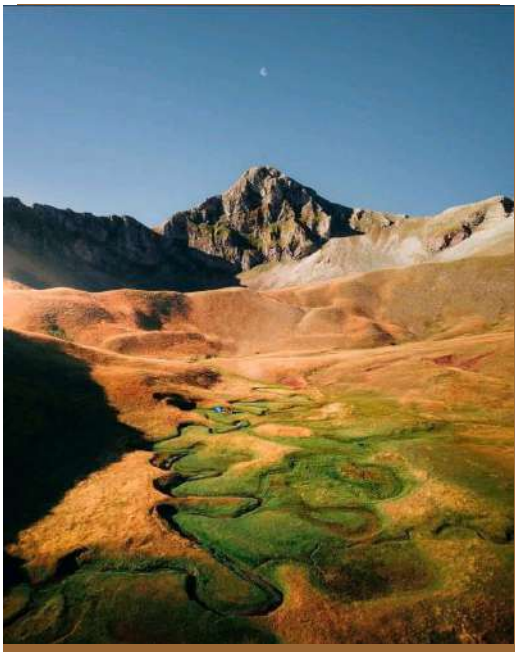


Δρακολίμνη

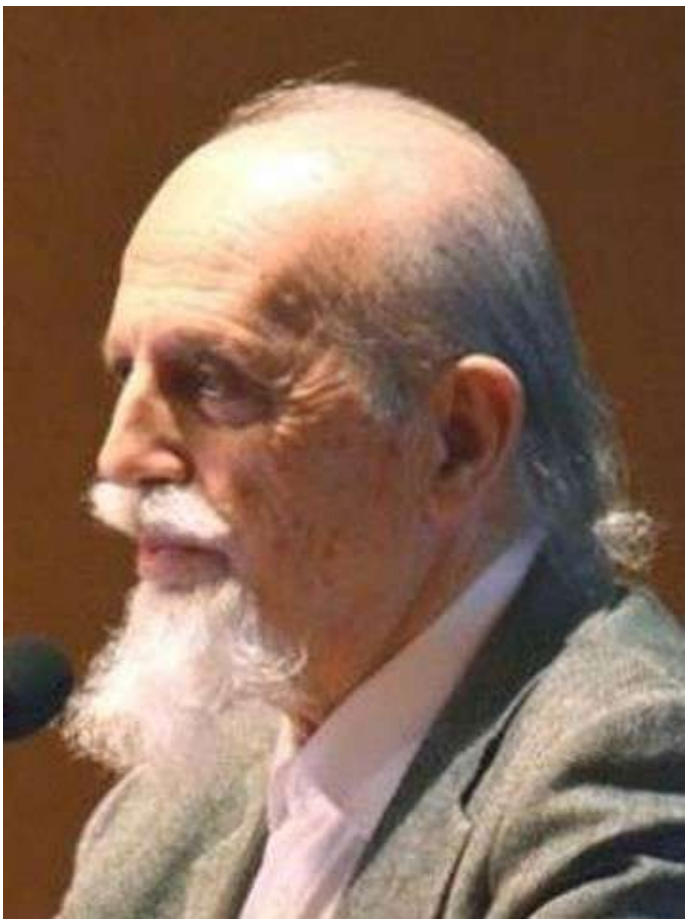
Αρ. 155 – ΟΚΤΩΒΡΙΟΣ 2021

ΕΛΛΗΝΙΚΗ ΕΠΙΣΤΗΜΟΝΙΚΗ ΕΤΑΙΡΕΙΑ ΕΔΑΦΟΜΗΧΑΝΙΚΗΣ & ΓΕΩΤΕΧΝΙΚΗΣ ΜΗΧΑΝΙΚΗΣ

Τα Νέα της Ε Ε Ε Ε Γ Μ

155

Στον Θεοδόση Τάσιο ο τίτλος του Master από την International Association for Earthquake Engineering



Ο Θεοδόσιος Τάσιος, Ομότιμος Καθηγητής του ΕΜΠ, τιμήθηκε με τον τίτλο του Master από τη Διεθνή Ένωση Σεισμικής Μηχανικής - International Association for Earthquake Engineering (IAEE).

(συνέχεια στην σελίδα 3)

Π Ε Ρ Ι Ε Χ Ο Μ Ε Ν Α

(συνέχεια από την 1η σελίδα)

17WCEE 17th WORLD CONFERENCE ON EARTHQUAKE ENGINEERING
With Bosai / Disaster Management Expo in Sendai
At Sendai International Center, Sendai, Japan (Hybrid Conference)

IAEE

"Masters" Program

Meet / Greet 2020

Theodossios P. TASSIOS (Greece)

The 17th World Conference on Earthquake Engineering Sendai, Japan, September 14-17, 2020

Based on such a fundamental philosophy, a research group worked with Tassios since 1970, including Greek as well as some Chinese and Italian students.

Early enough, one of the research topics of Tassios' Group was the rational re-dimensioning of structural elements after repair and seismic strengthening - a subject that was not perhaps being studied as intensively, internationally, as the non-linear analysis of existing structures.

Tassios and several members of his group served on various international professional associations (CEB, FIP, European Union), in drafting State-of-the-Art reports and Code-texts on seismic behaviour and design of structures.

In his own country, he drafted (in collaboration with his student G. Gazetas) and proposed the first modern Seismic Design Code of Greece (1978). And, as a Chairman of a National Committee (since 2001), he edited one of the first, internationally, design Codes on Seismic Repair and Strengthening,.

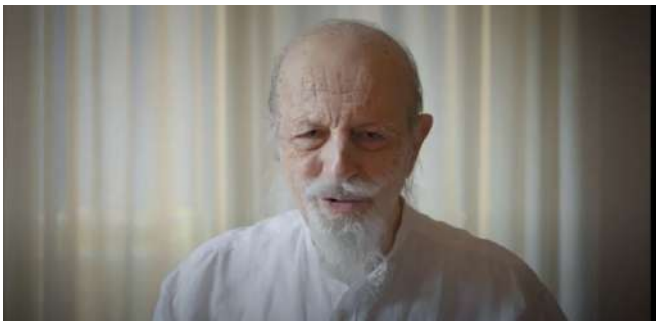
Seismic behaviour of masonry structures was another research field of Tassios. Hence his long-lasting activities related to the seismic resistance of monuments: European Union mission regarding colonial churches (Popayan, Colombia, 1991), the "1st Ambraseys Lecture" (14 ECEE, 2010), etc.

Of his non-engineering activities, I only wish to mention Tassios' honorary Presidentship of the Hellenic Society of Philosophy, as well as his role as founder and President of the Society for the Investigation of Ancient Greek and Byzantine Technology (EDAByT)

Dr. Eng. Elizabeth VINTZILEOU, Professor NTUA

Μαζί με τους άλλους τρείς τιμηθέντες με τον ίδιο τίτλο, ο Θ. Τάσιος προσεκλήθη και συμμετείχε στο «Meet the Masters» του 17ου Παγκόσμιου Συνεδρίου Σεισμικής Μηχανικής - 17th World Conference on Earthquake Engineering - που έγινε στην πόλη Sendai, Ιαπωνία, 27/9-2/10, 2021 (εξ αναβολής από το 2020, λόγω πανδημίας).

Οι Masters απευθύνθηκαν, ο καθένας σε ξεχωριστή συνεδρία, στους συνέδρους. Απολαύστε την ομιλία του Θ. Τάσιου στο παρακάτω βίντεο (youtube). Προηγείται εισαγωγή από τον Πρόεδρο του IAEE και τη στενή συνεργάτιδα του Θ. Τάσιου, Έλλη Βιντζηλαίου, Καθηγήτρια ΕΜΠ, και ακολουθεί, με εκκίνηση στο 8:18, η ομιλία.



https://www.youtube.com/watch?v=dWly-g_WOhI

Μετά το BIM...

What is a digital twin?

A digital twin is a complex digital representation of a physical thing with a real-time connection. It is an assembled aggregation of data captured by other tools, usually including a 3D model.

A digital twin in the construction industry spans the lifecycle of a project, from the beginning (planning and building), to the middle (operating and improving), to the end (decommissioning and disassembling the asset in a sustainable and cost-effective manner). For the construction industry, digital twins can play a profound role in how owners manage built assets, and how consumers interact with these structures.

Digital twins enter

The Covid pandemic and advances in computing are pushing the use of 'digital twins' into the construction mainstream. But experts say we are only beginning to see the implications for the technology. Lucy Barnard reports

Surrounded by grey water as far as the eye can see, the Clair Ridge oil platform off the coast of Shetland is a pretty remote spot in which to be carrying out routine maintenance.

But the technicians in blue overalls and hard hats abseiling down the side of the vast structure in Scottish territorial waters in the North Sea are connected to thousands of up-to-date maintenance reports and work instructions using digital twin technology as well as to dozens of other team members back on the mainland.

Using an iPad, workers on the remote platform can access a digital replica of the entire off-shore platform to check maintenance records and engineering data for each of the components they inspect.

At the touch of a screen they can access data from sensors throughout the platform which monitor everything from flow rates to temperature to wind speed. And any work or unusual findings can quickly be logged onto the digital twin.

"The implications for digital twin technology are huge," says Lee Tedstone, global VP, head of digital project execution at software developer Aveva, which worked with a team led by BP on the project. "We can use augmented reality where people use technology to see part of the digital twin. That means the guy conducting maintenance on the oil platform can look at each component and see its operational performance, scheduled maintenance etc."

Faced with a sudden need to maintain social distancing and enable more staff to work from home during the pandemic, more and more big oil, energy, construction and engineering companies have been speeding up their plans to create digital twins.

"We had quite a few customers coming to us in March/April 2020 with requests to help them keep the workforce connected through our online software offering for unified project delivery," says Tedstone.

"People had to work remotely, but company infrastructures were generally not geared to manage heavy remote working, in particular with their 3D design solutions. We saw a huge uptake in our offering during that time which in turn accelerated a lot of digitalisation initiatives forward. By having the software in the cloud it was easier to access therefore driving productivity."

But this is just the beginning. As advances in technology enable companies to harness the Internet of Things to constantly measure the things that they are building and operating, digital twins provide a good way to keep track of that real-time data and use it in a meaningful way.

JUST HOW BIG IS THE DIGITAL TWIN MARKET?

A survey by market research company Markets and Markets predicted that the global digital twin market is set to increase to €41.5 billion by 2026 – more than 15 times its size in 2020. Construction companies are expected to be among the biggest drivers.

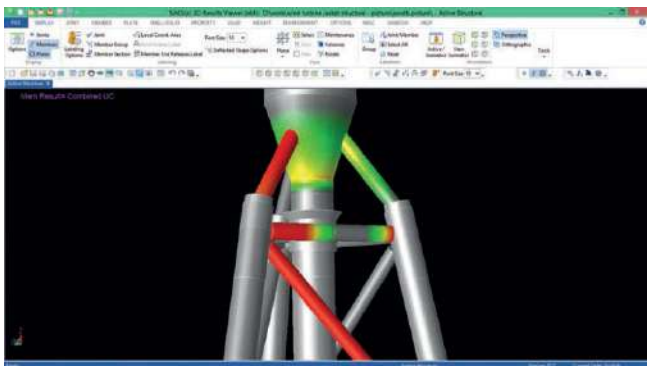
"Digital twin technology is one of the fastest growing concepts in the construction industry," says Frank Weiss, senior director for new products at Oracle Construction and Engineering, an arm of computer giant Oracle which specialises in developing software solutions for construction firms. "Digital twins can play a profound role in how owners manage built assets, and how consumers interact with these structures."

Weiss says that digital twins can make the construction process quicker and faster and help teams work together better using more up-to-date information, especially if teams are working on a project from different physical locations.

"Today's organisations want to consolidate as much as possible into a single, cloud-based platform, and eliminate on-premise silos of duplicate information," Weiss says. "A digital twin helps ensure that team members will be working off the latest data analytics for a project, including those for repeatable processes that are being built offsite. It can help act as the cornerstone for prefabrication and can play a prominent role in achieving efficient communication and construction business processes."

And, he says, the information from the digital twin can then be used in computer simulations to predict how a project will perform over time – providing information which can then be used by the designers and engineers to optimise their designs before work has even started.

"A 4D simulation [over time] provides the context and chronology to create simulation scenarios in the digital twin," he says. "It helps the design and engineering phase of a construction project by expediting and automating traditional design, production, and operational processes. It will identify opportunities to improve the construction of an asset as the project is evolving."



Rich Humphrey, vice president of construction product management at another software firm, Bentley Systems, agrees. He points out that unlike Building Information Modelling (BIM) software, which has been used to varying degrees in construction for the past twenty years, digital twins provide real-time information about projects, making them invaluable on construction sites where designs can be altered based on the conditions in the field.

"A digital twin is a realistic digital and dynamic representation of a physical asset, process, or system in its built environment," he says. "The keyword is dynamic and that is what distinguishes a digital twin from any other static model. It's living. It's changing along with the physical asset."

Humphrey says his teams start work on digital twins before construction has even started, capturing existing conditions on site such as survey results and encapsulating design models and engineering data from the design phase. Then, on-site sensors can monitor construction conditions in real time.

"Digital twins can significantly benefit the construction industry, helping users make data-driven decisions and achieve more predictable outcomes," he says. "They quickly allow users to perform construction sequences and simulations, so that they can detect and resolve errors before construction begins which reduces time for project teams and, therefore, costs for the owner."

By buying materials early and plugging the data from it into a digital twin, software firms say contractors can start engineering components such as piping 3-4 months earlier than would otherwise be possible, reducing overruns and bringing construction projects closer to budget.

HOW ARE DIGITAL TWINS USED IN CONSTRUCTION?

And, once a digital twin is built, the sky is pretty much the limit in terms of the sort of simulations you can perform. Engineers can assess how a structure would be likely to behave when faced with freak high winds or earthquakes.

They can run a test to see how a structure will perform over twenty or fifty years. They can look at what would happen if they changed a key part of the structure or designed it with cheaper materials.

DIGITAL TWIN TECHNOLOGY FOR CONSTRUCTION DESIGN AND ENGINEERING

Florent Thebault, areas sales director for Southern Europe at simulation software specialist Ansys, works with companies looking to understand how to design and engineer their products more efficiently.

Computer simulations of digital twins can give clients information about just how long each component can keep working efficiently, he says. Replacing a pipe too late could cause a costly and dangerous leek - but replacing them too early is a waste of money, time and global resources.

"You can optimise the efficiency and profitability of the company," he says. "So, simulation can ensure that a cable is not too small so it might break and you can also ensure it is not too big. So I can use a smaller or cheaper cable perhaps and save money or I can be faster to produce it. You can play with several parameters to optimize your design."

And, as part of a team helping to build the vast International Thermonuclear Experimental Reactor (ITER) experiment in the South of France which is hoping to produce nuclear fusion, Thebault is at the cutting edge of seeing where simulation technology could lead.

"The main value of simulation lies in being able to physically represent all the phenomena on the computer," Thebault adds. "It opens all the doors to testing in very difficult environments like space or deep seas. All of this kind of stuff can now be possible on the computer."

At ITER, where teams of scientists are building the world's largest nuclear fusion reactor by heating plasma into extreme temperatures and confining it within a superstrong electromagnetic cage or tokamak, Thebault says the technology really comes into its own.

PRACTICAL USE OF A DIGITAL TWIN

"For the ITER tokomak this is where simulation is making sense," he says. "We don't have any real prototype of the ITER tokomak but we can take the data of the materials and virtually test it in that environment. That it means that you are sometimes going to discover more in the research mode of what might be the results that you can expect in that situation that we have never faced."

As a result, Thebault says, Ansys has been able to help design and engineer key components of the experiment including the vacuum chamber, the cooling system and the microwave antenna which heat gas up to 150m degrees to turn it into plasma.

Aveva's Tedstone too believes that the full potential of digital twins is only starting to become apparent. Once companies get used to the concept, he believes it could revolutionise the way in which companies look at their environmental impact.

His aim is to include data on the amount of carbon produced by each component on a project in its digital twin in the same way that cost is currently treated, enabling engineers to model a structure's environmental impact over time and to procure and construct in the most sustainable manner.

HOW WILL DIGITAL TWINS DEVELOP IN CONSTRUCTION?

"When our customers are buying materials, we could include information from a government online catalogue of materials providing them with an associated carbon score," he says. "We could then give our customers the option of buying materials from place A or place B but place A has a much better sustainability initiative. You start making those types of decisions."

But, despite the optimism, many in the construction industry remain to be convinced. Sceptics point to the fact that many large companies in the sector are struggling to implement digital twins because they have legacy systems which are incompatible with the technology, or do not currently employ staff with the skills and training to be able to use the technology at scale.

"The use of digital twin is still in the early stages in the construction industry," admits Bentley's Humphreys. "Building Information Models [BIMs] aren't even that widespread."

"But the good news for those that have BIM, the gap isn't that big to take them to a digital twin and we don't suspect it will take long," he adds. "However, for those users in construction who haven't even embraced model technology as part of their contract, may take a little longer to transition to a fully digital world."

(CONSTRUCTION EUROPE, October 2021, pp. 22-24, https://digimag.construction-europe.com/magazine/reader/220993).

Deep innovations

In construction, nothing goes up before first going down. Mike Hayes looks at some foundations challenges and their imaginative solutions

In France, one of the largest and most ambitious infrastructure projects in Europe is ongoing – the Grand Paris Express.

When completed, the new metro network will reduce road traffic in the French capital, improve air quality and, hopefully, make the lives of Parisians a little easier.

The project encompasses the extension of line 14 of the metro and the construction of new lines 15, 16, 17 and 18. Along with approximately 200km of new lines, some 60 new stations are being constructed. In total, the planned investment for the network is more than €35 billion.

Capital Solutions

Undertakings of this magnitude can only be built on the most robust foundations, which is where the Trevi Group comes into the equation.

The company is undertaking foundation work as part of the construction of the underground stations of Paris' Le Bourget Airport, Aulnay and Saint-Denis Pleyel, set to be the largest of all the Grand Paris Express stations and crossed by tunnels of lines 14, 15 and 16.

Marcello Varese, project director at the Saint-Denis Pleyel station says it is "the main station of the whole Grand Paris project, as it connects four metro lines with two railway lines and is located near the Stade de France [the national sports stadium of France]."

What makes the station unique is its 9000m^2 surface area, as well as the fact that Trevi is undertaking excavation here using the 'top down' method. In fact, in order to allow the 'top down' excavation, it was necessary for the company to add 36 plunge columns, which allow simultaneous superstructure construction and basement excavation.

So, not only did Trevi construct 141 structural diaphragm wall panels, it also fabricated 36 plunge columns, each weighing 90 tonnes and which had to be laid to a depth of 36m. According to Trevi, this is a first.

Trevi is undertaking groundwork across the Grand Paris Express project, with one of the first items on the agenda being land treatment; consolidating the treated soil and significantly lowering the level of groundwater to ensure tunnels can be excavated safely.

Trevi is also involved in the excavation of a number of service shafts by tunnel boring machines (TBM), which will allow access for rescue and evacuation of passengers, ventilation and power supply.

These shafts run to significant depths and require the construction of reinforced retaining walls through diaphragm walls that can sometimes reach more than 60m in depth.

For these applications, Trevi is using drilling equipment including advanced heavy-duty buckets and hydromills.

Square Drills in Round Holes

Just as the Grand Paris project attempts to future-proof the capital city, in terms of transportation, Bauer Maschinen is looking to the future of megacities with its latest technology.

In cooperation with construction firm Denys, Bauer has developed the 'Cube system' of underground cutting equipment, which allows for the construction of, for example, subway stations, in busy urban areas, with greatly reduced noise, dust and traffic upheaval.

The cube milling system is based on Bauer's existing cutting technology, but with the cutters fitted into a container-sized frame, which can be individually lowered into a shaft.

The cube system can then progress along microtunnels with diameters as small as 3.8m, milling diaphragm walls.

Dr Rüdiger Kaub, managing director of Bauer Maschinen, says, "Imagine you're planning a new subway line in a densely populated metropolis.

"With our BAUER Cube System…this is now possible. It can be used exactly where the new subway station is to be built: underground – under the existing buildings!

"This opens up completely new possibilities for planners and architects."

The Cube system is still being tested by Bauer and Denys, but is expected to be fully developed and launched before the end of this year.

The River and the Rig

Where laying foundations is challenging on land, on the water things can get complicated in the extreme.

Such is the case with the foundations for Norway's longest railway bridge over the River Vorma in Minnevika, which is being undertaken by Aarsleff Ground Engineering.

Aarsleff was engaged by PNC, a company owned by Porr, to carry out the piling works for the foundations of the bridge. The construction consists of 20 pier shafts with 280 friction piles, which Aarsleff has to drive into the ground.

Dennis Jensen, senior project manager with Aarsleff, says, "Before rail traffic is permitted, the piles must rest for at least two years. The design challenge lay in achieving the ground bearing capacity because the rock lies so deep, therefore inclined piles were required. The project is situated in an inland lake, which makes the transportation of large machines and large materials much more difficult."

Aarsleff decided to us a Liebherr LRH 600 piling rig with fixed leader system for the task. Jensen says, "We decided for this machine because of the possible hammer sizes for inclined piles. It is very strong and stable.

"We have to drive in the piles with an inclination of up to 1:5 and the hammer size was an important requirement both for Aarsleff and also the capacity of the LRH 600. Liebherr was the only supplier that could fulfil our technical requirements with a short notice and deliver a carrier machine and leader as a complete package."

Aarsleff brought in a Liebherr HS 895 HD duty cycle crawler crane as the carrier machine, positioning it on a barge, from which the rig has to drive half of the piles into the bed of the river.

Each of these mighty piles is 58m long, with a diameter of 1016mm and a weight of 29 tonnes.

Jensen says, "The stability of the piling rig on the barge is surprising. Even with strong currents we can position the piles within the tolerances specified for the project in water 12-14 m deep."

Drilling in the digital age

On the site of a hospital to be built in Oberwart, Austria, deep foundations specialist Züblin Spezialtiefbau introduced connected Liebherr equipment to prepare the land for construction work.

In an area of 23000m2, Züblin was tasked with installing 1,310 piles in preparation for the hospital building. The piles are being installed using the continuous flight auger (CFA) method, with an anticipated construction period of approximately four months.

Züblin brought in a Liebherr LB 28 drilling rig for the job, equipped with the LIPOS positioning system, as well as a Liebherr THS 110 concrete pump in support.

How the System Worked

First, the total construction area was measured, with the location of each of the piles accuracy identified. This data was used to create a drilling plan, which was fed into the on board LIPOS system.

The operator was able to see the position of the rig at all times, with centimetre accuracy, moving easily between drilling points – no stakes or colour markings are required.

Using the LIPOS technology, the operator was able to handle the rig more quickly and flexibly, without having to worry about watching for ground markings or the concrete hose. The optimal drilling plan is also programmed into the LIPOS system.

Liebherr says that, without the system, the drilling points would have to be newly measured, drawn and marked at least three times a day.

Ultimately, Züblin was able to complete the contract in just three months; one month earlier than planned.

Site manager Harald Fugger says "The LIPOS positioning system is ideally suited for completing jobsites, especially using the CFA method. It has proven itself well on the jobsite and makes working processes easier allowing continuous real time control and monitoring.

"Quality management is considerably improved through the automatic recording of the processes. The LIPOS system is basically self-explanatory for the operator and convinces through easy handling."

In Gothenburg, Sweden, the Karlastaden development, which includes no fewer than nine high-rise buildings. One of these is the 245m-tall Karlatornet tower, the tallest building in Scandinavia.

Having completed its tasks on the Karlatornet project, specialist construction solutions firm Groundforce is now working on the adjacent building, Capella.

The basement of this building measures 72m long by 60m wide, with a cut-out in one corner. The excavation is only between 2m and 3m deep, but comprises soft clay soil, meaning the sheet-piled retaining walls require support ahead of the basement slab being cast.

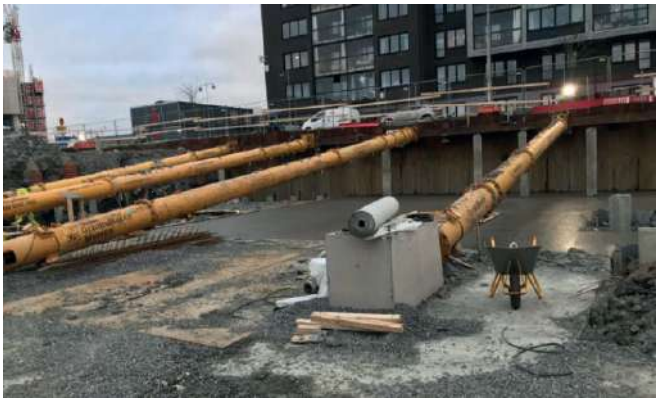
Due to the irregular heights of the basement sides, Groundforce braced the retaining walls across the corners with 150 tonne capacity MP150 hydraulic props as 'knee' braces.

These raking props transfer the lateral loads from the waling beam to concrete thrust-blocks cast into the floor of the excavation.

Groundforce's European sales manager Sam Oldroyd says "All the loadings were supplied by the client's consulting engineer and it was then a simple matter of sizing the equipment.

"The modular design means our props can be incredibly flexible. You can quickly modify the length by adding or removing components.

"In total, the Phase 2 excavation required only four MP150 knee-braces and four MP150 raking props. If we can reduce the number of props required, that will drastically cut down on transport and cost."



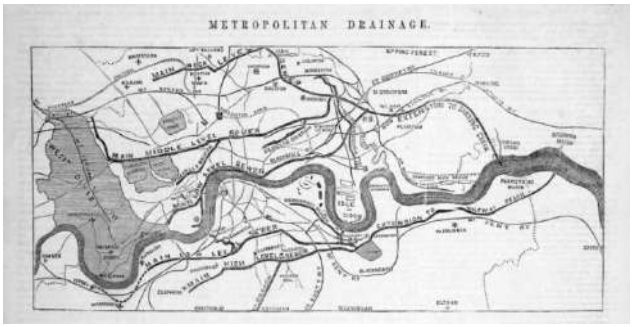
https://digimag.construction-europe.com/magazine/reader/220993).

Going underground: Tunnelling triumphs from The Engineer archive

It takes a lot more than the sea, a river or urban development to stop an engineer building the infrastructure that will help transport or improve the health of millions of people.

This can involve the perilous task of building tunnels and in 1858 a major tunnelling endeavour was required to save London from The Big Stink, a putrid stench that had befallen the capital.

June 1858: Commissioning London's sewers



MPs finally got to grips with London's growing waste problem when it literally got up their noses. The Big Stink – caused by a combination of hot weather and untreated human waste and industrial effluent – had forced MPs from the House of Commons, prompting them to rush a bill through parliament to build a new sewage system. The Metropolitan Board of Works' chief engineer, Joseph Bazalgette, was responsible for designing and building the huge system of intercepting sewers, which is still in use today.

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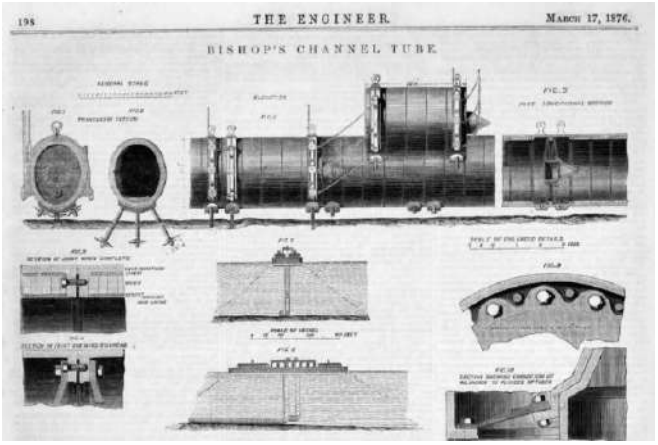
March 1876: Building a Channel Tunnel



Excavation is one of the greatest challenges in any tunnel project, and in 1876 *The Engineer* was in no doubt about the future success of plans by Sir John Hawkshaw and Sir James Brunlees, founders of the original Channel Tunnel Company, who proposed a 31-mile tunnel link.

"For the execution of the work, as far as mechanical aid is concerned, there need be no apprehension, there now being ample means in the way of tunnelling machinery, and ample experience in its extensive use," said The Engineer's correspondent.

Despite The Engineer's enthusiasm, a tunnel wasn't completed for another 118 years.

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March 1869: The Tower Subway

It might seem counterintuitive to build a tunnel in place of a bridge, but that was the situation in 1869 when The Engineer reported on the Tower Subway in London. An attempt to bridge the River Thames had failed in 1863 because of 'the great height required for the passage of ships'. This problem was eventually solved by Tower Bridge, but before it came Peter Barlow's Tower Subway, itself a forerunner of the modern deep-level Tube.

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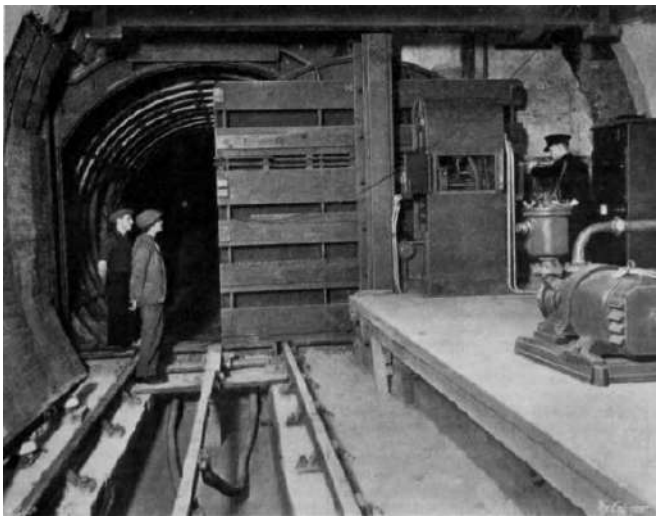
December 1939: Protective works on underground railways



With Britain's population being urged to Keep Calm and Carry On, passengers on London Underground were faced with the prospect of flooding as a result of bombing by the Luftwaffe. To mitigate the risks of flooding, a solution was found that literally closed the floodgates and sealed tunnels from the ingress of water.

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2012: Excavating Crossrail's tunnels

In just over three years, eight tunnel boring machines dug below London's streets to construct 42km of new rail tunnels for Crossrail, Europe's largest civil engineering project. When complete, new trains will run over 100km from Reading and Heathrow in the west, through new tunnels under central London to Shenfield and Abbey Wood in the east. In doing so, the project is predicted to bring an additional 1.5 million people within 45 minutes of London.

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2014: Thames Tideway tunnel

Joseph Bazalgette's Victorian sewers stand out as a highlight of Victorian tunelling, but even he couldn't have anticipated demands on a system that must now serve around 8.7 million Londoners. Bazalgette's low-level interceptor sewers fill up and overflow into the Thames, a situation that will be resolved by diverting overflow into the new tunnel instead of the river.

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2015: The world's longest immersed tunnel

Designed to be constructed from vast pre-fabricated concrete sections that will be installed in trenches on the seabed up to 35m beneath the surface, the 18km Fehmarnbelt tunnel will comprise twin railway lines, four motorway lanes and a separate emergency tube. The tunnel, which will connect Denmark with Germany, will be five times longer than the current record-holder, the Øresund tunnel, which is also in Denmark.

REVISIT THE ENGINEER'S ARCHIVE HERE

(Jason Ford / THE ENGINEER, 22nd November 2017, https://www.theengineer.co.uk/tunnelling-tunnels)

Integrating empirical models and satellite radar can improve landslide detection for emergency response

Katy Burrows, David Milledge, Richard J. Walters, and Dino Bellugi

Abstract

Information on the spatial distribution of triggered landslides following an earthquake is invaluable to emergency responders. Manual mapping using optical satellite imagery, which is currently the most common method of generating this landslide information, is extremely time consuming and can be disrupted by cloud cover. Empirical models of landslide probability and landslide detection with satellite radar data are two alternative methods of generating information on triggered landslides that overcome these limitations. Here we assess the potential of a combined approach, in which we generate an empirical model of the landslides using data available immediately following the earthquake using the random forest technique and then progressively add landslide indicators derived from Sentinel-1 and ALOS-2 satellite radar data to this model in the order they were acquired following the earthquake. We use three large case study earthquakes and test two model types: first, a model that is trained on a small part of the study area and used to predict the remainder of the landslides and, second, a preliminary global model that is trained on the landslide data from two earthquakes and used to predict the third. We assess model performance using receiver operating characteristic analysis and r^2, and we find that the addition of the radar data can considerably improve model performance and robustness within 2 weeks of the earthquake. In particular, we observed a large improvement in model performance when the first ALOS-2 image was added and recommend that these data or similar data from other L-band radar satellites be routinely incorporated in future empirical models.

How to cite.

Burrows, K., Milledge, D., Walters, R. J., and Bellugi, D.: Integrating empirical models and satellite radar can improve landslide detection for emergency response, Nat. Hazards Earth Syst. Sci., 21, 2993–3014, https://doi.org/10.5194/nhess-21-2993-2021, 2021.

1 Introduction

Earthquake-triggered landslides are a major secondary hazard associated with large continental earthquakes and disrupt emergency response efforts. Information on their spatial distribution is required to inform this emergency response but must be generated within 2 weeks of the earthquake in order to be most useful (Inter-Agency Standing Committee, 2015; Williams et al., 2018). The most common method of generating landslide information is manual mapping using optical satellite imagery, but this is a time-consuming process and can be delayed by weeks or even months due to cloud cover (Robinson et al., 2019), leading to incomplete landslide information during the emergency response.

In the absence of optical satellite imagery, there are two options for generating information on the spatial extent of triggered landsliding in the immediate aftermath of a large earthquake. The first is to produce empirical susceptibility maps, using factors such as slope, lithology and estimations of ground shaking intensity to predict areas where landslides are likely to have occurred (e.g. Nowicki Jessee et al., 2018; Robinson et al., 2017; Tanyas et al., 2019). The second is to estimate landslide locations based on their signal in satellite synthetic aperture radar (SAR) data, which can be acquired through cloud cover and so is often able to provide more complete spatial coverage than optical satellite imagery in the critical 2-week response window (e.g. Aimaiti et al., 2019; Burrows et al., 2019, 2020; Jung and Yun, 2019; Konishi and Suga, 2019; Mondini et al., 2019, 2021).

To generate an empirical model of triggered landslides following an earthquake, a training dataset of landslides is analysed alongside maps of "static" factors known to influence landslide likelihood, e.g. slope and land cover, as well as "dynamic" causative factors, e.g. ground shaking estimates, and a model is produced that predicts landslide likelihood based on these inputs. A range of methods have been used to generate landslide susceptibility models, including fuzzy logic (Kirschbaum and Stanley, 2018; Kritikos et al., 2015; Robinson et al., 2017), logistic regression (Cui et al., 2020; Nowicki Jessee et al., 2018; Tanyas et al., 2019) and random forests (Catani et al., 2013; Chen et al., 2017; Fan et al., 2020). When generating a susceptibility map for emergency response, the training dataset can be either a collection of landslide inventories triggered by multiple earthquakes worldwide (e.g. Kritikos et al., 2015; Nowicki Jessee et al., 2018; Tanyas et al., 2019) or a small sample of the affected area mapped immediately following the earthquake (e.g. Robinson et al., 2017). Here, we refer to these two model types as "global" and "same-event" models respectively. The global model of Nowicki Jessee et al. (2018) is routinely used to generate landslide predictions after large earthquakes, which are published on the United States Geological Survey (USGS) website (https://earthquake.usgs.gov/data/ground-failure/, last access: 27 January 2021). These products provide useful predictions of landslides triggered by earthquakes within hours of the event (e.g. Thompson et al., 2020). However, this model has been shown to struggle in the case of complicated events, for example in 2018, when landslides were triggered by a series of earthquakes in Lombok, Indonesia, rather than a single large event (Ferrario, 2019).

Several SAR methods have been developed for use in earthquake-triggered landslide detection based on the SAR amplitude (e.g. Ge et al., 2019; Konishi and Suga, 2018; Mondini et al., 2019) or interferometric SAR (InSAR) coherence (a pixel-wise estimate of InSAR signal quality) (e.g. Burrows et al., 2019, 2020; Olen and Bookhagen, 2018; Yun et al., 2015) or on some combination of the two (e.g. Jung and Yun, 2019). SAR data can be acquired in all weather conditions, and with recent increases in the number of satellites in operation, data are likely to be acquired within days of an earthquake anywhere on Earth. The removal of vegetation and movement of material caused by a landslide alters the scattering properties of the ground surface, giving it a signal in SAR data. Burrows et al. (2020) demonstrated that InSAR coherence methods can be widely applied in vegetated areas and can produce usable landslide information within 2 weeks of an earthquake. However, in some cases false positives can arise from building damage or factors such as snow or wind damage to forests.

Recently, Ohki et al. (2020) and Aimaiti et al. (2019) have demonstrated the possibility of combining SAR-based landslide indicators with topographic parameters in order to improve classification ability. Aimaiti et al. (2019) used a decision tree method to combine topographic slope with SAR intensity and InSAR coherence to detect landslides triggered by the 2018 Hokkaido earthquake, and Ohki et al. (2020) used random forest classification to combine several landslide indicators based on polarimetric SAR and topography to detect landslides triggered by two events in Japan: the 2018 Hokkaido earthquake and heavy rains in Kyushu in 2017. While these studies established the promise of a combined approach to landslide detection, they did not assess the relative merits of empirical, SAR and combined methods. Fur-

thermore, the two studies combined only SAR and topographic landslide indicators, omitting factors such as lithology, land cover and ground shaking data, which are also commonly used in empirical modelling of earthquake-triggered landslides (Nowicki Jessee et al., 2018; Robinson et al., 2017).

Here we aim to establish which of these three options provides the best indication of areas strongly affected by triggered landslides after an earthquake: landslide susceptibility maps, detection with InSAR coherence or a combination of these. In order to do this, we began with an empirical model of landslide susceptibility based on ground shaking, topography, lithology and land cover, all of which are available within hours of an earthquake. To this model, we then progressively added landslide indicators derived from InSAR coherence in the order that the SAR images became available following each case study earthquake. At each stage in this process, we assessed the ability of the model to recreate the landslide areal density (LAD) in the test area of the landslide dataset using receiver operating characteristic (ROC) analysis and by calculation of the coefficient of determination (r^2). For the modelling, we used random forests, a machine learning technique that has been demonstrated to perform well in landslide detection (Chen et al., 2017; Fan et al., 2020). Rather than attempting to delineate individual landslides, we chose to model LAD as both empirical models and detection methods based on InSAR coherence perform well at relatively coarse spatial resolutions (within the range 0.01–1 km^2, Burrows et al., 2019; Nowicki Jessee et al., 2018; Robinson et al., 2017). Similarly, the empirical models of landslide susceptibility released by the USGS following large earthquakes take the form of a predicted LAD, which can be interpreted as the probability for any location within the cell to be affected by a landslide (Nowicki Jessee et al., 2018; Thompson et al., 2020). We used three case study earthquakes and assessed the effect of adding SAR-based landslide indicators to both the same-event model type and a preliminary global model, which was trained on two events and used to predict the third, allowing speculation on the performance of a global model trained on a larger number of earthquakes.

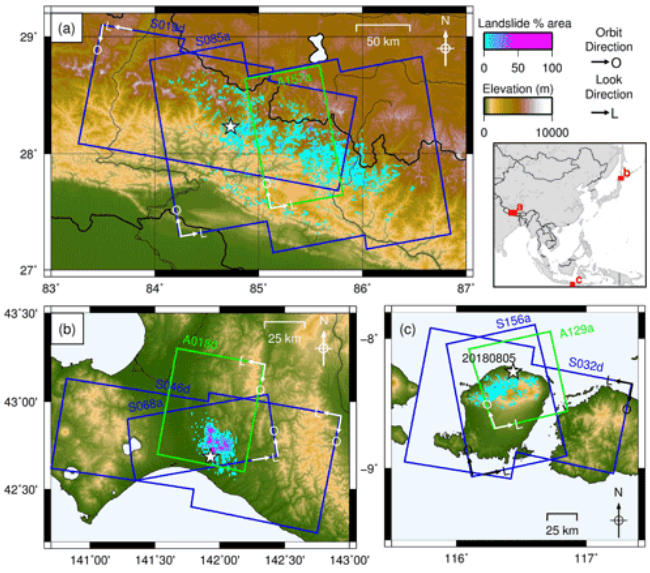


Figure 1SAR coverage of the three case study regions: **(a)** the 2015 Gorkha, Nepal, earthquake; **(b)** the 2018 Hokkaido, Japan, earthquake; and **(c)** the 2018 Lombok, Indonesia, earthquake. Sentinel-1 scenes shown in blue. ALOS-2 scenes shown in green. Landslide data from Ferrario (2019), Roback et al. (2017) and Zhang et al. (2019). White stars show earthquake epicentres. White arrows show satellite orbit (O) and look direction (L). Adapted from Burrows et al. (2020).

2 Data and methods

…

5 Conclusions

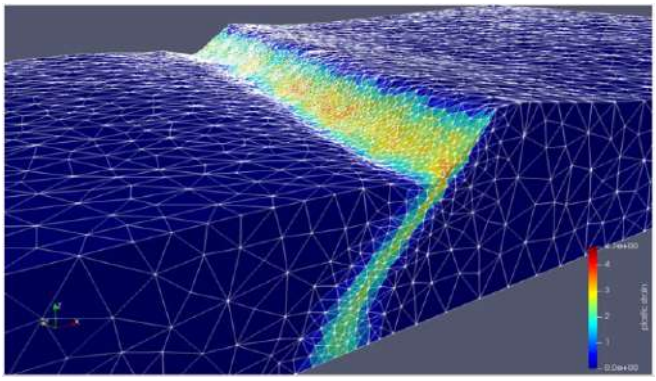
We have tested the relative performance of InSAR-coherence-based classifiers, empirical landslide susceptibility models and a combination of these using ROC analysis and r^2. The performance of all models was better with ROC analysis than with r^2, indicating that the models are better suited to discriminating between landslide and non-landslide areas following an earthquake than predicting continuous landslide areal density. We tested same-event and preliminary global empirical models and found that adding InSAR coherence features to these improved their performance in terms of both ROC and r^2. Importantly, a considerable improvement in model performance was seen using SAR data acquired within 2 weeks of each earthquake, meaning that these improvements could be made rapidly enough to be used in emergency response. We also expect that similar models could be developed to combine InSAR coherence and empirical models to predict rainfall-triggered landslides, or to predict earthquake-triggered landslides in more arid environments, although we did not test these cases here. For the same-event models, we observed that the empirical models without SAR performed considerably worse when the area available for training data was restricted as it could be by cloud cover following an earthquake, consistent with Robinson et al. (2017). However, we also found that the improvement in terms of ROC AUC offered by the inclusion of SAR data was particularly marked in this case. Both Sentinel-1 and ALOS-2 InSAR coherence features were observed to improve these models, with the best overall performance observed when both were used together. Before the acquisition of the first ALOS-2 image, when only Sentinel-1 InSAR coherence features were available, our same-event models outperformed our global models, but after this our global models performed best. Our global models were only trained on two events, but the addition of the first ALOS-2 SAR data acquired after each earthquake resulted in improved and more consistent performance compared to the model of Nowicki Jessee et al. (2018) in terms of ROC AUC. We therefore recommend that in the future, InSAR coherence features from L-band SAR should be routinely incorporated into empirical models of earthquake-triggered landsliding in vegetated regions.

Code availability

SAR data were processed using the commercial software package GAMMA and the LiCSAR software of Lazecký et al. (2020). The open-source GDAL software was used to reproject and resample the different datasets used here (https://gdal.org/, last access: October 2021) (GDAL, 2021). The random forest method was implemented in Python using the scikit-learn package (Pedregosa et al., 2011).

(https://nhess.copernicus.org/articles/21/2993/2021)

Repurposing a research tectonic modeling code as a community service: The case of DES3D



Three-dimensional model for core complex formation created with DES3D by Eunseo and his research group. Accelerated on NVidia V100 graphics card.

This week, Dr. Eunseo Choi, a professor at the Center for Earthquake Research and Information, the University of Memphis, talks about tectonic modelling using DES3D. *Spoiler alert* read till the end for an exciting opportunity to work on it

The advent of the open-source movement and the free public software repositories such as GitHub have drastically improved the way research codes are maintained, distributed, and attributed. However, it takes much more than free availability for a research code to serve a broad community beyond a small group of experts.

To be accepted community-wide, a research code would have to be versatile in addressing various problems deemed important in the community. It should also be maintained regularly and for a long term to be reliable. To attract experts and beginners alike, it should be easy to install and use. The last point is often termed user experience. For favorable user experiences, extensive documentations are necessary on installation, usage, and extension through API (application programming interface. Nowadays, it is common to help end users have the known working environment in the form of a container to be run on a local computer or on a cloud computing platform.

With a support from National Science Foundation (Grant No. 2104002), a project has launched to turn DES3D (Dynamic Earth Solver in 3D; https://github.com/tan2/DynEarth.git) into a community service. DES3D is an open source tectonic modeling code (Choi et al., 2013; Tan et al., 2013). DES3D inherits the main algorithms of geoFLAC (Fast Lagrangian Analysis of Continue for Geociences; https://github.com/tan2/geoflac.git) (Cundall, 1982; Poliakov et al., 1998), which is to find quasi-static momentum balance by dynamic relaxation, a form of damping. It can track the thermal evolution of crust and lithosphere, of which deformations can be described with elasto-visco-plastic rheology. DES3D is unique among the available tectonic modeling codes in that it employs the updated Lagrangian description of motion and solves the full momentum balance equation with damping rather than the Stokes equation.

To make DES3D usable for the next-generation research problems, coupling with earthquake cycle and surface process modeling will be pursued (Fig. 1). The importance of this capability is well reflected in the list of high-priority research questions recommended to the US National Science Foundation (NASEM, 2020), which includes "*What are the causes and consequences of topographic change?*" The importance of this question is in the emphasis on the two-way interactions of topography with "*processes that operate above, on, and below Earth's surface at many scales*" (p.32, NASEM, 2020). For instance, mantle dynamics, lithospheric deformations, earthquakes, and erosion can all change the surface morphology over different spatial and temporal scales; and the evolving topography itself can affect these processes by modifying lithospheric stresses and erosion processes. Efforts to model the interplay among the long-term tectonic deformations, landscape evolution, and earthquake cycles are under way (e.g., Beucher et al., 2019; Tong and Lavier, 2018; Upton et al., 2018; Van Dinther et al., 2013) and DES3D capable of the coupled modeling will add to the diversity and openness of the available tools.

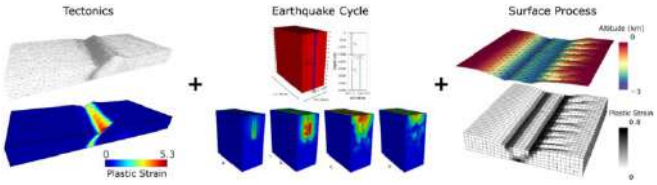


Fig.1: Examples of the three targeted modeling capabilities, tectonics, earthquake cycle and surface process, to be integrated into a single platform. (left) Tectonic modeling example showing a well-developed three-dimensional core complex. (middle) Rupture occurring on a vertical strike slip (Tong, 2019). (right) Landscape modified by channel incision during a basin formation.

Improvements will be made on the computational and software engineering side, too. The parallel performance of DES3D, currently multithread parallel via OpenMP, will be enhanced through hybrid parallelization combining domain decomposition across a cluster and co-processors on each node. Long-term maintenance will be aided by modern software engineering practices employed in the build system and unit and regression testing. User experiences will be improved through better documentation, more examples and tutorials and input file generator with graphic user interface.

The project is looking for a post-doctoral researcher who is interested in taking on any of the tasks described above. Please contact Eunseo Choi (echoi2@memphis.edu) for details.

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(Eunseo Choi Edited Arushi Saxena / EGU BLOGS, October 6, 2021 Geodynamics 101, News & Views No Comments, EGU BLOGS, https://blogs.egu.eu/divisions/gd/2021/10/06/repurposing-a-research-tectonic-modeling-code-as-a-community-service-the-case-of-des3d)

Monitoring Ground and Structure Stability from Space: Satellite-based InSAR

Marie-Josee Banwell, Chiara Giannico, Sara Del Conte, Giacomo Falorni

Introduction

At all project stages, a key tool in the civil engineer's risk mitigation strategy has been the deployment of instrumentation and monitoring systems to closely monitor ground and building movements and the results of any stabilisation work. These systems can be highly accurate while streaming almost continuous data. However, they are often invasive, complex and expensive with practical limitations on the number or density of measuring stations that may be deployed. Further, as these systems are only deployed at a specific project stage, for example at the beginning of construction, both spatial and temporal ambiguities can exist in terms of any claims for damage made against the builder.

The satellite remote sensing technology of radar interferometry, or InSAR, provides an effective supplement to conventional methods for monitoring the mm-scale ground movements associated with underground excavations or new building settlement. Based on relatively large image swaths, wider-than-AoI analysis is implicit, and with up to metre-grid coverage, InSAR supplements ground-based instrumentation when it comes to measurement point density.

Significantly, as satellite data have been repeatedly acquired for decades over the same places, time-series plots for every measurement point can be computed that show past movements to the present day, i.e. to reveal when a location's movement profile might have changed – critical in the management of liability.

InSAR Technology

Synthetic Aperture Radar (SAR) Interferometry (InSAR) is a remote sensing technique that provides measurements of ground displacements. Radar sensors mounted on satellites acquire images of the Earth's surface by emitting electromagnetic waves and analyzing the reflected signal. Basic Differential InSAR (D-InSAR) techniques consist of comparing the phase values of two SAR images, acquired at different times with similar looking angles. The phase difference is proportional to the target motion occurring along the sensor-target line-of-sight (LOS) direction during that time interval (Figure 1). As SAR satellites are continuously circumnavigating the globe, a number of radar images can be collected for the same area over time and information about the displacements of the earth's surface can be extracted.

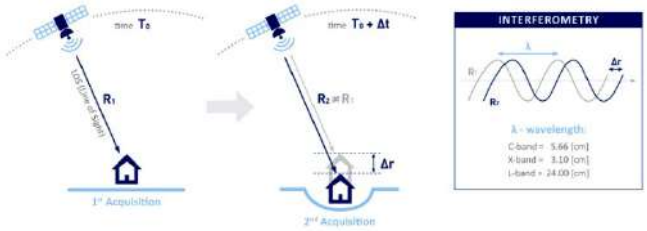


Figure 1. An illustration showing the relationship between ground displacement and signal phase shift. This is the basic principle of InSAR for measuring ground movement

In the late nineties, new Advanced DInSAR (A-DInSAR) techniques emerged in order to estimate and remove the atmospheric noises that affect basic DInSAR data and provide more accurate displacement measurements (sub-millimeter precision) by processing multiple images acquired over the same area over time. Permanent Scatterer Interferometry, the first A-DInSAR technique, identifies and monitors point-wise Permanent Scatterers (PS), pixels that display both stable amplitude and a coherent phase throughout every image of the dataset (Ferretti et al. 2000, 2001). PS are related to natural radar targets such as manmade structures (buildings, streetlights, transmission towers, etc.) as well as rocky outcrops, un-vegetated Earth surfaces, boulders, and any structure that can reflect a signal back to the satellite. In order to detect the highest possible density of measurement points in non-urban areas, a new technique known as SqueeSAR™ was presented by Ferretti et al. in 2011, which extracts information from Distributed Scatterers (DS). This extends measurement point coverage to areas with limited infrastructure and light vegetation. Together, these two types of measurement points form a ground network of radar benchmarks, similar to a Global Positioning System (GPS) network, and can be used for monitoring both the displacement of individual structures (a building, for instance) and the evolution of a large displacement field affecting hundreds of square kilometers.

The launch of satellites with a high frequency of acquisitions (up to a few days), combined with the development of sophisticated automatic processing algorithms, have made it possible to continuously provide reliable surface deformation measurements with each new satellite image (Raspini et al., 2018).

From Planning to Design and Construction

The existence of SAR data archives going back to the 1990s has led to the extensive use of InSAR to perform historical ground deformation analyses to assess any pre-existing ground deformation phenomenon at the planning and design phases of a project. At the construction stage, frequent, high-resolution InSAR updates form part of the structural health monitoring program, providing up to thousands of measurement points per square kilometer, in urban areas.

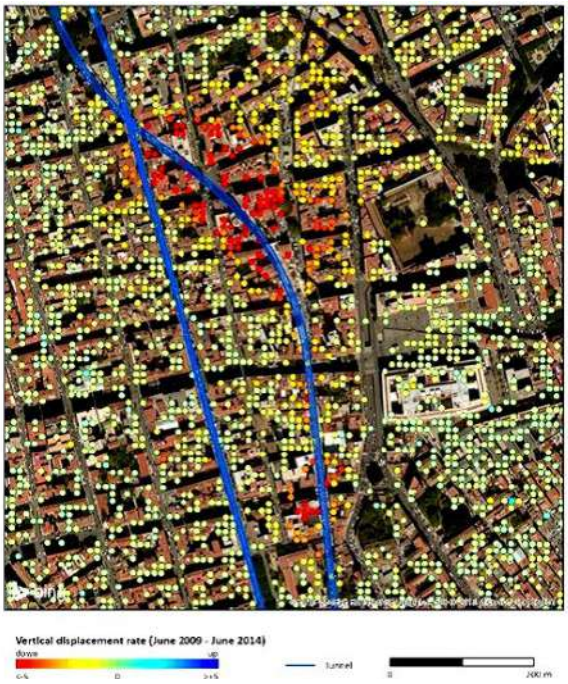


Figure 2. SqueeSAR Monitoring during tunnel excavation of single-track rail tunnel in a historic city centre where there was suface subsidence related to tunnel face advancement Source : Barla et al. 2016

Case History: High-Speed Railway Station (Bologna, Italy)

As part of the high-speed railway from Milan to Naples in Italy, the construction of a major station and tunnel under the

city of Bologna were completed in the early 2000s. This consisted of a double-track tunnel with an excavation area of approximately 130m^2, crossing an urban area at shallow depths (approximately 10m) with a high density of comercial and residential buildings.

Considering the delicate urban and geotechnical context and the tunneling-related subsidence, a comprehensive in situ monitoring system was combined with satellite remote sensing data during the construction phase (Pigorini et al., 2010).

After processing the SAR data archive, it was possible to identify a significant ground displacement trend. The alluvial deposits on which the city of Bologna is built are affected by land subsidence mainly induced by natural sediment compaction and ground-water exploitation for industrial, residential and agricultural uses. This was compounded with the effects induced by tunnel construction. In order to highlight the displacements induced by tunnelling activities alone, a reference point was selected in order to minimize the displacement gradients due to generalised subsidence and to isolate the displacements induced by the excavation works. The removal of masonry buildings on the surface caused the ground to rebound, with movement extending beyond the area monitored by the in-situ instrumentation, levelling benchmarks and total stations (Figure 3).

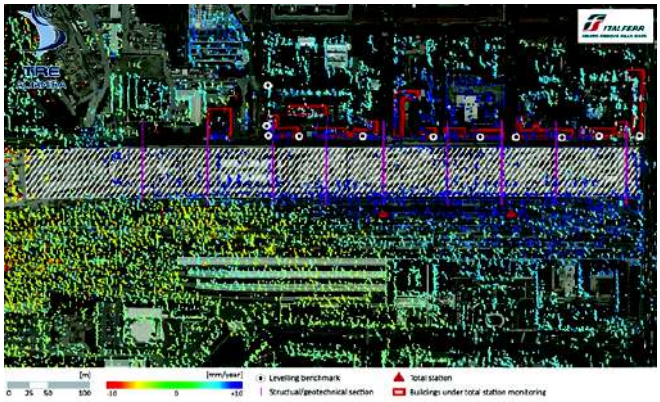


Figure 3. SqueeSAR measurements (coloured points) during the contruction of an underground high-speed rail station in a Bologna. Levelling benchmarks are indicated with white circles and total stations are indicated with red triangles.

Critical analysis of single measurement point displacement time series along with the chronology of the site and tunnel excavation activities (even before initiation of ground works) provided a detailed evaluation of any correlation and other interesting deformation effects that have occurred at on the ground's surface.

Figure 4 shows an example of a displacement time series of a measurement point located near the tunnel centre line. After the first period (2003-2007), which exhibits general stability, the image shows an increase in the displacement rate during 2007 and 2009-2010, both followed by stable periods. This behaviour is in exact agreement with the site work activities. The first acceleration is related to the construction of 10 micro-tunnels between March and October 2007; the second is related to tunnel advancement in the first months of 2010. In the subsequent period, the excavation front was far from this particular measurement point and displacement stopped, coinciding with the stable period at the end of the time series in the plot.

Comparing InSAR to Levelling Techniques

In a 2011-2017 SqueeSAR analysis over the Bond Street Station in Central London, measurements were validated using BRE (Building Research Establishment) levelling data obtained from Crossrail Ltd. Work at this site involved the construction of two 10 m diameter platform tunnels between 20 and 24 m deep within the London Clay Formation. The construction site is located underneath historical buildings that are largely supported by shallow footings, which meant that ground deformation during construction was closely monitored.

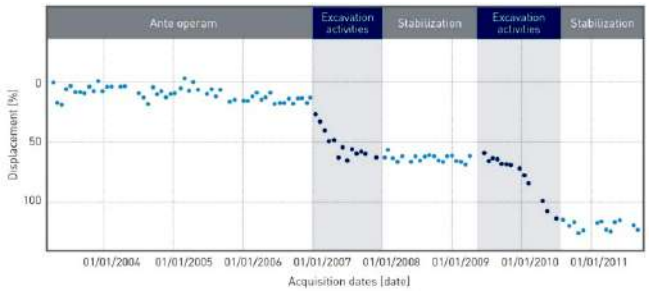


Figure 4. Modified from Pigorini et al. (2010): displacement time series showing the effect of tunnelling.

Figure 5 shows a comparison between three types of deformation monitoring techniques: BRE levelling (blue squares), levelling points/plates (red triangles) and SqueeSAR (green circles). The time series shown on the graph are from measurement points of the three techniques, which are located within less than 10 m of each other, as indicated on the map. To enable a comparison with the remote measurements, the ground-based measurements were averaged over 11 days. The time series are in excellent agreement, tracking relatively sudden movement such as the peaks in September 2012 and in August 2014.

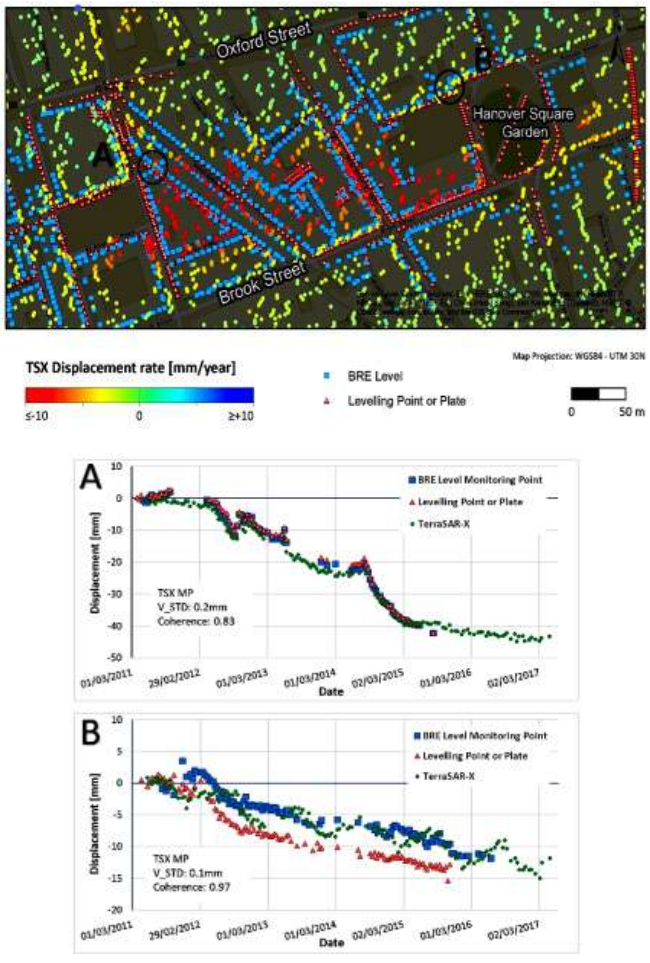


Figure 5. Comparison of SqueeSAR measurement values with BRE Levelling and Levelling Points around Bond Street.

Conclusion

Surface deformation monitoring is a key component in the identification and mitigation of risks related to construction, particularly in urban areas. Space-based InSAR has been validated in in-situ data and is now being included into comprehensive geotechnical monitoring program. It offers a synoptic, wide-area view, that coupled with localized, sparse in-situ real-time systems, provides the most thorough combination of spatially and temporally dense ground deformation data.

(DFI Deep Foundation Institute of India News, Volume 7 Book 3, October 2021, pp. 3-4 & 14-15, http://dfi.org/enews.asp?india)

New Data Management for Foundations Specifications by the DFI Project Information Management Systems Committee

Jamey Rosen, Chairperson, Deep Foundations Institute
Project Information Management Systems Committee

Introduction

The United States Army Corps of Engineers (USACE) and other owners of seepage barrier wall projects (including diaphragm walls, secant pile walls, jet grout columns, grout curtains, and more) increasingly require specific Information Management methods in their Specifications. The Project Information Management Systems (PIMS) Committee of the Deep Foundations Institute (DFI) has edited a USACE Information Management Guide Specification for general use throughout the foundations industry be removing USACE-specific language and language specific to the United States. Version 1.0 of this Specification is now available for general use (see DFI.org), and further revisions are pending with updates and expanded sections on specific technologies.

These generic Specifications require Contractors to use geospatial and other methods for compiling, organizing, analyzing, and visualizing data to demonstrate that sufficient quality control measures have been applied to the barrier wall construction. These data include:

- Element position/verticality;
- Slurry quality;
- Exploratory and Verification Borehole position and geology;
- Surveys of constructed elements;
- Photographs and other site documentation;
- and more, depending on the design and technologies used in the construction.

The Specifications dictate that these data be managed using a series of components:

- A centralized relational database;
- A Geographic Information System (GIS) and associated editable files and web-based viewers, generally in planimetric, profile, and 3D systems (including web-based viewers and editable desktop files);
- Reports for each element (or each secondary element in the case of closure reports) showing the calculated position of the element (and overlap with adjacent elements) at several depth intervals and in a profile view; and
- Progress and As-Built Drawings showing the positions of all proposed and completed elements.

An example outline of a typical data management Specifications for a deep foundations project is shown as Figure 1. Details of the Specifications will change depending on the barrier wall technology, however the major components listed above are applied universally.

The major components listed in Figure 1 can be developed with a range of technologies that vary with the barrier wall methodology.

Centralized relational database

A single database that stores and, importantly, relates all project data is the "heart" of a data management system. Modern PIMSs generally use an enterprise (i.e., intranet or internet-accessible) database (EDB) that allows storage of spatial objects. Most enterprise database platforms meet this need, including Microsoft SQL Server and Oracle. The EDB (and its various associated scripts and tools) is used to receive raw data, organize that data into tables and views, and serve the data to the GIS, reports, and drawings listed below.

SECTION 31 09 14.00 29

DATA MANAGEMENT

PART 1 GENERAL

1.1 SCOPE
1.1.1 Information Management System (IMS)
1.1.2 Secure FTP
1.1.3 ArcGIS Enterprise
1.1.4 On-Going Access to Data for the Duration of the Project
1.1.5 Data Management Plan
1.1.6 Interactive Spatial Access
1.1.7 Enterprise Database (EDB)
1.1.8 Tables for Government Entered Data
1.1.9 Interactive and Static Reports of Data
1.1.10 Boring Log Database
1.1.11 Training Sessions and User Manuals
1.1.12 Automated Data Acquisition System for Instrumentation Monitoring (ADAS) Data Integration
1.1.13 Joint Instrumentation Monitoring Plan (JIMP)
1.1.14 Data Management Meetings
1.1.15 Data Manager
1.1.16 Geographic Information Systems Professional
1.2 MEASUREMENT AND PAYMENT
1.3 REFERENCES
1.4 SUBMITTALS

PART 2 PRODUCTS

2.1 DATA OWNERSHIP
2.2 DATA INTEGRITY
2.2.1 Record Tracking Requirements
2.2.2 Raw Data Requirements
2.2.3 Backups, Archiving and Disaster Recovery
2.3 DOCUMENTED ENTERPRISE DATABASE
2.4 RECORDS STORED ON SFTP SITE
2.5 ARCGIS ENTERPRISE
2.6 SPATIAL DATA LAYERS
2.7 SPATIAL DATA PROJECTIONS AND DATUMS
2.8 DRILLING RECORDS AND BORINGS LOGS
2.9 FULL-SCALE GIS MAP FILE(S)
2.10 TESTING MONITORING AND RECORDS
2.11 OVERLAP, VERTICALITY AND LOCATION ANALYSIS OF BARRIER WALL ELEMENTS
2.12 SHEET PILE DRIVING RECORDS
2.13 PHOTOGRAPHY METADATA REQUIREMENTS

PART 3 EXECUTION

3.1 DATA GATHERING SYSTEMS

Figure 1. Example USACE Foundations Data Management Specification Outline

In addition to the reports and drawings, PIMSs generally allow raw and organized data in the EDB to be accessed securely by team members and owners via the internet. This can be accomplished through web-based tables, or more commonly by having the tables and views exported on a routine (i.e., nightly) basis to text files (i.e., comma separated values or csv files), spreadsheets, or tables in a desktop database application like Microsoft Access (i.e., a "mirror database"). These static offline files can then be used outside of the PIMS and as a routine archive of the state of the database.

Geographic Information System (GIS)

A GIS is used to organize, visualize, and analyze foundations data in 2 or 3 dimensions. A typical foundations project GIS will include planimetric, profile, and 3D views of the structure, ideally updated on some high frequency (i.e., daily or weekly) to efficiently track the project process. Modern GIS include secure web views (Figures 2 to 4) to allow access to data without requiring specialized software, and owners may require both web viewers for daily access and source files for offline analysis and to create a project archive.

Element Reports

Specifications typically also require that reports be created for each barrier wall element (or each "closure" of secondary element and adjacent primary elements) visualizing and summarizing the data for that element (Figure 5).

Progress And As-Built Drawings

Finally, Specifications require drawings to be produced on some regular basis (i.e., weekly) that represent an offline record of progress through that date. An example of a typical progress drawing showing proposed and completed elements of a barrier wall is in Figure 6.

Figure 2. Planimetric GIS web viewer showing the position and overlap of cutter soil mixer panels at a specific depth

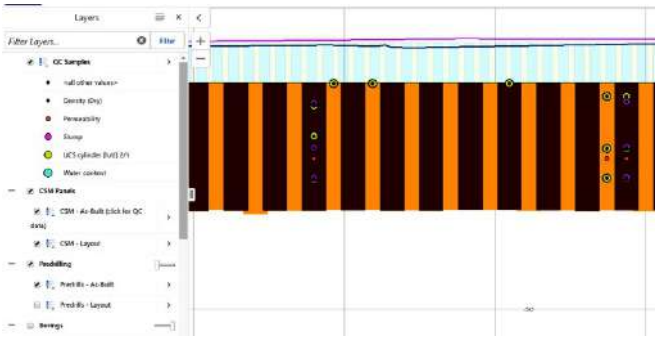


Figure 3. Profile GIS web viewer allowing access to quality control sample data

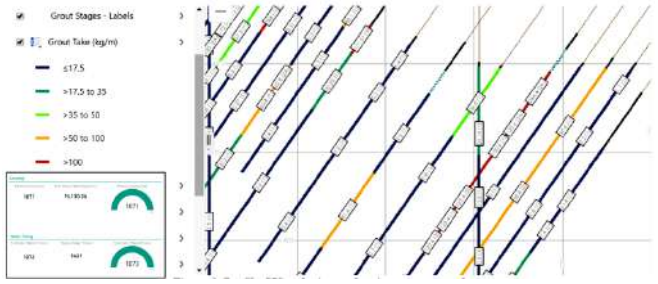


Figure 4. Profile GIS web viewer showing grout stage data and production status

Conclusions

As PIMS technologies develop and become more widespread across the foundations industry, there is an increasing need for specifications to allow owners to be clear on what they want to receive from contractors with respect to data formats and work products. The DFI PIMS Committee is working on an evolving Specifications document that will assist owners in meeting these needs.

(DFI Deep Foundation Institute of India News, Volume 7 Book 3, October 2021, pp.8-10, http://dfi.org/enews.asp?india)

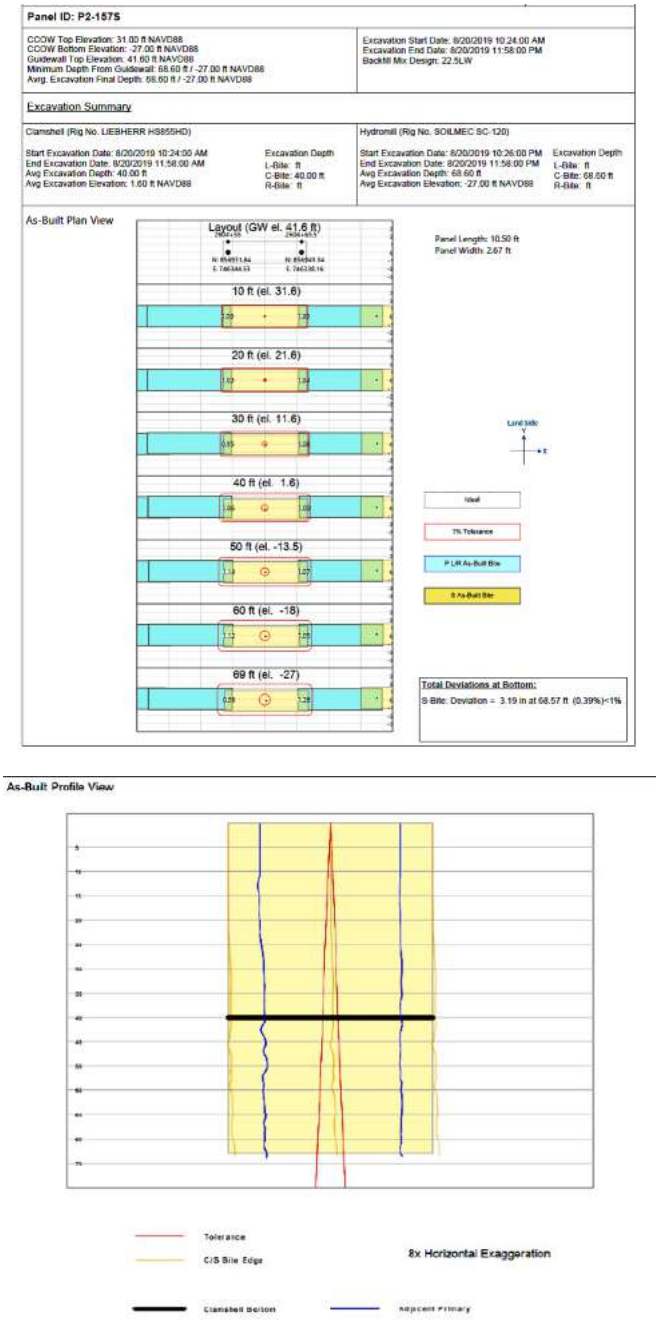


Figure 5. Element Report showing as-built position and overlap of diaphragm wall panel

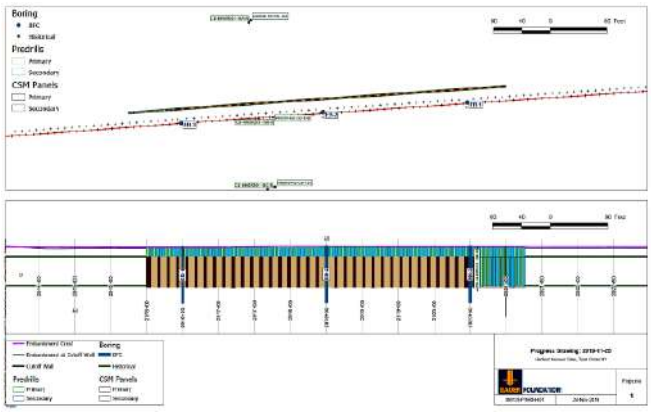


Figure 6. Progress Drawing

50 Years Ago: How the Continents Fit Together

50 years ago, on October 28, 1965, an unlikely British geophysicist made a map that set the record straight on how the world's tectonic plates fit together. As a child, Edward Bullard was such a slow learner that his family thought he'd end up mopping floors at their brewery. Instead, he became one of a half dozen scientists who proved plate tectonics – and he was knighted for some of his work.

Sir Edward's family could have given him a wide range of advantages, but they did their best to wreck the young man instead. He overcame the burden of privilege, but it took an unusual and sympathetic teacher to help him realize he wasn't stupid.

Bullard's great-grandfather Richard owned ***The Goat***, a once-popular Norwich pub, and started a brewery, making the family wealthy. Bullard's grandfather Harry was thrice elected mayor, knighted by Queen Victoria, and was Member of Parliament for Norwich – until he was expelled for bribery.

On the other side of the family, Bullard's maternal grandfather, Sir Frank Crisp, was a lawyer whose client list included the Japanese Imperial Navy. Crisp also inked the contract for cutting the largest diamond ever found, the 3,100-carat Star of Africa. Frank Crisp was an amateur scientist, an officer in the Royal Microscopist Society, an enthusiastic gardener, and was rumoured to be insane. He owned an estate where he erected a replica of the Matterhorn featuring a cave populated with garden gnomes. At the gate to Friar Park where he lived, the retired solicitor erected a statue of a monk holding a frying pan punctured by a pair of holes. He called the statue "The Two Holy Friars." Young Teddy Bullard, the future geophysicist, enjoyed spending a month each year at his eccentric Grandfather Crisp's 120-room house near Henley, until Sir Crisp died bankrupt in 1919, when Bullard was twelve. Years later, ex-Beatle George Harrison bought the holy friar estate and turned it into a comfortable home for his final years.

Bullard's father was dyslexic and performed miserably at school. Edward Bullard himself was similarly afflicted, claiming his inability to spell was hereditary. For his education, Sir Edward Bullard was first placed in a girls' school, a place dunces in those days were sometimes sent. At age 9, his parents transferred him to a stodgy grammar school which made him so miserable he considered suicide. Anxious because of his grandfather's mental state, the family alerted a psychiatrist who recommended that the child, by then 11, be sent away to a boarding school. Teddy refused, but his parents sent him anyway. There, at age 12, he was tested and placed next to last in a classroom of eight-year-olds.

He survived the experience and was rewarded with promotion to a strict secondary school with equally privileged classmates where he once again felt miserable and performed poorly. But a physics teacher with a doctorate arrived and took a serious interest in young Bullard's future. He set the young man loose in the library with problems to solve and lectured him privately two or three times a week. It worked. The physics teacher changed young Bullard's life. Edward Bullard applied to Cambridge and became a theoretical physicist. Against such disadvantages of upper-class birth, Edward Bullard became one of his generation's most brilliant and hard-working geophysicists.

At Cambridge, Bullard studied physics under Lord Patrick Blackett, his doctoral adviser for a quantum mechanics thesis, and a scientist later awarded a Nobel Prize. Then Bullard worked with Nobel laureate physicist Ernest Rutherford, also at Cambridge. But by 1931, the Great Depression dried up funding for pure research – advancing the science of quantum physics was not deemed essential while millions of unemployed roamed England's streets. Bullard's boss, Rutherford, reluctantly sent Bullard away to teach applied geodesy – glorified surveying techniques that might help farmers and navigators. Through geodesy, Bullard became a gravity expert. He understood the physics behind surveys and maps and he determined the Earth's gravity distortions and nuances of our planet's non-spherical shape. Geodesists calculate innumerable perturbations, all of which affect the orbits of satellites, the flight paths of missiles, and the drafting of maps.

Before the Second World War, **Edward Bullard also researched Earth magnetism and crustal heat transfer.** During the war, he found ways to use geophysics in Britain's fight to survive. He devised a method to demagnetize British ships so they could avoid German detection and he used magnetic disturbances to locate enemy mines. After the war, Bullard headed the University of Toronto physics department, then went to La Jolla, California, to work for Scripps Institution of Oceanography. At Scripps, Bullard designed a tool to measure heat as it flowed from the ocean's floor. But eventually Bullard returned to England to unravel the mystery of the source of the Earth's magnetic field. He did the math and physics that showed how motion deep inside our planet generated magnetism.

Magnetism figured large in the transformation of continental drift theory into plate tectonics. Edward Bullard wasn't the first to recognize the likelihood of crustal plates in motion. **But continental drift, being rediscovered as plate tectonics, was a hard sell.** Bullard later wrote:

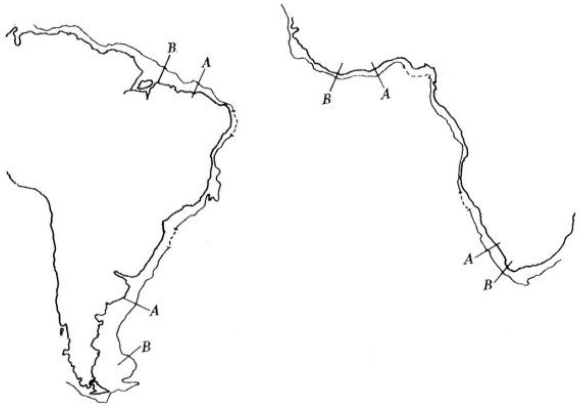
"There is always a strong inclination for a body of professionals to oppose an unorthodox view. Such a group has a considerable investment in orthodoxy: they have learned to interpret a large body of data in terms of the old view, and they have prepared lectures and perhaps written books with the old background. To think the whole subject through again when one is no longer young is not easy and involves admitting a partially misspent youth. Further, if one endeavours to change one's views in midcareer, one may be wrong and be shown to have adopted a specious novelty and tried to overthrow a well-founded view that one has oneself helped to build up. Clearly it is more prudent to keep quiet, to be a moderate defender of orthodoxy, or to maintain that all is doubtful, sit on the fence, and wait in statesmanlike ambiguity for more data (my own line till 1959)." – Bullard, Edward (1975). "The Emergence of Plate Tectonics: A Personal View," *Annal Review of Earth and Planetary Science*.

Edward Bullard's conversion to plate tectonics in 1959 made him an early adopter of the theory. Although Wegener and others had made their continental drift proposals early in the 20th century, the bulk of the geoscience community didn't switch until around 1967. For seven or eight years, Bullard was one of a handful of prescient scientists who saw the crust as a dynamic feature. But his conversion was only cautiously expressed.

Although his work in theoretical geophysics, heat flow from the crust, and magnetic field generation were his greatest triumphs, Bullard's signature contribution to plate tectonics was a map of the continents that cleared up one of the uncomfortable issues that made some geologists balk at the notion that continents once fit snuggly together in Pangaea.

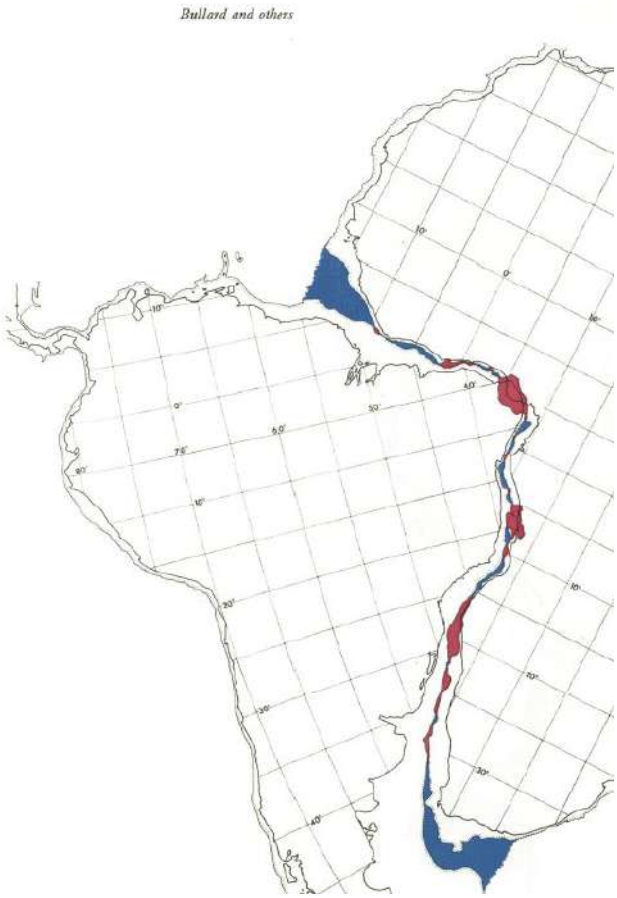
In 1965, **Bullard constructed a map that fit the continents together** without the huge gaps and overlaps that had plagued earlier researchers when they drew maps of Pangaea. **It was a simple remedy.** Rather than using today's coastlines as the outlines of continents, Bullard mentally drained the oceans, exposing the continental shelves, then he graphically connected the enlarged continents into Earth's

earlier supercontinent. The fit went from a sloppy cartoon to an almost perfect reconstruction.



From *Fit of the Continents* – part of Bullard's calculation that reconstructed Pangaea

In a paper written with JE Everett and AG Smith, *The Fit of the Continents around the Atlantic*, Bullard found that the best least squares fit of the outlines of the continents falls upon the steepest slope of the continental shelf. The authors believed that the fit of South America to Africa, Greenland to Europe, and North America to Greenland and Europe was so good they could "not be due to chance." As the paper states,



Bullard, et al., the mathematical fit of South America and Africa, 1965.

"Only two explanations have been proposed for the approximate fit of the continental blocks; either the fit is due to chance similarities, and is on a par with the similarity of the coast of Italy to a boot, or the continents were once united and have separated with the formation of the Atlantic Ocean. Other explanations are hard to find, they would involve similar processes carving similar shapes on the two sides of the ocean. It is difficult to decide by statistical theory alone whether two continental edges fit more closely than would be expected by chance." – Bullard, Everett, and Smith (1965), "The Fit of the Continents around the Atlantic", *Philosophical Transactions of the Royal Society of London A*.

Bullard and his colleagues conclude the paper by indicating that the evidence sides with continental fragmentation as the creator of the Atlantic. But even late in 1965, it was a tough sell so they nuanced their result. Bullard wrote that verification of the fit as part of a previous supercontinent would come with a comparison of stratigraphy, structure, mineral age dating, and remnant rock magnetism. He was right.

https://mountainmystery.com/2015/10/28/50-years-ago-how-the-continents-fit-together

The road to successful scientific writing for early-career scientists

The world of research is highly competitive, and early career scientists face many challenges while trying to carve out a successful career path. **Writing scientific articles** is one of those **challenges**. Prof. **Paolo Tarolli** (University of Padova) shared his personal experience on "*How to write a scientific article*" with 130 attendees last 7th September, during the first Campfire event, "*Soft skills for soft lunches – NH series*", organised by the ECS group of the EGU Natural Hazards Division. Paolo has written over 138 papers (indexed in Scopus) in 15 years of his career in academia. He collected a rich and articulated experience as an editorial board member (and guest editor) of several journals (under different publishers and fields) and as chief executive editor of the open-access journal *Natural Hazards and Earth System Sciences* published by Copernicus.

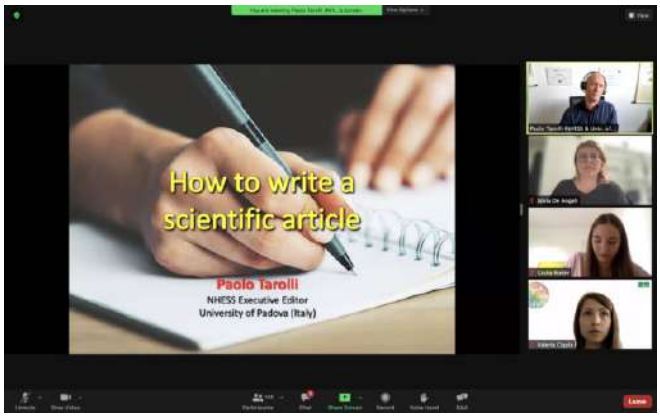


Figure 1. The beginning of the Campfire event "How to write a scientific article" hosted on the Zoom platform. In the top right there is Prof. Paolo Tarolli (University of Padova and NHESS Chief Executive Editor) and following the three organisers and members of the Early Career Scientists team of the NH Division: order, Silvia De Angeli (University of Genova), Giulia Roder (University of Udine and consultant at the UNU-IAS), Valeria Cigala (Ludwig-Maximilians-Universität Munich).

Get to know the journal you want to submit to

Selecting the appropriate journal is the basis of a successful submission process, highlighted Paolo at the beginning of the talk. While authors can easily choose among a research article, a systematic review, or a brief commentary, according to the type of research they are presenting, the selection of the fitting journal is driven by numerous factors:

(i) **Scope**: It is fundamental to read the focus of the journal carefully. Many scholars often take this action superficially, but most rejections come from out-of-scope submissions.

(ii) **Charging fees**: Open access or non-open access, that is the question. Part of the responsibility of scholars is to allocate the budget to their project research activities. One of them is undoubtedly connected to the payment for open access articles, which permit higher visibility and support Open Science. However, this is not possible for many scholars worldwide. Do not struggle too much; there are many journals for both options.

(iii) **Review process**: Open discussion or blind/double-blind. "*An open science starts from a transparent review process*", firmly stated Paolo. He is a strong supporter of the open discussion review method, which, despite being a blind method, allows multiple authors to join the review process by providing comments or suggestions. In some cases, double-blind peer-reviews may enable the author to protect his/her identity from prejudices driven by the topic investigated, among others.

"Your Article-Your Way", but there are some rules

Before writing down an article, it is essential to **write** its **skeleton**. It may seem a useless action, as all the papers follow the same structure. However, a juicier skeleton can help the writer avoid missing information or replicating them into different chapters. The problem of redundancy is prevalent when drafting the first time. Paolo was confident when he said: "*After the first reading, it is possible to cut up to 15-20% of the text and meet the journal wording requirements*". But also, he firmly added: "*Being concise is a sign of quality*". **There is no necessity to write enormous introductions or endless discussion sections to prove the quality of your piece of research**. If essential information needs to be shared, but the space for sharing is limited, Paolo reminded us that we can always use the *Supplementary Material* section.

Back to the structure of the paper, he gave us several helpful tips:

(i) **Title**: Avoid long titles. They need to be direct and concise, including the study area if it is part of the novelty of the paper;

(ii) **Keywords**: They are often misused, but they are essential to raising visibility in the web (science-related) engines. Find from 3 to 5 words that match your paper, the same you would use to find yours (or a similar one);

(iii) **Abstract**: The abstract needs to highlight the original aspect of your article. Although it follows a typical paper structure (introduction, methods, results, and conclusive remarks), it should emphasise the challenge but also the proposed solution with its impact among the scientific community but also within the society;

(iv) **Introduction**: A good introduction should focus on the literature gap the author wishes to fill and the paper objectives. "*Avoid plagiarism that often happens in this chapter*", recalled Paolo;

(v) **Materials and methods**: Include maps (when appropriate) that are clear and self-explain the area and the problem. Avoid hard-to-read figures with low resolution and missing information. Figure quality is perhaps one of the most critical parameters for an editor handling your manuscript and deciding on acceptance or rejection. Methods need to be clear and open (add a source code of algorithms as supplementary if required). Paolo also stressed, "*Be honest with colleagues and cite the source if you use part of an existing algorithm or derive a new one from a previous version*";

(vi) **Results**: Results need to be concise and analytical, supported by statistics and bias/uncertainty quantification (if appropriate);

(vii) **Discussion**: This chapter is used to compare the results with other works. However, it is often enriched with those open challenges that have not been addressed in the current manuscript and the actual paper contribution to society;

(viii) **Conclusions/Final remarks**: It is similar to the abstract structure to some extent but try not to copy and paste. Some future directions of research may also be stated here;

(iv) **References**: They need to represent the literature related to the discussed topic but not exaggerate with self-citations (if required, suggested to be less than 20%). In general, Paolo said, "*Avoid writing 200 references for a research paper, but also avoid proposing a paper with only 20!*".

Is a rejection ALWAYS a reflection of the poor quality of your work?

The answer is NO. There are several motivations behind it: a good idea but fewer competencies to develop it properly or the wrong journal, especially for multidisciplinary research that might encounter very traditional reviewers.

Paolo shared his personal experience of rejection (that is also my rejection being Paolo, my supervisor at that time). In the first year of the PhD, I decided to write a review paper about gender and disasters, which I thoroughly believed in. As a physical geographer taking the first steps into the social sphere, I was possibly too naive. This field is driven by pillars, not only experts, the same who perhaps rejected me hardly. After a careful analysis of the comments, we decided to expand the network and use our literature review in another way. This positive approach was rewarded with a paper published in the natural hazards field with a successful echo. Thus, what is Paolo's take-home message? **Rejections can arrive for multiple reasons: sometimes they are a true reflection of a weak article, sometimes they went through unfortunate conditions**. If the second, Paolo suggests being proactive and trying to convert the work done into something new, perhaps finding new collaborations (outside one's field) and trying again. And again. Humbly accept also to lose leadership if you realise that an article falls outside your background.

Another personal insight based on his career regarded the impact factor (IF). As scholars, we are pushed to look at the IF to boost our papers. That is true, as true is that we may find articles in top journals with few-to-no citations or with a minimal impact on society. So, what is important overall? Paolo explained that **it doesn't matter the IF** (although assuming that the journal is reputable) **and the immediate success of the article**. We need to have the right topic at the right moment with the right novel approach that can be useful to society. "*We cannot write merely for our narrow scientific community*," said Paolo. Our research must be useful, usable, and used, and some reward will come out. He also recalled a significant paper on agricultural terraces he published in 2014 in a journal with no IF at that time. He believed in his paper despite the journal being new with less visibility and impact. The story turned out that the article became the second most cited in his career with a sound impact on society. Similarly, the journal became popular in a relatively short amount of time.

Do's & Don'ts: addressing editorial malpractices

The most common malpractices regard **data use** and **plagiarism**: it is more common than we think. Data cannot be created nor stolen. Likewise, we cannot copy and paste someone else findings or paragraphs without appropriate citations and modifications. Regarding citations, Paolo repeated the importance of avoiding exaggerated **self-citations**. He thinks that "*there are some cases when an objective self-citation could be suitable, especially when introducing a new method or algorithm, and then testing it in other study areas to address novel findings, but not with the purpose to create the so-called salami-slicing"*.

On the other hand, over-citing friends' articles is not acceptable and inclusive, nor avoiding mentioning an author (who wrote a milestone in the field) just for personal issues. Scientific or **personal conflicts cannot lay in the ground of scientific writing**; thus, it is highly recommended to use neutral language when disagreeing with the work of other colleagues. If it is constructive and inclusive, analytical criticism is welcome.

Why not toss a coin for drafting the authorship list?

Many scholars often encounter problems with adding co-authors to their manuscripts. We all know that there are rules: the first author is given to the person who wrote the paper and the one who had the idea. Second, third and so forth are collaborators that actively contributed to the manuscript (it can regard methods, data collection, discussions, etc.). Instead, the last should be the principal investigator (PI) of the project (aka, your supervisor most of the time) who funded the research. In the case of multiple co-authors from different groups and projects, the last name should be given to the senior expert in the article's field. Honestly, this rule is not followed in many institutes worldwide (luckily, mine was not the case). How to handle those problems? Try to draft the authors' list yourself and give reasonable motivations for all mentioned people. Once you have done it, try to speak with the co-authors and the PI at last. **If you want a transparent list, you need to be honest first!** Indeed, it is not reasonable to have 10-15 co-authors for a single case study article.

A box of your Q&A served in pills

1. **Would you please cite some plagiarism software?** Without doing free advertising, there is: (i) Grammarly which offers plagiarism check with an upgrade, (ii) Plagiarism Checker X; (iii) iThenticate; (iv) Compilatio and (v) G2, among others for sure. Paolo's advice is to keep an eye on your university or Institute subscription to software, which most of the time includes those services. Otherwise, have you tried copying and pasting some sentences in Google? It works, but don't exaggerate with the length.

2. **How to approach a response to reviewers? How to handle a disagreement with reviewers?** Paolo's first answer is: "*always be polite*". Even if you disagree with one or more comments, use gentle words, and use analytical and bibliographical proofs to support your position. Try to find a balance: if you disagree with many comments, you can consider following some of them that would not revolutionise your manuscript. In my opinion, as an author and a reviewer, I suggest answers to the reviewer's queries in the most comprehensive way possible, without avoiding using the simple "done" or "ok" (it is not the case if it is a typo for example!).

3. **I have to build a paper out of my MSc thesis. How do I go about this?** If you wish to write a paper out of your MSc dissertation, the latter itself should be born for this purpose. I suggest looking at the previous section on how to write an article. Start first with a skeleton that comprises the main paragraphs you used in your MSc thesis.

4. **Can you give us recommendations for reproduction problems of study site figures?** As Paolo always suggests to his students: "*try to be original!*". There is no point in using previously published figures or maps that have no novel information in your current manuscript. Sometimes even minor edits may differ but remember to use the "*Modified from (citation)*" in the caption. If you cannot edit or construct a new figure, ensure you have the credits (of the authors and the journal) to reproduce the figure in your current manuscript.

5. **Are there overviews about which abbreviation must be explained or expected to be known by the readers?** For me, the best way to answer this question is to look at other similar papers in your field and see the most used practice. In general, Paolo suggested explaining acronyms whenever possible and try to avoid them in the abstract.

Do you have **more questions** regarding "How to write a scientific paper"? **Please write them in the comment box**!

Follow our official channels to be constantly updated on the following events organised under the Campfire series: "*Soft skills for soft lunches – NH series*" by the Early Career Scientist Team of the EGU Natural Hazards Division:

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Want to join the network? Write to Valeria Cigala: ecs-nh@egu.eu.

Edited by Valeria Cigala and Silvia De Angeli

(Giulia Roder / EGU Blogs, September 20, 2021, https://blogs.egu.eu/divisions/nh/2021/09/20/the-road-to-successful-scientific-writing-for-early-career-scientists)

Pythagoras' Mathematics in Architecture and his Influence on Great Cultural Works

Eustathios D. Chiotis

ABSTRACT

Pythagoras' life, teaching and contribution in science and philosophy has been transfigured by legend, which hardly can be separated. Tracing his fingerprints of mathematical nature is attempted here, based on evidence from great technical works and temples accomplished during his time in Samos and Magna Graecia. The application of the Pythagorean triples in the design of the Athena temple at Paestum built in c. 520 BC has already been established and was considered to attest the Pythagorean consciousness of the architect. Similar conclusions are also drawn in this article from the layout of the Polycratean temple of Heraion in Samos, where the earliest application of Pythagorean mathematics and proportions is disclosed in this article. It is also demonstrated that the achieved accuracy in pre-positioning of the Eupalinos' tunnel mouths and the well-designed maneuver at the crossing indicate the involvement of a mathematical mind supporting the engineering skills of Eupalinos. By comparison with the Hellenistic temple of Apollo at Didyma, where the systematic application of the Pythagorean triples is again revealed in temple modeling and layout, it is concluded that the geometrical method of design of the ancient temples and the concept of harmonic proportions was fully developed in Pythagoras' time and his philosophy of proportions in architecture, amalgamated later with Plato's ideas, prevailed since then until the present.

1. INTRODUCTION

Samos in its heyday hosted men of letters, outstanding architects, artists, and scientists. As conjectured, there must have been considerable geometrical activity in the sixth-century BC in Samos, required by the immense building projects. It is also believed that the origins of Greek mathematics lie in Greek engineering and that the building projects had greater influence on Pythagoras than Pythagoras had on the building works. Not only the Eupalinos' aqueduct, but primarily the temple of Heraion, the so-called Samian "labyrinth", presupposed careful application of mathematics and project design (Rihll and Tucker, 2003: 416).

Geometry is generally held to have been applied first in Babylonia and Egypt. It owed its development in Egypt to the practice of land measurement because the overflow of the Nile would disorder the boundaries of land pieces. It was Thales, who after a visit to Egypt first brought the study of geometry to Greece. Not only did he make numerous discoveries himself but laid the foundations for many other discoveries on the part of his successors.

Thales was regarded as the patron saint of mathematics even in the fifth century (Burkert, 1972: 413). Pythagoras has grown in this intellectual atmosphere. He was born in Samos in c. 570 BC and left for Italy most likely in 532/531 BC because of the oppressive tyranny of Polycrates (Bunkert, 1972: 110). He was in Samos when the works for the Heraion were in progress and of course during the completion of the tunnel for which the works started as early as c. 550 BC (Kienast, 2005: 37).

As eloquently epitomized by Burkert, there is no doubt of the historical reality of the Pythagorean society and its political activity in Croton; but the Master himself can be discerned, primarily, not by the clear light of history but in the misty twilight between religious veneration and the distorting light of hostile polemic. Pythagoras and the Pythagoras' legend cannot be separated (Burkert, 1972: 120).

It is hoped at least that the Master's fingerprints can be traced in great technical works of his time. I believe therefore that it is worth tracing and studying any indication of mathematical nature in the architectural and technical masterpieces which were being realized during Pythagoras' time in Samos, and Magna Graecia. This is partly the aim of this paper, along with the investigation of the origin of mathematical knowledge applied.

Our objectives, the steps we follow, start of course from Samos, and extend in Croton's metropolis in Achaea, near Aegion, and finally in Magna Graecia. The monuments examined, temples and the Eupalinos' aqueduct, fall in the span of Pythagoras' life. A further step brings us to the Hellenistic temple at Didyma in the domain of Miletus, Thales' place of origin, for the study of the evolution of Pythagoran ideas in the next centuries.

A polemic against Pythagoras extends from antiquity to the present and some scholars consider today that Pythagoras was not "a master geometer, who provides rigorous proofs, but rather someone who recognizes and celebrates certain geometrical relationships as of high importance" or even that "the traditional stories of discoveries made by Thales or Pythagoras must be discarded as totally unhistorical". Therefore, our study of the Pythagorean triples[1] extends into the Babylonian mathematics.

It is revealed for the first time that the layout of the temples at Heraion in Samos, Trapeza near Aegion, and Apollo temple at Didyma is designed based on Pythagorean triples; the method of temples' design and generation of the triples are also elucidated. Alternative methods of Pythagorean triples generation are investigated for the temples examined. The ingenuity of the Old Babylonian mathematics is appreciated, but it is concluded that Neugebauer's persistence on the use of generating functions is an unnecessary anachronism.

2. GEOMETRIC DESIGN OF THE LAYOUT OF LATE ARCHAIC TEMPLES BASED ON PYTHAGOREAN TRIPLES

Layout surveying for important constructions in ancient Egypt was both an important procedure and ceremony as described by Paulson (2005). At the beginning of the construction of the pyramid, the priests, builders, and perhaps the pharaoh himself would have performed a "stretching of the cord" ceremony. The Egyptian phrase for a surveyor was a "rope stretcher" and surveying was known as "stretching a rope". In fact, a calibrated rope was one of the tools used in surveying. Several tombs from the New Kingdom era about 1100 BC show the tomb owner overseeing men using ropes to measure fields, presumably to calculate the taxes for yield of these fields (Paulson, 2005: 2/12).

In the following the dimensions and layout of Archaic temples in Samos and Magna Graecia are investigated for possible Pythagoras' influence; the examined monuments were built in the second half of the 6th century BC, a period of Pythagoras's presence there.

2.1 The second dipteros temple of Heraion in Samos

The second dipteros temple of Heraion in Samos is described as a labyrinth (Pliny, Natural History 34.8 3). The enigmatic term "labyrinth" must be a popular name of the gigantic temple of Hera in her sanctuary in Samos, which through its dou-

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[1] A Pythagorean triple consists of three positive integers a, b, and c satisfying the Pythagorean theorem, such that $a^2+b^2=c^2$

ble and triple rows of over a hundred columns must have given the impression of labyrinthine complexity (Kyrieleis, 1990: 17). Despite that, the geometric design of the temple can be greatly simplified if the geometric rules applied are understood, a task which is attempted here.

During the tyranny of Polycrates, work began on a new temple, known as the second dipteros (Hellner, 2002: 168) or Polycratean temple, on a stylobate measuring 55.16×108.63 meters (magenta in Fig. 1), even larger than the first dipteros temple. It is revealed that the dimensions of the new temple signal a change of proportions at the Heraion in Samos, a new trend which was spread and applied to other Late Archaic temples soon. Thus, by comparison to the ratio 2:1 of the first dipteros temple, the stylobate's ratio at the second dipteros temple is 108.63: 55.16 = 1.9694 = (2- 132). It is indeed a minor numerical change by itself, associated however with a "latent" significant evolution at the level of geometric design, which is the expert application of Pythagorean triples. As estimated from the temple plan (Gruben and Kienast, 2014: Beilage 5), the columns are about 0.3 to 0.35 meters apart from the outline of the stylobate. Thus, if the stylobate dimensions are reduced by d=0.65 m, the dimensions of rectangle envelope around the outer colonnades, blue in Fig. 1, are calculated as follows:

(55.16-0.65) × (108.63-0.65) = 54.51 m × 107.98 m and their ratio:

107.98/54.51 = 1.98092 equals to 208/105 (1.98095).

Therefore, the blue rectangular envelope, which circumscribes tangentially the outer colonnade, is a Pythagorean one corresponding to the Pythagorean triple (105, 208, 233). Furthermore, it is:

54.51105 = 0.519143 m and 107.98208= 0,519135 m

and this implies a length unit at the Heraion temple, a cubit of 0.519 or ~0.52 m, impressively close to the Samian cubit calculated below from the tunnel measurements.

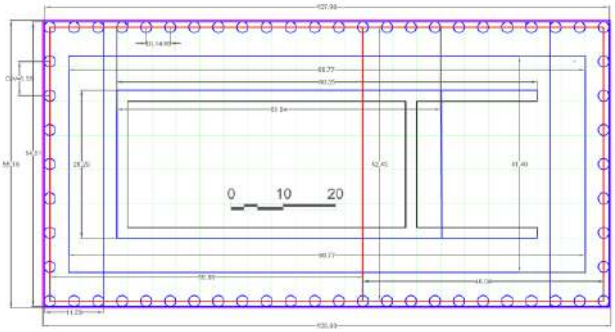


Figure 1: Simplified plan of the second peripteros temple of Heraion in Samos, based on the plan 5 by Gruben and Kienast (2014). The stylobate (magenta), the Pythagorean rectangles in blue (No 1, 2, 3 and 4 of the Table 1), the subdivision of the interaxial rectangle in red (No 5 and 6 in Table 1) and the inferred rectangular grid in green.

The interaxial distances in meters, for a column radius of one cubit at the base, are:

DL= (107.98-2x1.04)/23 = 4.60 m along the length and DW = (54.51-2x1.04)/8 = 6.55 m along the temple width. Their ratio is remarkably close to the square root of 2, which implies that DW equals the diagonal of a square with side DL, and that DW and DW served as modules of a rectangular grid.

Apart from the rectangle of the outer colonnade, some smaller Pythagorean rectangles are also delineated on the temple layout in blue and are summarized in the Table 1. They are characterized as Pythagorean because their sides and diagonals are proportional to a Pythagorean triple shown in the Table 1. The rectangles No 1 and No 2 in the table correspond to the envelope of the outer and inner colonnade respectively (Fig. 1). The rectangle No 3 is repeated twice and surrounds three rows of nine columns each, at both faces of the temple. The inner structure of the temple is based on the Pythagorean rectangle No 4 in the Table 1.

Table 1: Pythagorean rectangles revealed in the Heraion temple

Rectangle, No	Length, m	Width, m	Pythagorean triple
1	107.98	54.51	(105, 208, 233)
2	98.77	41.40	(5, 12, 13)
3	11.29	54.51	(5, 12, 13)
4	61.94	28.30	(115, 252, 277)
5	59.86	52.43	(48, 55, 73)
6	52.43	45.96	(48, 55, 73)

It is amazing that the rectangle formed by the axes of the outer colonnade, red in Fig. 1, measures 52.43x105.00 m and has a sides ratio 2.003, practically 2: 1, the harmonic ratio considered to correspond to the octave (diapason). The interaxial rectangle can be subdivided in two Pythagorean rectangles, No 5 and 6, respectively 13xDL and 10xDL long both proportional to the Pythagorean triple (48, 55, 73).

In short, it is supported that there is strong evidence of thorough mathematical design in the temple layout, including the multiple application of Pythagorean triples and simple proportions which are implemented by the use of a rectangular grid of dimensions DL by DW.

The application of Pythagorean rectangles provides a better design control because in addition to the intended dimensions of the rectangle sides, the diagonal is known in in round length units, so that right angles and the dimensions are more accurately implemented. This is particularly significant for the colonnades but is also locally applied through the rectangles 3 and 4 of the Table 1 and this indicates the great care for geometrical perfection. Besides, the application of the grid, a technique already in use by the Egyptians, facilitates the allocation and control of the architectural plan on the ground.

2.2 The Trapeza temple

Another Archaic temple, the layout of which is based on a Pythagorean rectangle, is the peripteral hecatombedos Doric temple at Trapeza of the city of Rhypes, a citystate of ancient Achaean Metropolis of Croton in Magna Graecia. The temple was founded in the decade 520- 510 BC (Vordos, 2016); however, Kanellopoulos and Kolia (2011: 148) date the temple earlier in 530-525 BC. The temple dimensions in meters, as given by Hellner and Gennatou (2015: 120), and the values of the Length to Width (L/W) ratio are summarized in the Table 2. It is underlined that the euthynteria sides correspond precisely to the Pythagorean triple (8, 15, 17) multiplied by 7, given that 31.56/16.84= 1.8741~15/8= 1.875 and that 1.875/1.8741 =1.0005. It is interesting too that the Trapeza temple is contemporary or older than the temple of Athena at Paestum. The calculated length unit **u** from the euthynteria dimensions is:

u= 31.56 m/15x7 = 16.84 m/8x7 = 0.3006 m.

It is noted that the crepis and stylobate dimensions are also expressed in round numbers in terms of the model unit,

shown bold in the Table 2; it should there-fore be examined how this unit **u** is correlated to the Attic foot. The location of the temple on the route from Delphi to Italy is also noted and the point is raised whether it could be corelated with Pythagoras' visit to Delphi. In any case, another reasonable way of Pythagoras' influence is through the city of Croton, an Achaean colony in Magna Graecia.

Table 2: Dimensions of Trapeza temple from Hellner – Gennatou (2015) in meters and model units (u)

Level	Length m/**u**	Width m/**u**	L/W
Euthynteria	31.56 **105**	16.84 **56**	15/8 (*1.875*)
Crepis	31.25 **104**	16.45 **54.75**	19/10 (*1.9*)
Stylobate	30.51 **101.5**	15.64 **52**	39/20 (*1.95*)

2.3 The Athena temple at Paestum

Especially important is the envisaged influence of Pythagoras in the design of the temples in Magna Graecia in the second half of the 6th century BC. Confirmation on that comes from the Athena temple at Paestum examined for "Pythagorean qualities" by Nabers and Wiltshire (1980). The temple is commonly dated to around 510 BC and demonstrates the application of Pythagorean triples in southern Italy during Pythagoras' time there, roughly 532/1 to 494/3 BC.

Nabers and Wiltshire (1980), using precise measurements of the temple, independently established, discovered that two Pythagorean triples were used in the design of the temple, one on the plan and a second one on the flank elevation. The Pythagorean triangle present in the plan of the Athena temple at Paestum is a version of the basic or "primitive" Pythagorean triangle (5, 12, 13), enlarged by a factor of 8. Yet another Pythagorean triangle exists in the design of the temple on the flank elevation with the sides (28, 96, 100), which is a version of the primitive Pythagorean triple (7, 24, 25), enlarged by a factor of 4. Therefore, Nabers and Wiltshire (1980: 215) conclude that the teachings of Pythagoras in southern Italy affected the design of the Athena temple and in particular that: "Here we have a structure of fairly certain date, contemporary with Pythagoras himself, which at least attests the Pythagorean consciousness of its architect and may reflect broader philosophical and political conditions at Paestum as well. Finally, as a physical monument, it manifests in an empirical way the fundamental Pythagorean proposition that "things are numbers" and suggests that the cosmic order apparent to the Pythagoreans in the musical scale may also be expressed in architectural form".

The application of a Pythagorean triple also on the elevation is particularly important for the interrelationship of proportions in three dimensions, projected from the plan layout to the whole monument.

2.4 The echo of Pythagorean harmony on the design of the Apollo temple at Didyma

The application of Pythagorean triples in ancient architecture became widespread as documented by Ranieri (1997: 210) who attributed to Pythagoras a rule of triads. For comparson's sake, a short reference to the Hellenistic Apollo temple at Didyma follows, selected as an outstanding case study. The temple is the best preserved and among the largest Greek temples (Weber 2011: 33), it has been studied systematically since long and reflects the Pythagorean-Platonic ideas of harmonic design. It is therefore reviewed here for investigating possible Pythagorean tradition a few centuries after the Heraion and Athena temples.

Birnbaum (2006) performed a thorough harmonic analysis of the dimensions of the Apollo temple at Didyma by calculating ratios of rectangle sides and other dimensions that correspond to musical consonances. Certain ratios in architecture are considered harmonic, by analogy to vibrating strings which sound at musical intervals if their lengths are in simple, rational numerical relationships. So, the ratio 2: 1 is considered to correspond to the octave (diapason), 2: 3 to the fifth (diapente) and 3: 4 to the fourth (diatessaron). It is underlined by Birnbaum (2006: 12) that the connection of numbers with music by the Pythagoreans gave the numbers an over-mathematical meaning and was used as a fundamental insight into the essence of reality, in the belief that the metaphysical order is expressed in the musical harmony. A rectangle is considered harmonic if the sides ratio deviates less than one percent from a musical interval. The crepis outline of Didymaion with a side's ratio of 197/100, is close to the ratio 2: 1 but not enough to be considered as harmonic. By contrast, the hypothetical rectangle which lies in the plan of the temple exactly in the middle between the second and third crepis step is harmonic with sides ratio exactly 2:1 (Birnbaum 2006:94). In short, Birnbaum (2006: 181) concludes that an interpretation of dimensions in connection with the Pythagorean-Platonic theory of numbers is not only possible, but rather mandatory.

It is understood that Birnbaum investigates Didymaion in Povilioniene's sense (2013: 96), as a link between music and architecture, as a philosophical-aesthetic problem of harmonious universality in which interaction between the art of sounds and visual art reveals itself most clearly through a constructive "common denominator" – the use of numbers, proportions and symmetry.

Particularly important and insightful for the plan design of the Didymaion temple is the system of inscribed letters at the upper blocks of the euthynteria, described and ingeniously interpreted by Weber (2011: 33). In places of the temple's euthynteria exist letters, carefully carved like inscriptions, at an average distance of b = 1.324 m, where b stands for the German term "Buchstabenabstand". Weber interpreted these letters as the legend of a grid of 44×88 square cells, green in Fig. 2, with elementary cell dimensions 1.324X1.324 m and total dimensions 58.256 × 116.512 m. On the plan eight large squares can be shaped into two rows, each of four squares of 22x22 cells. The crepis ABEF, shown in red, is larger than the green grid and measures 60.085 x118.340 m. So, the 2:1 ratio of the grid becomes in the crepis outline 197:100 and Weber investigated why this change from the "nice" 2:1 ratio (88:44) to an "ugly" one. More importantly, he also recognized that the regular distance between the letters (b = 1.324m) equals to one quarter of the interaxial distance, taken as the modulus, M, of the temple (M = 5.296 m), and to one half of the square bases of the columns. Incidentally, it is reminded that at the Heraion temple in Samos the sides ratio of the interaxial rectangle of the outer colonnade is 2:1.

Adherence to the harmonic theory prevented the researchers from recognizing that the temple layout originated from an "ugly" Pythagorean rectangle of the crepis outline as a background from which the "nice" rectangle of the grid resulted. The crepis outline is in fact composed of two equal Pythagorean rectangles ABCD and DCEF (Fig. 2) with sides 118.34 m and 60.085/2 = 30.043 m and sides ratio equal to 3.9394. This ratio practically equals to 63/16 = 3.9375 and therefore the rectangle sides 118.34 m 30.043 m are proportional to the members 16 and 63 of the Pythagorean triple (16, 63, 65).

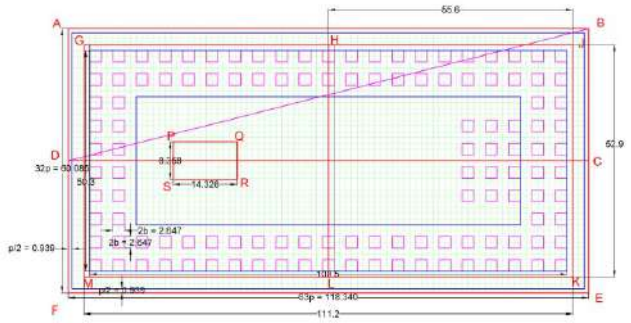


Figure 2: Division of the crepis (ABEF) of the Apollo temple at Didyma into the Pythagorean rectangles ABCD, DCEF, GHLM and HJKL (red), overlying the green grid. The Pythagorean rectangle of the Naiskos, PQRS in red, and the square bases of the columns (magenta) are also shown. Modified from Weber (2011).

The respective rectangles of the Pythagorean model, A'B'C'D' and D'C'E'F' (Fig. 3), measure 16x63 dimensionless model units, named here "Pythagorean" units (p). The equivalent of p-unit on the temple equals AB/63= 118.34/63 = 1.878 m. By shifting in the model of Fig. 3 the outline A'B'E'F' inwards by half a model unit, a "nice" rectangle results 31x62 in size, composed of eight squares 15.5x15.5 (p) units in two rows like the temple.

By analogy, by shifting the crepis outline ABEF of the temple (Fig. 2) by the equivalent of p/2=1.878 m/2 = 0.939 m the nice rectangular of the green grid results.

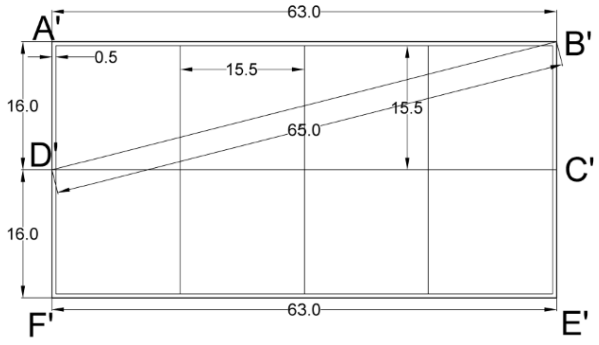


Figure 3: Pythagorean rectangles A'B'C'D' and D'C'E'F' proportional to the (16, 63, 65) triple, as a model of the Apollo temple crepis.

This relationship of the Pythagorean model and the actual geometry of the temple provides an insight into the process of architectural design. First, the geometrical pattern is designed on the Pythagorean model like Fig. 3, which is then scaled and transformed into the desired dimensions.

Furthermore, apart from the Pythagorean rectangle of the crepis outline, three more are recognized on the plan of the Apollo temple, shown in red in Fig. 2. The Naiskos, PQRS, with sides ratio 7:12, measures on the stylobate 8.358x14.328 m (Birnbaum, 2006: 161); it is therefore half of the Pythagorean rectangle 8.358x(2x14.328) m which is proportional to the Pythagorean triple (7, 24, 25). In addition, each of the rectangles GHLM and HJKL measures (20x2b)x(21x2b) and is proportional to the Pythagorean triple (20, 21, 29).

The length unit in the temple is in general considered to be the Attic foot and two alternative values are the most credible ones, either 29.85 cm (Birnbaum, 2006: 174) or 29.42 cm (Weber 2011: 45). However, a third alternative unit will be considered by the author in a forthcoming article, that is a cubit of 0.5296 m equal to one tenth of the module M and equivalent foot equal to 0.5296/1.5 = 0.353 m. It is noted that Weber's estimation of foot corresponds exactly to 0.353 x 5/6 meters and 2b/9 or M/18; it is therefore preferred as a commensurate estimation to the temple dimensions.

The geometric design and the harmonic proportions of the temple along with the roofless adyton and the axial orientation of the temple are among the outstanding features of a unique monumental architecture. Castro et al. (2016) examined five temples of Apollo on Mainland Greece and Ancient Ionia (Asia Minor), including Didyma, regarding their functioning through astronomical orientation, and showed that the rise, setting, orbit and observation of certain constellations in the celestial sphere, as well as the solar stands, can be directly related to the architecture of the temples. They underlined, that the unique architecture of the Great Temple of Apollo at Didyma, the most renowned Sanctuary and oracle after Delphi, can be related to astronomical observation.

3. INDICATIONS ON THE APPLICATION OF MATHEMATICS IN THE EUPALINOS' TUNNEL

Pythagoras was born in a period when intellectually astonishing things were happening in the neighboring city of Miletus, where Ionian natural philosophy was being developed. And on his home island Samos architectural and technical masterpieces were being realized, such as the tunnel of Eupalinos, which is still hailed as an "unsurpassed feat of engineering". This tunnel, 1,036 meters long and devised to guarantee a long-term water supply, was dug from both ends in order to shorten the construction time – a venture which required substantial mathematical and technical skills" (Riedweg, 2013: 51). Pythagoras' involvement in the design of the Eupalinos' tunnel, although reasonably suggested by Riedweg, has not been examined in this sense so far and is investigated in this article. According to Riedweg (2005: 46) the construction of the Eupalinos' tunnel "falls in Pythagoras' later youth and is hardly conceivable that he was not familiar with this bold engineering project, which must have taken years to complete".

Possible transfer of designing and monitoring expertise from the Heraion temple to the tunnel engineer cannot be excluded, since again Riedweg (2005: 45) notes that the Samian architect Theodorus who dealt with the giant temple of Hera was a many-faceted and innovative artist, who is supposed to have invented among other things a device for measuring angles, a water-level, and the lathe (Pliny, Natural History 7.198).

Certainly, a leveling device was constantly required in the construction of both, the Heraion temple and the horizontal tunnel, as well as in the positioning of the predetermined tunnel mouths. Tunneling started in parallel from both mouths, a fact meant by Herodotus' adjective "double-mouthed (αμφίστομον)" and convincingly confirmed already in 1884 by Fabricius (1884: 173-176). The tunnel floor elevation at the northern portal is 55.22 m and at the southern one 55.26 m (Kienast, 1995: Plan 2) and remains an unresolved mathematical conundrum how the one-kilometer apart portals were fixed so accurately.

The Eupalinos' aqueduct (Fig. 4) has been extensively studied and highlighted as exceptional engineering feat of the sixth century BC, as well as a mathematical problem studied already in antiquity by Heron (Burns, 1971: 173). The tunnel pierced the Kastro Hill at the same time, at two portals in the North near the Ayiades spring and in the South above the city of Samos (Fig. 5). The aqueduct is composed of three sectors, accommodating the water pipeline from the spring to the city. The supply sector, outside the city walls, carries water from the copious and still flowing spring to the northern mouth of the tunnel and the distribution sector starts from

the southern mouth, within the city walls; both end sectors were excavated using the shafts-and-gallery tunneling technique (Chiotis, 2017: 5). At the interval between the end sectors, a few meters below the floor of the tunnel and simultaneously, an inclined narrow gallery was dug, on which the water line rests, comprised of interconnected terracotta pipes.

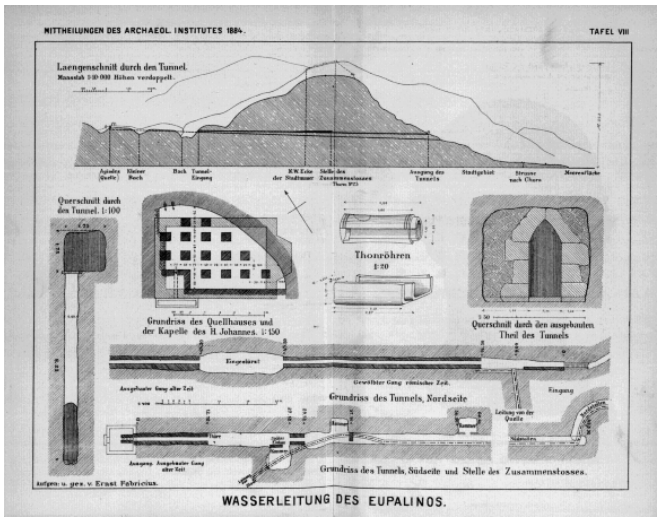


Figure 4: Eupalinos' aqueduct in general section on the top and detailed views below from Fabricius' first study in 1884.

Figure 5: Location maps projected on ESRI's satellite images: a. The aqueduct and the walls of the ancient city of Samos, in Greek coordinates (EGSA); b. The broader area, including the island Fourni where the marble for the Polycratean temple of Heraion was quarried (Cramer, 2004: 165).

Aqueduct description is kept to a minimum in this article, given the detailed documentation by the German Archaeological Institute (Kienast, 1995), as supplemented by recent publications of independent researchers (Lyberis et al., 2014; Zambas et al., 2017; Zambas, 2017; the latter being an updated source of references), working for the project of the tunnel's restoration of the Greek Ministry of Culture. Fabricius' first study of the aqueduct in 1884 has been practically confirmed and refined by modern studies and the aqueduct is perfectly illustrated in his outstanding synthetic presentation of Fig. 4, the best concise description of the tunnel and the aqueduct.

3.1 Geometric drawings on a rock slab

There are hints from the Eupalinos' tunnel itself of the practical application of mathematics for the design of the tunnel. Among them a recent discovery of a slab found 132 m from the north mouth during the restoration of the Archaic lining, with an incised rough geometric drawing (Fig. 6). The meaning of this geometric construction is not obvious. It seems like a mason's explanation of a geometric construction or possibly a comment on the V-shaped deviation of the north bore of the tunnel according to Zambas (2017: 126, his Fig. 27).

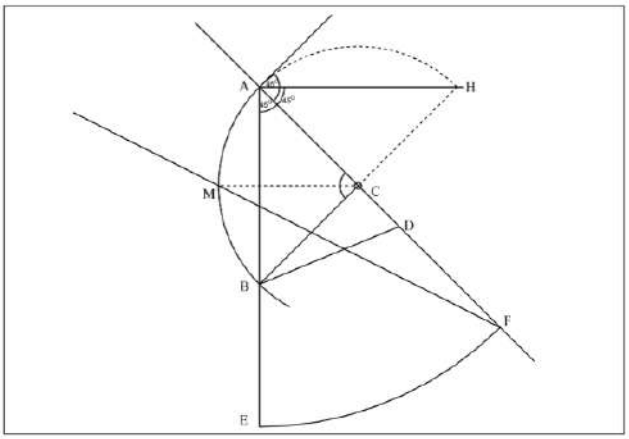


Figure 6: Our interpretation of the ancient drawing carved on a rock slab from the Eupalinos' tunnel lining, based on the slab's photo published by Zambas (2017). M is taken in the middle of the quadrant AB. Dashed lines were added to the drawing.

In our interpretation, the ancient drawing on the slab displays basic geometric rules, as if prepared for instructions by a mathematician to an engineer. The central angle ACB in a quadrant is right; the inscribed angle BAF in a quadrant is half of the right angle; the inscribed angle BAH in a semicircle is right, as expected from Thales' theorem; the tangent to the circle at A is drawn perpendicular to the radius; the right angle fractions of ¼, ½ and ¾ are also drawn and their tangents can be calculated as ratios of sides in right triangles.

3.2 The deviation from the alignment and possible application of Thales' theorem in tunnel surveying

It is generally accepted that the tunnel was planned horizontal, aligned between the predefined mouths but the original plan was significantly modified in the northern branch, and rather relatively early, given the significant deviation from the alignment about 250 meters from the north end.

Between points 23 and 24 of the longitudinal plan (Kienast, 1995: Plan 3a) of the northern branch, at a distance of c. 240 meters from the northern end (Fig. 7), there are adjacent symbols K and Λ of the ancient measurements at a distance of only 2.5 meters apart. However, the regular distance of the sequential measuring marks of the system 1 in the North is estimated by us to 20.52 m. As Kienast correctly concludes, the short distance between the symbols K and Λ indicates that the symbol Λ belongs to an earlier series of measurements from a different starting point.

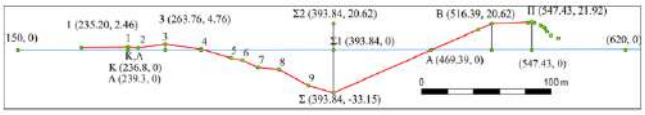
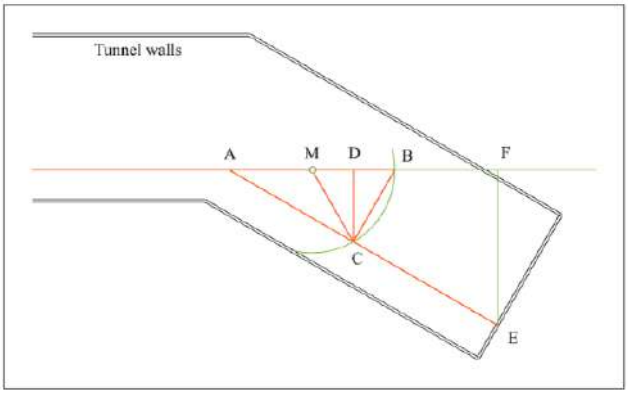


Figure 7: The route of the "triangular" detour and coordinates of critical points in regard with the tunnel axis, adopted from Kienast's longitudinal plan (1995: Plan 3a) of the northern branch. It is noted that observation between points: (2, 4), (6, 8), (7, 9), (9, B), (Σ, Π) is hindered.

We verified this conclusion through the calculation of the lengthening due to the deviation up to the point A in Fig. 7. It was found to be 18.42 m and, by the addition of 2.5 m for the distance between the points K and Λ, the interval of 20.92 m results relatively close to our estimation of the regular interval of ancient measurements of 20.52 m. In any case, depicting during tunneling the actual routing along the triangular detour and further up to the crossing point is a complicated task that requires accurate surveying measurements. Even the so-called "triangular" detour, shown in Fig. 7, is more complex than this description suggests, because the course between the points K and Σ is a crocked path and observing is hindered at least between the points 2 and 4, 6 and 8, 7 and 9, 9 and B and Σ and Π. Therefore, recording the tunnel direction is mandatory and the successful crossing infers accurate topographic mapping during tunneling for which we propose a possible method based on Thales' theorem.

Using a measuring cord or rod the direction change CAB, shown in Fig. 8, between two angular branches of the tunnel can be measured as a ratio of the perpendicular segments CB and CA, following the Egyptian practice. In the extension of the old direction it can be taken AM=MB=1, one length unit supposedly one cubit, and MC equal to one unit again to define the point C. Thus, ACB is a right angle according to Thales' theorem, since it is circumscribed in circle of diameter AB centered at M. In this way the "angle" between successive segments is measured as a ratio CB/CA sufficient for graphical solution for drawing the tunnel geometry.



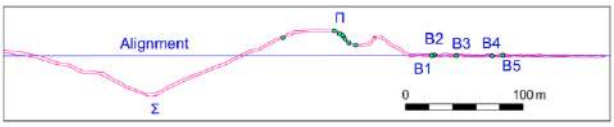
Equally well the ratio AC/AB can be used which corresponds to the notion of spread in Rational Trigonometry. The spread between two lines is a dimensionless quantity, and in the rational or decimal number fields takes on values between 0 and 1, with 0 occurring when lines are parallel and 1 occurring when lines are perpendicular. Forty-five degrees becomes a spread of 1/2, while thirty and sixty degrees become respectively spreads of 1/4 and 3/4. What could be simpler than that? (Wildberger, 2005: 13).

CD can also be measured to be used for the calculation of EF, the lateral offset from the previous direction, based on the similarity of the triangles ACD and AEF. The graphical solution of a scaled drawing on a board, as suggested by Riedweg (2005: 45), seems more realistic than the geometric design in full scale on a horizontal plane on one of the extensive beaches near the ancient city as suggested by Zambas (2017: 136).

3.3 The crossing maneuver and the stone bosses

A peculiar class of quasi measuring marks, not applied with paint and quite different from the rest ones are stone bosses protruding from the center of the gallery roof; they are up to 20 cm in height, at irregular distances from one to forty meters (Kienast, 1995: 163). Remarkably, they occur only along the meeting region of both branches, but their use and meaning are not clear.

In the northern branch there are nine bosses which lie along a smooth sigmoid path close to hearing distance from the southern branch, indicating self-reliance in the success of breakthrough and accurate surveying control. Instead of rushing to cross the southern branch along a shorter straight path, a gentle but longer maneuver was followed aiming at crossing at a right angle the deviated southern branch, as accurately as if they could observe it. This is clearly sketched by Fabricius at the lower right corner in Fig. 4, as well as in Fig. 9. We believe that this maneuver was not accidental but planned based on carefully calculated measurements and achieved by following exact tunneling instructions.



There are also five bosses of the southern branch which lie on a straight line but are not needed for keeping the alignment (Fig. 9). It is therefore questioned whether they encrypt a message. Possibly, the arrangement of the bosses B2, B3 and B4 in the southern branch could indicate division according to the golden rule ratio of 1.618. The ratios B2B4/B3B4 and B3B4/B2B are approximately equal to this value of 1.618. In fact, it is measured on Kienast's longitudinal southern plan that B2B3 = 18.79 m και B3B4 = 30.35 m, so that B2B4/B3B4= 1.619 and B3B4/B2B3= 1.615. The arrangement of the bosses might be unintended, but further investigation is recommended of their enigmatic nature and function.

3.4 Length unit and the tunnel length

The measuring interval of marks associated with ancient tunnel measurements described by Kienast (1995: 151 and 156), normally corresponds to 40 and 120 length units for the first and the second system of ancient measurements, respectively. However, some of the intervals are significantly longer or shorter, deviate from the above integers and because of that division of the calculated average interval by 40 or 120 for the estimation of the length unit can be misleading. We preceded to the estimation of the length unit from the measurements of the system 2, considered to be more accurate and consistent, taken after the tunnel breakthrough.

The estimation of the length unit was attempted through a statistical procedure designed especially for this case. It was based on the assumption that distances between measurement points are simply multiples of the length unit, the cubit. A deviation-error index was devised, and the length unit estimate was taken as the one that minimizes this deviation index. The distance of each pair was divided by an assumed

value of length unit in the range 0.5 to 0.55 m. Then, the nearest integer to this ratio was calculated and multiplied by the assumed length unit. The actual pair distance was subtracted from this product and squared for all pairs of marks; finally, the sum of the squares was calculated, and this calculation was repeated stepwise for consecutive values of assumed cubit length. The assumed value of length unit with the minimum sum of squared differences was taken as the best estimate of length unit. The procedure is similar in principle to the cosine quantogram described by Pakkanen (2013: 16), based however directly on the measurements. In this way the value of 0.52 m was calculated for the length unit of the system 2 (Fig. 10).

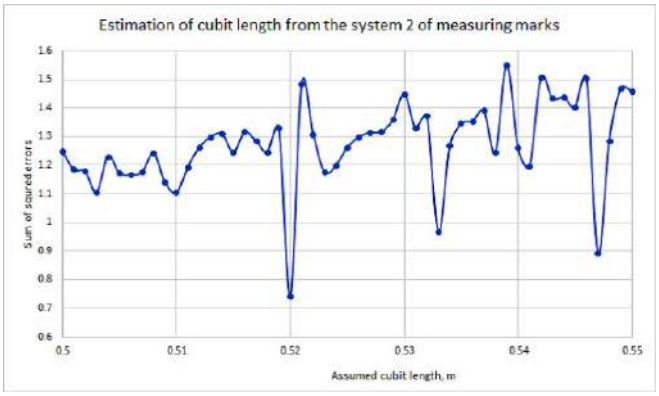


Figure 10: Diagram for the estimation of the length unit from the measuring marks of the system 2; the best estimate is taken at the points 0.52 m of minimum error index.

It is noted that both modern tunnel measurements (Kienast, 1995: 42; Zambas 2017: 122), have common conventional zero point taken on the lowest step of the modern stair of the portal in the north. Based on the measuring marks and the measuring intervals, the zero points of measurements used in antiquity were estimated as a step for addressing the question whether the tunnel's length was already estimated before tunneling works. It was calculated that the northern zero point of measurements in antiquity was about 24 m from the tunnel mouth and about 10.8 m from the southern one.

Next, the straight distance between the zero points of the measuring marks is estimated. This distance, from the north to the south, would be 27.46+ 1002.8 +10.82 = 1041.08 m. It is remarkably close to 50×40×0.52= 1040 m, where 0.52 m is the previously estimated length unit of cubit. Unless this round value is a rare coincidence, it is envisaged that the targeted distance between the end zero points in antiquity was defined in advance equal to 2000 Samian cubits.

3.5 Possible application of the Pythagorean theorem in land surveying

The accuracy in positioning the tunnel mouths is astonishing and doubtlessly confirmed by modern surveying, but difficult to explain. It is generally envisaged that most likely tunneling was contemporary with the construction of the city walls or marginally posterior and this could have facilitated surveying. Towers of the circuit walls near the crest of the Kastro Hill for example could have been used for the alignment between the candidate sites for the mouths along a rocky profile.

On the other hand, elevation measurements could proceed along another route at a second stage, after the alignment, along smoother paths such as AN-AS or BA-BS as shown in Fig. 11. Defining the level independently of the alignment has been also suggested by Rihll and Tucker (2003: 411). It would suffice to measure the elevation difference between the mouth sites N and S and a third convenient point like A or B. Along these paths the Kastro crest is bypassed, the elevation difference is smaller and the topography is smoother. Furthermore, the tunnel length could also have been calculated based on the length measurement of a shorter interval, like the perpendiculars AA' or BB' to the tunnel alignment. Accurate length measurements would be convenient by scaffolding. By the application of the Pythagorean theorem in combination with similar triangles the tunnel length and the elevation difference at N and S could have been calculated. After all, the successful breakthrough of the tunnel through the "triangular «deviation indicates the ability of surveying along slalom routing. No doubt, the achieved accuracy in positioning the mouths in advance and the well-designed maneuver at the crossing point indicate the involvement of a mathematical mind supporting Eupalinos' engineering skills.

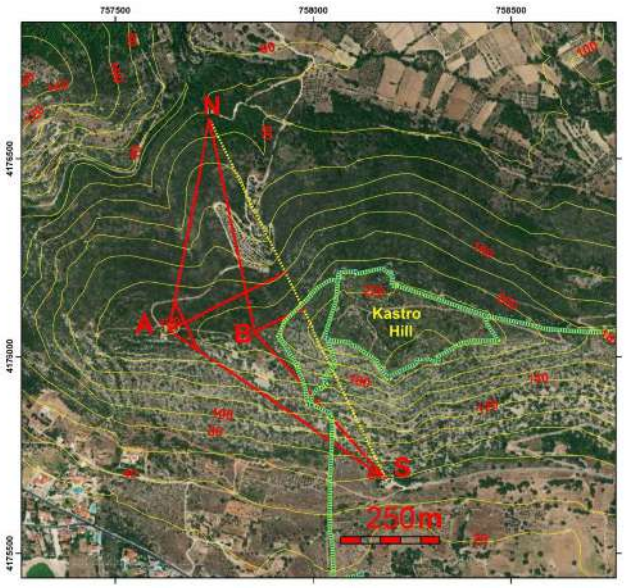


Figure 11: Proposed method of surface surveying for measuring AA΄ or BB΄, angle φ and elevation difference between the tunnel ends N and S and convenient points A or B, projected on ESRI's satellite images in Greek coordinates (EGSA).

4. DISCUSSION

4.1 On the temples' design

From the preceding analysis on the architectural layout of Late Archaic temples, the systematic application of a broad variety the Pythagorean triples is confirmed as a basic design tool both in Samos and Magna Graecia, accomplished in periods of Pythagoras' influential presence there. The procedure was fully developed at the Heraion temple of Samos in the sixth century BC and the following basic steps are recognized.

1. Selection of a cardinal Pythagorean rectangle as a model for the temple outline, which could be either the crepis or the stylobate or the colonnade; in the latter case the intercolumnar axes or the outer colonnade can alternatively be used, as at the Heraion temple.

2. Selection of a modulus for designing a grid, square or rectangular, related mostly with the interaxial column inter-val.

3. Subdivision of the model plan into smaller either Pythagorean or harmonic rectangles.

4. Correlation of the plan proportions to the elevation by extending the plan grid vertically or through a modified vertical grid on another Pythagorean rectangle. In this way the building proportions are interconnected in three dimensions.

5. Calculation of the actual dimensions from the model, based on a scale factor.

6. Accurate positioning of the Pythagorean rectangles constrained by the dimensions of the sides and the diagonals, along with implementation of the grid and delineation of architectural elements in situ.

The described basic method was fully developed in Pythagoras' time and perfected in the Hellenistic times, when more emphasis was put perhaps on the harmonic proportions.

4.2 On the Pythagorean triples in Babylonian mathematics

Neugebauer and Sachs (1945) deciphered and revealed the importance of mathematical Babylonian cuneiform tablets and concluded that the Plimpton 322 tablet, dated in the early second millennium BC, listed Pythagorean triples. More specifically, according to Neugebauer (1951: 40) there is a strong indication that the fundamental formula for the construction of triples of Pythagorean numbers was known to the Babylonians.

The tablet was originally larger, it was broken, and four columns of numbers are only preserved. In the second and third columns the numbers are Pythagorean, integer solutions b and d of the equation:

$$d^2 = b^2 + l^2$$

whereas the number of the fourth column corresponds to d^2/l^2 , where d the hypotenuse and l the long leg.

Neugebauer obtained the Pythagorean triples (a, b, c) of the tablet from the generating functions:

$$a = p^2 + q^2,\ b = p^2 - q^2 \text{ and } c=2pq$$

where p and q are arbitrary integers subject only to the condition that they are relatively prime, not simultaneously odd and p > q. Neugebauer (1957: 42) assumed that "this is indeed the formula which we needed for our explanation of the text dealing with Pythagorean numbers". However, this is Euclid's approach for the generation of Pythagorean triples, introduced much later.

Neugebauer and Sachs' views were disputed soon by Bruins (1949: 629) who proved that a simpler interpretation is possible, in which the production of Pythagorean numbers is feasible by using only one parameter, instead of the couple (p, q) of independent integers, by means of reciprocal sexagesimal numbers derived from Babylonian tablets.

Friberg (1981: 284) verified that the values listed in the Plimpton 322 tablet are precisely the ones that can be obtained from reciprocal pairs, under the condition that the reciprocal numbers t and t' are "regular", that is in the form: $t = 2^{\alpha}3^{\beta}5^{\gamma}$ where α, β, γ are integers not necessarily positive. Friberg went further to generate an arbitrarily large set of admissible values t, by letting the parameter t and its reciprocal t' as t=s/r and t'=r/s vary within a bounded strip in the (r, s) plane. So, Friberg, like Neugebauer, envisaged in the tablet "anachronistic" mathematics supposedly to be known by the Babylonians.

To clarify this point further and make this discrepancy better understood let us refer to the tablet YBC 6967 the calculations of which fortunately are described in the tablet. Høyrup (1990: 262-266) interpreted the impressive underlying "cut-and-paste" or "naive" geometric methodology on the solution of the system of equations:

$$xy=60 \text{ and } x-y = 7.$$

The problem deals with a pair of numbers (12 and 5, members of the Pythagorean triple 5, 12, 13) and the solution is given by a clever geometrical interpretation; any modernizing algebraic solution would be therefore irrelevant and out of historical context.

Plimpton 322 tablet has been and continues to the be subject of intensive and multidisciplinary research, but a few references only closely related to our topic, are compiled here. Robson (2001: 167) compared and evaluated in a broader mathematico-historical con-text both alternative interpretations, Neugebauer's proposal of generating functions with two parameters and Bruins' approach based on one parameter and reciprocal sexagesimal numbers from tablets. She based her judgement on certain criteria, the first of which was the historical sensitivity and the condition that "the theory should respect the historical context of Plimpton 322 and not impose conceptually anachronistic interpretations on it" (Robson, 2001: 176). She considered the first column in decimal notation as the ratio d^2/l^2 or b^2/l^2, depending on the acceptance or not of the supposed missing unit of the broken part of the tablet, where d is the hypotenuse, l the long side and b the short one. She also transliterated a grammatically and mathematically meaningful heading for Column I, as "The takiltum of the diagonal from which 1 is torn out, so that the short side…".

We believe that this heading, as translated above, is a concise expression of the Babylonian "diagonal rule", the Pythagorean theorem in modern terminology, transliterated in our algebraic notation as:

$$d^2/l^2-1= b^2/l^2$$

a genuinely beautiful equation in normalized notation.

Robson (2001: 167) showed that the Neugebauer's widespread theory of generating functions cannot be correct. She provided supporting evidence for an alternative way of triples generation using regular reciprocal pairs and applying common Babylonian mathematics. She also proposed a possible completion of the 15 rows of the tablet with the missing columns (Robson, 2001: 185-186).

As to the purpose of the tablet, Robson's remarks are enlightening (2002: 118): "Plimpton 322, analyzed solely as a piece of mathematics, looked very modern, millennia ahead of its time, incomparably more sophisticated than other ancient mathematical documents. But if we treat Plimpton 322 as a cuneiform tablet that just happens to have mathematics on it, a very different picture emerges. We see that it is a product of a very particular place and time, heavily dependent on the ancient scribal environment for its physical layout as a table, its mathematical content, and its function as a teacher's aid. All the techniques it uses are widely attested elsewhere in the corpus of ancient Mesopotamian school mathematics. In this light we can admire the organizational and arithmetical skills of its ancient author but can no longer treat him as a far-sighted genius. Any resemblance Plimpton 322 might bear to modern mathematics is in our minds, not his". Incidentally, according to Robson (2002: 111), the tablet was written by someone familiar with the temple administration in the Mesopotamian city of Larsa in around 1800 BC.

In our opinion, the unique Plimpton 322 tablet could be of practical significance too, since the triples offer a good basis for the design of Pythagorean rectangles, useful for the layout of grids in architecture and the subdivision of land parcels, as well as for the layout of inclined surfaces.

4.3 On the Pythagorean triples of the temples examined

We continue with the investigation of the generation method of the Pythagorean triples of the temples examined, starting as usual, from the Pythagorean equation with a<b<c:

$a^2+b^2 = c^2$ and for a=1 it is:

$1= c^2-b^2 = (c+b)(c-b)$, $c+b = \lambda$ and $c-b = 1/\lambda$.

$b= ½ (\lambda - 1/\lambda)$ and $c= ½ (\lambda + 1/\lambda)$.

For a supposed Pythagorean triple A<B<C, λ can be calculated from either of the equations $\lambda^2 - 2(B/A) - 1 =0$ and/or $\lambda^2 -2(C/A) + 1 =0$

If λ can be expressed as a fraction of integers R_1 and R_2, then

$\lambda = R_1/R_2$ *and* $b= (\lambda^2-1)/ 2\lambda = [(R_1/R_2)-(R_2/R_1)]/2$ and
$c= (\lambda^2+1)/2\lambda = [(R_1/R_2)+(R_2/R_1)]/2$

The reduced triad of rational numbers:

$½\{R_1/R_2+R_2/R_1\}$, $½\{R_1/R_2-R_2/R_1\}$ and 1

satisfies the Pythagorean equation because:

$¼\{R_1/R_2+R_2/R_1\}^2 = ¼\{R_1/R_2-R_2/R_1\}^2 + 1$

Incidentally, this is the algebraic expression of a Babylonian algorithm proven by cut-and-paste by Simoson (2019).

Then $A=R_1R_2$, B=bA and C=cA, where:

$B=½\{R_1/R_2-R_2/R_1\}R_1R_2 = ½\{(R_1)^2-(R_2)^2\}$

$C=½\{R_1/R_2+R_2/R_1\}R_1R_2 = ½\{(R_1)^2+(R_2)^2\}$

So, A, B, C make up a Pythagorean triple because R_1, R_2, A, B and C are integers and $A^2+B^2=C^2$.

The above equations are actually Euclid's formulas and can be used for the calculation of Pythagorean triples for an arbitrary pair of integers (R_1, R_2). They were applied to the triples calculated at the examined temples and the relevant coefficients c and b are shown in the Table 3. It is found that if either R_1 or R_2 is an even integer, then $A=2R_1R_2$. It is worth noting that both methods, the Euclid's formulas and the simpler approach of reciprocal pairs produce identical results. It is therefore concluded that Neugebauer's persistence on the advanced formulas of generating functions is an unnecessary anachronism.

Table 3: Validation of the Pythagorean triples of the ancient temples investigated.

Pythagorean triple (A, B, C)	Temple	$\lambda=\frac{R1}{R2}$	(R1, R2)	$c=\frac{R1}{R2}+\frac{R2}{R1}$ / 2	$b=\frac{R1}{R2}-\frac{R2}{R1}$ / 2
115, 252, 277	Heraion	23/5	(23, 5)	2.408696	2.191304
105, 208, 233	Heraion	21/5	(21, 5)	2.219048	1.808696
48, 55, 73	Heraion	8/3	(8, 3)	1.520833	1.145833
5,12,13	Heraion Athena, Paestum	5	(5, 1)	2.6	2.4
8,15,17	Trapeza, Aigialeia	4	(4, 1)	2.125	1.875
7,24,25	Athena, Paestum Didyma	7	(7, 1)	3.571429	3.428571
20,21,29	Didyma	5/2	(5, 2)	1.45	1.05
16,63,65	Didyma	8	(8, 2)	4.0625	3.9375

The Pythagorean triples of the temples in Table 3 are not included in the fifteen triples of the Plimpton 322 tablet and only three of them - (5, 12, 13), (7, 24, 25) and (8, 15, 17) - are among the 38 triples of the ex-tended version calculated by Simoson (2019). This can be considered as a strong indication that the Late Archaic Pythagorean triples in the Greek temples were produced independently and did not originate from the Plimpton 322, the unique known tablet with Pythagorean triples as remarked by Robson (2002: 108).

4.4 Hints on Pythagoras' contribution to the field of mathematics

In recent scholarship the consensus view on the Pythagorean theorem has received strong challenges, which in agreement with Neugebauer's views are best exemplified in the Stanford Encyclopedia of Philosophy (2018), summarized as following. "There is evidence that Pythagoras valued relationships between numbers such as those embodied in the so-called Pythagorean theorem, though it is not likely that he proved the theorem. All that tradition ascribes to Pythagoras, then, is discovery of the truth contained in the theorem. The truth may not have been in general form but rather focused on the simplest such triangle (with sides 3, 4 and 5), pointing out that such a triangle and all others like it will have a right angle. Modern scholarship has shown, moreover, that long before Pythagoras the Babylonians were aware of the basic Pythagorean rule and could generate Pythagorean triples, although they never formulated the theorem in explicit form or proved it. Thus, it is likely that Pythagoras and other Greeks first encountered the truth of the theorem as a Babylonian arithmetical technique. It is possible, then, that Pythagoras just passed on to the Greeks a truth that he learned from the East. All that this tradition ascribes to Pythagoras, then, is discovery of the truth contained in the theorem. The truth may not have been in general form but rather focused on the simplest such triangle (with sides 3, 4 and 5), pointing out that such a triangle and all others like it will have a right angle. What emerges from this evidence, then, is not Pythagoras as the master geometer, who provides rigorous proofs, but rather Pythagoras as someone who recognizes and celebrates certain geometrical relationships as of high importance".

As expected, Neugebauer was fully aware of the level of the Babylonian mathematics when writing that "in spite of the numerical and algebraic skill and in spite of the abstract interest which is conspicuous in so many examples, the contents of Babylonian mathematics remained profoundly elementary. Babylonian mathematics never transgressed the threshold of prescientific thought. It is only in the last three centuries of Babylonian history and in the field of mathematical astronomy that the Babylonian mathematicians or astronomers reached parity with their Greek contemporaries" (Neugebauer, 1957: 48).

However, unjustifiably, he degraded the contribution of early Greek philosophers in mathematics, as inferred from his comments (1957: 148, 149, 152).

- "It seems to me evident, however, that the traditional stories of discoveries made by Thales or Pythagoras must be discarded as totally unhistorical".
- "The elementary theory of numbers, however, may or may not eventually be based on much older oriental material. I do not doubt that any connection with the name of Pythagoras is purely legendary and of no historical value".
- "I think that it is evident that Plato's role has been widely exaggerated. His own direct contributions to mathematical knowledge were obviously nil".

It is commonly repeated that Pythagoras' theorem was already known in Mesopotamia in 1500 BC and Leonid Zhmud (2003) meaningfully notes in his review of Riedweg's book "*Pythagoras. Leben, Lehre, Nachwirkung"* that Riedweg (2002) mentions this twice. Nevertheless, Zhmud convincingly remarks that in fact, what the Babylonians knew was not a general geometrical proposition, let alone its deductive proof, but only an empirical arithmetic formula for some Pythagorean triples (i.e. 3, 4, 5; 5, 12, 13, etc.)".

Even more enlightening on that is Burkert (1972: 401), in his monumental book, in a section entitled "Did the Pythagoreans lay the foundations of Greek mathematics?" he notes that "as pre-Greek mathematics has been rediscovered in Egyptian papyri and Babylonian clay tablets, a clearer light has been thrown on the outstanding achievement of the Greeks in the development of pure mathematics. The Babylonians had made considerable progress in the accumulation of detailed knowledge, in practical calculation, and in the solution of even rather complicated problems in arithmetic; beyond question, the Greeks had much to learn from them. But it was always single problems they were concerned with, making use of certain "recipes," without any theoretical explanation or even an attempt at proof; we cannot even be certain that the Babylonians formulated theorems in general terms. Some of the "recipes" or formulas are inexact, but this did not matter as long as they provided a practically useful approximation. Only with the advent of Greek geometry do we find the demand for generalized and stringent proof, for a deductive system based on axioms and postulates. This is the system presented to us in the Elements of Euclid, model which until the nineteenth century seemed not to require any essential improvement. All later achievements, including those of the Indians and the Arabs, build on the foundations laid by the Greeks".

On the query "Who discovered the Pythagorean theorem?" Meera Nanda (2016: 47) concluded that: "the geometric relationship described by this theorem was discovered independently in many ancient civilizations. The likely explanation is that the knowledge of the relationship between sides of a right-angle triangle emerged out of practical problems that all civilizations necessarily face, namely, land measurement and construction of buildings – buildings as intricate as the Vedic fire altars, as grand as the Pyramids, as functional as the Chinese dams and bridges, or as humble as simple dwellings with walls perpendicular to the floor". As summarized by Nanda (2016: 21) "The first recorded evidence for the Pythagorean conjecture dates back to some 1800 years BCE and it comes from Mesopotamia, the present-day Iraq. The first proof comes from the Chinese, preempting the Euclidean proof by a couple of centuries, and the Indian proof by at least 1000 years. Even though Pythagoras was not the first to discover and prove this theorem, it does not diminish his achievement. He remains an extremely influential figure not just for history of mathematics, but history of science as well. Pythagoras and his followers were the "first theorists to have attempted deliberately to give the knowledge of nature a quantitative, mathematical foundation". Giants of the Scientific Revolution, including Johannes Kepler and Galileo Galilei walked in the footsteps of Pythagoras.

However, the gap between a practical rule and a theorem is huge and Exarchakos (2006: 92) is right to remark that there is no theoretical approach in the Babylonian mathematics, nor a general proposal proven on logical reasoning to be considered as a theorem. We believe therefore that what was discovered in many ancient civilizations was a practical rule, the diagonal rule in the case of the Babylonians, but not a theorem embodied in a general theoretical system.

On this point Angelika-Nikita (2018: 61) remarks that" The Greeks understood something that had somehow eluded the Egyptians and Babylonians: the importance of mathematical rigor. Rigor was the thoroughness and attention to detail for improving accuracy. For example, ancient Egyptians, equated the area of a circle to the area of a square with sides equal to 8/9 of the circle's diameter. According to this calculation, the value of the mathematical constant π is 256/81. Though it is a highly accurate calculation (around 0.5% error), it is mathematically incorrect. However, for the purposes of Egyptian engineering, this error was insignificant. But, ignoring this 0.5% error neglects a fundamental property of the true value of π, that no fraction can express it, as it is an irrational number".

The real – and path-breaking – contribution of Pythagoras was the fundamental idea that nature can be understood through mathematics. He was the first to imagine the cosmos as an ordered and harmonious whole, whose laws could be understood by understanding the ratios and proportions between the constituents. It was this tradition that was embraced by Plato, and through Plato became a part of Western Christianity, and later became a fundamental belief of the Scientific Revolution expressed eloquently by Galileo: "The Book of Nature is written in the language of mathematics" (Nanda, 2016: 33).

It is similarly underlined by Burov and Burov (2015) that when Galileo stated this, he was expressing the ancient Pythagorean credo. The same can be said about Dirac, whose fundamental belief was that "the laws of nature should be expressed in beautiful equations". Our universe is special not only because it is populated by living and conscious beings but also because it is theoretizable by means of elegant mathematical forms, both rather simple in presentation and extremely rich in consequences. Such a special universe deserves a proper term, and we do not see a better choice than to call it Cosmos or to qualify it as Pythagorean, in honor of the first prophet of theoretical cognition, who coined such important words as cosmos (order), philosophy (love of wisdom), and theory (contemplation).

5. EPILOGUE

Although Pythagoras' involvement in the design of temples cannot be directly proved, it is a reasonable assumption, given the crucial and innovative application of the Pythagorean triples at the Heraion temple during his period in Samos. The foundation of the second peripteros temple of Heraion started during Pythagoras' time in Samos. The early application of the Pythagorean triples is revealed in the architectural design of the huge temple, based on a mathematical model thanks to which a coherent system of proportions was realized. For geometrical accuracy, a grid was used, and dimensioning was based on a common module for the various parts of the monument. The Heraion temple resembles a demonstration project of the application of Pythagorean triples which are not related to the triples of the Old Babylonian Plimpton 322 tablet.

A Pythagorean rectangle was also recognized at the Trapeza temple, built in Pythagoras' time at the Achaean Metropolis of Croton. The same process of design based on Pythagorean triples, in particular in three dimensions, is also confirmed in the Athena temple at Paestum during the period of the greatest philosophical influence of Pythagoras in Magna Graecia. His influence here was dual, geometric, and aesthetic, thanks to the combined application of mathematics and harmonic proportions inspired from Pythagoras' philosophy. The dual geometric-harmonic design of temples was fully developed in Pythagoras' time, starting from the Heraion temple in Samos, and his philosophy of proportions, amalgamated perhaps with Platonic ideas, prevailed in later times until the present.

The Eupalinos' aqueduct is a revolutionary work in many aspects, accomplished while Pythagoras' was in Samos. The surveying problems of the tunnel were examined in this article, to evaluate the level of mathematics involved. The complications of the work and the astonishing accuracy achieved would have been impossible without the application of mathematics and proper instrumentation; in this regard, it is reminded that the Architect Theodorus of Samos is credited with the invention of several measuring instruments. It is demonstrated that in addition to the Eupalinos' engineering skills a mathematical mind was required for the accomplishment of the work.

As to the Plimpton 322 tablet, it is concluded that the method of reciprocal pairs is the most convenient for the generation of the Pythagorean triples. Besides the tablet application in teaching, a practical use is also envisaged. It is worth noting that both methods, the Euclid's formulas and the simpler method of reciprocal pairs produce identical results. It is therefore concluded that Neugebauer's persistence on the advanced formulas of generating functions is an unnecessary anachronism.

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ΝΕΑ ΑΠΟ ΤΙΣ ΕΛΛΗΝΙΚΕΣ ΚΑΙ ΔΙΕΘΝΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΝΩΣΕΙΣ

International Society for Soil Mechanics and Geotechnical Engineering

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

5. 3rd HUTCHINSON LECTURE - 3rd JTC WORKSHOP NORWAY, 2022 CALL FOR PROPOSALS

The Joint Technical Committee (JTC1) on Natural Slopes and Landslides of the Federation of the International Geo-engineering Societies (FedIGS) is organizing the 3rd JTC1 workshop, which will be held in Norway in Spring, 2022; the provisional title of the event is Landslide initiation, prediction and risk mitigation.

The workshop will host the 3rd Hutchinson Lecture, which has been established by the same JTC1 to award a scholar, aged 42 or less at the time of the event, who has significantly contributed to the development of knowledge in the field of slope stability and landslides. The Hutchinson Lecture should deal with a subject consistent with the workshop issues. The lecture will be published in an international journal.

The Hutchinson lecturer, who should have a disciplinary background from one or more of the domains of the geosciences, will be chosen - by vote of JTC1 Committee members - among candidates proposed by national societies. All countries are then asked to propose their own candidate. The proposals, accompanied by the candidate CV, should be submitted to the JTC1 chairman, Luciano Picarelli, by September 15th 2021 (luciano.picarelli@unicampania.it) .

6. BULLETIN

The latest edition of the ISSMGE Bulletin (Volume 15, Issue 3, August 2021) is available from the website https://www.issmge.org/publications/issmge-bulletin/vol-15-issue-4-august-2021

7. 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

17TH DANUBE - EUROPEAN CONFERENCE ON GEOTECHNICAL ENGINEERING 07-06-2023-09-06-2023 Ramada Parc, Bucharest, Romania; Language: English; Organiser: Romanian Society for Geotechnical and Foundation Engineering; Contact person: Alexandra Ene; Address: Bvd. Lacul Tei 124; Email: srgf@utcb.ro; Website: http://www.17decge.ro

NON-ISSMGE Events

THE 60TH RANKINE LECTURE: THE UNUSUAL AND THE UNEXPECTED IN GEOTECHNICAL ENGINEERING: OBSERVATION ANALOGY EXPERIMENT 16-03-2022 Imperial College London, United Kingdom; Language: English; Organiser: British Geotechnical Association; Contact person: Shelagh Fleming; Email: Shelagh.Fleming@ice.org.uk; Website: https://www.britishgeotech.org;
Email: bga@ice.org.uk

TC309 Student Contest - Kaggle-contest
MLRA2021 groundwater time-series forecasting

Machine learning prediction event for the international conference in "Machine learning & Risk assessment in geoengineering"

Introduction

Machine learning as a technique is increasingly used as a "tool" to handle challenging problems in geotechnical engineering. The number of successful use-cases is growing rapidly, which can be seen from the number of related research papers and real-life applications.

The machine learning competition is organized as an event at the MLRA2021 (Machine Learning and Risk Assessment in geoengineering) Conference in Wroclaw, Poland, in October 2021 (conference website). The results from the contest will be presented at the conference. Geotechnical engineers (students and practitioners) are invited to take part in the competition. Participants are encouraged to share knowledge in the Discussion forums while participating.

Problem statement

The task is to perform time-series forecasting on 2 groundwater sensors of 3 types, in total 6 sensors, for a total period of 90 days:

- pore pressure, unit - KPa
- water level in core-drilled hole, unit - MOBT (meter below surface level of drillhole)
- water level in lake, unit - mVs (water level in meter relative to a reference level)

Example plots from the 3 types of sensors can be found under "Code" fane.

The sensor-data comes from the combined railway and road project called FRE16, located in the southeastern part of Norway: Link to project. See the map in the figure below.

Construction start is planned to 2022 for the 40 km long megaproject, containing long tunnels, open pits, bridges and railway-stations. Environmental concerns is an important issue in the project. One of these issues is to preserve the natural ground water level. A decreasing ground water level due to constructing activities will have detrimental effects on nature and buildings in a broad zone along the project.

In order to carry out the correct actions to mitigate a decreasing ground water table during construction, it is vital to have information about what will be the natural ground water level, un-affected by construction activities. The actual measured values in the construction period can then be compared with the forecasted values in order to highlight construction influence on the local ground water table.

Let's hope machine learning can help us to do a realistic forecasting that is valuable for making decisions.

To join us, please see the details of the contest description here and register on the link.

The Summary of The first ERTC10 Seminar on "Second Generation of Eurocode 7 - Improvements and Challenges" (28.09.2021)

The 1st ERTC10 Seminar on "Second Generation of Eurocode 7 - Improvements and Challenges" held online on Tuesday 28th September 2021 exceeded our expectations with **almost 600 registrations** from all around the world. It highlighted the considerable international interest in the development of the next generation of European standards for structural and geotechnical design. We are glad to see that the primary interest in the event came from the designers and consultants, people who will be the main users of the new standard.

The event included three main presentations covering:

1. Introduction to Second Generation of Eurocode 7 by Adriaan van Seters (SC7 chair)

2. Ensuring Reliability in the new EC7 by Gunilla Franzén (SC7 vice-chair)

3. Deriving the Ground Model by Jose Estaire (SC7 PT6 member)

In addition, **the Interactive Session** prepared by Loretta Batali (SC7 MG member) gave us a really valuable insight into the interests of participants and their expectations for the next events.

The presentations from the Seminar, together with the Q&A answers and results of the interactive session, can be accessed via the NEN website:

https://second-generation-of-eurocode7.nen-evenementen.nl/page/904446

ERTC10 would like to thank the SC7 committee and the presenters for their contributions, as well as NEN (Dutch national standardization organization) for the technical and organizational support with the live event.

3rd International Symposium on Coupled Phenomena in Environmental Geotechnics (CPEG2020) coming up on October 20-21. Register for free until October 15 2021

The 3rd International Symposium on Coupled Phenomena in Environmental Geotechnics (CPEG2020), organized by the Japanese Geotechnical Society and the Kyoto University with the support of TC215 Environmental Geotechnics Technical Committee of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), will take place on October 20-21, 2021. The symposium will be held online using the Zoom platform.

The organizing committee decided to make conference participation free. However registration is compulsory for all attendees since the Zoom link will be sent only to the registrants. The last day for registration is Friday, October 15, 2021.

More information about the conference, its program and conference registration is available at: https://cpeg2020.org/

SOA paper on Numerical modelling of large deformation problems

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, S. J. Lee, D. Loukidis, promoted by TC103 is available on line at https://authors.elsevier.com/sd/article/S0038-0806(21)00120-7.

Abstract

Many problems in geotechnical engineering involve large movements or rotations, examples include natural processes such as landslides, and man-made processes such as earth-moving and pile penetration. While the use of numerical modelling, primarily the finite element method (FEM), is now routine in geotechnical design and analysis, the limitations of conventional FEMs soon become apparent when attempting to model large deformation problems. For this reason, the search for alternatives remains a key goal of many geotechnical researchers, both to find accurate methods but also to develop efficient ones. In this review paper, prompted by Technical Committee 103 of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE), we survey the current state-of-the-art in numerical modelling techniques aimed at large deformation problems in geotechnics. The review covers continuum and discontinuum methods and provides a clear picture of what is and is not currently possible, which will be of use to both practitioners seeking suitable methods and researchers developing existing or new methods.

Special Issue on Engineering Practice of Risk Assessment and Management by ISSMGE TC304 published

We are pleased to announce the Special Issue #4 of Volume #6 of the International Journal of Geoengineering Case Histories, an official Journal of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE).

This Special Issue of the ISSMGE International Journal of Geoengineering Case Histories draws from eight recent case histories that demonstrate the developments and applications of geotechnical risk assessment and management approaches in engineering practice. Recent years have seen rapid theoretical developments on the characterization and evaluation of geotechnical uncertainty, and the approaches that quantify the propagation of such into risks in engineering system performance. This Special Issue is a showcase of these various aspects, with studies adopting a wide range of techniques from geostatistical analysis, random field modelling to machine learning approaches, addressing practical issues that include subsurface characterization, performance of dams and embankments, geogrid-reinforced soil walls, soil liquefaction and beyond.

Papers published in this refereed journal are freely available in color and are accompanied by databases that include the electronic data presented in the paper as well as additional figures (as necessary). The locations of the case histories are also positioned in the IJGCH Geographic Database.

Papers published in this journal are downloaded many thousands of times. Please consider the International Journal of Geoengineering Case Histories for the publication of well-documented case histories.

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

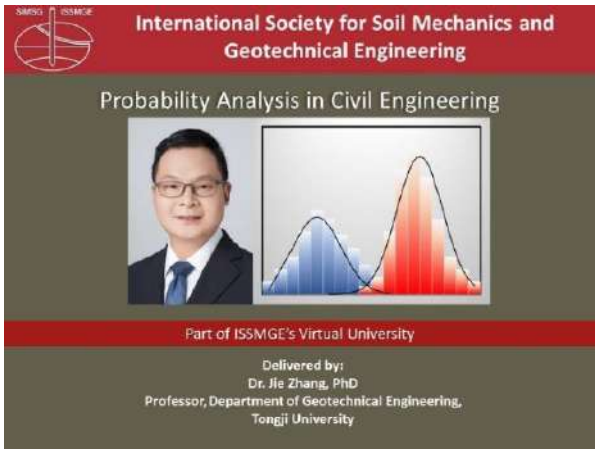
About the course

Uncertainties are pervasive in geotechnical engineering. In the past decades, reliability methods have been developed as a powerful tool to model and quantify the effect of uncertainties in geotechnical engineering. The purpose of this course is to systematically introduce the reliability methods in the context of geotechnical engineering.

There are four modules in this course:

1. Analytical models for modeling uncertainties
2. Reliability methods
3. Reliability-based design, and
4. Bayesian methods for uncertainty reduction

Students can choose to learn one or more modules that they are interested in. A unique feature of this course is that the reliability methods are taught using a computation visualization technique, through which almost all the reliability methods are implemented and illustrated in Microsoft Excel. As such, the programming work involved in the reliability methods is bypassed, which will provide an efficient and transparent way to learn reliability methods effectively. Although this course is taught using examples in geotechnical engineering, the knowledge learned are also applicable to general civil engineering problems.



Dr. Jie Zhang is a Professor at the Department of Geotechnical Engineering of Tongji University, China. He received his PhD degree in Civil Engineering from the Hong Kong University of Science and Technology in 2009. He is currently the secretary of TC304, ISSMGE, and is one of the founding managing editors of the journal of Underground Space. His research mainly focuses on probabilistic analysis and assessment of geohazards.

Register for free to Probability Analysis in Civil Engineering

Géorisques - VIII - Geohazards

Luciano Picarelli, JTC1, 27-10-2021

https://georisques8.ca/

Prolongation de l'appel des résumés jusqu'au 5 novembre, 2021 / Call for abstracts extended until November 5, 2021

News
https://www.isrm.net

Tribute session to Pierre Habib and Pierre Duffaut - 15/Oct/2021, CNAM, Paris and online 2021-10-05

The French Committee of Rock Mechanics will organize on 15 October 2021 a tribute session to Pierre Habib and Pierre Duffaut. Both were distinguished rock engineers and Pierre Habib was the ISRM President from 1974 to1979.

This meeting will be in French and can be followed on line at this link for the Youtube channel: https://youtu.be/XsT2qlhgyM4.

The programme can be downloaded by clicking here. The ISRM will be represented by the Vice President for Europe Leandro Ajejano.

56th U.S. Rock Mechanics/Geomechanics Symposium - Call for abstracts 2021-10-11

The American Rock Mechanics Association invites you to its 56th US Rock Mechanics / Geomechanics Symposium to be held in Santa Fe, New Mexico, USA, from 26 to 29 June 2022.

Abstracts for the conference are now being sought. The deadline for abstract submission is 9 November 2021.

Information on symposium registration, exhibition, accommodation and sponsorship can be found on the website https://www.armarocks.org/santa-fe-2022-symposium or by contacting santafe2022@armarocks.org.

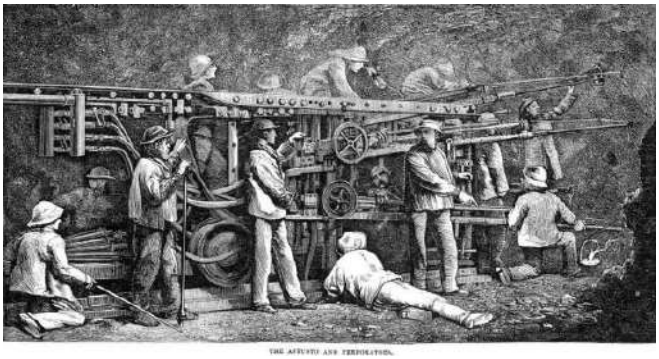
Eurock Debate 1 - "Using Hydraulic Fracturing to measure in situ stresses" on 27 October 2021-10-25

In the last informal meeting of the ISRM European National groups, Charlie Li form Norway suggested the organization of European Rock Mechanics Debates aiming at stimulating communication among academics and practitioners of rock mechanics and rock engineering in Europe. Based on this suggestion, with the support of the ISRM president, Resat Ulusay, and with the help of the Secretariat in Lisbon, an ad-hoc committe formed by Charlie Li, Philippe Vaskou and myself, has organized the first of these debates to be held next Wednesday, 27th October, at 15:00 CEST (13:00 GMT).

The title of the debate is "Using Hydraulic Fracturing to measure in situ stresses", it will feature the participation of Gerd Klee form Germany and Arne Marius Raaen form Norway and will be chaired by Philippe Vaskou form France. A flyer with the contents and indicative rules of this debate can be downloaded here. In this flyer you will find the Zoom link to join the meeting (maximum of 100 participants) and the ISRM YouTube channel link, where it will be broadcast.

Leandro R. Alejano
ISRM VP for Europe

150th Anniversary of the Frejus tunnel



On the 6 and 7 October, a workshop has been organised by the Academy of Sciences of Torino, in partnership with the Politecnic Institute of Torino to celebrate the 150th Anniversary of the Frejus tunnel. The first railway tunnel under the Alpes, 12.6 km long, inaugurated in September 1871.

At this occasion have been demonstrated the innovation techniques used at that time and notably the pneumatic rock drilling machine and the continuous development in the tunnelling industry.

ITA was represented by Giuseppe Lunardi, Vice President and Olivier Vion, Executive Director. Prof Pelizza, ITA former President, Daniele Peila, ITA former Vice President, Michel Deffayet, AFTES President and Andrea Pigorini SIG President participated as well.

The workshop is available on Youtube
Session 1
Session 2
Session 3
Session 4

Scooped by ITA-AITES #53, 12 October 2021

Fire tests show that Austria's tunnels are fit for electric cars

Metro Tunnel dismantles TBMs | Australia

Taihu Tunnel to aid regional economy, connectivity in China

North Vancouver to Burnaby water tunnel complete | Canada

Metro tunnel on Shivajinagar to Swargate stretch 75% complete | India

India completes first tunnel in $1bn project to improve access to Chinese border

One mile mark completed on Britain's high speed rail tunnel

Alpine Tunnel | United States of America

Work started this week on second Gotthard road tunnel | Switzerland

Turkey goes "underground" for dams amid drought stress

Scooped by ITA-AITES #54, 26 October 2021

Breakthrough for Rio Tinto's smelter hydropower project in British Columbia | Canada

Elon Musk's The Boring Company gets approval from County Commissioners for 'Vegas Loop' | United States of America

Auckland's City Rail Link tunnel boring machine breaks through to Karangahape Station | New Zealand

Thane-Borivli twin tunnel project makes headway | India

New startup takes vertical farming underground literally | Canada

NTU team looking into storing of CO2 underground | Singapore

HS2 shortlist for phase 2a DDP | UK

Ho Chi Minh City to dig deep for more downtown space | Vietnam

Finalists Announced for 2021 ITA Tunnelling Awards

Fehmarn tunnel cleared for construction | Germany - Denmark

Gozo tourism providers and workers in Malta want metro connectivity, not car tunnel | Malta

Two huge tunnel-boring machines will help link east Mississauga to Toronto, and maybe the airport | Canada

Low, intermediate and high pressure compressed air work
Launch of the revised BTS CAWG Guide

Speakers Dr Donald Lamont MBE & Roy Slocombe

A revision of the BTS "Guide to the Work in Compressed Air Regulations" has been released; now called "Guidance on good practice for Work in Compressed Air".

The Guide represents a revision and update of the 2012 edition and has been extended to provide guidance on integrating high pressure compressed air work into the UK regulatory framework. It complements BS 6164 and ITA/BTS CAWG Report 10, 2nd rev, but is readily applicable to work in compressed air anywhere. It also contains interim technical guidance on airlock safety, until the current revision of EN 12110 is harmonised.

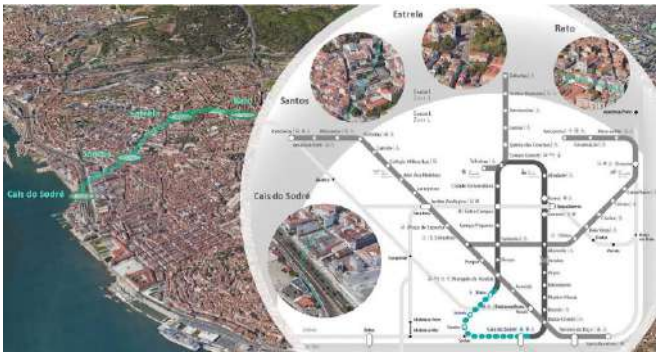
This lecture will explore the phenomenon of saturation and specifically address some of the important differences between saturation exposure techniques as used in tunnelling compared with saturation exposure techniques in diving. It will also seek to explain the BTS CAWG opinion that ~3.5 bar(g) is an appropriate pressure at which to move to mixed gas breathing during construction.

This in-person lecture (Thursday 21st October 2021) was also streamed live at https://youtu.be/THILlxErIFo

Lisbon Metro/ Metropolitano de Lisboa
Green & Yellow Line Extension

Speaker: Francisco Bernardo - *Geotechnical Engineer at COBA Consulting Engineers SA*

Friday 29th October 2021, Online at:
https://youtu.be/cuJ44cqKhfg



The Green and Yellow line extension is the most significant upgrade to Lisbon's rail underground network in the last decade. By creating a new connection between the two existing lines, this project will enable forming a circle line which will enhance the usability of public transportation services in the city centre.

The project comprises a total of 1984 meters of running tunnels, two new underground stations, upgrades at Rato and Cais do Sodré stations and a new flyover at Campo Grande. Running tunnels and station platform tunnels will be excavated using the NATM/SCL construction methodology. The project includes many technical challenges, such as running tunnels gradients of up to 4%, and variable geological and hydrogeological conditions.

Tunnelling has already begun in April this year for Construction Package 1 and enabling works for Construction package 2 started in June. Services are planned to start in Q4 2024.

In this presentation, Francisco will provide an overview of the extension works, the associated challenges and proposed solutions.

Commission internationale des grands barrages
International Commission on large dams

I am pleased to announce that the videos of our last online meeting (june 15, 2021) can be seen on the new youtube channel of the EWG Dams and Earthquakes :

https://www.youtube.com/channel/UCDadRBeCphJ0nIx-ElkKVAew

Best regards.

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ΔΙΑΚΡΙΣΕΙΣ ΕΛΛΗΝΩΝ ΓΕΩΤΕΧΝΙΚΩΝ ΜΗΧΑΝΙΚΩΝ

Ο Γιάννης Αναστασόπουλος εξελέγη μέλος στο Board of Directors of the International Association for Earthquake Engineering (IAEE)

It is with great pleasure that we announce the election of Prof. Anastasopoulos to the Board of Directors of the International Association for Earthquake Engineering (IAEE). The Board of Directors is composed of up to eleven internationally leading scholars in the field of earthquake engineering. The election took place during the 17th World Conference on Earthquake Engineering (#17WCEE), during which the General Assembly convened in a remote mode. The fundamental goal of the IAEE is to contribute to the improvement of worldwide seismic safety. It includes representation from the world's national earthquake engineering societies, and oversees the World Conferences on Earthquake Engineering. Its flagship Journal, Earthquake Engineering and Structural Dynamics, has been a leading publication in the field since 1972.

#eth_zurich #geotechnics_ethz_ch #professor_ioannis_anastasopoulos #chair_of_geotechnical_engineering

Η Σταυρούλα Κοντοέ new Associate στην Geotechnical Consulting Group

GCG is delighted to welcome three new Associates.

- Dr James Lawrence, Senior Lecturer in Engineering Geology/ Geotechnics, Imperial College London (https://www.imperial.ac.uk/people/j.lawrence)
- Dr David Taborda, Senior Lecturer in Geotechnics, Imperial College London (https://www.imperial.ac.uk/people/d.taborda)
- Dr Stavroula Kontoe, Reader in Soil Dynamics, Imperial College London (https://www.imperial.ac.uk/people/stavroula.kontoe)

The new Associates will bring in a range of additional expertise enhancing GCG's capabilities and further reinforce our link with academia.

Click on their profile pages above to find out more about their expertise.

Welcome aboard James, David and Stavroula!

(October 21, 2021, https://gcg.co.uk/news/announcing-new-associates)

Η Σταυρούλα Κοντοέ ICE David Hislop Award Winner 2021

ICE David Hislop Award Winners 2021

The prestigious Institution of Civil Engineers (ICE)'s David Hislop award (also known as the Offshore award) has been won by our Senior Partner, Dr. Felix Schroeder, our Associates, Prof. Richard Jardine and Dr. Stavroula Kontoe, and their co-authors Dr. Róisín Buckley of University of Glasgow and Mr. Pedro Barbosa of Scottish Power. The authors received their award at the ICE publishing awards ceremony 2021. Their award-winning paper, "Full-scale observations of dynamic and static axial responses of offshore piles driven in

chalk and tills", is freely available through the ICE virtual library. Geotechnical Consulting Group congratulates all the authors for their achievement.

The paper is another publication resulting from the authors' work on the Innovate UK sponsored Joint Industrial Project between Imperial College London, Scottish Power and Geotechnical Consulting Group on "Rationalising offshore wind-turbine pile design and assurance in difficult ground".

(October 25, 2021, https://gcg.co.uk/news/ice-david-hislop-award-winners-2021)

Full-scale observations of dynamic and static axial responses of offshore piles driven in chalk and tills

Roisin M. Buckley, Richard J. Jardine, Stavroula Kontoe, Pedro Barbosa, Felix C. Schroeder

Abstract

This paper describes and interprets tests on piles driven through glacial tills and chalk at a Baltic Sea windfarm, covering an advance trial campaign and later production piling. The trials involved six instrumented 1·37 m dia. steel open-ended tubes driven in water depths up to 42 m. Three piles were tested statically, with dynamic re-strike tests on paired piles, at 12–15 week ages. Instrumented dynamic driving and re-strike monitoring followed on up to 3·7 m dia. production piles. During driving, the shaft resistances developed at fixed depths below the seabed fell markedly during driving, with particularly sharp reductions occurring in the chalk. Shaft resistances increased markedly after driving and good agreement was seen between long-term capacities interpreted from parallel static and dynamic tests. Analyses employing the sites' geotechnical profiles show long-term shaft resistances in the chalk that far exceed those indicated by current design recommendations, while newly proposed procedures offer good predictions. The shaft capacities mobilised in the low-plasticity tills also grew significantly over time, within the broad ranges reported for sandy soils. The value of offshore field testing in improving project outcomes and design rules is demonstrated; the approach described may be applied to other difficult seabed conditions.

Published Online: July 14, 2020,
https://doi.org/10.1680/jgeot.19.TI.001

(https://www.icevirtuallibrary.com/doi/full/10.1680/jgeot.19.TI.001)

ΘΕΣΕΙΣ ΓΙΑ ΓΕΩΤΕΧΝΙΚΟΥΣ ΜΗΧΑΝΙΚΟΥΣ

Imperial College London

UKRI Natural Environment Research Council

2022_19_Civil Eng_Tsiampousi: Climate resilient earthwork design using green infrastructure

Supervisors: Dr Katerina Tsiampousi (mailto:aikaterini.tsiampousi@imperial.ac.uk); Dr Athanasios Paschalis

Department: Department of Civil and Environmental Engineering

There are tens of thousands of miles of vegetated infrastructure slopes, i.e. man-made embankments and cut slopes which support railways and highways, in the UK. Network Rail alone owns 52,000 hectares of land on which there are nearly 6.3 million trees. As earthworks are known to demonstrate poor serviceability when interacting with vegetation, Engineers tend to perceive it as a liability rather than to appreciate it as a national asset. Well-maintained vegetation, however, has the potential to enhance slope stability and has undeniably positive environmental outcomes. It is estimated that hundreds of millions of pounds will be spent over the next 20 years to manage vegetation while complying with safety and operational standards.

Interaction between atmosphere and soil as an engineering material has only recently attracted significant interest. Serviceability problems arise in densely vegetated slopes during dry periods, as the soil shrinks excessively. Shrinkage is not fully recovered when water from precipitation percolates into the earthworks' soils causing swelling, hence shrinkage accumulates year on year. This cycle of swelling and shrinkage is expected to intensify, as climate change projections show a substantial increase in rainfall extremes, followed by long periods of intensified drought. On the other hand, vegetation establishment on earthworks can increase slope stability via its roots, reduce the infiltration rate in the soils, protect the soil against erosion.

To properly understand and quantify the problems as well as to propose solutions for best greening strategies, we need to develop robust models integrating water transport from the soils to vegetation and the atmosphere, and soil hydro-mechanical behaviour. Detailed data are needed to validate these models, which upon successful implementation and validation can be used to inform new-generation geotechnical engineering standards for modern construction as well as maintenance of existing earthworks.

The project aims to bridge ecohydrological, soil and geotechnical modelling, with the scope of enhancing the resilience of vegetated infrastructure earthworks to climate change.

The project will be organised in the following tasks:

1 Analyse with the aid of the CASE partner Geotechnical Observations field data from selected infrastructure slopes and identify representative case studies;

2 Generate new data though field and laboratory studies (data of soil mechanical and hydraulic properties and field data monitoring the behaviour of existing infrastructure);

3 Develop a unique soil-plant-atmosphere model that integrates geotechnical modelling with all necessary ecohydrological processes. The model development will integrate modelling expertise between the Hydrology and Geotechnics sections at Imperial College London;

4 Perform risk analysis under a changing climate using the last generation CMPI6 climate model projections for the UK.

2022_20_Civil Eng_Lawrence: Developing drone based InSAR to monitor natural processes and climate impact

Supervisors: James Lawrence (j.lawrence@imperial.ac.uk); Philippa Mason

Department: Department of Civil and Environmental Engineering

Overview:

Interferometric Synthetic Aperture Radar (InSAR) monitoring is a satellite remote sensing technique with value for monitoring of infrastructure, natural processes and changes in the natural environment. Over the last five years InSAR satellite monitoring technology has progressed very rapidly so that it is now possible to monitor the globe which is of value to numerous disciplines including geohazards, infrastructure projects and agronomy. Earth Observation techniques such as InSAR are becoming standard tools for monitoring a range of ground movement related natural processes such as slope movement and ground subsidence.

The Problem:

Notwithstanding the successes of satellite InSAR, there is a demand for an InSAR methodology to provide improved spatial, temporal and spectral resolutions. Importantly, the ability to accurately detect micro-scale deformation and deformation at angles that the satellites can't observe. To address these limitations of the current satellite monitoring this project will develop low altitude monitoring tools using UAV's (drones) to satisfy the requirement for improved resolutions across the aforementioned domains. Drones have many advantages, they may be flown regularly, with autonomous flight programming, drones can fly at a lower altitude thus achieving an improved spatial resolution of data points compared to satellites. These low altitude drones will be able to monitor side views in the natural environment and also civil infrastructure such as the side of buildings, which are not visible to orbiting satellites. The increased resolution will allow for monitoring of very small scale movements and when couple with existing satellite networks this will provide an unprecedented ability to monitor ground movements related to natural processes (e.g. slopes) and geohazards such as subsidence.

The Project:

The project comprises two main parts the first will be to develop a coupled methodology combining data from the drones and existing satellites at a number of research sites where ground movements can be monitored (e.g. slopes). This two-part system should provide improved spatial, temporal and spectral resolutions compared to satellite InSAR. This system should be capable of monitoring natural ground movements and providing structural health monitoring

(SHM) data for any manmade infrastructure. In order to achieve this aim, several research objectives are defined below:

1. Analyse historical satellite InSAR data to provide baseline contextuality;

2. Refine the drone based radar system to detect micro-scale ground deformations;

For more information on how to apply to us please visit: *https://www.imperial.ac.uk/grantham/education*

ΠΡΟΣΕΧΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΚΔΗΛΩΣΕΙΣ

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

5TH World Landslide Forum Implementation and Monitoring the USDR-ICL Sendai Partnerships 2015-2025, 2-6 November 2021, Kyoto, Japan, http://wlf5.iplhq.org

https://www.icold2021.org

Monday 15 November 12.00-14.30 (Paris Time)
ICOLD Chairmen Committee Meeting *(by invitation only)*

Tuesday 16 November 12.00-16.00 (Paris Time)
Symposium - Sharing Water: Multi-purpose of Reservoirs & Innovations *(Paid Access)*

Wednesday 17 November 12.00-15.30 (Paris Time)
Technical Committee Workshops *(Paid Access)*

Thursday 18 November 12.00-15.30 (Paris Time)
Technical Committee Workshops *(Paid Access)*

Friday 19 November 12.00-15.00 (Paris Time)
ICOLD 89th General Assembly *(by invitation only)*

Register Now !

The Detailed Program and more information are available on the website: **www.icold2021.org**

ASIAFUGE 2021 - Tackling Modern Geotechnical Complexity with Physical Modelling, 18th & 19th November 2021, Singapore, www.asiafuge-sg.com

NSCM-33
33rd Nordic Seminar in Computational Mechanics
25-26 November, 2021, Jönköping, Sweden (online)
https://congress.cimne.com/NSCM-33/frontal/default.asp

Objectives

Background

The NSCM is organized annually by the **Nordic Association for Computational Mechanics** (NoACM, http://noacm.no/), which represents the interest for the Nordic and Baltic countries in the European Community on Computational Methods in Applied Sciences (ECCOMAS) and the International Association for Computational Mechanics (IACM). The first event was held at Chalmers University in Gothenburg, Sweden in 1988.

Mission

The overall mission for these events is to be a meeting place for researchers developing computational methods and scientists and engineers focusing on challenging applications in broad aspects of mechanics. In particular, presentations by graduate students are welcomed. Thus, making a friendly and creative atmosphere for the participants is considered important.

Conference Secretariat

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

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

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

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

The 9th International Congress on Environmental Geotechnics is part of the well established series of ICEG. This conference will be held on an outstanding resort in the town of Chania of the island of Crete in Greece. The theme of the conference is "Highlighting the role of Environmental Geotechnics in Addressing Global Grand Challenges" and will

highlight the leadership role of Geoenvironmental Engineers play on tackling our society's grand challenges.

Contact Information

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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

Due to the global development and concerns over the coronavirus (Covid-19) situation, EuroGeo7 Conference which was scheduled to take place from 19 to 22 September, 2021 in Warsaw, Poland, is now postponed until **4-7 September 2022**.

The decision to postpone EuroGeo7 was made in the interest of the health and safety of everyone participating in the conference. The organisers of EuroGeo7 are working closely with partners and authorities, and will announce a new schedule of extended deadlines shortly. Please keep visiting our website regularly.

We are pleased to invite you to the 7th EuroGeo conference, to be held in Warsaw, Poland in 2022. PPSG-IGS, a Polish Chapter of IGS is young but thriving organization successfully cooperating with several chapters within Central Europe. It is an honour to host such a prestigious conference in Warsaw and We sincerely believe that the sessions will prove to be a success.

Proposed Sessions for EUROGEO7

- Agricultural Applications
- Coastal Protection
- Direct and Life-Cycle Cost Savings
- Drainage and Filtration
- Durability
- Embankments on Soft Soils
- Environmental Benefits
- Erosion Control
- Geosynthetics as Formwork
- Hydraulic Applications
- Innovations and New Developments
- Landfills
- Lightweight Construction
- Mining
- Monitoring
- Pavements
- Physical and Numerical Models
- Polymeric and Clay Geosynthetic Barriers

- Properties and Testing
- Quality Control and Quality Assurance
- Reinforced Walls and Slopes
- Roads, Railroads and Other Transportation Applications
- Seismic Applications
- Sustainability
- Stormwater Management
- Unpaved Roads
- Wastewater and Fresh Water Storage

Conference Secretariat
Professional Congress Organizer
Mazurkas Congress & Conference Management
Al. Wojska Polskiego 27
01-515 Warsaw, Poland
email: info@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/

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 organ-

ization 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
Email jardtaeknifelagid@gmail.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

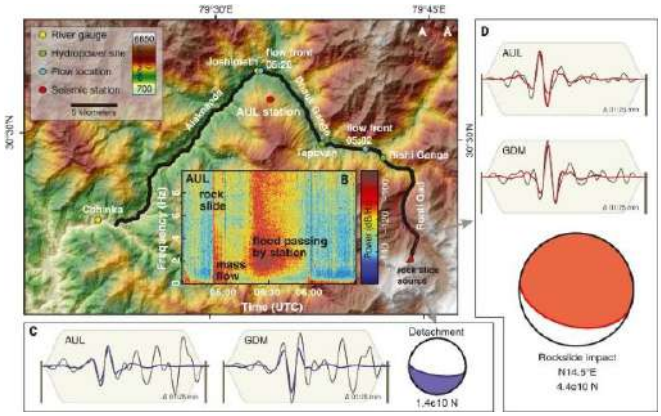
ΕΝΔΙΑΦΕΡΟΝΤΑ ΓΕΩΤΕΧΝΙΚΑ ΝΕΑ

The seismic signals of the Chamoli landslide and debris flow

The devastating 7 February 2021 rockslide and debris flow at Chamoli in northern India was well-described in our recent paper (Shugar *et al.* 2021). Subsequently a number of other papers have been published, with generally similar conclusions about the event, putting to bed the misreporting in the month or so after the disaster. Naturally, more detailed investigations are ongoing.

An important contribution has just been published in the journal *Science*, (Cook *et al.* 2021, sadly behind a paywall), which looks at the seismic signals generated by the event. Unsurprisingly, it concludes that the event was detected by the regional seismic network – indeed instruments located up to 100 km from the landslide were able to resolve the event.

Cook *et al.* (2021) conclude that the seismic data allows three phases of movement to be detected. The first was the initial rockslide, the second was the debris flow and the third was the flood that then travelled downstream. One seismic station was located close to the source of the rockslide, capturing the seismic signal from the disaster well:



The seismic signal generated by the Chamoli landslide and debris flow, from Cook *et al.* (2021). (A) Shaded relief map of area affected by the 7 February event, showing key geographic and instrument locations and visual constraints on flow location. (B) Spectrogram at AUL station. (C and D) Lower hemisphere projections of single force focal sphere (detachment force is oriented upward/south, impact force downward/north). Focal sphere areas are proportional to force amplitudes. Waveform fits are shown for two stations at almost perpendicular azimuth. Black represents data displacement, filtered 0.08 to 0.15 Hz), color denotes the corresponding synthetics (note that blue and red synthetics are almost anticorrelated, because the source model is essentially flipped).

The seismic data allowed Cook *et al.* (2021) to analyse the event in more detail than had been possible previously. For example, they time the arrival of the debris flow at the Tapovan hydropower project at 15 minutes after the initial failure. The debris flow component of the reduced in seismic energy as the flow moved downstream. The flow transitioned into a flood when the event entered the Dhauli Ganga valley; thereafter it progressively slowed.

This work is valuable in its own right, but is perhaps most important in terms of signalling the possibility for an early warning system. There were 15 minutes between the initial failure and the location at which most people lost their lives. An automated warning system, based on the seismic signal generated by the initial rockslide, could have made a difference. But Cook *et al.* (2021) rightly highlight the challenges of making such a system operational:

"In addition to network optimization, automated processing routines must be developed for detection and location of events from a variety of sources and triggers. This will require a larger catalog of seismically recorded events. Ultimately, the ability to rapidly issue effective warnings for catastrophic flow events will depend on a complex array of physical, technological, and social factors, including the detectability of the event, the efficiency of signal transmission and automatic processing, the infrastructure of warning dissemination, and communication and education about warning protocols and responses."

In essence, such a system will need an appropriate seismic network, reliable automated signal processing, a way to transmit and communicate the warning the those at risk and a population who understand the meaning of the warning, are able to respond in the right manner, and are able to get to safety. In the case of the Chamoli event, if the appropriate seismic network had been in place then all of the this would have needed to happen in 15 minutes. This is not impossible, but the challenges are clear.

On the back of the above study, CSIR National Geophysical Research Institute in India has launched an Environmental Seismology group to work on the development of such warning systems.

Reference

Cook, K.l., *et al.* 2021. Detection and potential early warning of catastrophic flow events with regional seismic networks. *Science*, **374** (6563), 87-92. DOI: 10.1126/science.abj1227

Shugar, D.h. 2021. A massive rock and ice avalanche caused the 2021 disaster at Chamoli, Indian Himalaya. *Science*. DOI: 10.1126/science.abh4455

(Dave Petley / THE LANDSLIDE BLOG, 4 October 2021, https://blogs.agu.org/landslideblog/2021/10/04/the-seismic-signals-of-the-chamoli-landslide-and-debris-flow)

Analyses performed in GEP demonstrated the activity of an extremely slow landslide

The Chgega Landslide, in northern Tunisia, represents an outstanding mass movement because of the particular landscape it creates.

The landslide involves a great block of limestone —about 900 m long and 400 m wide— sliding over ductile clays and marls. The viscoplastic creep of the clays drives the landslide and creates, in its crown, a graben ~800 m long and ~120 m wide that breaks the summit of the Chgega Mountain. Using the P-SBAS service of GEP, it has been demonstrated that **this complex landslide is currently active**, and moreover shows progressive movement without clear episodic accelerations. **Adjusting the parameters in GEP, we were able to measure the velocity of the landslide in just above 2**

mm/yr. To do so, we ran several preliminary processing trials with the following objectives: to check if the slope was in motion in the analyzed period of time and if so, to know the approximate velocity of the movement, and finally, to fine-tune the processing. When we found that Chgega landslide appeared to be in motion but at a very-low velocity—because we were able to recognize the pattern of the movement, but below the common error range of this kind of analysis with Sentinel-1 images (i.e., ±5 mm/yr)—we decided to increase the precision of our measurements through two strategies: (1) selecting a reference point close to the landslide that showed great coherence and stability; and (2) defining a high coherence threshold. Thus, **we reduced the error range to ±2 mm/yr**, increasing the sensitivity of our analysis.

The rapid processing performance of GEP was well suited to make these adjustments. We checked different numbers and combinations of images in order to improve the quality of the results. GEP greatly facilitated our work.

This characterization of the Chgega landslide can serve as the basis for future studies about the origin of this dramatic slope movement.

The results of the investigation has just been published in the journal Remote Sensing (**Analysis of the Geological Controls and Kinematics of the Chgega Landslide (Mateur, Tunisia) Exploiting Photogrammetry and InSAR Technologies,** https://www.mdpi.com/2072-4292/13/20/4048)

If you want to get more information about this case please contact jpgalve@ugr.es or c.reyes@igme.es.

(DISCUSS, 10 Oct, https://discuss.terradue.com/t/analyses-performed-in-gep-demonstrated-the-activity-of-a-extremely-slow-landslide/1037)

A large rock slope collapse from Punta dei Ross, Croda Marcora in the Italian Dolomites

On 9 October 2021 a large rock slope collapse occurred on the Punta dei Ross, Croda Marcora in the Dolomites of northern Italy. The failure was captured on a series of videos that have been posted online.

Probably the best video of a part of the failure process has been captured by Emanele Compagno and posted to Youtube. The really interesting part of the video starts at the 38 second mark:

https://www.youtube.com/watch?v=Fk1QsJGVOiI

A very nice compilation of other videos has been created the Vacanze Dolimiti website, and posted to Youtube:

https://www.youtube.com/watch?v=l1y7qTqeXjw

The videos appear to show a major collapse that initiates near to the ridge line. As is often the case for large rock slope failures, it occurs in a series of collapses rather than in a single failure event. One of the videos shows the collapse of a pinnacle, but the fresh scar and presence of dust shows that this was not the first failure:-

A part of the collapse of the 9 October 2021 Punta dei Ross, Croda Marcora in the Italian Dolomites.

It appears that after collapse the debris has gone through a near freefall stage and then transitioned into a rockslide or a rock avalanche.

(Dave Petley, 12 October 2021, https://blogs.agu.org/landslideblog/2021/10/12/a-large-rock-slope-collapse-from-punta-dei-ross-croda-marcora-in-the-italian-dolomites)

How landslides affect landscape morphology and hydrography

A giant prehistoric landslide (deep-seated gravitational slope deformation - DGSD) shifted the river-bed of Rio La Leona, in Patagonia, Argentina. Copernicus #Sentinel2 image.

(Sotiris Valkaniotis / Twitter, Oct 19, 2021, https://twitter.com/SotisValkan/status/1450541300135104513?cn=ZmxleGlibGVfcmVjcw%3D%3D&refsrc=email)

Austria opens advanced mine-based tunnel research centre

A new, highly advanced tunnel research and training centre for the development of construction methods, materials and equipment has opened at Eisenerz in the Austrian state of Styria.

Located in an abandoned iron-ore mine in the mountainous Erzberg area, 60km northwest of Graz and around 1,000m above sea level, the Zentrum am Berg (ZaB) facility was opened on Monday 18 October to the applause of 300 invited guests.

ZaB will enable research, testing and development of construction methods, materials and equipment undertaken in life-size conditions. This will include:

- Geotechnical monitoring
- Numerical simulations in geotechnics and tunnelling
- Safety research and technologies
- Tunnel ventilation systems
- Fire detection and fire-protection testing
- Thermo- and aerodynamic research
- Long-term durability of materials
- Effects of climate change
- Low-vibration excavation methods
- Risk management.

Education and training under 'very high fire loads' will also be possible for international emergency services.

To achieve all this, the centre offers several kilometres of interconnected tunnels, with the centrepiece being two parallel 800m-long road tunnels; two parallel rail tunnels (each 400m long) and a further tube once used as a conveyor tunnel. Tunnels can be reached via three entry portals. Road tunnels are designed for unidirectional traffic travelling at 100km/h, and have a clear height of 4.7m above the roadway.

The centre will cover research and testing on new methods for both NATM and TBM tunnelling, and also has a segment-testing facility. Twenty national and international partners are said to be already undertaking a wide variety of research

projects at the centre. A study programme will also offer students a choice of undergraduate- and postgraduate-level qualifications in tunnelling, geotechnics and mining.

Funding for the €30m (US$35m) ZaB project has come from the state of Styria (€12m), and €6m each from Austria's Ministry of Education, Ministry of the Environment and the University of Leoben (German: Montanuniversität Leoben).

20 October 2021

Take a tour inside a HS2 tunnel boring machine

Take a tour inside a HS2 tunnel boring machine (TBM) with one of our tunnelling engineers. Walk the length of this 170m long underground 'factory' and discover how it excavates the 10 mile long Chiltern tunnel high speed trains will run through. See inside the control room of TBM Cecilia and find our where the crew make their coffee!

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

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΣΕΙΣΜΟΙ & ΑΝΤΙΣΕΙΣΜΙΚΗ ΜΗΧΑΝΙΚΗ

Σεισμός: Βασικές αλλά ζωτικές επεμβάσεις για τη θωράκιση παλαιών κτιρίων

«Καμπανάκι» για την ενίσχυση των κτιρίων, ιδίως των λιθόκτιστων ή όσων έχουν χτιστεί με παλαιότερους αντισεισμικούς κανονισμούς, είναι οι σεισμοί των τελευταίων δύο ετών

Όσον αφορά τα διδάγματα από τους πρόσφατους σεισμούς στο Ηράκλειο, στην Ελασσόνα (φωτ.) και στη Σάμο, οι ειδικοί εκτιμούν ότι αποδεικνύεται η χρησιμότητα των προσεισμικών ενισχύσεων των παλαιότερων κτιρίων, τουλάχιστον για να αποτραπεί η κατάρρευσή τους. (INTIME NEWS)

«Καμπανάκι» για την ενίσχυση των κτιρίων, ιδίως των λιθόκτιστων ή όσων έχουν χτιστεί με παλαιότερους αντισεισμικούς κανονισμούς, είναι οι σεισμοί των τελευταίων δύο ετών. Σύμφωνα με τους ειδικούς, οι παλαιότερες κατασκευές είναι κατά κανόνα εξαιρετικά ευάλωτες και η ενίσχυσή τους, τουλάχιστον ώστε να μην καταρρεύσουν σε περίπτωση σεισμού, δεν είναι πια τόσο «απλησίαστη» οικονομικά. Επίσης, ο «τραυματισμός» των λιθόκτιστων σπιτιών στα χωριά δεν θα πρέπει απαραιτήτως να αποτελέσει την αιτία για την κατεδάφισή τους, επισημαίνουν, καθώς η επιστήμη προσφέρει επαρκείς λύσεις ώστε να μην χαθεί το «χρώμα» των οικισμών της υπαίθρου. Το πρόβλημα είναι οικονομικό και όχι τεχνικό, καταλήγουν.

«Θα μπορούσαμε να χωρίσουμε τις βλάβες σε κτίρια στο Ηράκλειο σε δύο κατηγορίες: σε εκείνες που έγιναν σε λιθόκτιστα κτίρια και σε εκείνες που έγιναν σε κτίρια από σκυρόδεμα, τα οποία είχαν χτιστεί με βάση παλαιότερους αντισεισμικούς κανονισμούς» **λέει στην «Κ» ο Κωνσταντίνος Σπυράκος**, καθηγητής Αντισεισμικών Κατασκευών στο ΕΜΠ (και συγγραφέας του βιβλίου «Κατασκευές από τοιχοποιία: αποτίμηση και επεμβάσεις για σεισμικά φορτία» εκδόσεις Εργονόμος). «Στα λιθόκτιστα κτίρια, οι ζημιές που είδαμε μπορούν να αποδοθούν σε μερικές βασικές αιτίες. Κατ' αρχάς, στην κακής ποιότητας δόμηση. Τα σπίτια χτίστηκαν με μικρούς και ακατέργαστους λίθους, με πολύ φτωχό κονίαμα, χωρίς σύνδεση της εσωτερικής και της εξωτερικής πλευράς του τοίχου. Κατά δεύτερον, στην προσθήκη βαριάς πλάκας οροφής από σκυρόδεμα σε τέτοια κτίρια. Κατά τρίτον, στην αυθαίρετη κατεδάφιση εσωτερικών τοίχων και στην υποκατάστασή τους με λεπτότερους, από τούβλα. Κατά τέταρτον, στην απουσία "ξυλοδεσιάς" μέσα στους τοίχους και κάτω από τη στέγη. Τέλος, στις προσθήκες από σκυρόδεμα με μικρότερο ύψος από το κτίριο, που το "εμβολίζουν" οριζόντια σε περίπτωση σεισμού. Στα κτίρια από σκυρόδεμα που έχουν χτιστεί με παλαιότερους αντισεισμικούς κανονισμούς διαπιστώνουμε ότι πρόκειται συνήθως για κτίρια που δεν είχαν συντηρηθεί επαρκώς και για κτίρια σε πιλοτή»

Υπάρχουν πλέον νέες τεχνολογίες, πιο οικονομικές, ώστε να μη χαθεί το «χρώμα» των οικισμών της υπαίθρου.

Σε κάθε περίπτωση, η εγγύτητα του Αρκαλοχωρίου (όπως προ μηνών του Δαμασίου στην Ελασσόνα) στο επίκεντρο του σεισμού λειτούργησε σωρευτικά. «Ο σεισμός έγινε πολύ κοντά στο Αρκαλοχώρι, με αποτέλεσμα η σεισμική επιτάχυνση να είναι 3-4 φορές μεγαλύτερη από αυτές για τις οποίες είχαν σχεδιαστεί οι κατασκευές προ του '86» λέει ο κ. Σπυράκος.

Όσον αφορά τα διδάγματα από τους πρόσφατους σεισμούς στο Ηράκλειο, στην Ελασσόνα και στη Σάμο, οι ειδικοί εκτιμούν ότι αποδεικνύεται η χρησιμότητα των προσεισμικών ενισχύσεων των παλαιότερων κτιρίων. «Το κόστος μερικής αναβάθμισης ενός κτιρίου είναι σημαντικά μικρότερο από αυτό της πλήρους αναβάθμισης, όμως μπορεί να αποδειχθεί ικανό να αποτρέψει τουλάχιστον την κατάρρευσή του, το οποίο αποτελεί και το ελάχιστο ζητούμενο» εκτιμά ο **Αναστάσιος Σέξτος**, καθηγητής Αντισεισμικής Μηχανικής στο Πανεπιστήμιο του Μπρίστολ και πρόεδρος του Ελληνικού Τμήματος Αντισεισμικής Μηχανικής (ΕΤΑΜ). «Ακριβώς προς αυτή την κατεύθυνση κινείται και η πρόταση της κοινής ομάδας εργασίας ΟΑΣΠ/ΤΕΕ, αναμένοντας από την πολιτεία να θεσμοθετήσει φορολογικά και άλλα κίνητρα για την προσεισμική αναβάθμιση των ιδιωτικών κτιρίων κατά το πρότυπο του προγράμματος SismaBonus της Ιταλίας. Ειδικώς σε ό,τι αφορά κτίρια από τοιχοποιία, τα οποία όπως είδαμε και στους πρόσφατους σεισμούς της Σάμου, της Ελασσόνας και της Κρήτης αποτελούν το κύριο δομικό απόθεμα εκτός των αστικών κέντρων και είναι αρκετά παλαιά, άρα ευάλωτα στη σεισμική δράση, τέτοιες λύσεις μπορεί να περιλαμβάνουν, μεταξύ άλλων, και απλά, όχι πολύ δαπανηρά, μέτρα. Για παράδειγμα, την τοποθέτηση ελκυστήρων για τη σύνδεση των απέναντι τοίχων, ώστε να αποφευχθεί η κατάρρευσή τους, βαθύ αρμολόγημα, χρήση ενεμάτων, την κατασκευή αντηρίδων αντιστήριξης υψηλών και εύκαμπτων τοίχων σε εκκλησίες, την καλύτερη σύνδεση αυτών με τη θολοδομία κ.λπ Βασικές αλλά ζωτικές επεμβάσεις, που μειώνουν την πιθανότητα κατάρρευσης. Αυτό που απλούστερα θα λέγαμε "καλύτερα λίγα, στοχευμένα και σε μεγάλη κλίμακα παρά καθόλου", με σκοπό την προστασία εκείνων των κοινωνικών στρωμάτων που δεν μπορούν να φέρουν το κόστος της πλήρους αναβάθμισης των σπιτιών τους, έχουν όμως το ίδιο ακριβώς δικαίωμα στην προστασία της ζωής τους έναντι σεισμού. Το πρόβλημα είναι οικονομικό και όχι τεχνικό»

«Υπάρχουν τρία σημεία που θέλω να τονίσω σε σχέση με το Ηράκλειο» λέει ο κ. Σπυράκος. «Το πρώτο αφορά την ώρα του σεισμού: είδαμε από βίντεο στην Κρήτη τον κόσμο να πετάγεται έξω τη στιγμή του σεισμού, που όσο κατανοητό κι αν είναι, είναι λανθασμένη αντίδραση. Βγαίνοντας στον δρόμο εκείνη τη στιγμή μπορεί να χτυπηθείς από κάποιο αντικείμενο ή τζάμι και να τραυματιστείς. Το δεύτερο σημείο αφορά την περίοδο πριν από τον σεισμό. Πρέπει ο κόσμος να καταλάβει ότι ένας μηχανικός μπορεί σε μισή ώρα να του υποδείξει ποια χαρακτηριστικά της κατοικίας του είναι ευάλωτα και να προγραμματίσει κάποιες εργασίες. Υπάρχουν νέες τεχνολογίες για τον έλεγχο και τις παρεμβάσεις που είναι πολύ φθηνότερες από το παρελθόν. Το τρίτο σημείο αφορά την επόμενη ημέρα. Οι περισσότερες κατοικίες από λιθοποιία έχουν πληγεί. Αυτό δεν σημαίνει ότι πρέπει να τις κατεδαφίσουμε όλες. Υπάρχουν πολλές που ενδεχομένως μπορούν να επισκευαστούν. Τα πέτρινα σπίτια είναι το "χρώμα" των χωριών μας και δεν θα πρέπει να τα εξαφανίσουμε εν θερμώ»

(Γιώργος Λιάλιος / Η ΚΑΘΗΜΕΡΙΝΗ, 09.10.2021,
https://www.kathimerini.gr/society/561528973/seismos-

vasikes-alla-zotikes-epemvaseis-gia-ti-thorakisi-palaion-ktirion)

Institute of Physics of Earth's Interior & Geohazards

Hellenic Mediterranean University Research Center

Εφαρμογή οπτικών ινών ως σεισμογράφων στα Χανιά

Πειραματική εφαρμογή στα Χανιά για τη χρήση οπτικών ινών που μπορούν να λειτουργήσουν και ως σεισμογράφοι

Ένα πολύ ενδιαφέρον πείραμα διεξάγεται στα Χανιά, τα αποτελέσματα του οποίου μπορεί να αποδειχθούν εξαιρετικά σημαντικά στην προσπάθεια που καταβάλλει ο άνθρωπος να αντιμετωπίσει το φαινόμενο των σεισμών. Το Ινστιτούτο Φυσικής Εσωτερικού της Γης & Γεωκαταστροφών του Πανεπιστημιακού Ερευνητικού Κέντρου του Ελληνικού Μεσογειακού Πανεπιστημίου (Διευθυντής Φίλιππος Βαλλιανάτος, Καθηγητής Γεωφυσικής-Εφ. Γεωφυσικής ΕΚΠΑ) σε συνεργασία με το Πανεπιστήμιο Alcala (Ισπανία) πειραματίζονται στο Μητροπολιτικό δίκτυο οπτικών ινών των Χανίων για να λειτουργήσει το δίκτυο οπτικών ινών ως δίκτυο σεισμογράφων.

Στο πείραμα που διεξάγουν, στέλνοντας απλά ένα παλμό φωτός λέιζερ στο δίκτυο οπτικών ινών, συλλέγονται πολύτιμες πληροφορίες για την παραμόρφωση της οπτικής ίνας από την παρουσία ελαστικών κυμάτων σεισμικής ή/και ανθρωπογενούς προέλευσης. Το δίκτυο οπτικών ινών μετά τις τροποποιήσεις που έγιναν σε αυτό μπορεί να καταγράφει τη σεισμική δραστηριότητα στην περιοχή αλλά και να διακρίνει από πού προέρχεται. Ενσωματώνει την τεχνολογία Distributed Acoustic Sensing με την οποία ένα καλώδιο οπτικών ινών μπορεί να ανιχνεύει σε 24ωρη βάση ακόμη και τις πιο ανεπαίσθητες κινήσεις και μεταβολές που συμβαίνουν γύρω του. Με αυτό τον τρόπο δίνεται η δυνατότητα εντοπισμού σεισμικών γεγονότων. Με ειδικές έξυπνες τεχνικές γίνεται διαχωρισμός της σεισμικής δραστηριότητας από άλλου είδους πηγές.

Η χρήση των δικτύων οπτικών ινών (ειδικά σε αστικό περιβάλλον) μπορεί να προσφέρει σεισμολογικές υπηρεσίες με τεράστιες δυνατότητες αφού τέτοια δίκτυα είναι εγκατεστημένα σε μεγάλη έκταση στις περισσότερες περιοχές του ανεπτυγμένου κόσμου αλλά ταυτόχρονα μπορούν να δημιουργήσουν και πυκνότητα δικτύων που τα συμβατικά συστήματα αδυνατούν να υλοποιήσουν.

Το πείραμα, που διερευνά τις δυνατότητες παρατήρησης στη σεισμολογία της επόμενης δεκαετίας, διεξάγεται από το Ινστιτούτο Φυσικής Εσωτερικού της Γης & Γεωκαταστροφών με την υποστήριξη του Δήμου Χανίων, που προσφέρει τη χρήση του Μητροπολιτικού Δικτύου Οπτικών Ινών, και με τη βοήθεια του ΟΤΕ Χανίων που συνδράμει στην τεχνική υποστήριξη του πειράματος.

(25/10/2021, https://www.hmu.gr/el/news/16869)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΓΕΩΛΟΓΙΑ

Tectonic Geomorphology of Normal Faults and Their Scarps

Paula Marques Figueiredo & DavidNash

Abstract

A seismogenic fault capable of generating moderate to large earthquakes can actively displace topography repeatedly through time, and can condition surface processes helping form new landscapes. When faults rupture Earth's surface, they generally produce scarps, which are the most common landforms associated with normal faulting. The scarps are the emerged (exhumed) fault plane and are recognized as planar features, with variable dips and heights. Fault scarps can be the product of more than one earthquake and may form a complex morphology in rock or unconsolidated materials. Fault scarps generated during normal faulting of unconsolidated or poorly consolidated materials tend to have a relatively simple initial morphology. These types of fault scarps are common in alluvial fans located along mountain fronts. Such fault scarp result from horizontal tensional stress and, in frictional materials, will have initial dipangles of around 60°. However, as the initial scarp retreats, the degradation of the upper part progressively buries their base with an apron of colluvial debris at the angle of repose. The rate of the fault scarp degradation may be applied to determine the time elapsed since the burial of the initial normal fault scarp by examining the change in morphology of the scarp as its height varies along its length. Fault scarps in consolidated sediments or bedrock are preserved well in the landscape, recording evidence for individual earthquakes. Dating these faults enables the determination of short and long-term slip rates, timing of individual earthquakes, and the amount of displacement per event.

https://doi.org/10.1016/B978-0-12-818234-5.00203-0

(Earth Systems and Environmental Sciences, available online 30 September 2021, https://www.sciencedirect.com/science/article/pii/B9780128182345002030?via%3Dihub)

Νέα ηφαίστεια στη Σαντορίνη

Τι φέρνει στο φως επιστημονική έρευνα με σεισμική διασκόπηση του πυθμένα

Νέα, άγνωστα –και ευτυχώς ανενεργά– ηφαίστεια γύρω από τη **Σαντορίνη** φέρνει στο φως η επιστημονική έρευνα. Με τη σεισμική διασκόπηση του πυθμένα, χρησιμοποιώντας ηχητικά κύματα, ανακαλύφθηκε ένα μέχρι πρότινος άγνωστο ηφαιστειακό κέντρο, θαμμένο κάτω από τις αποθέσεις των ηφαιστειακών εκρήξεων δυτικά της Σαντορίνης. Παράλληλα αποκαλύπτεται για πρώτη φορά το πώς δημιουργήθηκαν και εξελίχθηκαν χρονικά η Σαντορίνη και τα **γειτονικά της ηφαίστεια, Χριστιανά και Κολούμπο**.

Το σύστημα Χριστιανά – Σαντορίνη – Κολούμπο δημιουργήθηκε σε τέσσερις φάσεις, αρχής γενομένης από το Υστερο Πλειόκαινο (πριν από 2,6 εκατ. χρόνια).

Τα αποτελέσματα της έρευνας δημοσιεύθηκαν προ ημερών στο επιστημονικό περιοδικό της **Αμερικανικής Γεωλογικής Εταιρείας «Geology»**. Επικεφαλής της έρευνας ήταν ο Γιόχαν Πράινε, από το Ινστιτούτο Γεωφυσικής του Πανεπιστημίου του Αμβούργου, ενώ από ελληνικής πλευράς συμμετείχαν από το τμήμα Γεωλογίας και Γεωπεριβάλλοντος του Πανεπιστημίου Αθηνών η αναπλ. καθηγήτρια Εύη Νομικού και ο ομότιμος καθηγητής Δημήτρης Παπανικολάου. Στην ομάδα συμμετείχαν επίσης ερευνητές από το Ωκεανικό Ινστιτούτο Κιέλου και το Πανεπιστήμιο Κλεμόντ Οβέρν. «Η γεωλογία της Σαντορίνης έχει μελετηθεί εκτενώς τις τελευταίες δεκαετίες, με αποτέλεσμα να γνωρίζουμε την ιστορία του ηφαιστείου της τα τελευταία 650.000 χρόνια», λέει η κ. Νομικού. «Ωστόσο η γνώση μας για τα γειτονικά της ηφαίστεια, Χριστιανά και Κολούμπο, είναι περιορισμένη. Το ηφαιστειογενές νησί Χριστιανά, στα νοτιοδυτικά της Σαντορίνης, πιστεύαμε πως ήταν ό,τι απέμεινε από ένα παλαιό ηφαίστειο, χωρίς να μπορούμε να το συνδέσουμε με την ηφαιστειακή ιστορία της περιοχής. Ενώ δεν γνωρίζουμε τίποτα για τις παλαιότερες εκρήξεις του ενεργού υποθαλάσσιου ηφαιστείου Κολούμπο, εκτός από τη βίαιη έκρηξη το 1650».

Στη νέα μελέτη, η επιστημονική ομάδα αξιοποίησε τις σεισμικές έρευνες που πραγματοποιήθηκαν με το γερμανικό ερευνητικό σκάφος RV Poseidon το 2019, αλλά και στοιχεία που είχαν συλλεχθεί τα προηγούμενα έτη. Με βάση αυτά οι επιστήμονες μπόρεσαν να εκτιμήσουν την εποχή που έγιναν μεμονωμένες ηφαιστειακές εκρήξεις και κατέληξαν, όπως αναφέρει ο κ. Πράινε, στο «ότι το σύστημα Χριστιανά – Σαντορίνη – Κολούμπο δημιουργήθηκε σε τέσσερις φάσεις, αρχής γενομένης από το Υστερο Πλειόκαινο (πριν από 2,6 εκατ. χρόνια), πολύ νωρίτερα από ό,τι εκτιμούνταν μέχρι σήμερα με βάση τα επίγεια στοιχεία από τη Σαντορίνη.

Στην πρώτη φάση δημιουργήθηκε το ηφαίστειο στα Χριστιανά, από τη λάβα του οποίου σχηματίστηκαν τα ομώνυμα νησάκια. Στη δεύτερη φάση δημιουργήθηκε το νεοανακαλυφθέν

ηφαιστειακό κέντρο που ονομάστηκε Ποσειδών (προς τιμήν του ερευνητικού σκάφους) και άρχισε η πρώιμη φάση του ηφαιστείου Κολούμπο. Στην τρίτη φάση αλλάζει η ηφαιστειακή δραστηριότητα στην περιοχή, με τη δημιουργία πολλών μικρών ηφαιστειακών κέντρων σε όλη την περιοχή, συμπεριλαμβανομένων των πρώιμων ηφαιστειακών κέντρων στο Ακρωτήρι και στη βόρεια πλευρά της Σαντορίνης (Περιστέρια). Τέλος, στην τέταρτη φάση (που φθάνει έως τις ημέρες μας) η ηφαιστειακή δράση εστιάζεται στη Σαντορίνη, προκαλώντας μια σειρά από σημαντικές εκρήξεις, χάρη στις οποίες δημιουργήθηκε η εντυπωσιακή καλντέρα». Η δημοσίευση της νέας μελέτης έρχεται λίγες εβδομάδες μετά την έγκριση ενός νέου, πολύ σημαντικού ερευνητικού προγράμματος στην περιοχή. «Το Διεθνές Πρόγραμμα Διερεύνησης των Ωκεανών» –IODP– είναι μια διεθνής επιστημονική συνεργασία για το θαλάσσιο γεωπεριβάλλον, που θα ενισχύσει την κατανόησή μας για τη Γη μέσω ερευνητικών υποθαλάσσιων γεωτρήσεων. Η πραγματοποίηση του προγράμματος στην Ελλάδα το 2022 είναι ένα κορυφαίο ερευνητικά γεγονός», εξηγεί η κ. Νομικού. «Στο πλαίσιό του θα διανοιχθούν έξι ερευνητικές γεωτρήσεις εντός και εκτός της καλντέρας, προσφέροντας για πρώτη φορά λεπτομερή στοιχεία για την εξέλιξη του ηφαιστειακού συστήματος της περιοχής».

(Γιώργος Λιάλιος / Η ΚΑΘΗΜΕΡΙΝΗ, 23 Οκτωβρίου 2021, https://www.kathimerini.gr/society/561552646/nea-ifaisteia-sti-santorini)

(Spatio-temporal evolution of the Christiana-Santorini-Kolumbo volcanic field, Aegean Sea · J. Preine; J. Karstens; C. Hübscher; P. Nomikou; F. Schmid, GEOLOGY, The Geological Society of America).

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΠΕΡΙΒΑΛΛΟΝ

Στην Κρήτη βρέθηκαν οι αρχαιότερες γνωστές πατημασιές ανθρώπου: Είναι 6,05 εκατομμυρίων ετών

Πριν 6,05 εκατ. χρόνια χρονολογούνται οι αρχαιότερες πατημασιές προγόνων του ανθρώπου που είχαν βρεθεί στην Κρήτη σύμφωνα με νεότερες εκτιμήσεις ξένων και Ελλήνων επιστημόνων.

Οι αρχαιότερες **γνωστές πατημασιές προγόνων του ανθρώπου**, οι οποίες είχαν αρχικά **ανακαλυφθεί στην Κρήτη το 2002,** έχουν ηλικία 6,05 εκατομμυρίων ετών, είναι δηλαδή περίπου 0,35 εκατομμύρια χρόνια παλαιότερες από ό,τι είχε εκτιμηθεί αρχικά, σύμφωνα με μια νέα διεθνή επιστημονική έρευνα με ελληνική συμμετοχή. Τα απολιθωμένα ίχνη όρθιας βάδισης ανακαλύφθηκαν στην ακτή στο χωριό Τράχηλος, κοντά στο **Καστέλι Κισσάμου** της δυτικής Κρήτης.

Οι ερευνητές από Γερμανία, Ελλάδα, Σουηδία, Αγγλία και Αίγυπτο, οι οποίοι έκαναν τη σχετική δημοσίευση στο περιοδικό "Nature Scientific Reports", με επικεφαλής τους Ούβε Κίρσερ και Μαντελάιν Μπέμε του Κέντρου Σένκεμπεργκ για την Ανθρώπινη Εξέλιξη και το Παλαιοπεριβάλλον του γερμανικού Πανεπιστημίου του Τίμπινγκεν, χρησιμοποίησαν γεωφυσικές και μικροπαλαιοντολογικές μεθόδους για να κάνουν ακριβή χρονολόγηση.

«*Τα ίχνη είναι σχεδόν 2,5 εκατομμύρια χρόνια παλαιότερα από τα ίχνη που αποδίδονται στον Αυστραλοπίθηκο αφαρένσις (Λούσι) από το Λαέτολι της Τανζανίας*», δήλωσε ο δρ Κίρσερ. Οι πατημασιές της Κρήτης έχουν περίπου την ίδια ηλικία με τα απολιθώματα (όχι πατημασιές) του είδους Orrorin tugenensis από την Κένυα, που βάδιζε όρθιος.

Πριν έξι εκατομμύρια χρόνια η Κρήτη συνδεόταν με την ηπειρωτική Ελλάδα μέσω της Πελοποννήσου. Όπως ανέφερε η δρ Μπέμε, «*δεν μπορούμε να αποκλείσουμε μια σύνδεση ανάμεσα στον δημιουργό των ιχνών βάδισης και στον πιθανώς προ-άνθρωπο Γκρεκοπίθηκο*». Πριν μερικά χρόνια είχαν βρεθεί στην Αττική τα απολιθώματα ενός άγνωστου προ-ανθρώπινου είδους (Graecopithecus freybergi), τα οποία χρονολογούνται πριν από περίπου 7,2 εκατομμύρια χρόνια.

Η νέα μελέτη επιβεβαιώνει επίσης πρόσφατη έρευνα των ίδιων Γερμανών επιστημόνων του Τίμπινγκεν, σύμφωνα με την οποία πριν έξι εκατομμύρια χρόνια η Ευρώπη και η Μέση Ανατολή χωρίζονταν από την υγρή Ανατολική Αφρική από μια σχετικά στενή έκταση της Σαχάρας. Η γεωχημική ανάλυση του εδάφους της ακτής της Κρήτης, ηλικίας έξι εκατ. ετών, δείχνει ότι σκόνη της ερήμου από τη Βόρεια Αφρική είχε μεταφερθεί εκεί από τους ανέμους.

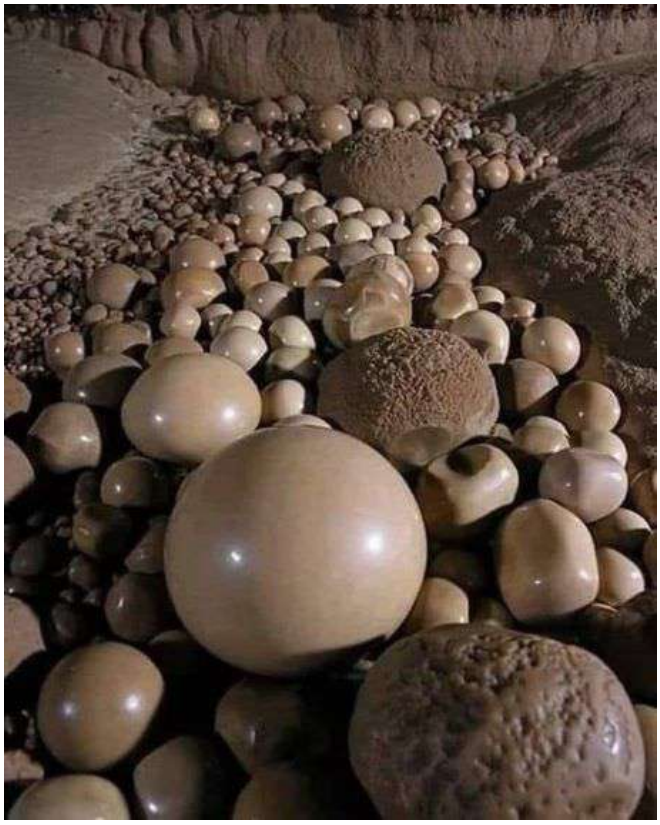
Οι ερευνητές ανέφεραν επίσης ότι πρόσφατες παλαιοανθρωπολογικές έρευνες δείχνουν πως ο αφρικανικός πίθηκος Σαχελάνθρωπος δεν βάδιζε όρθιος σε δύο πόδια, ενώ ο Orrorin tugenensis της Κένυας, ο οποίος έζησε πριν από 6,1 έως 5,8 εκατομμύρια χρόνια, υπήρξε ο αρχαιότερος προ-άνθρωπος στην Αφρική, ο οποίος πιθανώς εξελίχτηκε ανεξάρτητα από έναν Ευρωπαίο προ-άνθρωπο, όπως εκείνον της Κρήτης.

Στη μελέτη συμμετείχαν από ελληνικής πλευράς ο Αθανάσιος Αθανάσιου της Εφορείας Παλαιοανθρωπολογίας-Σπηλαιολογίας στην Αθήνα και ο γεωλόγος του Μουσείου Φυσικής Ιστορίας του Πανεπιστημίου της Κρήτης δρ Χαράλαμπος Φασουλάς.

(12 Οκτωβρίου 2021,
https://www.qazzetta.gr/plus/2050395/stin-kriti-brethikan-oi-arhaioteres-gnostes-patimasies-anthropoy-einai-605)

Cave Pearls

A Cave Pearl is a small, usually spherical, speleothem (cave formation) found in limestone caves. Cave Pearls are formed by a concretion of calcium salts that form concentric layers around a nucleus. Exposure to moving water polishes the surface of Cave Pearls, making them glossy; if exposed to the air, cave pearls can degrade and appear rough.



A Cave Pearl is composed primarily of calcite. Cave pearls are generally not considered to be a type of oolite. Other minerals found in small quantities in cave pearls include quartz, apatite, iron, aluminum, and magnesium.

Most Cave Pearls are smaller than 1 cm (0.39 in) wide. Large cave pearls grow as big as 20 cm (7.9 in) in diameter. The world's largest cave, Son Doong Cave in Vietnam, has cave pearls "the size of baseballs".

Από τον συνάδελφο Yiannis Metaxas (κοινοποίηση δημοσίευσης Robert MacFarlane).

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΛΟΙΠΑ

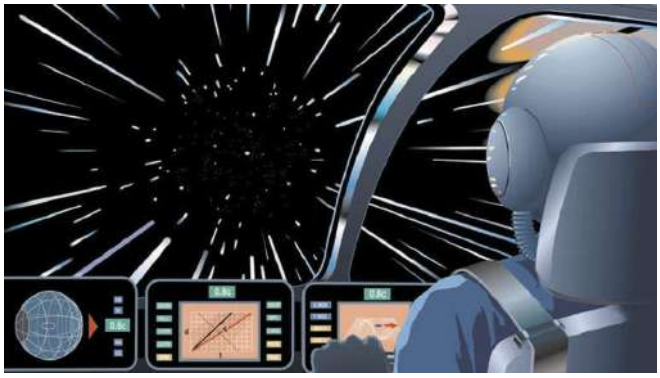
7 ways Einstein changed the world

Einstein's ideas have shaped the way we see and interact with the universe.

Albert Einstein (1879-1955) is one of the most famous scientists of all time, and his name has become almost synonymous with the word "genius." While his reputation owes something to his eccentric appearance and occasional pronouncements on philosophy, world politics and other non-scientific topics, his real claim to fame comes from his contributions to modern physics, which have changed our entire perception of the universe and helped shape the world we live in today.

Here's a look at some of the world-changing concepts we owe to Einstein.

Space-time



One of Einstein's earliest achievements, at the age of 26, was his theory of special relativity — so-called because it deals with relative motion in the special case where gravitational forces are neglected. This may sound innocuous, but it was one of the greatest scientific revolutions in history, completely changing the way physicists think about space and time. In effect, Einstein merged these into a single space-time continuum. One reason we think of space and time as being completely separate is because we measure them in different units, such as miles and seconds, respectively. But Einstein showed how they are actually interchangeable, linked to each other through the speed of light — approximately 186,000 miles per second (300,000 kilometers per second).

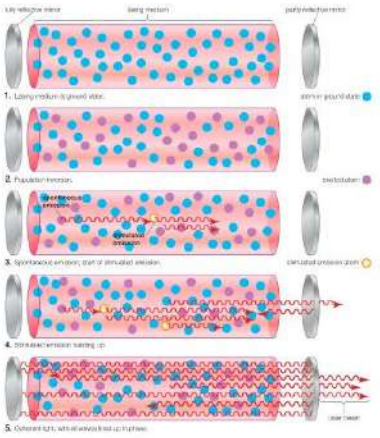
Perhaps the most famous consequence of special relativity is that nothing can travel faster than light. But it also means that things start to behave very oddly as the speed of light is approached. If you could see a spaceship that was traveling at 80% the speed of light, it would look 40% shorter than when it appeared at rest. And if you could see inside, everything would appear to move in slow motion, with a clock taking 100 seconds to tick through a minute, according to Georgia State University's HyperPhysics website. This means the spaceship's crew would actually age more slowly the faster they are traveling.

E = mc^2

An unexpected offshoot of special relativity was Einstein's celebrated equation E = mc^2, which is likely the only mathematical formula to have reached the status of cultural icon. The equation expresses the equivalence of mass (m) and energy (E), two physical parameters previously believed to be completely separate. In traditional physics, mass measures the amount of matter contained in an object, whereas energy is a property the object has by virtue of its motion and the forces acting on it. Additionally, energy can exist in the complete absence of matter, for example in light or radio waves. However, Einstein's equation says that mass and energy are essentially the same thing, as long as you multiply the mass by c^2 — the square of the speed of light, which is a very big number — to ensure it ends up in the same units as energy.

This means that an object gains mass as it moves faster, simply because it's gaining energy. It also means that even an inert, stationary object has a huge amount of energy locked up inside it. Besides being a mind-blowing idea, the concept has practical applications in the world of high-energy particle physics. According to the European Council for Nuclear Research (CERN), if sufficiently energetic particles are smashed together, the energy of the collision can create new matter in the form of additional particles.

Lasers



Lasers are an essential component of modern technology and are used in everything from barcode readers and laser pointers to holograms and fiber-optic communication. Although lasers are not commonly associated with Einstein, it was ultimately his work that made them possible. The word laser, coined in 1959, stands for "light amplification by stimulated emission of radiation" — and stimulated emission is a concept Einstein developed more than 40 years earlier, according to the American Physical Society. In 1917, Einstein wrote a paper on the quantum theory of radiation that described, among other things, how a photon of light passing through a substance could stimulate the emission of further photons.

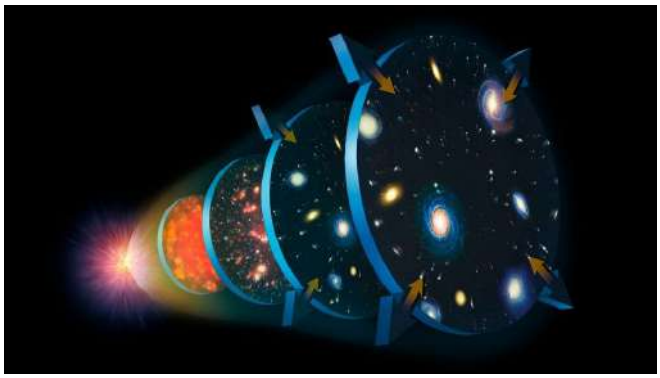
Einstein realized that the new photons travel in the same direction, and with the same frequency and phase, as the original photon. This results in a cascade effect as more and more virtually identical photons are produced. As a theoretician, Einstein didn't take the idea any further, while other scientists were slow to recognize the enormous practical potential of stimulated emission. But the world got there in the end, and people are still finding new applications for lasers today, from anti-drone weapons to super-fast computers.

Black holes and wormholes

Einstein's theory of special relativity showed that space-time can do some pretty weird things even in the absence of gravitational fields. But that's only the tip of the iceberg, as Einstein discovered when he finally succeeded in adding gravity into the mix, in his theory of general relativity. He found that massive objects like planets and stars actually distort the fabric of space-time, and it's this distortion that produces the effects we perceive as gravity.

Einstein explained general relativity through a complex set of equations, which have an enormous range of applications. Perhaps the most famous solution to Einstein's equations came from Karl Schwarzschild's solution in 1916 — a black hole. Even weirder is a solution that Einstein himself developed in 1935 in collaboration with Nathan Rosen, describing the possibility of shortcuts from one point in space-time to another. Originally dubbed Einstein-Rosen bridges, these are now known to all fans of science fiction by the more familiar name of wormholes.

The expanding universe



One of the first things Einstein did with his equations of general relativity, back in 1915, was to apply them to the universe as a whole. But the answer that came out looked wrong to him. It implied that the fabric of space itself was in a state of continuous expansion, pulling galaxies along with it so the distances between them were constantly growing. Common sense told Einstein that this couldn't be true, so he added something called the cosmological constant to his equations to produce a well-behaved, static universe.

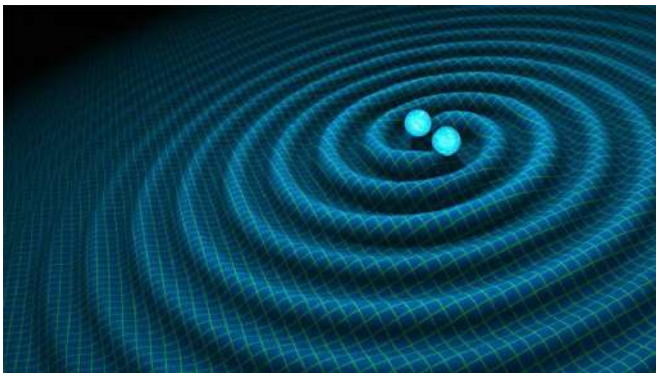
But in 1929, Edwin Hubble's observations of other galaxies showed that the universe really is expanding, apparently in just the way that Einstein's original equations predicted. It looked like the end of the line for the cosmological constant, which Einstein later described as his biggest blunder. That wasn't the end of the story, however. Based on more refined measurements of the expansion of the universe, we now know that it's speeding up, rather than slowing down as it ought to in the absence of a cosmological constant. So it looks as though Einstein's "blunder" wasn't such an error after all.

The atomic bomb

Einstein is occasionally credited with the "invention" of nuclear weapons through his equation E = mc^2, but according to the Max Planck Institute for Gravitational Physics's Einstein Online website, the link between the two is tenuous at best. The key ingredient is the physics of nuclear fission, which Einstein had no direct involvement with. Even so, he played a crucial role in the practical development of the first atomic bombs. In 1939, a number of colleagues alerted him to the possibilities of nuclear fission and the horrors that would ensue if Nazi Germany acquired such weapons. Eventually, according to the Atomic Heritage Foundation, he was persuaded to pass on these concerns in a letter to the president of the United States, Franklin D. Roosevelt. The ultimate outcome of Einstein's letter was the establishment of the Manhattan Project, which created the atomic bombs used against Japan at the end of World War II.

Although many famous physicists worked on the Manhattan Project, Einstein wasn't among them. He was denied the necessary security clearance because of his left-leaning political views, according to the American Museum of Natural History (AMNH). To Einstein, this was no great loss — his only concern had been to deny a monopoly on the technology to the Nazis. In 1947 Einstein told Newsweek magazine, "Had I known that the Germans would not succeed in developing an atomic bomb, I would have never have lifted a finger," according to Time magazine.

Gravitational waves



Einstein died in 1955, but his huge scientific legacy continues to make headlines even in the 21st century. This happened in a spectacular way in February 2016, with the announcement of the discovery of gravitational waves — yet another consequence of general relativity. Gravitational waves are tiny ripples that propagate through the fabric of space-time, and it's often bluntly stated that Einstein "predicted" their existence. But the reality is less clear-cut than that.

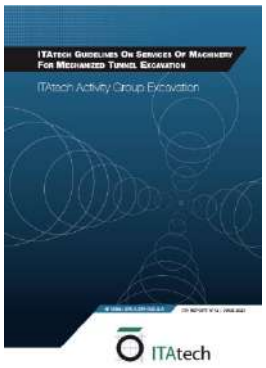
Einstein never quite made up his mind whether gravitational waves were predicted or ruled out by his theory. And it took astronomers decades of searching to decide the matter one way or the other.

Eventually they succeeded, using giant facilities such as the Laser Interferometer Gravitational-Wave Observatories (LIGO) in Hanford, Washington, and Livingston, Louisiana. As well as being another triumph for Einstein's theory of general relativity (albeit one he wasn't too sure about himself), the discovery of gravitational waves has given astronomers a new tool for observing the universe — including rare events like merging black holes.

Originally published on Live Science.

(Andrew May , 3 October 2021, https://www.livescience.com/ways-einstein-changed-the-world?utm_source=notification)

ΝΕΕΣ ΕΚΔΟΣΕΙΣ ΣΤΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΠΙΣΤΗΜΕΣ



Services of machinery for mechanized tunnel excavation

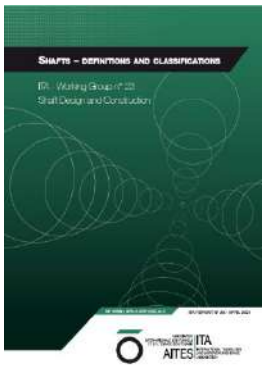
The last ITAtech guideline N°12 on **services of machinery for mechanized tunnel excavation** is available!

The report is to provide guidance for project owners, designers, TBM users, TBM manufacturers and TBM service providers when specifying requirements for TBM services, through the creation of a common language in terms of TBM Services.

It does not cover TBM refurbishment which in some cases may be considered a TBM Service activity. Guidance for this is given in ITAtech report N°5-V2 "Guidelines on rebuilds of machinery for mechanized tunnel excavation.

Download document

(ITAtech publication, 04 October 2021)



Shafts - definitions & classifications

WG23 on Design and Construction of Shafts

The latest Working group (WG23 on Design and construction of shafts) that has been approved by the 2019 ITA General Assembly, has just published its first ITA report.

Following the first WG 23 meeting in Naples, the need for defining common terms was raised and it was decided to prepare a document to explain and develop the correct terminology and nomenclature for shaft design and construction.

It was also discussed that suitable classifications for shafts based on their geometry, application, ground conditions, and construction methods was needed for a more uniform understanding of design and construction implications.

This document is prepared in response to the above mentioned needs and provides common definitions for relevant terms in addition to introducing different types of classification systems for shafts that can be implemented during design and construction of these structures.

The document contains contributions of various individuals. Work has been coordinated by Siamak Hashemi (Animateur of WG 23) and Jamal Rostami. Tarcisio Celestino was the Tutor of WG 23.

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(2021 ITA publication, 13 July 2021)

ΗΛΕΚΤΡΟΝΙΚΑ ΠΕΡΙΟΔΙΚΑ

International Journal of Geoengineering Case Histories

An official journal of the International Society for Soil Mechanics and Geotechnical Engineering

Special Issue on Engineering Practice of Risk Assessment and Management by ISSMGE TC304 published

Volume 6, Issue #4, https://www.geocasehistoriesjournal.org/pub/issue/view/50

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- World Forum on Underground Urban Transportation, Read more
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- Message from Robert Galler - ITA Chairman and Michel Deffayet - Vice Chairman
- **Listen, lunch, learn!** Our short lunchtime lecture series has met with considerable success (page 2)
- **A team effort** We look at how ITA-CET is seeking to improve its collaboration with ITA Working Groups and Committees (page3)
- **The show must go on!** A reminder that despite the pandemic, tailor-made training solutions remain available for ITA Member Nations (page 4)
- **PhD students to take centre stage** The 2nd meeting of ITA-CET university professors and PhD students will be a chance to exchange on research projects in tunnelling from around the world (page 5)
- **Tunnel vision** Our newest member of the ITA-CET Steering Board, Eyðbjørg Amanda Petersen, introduces herself (page 6)

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