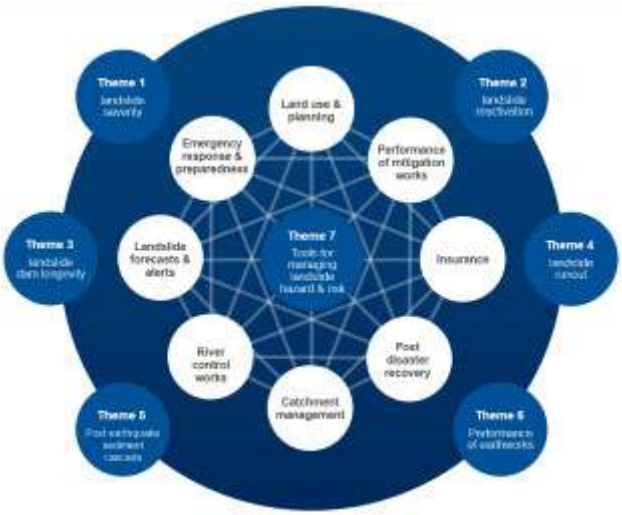
Managing the risk from earthquake induced landslides

Large earthquakes, like the November 2016 Mw 7.8 Kaikōura earthquake, can generate thousands of landslides, landslide dams and damage hillslopes that are susceptible to failure during rainstorms and aftershocks. This debris, when mobilised, creates new hazards, including further landslides, landslide dams, rapid aggradation and formation of alluvial fans and floodplains, and increased river channel instability, as the debris cascades from hillslope to sea. These hazards may persist for decades and therefore represent a prolonged risk that must be managed by the impacted communities and stakeholders.

Earthquake-induced landscape dynamics is funded by the New Zealand Ministry for Business, Innovation and Employment Endeavour fund. The five year programme (2018-2023) is led by GNS Science in association with a number of research partners. The research is directed to effectively manage earthquake- and post-earthquake landslide risk using an integrated set of predictive tools guided by an evidence-based decision making framework by determining over what time scales do landscapes heal after major earthquakes. The Kaikōura earthquake provides a laboratory to quantify post-earthquake landscape dynamics.

The research will:

Develop a framework and tools to allow people to manage the risk to life, property and infrastructure from landslide and other sediment hazards caused by the Kaikōura earthquake and other earthquakes in NZ. The research programme has seven themes



A tool box and decision-making framework will be developed that will better inform landslide risk avoidance and residual risk-management methods and practices for people and stakeholders: 1) affected by the Kaikōura earthquake; and 2) affected by future earthquakes in New Zealand and overseas.

Research

The EILD research programme consists of seven themes:

Theme 1: Landslide severity

Forecasting landslide severity at different magnitudes of ground shaking and rain.

Theme 2: Landslide reactivation

Quantifying post-earthquake landslide triggering and reactivation thresholds from ground shaking, rain and time.

Theme 3: Landslide dam longevity

Evaluating how long landslide dams may last in the landscape

Theme 4: Landslide runout

Determining how far landslide debris may travel downslope, once triggered

Theme 5: Post-earthquake sediment cascades

Modelling how sediment cascades from hillslope to sea.

Theme 6: Performance of earthworks

Assessing the performance of earthworks infrastructure subject to landsliding.

Theme 7: Tools for managing landslide hazard and risk

An integrated set of predictive tools within a decision making framework.

Partners

NZ Research Collaborators

Our New Zealand universities and consultancy collaborators are:

International Research Collaborators

Our international research collaborators include:

Collaborators and co-researchers

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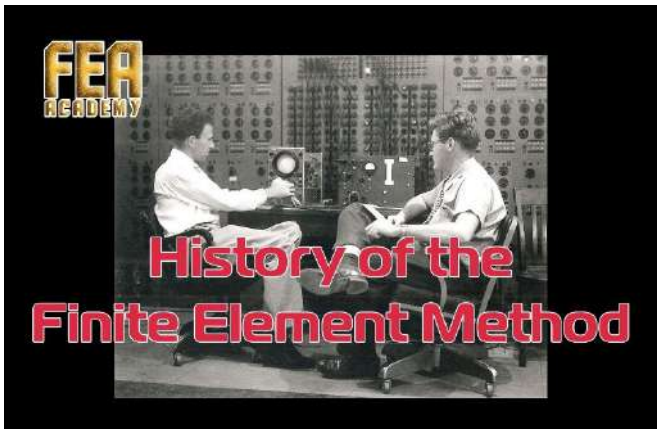
History of Finite Element Method

Dominique Madier



The exact date of the emergence of the Finite Element Method is quite difficult, if not impossible, to determine precisely. Its origins can be traced to the need to solve practical problems in Aerospace, Mechanical and Civil Engineering.

The Pioneers

Usage of the finite element method began in the early 1940s, with the work of the Russian-Canadian structural engineer, ***Alexander Hrennikoff***, and German American mathematician, ***Richard Courant.***

Although very different, the work of these two men shared a common characteristic— the discretization of a continuous domain into several elements. ***Hrennikoff's*** proposals were based on lattice discretization, while ***Courant's*** approach was based on triangular elements.

The finite element method was developed in parallel in Europe and North America, by a number of independent actors:

- ***Ray Clough*** and colleagues at UC Berkeley (California, USA)
- ***John Argyris*** and colleagues at the University of Stuttgart (Germany)
- ***Olgierd Zienkiewicz*** and colleagues at the University of Swansea (UK)
- ***Bruce Irons*** and colleagues at the University of Swansea (UK)
- ***Richard Gallagher*** and colleagues at Cornell University (New York, USA)

A Very Popular Domain

The Finite Element Method (FEM) and Finite Element Analysis (FEA) have been generalized to a wide variety of engineering disciplines such as structural analysis, electromagnetism, heat transfer, and fluid dynamics, for the numerical modeling of physical systems.

The FEA domain is very popular in the universities due to its wide range of applications. Consequently, the number of papers published on the subject has increased exponentially over time.

The table below is showing the number of papers about FEM published from 1956 to present.

Year	1956	1961	1966	1971	1976	1986	Today
papers	1	10	134	844	7,000	20,000	$> 10^6$

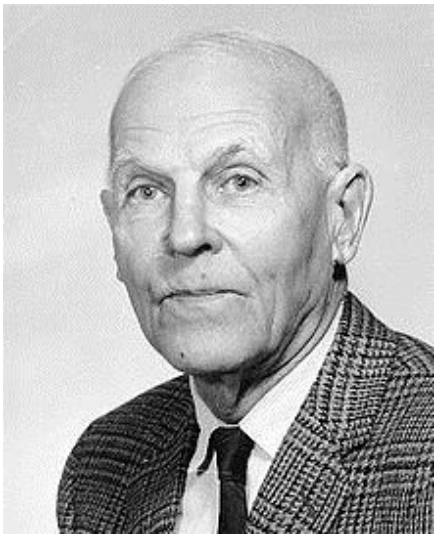
FEM Timeline

Early 1940s

Alexander Hrennikoff and ***Richard Courant*** establish the mathematical foundations of the present form of the Finite Element Method for solving elasticity and structural analysis problems in civil and aeronautical engineering.

1941 – 1943

Hrennikoff presents the discretization of a continuous domain into several elements using the lattice analogy to model membrane and plate bending parts of a structure. However, this analogy could not be applied to nonrectangular areas.



Hrennikoff, A. "Solution of Problems in Elasticity by the Framework Method", Journal of Applied Mechanics, 8, pp. 169-175, 1941.

1943

Richard Courant presents his approach based on constant strain triangular elements using the Ritz method. This approach was not pursued at that time due to the lack of high-speed computers.

Courant, C., "Variational Methods for Solution of Equilibrium and Vibration", Bull. Am. Math Soc., Vol. 49, 1943, pp. 1-43.

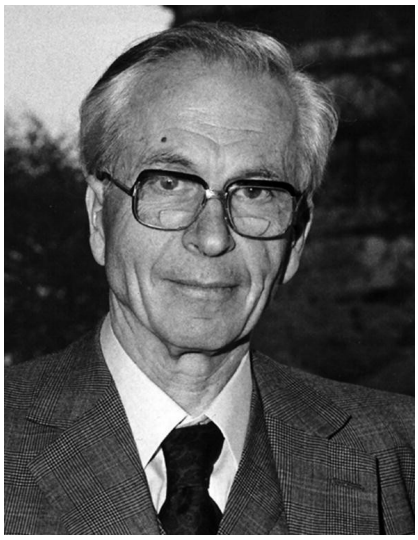
1952 – 1953

Ray Clough worked with ***John Turner*** at the Boeing Structural Dynamics Unit on the calculation of bending and torsional flexibility influence coefficients on low aspect wings. Static experimental results had been obtained for a swept-back box wing structure, but they did not agree with the results produced by a structural analysis model using the lattice analogy. They conceived the procedure for the development of the constant strain triangle.

In addition to the constant strain triangular membrane element, a rectangular membrane element, based on equilibrium stress patterns, was presented which avoided shear locking. The node equilibrium equations were formed by the direct stiffness method.

Their work was presented at Boeing in 1954 and a paper was published in 1956 (see reference below).

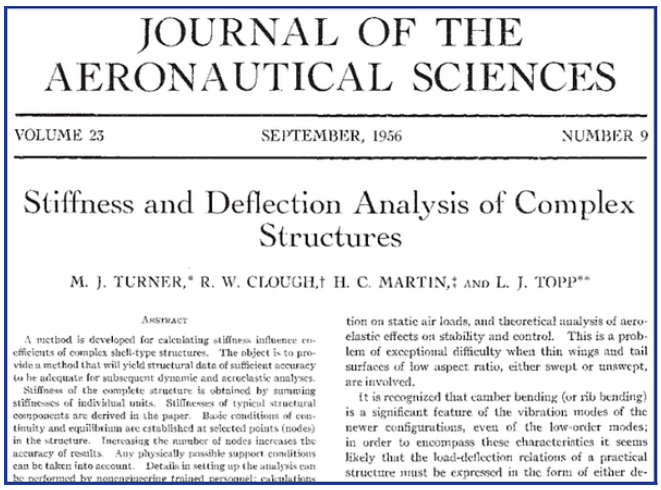
1954 – 1955



John Argyris, from the University of Stuttgart, unified many different approximate methods for the solution of both continuous and one-dimensional frame structures. By using matrix transformation methods, he clearly shown that most structural analysis methods could be categorized as either a force or a displacement method.

Argyris, J, "Energy Theorems and Structural Analysis", Aircraft Engineering, 1954 and 1955.

1956



JOURNAL OF THE AERONAUTICAL SCIENCES

VOLUME 23 SEPTEMBER, 1956 NUMBER 9

Stiffness and Deflection Analysis of Complex Structures

M. J. TURNER,* R. W. CLOUGH,† H. C. MARTIN,‡ AND L. J. TOPP**

ABSTRACT

A method is developed for calculating stiffness influence coefficients of complex shell-type structures. The object is to provide a method that will yield structural data of sufficient accuracy to be adequate for subsequent dynamic and aeroelastic analyses. Stiffness of the complete structure is obtained by summing stiffnesses of individual units. Stiffnesses of typical structural components are derived in the paper. Basic conditions of continuity and equilibrium are established at selected points (nodes) in the structure. Increasing the number of nodes increases the accuracy of results. Any physically possible support conditions can be taken into account. Details in setting up the analysis can be performed by nonengineering trained personnel; calculations tion on static air loads, and theoretical analysis of aeroelastic effects on stability and control. This is a problem of exceptional difficulty when thin wings and tail surfaces of low aspect ratio, either swept or unswept, are involved.

It is recognized that camber bending (or rib bending) is a significant feature of the vibration modes of the newer configurations, even of the low-order modes; in order to encompass these characteristics it seems likely that the load-deflection relations of a practical structure must be expressed in the form of either de-

M. J. Turner, R. W. Clough, H. C. Martin, and ***L. J. Topp*** published *"Stiffness and Deflection Analysis of Complex Structures,"* in the *Journal of the Aeronautical Sciences,* one of the first articles concerning the application of the finite element method.

1957 – 1960

Clough initiated a new structural analysis research program at UC Berkeley and started a new graduate course entitled Matrix Analysis of Structures. An IBM 701 digital computer, with 4k of 16-bit memory, was installed in the College of Engineering. The maximum number of equations that could be solved by this computer was approximately 40. ***Clough*** developed a matrix algebra program to permit students learning programming in order to solve finite element problems. So, by using submatrix techniques and tape storage it was possible to solve larger systems.

Under the direction of ***Clough***, graduate student ***Ari Adini*** used the matrix algebra program to solve several plane stress problems using triangular elements. Even a simple structure required a significant amount of time. Hence, only coarse mesh solutions were possible. This approach was used to develop all examples for the paper *"The Finite Element Method In Plane Stress Analysis"* presented by ***Clough*** in 1960 (see reference below).

1958

Ed Wilson, a graduate student, who shared an office with ***Adini*** at UC Berkeley, was not satisfied with the large amount of work required to solve finite element problems by using the matrix algebra program. Under the direction of ***Clough***, he started the development of an automated finite element program based on the rectangular plane stress finite element developed at Boeing. ***Wilson*** created a limited capacity,

semiautomated program which was based on the force method.

1959 – 1960

The IBM 704 computer is deployed at UC Berkeley (it had 32K of 32-bit memory and a floating-point arithmetic unit which was approximately 100 times faster than the IBM 701).

Under the direction of ***Clough***, ***Wilson*** wrote a two-dimensional frame analysis program with a nonlinear, moment-curvature relationship defined by the classical Ramberg-Osgood equation. The loads were applied incrementally and produced a pushover type of analysis. The incremental load approach was general and could be used for all types of finite element systems. ***Wilson*** presented his work in 1960 at the *2nd American Society of Civil Engineers* (ASCE) *Conference on Electronic Computation*.

1960

Ray Clough coins the term "Finite Element Method" in his paper, *"The Finite Element Method in Plane Stress Analysis"* presented at the *2nd American Society of Civil Engineers* (ASCE) *Conference on Electronic Computation*, Pittsburgh, September 1960.

1960

Clough and ***Wilson*** developed a fully automated finite element program in which the basic input was the location of the nodes and the node numbers where the triangular plane stress elements were attached.

It was then possible for structural engineers, without a strong mathematical background in continuum mechanics, to solve practical plane stress structures of arbitrary geometry built by using several different materials. The work required to prepare the computer input data was simple and could be completed in a few hours for most structures.

1960s

Many different research activities are pursued at ***UC Berkeley.*** FEA is the analysis tool that complements all such analytical and experimental research activities and contributes to the development of the finite element method:

- The US Department of Defense studies the cost and ability to reinforce buildings and underground structures to withstand nuclear blasts.
- A very significant program on earthquake engineering research, including the construction of the world's largest shaking table, is initiated by ***Profs. Jack Bouwkamp, Ray Clough, Joseph Penzien,*** and ***Harry Seed.***
- The US Federal Government and California Department of Transportation rapidly expand the state freeway system and sponsor research at Berkeley on the behavior of bridges and overpass structures, led by ***Profs. Alex Scordelis*** and ***Carl Monismith.***
- The US human spaceflight program becomes a national priority, and ***Profs. Karl Pister, Joseph Penzien, Egor Popov, Jerry Sackman, Bob Taylor,*** and ***Edward Wilson*** are very active conducting related research.
- Offshore deep-water oil drilling and construction of the Alaska pipeline require new technology for steel structures, which is developed by ***Profs. Egor Popov, Jack Bouwkamp,*** and ***Graham Powell.***
- Construction of nuclear reactors and cooling towers requires the development of new analytical methods and materials. ***Profs. Egor Popov, Alex Scordelis,*** and ***T.Y. Lin*** are consultants in the design and construction of many important long-span shell structures.

1960 – 1962

Adini continued his finite element research at UC Berkeley by using the matrix algebra program to solve plate bending problems using rectangular finite elements and demonstrated that this class of structures could be modeled accurately by the method. He demonstrated that plate bending problems could also be solved by the finite element method. ***Adini*** solved several simple shell structures using the matrix algebra approach and additional commands to form membrane and bending stiffness matrices for rectangular elements.

Adini, A. and Clough, R. W., "Analysis of Plate Bending by the Finite Element Method", NSF Report, Grant G7337, 1960.

Adini, A., "Analysis of Shell Structures By the Finite Element

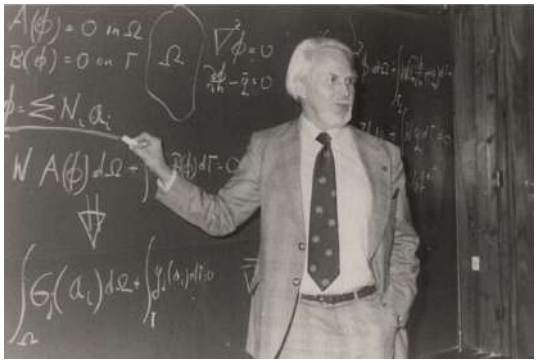
Method", University of California, Berkeley, Ph.D. Dissertation, 1961.

Late 1960s

James Tocher, a Ph.D. student working under the direction of ***Clough*** at UC Berkeley, started a search for a practical triangular plate-bending element. With the help of a former student of ***Clough***, ***T. K. Hsieh***, they developed the first triangular plate-bending elements. The resulting plate bending element was implemented and tested by ***Tocher*** while working at Boeing. The element produced excellent results and was named the HCT element.

Clough, R. W. and J. L. Tocher, "Finite Element Stiffness Matrices For the Analysis of Plate Bending', Proc. Matrix Methods in Structural Analysis, Wright-Patterson Air Force Base, Ohio, October 26-28, 1965.

1964 – 1965



Dr. Olgierd Zienkiewicz, who was installed as a Professor at the University of Wales in Swansea (UK), asked ***Clough*** and many other leading specialists on the development of

Stress Analysis – Recent Developments in Numerical and Experimental Methods, John Wiley & Sons Ltd. 1965.

1965

Conference on *Matrix Methods in Structural Analysis* at the *Wright-Patterson Air Force Base (USA)* in October. It brought together the major structural analysis research groups from many areas of the world. The presented works used two and three-dimensional elements to solve problems in continuum mechanics.

A session chaired by ***Professor Richard Gallagher*** was devoted to the Finite Element Method. ***John Argyris*** presented many applications on the analysis of solids, plates and shells. In addition, he presented the six-node triangular plane element formulated in a natural area coordinate system and a ten-node solid tetrahedral element formulated in a natural volume coordinate system.

1965

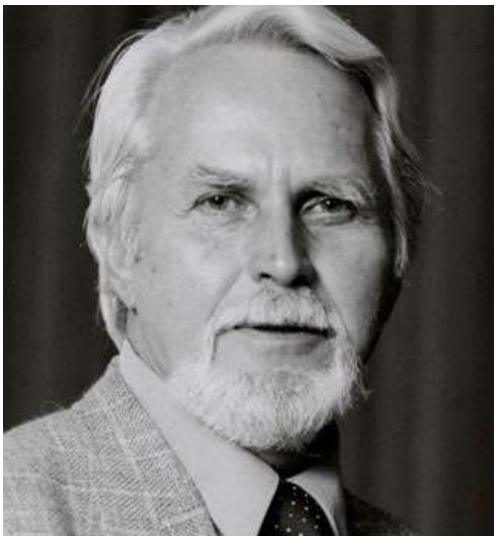
NASA issues a request for a proposal for the development of a structural analysis software.

The result is the **NA**sa **STR**uctural **AN**alysis application (**NASTRAN**), which implements available FEA technology to solve structural problems.

1965

The terminology ***"Finite Element Method"*** was accepted as replacement terminology for the ***"Direct Stiffness Method"***.

1967



The book "*The Finite Element Method"* is published by ***Olgierd Zienkiewicz, Robert Taylor,*** and ***Jianzhong Zhu***. It remains, to this day, the standard reference text on the theoretical basis of the method.

1968

Bruce Irons and ***Olgierd Zienkiewicz***, from the University of Wales in Swansea (UK), presented the isoparametric formulation of finite element stiffness matrices. This work had a significant impact on the finite element research.

1968

Computer Sciences Corporation (CSC) releases the FEA program **NASTRAN** (**NA**sa **STR**uctural **AN**alysis) to NASA.

1969

Kenneth Kavanagh, under the direction of ***Clough***, used the eight-node solid element for structural analysis of 3D problems.

1969

Wilson and ***Taylor*** solve the problem of shear locking which occurred with the use of the four-node plane element and the eight-node solid element. They successfully solved the problem by using reduced integration and incompatible displacement modes.

1969

MSC Nastran™

MacNeal-Schwendler Corporation (MSC, now MSC Software) initiates the first commercially available version of **NASTRAN**, dubbing it MSC/NASTRAN (now **MSC NASTRAN**), which would become known as the first generation of FEA software.

MacNeal-Schwendler Corporation was formed in 1963 by Dr. Richard H. MacNeal and Robert Schwendler.

1970

John Swanson releases the first version of his **AN**alysis **SYS**tems (**ANSYS**) FEA software.

1972

"Lectures on Mathematical Foundations of the Finite Element Method," the first mathematical proofs on the properties of the finite element method, are published by ***Ivo Babuska*** and ***A. Aziz.*** Until then, the method had been implemented but not mathematically proven.

1978

Hibbitt, Karlsson, and ***Sorensen*** release the first version of the FEA software **ABAQUS**.

1980s

Graphical and computational developments accelerate quickly.

1990s

Low-cost, powerful personal computer (PC) workstations emerge, and FEA is adopted by small- and medium-sized industries.

1991

Implementation of model hierarchies in FEA software is successfully completed, meaning that for the first time in FEA history, FEA analysts are able to separate discretization and idealization errors, a process essential to verification, validation, and uncertainty quantification.

2006

The *Guide for Verification and Validation in Computational Solid Mechanics* is released by the *American Society of Mechanical Engineers* (**ASME**). This ground-breaking guide lays the foundation of requirements for controlling errors in numerical simulations.

2008

NASA releases the *"Standard for the Development of Models and Simulations"*, NASA-STD-7009. Any FEA simulation must pass strict verification requirements to be deemed compliant.

(FEA ACADEMY, https://www.fea-academy.com/index.php/component/content/article/27-blog/fea-generalities/73-fem-history)

ΑΡΘΡΑ

Geomythology: Japan's Earthquakes – The work of Namazu?

Filippo Carboni

Namazu the giant catfish

Welcome to this first post on the EGU TS blog's newest series on Geomythology. Plate tectonic theory has existed for just over half a century but the Earth beneath us has always been active. In this series we explore historical and mythological explanations to tectonic phenomena we now understand, such as earthquakes, volcanoes, mountains, and others.

Japanese Earthquakes

Japan is one of the countries with the highest frequency of localised earthquakes in the world (USGS Natural hazards FAQ). The island is located along the Pacific Ring of Fire, an extended area of subduction zones which cause volcanoes and ~90% of the worldwide earthquakes (Fig. 1a). The island of Japan is a volcanic arc, formed in response of a complex setting of four subduction zones (Fig.1b), between the Pacific, the Philippine, the North America, and the Eurasian tectonic plates, although the boundary between the Eurasian and the North American Plate in this area is still debated. The activity of these sinking plates generates recurrent volcanic eruptions and strong earthquakes, which in turn can cause tsunamis.

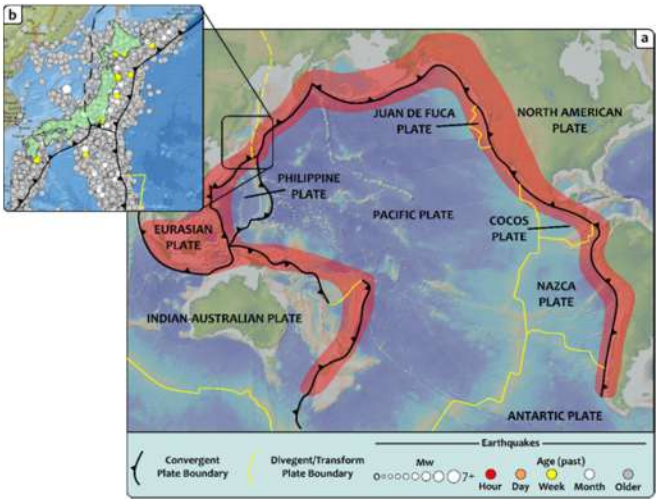


Fig. 1. (a) Simplified scheme of the tectonic plates setting around the Pacific Ring of Fire (red area). Base map from GeoMapApp (Ryan et al., 2009). (b) zoom on Japan seismicity from the USGS earthquake catalog.

This scientific explanation of recurring earthquakes is quite modern. In the period between 1600 and 1868, when a series of strong earthquakes struck Japan (Edo Period, NDLGEJEA Earthquake chronological table), the people did not know anything about subduction zones or tectonic plates, they believed it was the misbehaviour of Namazu instead.

Namazu the giant catfish

Namazu is the giant catfish of Japanese mythology, who lives and swims in the underground muddy and dense waters below Japan. Namazu is a cheeky catfish, who likes to cause trouble, and each time he moves his tail, he causes earthquakes. To stop Namazu from moving, Kashima, the god of thunder and war, is said to have dug deep down into the earth to weigh him down with a special stone, the *kaname-ishi* aka "foundation stone" (Fig. 2a), which is sometimes replaced by a sword (Fig. 2b).

Fig. 2. (a) The thunder god Kashima immobilizes the guilty Namazu with the kaname-ishi, in front of other smaller kneeling catfish, which represent the earthquakes of the past, or aftershocks. (b) The same Kashima who immobilizes Namazu with his sword. Both illustrations are from the 1855 Edo (modern Tokyo) earthquake.

The tip of this massive stone can be seen at the Kashima shrine of Hitachi, to the northeast of Tokyo, the place where Kashima is supposed to live. However, just the weight of the stone is insufficient to immobilize Namazu, thus Kashima's role of pressing down the stone is crucial. He is the only deity strong enough to keep Namazu motionless and when he leaves his duty or he is tired, Namazu can freely move. The intensity of his movement is then positively correlated with the intensity of the produced earthquake.

The role of catfish in generating earthquakes gradually replaced, over centuries, the myths of water-related dragons and snakes, who were believed to be the creatures responsible for earthquakes until around the 1700 (Ludwin and Smits, 2007). In 1650, a broadsheet entitled "*Earthquakes and Tsunamis Explained*" illustrated a snake-shape dragon, while eating his tail and creating a circle, to represent the dragon able to move around under the earth causing earthquakes (Miyata & Takada 1995.)

Namazu's role in the 1855 Edo earthquake

Every tenth lunar month of the year (November in solar calendar), the so called *Kannazuki* (month of no deities), the major Japanese deities, including Kashima, have to attend a meeting at Izumo, leaving their tasks behind. The 1855 Edo (modern Tokyo) earthquake happened during that exact month of the year. Supposedly, in his absence, Kashima left Ebisu, the deity of trading and fishing, to guard Namazu.

However, Ebisu was Namazu, allowing the catfish to move his tail causing the earthquake which struck Edo.

The estimated magnitude of the 11 November 1855 Edo earthquake was 7.2 with a focal mechanism located near Edo, at a depth of 30 km (Bakun, 2005). Despite being a strong earthquake, it did not produce any tsunami however, due to the heterogeneous soil and geomorphology of the region, damage was heavy in some areas and light in others. The areas with the highest damage belonged to the elite citizens, such as the neighbourhoods of *daiymōs* (feudal lords), samurai, and wealthy merchants. Therefore, this earthquake was considered a clear statement of cosmic forces acting against the government, and those in power (Ludwin and Smits, 2007).

The illustration of Figure 3 is emblematic of what Edo inhabitants felt after the earthquake. Edo is on fire and earth shakes above Namazu, who smiles sinisterly. Below, Ebisu is sleeping on the *kaname-ishi* while Rajin, the thunder deity, farts on Ebisu, expelling small drums to emphasize the earthquake's booming noise. This particular image represents a typical pastime of some Edo inhabitants, who used to play at "extreme farting", a game aimed at make more noise than one's opponent (Smits, 2006).

Fig. 3. The Namazu to kaname-ishi (Namazu and the foundation stone) illustration from the 1855 Edo earthquake (Image credit pinktentacle.com).

In the meantime Kashima is riding back to Edo from his meeting with the major Japanese deities in Izumo. Large gold coins falling from the burned Edo, represents the good of redistribution of wealth due to the rebuilding phase after the destruction of the earthquake (Smits, 2006). The falling coins, suggests contrasting thoughts among Edo citizens. Instead of looking at the destruction, many looked at the earthquake as a remedy to the uneven distribution of wealth, sent by the gods to take money from the wealthy merchants and rulers and put it in the hands of ordinary people (Smits, 2006). Many *Namazu-e* (illustrations of Namazu) illustrated a catfish as a distributor of richness (Fig. 4a) and wealth (Fig. 4b), suggesting that, alongside bringing destruction, he also has a positive effect on the population.

Fig. 4. (a) Illustration entitled Furidashi namazu kusuri (Powdered medicine selling Namazu). (b) illustration entitled Ō-Namazu Edo no furui (The giant namazu and Edo's prosperity/shaking). Both illustrations from the 1855 Edo earthquake(Image credit pinktentacle.com).

Namazu represented the renewal from which poor and ordinary people have an opportunity to climb up the social classes (Ludwin and Smits, 2007). Figure 4a is an illustration of a whale-like Namazu spouting coins from a blowhole located in the middle of his body, as if he was a steamship. Fisherman on small boats and on the ground try to catch Namazu in order obtain the money (Ludwin and Smits, 2007). Figure 4b illustrates a personified Namazu while selling medicine which is a metaphor of economical wealth distribution. He carries doll-like images of different kind of workers who benefitted from the destruction and rebuilding of Edo, such as carpenters, plasterers, and roof-tile makers (Ludwin and Smits, 2007).

References

Bakun, W.H., 2005. Location and Magnitude of the 1855 Ansei Edo Earthquake. American Geophysical Union, Fall Meeting 2005, abstract id. S21A-0197.

Ludwin, R.S., Smits, G.J., Carver, D., James, K., Jonientz-Trisler, C., McMillan A.D., Losey, R., Dennis, R., Rasmussen, J., De Los Angeles, A., Buerge, D., Thrush, C.P. Clahue, J., Bowechop, J., Wray, J., Folklore and earthquakes: Native American oral traditions from Cascadia compared with written traditions from Japan. In L. Piccardi, and W.B. Masse (Eds.), Myth and Geology. Geological Society, London, Special Publication 273, 67 – 94.

National Diet Library Great East Japan Earthquake Archive, Earthquake chronological table (Edo period: 1605-1868), https://kn.ndl.go.jp/static/en/edoearthquake.html. (visited on 11/10/2021).

Smits, G., 2006. Shaking up Japan: Edo society and the 1855 catfish picture prints. Journal of Social History, 1045 – 1078.

Smits, G., The Ansei Edo Earthquake and Catfish Prints. In R.G. Tristan and N. Kato (Eds.), Digital Meijis: Revisualizing

Japanese History at 150. Vancouver: University of British Columbia Library, 2019.

UGSG Earthquake Catalog. https://earthquake.usgs.gov/earthquakes/search/ (visited on 11/10/2021).

UGSG Natural Hazards FAQ. https://www.usgs.gov/faqs/which-country-has-most-earthquakes?qt-news_science_products=0#qt-news_science_products. (visited on 11/10/2021).

Ryan, W. B. F., S.M. Carbotte, J. Coplan, S. O'Hara, A. Melkonian, R. Arko, R.A. Weissel, V. Ferrini, A. Goodwillie, F. Nitsche, J. Bonczkowski, and R. Zemsky (2009). Global Multi-Resolution Topography (GMRT) synthesis data set. *Geochem. Geophys. Geosyst.*, 10, Q03014, doi:10.1029/2008GC002332, www.geomapapp.org/CC-BY.

(Filippo Carboni / EGU Blogs » Divisions » Tectonics and Structural Geology, October 22, 2021, https://blogs.egu.eu/divisions/ts/2021/10/22/geomythology-japans-earthquakes-the-work-of-namazu)

Investigating causal factors of shallow landslides in grassland regions of Switzerland

Lauren Zweifel, Maxim Samarin, Katrin Meusburger, and Christine Alewell

Abstract

Mountainous grassland slopes can be severely affected by soil erosion, among which shallow landslides are a crucial process, indicating instability of slopes. We determine the locations of shallow landslides across different sites to better understand regional differences and to identify their triggering causal factors. Ten sites across Switzerland located in the Alps (eight sites), in foothill regions (one site) and the Jura Mountains (one site) were selected for statistical evaluations. For the shallow-landslide inventory, we used aerial images (0.25 m) with a deep learning approach (U-Net) to map the locations of eroded sites. We used logistic regression with a group lasso variable selection method to identify important explanatory variables for predicting the mapped shallow landslides. The set of variables consists of traditional susceptibility modelling factors and climate-related factors to represent local as well as cross-regional conditions. This set of explanatory variables (predictors) are used to develop individual-site models (local evaluation) as well as an all-in-one model (cross-regional evaluation) using all shallow-landslide points simultaneously. While the local conditions of the 10 sites lead to different variable selections, consistently slope and aspect were selected as the essential explanatory variables of shallow-landslide susceptibility. Accuracy scores range between 70.2 % and 79.8 % for individual site models. The all-in-one model confirms these findings by selecting slope, aspect and roughness as the most important explanatory variables (accuracy = 72.3 %). Our findings suggest that traditional susceptibility variables describing geomorphological and geological conditions yield satisfactory results for all tested regions. However, for two sites with lower model accuracy, important processes may be under-represented with the available explanatory variables. The regression models for sites with an east–west-oriented valley axis performed slightly better than models for north–south-oriented valleys, which may be due to the influence of exposition-related processes. Additionally, model performance is higher for alpine sites, suggesting that core explanatory variables are understood for these areas.

How to cite.

Zweifel, L., Samarin, M., Meusburger, K., and Alewell, C.: Investigating causal factors of shallow landslides in grassland regions of Switzerland, Nat. Hazards Earth Syst. Sci., 21, 3421–3437, https://doi.org/10.5194/nhess-21-3421-2021, 2021.

1 Introduction

Soil erosion is an issue affecting many regions of the world and can have severe consequences for the environment and humanity (e.g. water pollution or food production) (Pimentel et al., 1995; Pimentel and Burgess, 2013; O'Mara, 2012; Alewell et al., 2009, 2020). In Switzerland, grasslands of mountain and hill slopes can be strongly affected by soil erosion, which can be caused by natural (e.g. precipitation events) and anthropogenic processes (e.g. land-use management) (Tasser et al., 2003; Meusburger and Alewell, 2008; Zweifel et al., 2019; Geitner et al., 2021; Lepeška, 2016). The most visible form of erosion in grassland soils showing bare soil areas can be categorised as shallow erosion (Geitner et al., 2021) (Fig. 1). These shallow-erosion sites are mainly triggered by prolonged and intense rainfall events (shallow landslides) or through abrasion by snow (snow gliding, avalanches) (Wiegand and Geitner, 2010; Geitner et al., 2021). However, in many cases, a combination of these processes can lead to shallow-erosion sites, and triggering processes cannot be distinguished from aerial photos. Therefore, we use the term *shallow landslides* in our regions and the frame of this study with no implication of the triggering event.

Figure 1 Images showing examples of shallow landslides. Shallow-landslide sites show displaced topsoil layers and have a distinct boundary to the vegetation. **(a)** Taken in the Urseren valley, showing a larger section of a south-east-facing slope area affected by many shallow landslides (light-coloured patches). **(b)** Taken in Val Piora, showing a close-up of a shallow landslide facing south. **(c)** Showing an image taken with a UAV in Val Piora with an approximate length of 10 m.

The aim of our study is to statistically evaluate shallow-landslide occurrence for 10 different sites (between 16 and 54 km^2) across Switzerland. In the past, shallow-landslide susceptibility studies have mainly focused on one or two study sites while often testing multiple modelling techniques (Gómez and Kavzoglu, 2005; Meusburger and Alewell, 2009; Vorpahl et al., 2012; Tien Bui et al., 2016; Oh and Lee, 2017; Lee et al., 2020; Nhu et al., 2020b), except for Persichillo et al. (2017), who evaluated four sites in different catchments. For our shallow-landslide inventory we map the eroded sites on aerial images (0.25 m resolution) using a *U-Net* deep learning approach (Ronneberger et al., 2015). The U-Net tool was trained by Samarin et al. (2020) to identify and map the extent of soil erosion features on grassland. While this mapping tool is able to distinguish between different erosion processes and appearances (i.e. shallow landslides, livestock trails, sheet erosion and management effects; Samarin et al., 2020), here, we focus on shallow landslides as we aim to understand their causal factors and spatial patterns better. With the U-Net mapping tool, we can

identify locations of shallow landslides in a very efficient and precise manner, increasing the possibilities for mapping but also future model validation of soil erosion studies (Samarin et al., 2020). The mapped shallow-landslide sites are subsequently evaluated with a statistical model to identify the most important explanatory variables and gain a better understanding of causal factors as well as regional differences. For this purpose we use the *group lasso* approach for logistic regressions (Tibshirani, 1996; Yuan and Lin, 2006; Meier et al., 2008). The group lasso can deal with continuous and categorical variables and is able to estimate coefficients of classes within a categorical variable. In addition to estimating coefficients, the lasso can do variable selection simultaneously (Sect. 2.2). The lasso tends to yield sparse and interpretable models, avoids overfitting, and is tolerant towards possible collinearity of variables (Dormann et al., 2013). Despite these advantages, the lasso has only been applied a small number of times for landslide susceptibility modelling (Camilo et al., 2017; Lombardo and Mai, 2018; Amato et al., 2019; Gao et al., 2020; Lombardo and Tanyas, 2021; Tanyaş et al., 2021). We evaluate the shallow landslides within each study site (10 models) and across all 10 study sites simultaneously (all-in-one model) and consider only grassland surfaces. Our aim is to identify explanatory variables that have local importance but also identify variables which may explain regional differences in shallow-landslide occurrence. The selected study sites are a combination of alpine (above 1500 ma.s.l.) and foothill regions (below 1500 ma.s.l.) as well as one site in the Jura Mountains (below 1500 ma.s.l.). The explanatory variables we use are the same for all sites and consist of a combination of classic landslide susceptibility variables (Budimir et al., 2015) as well as climate-related variables (Karger et al., 2017, 2018), which may aid in explaining regional differences in shallow-landslide occurrence (Sect. 3.2). To understand how well the selected variables and their coefficients perform, we evaluate the models on held-out test data. We determine receiver–operator characteristic (ROC) curves and the corresponding area under curve (AUC) as well as the Brier score, which is suitable for binary variables (presence or absence of shallow landslides) (Sect. 2.3).

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5 Conclusions

In this study we located shallow landslides across 10 study sites spread across Switzerland. We use the term shallow landslides to describe the erosion sites, which classifies the erosion feature without implications for the triggering event. Using the lasso regression model, we identified the most important explanatory variables for these shallow landslides located on grassland slopes. Due to the different local conditions of the varying sites, different explanatory variables were identified as important. Slope and aspect are among the most important variables. Shallow landslides of sites with an east–west orientation of the valley axis as well as alpine sites were better explained by the available explanatory variables (Urseren, Val Piora, Rappetal and Arosa). This means that exposition-related processes in mountainous regions are essential for understanding regional patterns (e.g. snowmelt, snow movement). For the remaining sites, the available selection of explanatory variables was not as well suited, and therefore important processes could be missed. Sites outside of the main Alpine region (Baulmes and Hornbach) or located in the Swiss National Park (Val Cluozza) have a small number of SLS points, which were not well explained by the available variables. Performance scores for individual-site models range between BS = 0.144, AUC = 0.865 (Urseren) and BS = 0.210, AUC = 0.733 (Baulmes). Although we find that slope was the most important variable, predictions using only slope yield lower accuracies, indicting that additional variables are important to explain local shallow-landslide occurrence. An all-in-one model evaluating all 10 sites simultaneously found comparable results to the individual-site models (i.e. slope and aspect), with performance values of BS = 0.186 and AUC = 0.786. Additionally, this model showed a relatively strong negative correlation for roughness, indicating that smooth grassland surfaces are more susceptible to shallow landslides. The decisive causal factors identified are generally related to static variables (e.g. geo-morphological, geological), while the available climate-related data sets have proven to be less informative on both local and cross-regional scales. Nevertheless, data sets representing triggering shallow-landslide conditions and processes in appropriate spatial resolutions would likely improve model performance. Studies focusing on understanding small-scale processes are therefore of great importance, and with data availability shifting towards open access and higher spatial resolutions as well as large spatial coverage, such statistical evaluations may improve in the future.

(European Geosciences Union, Natural Hazards and Earth System Sciences Articles, Volume 21, issue 11, NHESS, 21, 3421–3437, 2021, https://nhess.copernicus.org/articles/21/3421/2021)

Variable-resolution building exposure modelling for earthquake and tsunami scenario-based risk assessment: an application case in Lima, Peru

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Abstract

We propose the use of variable resolution boundaries based on central Voronoi tessellations (CVTs) to spatially aggregate building exposure models for risk assessment to various natural hazards. Such a framework is especially beneficial when the spatial distribution of the considered hazards presents intensity measures with contrasting footprints and spatial correlations, such as in coastal environments. This work avoids the incorrect assumption that a single intensity value from hazards with low spatial correlation (e.g. tsunami) can be considered to be representative within large-sized geo-cells for physical vulnerability assessment, without, at the same time, increasing the complexity of the overall model. We present decoupled earthquake and tsunami scenario-based risk estimates for the residential building stock of Lima (Peru). We observe that earthquake loss models for far-field subduction sources are practically insensitive to the exposure resolution. Conversely, tsunami loss models and associated uncertainties depend on the spatial correlations of the hazard intensities as well as on the resolution of the exposure models. We note that for the portfolio located in the coastal area exposed to both perils in Lima, the ground shaking dominates the losses for lower-magnitude earthquakes, whilst tsunamis cause the most damage for larger-magnitude events. For the latter, two sets of existing empirical flow depth fragility models are used, resulting in large differences in the calculated losses. This study, therefore, raises awareness about the uncertainties associated with the selection of fragility models and spatial aggregation entities for exposure modelling and loss mapping.

How to cite.

Gomez-Zapata, J. C., Brinckmann, N., Harig, S., Zafrir, R., Pittore, M., Cotton, F., and Babeyko, A.: Variable-resolution building exposure modelling for earthquake and tsunami scenario-based risk assessment: an application case in Lima, Peru, Nat. Hazards Earth Syst. Sci., 21, 3599–3628, https://doi.org/10.5194/nhess-21-3599-2021, 2021.

1 Introduction

The spatial distribution of damage and/or losses expected to be incurred by an extensive building portfolio from a natural hazard event can be quantified and mapped once a physical vulnerability analysis is performed. For such a purpose, a set of fragility functions per building class is conventionally used. Fragility functions describe the probability of exceeding a certain damage limit state for a given intensity measure (IM) associated with a natural hazard, such as spectral acceleration at the yield period (e.g. Fäh et al., 2001) for earthquakes or tsunami inundation height for tsunamis (Koshimura et al., 2009). These vulnerability calculations are performed at the centroid of every aggregation unit of a building exposure model with some level of uncertainty associated with them (Bazzurro and Luco, 2005), or over weighted locations (e.g. Weatherill et al., 2015; Kappos et al., 2008). These aggregation entities can be very diverse, ranging from administrative units such as district/communes (e.g. Dunand and Gueguen, 2012) to urban blocks (e.g. Papathoma and Dominey-Howes, 2003; Kappos et al., 2008; Figueiredo et al., 2018; Kohrangi et al., 2021), regular grids (e.g. Erdik and Fahjan, 2008; Figueiredo and Martina, 2016), or variable-resolution CVT (central Voronoi tessellation) geo-cells (Pittore et al., 2020). Throughout the physical vulnerability assessment, it is implicitly assumed that the intensity observed or estimated at that location (i.e. centroid or weighted points) is representative for the entire aggregation area. Depending on the considered hazard footprint and IM attenuation, this assumption might not be valid if the aggregation area is too coarse compared to the correlation length of a highly varying IM. In addition to the aggregation of the building exposure itself, the importance of these geographical aggregation entities in natural hazard risk assessment is that they are ultimately used to calculate and map the expected damage and loss metrics (e.g. building replacement/repair costs, human casualties). The diverse types of visualisation and interpretations of this kind of geospatial data define the so-called thematic uncertainties (Smith Mason et al., 2017) that can heavily impact the decision-making processes (Viard et al., 2011). It is, therefore, important to find a compromise between the intrinsic resolution of the hazard IM, on the one hand, and the cartographic representation of the exposure models and risk metrics on the other.

When a geographically distributed hazard IM presents no significant spatial variability within distances of the order of tens of kilometres, they are said to be highly spatially correlated (e.g. Gill and Malamud, 2014; Merz et al., 2020). This is the case of hazards with relatively low attenuation and widespread footprints, such as ash-falls and earthquakes (de Ruiter et al., 2021). For the latter case, when seismic site conditions (e.g. soil amplification) and path effects (e.g. seismic directivity) are insignificant, seismic ground motion correlation lengths between 10 and 25 km are typical (e.g. Esposito and Iervolino, 2012; Schiappapietra and Douglas, 2020). On the other hand, hazards are described as being low spatially correlated if their IMs are highly prone to being modified by specific features of the propagation medium. For instance, the modelling of inland IMs from a tsunami (i.e. inundation depth, flow velocity, momentum flux) is highly dependent on the nature and resolution of the bathymetry and digital elevation models (e.g. Tang et al., 2009), coastal topography (e.g. Goda et al., 2015), coastal morphology (e.g. Song and Goda, 2019), and even the nature of the built-up areas that have the potential to interact with and modify the inundation footprint and flow velocities (e.g. Kaiser et al., 2011; Lynett, 2016). Moreover, in the case of earthquake-triggered tsunamis, the maximum tsunami IMs also depend on the properties of the triggering mechanism, for example, the earthquake's magnitude (e.g. Goda et al., 2014), slip distribution (Miyashita et al., 2020), and directivity of the radiated energy (e.g. Kajiura, 1972). Thus, the spatial correlation of inland IMs from tsunamis is very low and remarkably nonlinear compared to the much more uniform and highly spatially correlated seismic ground motion. Efforts to visualise uncertainties in the tsunami hazard and risk mapping that address some of the aforementioned modifiers have been reported in a few studies (e.g. Goda and Song, 2016; Goda et al., 2020).

Usually, the resolution of exposure models is constrained independently of the hazard, and to a certain extent, also independently of the exposure distribution. That might lead to poor exposure resolutions where it really matters, i.e. in areas where buildings are densely distributed and/or hazard intensities vary over short distances. Or, by contrast, it might lead to the unnecessary computation demands for loss assessment in areas with few exposed assets. If aggregation areas of the exposure model are coarser in resolution than the typical correlation lengths of low spatially correlated hazard intensities, then local variations in these intensities would remain hidden in the vulnerability analysis, propagating the associated uncertainties up to the loss estimates. This dependency between exposure resolution and spatial correlation of hazard intensities has usually been disregarded, although some examples can be found in soil liquefaction risk assessment. Despite the fact that the hazard component can

be spatially downscaled (e.g. Bozzoni et al., 2021a), thematic uncertainties related to visualisation and the interpretation of risk metrics can arise if they are mapped over larger regional administrative units (e.g. Yilmaz et al., 2021) instead of being represented at more hazard-compliant resolutions (e.g. Bozzoni et al., 2021b). Similarly, despite building exposure models for flood and earthquake vulnerabilities being able to be aggregated at moderate resolutions (e.g. 4×4 km grid in Dabbeek and Silva, 2019), similar thematic uncertainties can evolve due to the profound differences between both spatially correlated hazard intensities and when the calculated losses are mapped over regional administrative units (Dabbeek et al., 2020).

To the best of the authors' knowledge, different hazard footprints and the spatial correlation of their intensity measures for the construction of aggregation entities for exposure modelling have been seldom discussed in the literature. For instance, Chen et al. (2004) described the importance of ensuring a consistent delimitation of the resolution of exposure models along with the spatial variation in their two considered hazards, earthquakes and hailstorms, which impose damage footprints of very different extents. Meanwhile, Douglas (2007) and Ordaz et al., (2019) highlighted the importance of the geographical scale to represent the building exposure models that are affected differently, depending on variable hazard footprints. The study reported in Zuccaro et al. (2018) is perhaps the most advanced framework in the state of the art for the construction of a common aggregation entity for multi-hazard risk assessment, referred to as the minimum reference unit (MRU). This geographical unit coincides with the minimum resolution of analysis of input (i.e. hazard intensities and exposure model) and output elements (i.e. damage and loss estimates) and remarks that despite high-resolution hazard models, one would achieve neither an accurate risk assessment nor meaningful loss mapping if there is no compatibility between the cartographic representation of the building exposure model, the hazard footprints, and their IM correlation.

A denser set of geo-cells in the same area occupied by a coarser regular-sized cell or administrative units provides a denser arrangement of hazard intensity values (when there are local IM variations) to the set of fragility functions per considered hazard. When local IM variations are not sufficiently represented as finer aggregation entities during the vulnerability analysis, thematic uncertainties might appear in the mapping, visualisation, and interpretation of the loss estimates. Therefore, besides the conventional epistemic and aleatory uncertainties linked to the hazard, exposure, and vulnerability components, thematic uncertainties are also present in the risk chain when the loss metrics are mapped. Awareness of the thematic uncertainties as well as clear and meaningful vulnerability and loss mappings towards the most relevant hazards a community is exposed to is necessary to improve urban planning, mitigation strategies, and emergency response actions (e.g. Pang, 2008; Aguirre-Ayerbe et al., 2018).

We can distinguish two types of approaches formerly proposed in the literature to investigate the exposure aggregation for natural hazard risk applications.

1. Researchers can independently represent the building portfolio over a series of aggregation entities such as administrative units, or equidimensional regular grids, and explore their individual contribution to the uncertainty in the losses imposed by certain hazard(s) to ultimately select a representative aggregation model. This option has been explored in Bal et al. (2010), Frolova et al. (2017), Senouci et al. (2018), and Kalakonas et al. (2020) for seismic vulnerability applications and in Figueiredo and Martina (2016) for flood vulnerability. These studies discuss the weakness of physical vulnerability mapping at the individual building scale and over coarse aggregation areas and highlight the importance of finding an optimal resolution for building exposure modelling while minimising the uncertainties in the loss estimates. However, these attempts did not explicitly address the spatial correlation or attenuation of the hazard intensity onto the predefined aggregation areas and focused on the vulnerability towards individual hazards rather than on multi-hazard risk applications.

2. Researchers can aggregate the exposure models over variably resolved entities that are not necessarily administrative boundaries. This has been done in fewer studies. For instance, Muis et al. (2016) assessed the global population exposure to coastal flooding (from storm surges and extreme sea levels) through the application of a hydrodynamical model based on unstructured grids to ensure sufficient resolution in shallow coastal areas. Scheingraber and Käser (2019) explored the uncertainty in regional building portfolio locations for seismic risk through the use of weighted irregular grids. This weighting was carried out as a function of the population density and did not use any hazard IM or footprints. Scheingraber and Käser (2020) described the advantages of the former procedure in terms of computational efficiency and the treatment and communication of uncertainties in probabilistic seismic risk assessment on a regional scale. Alternatively, aggregating the building portfolio into anisotropic CVT-based geo-cells (central Voronoi tessellations) is suggested by Pittore et al. (2020).

In this study, we employ anisotropic CVTs to aggregate the residential building exposure models. Voronoi regions have proved to be useful in geographical partitioning (e.g. political districting; Ricca et al., 2013), as well in other hazard-related applications, such as climatological modelling (e.g. Zarzycki and Jablonowski, 2014). We present for the first time how CVT can be constructed using underlying combinations of geospatial distributions to achieve a larger resolution of spatially aggregated building portfolios where it matters for risk assessment. We adapt and customise their derivation to explicitly account for the combination of a low-correlated hazard intensity (tsunami inundation) and one exposure proxy (population density) to generate the Voronoi regions.

The aggregated building portfolios are used for earthquake and tsunami scenario-based risk applications. We have systematically investigated six megathrust subduction earthquakes and their respective tsunamis with moment magnitudes ranging between 8.5 and 9.0. We consider the residential building stock of metropolitan Lima (Peru) classified in terms of one set of earthquake vulnerability classes and two sets of tsunami vulnerability classes. These building portfolios have been aggregated within six customised CVT models and administrative units at the highest resolution available (i.e. the block level). By using the respective set of fragility functions, we have independently calculated the direct losses from scenario-based physical vulnerability analyses (seismic ground shaking and tsunami inundation). We show that the implementation of this approach is beneficial not only in finding a balance between accuracy and computational demand, but also in the efficient representation of the loss estimates while reducing bias generated in the loss mapping. The role of the spatial correlation of both hazard intensities in the efficiency and accuracy of the CVT-based exposure models is also discussed. Since the main scope of this work is to investigate an efficient manner to aggregate the building exposure for risk applications considering multiple hazards, we have not investigated the conditional probabilities related to cascading events (e.g. Goda et al., 2018). Instead, we have assumed that every seismic rupture produces a tsunami. Hence, we are not accounting for cumulative damage on buildings due to consecutive ground shaking and tsunami (e.g. Park et al., 2019; Negulescu et al., 2020; Goda et al.,

2021) or the risk due to other seismically induced hazards (i.e. earthquake-triggered landslides, liquefaction, ground failure; see Daniell et al., 2017).

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5 Conclusions

This work has introduced a novel contribution to derive spatial aggregation entities with variable resolution for large-scale building portfolios for physical risk assessment applications. To this aim, we have presented a workflow to find an adequate resolution of the exposure model where it really matters, i.e. in areas where buildings are densely distributed and/or hazard intensities vary over short distances. This contrasts with the current state of the art related to building exposure modelling (aggregation) that uses regular grids or purely administrative boundaries for exposure aggregation.

In the context of earthquake and tsunami risk, we take advantage of the focus map concept to integrate spatially correlated hazard intensity measures (IMs) with exposure proxies (i.e. population density) in order to spatially identify hotspot areas where higher values from both spatial distributions are expected. These resultant focus maps can then be sampled by a heterogeneous Poisson point process, as proposed by Pittore et al. (2020) in order to generate variable-resolution aggregation entities in the form of central Voronoi tessellations (CVTs). Each CVT geo-cell becomes a minimum resolution of risk computational analysis, handling the inputs (i.e. hazard intensities and exposure model) and output elements (i.e. damage and loss estimates).

Variable-resolution CVT-based exposure models proposed in this work have proved their efficiency in integrating large-area building portfolios for combined earthquake and tsunami loss estimations. Several advantages over conventional models based on administrative aggregation entities are as follows.

- CVT-based models provide alternative an approach to aggregate an extensive building portfolio constructed from ancillary data (i.e. population) in the case when existing administrative aggregation areas are not suitable (either not publicly available or too coarse in resolution) for a certain area of interest, as well as to perform scenario-based risk assessments for various hazards.

- We have observed that CVT-based models correct some bias in the spatial aggregation of buildings due to the smaller, more compact areas in high-resolution CVT geo-cells with respect to a coarser block-based cell. This correction is further propagated to the loss estimates due to the higher density of IM values employed by the respective fragility functions during the loss assessment. This is especially observed in areas of the largest concentration of exposed assets located within the hazard footprint area and where local spatial variations in the IM are expected, leading to more accurate estimates.

- CVT-based exposure models are computationally more efficient than the block-based models in earthquake and tsunami vulnerability assessments. This is advantageous when thousands of stochastic realisations of hazard scenarios are calculated over the aggregation boundaries that are used to model building portfolios.

- CVT-based exposure models have shown to be beneficial for mapping loss estimates in continuous space with adjacent and compact geo-cells. These features allow the spatial identification of zones with similar vulnerability to the hazards considered and within the area of interest. They contribute to a more intuitive visualisation and interpretation of the loss mapping and hence contribute to raising awareness about epistemic and thematic uncertainties in the loss mapping.

For the portfolio exposed to both perils in Lima, we have found that the expected median loss values induced by seismic ground shaking are insensitive to the representation of the exposure model over varying resolutions. Thus, we confirm the findings of Bal et al. (2010) and expand them to the case when cross-correlated ground motion fields are considered. However, this contrasts with the tsunami loss results, whose differences with respect to a high-resolution model (i.e. block-based) decrease as the resolution of the CVT geo-cells increases. Similarly, these differences are remarkably minimised for incrementally correlated tsunami intensities from the large-magnitude tsunami scenarios (i.e. M_w 8.8, 8.9, 9.0). According to our observations, the adopted tsunami fragility model based solely on flow depth as the IM and linear square fitting (Suppasri et al., 2013) predicts much larger tsunami-induced losses on the residential building portfolios in Lima than the model of De Risi et al. (2017), which was derived through multinomial logistic regression and with similar values as if the flow velocity was accounted for. For the residential building portfolio exposed to both perils, we have found that the earthquake scenarios dominate the losses at lower magnitudes (M_w 8.5, 8.6) whilst the contribution of the tsunami is dominant for larger-magnitude events.

Bearing in mind the scope of this study, but also the limitations presented in the discussion section, we are not claiming that the economic losses we have obtained for the residential building stock of Lima are exhaustive. Instead, through the adoption of the condition tree, we have drawn a branched methodological workflow to explore the differential impact of the exposure aggregation models, and the selection of building schemes on the epistemic and thematic uncertainties that are embedded in scenario-based risk applications. As described by Beven et al. (2018), condition trees facilitate the communication of the meaning of the resulting uncertainties while providing a clear audit trail for their analysis that can be reviewed and evaluated by others (e.g. local experts and stakeholders) at a later date. This study also highlights the relevance of hazard-based aggregation entities for exposure modelling, risk computations, and loss mapping. Thus, the continuous understanding of those uncertainty sources will contribute to enhancing future risk communications, mitigation, and disaster management activities by local decision-makers.

(European Geosciences Union / Natural Hazards and Earth System Sciences, Volume 21, issue 11, NHESS, 21, 3599–3628, 2021, https://nhess.copernicus.org/articles/21/3599/2021)

ΝΕΑ ΑΠΟ ΤΙΣ ΕΛΛΗΝΙΚΕΣ ΚΑΙ ΔΙΕΘΝΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΝΩΣΕΙΣ

ΕΛΛΗΝΙΚΗ ΕΠΙΣΤΗΜΟΝΙΚΗ ΕΤΑΙΡΕΙΑ ΕΔΑΦΟΜΗΧΑΝΙΚΗΣ & ΓΕΩΤΕΧΝΙΚΗΣ ΜΗΧΑΝΙΚΗΣ

Πρόσφατες εξελίξεις στον αντισεισμικό σχεδιασμό υπογείων αγωγών σε ρευστοποιήσιμο έδαφος

Διαδικτυακή Διάλεξη
Αναπληρωτή Καθηγητή Ε.Μ.Π. Αχιλλέα Παπαδημητρίου
την Τετάρτη 8 Δεκεμβρίου 2021 στις 6:00μμ

Περίληψη Διάλεξης

Ως αφορμή για την παρούσα διάλεξη είναι οι συχνές αστοχίες υπογείων αγωγών μεταφοράς ορυκτών καυσίμων παγκοσμίως λόγω μεγάλων εδαφικών μετατοπίσεων προκληθέντων από ρευστοποίηση, καθώς και οι εκτεταμένες αστοχίες δικτύων υπογείων αγωγών σε αστικά κέντρα από την ίδια αιτία (π.χ. στο Christchurch της Νέας Ζηλανδίας το 2011). Με βάση τα παραπάνω, η διάλεξη χωρίζεται σε δύο μέρη. Το πρώτο αφορά στην βελτίωση των υπαρχουσών μεθόδων ανάλυσης υπογείων αγωγών έναντι μονίμων μετατοπίσεων λόγω ρευστοποίησης (οριζόντια εξάπλωση, καθίζηση, ανύψωση), ενώ το δεύτερο αφορά σε νέες εύχρηστες μεθόδους βελτίωσης του εδάφους έναντι ρευστοποίησης, με εφαρμογή σε υπάρχοντα δίκτυα υπογείων αγωγών.

Μέρος Α: Ο γεωτεχνικός σχεδιασμός υπογείων αγωγών γίνεται με αριθμητικές μεθόδους, όπου η αλληλεπίδραση εδάφους -αγωγού λαμβάνεται υπόψη μέσω ελαστο-πλαστικών ελατηρίων. Αν ο αγωγός βρίσκεται σε ρευστοποιημένο έδαφος, τότε η τρέχουσα πρακτική θεωρεί ελατήρια με τιμές μέγιστου φορτίου και ελαστικής στιβαρότητας που αντιστοιχούν σε ένα κοινό πολύ μικρό ποσοστό (π.χ. 3%) των αντίστοιχων τιμών τους για σταθερό έδαφος, ανεξαρτήτως διεύθυνσης των εδαφικών μετατοπίσεων. Μέσω μη-συζευγμένων μη-γραμμικών αναλύσεων πεπερασμένων διαφορών υποδεικνύεται ότι, ορθώς μεν τα εν λόγω ελατήρια για ρευστοποιημένο έδαφος ποσοτικοποιούνται ως ποσοστά των αντίστοιχων τιμών τους για σταθερό έδαφος, αλλά τα ποσοστά αυτά διαφοροποιούνται σημαντικά ανά διεύθυνση εδαφικής μετατόπισης, ενώ επιπρόσθετα είναι διαφορετικά για το μέγιστο φορτίο και για την ελαστική στιβαρότητα. Σε κάθε περίπτωση, οι ελάχιστες τιμές αυτών των ποσοστών είναι σημαντικά μεγαλύτερες από εκείνες της τρέχουσας πρακτικής, η οποία αποδεικνύεται μη-συντηρητική.

Μέρος Β: Η συνήθης μέθοδος βελτίωσης εδάφους δικτύων υπογείων αγωγών είναι η εκσκαφή και επανεπίχωση με μη-ρευστοποιήσιμο υλικό, δηλαδή μια χρονοβόρος και οικονομικά ασύμφορη διαδικασία. Εδώ συνοψίζονται «έξυπνες» εναλλακτικές, με προεξάρχουσα τη χρήση της παθητικής σταθεροποίησης, δηλαδή τη βραδεία εισπίεση κολλοειδούς πυριτίας (υδατικό αιώρημα νανο-σωματιδίων οξειδίου του πυριτίου Si02), η οποία γίνεται γέλη στους πόρους του εδάφους στην περιοχή του υπογείου αγωγού καθιστώντας το μη-ρευστοποιήσιμο. Μη-συζευγμένες μη-γραμμικές δυναμικές αναλύσεις πεπερασμένων διαφορών υποδεικνύουν τη βέλτιστη πρακτική στη χρήση της.

Σύντομο Βιογραφικό Σημείωμα Ομιλητή

Ο Δρ. Αχιλλέας Παπαδημητρίου είναι Αναπληρωτής Καθηγητής στη Σχολή Πολιτικών Μηχανικών του Ε.Μ.Π.. Έλαβε το δίπλωμα Πολιτικού Μηχανικού από το Ε.Μ.Π. (1993), M.Sc. από το Massachusetts Institute of Technology (1995) και Διδακτορικό από το Ε.Μ.Π. (1999). Διατέλεσε Λέκτορας και Επίκουρος Καθηγητής στο Πανεπιστήμιο Θεσσαλίας (2007-2014), ενώ από το 2014 είναι μέλος ΔΕΠ του Ε.Μ.Π.. Η έρευνά του επικεντρώνεται στην Υπολογιστική Γεωμηχανική (καταστατικοί νόμοι γεωϋλικών, αλγόριθμοι τασικής ολοκλήρωσης, μέθοδος διακριτών στοιχείων) και στη Γεωτεχνική Σεισμική Μηχανική (ρευστοποίηση και επίδρασή της σε κατασκευές, εδαφική-τοπογραφική-γεωμορφική επιδείνωση, μικροζωνικές μελέτες, βελτίωση εδαφών, διάρρηξη ρηγμάτων μέσω εδάφους, σεισμική ευστάθεια φραγμάτων, γεωτεχνικός σχεδιασμός υπογείων αγωγών). Έχει συ-συγγράψει πάνω από 100 δημοσιεύσεις σε διεθνή τεχνικά περιοδικά και διεθνή συνέδρια και το έργο του έχει δεχτεί πάνω από 2400 αναφορές (Google Scholar). Έχει δώσει προσκεκλημένες ομιλίες σε 4 διεθνή συνέδρια, ενώ καταστατικά προσομοιώματα της έρευνάς του διατίθενται προς χρήση σε εμπορικά λογισμικά πεπερασμένων στοιχείων και πεπερασμένων διαφορών για την ανάλυση γεωτεχνικών προβλημάτων. Έχει διατελέσει Ερευνητικός Υπεύθυνος σε 3 ερευνητικά προγράμματα, ενώ έχει εργασθεί (ως Κύριος Ερευνητής) σε μεγάλο πλήθος ανταγωνιστικών ερευνητικών προγραμμάτων στην Ελλάδα, Ε.Ε. και τις ΗΠΑ. Έχει συμπράξει ως Γεωτεχνικός Σύμβουλος σε μεγάλο αριθμό σημαντικών τεχνικών έργων στην Ελλάδα και στο εξωτερικό, με έμφαση στον σχεδιασμό υψηλών επιχωμάτων και υπογείων αγωγών έναντι σεισμικής διέγερσης, ρευστοποίησης και διάρρηξης ρηγμάτων.

Η διάλεξη **θα μεταδοθεί ζωντανά με ελεύθερη πρόσβαση** στον παρακάτω σύνδεσμο:

https://teams.microsoft.com/l/meetup-join/19%3ameeting_YzJhOWM4YjYtNzJmNy00NmNhLWEyZmQtMzE4NzNhNTAzYzk1%40thread.v2/0?context=%7b%22Tid%22%3a%220c8943ee-c370-4bb3-ba51-321f406f32ec%22%2c%22Oid%22%3a%226b883abd-a37c-43ff-a400-ec4c76e9ba8c%22%2c%22IsBroadcastMeeting%22%3atrue%7d&btype=a&role=a

SIMSG ISSMGE

International Society for Soil Mechanics and Geotechnical Engineering

ISSMGE News & Information Circular November 2021
https://www.issmge.org/news/issmge-news-and-information-circular-november-2021

1. ELECTION OF ISSMGE PRESIDENT 2022-2026

As a consequence of the 20ICSMGE being pushed back to May 2022, and in accordance with the Statutes and Bylaws, the deadline for receiving nominations for the next ISSMGE President has been extended to 30th January 2022.

2. 20ICSMGE / 7iYGEC NEW DATES MAY 2022

New dates have been confirmed for the conferences in Sydney as follows;

7iYGEC - Friday 29 April - Sunday 1 May 2022
20ICSMGE - Sunday 1 May - Thursday 5 May 2022.

Registration is now open via the conference website https://icsmge2022.org/registration.php

3. TIME CAPSULE PROJECT (TCP) - Informal "showcases" to start in Nov 2021

The Time Capsule Project (TCP) aims to create and sustain a conversation about the past, present and future of geotechnical engineering to the benefit of our over 20,000 members. Contributions from all sectors of the ISSMGE, including legacy material, will be held and promoted through an online platform. This platform will be formally launched at the 20th ICSMGE (1-5 May 2022).

From November 2021 onwards, a series of informal and engaging "showcases" will be hosted to enable contributors to learn from each other's experience. Even draft contributions can be presented so we can learn from each other. The concept is novel and exciting even for us in the TCP Design Team!

For further information, please make contact with TCP Design Team directly or through the form available at: https://www.issmge.org/the-society/time-capsule .

4. VIRTUAL UNIVERSITY

The following have recently been added to the website:

How to perform reliability analyses on a spreadsheet Dr Lei Wang

Collapse of Fujinuma Dam by the 2011 Great East Japan Earthquake and its reconstruction - Prof. Fumio Tatsuoka and Dr. Antoine Duttine.

Probability Analysis in Civil Engineering Prof. Jie Zhang

5. BULLETIN

The latest edition of the ISSMGE Bulletin (Volume 15, Issue 4, October 2021) is available from the website https://www.issmge.org/publications/issmge-bulletin/vol-15-issue-5-october-2021

1. ISSMGE FOUNDATION

The next deadline for receipt of applications for awards from the ISSMGE Foundation is the 31st January 2022. Click here for further information on the ISSMGE Foundation.

8. 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 events 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

6th INTERNATIONAL SYMPOSIUM ON TUNNELS AND SHAFTS IN SOILS AND ROCKS - 29-03-2022 - 07-04-2022 Mexico City, Mexico; Languages: English and Spanish; Organiser : Mexican Society of Geotechnical Engineering (SMIG); Contact person: Miss. Brenda Aguilar; Email: administracion@smig.org.mx; Website: http://www.smig.org.mx

THIRD INTERNATIONAL CONFERENCE ON GEOTECHNICAL ENGINEERING-IRAQ 2022 - 17-05-2022 - 19-05-2022 University of Baghdad, Iraq; Language: English; Organiser: Iraqi Scientific Society for Soil Mechanics and Foundation Engineering; Contact person: Mahdi O Karkush; Address: University of Baghdad, Aljadriah, Baghdad; Phone: 009647801058893; mail: mahdi_karkush@coeng.uobaghdad.edu.iq; Website: https://ocs.uobaghdad.edu.iq/index.php/ICGEI/ticgei

GEOHAZARDS 8 - 12-06-2022 - 15-06-2022 Musée de la Civilisation, Quebec, Canada: Languages: English & French; Organiser: Canadian Geotechnical Society Eastern Quebec Section; Contact person: Ariane Locat; Email: ariane.locat@gci.ulaval.ca; Website: https://geohazards8.ca/; Email: info@geohazards8.ca

International Society for Rock Mechanics and Rock Engineering
ISRM

News
https://www.isrm.net

Eurock 2022, Hensinki, Finland - deadline for abstract submission postponed to 15 November 2021 2021-11-03

The deadline for abstract submission to Eurock 2022 was postponed to 15 November 2021.

Eurock 2022 is the ISRM Regional Symposium and will take place in Helsinki, Finland, 12-15 September 2022. For more information, visit the conference website: https://www.ril.fi/en/events/eurock-2022.html.

Prof. Seokwon Jeon from the Republic of Korea elected ISRM President for 2023-2027 2021-11-22

The election took place during the ISRM Council meeting on 17 November 2021. The President-elect will now join the Board and will assume the Presidency of the Society after the 15th International Congress on Rock Mechanics in October 2023.

Tunnelling the World 2021 Video

04 November 2021

On the occasion of the unveiling of the ITA Tunnelling Awards 2021 finalists which took place during the Tunnelling Week, ITA released a video on the tunnelling works done over the world in 2020/2021.

Enjoy watching it and share it with friends and colleagues!

https://www.youtube.com/watch?v=O1p8bs_CCI4

Scooped by ITA-AITES #55, 9 November 2021

Infrastructure bill secures billions for Hudson River tunnel | United States of America

Madhya Pradesh: 5 Austrian tunnels' construction underway at Barkheda-Budhni Ghat | India

Swiss advance plans to take goods transport underground

Mumbai-Ahmedabad High-Speed Rail: Bids invited for tunnel construction under India's first Bullet Train project | India

Auckland light rail: Govt releases new proposals for rail route to airport | New Zealand

BART extension receives FTA funding commitment | United States of America

TfL shares major update on London Underground Bakerloo line extension | UK

A New Megaproject in Istanbul Features an Underground Cruise Ship Port | Turkey

Century-old Mount Royal tunnel gets shored up for REM's McGill station | Canada

Final tunnelling breakthrough on the M4-M5 link tunnels | Australia

US$1.6bn Argentina-Chile border tunnel's long road ahead

Melbourne's North East Link tunnel consortium announced for $11.1b contract | Australia

Scooped by ITA-AITES #56, 23 November 2021

Hudson Tunnel engineering enters new phase | United States of America

Guiyang-Nanning high-speed railway tunnel to be drilled through | China

Construction begins on Albania's Riviera Tunnel

Cost of developing Dart Underground, metro line 'to exceed €10bn' | Ireland

Bengaluru Metro's tunnel boring machine Varada completes work | India

New CEO of Calgary's Green Line confident downtown tunnel can go ahead | Canada

Etihad Rail completes tunnelling works for UAE rail network

Micro-tunnelling relief for Kolkata roads | India

Bicycle Garage The Haque provides 8,000 cyclists with room to park in "museum-like" space | Netherlands

China's first high-speed railway connecting port bordering Vietnam cuts through all tunnels

The Harding Prize Competition 2022 for Younger Engineers Involved in Tunnelling

The Harding Prize is named after the founder Chairman of the Society, Sir Harold Harding. Entrants must submit an original paper relating to any aspect of tunnelling which they consider of interest to those in the tunnelling industry. The papers will be reviewed by the BTS Sub-Committee and authors of selected papers will be invited to make an oral presentation to the BTS meeting on Thursday 21st April 2022.

The winner will be given two tickets for the Society's Annual Dinner in May 2022 where he/she will be presented with a copy of the BTS's 50th Anniversary book, a certificate and a cheque for £500.

Finalists whose papers are selected for presentation will each receive £100 and all remaining entrants who submitted a paper to an approved standard will receive £50.

The papers of the winner and finalists will be published in the Tunnels & Tunnelling Journal.

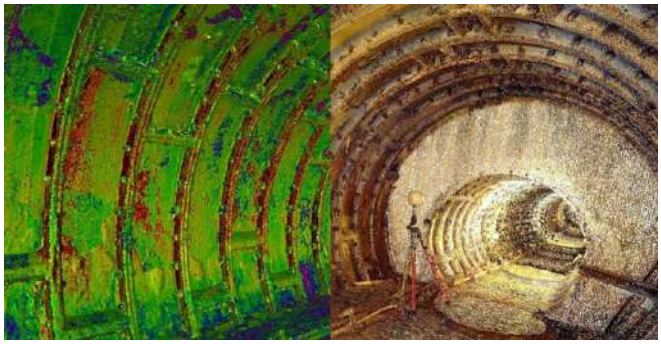
The papers not selected for the final presentation may be published in The ICE Proceedings. We encourage the entrants to take up this opportunity to make their work visible to the civil engineering community.

For any paper selected for publication, the Editors reserve the right to condense papers.

The closing date for submission of papers is **11 February 2022.**

Please submit applications by email only to: **bts@british-tunnelling.com**

Digital twins for condition assessment of Brunel's rail tunnels and future applications



Dr Anmol Bedi & Marco Invernici will be presenting their multi-award winning work on 3D scanning and using AI for the condition assessment of existing tunnels.

Speakers : Dr Anmol Bedi – Director & Marco Invernici – Bedi Consulting

When : Thursday, **18 November at 18:00** hrs

Where : Institution of Civil Engineers, One Great George Street, London SW19 3AAh

Streaming Link : https://bit.ly/3jM1eNZ

BTSYM On-Line Workshop – Soft Ground Tunnel Design

Dr Benoit Jones will be delivering a workshop on Soft Ground Tunnel Design on the 2nd of December 2021. Further information will be made available on BTSYM's social media platforms in the coming days.

However, to register your interest, please fill this form.

Speaker : Dr Benoit Jones – InBye Engineering

When : Thursday, **2 December at 14:30** – **17:00** hrs

Where : Online

Booking Link : https://bit.ly/31lJ1l3

BRITISH TUNNELLING SOCIETY YOUNG MEMBERS

Explaining Quality Engineering

Speaker: Tiago Geraldes-Rodrigues MEng CQP MCQI
Quality Lead (HPC), Balfour Beatty

Amongst construction & infrastructure professionals, Quality Management is considered an important element of contemporary Project Delivery; with the aim to support Designers and Contractors to meet customers' requirements by ensuring and demonstrating compliance along the way.

Typically, Quality Professionals from various trades would join the ranks of both Construction and Infrastructure projects due to their expertise in auditing and implementing cross-industries management systems; however, lacking civil and tunnelling engineering knowledge and experience at times.

Tiago's presentation will provide an overview of his engineering-led Quality Department at Hinkley Point C (Marine Works) and shed light on career prospects in Quality Management.

This in-person lecture (Thursday 4th November 2021) was also streamed live at https://youtu.be/NQreixznQhc.

TunnelSkills – Immersive Learning Resources

TunnelSkills have developed some Immersive Learning Resources comprising VR and AR models.

A list of these resources, with relevant hyperlinks, is as below

1. **Shaft and Tunnel Construction** (VR 'See It' – App 3).

This experience demonstrates how to navigate scenes in a **Tunnel Boring Machine [TBM]** environment, a **Sprayed Concrete Lining** [**SCL]** environment, a **Hand Mining** environment, and a **Pipe Jack** environment.

2. **Insights into Tunnelling, Past and Present** (VR 'Hear It' 360° documentary – App 4).

This experience demonstrates how tunnelling has changed over the years, what attracts people to a career in tunnelling, and some of the health and safety considerations to be aware of on tunnelling projects.

3. **Augmented Reality – Scenario 1 – Accessing the shafts and tunnels**

This experience demonstrates the correct procedures to follow when entering a tunnel under construction, including identifying the correct PPE, site access and tunnel access points, an overview of typical self-rescue equipment, tally protocols and using the passenger hoist safely.

4. **Augmented Reality – Scenario 2 – What to do in an emergency**

This experience demonstrates the correct procedures to follow when an emergency occurs in the tunnel.

TunnelSkills is keen to receive feedback regarding the above from members of the industry. Therefore, if you have any comments or suggestions, please communicate them to TunnelSkils using this form.

Also, for further information or to request a demonstration, please contact fto@tunnelskills.org

Kind regards,

David

David Ashworth CEng MICE
BTSYM Secretary
BTSYM.Secretary@britishtunnelling.com

ΘΕΣΕΙΣ ΓΙΑ ΓΕΩΤΕΧΝΙΚΟΥΣ ΜΗΧΑΝΙΚΟΥΣ

CMW are hiring!

Due to increasing and ongoing projects in the Waikato and beyond, we are looking for an Intermediate level Geotechnical/ Civil Engineer or Engineering Geologist to join our Hamilton team. Our portfolio spans a range of projects, including roading, buildings, land development and infrastructure, such as the Amberfield and Lakeside Te Kauwhata developments and the Ruakura Super Hub.

Please follow the link below to find out more!

#cmw #geotechnical

Geotechnical Project Manager / Engineer Job in Waikato

Kostas Lontzetidis • Principal Geotechnical Engineer at CMW Geosciences, CPEng

ΠΡΟΣΕΧΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΚΔΗΛΩΣΕΙΣ

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

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

International Conference on Recent Advances in Geotechnics
9-11 December 2021 (virtual)
http://egcon2021.com

Infrastructural development in open and underground space for river valley projects, railways, highways and in other large civil structures poses innumerable challenges during construction stage. Appropriate application of Geo-technology helps in understanding the mechanism of geotechnical problems beforehand and the problems can be tackled effectively to prevent time and cost over-run as well as safety of men and machinery.

Since Independence, country has achieved several milestones in infrastructure development and this has led spectacular developments in Geo-technology. ISEG has emerged as the flag bearer in dissemination of developments in the field of Geo Techniques since 1965. In 2015 the society very rightfully celebrated its golden jubilee year and successfully organized an International Seminar EGNM 2015 on Engineering Geology in New Millennium . It has successfully published the 45th volume of its flagship journal JOEG with all its back volumes archived electronically for future reference. The newsletter of the society is a continuous feature providing its members with interesting and informative updates in this field. Also the organization of EGCON had become a regular annual feature of the society which was unfortunately stalled for last two years due to pandemic. Now with renewed zeal, I invite you for participation in EGCON 2021 which is being planned on virtual platform in line with the current situation. EGCON 2021 plans to delve on recent advancement in geotechnology in handling geological and geotechnical challenges for development of infrastructure projects.

I take this opportunity to invite geologists, civil engineers, geophysicists, geotechnical engineers, mining engineers, academicians, instrumentation engineers, software developers, research scholars and other professionals to contribute technical papers and for attending conference.

Conference Theme

- Geological and Geotechnical Challenges in Infrastructure Projects.
- Advances in Ground Mass Characterization and Rockmass Classification Systems.
- Seismological and Earthquake Engineering Aspects for Infrastructure Projects.
- Geotechnics for NATM, NMT & Mechanised Tunnelling.
- Landslide / Slope Stability & Mitigation Measures.
- Remote Sensing & Drone Technology for Infrastructure Projects.
- Dam Rehabilitation & Improvement.
- Investigation, Design and Construction of Surface & Subsurface Structures.
- Advances in Engineering Geophysical Investigation Technology.
- In-situ and Laboratory Testing for Infrastructure Projects.
- Blasting Technologies for Surface & Sub-Surface Excavation.
- Disaster Management for Sustainable Infrastructure Projects.
- Geotechnics for Development of Solar, Wind & Smart City Projects.
- Geotechnical Instrumentation & Monitoring

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2nd International Conference TMM-CH Transdisciplinary Multispectral Modelling and Cooperation for the Preservation of Cultural Heritage - Rebranding The World In Crisis Through Culture, 12-15 December, 2021 Athens, Greece https://tmm-ch.com/

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

16th ICGE 2022 – 16th International Conference on Geotehnical Engineering, Lahore, Pakistan, 23-24 February, 2022, https://16icge.uet.edu.pk/

15 - 17 March 2022, Kuala Lumpur, Malaysia
www.hydropower-dams.com/asia-2022

THE SECOND BETANCOURT CONFERENCE "NON-LINEAR SOIL-STRUCTURE INTERACTION CALCULATIONS"
April 2022

Augustin Betancourt was an outstanding offspring of the Spanish nation and a citizen of the Russian empire, the founder of the Russian engineering school, the first head of a Russian agency for architecture and civil engineering. Betancourt Conferences are devoted to discussion of the important engineering problems faced by the professional community. The conference characteristic feature is involvement of experts of various profiles in discussion of relevant issues that fosters interdisciplinary communication and synthesis of knowledge.

The first conference held in June 2019 was devoted to underground urban planning, it drew attention of city planners, architects, geotechnical engineers, historical city preservation activists. Expectedly, the discussion of issues of underground space development resulted in creation of the regulatory document – Set of Rules 473.1325800.2019 "Buildings, structures and underground complexes. The rules of city planning design".

At the Second Betancourt Conference, which is going to be held in April in the format of video conference, we suggest to discuss burning issues of soil-structure interaction calculations taking into account non-linear and rheological properties of soils and structures which solution is impossible without a synthesis of engineering knowledge in the field of geotechnical engineering and design of superstructures.

For the Organizing Committee of the Conference

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16th International Benchmark Workshop on Numerical Analysis of Dams, 6–8 April 2022, Ljubljana, Slovenia, https://icold-bw2022.fgg.uni-lj.si

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

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

RaSim 10 Rockbursts and Seismicity in Mines, 24 – 29 April 2022, Tucson, USA, www.rasimsymposium.com

SYDNEY 7iYGEC 2021 7th International Young Geotechnical Engineers Conference A Geotechnical Discovery Down Under, 29 April - 1 May 2022, Sydney, Australia, http://icsmge2021.org/7iygec

SYDNEY ICSMGE 2021 20th International Conference on Soil Mechanics and Geotechnical Engineering, 1–5 May 2022, Sydney, Australia, www.icsgme2021.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

Third International Conference on Geotechnical Engineering - Iraq 2022
May 17 –19, 2022, Baghdad, Iraq
https://ocs.uobaghdad.edu.iq/index.php/ICGEI/ticgei

Third International Conference on Geotechnical Engineering-Iraq, 2022 (ICGE-2022) is going to be held on 17-19th May 2022 at University of Baghdad/Baghdad/Iraq. The conference is organized by the Iraqi Scientific Society of Soil Mechanics and Foundation Engineering (ISSSMFE) in collaboration with the College of Engineering/University of Baghdad and College

of Engineering/University of Kerbala under the auspices of Imam Hussain Holy Shrine. The conference aims to provide a scientific platform to present and discuss the latest research and studies in geotechnical engineering and all related researches in different fields such as civil engineering, environmental engineering, and architectural engineering. This scientific event is a great chance for participants from both academics and industry to meet and exchange the development and experiences in these fields. This conference will be real opportunity to share new ideas and experiences face to face, establish business or research relations, and find global partners for future collaboration.

THEMES OF CONFERENCE

The main themes of conference are:

1. Soil Mechanics (SM)
2. Foundation Engineering (FE)
3. Infra Structure Engineering (ISE)
4. Structural Dynamics and Earthquakes (SDE)
5. Structural Engineering (SE)
6. Transportation Engineering and Construction Materials (TEM)
7. Construction Management (CM)
8. Remote Sensing and Sustainability (RSS)
9. Architectural and Environmental Engineering (AEE)
10. Water Resources Engineering (WRE)

Iraqi Scientific Society for Soil Mechanics and Foundation Engineering College of Engineering/University of Baghdad College of Engineering/University of Kerbala, Kerbala Center for Studies and Research

2022 ICOLD 27th Congress - 90th Annual Meeting 27 May - 3 June 2022, Marseille, France, https://cigb-icold2022.fr/en

CPT'22 5th International Symposium on Cone Penetration Testing, 8-10 June 2022, Bologna, Italy, http://cpt22.org

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

3rd International Symposium on Geotechnical Engineering for the Preservation of Monuments and Historic Sites 22-24 June 2022, Napoli, Italy, https://tc301-napoli.org

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

5.ICNDSMGE – ZM 2020 5th International Conference on New Developments in Soil Mechanics and Geotechnical Engineering, June 30 to July 2, 2022, Nicosia, Cyprus, https://zm2020.neu.edu.tr

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

ICONHIC2022: THE STEP FORWARD - 3rd International Conference on Natural Hazards & Infrastructure, 5 – 7 July 2022, Athens, GREECE, https://iconhic.com/2021

RocDyn-4 4th International Conference on Rock Dynamics an ISRM Specialized Conference, 17-19 August 2022. Xuzhou, China, http://rocdyn.org

ISFOG 2020 4th International Symposium on Frontiers in Offshore Geotechnics, 28 – 31 August 2022, Austin, United States, www.isfog2020.org

16th International Conference of the International Association for Computer Methods and Advances in Geomechanics – IACMAG 30-08-2022 – 02-09-2022, Torino, Italy, www.iacmag2022.org

11th International Symposium on Field Monitoring in Geomechanics, September 4 - September 7, 2022, London, UK, https://isfmg2022.uk

7th European Geosynthetics Conference, 4 to 7 September, 2022, Warsaw, Poland, https://eurogeo7.org

The 17th Danube - European Conference on Geotechnical Engineering
5-7 September, 2022, Bucharest, Romania
https://sites.google.com/view/17decgero/home

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

IAEG XIV Congress 2022, Chengdu, China September 14-20, 2022, https://iaeg2022.org

28th European Young Geotechnical Engineers Conference and Geogames, 15 – 17 – 19 September 2022, Moscow, Russia, https://www.eygec28.com/?

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

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

10th International Conference on Physical Modelling in Geotechnics (ICPMG 2022), September 19 to 23, 2022, KAIST, Daejeon, Korea, https://icpmg2022.org

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

10th Nordic Grouting Symposium, 4 - 6 October, 2022, Stockholm, Sweden, https://www.ngs2022.se/

IX Latin American Rock Mechanics Symposium - Challenges in rock mechanics: towards a sustainable development of infrastructure, an ISRM International Symposium, 16-19 October 2022, Asuncion, Paraguay, http://larms2022.com

2022 GEOASIA7 - 7th Asian Regional Conference on International Geosynthetics Society, October 31 – November 4, 2022, Taipei, Taiwan, www.geoasia7.org

AUSROCK Conference 2022, 6th Australasian Ground Control in Mining Conference –an ISRM Regional Symposium, 29 November – 1 December 2022, Melbourne, Australia, www.ausimm.com/conferences-and-events/ausrock/

https://16icge.uet.edu.pk

The Pakistan Geotechnical Engineering Society (PGES) under the aegis of International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE) takes pleasure in hosting 16th International Conference on Geotechnical Engineering from February 23-24, 2022 in Lahore Pakistan.

The broad theme of "Geotechnical Engineering" has been kept for 16ICGE to attract a diversity of quality papers from around the globe. The Conference will act as a platform for exchange of technical ideas between Clients, Consultants, Contractors and Manufacturers. Outstanding keynote lectures, presentations and technical discussions will afford opportunity to explore the advancements in geotechnical engineering.

The 16ICGE will also provide a great opportunity to the engineers, geologists, seismologists and other professionals engaged in the field of geotechnical engineering, foundation design, construction and manufacturing, to share their expertise in the realm of Geotechnical Engineering.

Main Themes

1. Dams and Hydropower
2. Field Investigations and Laboratory Testnig
3. Environmental Geotechnics
4. Tunnelling and Underground Structures
5. Problematic Soils
6. Ground Improvement
7. Liquefaction Potential and Mitigation
8. Risk Assessment in Geotechnical Engineering
9. Risk Preparedness and Early Warning Systems
10. Earthquake Geotechnical Engineering
11. Deep Excavations
12. Numerical Modeling
13. Geotechnical Analysis and Design
14. Case Histories
15. Any other relevant topic

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4th African Regional Conference on Geosynthetics – Geosynthetics in Sustainable Infrastructures and Mega Projects, 20-23 February 2023, Cairo, Egypt, www.geoafrica2023.org

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

World Tunnel Congress 2023
Expanding Underground
Knowledge & Passion to Make a Positive Impact on the World
12 - 18 May 2023, Athens, Greece
https://wtc2023.gr

Rapid **urbanization**, natural **hazards**, **climate** change, sustainable **energy** geo-resources, people's mobility and transportation of goods are first-priority demanding challenges that the globe is facing.

Cities and infrastructure expansion towards underground provide safe, sustainable and **green solution** facilitating the transformation of millions of people's lives into a more **resilient** lifestyle. A comprehensive understanding, **rethinking and reshaping** of the underground spaces have become even more vital and crucial in the urban transformation of **future** cities. For the latter to be attained, planning and organization of **underground development**, a **holistic approach** is required not only in terms of spatial organization or overcoming engineering challenges, but also in regards to the establishments of policies, regulations and consideration of social factors.

WTC 2023 in Athens will highlight the multiple advantages and solutions that underground space could provide, at the prospect of a whole new era of **smart technology** where sophisticated **"digital tools"** change investigation, design, construction and operation methods and **strategies** rapidly. WTC 2023 will additionally provide an ideal opportunity to showcase recent innovations and the perspective of technology to further efficiently upgrade underground infrastructure assets, transforming the industry and the **societies** it serves.

Athens (Greece) has the knowledge, and we strongly believe we have the **means** and the **responsibility** to literally make a **positive impact** on the world.

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NROCK2022

The IV Nordic Symposium on Rock Mechanics and Rock Engineering
24 – 25 May 2023, Reykjavic, Iceland
www.nrock2023.com

Address

Icelandic Geotechnical Society Engjateigur 9 105 Reykjavík ICELAND

Contact Person Name Thorbjorg Thrainsdottir
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9th International Congress on Environmental Geotechnics
Highlighting the role of Environmental Geotechnics in Addressing Global Grand Challenges
25-28 June 2023, 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

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- Email: rallisko@grid-engineers.com

17th Asian Regional Geotechnical Engineering Conference
14-18 August 2023, Nur-Sultan, Kazakhstan

Organiser: Kazakhstan Geotechnical Society;
Contact person: Ms. Bibigul Abdrakhmanova;
Address: 2, Satpayev Street, Eurasian National University, Geotechnical Institute;
Phone: +7-7172- 34479;
Fax: +7-7172-353740;
Email: bibakgs@gmail.com; milanbi@mail.ru

XII ICG - 12th International Conference on Geosynthetics, September 17 – 21, 2023, Rome, Italy, www.12icg-roma.org

2023 15th ISRM Congress, International Congress in Rock Mechanics Challenges in Rock Mechanics and Rock Engineering, 9÷14 October 2023, Salzburg, Austria, https://www.isrm2023.info/en/

World Tunnel Congress 2024
Shenzhen, China

China is the official host of the ITA-AITES World Tunnel Congress 2024 and 50th General Assembly.

The General Assembly which took place on June 30th by video-conference, has confirmed the candidacy of Shenzhen to organise the WTC 2024.

XVIII European Conference on Soil Mechanics and Geotechnical Engineering
25-30 August 2024, Lisbon, Portugal

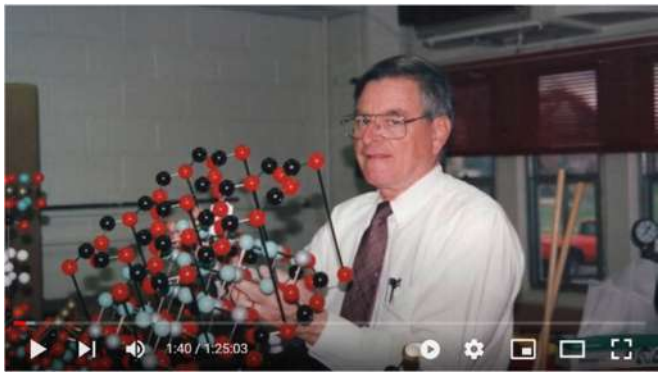
Organiser: SPG
Contact person: SPG
Address: Av. BRASIL, 101
Email: spg@lnec.pt
Website: http://www.spgeotecnia.pt

ΕΝΔΙΑΦΕΡΟΝΤΑ ΓΕΩΤΕΧΝΙΚΑ ΝΕΑ

Geo-Legends Series

The Geo-Legends series features our most eminent members.

Geo-Legends S01 E01 - Jim Mitchell



In episode 1 of season 1, Rudy Bonaparte of Geosyntec interviews Jim Mitchell, retired from the University of California at Berkeley and Virginia Tech. Jim was the 1984 Terzaghi Lecturer and the 2004 Seed Lecturer.

He talks about everything from his early life to his time at MIT, Berkeley, Virginia Tech, and beyond!

https://www.youtube.com/watch?v=AjPJ6Oo7LUE

Geo Legends S01 E02 - Harry Poulos

In episode 2 of season 1, Rod Salgado of Purdue University interviews Harry Poulos of Coffey Engineering and the University of Sydney. Harry was the 2000 Buchanan Lecturer and the 2004 Terzaghi Lecturer.

He talks about everything from his early life in Australia to his work on very tall buildings in Dubai and other cities!

https://www.youtube.com/watch?v=n7HjcSS_Qq0

Geo Legends S01 E03 - Izzat "Ed" Idriss

In episode 3 of season 1, Katerina Ziotopoulou of UC Davis interviews Izzat "Ed" Idriss of UC Davis. Ed was the 1995 Seed Lecturer, the 2010 Peck Lecturer and the 2019 Terzaghi Lecturer, the only individual to give all three lectures.

He talks about everything from his early life in Syria to his work on dams, earthquakes, moving from consulting to academia and back, and more!

https://www.youtube.com/watch?v=WHHY-ZEbh60

Geo Legends S01 E04 - Suzanne Lacasse

In episode 4 of season 1, Don DeGroot of the University of Massachusetts interviews Suzanne Lacasse of the Norwegian Geotechnical Institute. Suzanne was the 2001 Terzaghi Lecturer, the 2013 Terzaghi Orator, and the 2015 Rankine Lecturer.

She talks about everything from her early life in Quebec to her time at MIT, her relationship with Ralph Peck, her time at the Norwegian Geotechnical Institute, and more!

https://www.youtube.com/watch?v=vjVIu8z8cY0

2019 H. Bolton Seed Medal Lecture
Geotechnical Judgment and Risk

Dr. W. Allen Marr delivered the 2019 H. Bolton Seed Lecture at Geo-Congress 2019 in Philadelphia, PA, on March 24, 2019.

https://www.youtube.com/watch?v=qiNUoJVoV2M

Risk assessment of rainfall-induced landslides in urban regions

Rainfall-induced landslides in the Rio de Janeiro area of Brazil (2010).

A new study suggests that urban areas are more prone to rainfall-induced landslides compared to rural regions.

Urban environments have mostly been expanded in flat regions that benefit development and growth. However, the growing population arises additional needs to urbanize regions that are more prone to natural hazards. Cities currently expand to foothills that may present higher inclination and where rainwaters accumulate. The combination of extreme urbanization with the increasing intensity of precipitation events makes rainfall-induced landslides a major issue in such environments. Given that more than 50% of the world's population lives in cities, the ramifications of such landslides are significant and include infrastructure damage, disturbances in the urban networks, or potential fatalities.

Landslides comprise a wide range of ground movements including falls, topples, slides, lateral spreads, flows, or a combination of one or more movements. The majority of landslide phenomena are associated with precipitation rates. The new research suggests that precipitation-triggered landslides are impacted by the surrounding environment however, the impact of man-induced land use has not been taken into consideration in slope stability assessment. The team investigated the landslide sensitivity of urban regions to alteration in rainfall rates by utilizing a large database of ground failures accounting for the United States Pacific coast. The precipitation data referred to daily, 10-day and 30-day periods. The researchers isolated the effect of precipitation on landslide phenomena by using a panel regression technique with fixed effects. Thus, they controlled the impact of additional influential parameters such as slope inclination, wildfire or soil/rock type.

The study's findings suggest that urban areas are 10 times more sensitive to precipitation changes. This means that the probability of a rainfall-induced landslide occurring in an urban area is 10 times higher than the correspondent probability in a rural region. The cause of this difference is related to human activities that have altered the landscape by changing the topography, removing vegetation or constructing impervious surface covers (e.g., roads, parking lots, etc.). These actions are responsible for reducing the slopes' factors of safety and thus making them more prone to instabilities during rainfalls. "I didn't set out to study urban versus rural hazards, but the urbanization signal was the strongest in preliminary models. I recognized something was there," Elizabeth C. Johnston, lead author of the study and a Ph.D. candidate in Earth System Science, Stanford University, stated. The fact that urbanized areas are more prone to landsliding during rainfalls has been hypothesized but this is the first study to derive quantitative results and to validate the idea.

The results indicate that landslide hazard assessment should be site-specific and take into consideration the urbanization rates. "If we assume different land-use types have the same relationship between precipitation and landslide hazard, we're going to end up underestimating landslide hazard," Johnston, added.

The authors conclude that their work framework can be used to study the effects of additional parameters that impact landslide hazard such as snow accumulation or wildfires.

(Geoengineer.org, Aug, 09, 2021, https://www.geoengineer.org/news/the-risk-of-rainfall-induced-landslides-in-urban-regions)

Quantifying the Effect of Precipitation on Landslide Hazard in Urbanized and Non-Urbanized Areas

Elizabeth C. Johnston, Frances V. Davenport, Lijing Wang, Jef K. Caers, Suresh Muthukrishnan, Marshall Burke, Noah S. Diffenbaugh

Abstract

Although most landslides are precipitation-triggered, a number of other complex conditions simultaneously predispose any given slope to failure, with the impact of urbanization posing particular scientific challenges. We use panel regression with fixed effects—which controls for observed and un-

observed time-variant and time-invariant influences—to quantify the effect of precipitation accumulation on landslide concentration across the Pacific Coast region of the United States. We find that landslide hazard is most sensitive to precipitation variations in urbanized areas. This finding is robust across 1-day, 10-day, and 30-day periods of precipitation accumulation, among individual Pacific Coast states, and when the analysis is confined to the San Francisco Bay Area (a subregion with both urban and rural areas). Our results corroborate existing hypotheses that urbanization increases landslide hazard, while demonstrating the importance of considering interactions with urbanization when predicting landslide hazard in the current climate, and under climate change scenarios.

Plain Language Summary

Generalizable understanding of where and how landslides occur may inform efforts to adapt to these devastating natural disasters. While most landslides are triggered by precipitation, a number of other complex factors also play a role in slope destabilization. Employing an empirical framework that accounts for these confounding factors, we find that landslide hazard is most sensitive to precipitation variations in urbanized areas. Our results enhance understanding of the impact of urbanization on precipitation-triggered landslide hazard and highlight the importance of considering urbanization when predicting landslide hazard, particularly in response to global warming and climate change.

1 Introduction

Landslides are among the most devastating and costly natural disasters, causing thousands of deaths and many billions of dollars in damages annually (Froude & Petley, 2018; Petley, 2012; Schuster et al., 2001). Landslides broadly include debris flows, rock falls, avalanches, mudslides, and any other downgradient movement of soil, rock, or debris under the direct influence of gravity (Cruden & Varnes, 1996; Hungr et al., 2014; Varnes, 1954, 1978). Although landslides occur over a broad range of lithologies, climatologies, hydrological regimes, and land use types (Kirschbaum et al., 2015), the majority are precipitation-triggered (Petley et al., 2005). However, for most precipitation-triggered landslides, other complex atmospheric, surface, and subsurface conditions also play a role in predisposing the slope to failure by increasing the effects of downgradient forces and/or reducing the strength of the underlying slope (Sidle & Ochiai, 2006; Terzaghi, 1950). Isolating the effect of precipitation from these confounding factors is thus essential both for enhancing fundamental understanding of landslides and for evaluating the impact of climate change on slope failure.

A principal way that climate change is likely to impact landslide hazard is by intensifying precipitation (Chiang & Chang, 2011; Handwerger et al., 2019; Huggel et al., 2012; Jakob & Lambert, 2009). This shift toward heavier precipitation events (Davenport et al., 2021; Singh et al., 2013) may decrease slope stability via a number of physical mechanisms, for example, by altering drainage conditions, throughflow, infiltration rates, and/or the hydraulic conductivities of slope materials (Crozier, 2010; Gariano & Guzzetti, 2017; Iverson, 2000). Importantly, different mechanisms may trigger different types of landslides (e.g., shallow vs. deep-seated; Van Asch et al., 1999), and slope stability is likely impacted by variations in precipitation over both daily-to-weekly and monthly-to-yearly timescales (e.g., Iverson & Major, 1987; Schmidt & Dikau, 2004).

While there is "high confidence" that climate change will affect landslide hazard in some regions (Seneviratne et al., 2012), the extent to which anthropogenically forced precipitation intensification impacts landslide hazard on regional-to-global spatial scales remains uncertain (e.g., East & Sankey, 2020). A persistent scientific challenge lies in accounting for the concurrent effects of urbanization since the location of urban areas is not independent of precipitation and other factors that affect slope stability. For example, urban areas tend to be located at lower elevations and on flatter topography and may thus receive less precipitation due to lack of orographic enhancement. Meanwhile, urban slopes are likely more sensitive to changes in precipitation, given that land use modifications associated with urbanization (e.g., deforestation, hillslope cutting) often increase the likelihood of slope failure (Cerovski-Darriau & Roering, 2016; Glade, 2003; Saito et al., 2017; Swanson & Dyrness, 1975; Wasowski, 1998; Wasowski et al., 2010).

We thus test the hypothesis that urbanized areas are more sensitive to changes in precipitation than rural areas (e.g., Bruschi et al., 2013; G. Li et al., 2017; Petley, 2010). Testing this hypothesis has been challenging, as landslides are more likely to be reported in densely populated areas, making it difficult to differentiate the effect of urbanization from geographic reporting bias. To advance understanding of landslide hazard, we therefore employ analytical methods that isolate the response of landslide frequency to precipitation variations within distinct land use classifications.

Traditional empirically based landslide hazard studies use a variety of statistical approaches (e.g., fuzzy logic, tree-based methods, and regression) that rely on the spatial relationship between predictors (i.e., independent variables; e.g., slope, lithology, land cover) and landslide observations to estimate landslide likelihood (Budimir et al., 2015; Nowicki Jessee et al., 2018; Reichenbach et al., 2018). While these cross-sectional approaches can be useful for evaluating the relative spatial likelihood of slope failure, they may be vulnerable to omitted variable bias and thus may not distinguish causal relationships from correlations (Müller & Levy, 2019; Steinschneider et al., 2013).

Therefore, to isolate the effect of precipitation on landslides within each land use classification, we employ a panel regression with fixed effects—an econometric approach increasingly applied to answer causal inference questions about the coupled human-natural system (e.g., Bassiouni et al., 2016; Blum et al., 2020; Burke et al., 2015; Davenport et al., 2020, 2021; Heft-Neal et al., 2018; G. Li et al., 2017). By exploiting daily-scale observations of landslides and precipitation over time across many cross-sectional (i.e., spatial) units, this empirical framework helps isolate the role of precipitation from other time-varying factors (e.g., seasonality) and time-invariant but spatially varying factors (e.g., topography) that could be correlated with either precipitation or landslides. An additional benefit of panel regression over cross-sectional approaches (which treat precipitation as a temporally static variable) is that it allows us to analyze antecedent precipitation for individual landslides instead of relying on average precipitation for the landslide location.

We focus on the Pacific Coast region of the conterminous United States, where surface orography contributes to a spatially pronounced precipitation gradient (Figure 1c). Mountain ranges along the coast (e.g., Coastal Ranges) and further inland (e.g., Sierra Nevada and Cascade Ranges) create sharp orographic rain shadows, with heavy rain and snow on the western side of these mountains and dry conditions to the east (e.g., Roe, 2005). The largest metropolitan areas are located on or near the coast (e.g., Los Angeles, San Francisco, Portland, Seattle; Figure 1a) and are thus subject to orographic precipitation and slope failure. Meanwhile, extensive precipitation- and landslide-prone mountain ranges further inland remain largely undeveloped. These variations make the Pacific Coast region well-suited for investigating the sensitivity of landslide hazard to precipitation variations within distinct land use classifications.

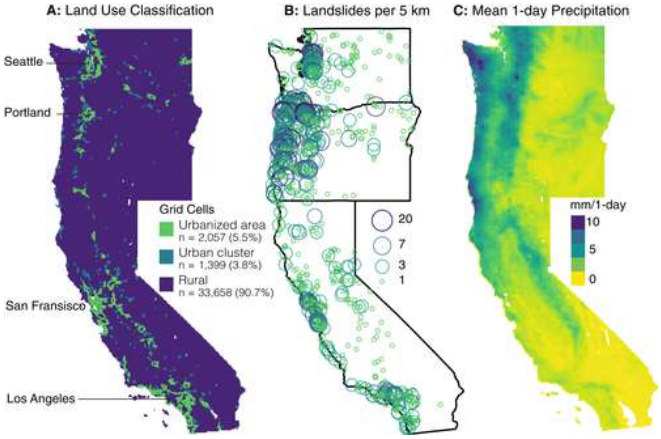


Figure 1

Pacific Coast region of the United States. (a) Spatial distribution of land use classifications. (b) Total number of landslides occurring between 2010 and 2017 per 5 km. (c) Spatial distribution of average 1-day precipitation for all days between 2010 and 2017.

To account for potential lags in the landslide response, we consider 10-day and 30-day periods (or durations) of precipitation accumulation in addition to daily precipitation. Though some studies rely on precipitation thresholds (e.g., intensity-duration; Caine, 1980) to examine landslide-triggering precipitation events, there is likely no single value of intensity that, once exceeded, will trigger landslides across the Pacific Coast region (e.g., Oakley et al., 2018), especially since these intensity-duration controls are thought to vary regionally and seasonally (Guzzetti et al., 2008).

In addition to presenting an empirical framework for analyzing causal relationships between land use, precipitation, and landslides, this study offers three additional contributions. First, we quantify an average effect of precipitation on landslide likelihood within land use classifications across the Pacific Coast region, while testing for heterogeneity in this effect by conducting subregional analyses and robustness checks. Second, this work provides a unique test of existing hypotheses by providing empirical evidence of the distinct response of landslides to precipitation in urbanized versus non-urbanized areas. Third, our results highlight the importance of considering interactions with urbanization when predicting regional landslide hazard in the current climate, and under climate change scenarios.

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https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2021GL094038

(09 August 2021, https://doi.org/10.1029/2021GL094038)

The mobility of a rolling volcanic boulder

On this blog I have frequently written about the mobility of boulders once they start rotating on their way down slope. A very beautiful example of this was posted to Twitter yesterday by Harri Geiger. The video was shot on the flanks of the still erupting Cumbre Vieja volcano on La Palma in Spain:

https://twitter.com/harrigeiger/status/1453784459686318082

The video captures a spallation lava bomb. As the video shows, this was a boulder that was roughly spherical, and it was moving on a surface essentially devoid of obstructions and that had, until late in the sequence, a steady slope. The resultant video is a remarkable record of the extreme mobility in these situations.

If the film Raiders of the Lost Ark is ever remade then this video of a high mobility, extremely hot boulder might be food for thought.

The boulder chasing Harrison Ford in the Film Raiders of the Lost Ark.

Meanwhile, the eruption continues with a great deal of energy. There is no reported evidence of the much-hyped catastrophic flank collapse, and thus of the resultant mega-tsunami, as far as I can see. On 25 October Sotiris Valkaniotis tweeted his latest InSAR analysis of deformation on La Palma:

As I'd expect, this shows inevitable inflation and deflation around the vents, but no indication of large scale instability in the flank. La Palma is being monitored closely by multiple groups using multiple sets of tools, so any changes would be rapidly detected.

(Dave Petley / THE LANDSLIDE BLOG, 29 October 2021, https://blogs.agu.org/landslideblog/2021/10/29/volcanic-boulder)

Αστοχία Ωπλισμένων Πρανών Ορύγματος

Impressive! Landslide caused the collapse of a retaining wall and the closure of the Cúcuta - Bucaramanga highway → https://bit.ly/2Zz2LkV

(29 October 2021, https://twitter.com/BLUSantanderes/status/1454094653272338443)

The Tonghua landslide in Sichuan Province, China

A paper just published in the journal Landslides (Cheng, Yang and Du 2021) describes the Tonghua landslide, which is located at 37.575, 103.414, in Sichuan Province, China. This landslide occurred on 8 August 2017. The authors used InSAR to extract pre-failure creep with rates in the order of 15-25 mm per year in the three years prior to the failure event.

This is a really interesting landslide – the image below shows the slope that failed before and after the event:

Google Earth images showing before and after the Tonghua landslide in China

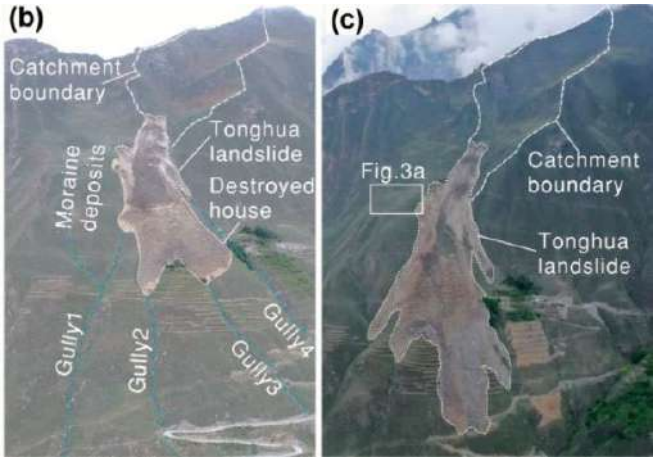
The image below shows the landslide itself in more detail:

Google Earth image showing the 8 August 2017 Tonghua landslide in Sichuan Province, China.

As the image above shows, the Tonghua landslide is a 600 m long translational debris slide in moraine deposits, with a volume of about 220,000 cubic metres. The analysis of Cheng, Yang and Du (2021) suggests that three earthquake events are associated with the landslide. The epicentre of the M=8.0 2008 Wenchuan earthquake was 59 km south of the landslide, whilst the epicentre of the M=7.0 2013 Lushan earthquake was located 158 to the southwest. On the day of the landslide, the M=7.0 2017 Jiuzhaigou earthquake was located 195 km to the northeast, but as this occurred ten hours after the failure, it was not a factor. The first two earthquakes may have played a role in preparing the slope for failure.

Perhaps the most interesting aspect of the landslide is the trigger. Cheng, Yang and Du (2021) note that there was no seismic event that coincided with the failure, and that rainfall in the 30 days prior to the collapse was not exceptional. There was no heavy rainfall event in the days immediately preceding the collapse. However, 25 days before the failure event, drilling and blasting commenced for the CNH G4217 Tonghua No. 1 tunnel, close to the site. In the days leading up to the failure event, Cheng, Yang and Du (2021) record 13 blasting events, with the last occurring about one hour before the failure. They conclude that ground vibrations associated with the tunnel construction were responsible for the failure.

Since the main failure event the Tonghua landslide has continued to creep and to expand. Initially rates were high, but they have now declined to rates in the range of 0.1 – 1.0 mm per day. The image below, from Cheng, Yang and Du (2021), illustrates how the landslide has evolved since the initial failure event:



The evolution of the Tonghua landslide in China post-failure, from Cheng, Yang and Du (2021). The left image was taken on 9 September 2017, after the failure, whilst the right image was taken on 30 May 2019.

Reference

Cheng, Q., Yang, Y. & Du, Y. Failure mechanism and kinematics of the Tonghua landslide based on multidisciplinary pre- and post-failure data. *Landslides* (2021). https://doi.org/10.1007/s10346-021-01770-x

(Dave Petley / THE LANDSLIDE BLOG, 2 November 2021, https://blogs.agu.org/landslideblog/2021/11/02/the-tonghua-landslide-in-sichuan-province-china)

Mallama: a deadly landslide in Colombia on 2 November

On 2 November 2021 heavy rainfall triggered a deadly landslide in the village of Mallama in Nariño Province of Colombia, killing 17 people and injuring a further nine.

The best image that I can find that provides a good view of this failure is on the Nariño Government website:-

The 2 November 2021 landslide at Mallama in Colombia, which killed 17 people.

Based on this image this is a failure in deeply weathered regolith on a very steep slope. It appears to have demolished a number of houses. This is probably best characterised as a debris avalanche, although with a comparatively moderate runout distance.

RCN Radio has this very dramatic image of the aftermath of the landslide from a different perspective:-

The aftermath of the landslide at Mallama in Colombia.

According to news reports, the site had not previously been identified as being at risk of landslides, and the reason for the failure at this time is not clear. There is however a risk of further failures that will necessitate the relocation of people whose houses are as yet undamaged.

(Dave Petley / THE LANDSLIDE BLOG, 2 November 2021, https://blogs.agu.org/landslideblog/2021/11/08/mallama-a-deadly-landslide-in-colombia-on-2-november)

A large landslide at the Ministro Hales mine in Chile

Loyal reader Luis Donoso highlighted to me yesterday a tweet of a video that showed the aftermath of a very large landslide in a high wall mine:-

NOTICIA NO CONFIRMADA Circula este video de un derrumbe de bancos en mina a rajo abierto. Se especula Ministro Hales. #Antofagasta

The tweet speculated that this was at the Ministro Hales mine in Chile, which is operated by Coldelco. A second tweet suggested that the failure might have been "expected and controlled".

Planet Labs imagery of the Ministro Hales mine suggests that a large landslide did indeed occur at this site sometime between 8 and 9 November. An image captured at 13:55 UTC on 8 November shows no new landslide (although a smaller previous event is visible):

The Ministro Hales mine in Chile on 8 November 2021.

An image captured at 14:42 UTC on 9 November clearly shows a large landslide.

Based upon the imagery the landslide is about 700 m long and 450 m wide. It has encompassed the existing slide but is far larger. The mobility of the landslide does not seem to be exceptional. There are some large blocks visible in the head scarp region.

The Ministro Hales mine in Chile on 9 November 2021, showing the landslide.

Large rock slope failures in high wall pits are not unusual, and this is not the largest event that I have described. Big pits typically use radar and other monitoring methods to detect potential failures, so it is credible to believe that this landslide was anticipated. It will be interesting to see better imagery of the aftermath of the landslide, and to learn about the transition to failure.

Reference

Planet Team (2021). Planet Application Program Interface: In Space for Life on Earth. San Francisco, CA. https://www.planet.com/

(Dave Petley / THE LANDSLIDE BLOG, 2 November 2021, https://blogs.agu.org/landslideblog/2021/11/10/ministro-hayes-1)

An update on the Ministro Hales mine landslide in Chile

A picture has now emerged of the 9 November 2021 Ministro Hales landslide in Chile:-

The 9 November 2021 landslide at the Ministro Hales mine in Chile. Image tweeted by Marcela Hernando.

This confirms the satellite image that I published on Wednesday, showing that this is a large rockslide in a benched section of slope.

News reports indicate that the landslide was anticipated. Movement was detected in the wall in July, allowing a plan to be put in place to mitigate the threat. BNAmericas reports that Codelco have stated that:

"In July – through focused monitoring – the control and contingency plan was designed and defined based on the safety of people, which considered the total closure of all access to the identified area and preventive detention of the adjacent phase"

Codelco report that the landslide occurred in a sterile part of the mine and that operations are unaffected.

(Dave Petley / THE LANDSLIDE BLOG, 12 November 2021, https://blogs.agu.org/landslideblog/2021/11/12/an-update-on-the-ministro-hales-mine-landslide-in-chile)

The British Columbia landslides and floods – new images of the impacts

Over the last few days new sets of images have been posted online of the enormous impact of the landslides that affected parts of British Columbia a week ago, caused by an exceptional rainfall event. The most comprehensive images that I have seen were posted to Twitter by Brent Ward (@GeoBrentatlarge) from Simon Fraser University, resulting from a helicopter flight that he took with my former PhD student Sergio Sepulveda, also of SFU. The Twitter thread is below:

> Friday Sergio Sepulveda and I examined landslides along some of the highway corridors. We are both at SFU @SFUEarthScience and @CNHR_SFU. We were focused on getting photogrammetry of landslides and evaluating initiation zones. This thread is mainly about landslides. 1/n

Meanwhile, Jeremy Venditti (@VendittiLab), also from SFU, has posted some images of the terrible impacts at Tank Hill on Highway 1:

> Many have seen the mess at #TankHill that closed #Highway1. Few have seen the source area. No point source, just too much water on hydrophobic soils, burnt by the Lytton fires. A flood turned to a landslide. A classic natural hazard cascade. #BCStorm #BCLandslides #BCfloods
>
> 

Meanwhile, BC Transportation has compiled a gallery of images including over 100 photographs and seven videos of the impacts of the extreme rainfall. This for example is an image from Tank Hill:

The aftermath of the debris flow / flood at Tank Hill in British Columbia.

The human cost of the disaster has slowly increased as the recovery operation has continued. At least four people are now known to have died in the landslides, with one more person missing. The three new confirmed fatalities occurred in the Duffy Lake area.

The Mining Journal has an interesting article focusing on the impact of the events on the extractive industries in the area, most notably the rail links that are the primary route for moving the ore to the coast. There is also damage to pipelines used to transport crude oil and other hydrocarbon products, leaving fuel shortages in some areas. Another potential impact that is causing concern is the fisheries industry, with concerns that the large volumes of water and sediment may have damaged wild salmon spawning grounds.

Unfortunately further heavy rainfall is forecast in the area. This is not expected to be an extreme event, but with the ground already saturated the impacts might be greater than would be expected normally.

(Dave Petley / THE LANDSLIDE BLOG, 22 November 2021, https://blogs.agu.org/landslideblog/2021/11/22/british-columbia-landslides-2)

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Breaking Ground – a podcast episode on climate change and slope behaviour

Breaking Ground is a podcast run by Ground Engineering magazine. Hosted by Steve Hadley (Chair of the Federation of Piling Specialists and Managing Director of Central Piling), it features people from across the ground engineering profession.

Last week I recorded an episode with Steve, which I found to be really interesting and fun. That episode is now online on audible and is freely available. Steve and I discuss a wide range of issues about slopes and slope behaviour, with a central focus on climate change.

I hope you enjoy it.

(Dave Petley / THE LANDSLIDE BLOG, 26 November 2021, https://blogs.agu.org/landslideblog/2021/11/26/breaking-ground-a-podcast-on-climate-change-and-slope-behaviour)

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Corinth Canal rockfall failure in Greece

Stratis Karantanellis, Aristotle University of Thessaloniki, Greece

Failure was last spring and was taken from UAV (drone).

(IAEG Connector E-News, November 24, 2021)

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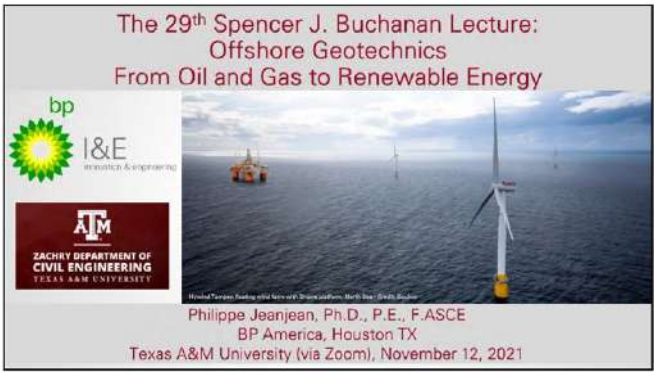
Buchanan Lecture 2021: video available



The following material has been provided by ASCE President and Distinguished Professor and Buchanan Chair Holder Jean-Louis Briaud of Texas A&M University.

The 2021 Buchanan Lecture, held on November 12, 2021, is now available online!

The 2021 Buchanan Lecturer is Dr. Philippe Jeanjean who is the Senior Advisor for Geotechnical Engineering at BP America in Houston, Texas. Dr. Jeanjean's lecture is entitled "Offshore Geotechnics: From Oil & Gas to Renewable Energy."

Also on the agenda is Professor Edward J. Cording, who presented his 2020 Terzaghi Lecture "Observing and Controlling Ground Behavior with Tunnel Boring Machines." Professor Cording is Professor Emeritus in the Department of Civil and Environmental Engineering at the University of Illinois at Urbana Champaign.

The full event can be watched through the Youtube video below.

https://www.youtube.com/watch?v=CWCxf1x7w4E

Also, in *Education Resources* section below you can find the 29th Buchanan lecture Booklet which contains information on the Spencer J. Buchanan Lecture Series, biographies of the 2021 speakers, as well as the associated presentation slides.

Educational Resources

2021 Buchanan Lecture Booklet New

(Geoengineer, https://www.geoengineer.org/education/offshore-geotechnics/buchanan-lecture-2021-video-available)

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Rocscience International Conference 2021 - Lifetime Achievement Session - Dr. Evert Hoek

Recently at the Rocscience International Conference 2021, Dr. Evert Hoek received the Lifetime Achievement Medal for his contributions in the field of Rock Engineering. Below you can watch the special session in which Dr. Hoek discusses the Developments in Rock Engineering from 1958 to 2020.

https://www.youtube.com/watch?v=dy83dYaXHVY

(Geoengineer, https://www.geoengineer.org/education/rock-mechanics/rocscience-international-conference-2021-lifetime-achievement-session-dr-evert-hoek)

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Ananea: a significant mine waste failure in Peru

On 26 November 2021 a significant landslide occurred in mine waste near to the town on Ananea in Peru. I will say from the start that I am finding it extremely difficult to piece this event together as there is a wide range of conflicting information and images. I am unsure as to whether this was a single event or a series of related failures, and I am unsure as to the level of damage. Unfortunately at present there is no good satellite imagery.

I would welcome any insight that anyone can provide.

I'll try to set out what I do know. The official COEN-INDICI (Centro de Operaciones de Emergencia Nacional) Twitter site confirms that an event occurred on that date:-

The translation is: *On 11/26 there was a #landslide that caused damage to homes and roads in the Ananea district, San Antonio de Putina province (Puno). Local authorities evacuated the affected people and are coordinating their relocation.*

The photograph shows the aftermath of a large landslide.

There is also a set of images on the Sin Fronteras website, with a set of photographs. The text says:

ANANEA. IN THE CHAOS! THE OVERFLOW OF THE MINING TAILINGS FROM A SEDIMENTATION POOL HAS LEFT THE ANANEA DISTRICT, IN THE SAN ANTONIO DE PUTINA PROVINCE, WITH THE STREETS FLOODED WITH MUD AND IMPASSABLE, SO THE RESIDENTS ASK THAT IT BE DECLARED IN EMERGENCY.

The overflow occurred yesterday at 8:30 in the morning, apparently from one of the sedimentation ponds of the San Antonio mining cooperative, located on the Q'oñiunu hill.

The collapse of the highly toxic material would have occurred due to the alleged negligence in the management and control of the mining waste pools; irresponsible work of some cooperatives.

It also includes some images, but I cannot figure out how they all fit together:-

An image of the aftermath of the landslide at Ananea in Peru.

The image above is consistent with that tweeted by COEN. However, another image appears to show a different site altogether:

There are also some videos of a flood event circulating, such as this one on Tic Toc, and this one on Twitter:

https://twitter.com/luroel/status/1465127172574625793?ref_src=twsrc%5Etfw%7Ctwcamp%5Etweetembed%7Ctwterm%5E1465127172574625793%7Ctwgr%5E%7Ctwcon%5Es1_&ref_url=https%3A%2F%2Fblogs.agu.org%2Flandslideblog%2F2021%2F11%2F30%2Fananea-1%2F

But again I am unsure as to whether this is the same event.

An image of the aftermath of the landslide at Ananea in Peru.

Can anyone shed any more light on this event, or set of events?

(Dave Petley / THE LANDSLIDE BLOG, 30 November 2021, https://blogs.agu.org/landslideblog/2021/11/30/ananea-1/)

Geoengineer
Online Lecture Notes on Soil Mechanics

In the first part of the series "Online Lecture Notes on Soil Mechanics", by Prof. G.A. Athanasopoulos, Chapter 7 discusses Earth Pressures and Earth Retaining Walls. Read more: https://www.geoengineer.org/education/online-lecture-notes-on-soil-mechanics/chapter-7-earth-pressures

Chapter 7: Earth Pressures

This section is part of: Athanasopoulos, G. A. (2021) "Online Lecture Notes on Soil Mechanics", Geoengineer.org, DOI: https://doi.org/10.48246/GEOENG-EDU-001

1. Chapter 1: Physical Properties of Soils
2. Chapter 2: Stresses in Soils
3. Chapter 3: Seepage
4. Chapter 4: Soil Deformations
5. Chapter 5: Shear Strength of Soils
6. Chapter 6: Soil Compaction
7. Chapter 7: Earth Pressures
   - 7.1. Rankine Theory
   - 7.2. Coulomb Theory
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   - 7.4 Types of Retaining Structures
     - 7.4.1. Gravity Walls
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     - 7.4.4. Anchored Diaphragm Walls
     - 7.4.5. Values for (φ,δ) for Flexible Walls
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7.5.6. Problem 7.6
7.5.7. Problem 7.7
7.5.8. Problem 7.8

8. Chapter 8: Slope Stability
9. Chapter 9: Bearing Capacity

(Geoengineer, https://www.geoengineer.org/education/online-lecture-notes-on-soil-mechanics/chapter-7-earth-pressures)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΣΕΙΣΜΟΙ & ΑΝΤΙΣΕΙΣΜΙΚΗ ΜΗΧΑΝΙΚΗ

Ελληνικό μοντέλο πρόγνωσης σεισμικότητας

Η σεισμολόγος δρ Μαργαρίτα Σέγκου δημιούργησε υπόδειγμα ημερήσιας εκτίμησης μετασεισμών για το Αρκαλοχώρι

Νέα δεδομένα στη δυνατότητα αξιολόγησης της εξέλιξης της μετασεισμικής δραστηριότητας διαμορφώνονται από τα εξαιρετικά αξιόπιστα προγνωστικά μοντέλα σεισμικότητας της επόμενης μέρας, τα οποία ανέπτυξε για την περιοχή του Αρκαλοχωρίου στην Κρήτη η σεισμολόγος δρ Μαργαρίτα Σέγκου, διευθύντρια ερευνών της Βρετανικής Γεωλογικής Υπηρεσίας (φωτ. INTIME NEWS).

Στην Ελλάδα δεν έχουμε ακόμη έναν επιχειρησιακό μηχανισμό πρόγνωσης της μετασεισμικής δραστηριότητας της ημέρας σε μια περιοχή όπου εκδηλώθηκε μεγάλος σεισμός, κάτι σαν το δελτίο καιρού, τους ημερήσιους χάρτες πρόβλεψης κινδύνου πυρκαγιάς, τα μοντέλα για την εξέλιξη της πανδημίας. Σε άλλες χώρες, όπως η Ιταλία, οι ΗΠΑ, η Ιαπωνία, μετά τα ισχυρά Ρίχτερ η Πολιτική Προστασία λαμβάνει στα χέρια της την εκτίμηση για τους επικείμενους μετασεισμούς και δρα ενημερώνοντας τους αρμόδιους φορείς ή το κοινό. Ομως μια Ελληνίδα σεισμολόγος, η **δρ Μαργαρίτα Σέγκου**, διευθύντρια ερευνών της Βρετανικής Γεωλογικής Υπηρεσίας, επικεφαλής διεθνούς ομάδας σεισμολόγων, οι οποίοι σχεδιάζουν το μέλλον των μοντέλων πρόγνωσης σε παγκόσμια κλίμακα, δημιούργησε με τη βοήθεια της τεχνητής νοημοσύνης εξαιρετικά αξιόπιστα προγνωστικά μοντέλα σεισμικότητας της επόμενης μέρας για την περιοχή του **Αρκαλοχωρίου στην Κρήτη**, ξετυλίγοντας τις νέες δυνατότητες στην αντιμετώπιση σεισμικών κρίσεων που ανοίγονται και για τη χώρα μας στο μέλλον με τη βοήθεια της τεχνητής νοημοσύνης.

Η μελέτη

Η μελέτη αυτή της δρος Σέγκου, με τους διαθέσιμους σήμερα καταλόγους σεισμικότητας της περιοχής και την ημερήσια στατιστική εκτίμηση μετασεισμών, θα προστεθεί σε εκείνες που η ίδια διεξήγαγε με τους αλγόριθμους μηχανικής μάθησης για δεκάδες σεισμούς στη Γη, στην Ιταλία, την Καλιφόρνια, την Ιαπωνία, τη Νέα Ζηλανδία και αλλού, μετατρέποντας την περίπτωση του Αρκαλοχωρίου σε άλλο ένα αντιπροσωπευτικό σεισμικό γεγονός που θα εμπλουτίσει την παγκόσμια τράπεζα πληροφορίας για τους σεισμούς και θα συμβάλει στη βαθύτερη κατανόησή τους.

Επεξεργάστηκε τα διαθέσιμα δεδομένα σεισμικότητας 254 ημερών πριν από τον σεισμό μεγέθους 5,8 Ρίχτερ στο Αρκαλοχώρι και κατασκεύασε προγνωστικά μοντέλα εκτίμησης των μετασεισμών της επόμενης ημέρας για ένα διάστημα 24 ημερών. Της εκδήλωσης του μεγάλου σεισμού στις 27 Σεπτεμβρίου είχαν προηγηθεί, από την αρχή του 2021, 418 σεισμοί, από τους οποίους οι 68 με μέγεθος μεγαλύτερο των 3 Ρίχτερ, ενώ ακολούθησαν 1.404 μετασεισμοί. Για ένα διάστημα 50 ημερών πριν από τον σεισμό εκδηλώνονταν περισσότεροι από ένας αισθητός σεισμός (γύρω στα 3 Ρίχτερ) την ημέρα. Μάλιστα ορισμένες ημέρες του Ιουλίου καταγράφηκαν 5 αισθητοί σεισμοί. Αλλά η εκδήλωση σεισμών μικρού μεγέθους, 9 στις 10 φορές περίπου δεν συνδέεται με επικείμενο σεισμό μεγαλύτερου μεγέθους.

Ο ρόλος των επιχειρησιακών προγνωστικών είναι να εκτιμούν σε πραγματικό χρόνο την εξέλιξη της σεισμικής ακολουθίας βασιζόμενα στα δεδομένα των προηγούμενων ημερών.

«Ο ρόλος των επιχειρησιακών προγνωστικών μοντέλων είναι να εκτιμούν σε πραγματικό χρόνο την εξέλιξη της σεισμικής ακολουθίας βασιζόμενα στα δεδομένα των προηγούμενων ημερών. Χρησιμοποιούν την πληροφορία από προηγούμενους μικρού μεγέθους σεισμούς προκειμένου να "μάθουν" τα χαρακτηριστικά της σεισμικότητας της περιοχής και να κάνουν την πρόγνωση. Το μοντέλο "ενημερώνεται" για τα συμβάντα της ημέρας που πέρασε και "ενημερώνει" για εκείνα της επόμενης. Η αξιοπιστία της πρόγνωσης αξιολογείται και σε περίπτωση απόκλισης επανελέγχονται οι πληροφορίες που δίνονται αλλά και το ίδιο το μοντέλο», εξηγεί η δρ Σέγκου.

«Στη χώρα μας οι σεισμοί μικρού μεγέθους καταγράφονται, όμως οι κατάλογοι του ελληνικού χώρου δεν είναι πλήρεις, στερούνται πληροφορίας υψηλής αναλυτικής δύναμης. Λείπουν τα νέα εργαλεία, όπως και τα εργαλεία τεχνητής νοημοσύνης για την υψηλής ποιότητας αποτύπωση της σεισμικότητας του ελληνικού χώρου, των χιλιάδων πολύ μικρών σεισμών που δεν ανιχνεύονται, και των ιδιαίτερων χαρακτηριστικών τους. Σε κάθε σεισμό με μέγεθος μεγαλύτερο του 3 αντιστοιχούν 10 με μέγεθος άνω του 2. Πρόσφατα αποτελέσματα δείχνουν ότι νέες μέθοδοι ανάλυσης παρέχουν δεκαπλάσιο αριθμό γεγονότων κοντά σε πραγματικό χρόνο. Χαρακτηριστικά των πολύ μικρών σεισμών, όπως τα πολύ μικρά ρήγματα που τους προκαλούν, αποτελούν το «κλειδί» για τη βαθιά κατανόηση του συνολικού φαινομένου. Δημιουργούν έναν μικρόκοσμο αλληλεπιδράσεων που διαμορφώνει το αύριο που περιμένουμε», σημειώνει η δρ Σέγκου.

«Η δημιουργία του Ενιαίου Εθνικού Σεισμολογικού Δικτύου το 2008 αποτέλεσε τη σημαντικότερη προσπάθεια για την ενοποίηση των σεισμολογικών δεδομένων στη χώρα μας, όμως η σεισμική παρατήρηση δεν αρκεί για να μας πληροφορήσει για το τι θα συμβεί την επόμενη μέρα. Χρειαζόμαστε νέα εργαλεία ανάλυσης και μοντελοποίησης, που να στηρίζουν τα λεγόμενα επιχειρησιακά προγνωστικά μοντέλα. Υπάρχει η επιτροπή εκτίμησης σεισμικού κινδύνου, όμως τα πορίσματά της στηρίζονται σε επιστημονικές απόψεις, οι οποίες είναι πολύ σημαντικές, εξαιρετικά χρήσιμες, διαμορφώνονται όμως με βάση την προσωπική εμπειρία. Τα προγνωστικά μοντέλα παρέχουν μια αντικειμενική πληροφορία για την επαύριο, βασιζόμενα σε δεδομένα ενός πλήθους σεισμικών ακολουθιών από όλον τον κόσμο, τα οποία κανένας επιστήμονας δεν θα μπορούσε να αναλύσει στη διάρκεια της επιστημονικής του ζωής. Τα προγνωστικά μοντέλα είναι ο φρουρός της σκέψης μας, αυτό που μας κρατάει αντικειμενικά ορθούς».

Εξελισσόμενη πληροφορία

Στην περίπτωση του Αρκαλοχωρίου, τα αποτελέσματα εκτίμησης της σεισμικότητας ήταν εξαιρετικά κοντά στη γραμμή πραγματικής εκδήλωσης των σεισμών, «ειδικά τις τέσσερις πρώτες ημέρες. Ομως ο όγκος των δεδομένων που συσσωρεύεται θα ήταν δυνατό να αναλυθεί καλύτερα, προκειμένου να αναγνωρίζονται σταθερά στην πορεία των ημερών όλα τα γεγονότα, ακόμα και εκείνα πολύ μικρού μεγέθους. Είναι πρακτικά αδύνατο να ανιχνευθεί και να μεταφραστεί ο όγκος της πληροφορίας σε πραγματικό χρόνο από αναλυτές. Αντίθετα τα συστήματα μηχανικής εκμάθησης μπορούν σήμερα να αντεπεξέλθουν σε αυτό το γιγαντιαίο αναλυτικό έργο. Τα προγνωστικά μοντέλα μας θα ήταν δυνατό να ενημερώνονται διαρκώς αλλά και οι ειδικοί, επιστήμονες και φορείς, θα μπορούσαν να έχουν στη διάθεσή τους μια υψηλής ανάλυσης, δυναμικά εξελισσόμενη πληροφορία για να διαμορφώσουν το επιχειρησιακό πλαίσιο της επόμενης ημέρας. Για παράδειγμα, υπάρχουν σεισμικά γεγονότα που χάνονται γιατί συμβαίνουν σχεδόν ταυτόχρονα και αλληλοεπικαλύπτονται ή χάνονται μέσα στον θόρυβο της καταγραφής. Το προγνωστικό μοντέλο σημείωσε σε αυτές τις περιπτώσεις περισσότερα γεγονότα από όσα καταγράφηκαν, αποκαλύπτοντας εν μέρει το εύρος της πληροφορίας που χάνεται».

Στην ερώτηση αν το επιχειρησιακό μοντέλο για το Αρκαλοχώρι εξακολουθεί να παρέχει την εκτίμηση για την επόμενη μέρα με την ίδια πιστότητα, η δρ Σέγκου απαντά: «Βεβαίως. Αυτά τα μοντέλα δεν σταματούν ποτέ, συνεχίζουν να παρέχουν την πρόγνωση, συνήθως διαρκώς βελτιούμενα. Ο αριθμός των μετασεισμών βαίνει μειούμενος, όμως το σύννεφο των πορτοκαλί σημείων (μετασεισμοί) στον χάρτη εξαπλώνεται, καθώς, κατά την εξέλιξη της σεισμικής ακολουθίας ενεργοποιούνται μικρά ή μεγαλύτερα ρήγματα. Αυτό θα σταματήσει όταν η περιοχή θα βρει τη νέα της ισορροπία». Το ζήτημα είναι πότε θα συμβεί αυτό και μέσα από ποιες υπόγειες «διαδρομές»…

(Τασούλα Καραϊσκάκη / Η ΚΑΘΗΜΕΡΙΝΗ, 02.11.2021, https://www.kathimerini.gr/society/561566809/elliniko-montelo-prognosis-seismikotitas)

A tsunami is a series of enormous waves created by an underwater disturbance usually associated with earthquakes occurring below or near the ocean.

International cooperation for developing countries to raise tsunami awareness

In 2021, World Tsunami Awareness Day promotes "Sendai Seven Campaign," target (f), which aims to 'substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the present Framework by 2030.'

By the year 2030, an estimated 50 per cent of the world's population will live in coastal areas exposed to flooding, storms and tsunamis. Scaling up international cooperation to developing countries will help ensure that 100% of communities at risk of tsunami are prepared for and resilient to tsunamis by 2030.

In December 2015, the UN General Assembly designated 5 November as World Tsunami Awareness Day, calling on countries, international bodies and civil society to raise tsunami awareness and share innovative approaches to risk reduction.

World Tsunami Awareness Day was the brainchild of Japan, which due to its repeated, bitter experience has over the years built up major expertise in areas such as tsunami early warning, public action and building back better after a disaster to reduce future impacts. UN Disaster Risk Reduction (UNDRR) facilitates the observance of World Tsunami Awareness Day in collaboration with the rest of the United Nations system.

Background

Tsunamis are rare events but can be extremely deadly. In the past 100 years, 58 of them have claimed more than 260,000 lives, or an average of 4,600 per disaster, surpassing any other natural hazard. The highest number of deaths in that period was in the Indian Ocean tsunami of December 2004. It caused an estimated 227,000 fatalities in 14 countries, with Indonesia, Sri Lanka, India and Thailand hardest-hit.

Just three weeks after that the international community came together in Kobe, in Japan's Hyogo region. Governments adopted the 10-year Hyogo Framework for Action, the first comprehensive global agreement on disaster risk reduction.

They also created the Indian Ocean Tsunami Warning and Mitigation System, which boasts scores of seismographic and sea-level monitoring stations and disseminates alerts to national tsunami information centres.

Rapid urbanization and growing tourism in tsunami-prone regions are putting ever-more people in harm's way. That makes the reduction of risk a key factor if the world is to achieve substantial reductions in disaster mortality – a primary goal of the Sendai Framework, the 15-year international agreement adopted in March 2015 to succeed the Hyogo Framework.

United Nations

World Tsunami Awareness Day
5 November

What are tsunamis?

The word "tsunami" comprises the Japanese words "tsu" (meaning harbour) and "nami" (meaning wave). A tsunami is a series of enormous waves created by an underwater disturbance usually associated with earthquakes occurring below or near the ocean.

Volcanic eruptions, submarine landslides, and coastal rock falls can also generate a tsunami, as can a large asteroid impacting the ocean. They originate from a vertical movement of the sea floor with the consequent displacement of water mass.

Tsunami waves often look like walls of water and can attack the shoreline and be dangerous for hours, with waves coming every 5 to 60 minutes.

The first wave may not be the largest, and often it is the 2nd, 3rd, 4th or even later waves that are the biggest. After one wave inundates, or floods inland, it recedes seaward often as far as a person can see, so the seafloor is exposed. The next wave then rushes ashore within minutes and carries with it many floating debris that were destroyed by previous waves.

What are the causes of tsunamis?

Earthquakes

It can be generated by movements along fault zones associated with plate boundaries.

Most strong earthquakes occur in subduction zones where an ocean plate slides under a continental plate or another younger ocean plate.

All earthquakes do not cause tsunamis. There are four conditions necessary for an earthquake to cause a tsunami:

- The earthquake must occur beneath the ocean or cause material to slide into the ocean.
- The earthquake must be strong, at least magnitude6.5 on the Richter Scale
- The earthquake must rupture the Earth's surface and it must occur at shallow depth – less than 70km below the surface of the Earth.
- The earthquake must cause vertical movement of the sea floor (up to several metres).

Landslides

A landslide which occurs along the coast can force large amounts of water into the sea, disturbing the water and generate a tsunami. Underwater landslides can also result in tsunamis when the material loosened by the landslide moves violently, pushing the water in front of it.

Volcanic eruptions

Although relatively infrequent, violent volcanic eruptions also represent impulsive disturbances, which can displace a great volume of water and generate extremely destructive tsunami waves in the immediate source area.

One of the largest and most destructive tsunamis ever recorded was generated in August 26, 1883 after the explosion and collapse of the volcano of Krakatoa (Krakatau), in Indonesia. This explosion generated waves that reached 135 feet, destroyed coastal towns and villages along the Sunda Strait in both the islands of Java and Sumatra, killing 36,417 people.

Extraterrestrial collisions

Tsunamis caused by extraterrestrial collision (i.e. asteroids, meteors) are an extremely rare occurrence. Although no meteor/asteroid-induced tsunamis have been recorded in recent history, scientists realize that if these celestial bodies should strike the ocean, a large volume of water would undoubtedly be displaced to cause a tsunami.

https://www.youtube.com/watch?v=frT6meudLRI

(United Nations, https://www.un.org/en/observances/tsunami-awareness-day)

Paleoseismological Studies

HisaoKondo, Lewis A.Owen, Paula M.Figueiredo

Abstract

Paleoseismology utilizes aspects of tectonic geomorphology, structural geology, sedimentology, and stratigraphy to determine the location, timing, and displacement of past earthquakes. Most studies concentrate on providing data on late Quaternary earthquakes to extend the historical seismic record. Recent methodological developments, including remote sensing, geodesy, fault trenching, and numerical dating, have helped accelerate knowledge and study of past earthquakes. Paleoseismic studies include on-fault and off-fault investigations. The former involves mapping active fault traces including directly displaced landforms and fault trenching. Off-fault studies mainly include studies across the broader seismogenic area, studying and examining paleoliquefaction features, earthquake-triggered landslides, and tsunami and subaqueous deposits as well as vertical variations of deformed landforms as marine terraces and coral-reef tracts, river terraces and drainages anomalies. Seismic hazard analysis is concerned with the long-term forecast of large earthquakes and/or determining or estimating the amount of ground motion expected during a future earthquake. Effective seismic hazard mapping includes developing ground acceleration maps based on high resolution, detailed geomorphic, and Quaternary geologic mapping. Recent studies on modern earthquakes provided additional knowledge on earthquake fault rupture and surficial deformation. Significant future challenges for paleoseismology include reconstructing the timing and magnitude of past earthquakes beyond a few tens of thousands of years to enhance understanding of the nature of seismicity with long recurrence intervals, recognize how neighboring faults interact during seismic cycles and improve regional seismic cycles models, and integrate new knowledge contributing to updating current fault-calling relationships, all crucial for probabilistic analysis of seismic hazard and effective mitigation.

Treatise on Geomorphology, Volume 5, 2013, Pages 267-299, https://doi.org/10.1016/B978-0-12-818234-5.00156-5

https://www.sciencedirect.com/science/article/pii/B9780128182345001565?via%3Dihub

The Kaikōura Earthquake M7.8 earthquake (14 November 2016)

Kerry Leith Retweeted

Remembering the Kaikōura Earthquake. 12.02 am on Monday 14 November 2016, a M7.8 earthquake struck 15 km north-east of Culverden, North Canterbury, starting near the town of Waiau. The earthquake is one of the most complex earthquakes ever recorded with modern instruments.

The earthquake and surface rupture involved more than 20 different faults (a world record), triggered the biggest local-source tsunami recorded in New Zealand since 1947, caused extensive coastal uplift, widespread landslides & landslide dams, as well as slow-slip 'silent' quakes

(GeoNet, https://twitter.com/geonet/status/1459659885180690432)

Landslide-generated Tsunamis

Landslide-generated waves were responsible for two deadly Tsunamis in Indonesia in 2018: Palu and Anak Krakatau events. Our recent article sheds light on the mechanism of complex waves generated by Landslides and how to predict them (free pdf): https://link.springer.com/article/10.100

A new empirical equation for predicting the maximum initial amplitude of submarine landslide-generated waves

Ramtin Sabeti & Mohammad Heidarzadeh

Abstract

The accurate prediction of landslide tsunami amplitudes has been a challenging task given large uncertainties associated with landslide parameters and often the lack of enough information of geological and rheological characteristics. In this context, physical modelling and empirical equations have been instrumental in developing landslide tsunami science and engineering. This study is focused on developing a new empirical equation for estimating the maximum initial landslide tsunami amplitude for solid-block submarine mass movements. We are motivated by the fact that the predictions made by existing equations were divided by a few orders of magnitude (10^{-1}–10^{4} m). Here, we restrict ourselves to three main landslide parameters while deriving the new predictive equation: initial submergence depth, landslide volume and slope angle. Both laboratory and field data are used to derive the new empirical equation. As existing laboratory data was not comprehensive, we conduct laboratory experiments to produce new data. By applying the genetic algorithm approach and considering non-dimensional parameters, we develop and examine 14 empirical equations for the non-dimensional form of the maximum initial tsunami amplitude. The normalized root mean square error (*NRMSE*) index between observations and calculations is used to choose the best equation. Our proposed empirical equation successfully reproduces both laboratory and field data. This equation can be used to provide a preliminary and rapid estimate of the potential hazards associated with submarine landslides using limited landslide parameters.

(https://link.springer.com/article/10.1007/s10346-021-01747-w)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΓΕΩΛΟΓΙΑ

The History of Mother Earth: Gaia Uncovered

Hello dear everyone in #USA and #Canada! News! We investigate #Gaia and 10 000 years of our relationship with #PlanetEarth through #archaeology #history #myth @bbcselect in this new film #GaiaUncovered - enjoy and please do spread the word.

(https://twitter.com/bettanyhughes/status/1455201556425580545)

Scientists figure out what happens to Earth's disappearing crust

Modern plate tectonics may have only got going in the past billion years.

Like a giant broken-up cookie whose pieces float atop a sea of scalding milk, Earth's outer shell is made of (less-tasty) rocky rafts that constantly bump into and dive beneath each other in a process called plate tectonics.

So what happens to those hunks of disappearing crust as they dive into Earth's milky interior?

It turns out that they get weak and bendy, like a slinky snake toy, but they don't disintegrate completely, new modeling shows. The models also suggested that plate tectonics, at least in its modern form, likely only got going in the past billion years.

Plate tectonics drives earthquakes and volcanoes, creates mountain ranges and islands, and is the reason Earth's continents, once a supercontinent, are now oceans apart. But there's still much unknown about how plate tectonics works, such as what happens when a plate slides beneath another (in an area called a subduction zone) and disappears into the mantle, the middle layer of the planet, which is, perhaps sadly, not composed of milk but rather of sizzling solid rock.

To figure this out, the researchers used 2D computer models of subduction zones and programmed them using known physics of how materials behave, such as how rocks deform under certain forces. Then, they observed the model to see what happened at the subduction zone and compared their findings to real-life observations.

Their models suggested that as one plate dove beneath another, the descending piece, known as a slab, abruptly bent downward and cracked; the bending also caused the grains on the underside of the plate to become finer and weaker. The pressures left the plate mostly intact but with many weak points.

That means that the plates don't break apart and thus keep pulling on the parts behind them, "for a very long time," said lead author Taras Gerya, a professor of geophysics at ETH Zurich in Switzerland. Indeed, the plate can keep sliding under the other plate for hundreds of millions of years, he said.

Their simulations matched observations and deep seismic imaging that showed weakened areas of a subduction zone in Japan, Gerya told Live Science.

Kent Condie, a professor emeritus of geochemistry and Earth and environmental science at the New Mexico Institute of Mining and Technology who was not involved in the study, called their models "robust and meaningful."

When did it start?

The team also modeled what would have happened if Earth's interior were 270 degrees Fahrenheit (150 degrees Celsius) hotter, similar to temperatures it would have reached about a billion years ago.

They found that in these simulations, the slab broke up only a few miles into the mantle, because it was unable to sustain its own weight in a mantle that was less viscous due to the hot conditions. So, unlike modern subduction that can continue for hundreds of millions of years, subduction back then would have ended very quickly, within a few million years, Gerya said.

This finding suggests that modern plate tectonics may not have begun until sometime in the past billion years, he added.

While a primitive form of plate tectonics may have existed between 3.5 billion and 2 billion years ago, during the Archean or Proterozoic eras, it was probably very different from what the planet experiences today, Gerya said. And around 1.8 billion to 1 billion years ago, there was a quiet period in which the plates were much less active.

But this is just speculation, he said, and there is currently a lot of controversy surrounding when plate tectonics started.

Condie agreed with Gerya. "Modern plate tectonics, with all the geologic indicators … probably did not begin until the last

billion years," Condie told Live Science. But "plate tectonics in some form has been with us since at least 2 billion years ago."

Still, because we don't know the exact temperatures of Earth's core through time, it's not yet possible to give a precise timeline of when slabs stopped breaking apart and started a more continuous journey into the mantle, Condie said.

That's really when modern plate tectonics began, Gerya said. The researchers now hope to explore the phenomenon and its relation to earthquakes, using more advanced 3D models.

The findings were published Nov. 10 in the journal Nature.

(Yasemin Saplakoglu / LIVESCIENCE, 20.11.2021, https://www.livescience.com/what-happens-sinking-tectonic-plates)

Dynamic slab segmentation due to brittle–ductile damage in the outer rise

T. V. Gerya, D. Bercovici & T. W. Becker

Subduction is the major plate driving force, and the strength of the subducting plate controls many aspects of the thermochemical evolution of Earth. Each subducting plate experiences intense normal faulting during bending that accommodates the transition from horizontal to downwards motion at the outer rise at trenches. Here we investigate the consequences of this bending-induced plate damage using numerical subduction models in which both brittle and ductile deformation, including grain damage, are tracked and coupled self-consistently. Pervasive slab weakening and pronounced segmentation can occur at the outer-rise region owing to the strong feedback between brittle and ductile damage localization. This slab-damage phenomenon explains the subduction dichotomy of strong plates and weak slabs, the development of large-offset normal faults near trenches, the occurrence of segmented seismic velocity anomalies and distinct interfaces imaged within subducted slabs, and the appearance of deep, localized intraplate areas of reduced effective viscosity observed at trenches. Furthermore, brittle–viscously damaged slabs show a tendency for detachment at elevated mantle temperatures. Given Earth's planetary cooling history, this implies that intermittent subduction with frequent slab breakoff episodes may have been characteristic for Earth until more recent times than previously suggested.

https://www.nature.com/articles/s41586-021-03937-x

New tool provides users with free access to geological models for three major UK cities

A new Urban Interactive Models Tool that provides free user access to 3D geological models for selected UK cities, has been added to the BGS GeoIndex service.

A new Urban Interactive Models Tool that provides free user access to geological models for selected UK cities, has been added to the British Geological Survey's (BGS) GeoIndex service.

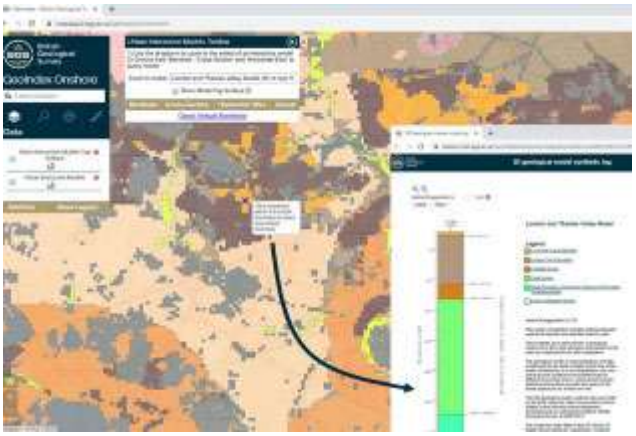
BGS GeoIndex already provides access to a range of 2D information and data resources through an interactive map viewer, enabling users to navigate to their area of interest, view and query datasets, download reports and clip data and make enquiries.

3D urban geology on the BGS GeoIndex

The new tool allows users to capture synthetic boreholes, geological cross-sections and slices through 3D models developed by BGS for London, Glasgow and Cardiff, the largest cities in England, Scotland and Wales.

Making key urban models freely accessible for the first time, it will benefit a range of technical, professional and academic users, in particular consultancy for the geotechnical, construction and groundwater sectors.

The models provide regional geological understanding (50 m resolution) designed to help users develop conceptual ground models and plan ground investigations.



Example of the new tool in use, showing part of a borehole through the London model.

Users can query the geological model to obtain a range of visualisations of geological conditions beneath each of the cities. The views can also be downloaded as a standard format PDF.

Each of the geological models were constructed through the analysis of thousands of borehole records and integration with geological map data, and informed by extensive literature review. In addition to the virtual borehole and section functions, a new slice function is being trialled for displaying geological units at specified depths.

Katie Whitbread, who leads the national geological modelling programme at the BGS, said the tool helps inform the devel-

opment of Conceptual Ground Models for construction and groundwater management, as well as supporting early-stage planning.

"Urban geological models encapsulate a huge amount of geological data and knowledge to provide comprehensive 3D information on the variability of the rocks and sediments underlying our cities. Understanding this variability is critical for de-risking decision making and investment in a range of applications from construction to the management of surface and groundwater.

"Conceptual Ground Models are a key component of early planning and desktop studies, helping to identify potential risks, develop hypotheses around ground conditions, optimise the design of targeted investigations and allow communication of the geological conditions to different stakeholders.

"The Urban Interactive Model Tool adds value to the initial stages of this development process, providing accessible regional geological understanding for key UK cities derived directly from three-dimensional geological characterisation of the upper few 100m of the ground."

Katie Whitbread, BGS National Geological Model project manager

Through the tool users can link to other BGS resources including the Lexicon, model metadata reports and relevant research reports for the selected cities, and access wider BGS 2D and 3D data services.

The underlying model data, along with a range of other BGS LithoFrame models, can be licensed through BGS Data Services, who can also arrange academic licences. BGS also provides bespoke modelling services and commissioned research for users requiring access to more detailed information. Users are encouraged to provide feedback by email to the BGS enquiries service and are invited to get in touch if they are interested in being part of a user forum to help inform the design and development of new features and functions.

"Whilst the tool is not intended to provide a substitute for detailed site investigations and we recognise these evaluations require additional information, the geological model provides a base-line dataset and regional context that crucially, can inform early decision-making, particularly at the desk study stage.

"We are committed to working closely with potential users and stakeholders to develop the model and explore how BGS can advance its 3D geology services to help support planning and resource assessments.

"Working with our stakeholders we would like to explore future development of the tool such as increasing the coverage of UK urban areas, adding geotechnical and hydrogeological information, and providing additional digital output formats so that GeoIndex continues to provide subsurface knowledge where it is needed most."

Katie Whitbread, BGS National Geological Model project manager

The new tool can be accessed by opening the onshore GeoIndex online and navigating to the new '3D Models' layer under the data list.

(BGS Press, 18/11/2021, https://www.bgs.ac.uk/news/new-tool-provides-users-with-free-access-to-geological-models-for-three-major-uk-cities)

Famous Kotsifou Fault on Crete

Nikolaos Tavoularis, Dr. Engineering Geologist NTUA, Greece

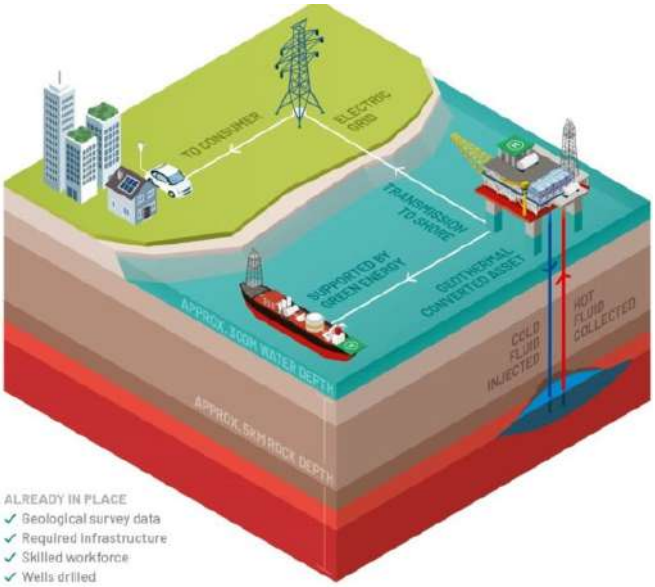
Here is an interesting geological photo from a well-known fault on the island of Crete from the Rethimno area in Greece, named Kotsifou fault, where part of the basic national road (connecting particular villages in Rethimno prefecture) is designed along this particular fault.

(IAEG Connector E-News, November 17, 2021)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΠΕΡΙΒΑΛΛΟΝ

Shift Geothermal calls for national geo-energy centre

Shift Geothermal is launching a bid to establish a new national centre for geo-energy to realise the potential of a huge untapped UK energy source.



The organisation, a non-profit comprised of academics and energy sector specialists, believes geological resources from the UK's oil and gas sectors can be repurposed to produce geo-energy but a lack of collaboration and coordination is undermining progress.

According to Shift Geothermal, geo-energy could deliver up to 25 per cent of the UK's energy mix by 2050 but this would require government commitment and a strategic approach to sharing research to propel innovation and pilot projects.

In a statement, Dr Alison Auld, a director of SHIFT Geothermal said: "Geo-energy has huge potential in the UK, but this has been largely overlooked and we now risk being left behind in terms of both investment and projects despite that potential.

"The future energy mix will be increasingly diverse, and technologies must be accelerated to rapidly enable sources of net zero carbon energy. People all too often think of Iceland and volcanoes when they think of geo-energy, but the technology has moved on. Repurposing and reusing existing offshore infrastructure for geo-energy is a transformational pivot for the UK to develop a new, limitless, home-grown clean energy source whilst supporting the economy and creating jobs."

Geothermal power generation is estimated to have grown by approximately 75 per cent in the last five years and this growth has been aided by similarly rapid developments in geothermal technology that generate power from relatively low temperatures. Consequently, the number of viable sites including existing oil and gas production facilities has increased.

Concepts including power generation from co-produced fluids from oil and gas wells saw initial research projects dating back to the early 1990s and are being developed globally. Continually improving technology has meant that the rate of development has increased, and useful amounts of power have been generated at several oil and gas sites.

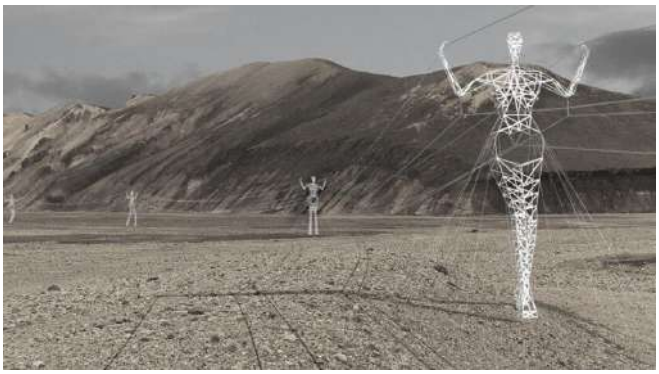
Shift Geothermal is seeking government and industry support to accelerate coordinated research and act as a catalyst for projects. It will identify and progress demonstrator and at scale projects and lobby for legislative and regulatory structures to establish geo-energy as part of the future energy mix.

Professor Jon Gluyas of Durham University and executive director of Durham Energy Institute said: "The UK has an opportunity to be a leader in how it recycles and repurposes its existing oil and gas infrastructure. Why charge ahead with decommissioning when we can rethink the future offshore sector and create new value by creating geo-energy hubs that provide clean power to existing oil and gas platforms, bring power to the shore and safeguard and create many thousands of jobs. It's simply too big a resource to be ignored."

(The Engineer, 10th November 2021, https://www.theengineer.co.uk/shift-geothermal-geo-energy)

Πυλώνες Μεταφοράς Ενέργειας στην Ισλανδία

Το έργο Shine Architects dic Pylon Competition Entry του αρχιτεκτονικού γραφείου Choi & Shine



(https://karanik.gr/2014/04/02/blog-pos-14)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΛΟΙΠΑ

Στα μαθηματικά υπάρχει Θεός

Υπάρχει Θεός; Το ερώτημα αυτό απασχολεί τους φιλοσόφους και τους θεολόγους εδώ και δεκάδες αιώνες.

Βάρβογλης Χάρης

Υπάρχει Θεός; Το ερώτημα αυτό απασχολεί τους φιλοσόφους και τους θεολόγους εδώ και δεκάδες αιώνες. Ξαφνικά πριν από λίγους μήνες εμφανίστηκε η είδηση ότι δύο ευρωπαίοι μαθηματικοί, χρησιμοποιώντας έναν ηλεκτρονικό υπολογιστή και τη σχετική θεωρία του αυστριακού μαθηματικού *Κουρτ Γκέντελ*, κατάφεραν να αποδείξουν μαθηματικά την ύπαρξη του Θεού! Το τι ακριβώς απέδειξαν και με ποιον τρόπο σχετίζεται άμεσα με την κατανόηση της Μαθηματικής Λογικής και των κανόνων που τη διέπουν.

Το θεώρημα του Θεού

Λίγο πριν από τον θάνατό του ο μεγάλος αυστριακός μαθηματικός Κουρτ Γκέντελ (Kurt Gödel) δημοσιοποίησε μια μαθηματική απόδειξη για την ύπαρξη του Θεού την οποία επεξεργαζόταν επί 30 χρόνια. Η απόδειξη αυτή βασίζεται στη σύγχρονη αξιωματική θεμελίωση των Μαθηματικών, η οποία με τη σειρά της αποτελεί συνέχεια της αρχαιοελληνικής μαθηματικής παράδοσης και της Γεωμετρίας του Ευκλείδη. Σε αυτόν τον τρόπο θεμελίωσης ξεκινάμε με τη διατύπωση αξιωμάτων, δηλαδή υποθέσεων που δεν αποδεικνύονται αλλά φαίνονται προφανείς. Στη συνέχεια, με τη βοήθεια των αξιωμάτων και της Μαθηματικής Λογικής, μπορούμε να αποδείξουμε θεωρήματα και να οικοδομήσουμε μια ολόκληρη θεωρία. Για παράδειγμα, ένα από τα πέντε αξιώματα της Ευκλείδειας Γεωμετρίας είναι το ότι όλες οι ορθές γωνίες είναι ίσες μεταξύ τους. Ο Γκέντελ προσπάθησε να «αποδείξει» την ύπαρξη του Θεού ως ένα θεώρημα ξεκινώντας από ένα σύνολο πέντε αξιωμάτων που φαίνονται «προφανή» στο πλαίσιο της Μαθηματικής Λογικής.

Η «απόδειξη» αυτή φάνηκε εξαρχής ότι είχε δύο αδύνατα σημεία. Πρώτον, είναι άραγε τα αξιώματα όντως προφανή και, δεύτερον, είναι άραγε συμβατά μεταξύ τους ώστε να μην έχουν κρυφές ασυνέπειες; Για το πρώτο δεν μπορούμε να κάνουμε και πολλά πράγματα, αφού τα αξιώματα στα Μαθηματικά μπορεί να φαίνονται «λογικά» αλλά κατά τα άλλα είναι αυθαίρετα, οπότε ο Θεός υπάρχει *αν τα αξιώματα αυτά αληθεύουν*. Το δεύτερο όμως αποτέλεσε αντικείμενο έρευνας για πάνω από 40 χρόνια επειδή έπρεπε να αποδειχθεί ότι τα πέντε αυτά αξιώματα δεν περιέχουν κρυφές αντιφάσεις και άρα είναι αυτοσυνεπή.

Το κατόρθωμα των δύο ευρωπαίων μαθηματικών, του Γερμανού **Κρίστοφ Μπεντζμίλερ** (Christoph Benzmüller) και του Αυστριακού **Μπρούνο Βολτσενλόγκελ Παλέο** (Bruno Woltzenlogel Paleo), ήταν ότι κατάφεραν να αναπαραστήσουν τα αξιώματα του Γκέντελ και τους συλλογισμούς του με μαθηματικά σύμβολα. Στη συνέχεια, με τη βοήθεια εξειδικευμένου λογισμικού που χειρίζεται έννοιες λογικής σε ηλεκτρονικό υπολογιστή, μπόρεσαν αφενός μεν να διαπιστώσουν ότι τα αξιώματα δεν περιέχουν κρυφές αντιφάσεις και αφετέρου να επιβεβαιώσουν την απόδειξη του θεωρήματος.

Ιδέα με αρχαίες βάσεις

Θα πρέπει να σημειωθεί ότι, πέρα από το καθαρά μαθηματικό μέρος, η βάση της απόδειξης του Γκέντελ περί της υπάρξεως του Θεού δεν ήταν εντελώς καινούργια αφού έμοιαζε με το επιχείρημα του άγγλου θεολόγου και φιλοσόφου του 11ου αιώνα *Ανσέλμου του Καντέρμπουρι*, το οποίο, με τη σειρά του, βασίζεται στη μέθοδο της «εις άτοπον απαγωγής» των αρχαίων ελλήνων φιλοσόφων και μαθηματικών. Ο συλλογισμός του Ανσέλμου ήταν ο εξής:

1. Ο Θεός είναι η υπέρτατη ύπαρξη.
2. Η ιδέα του Θεού υπάρχει στη σκέψη μας.
3. Μια ύπαρξη που υπάρχει τόσο στη σκέψη όσο και στην πραγματικότητα είναι ανώτερη από μια ύπαρξη που υπάρχει μόνο στη σκέψη.
4. Αν ο Θεός υπήρχε μόνο στη σκέψη μας, τότε θα μπορούσαμε να συλλάβουμε την ιδέα μιας ανώτερης ύπαρξης η οποία υπάρχει *και* στην πραγματικότητα.
5. Αλλά δεν μπορούμε να φανταστούμε μια ύπαρξη ανώτερη από τον Θεό.
6. Αρα ο Θεός υπάρχει στην πραγματικότητα.

Η βασική συνεισφορά του Γκέντελ ήταν η μαθηματική περιγραφή του παραπάνω συλλογισμού και ειδικά των σημείων 3 και 4. Εκεί χρησιμοποίησε την έννοια της *πιθανής αλήθειας* μιας πρότασης, η οποία επεκτείνει την αριστοτελική λογική που δέχεται ότι μια πρόταση είναι είτε *αληθής* είτε *ψευδής*.

1+1 κάνουν 2;

Ο Γκέντελ έγινε διάσημος σε νεαρή ηλικία όταν διατύπωσε το περίφημο «θεώρημα της μη πληρότητας». Συνέπεια του θεωρήματος αυτού είναι ότι, στο πλαίσιο της «Απλής Αριθμητικής» των ακεραίων αριθμών, η οποία βασίζεται σε αξιώματα όπως το γνωστό «1+1=2», υπάρχουν προτάσεις που δεν είναι δυνατόν να διαπιστώσουμε αν αληθεύουν ή όχι βασιζόμενοι μόνο στα αξιώματα αυτά. Οι προτάσεις αυτές χαρακτηρίζονται από μια αυτοαναφορά και το πιο γνωστό ανάλογό τους στο πλαίσιο της απλής λογικής είναι το παράδοξο του αρχαίου έλληνα φιλοσόφου Ευβουλίδη, σύμφωνα με το οποίο «αν κάποιος παραδεχθεί ότι ψεύδεται, αυτό που λέει είναι αλήθεια ή ψέμα;». Η πρόταση αυτή οδηγεί σε φαύλο κύκλο, αφού αν η πρόταση είναι αληθής συμπεραίνουμε ότι ο συνομιλητής μας ψεύδεται ενώ αν η πρόταση είναι ψευδής συμπεραίνουμε ότι ο συνομιλητής μας λέει την αλήθεια. Το θεώρημα της μη πληρότητας του Γκέντελ είχε σοβαρότατες συνέπειες στη θεμελίωση των Μαθηματικών με βάση την αξιωματική μέθοδο, η οποία στη δεκαετία του 1920 φαινόταν ότι θα κατάφερνε να ενοποιήσει όλους τους κλάδους αυτής της επιστήμης σε ένα ενιαίο οικοδόμημα. Παράλληλα όμως υπήρξε ο λόγος που του προσφέρθηκε το 1940 μια θέση στο Ινστιτούτο Προχωρημένων Σπουδών του Πρίνστον, όπου και παρέμεινε ως καθηγητής ως τον θάνατό του το 1978. Η συνεισφορά του Γκέντελ στη θεμελίωση της Μαθηματικής Λογικής αναγνωρίστηκε επανειλημμένως, με σημαντικότερο κατά τη γνώμη μου το βραβείο Αϊνστάιν του Ινστιτούτου που του απονεμήθηκε το 1951 από τον ίδιο τον Αϊνστάιν, ο οποίος ήταν συνάδελφός του σε αυτό το ίδρυμα και στενός φίλος του.

Οι συνθήκες θανάτου του Γκέντελ ήταν πολύ ασυνήθιστες και αποτέλεσαν την έμπνευση για το θεατρικό έργο «Δέκατη έβδομη νύχτα» του **Απόστολου Δοξιάδη**. Ο Γκέντελ έπασχε

από έλκος του δωδεκαδακτύλου και ακολουθούσε, με δική του πρωτοβουλία, μια πολύ αυστηρή δίαιτα. Σιγά-σιγά άρχισε να πιστεύει ότι τον δηλητηριάζουν και κατέληξε να αρνείται να φάει το φαγητό του. Το αποτέλεσμα αυτής της κατάστασης, θα έλεγε κανείς, αποτέλεσε το κορυφαίο λογικό παράδοξο *υλοποιημένο* – και όχι *διατυπωμένο* – από τον θεμελιωτή της Μαθηματικής Λογικής. Αν δεν έτρωγε, *ήταν σίγουρο* ότι ο Γκέντελ θα πέθαινε από ασιτία. Αν έτρωγε *ίσως* να πέθαινε από δηλητηρίαση – αλλά και ίσως όχι. Ο Γκέντελ, πέρα από κάθε λογική, διάλεξε ενσυνείδητα την πρώτη επιλογή – και πέθανε από ασιτία.

Ο κ. Χάρης Βάρβογλης είναι καθηγητής του Τμήματος Φυσικής του ΑΠΘ.

(https://www.tovima.gr/2014/06/28/science/sta-mathimatika-yparxei-theos)

Στα Μονοπάτια των Θεών

Το 1995 η τηλεόραση ΕΡΤ παρήγαγε και πρόβαλε μια διεθνή σειρά 8 επεισοδίων με γενικό τίτλο «ΣΤΑ ΜΟΝΟΠΑΤΙΑ ΤΩΝ ΘΕΩΝ», με την οποία επιχείρησε (με μεγάλη επιτυχία τότε) ένα οδοιπορικό στα χρυσά μονοπάτια της Ελληνικής Μυθολογίας, προβάλλοντας παράλληλα την ομορφιά του ελληνικού τοπίου και των αρχαιολογικών χώρων μας.

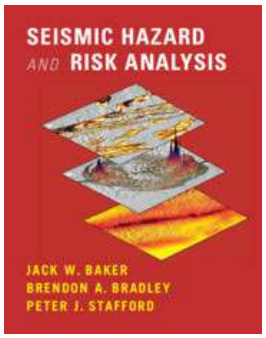
Αφηγείται τις ιστορίες των Ελλήνων θεών, ανατρέχει στις ρίζες της ελληνικής μυθολογίας, εξηγεί τις αντιπαλότητες μεταξύ των θεών και εξερευνά την ανθρώπινη αναζήτηση για νόημα στις χαοτικές δυνάμεις της φύσης και του σύμπαντος θυμίζοντας το σύγχρονο κοινό τη σημασία των μύθων και των θρύλων για τη δική μας εποχή.

Την προσαρμογή των κειμένων, καθώς και την παρουσίαση, είχε επιμεληθεί ο διεθνώς καταξιωμένος ηθοποιός Sir Peter Ustinov.

https://www.youtube.com/watch?v=c2cfP3ZxfZw

Από 00:00 Ζευς Ο Βασιλιάς Των Θεών
Από 27:35 Αθηνά Και Αφροδίτη Η Σοφία Και Το Κάλλος
Από 52:07 Ποσειδώνας Ο Άρχοντας Των Θαλασσών
Από 01:17:25 Δήμητρα Το Θαύμα Της Γονιμότητας
Από 01:41:51 Απόλλων Αρμονία Και Φως
Από 02:06:15 Διόνυσος Η Χαρά Της Ζωής
Από 02:30:40 Άρτεμις Το Αγκάλιασμα Της Φύσης
Από 02:55:22 Άρης Και Έρις Φιλονικίες

ΝΕΕΣ ΕΚΔΟΣΕΙΣ ΣΤΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΠΙΣΤΗΜΕΣ



Seismic Hazard and Risk Analysis

Jack Baker, Brendon Bradley, Peter Stafford

Seismic hazard and risk analyses underpin the loadings prescribed by engineering design codes, the decisions by asset owners to retrofit structures, the pricing of insurance policies, and many other activities. This is a comprehensive overview of the principles and procedures behind seismic hazard and risk analysis. It enables readers to understand best practises and future research directions. Early chapters cover the essential elements and concepts of seismic hazard and risk analysis, while later chapters shift focus to more advanced topics. Each chapter includes worked examples and problem sets for which full solutions are provided online. Appendices provide relevant background in probability and statistics. Computer codes are also available online to help replicate specific calculations and demonstrate the implementation of various methods. This is a valuable reference for upper level students and practitioners in civil engineering, and earth scientists interested in engineering seismology.

- Focuses on concepts and procedures rather than the details of scientific models, allowing the topic to be broadly accessible
- Collects and synthesizes work from currently disparate fields, showing how they fit together
- Draws on the authors' decades of experience as researchers and practitioners in the field

Reviews & endorsements

Advance Praise: 'An enormously valuable contribution, which teachers and students of seismic hazard analysis have been crying out for. Baker, Bradley and Stafford have produced a clear and comprehensive textbook for students, practitioners and end-users that I predict will lead to a significant and lasting improvement in the state-of-practice over the coming years.' Dr Julian J Bommer, Seismic Hazard and Risk Consultant

Advance Praise: 'Seismic hazard and risk analysis has become so complex as to be regarded by many as an opaque, mysterious topic only to be understood by a small group of specialists. With this book, the veil has been lifted. It should be on the shelves of all serious students, practitioners, and researchers in the areas of seismic hazard analysis, earthquake engineering, and risk analysis.' Professor Steve Kramer, University of Washington

Advance Praise: 'The authors' profound knowledge and understanding of the interdisciplinary fields used in seismic hazard and risk analysis, and their own remarkable contributions to it, have yielded a comprehensive foundation for its more uniform, rigorous and advanced practice worldwide.' Dr Paul Somerville, AECOM, Los Angeles

(Cambridge University Press, October 2021)

ΗΛΕΚΤΡΟΝΙΚΑ ΠΕΡΙΟΔΙΚΑ

https://www.issmge.org/filemanager/article/950/ISSMGE_BULLETIN_2021_OCT_FINAL.pdf

Κυκλοφόρησε το Τεύχος 5 / Τόμος 15 Οκτωβρίου 2021 του ISSMGE Bulletin με τα ακόλουθα περιεχόμενα:

- President's message
- ISSMGE Time Capsule Project
- Case study
  An innovation method of assessing the capacity of existing wharf piles, Australia
- Conference reports
  XIX Technical Dam Control International Conference, Poland
- ISSMGE Foundation reports
- Obituary – Prof. Paul Marinos
- Event Diary
- Corporate Associates
- Foundation Donors

GeoWorld

Geo-Trends Review
Issue #17 - November 2021
www.mygeoworld.com/geotrends/issues/17-november-2021

News and Information Circular - November 2021
ISSMGE 02 Nov 2021. Read More

Prof. Adda Athanasopoulos-Zekkos on CNN's J. Vause show discussing climate change and infrastructure news 05 Sep 2021

I had a great conversation with CNN's John Vause, on his show last week, on the impact of #climatechange and the need for continued investment in #infrastructure. Read More

Sonic Integrity Tests

Carlos Fernandez, In-situ Testing, 29 Oct 2021. Read More

Future of Geotechnics - Records available! Lucy Wu YMPG, 24 Oct 2021

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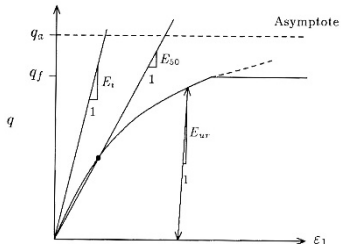
Numerical Modelling: The Hardening Soil Model

Geoengineer.org, news, 14 Sep 2021



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15-min short videos coordinated by TC304 Young Group (Andy Leung, Zijun Cao & Lei Wang)

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Geo-Challenge 2022 Rules Announced

Binod Tiwari, Geo-Challenge 2022, 03 Oct 2021

Dear all, The National Geo-Challenge 2022 Student Competitions will be organized on March 21, 2022, during the Geo-Congress 2022 at Charlotte, North Carolina. Please see below the link to the files... Read More

International Symposium on Risk and Insurance of Engineering

ISSMGE group, 20 Aug 2021

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Adda Athanasopoulos-Zekkos, news, 27 Aug 2021

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SOA paper on Numerical modelling of large deformation problems

ISSMGE TC103, 20 Oct 2021

We are pleased to announce that the paper "Numerical modelling of large deformation problems in geotechnical engineering: a state-of-the-art review " by C. E. Augarde,... Read More

In Memoriam: Distinguished Professor Paul G. Marinos (1944-2021)

Geoengineer.org news, 19 Oct 2021

The following obituary was prepared and presented by the International Association for Engineering Geology and the Environment (IAEG): "May the earth be light to you, rest in peace Prof. Paul Marinos [..]" Read More

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Bentley Systems YII2021, 27 Sep 2021

The Bentley team is back and ready for another amazing Year in Infrastructure and the 2021 Going Digital Awards virtual event featuring Bentley executives, Siemens, AEC Advisors, and our Going Digital Award winners! Join Bentley virtually on December 1 and December 2 for the latest executive insights and attend the event to learn how the people behind the award-winning projects made amazing impacts in cities, energy, mobility, project delivery, and water. Read More

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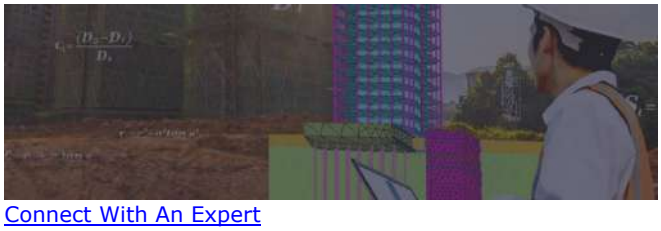
Bentley Systems, Digging Deep for Safe Solutions



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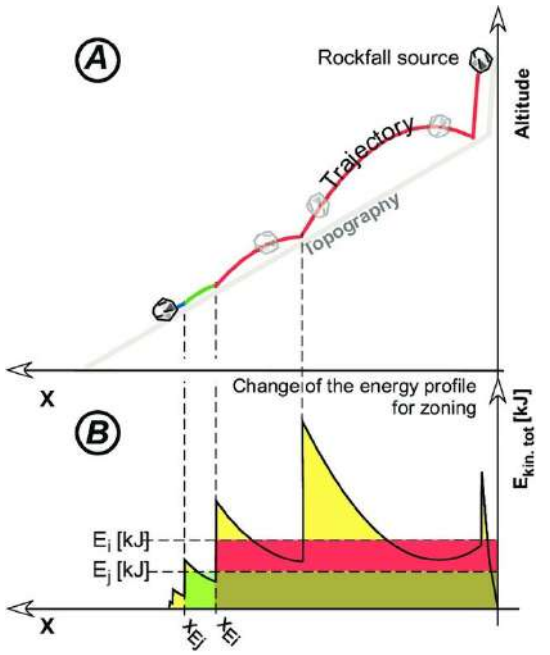
The effect of rock shape on rockfall risk assessment

Geoengineer.org news, 16 Oct 2021



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Bentley Education Program Expands to Global Scope

Bentley Systems Education, 29 Oct 2021

Now, with global expansion, the Bentley Education program is accessible to all students and educators at middle schools,

high schools, community colleges, polytechnics, institutes, and universities across the world... Read More

New TC304 Course on "Probability Analysis in Civil Engineering" by Dr. Jie Zhang

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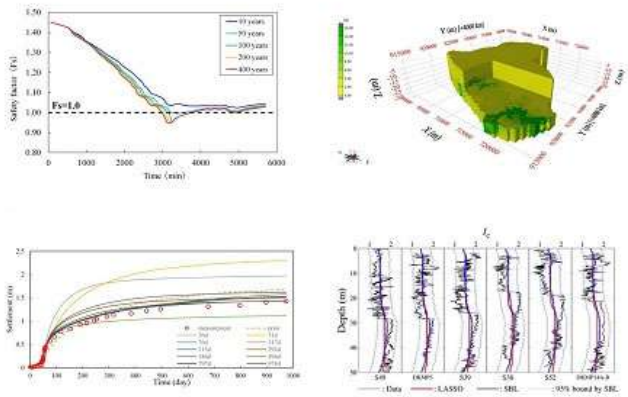
International Journal of Geoengineering Case Histories news, 08 Nov 2021



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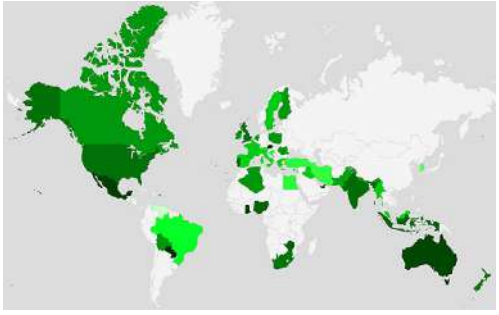
GeoWorld



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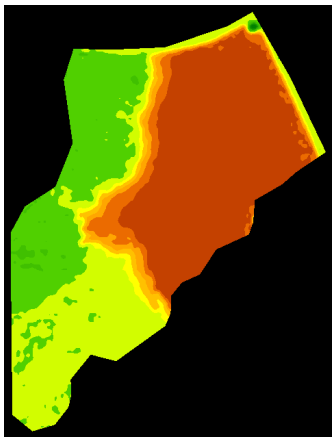

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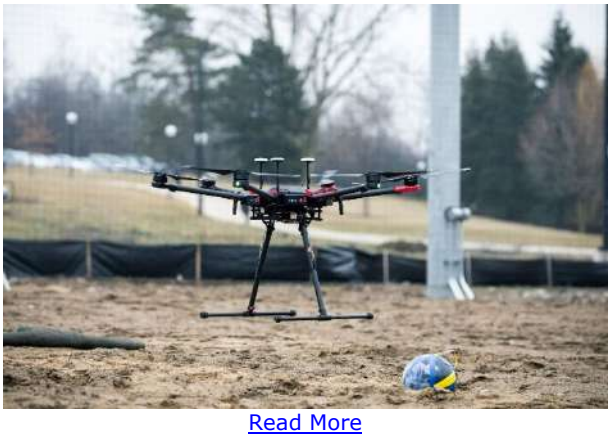
Dimitrios Zekkos, news, 27 Aug 2021



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ISSMGE Resources and Information

Lucy Wu / YMPG, 24 Oct 2021

Here are some information on how to stay up-to-date on ISSMGE activities as well as resources that the Society is providing to its members: https://www.myge-oworld.com/file/139843/information-for-ym ... Read More

Case studies of full-scale lateral loading of piles – University of Blida

Ali Bouafia / group, 01 Sep 2021, Read More

China considers shutting down numerous dam facilities

Geoengineer.org, news, 09 Sep 2021

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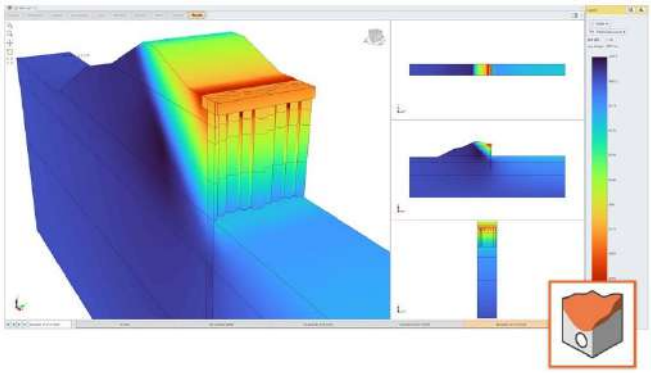
3D Finite Element Analysis of a Contiguous Pile Wall

Geoengineer.org, news, 15 Sep 2021



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International Geosynthetics Society

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

IGS NEWSLETTER – November 2021

Helping the world understand the appropriate value and use of geosynthetics

httpwww.geosyntheticssociety.org/newsletters

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- Pete Stevenson (1940 - 2021) READ MORE
- Upcoming Webinars
  - Durability of polyethylene geomembrane materials, November 23, repeated November 30 Presented by Boyd Ramsey REGISTRATION INFORMATION
  - Sustainable Applications of Green Geosynthetics Engineering, November 24 Presented by Prof. Nelson Chou REGISTRATION INFORMATION
  - Geosynthetics in Gas Harvesting and Renewable Energy, November 25 Presented by Graham Fairhead REGISTRATION INFORMATION
  - Spanish Webinar: Reinforced Soil Works Province of Santander del Sur – Colombia, November 30 Presented by Eng. MSc. Mario H Ramírez Carrero REGISTRATION INFORMATION
- Calendar of Events

www.iaeg.info

Κυκλοφόρησε το Issue No. 3, 2021 του Newsletter της IAEG με τα ακόλουθα περιεχόμενα:

- News of Executive Committee Meeting
- News of Coucil Meeting
- News of 1st Sarc
- News of 3rd Erc
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