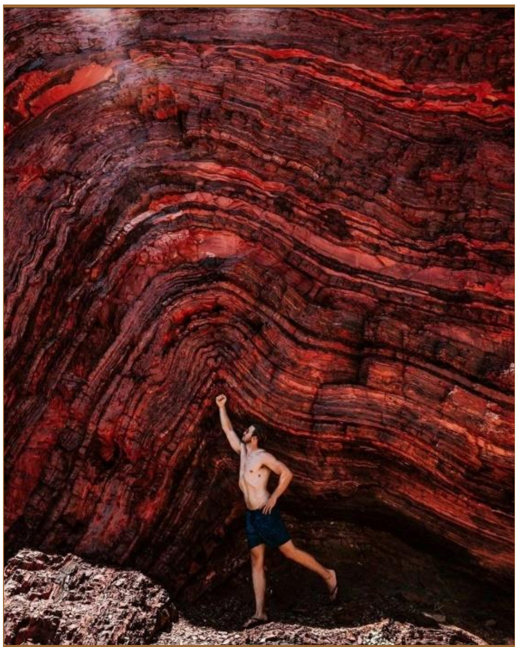

Pilbara, Western Australia

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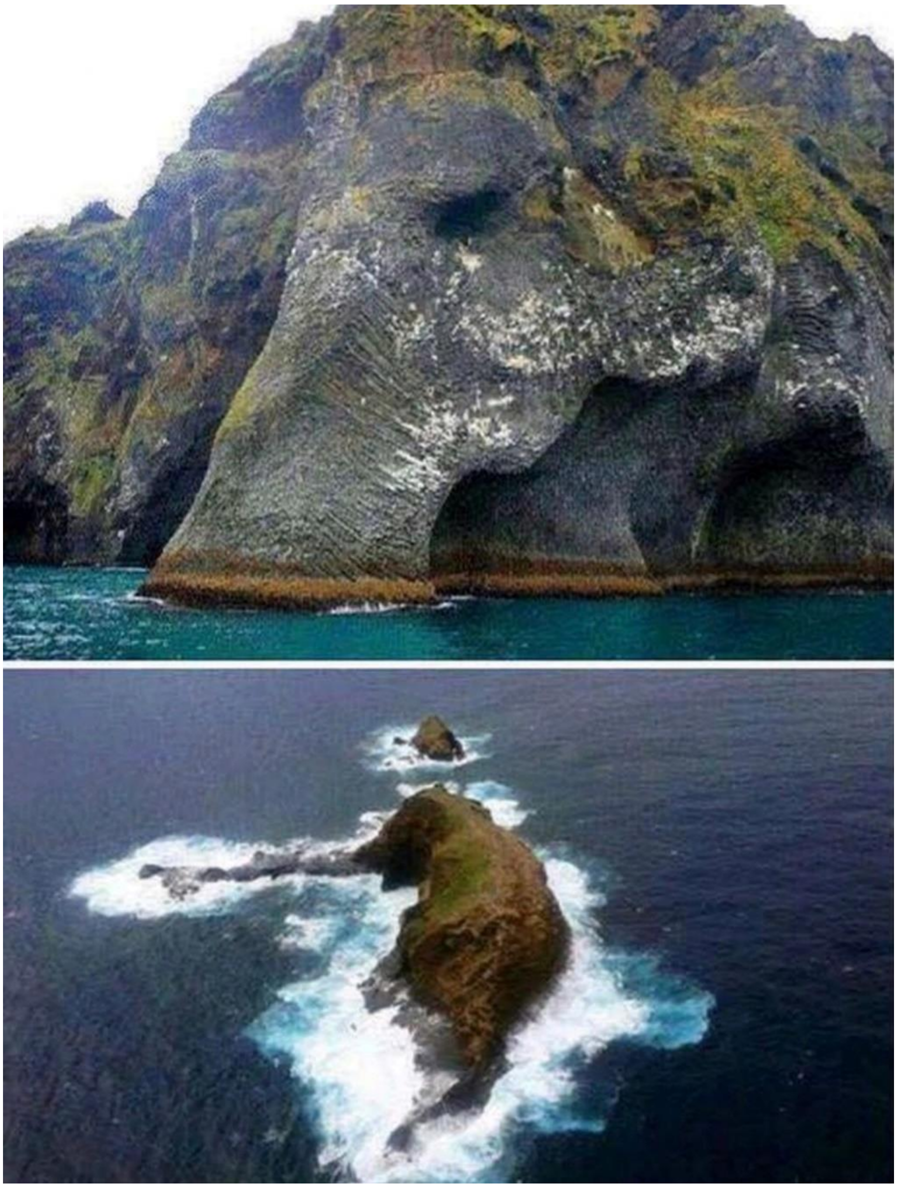

The Elephant Rock in Iceland

ISSN: 2732-7248

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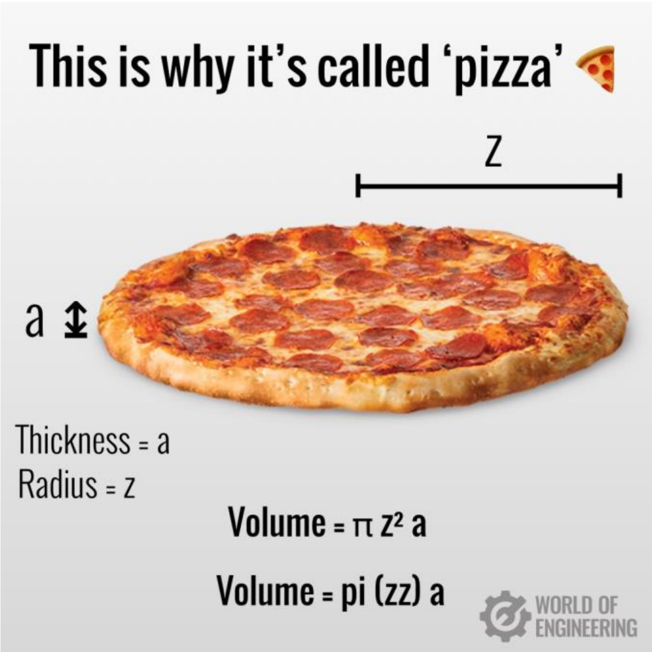

Landslide susceptibility maps of Italy: Lesson learnt from dealing with multiple landslide types and the uneven spatial distribution of the national inventory

Marco Loche , Massimiliano Alvioli, Ivan Marchesini, Haakon Bakka, Luigi Lombardo

Abstract

Landslide susceptibility corresponds to the probability of landslide occurrence across a given geographic space. This probability is usually estimated by using a binary classifier which is informed of landslide presence/absence data and associated landscape characteristics. Here, we consider the Italian national landslide inventory to prepare slope-unit based landslide susceptibility maps. These maps are prepared for the eight types of mass movements existing in the inventory, (Complex, Deep Seated Gravitational Slope Deformation, Diffused Fall, Fall, Rapid Flow, Shallow, Slow Flow, Translational) and we build one susceptibility map for each type. The analysis – carried out by using a Bayesian version of a Generalized Additive Model with a multiple intercept for each Italian region – revealed that the inventory may have been compiled with different levels of detail. This would be consistent with the dataset being assembled from twenty sub–inventories, each prepared by different administrations of the Italian regions. As a result, this spatial heterogeneity may lead to biased national–scale susceptibility maps. On the basis of these considerations, we further analyzed the national database to confirm or reject the varying quality hypothesis on the basis of the model equipped with multiple regional intercepts. For each landslide type, we then tried to build unbiased susceptibility models by removing regions with a poor landslide inventory from the calibration stage, and used them only as a prediction target of a simulation routine. We analyzed the resulting eight maps finding out a congruent dominant pattern in the Alpine and Apennine sectors.

The whole procedure is implemented in R–INLA. This allowed to examine fixed (linear) and random (nonlinear) effects from an interpretative standpoint and produced a full prediction equipped with an estimated uncertainty.

We propose this overall modeling pipeline for any landslide datasets where a significant mapping bias may influence the susceptibility pattern over space.

1. Introduction

A landslide inventory is a database of the location of past landslides and their characteristics. It may contain a unique identification code for each landslide recorded and related information about type of landslide, state of activity, date of occurrence and material involved (Galli et al., 2008; Hervás and Bobrowsky, 2009). The inventory may be polygonal or point-based and it may correspond to an event-based inventory, in which all landslides share the same and simultaneous trigger, such as a storm or an earthquake (Iadanza et al., 2016; Cama et al., 2015; Fan et al., 2019; Loche et al., 2022b). The alternative can encompass landslides with a ill-defined time of occurrence, which one would refer to as geomorphological inventory (Guzzetti et al., 2012).

National landslide inventories are geomorphological inventories in most cases. They may cover wide areas and thus, may require different data (orthophotos or satellite images) and/or research groups to undertake the mapping effort. Unfortunately, when different data and/or groups are involved in the task, each output inventory inevitably suffers from the different quality and completeness (Guzzetti et al., 2012; Tanyas and Lombardo, 2020; Pokharel et al., 2021) brought by some degree of subjectivity. For instance, some areas may be preferentially mapped, either for a specific choice, a topographic limitation, or for other reasons (Bornaetxea et al., 2018; Bornaetxea and Marchesini, 2021).

For example, Devoli et al. (2015) showed a significant presence of landslides around the Norwegian road network, for mapping at national scale is mostly undertaken by road authorities. The same preferential mapping was noted by Steger et al. (2021) in northern Italy or by Tanyas et al. (2022) in eastern Turkey. Steger et al. (2016a) investigated bias effects due to specific land cover types, and Steger et al. (2016b) explored the same issue over a large portion of the Austrian territory, further extended to the whole Austria by Lima et al., 2017, Lima et al., 2021. Van Den Eeckhaut et al. (2012) and Kirschbaum et al. (2015) made similar considerations for the European and Global landslide catalogues, respectively. More recently, this topic has been also examined for the whole Chinese territory by Lin et al. (2021) and Wang et al. (2022), who stressed the negative influence of an incomplete landslide inventory and the necessity to find ways to reduce the propagation of this spatial bias onto the final susceptibility map. Notably, recent technological developments are contributing to reduce this issues through accurate aerial photograph interpretation (Karakas et al., 2021) and automated landslide mapping routines (Meena et al., 2022).

Nevertheless, in situations like Italy, where the national inventory is compiled by several groups and thus likely using different criteria, some degree of spatial biases are to be expected. Trigila et al. (2010) discussed the quality of the Italian Landslide Inventory (known as IFFI, Trigila et al., 2007) and its completeness for individual administrative regions. However, few articles have used the IFFI information for susceptibility purposes. Iadanza et al. (2016) and Segoni et al. (2015) used it as a reference to extract rainfall triggering thresholds, whereas Bianchini et al. (2013) and Hölbling et al. (2012) used it to validate slope deformation detected through persistent scatterer interferometry. Colombo et al. (2005) adopted it to empirically study the hazard in the north–western Italian sector corresponding to the Piedmont region. Recently, Alvioli et al. (2021) adopted a subset of IFFI to partially validate simulations of rockfall trajectories. Only one case exists where the authors considered the whole IFFI at the national scale (Marchesini et al., 2014), and only for validation, not for training a model.

Overall, the geomorphological literature lacks a unified/objective approach on how to deal with the propagation inventory biases to the resulting landslide susceptibility maps. The procedure presented in Steger et al. (2021) is currently the most comprehensive, and we will take inspiration from it in this work.

In terms of modeling approaches, the literature on landslide susceptibility features a large number of modeling techniques. The most common approach still belongs to the binomial Generalized Linear Model (GLM) or, as more specifically referred, to the Binary Logistic Regression (BLR) case, as also reported by Lombardo and Mai (2018) and Reichenbach et al. (2018). This method assumes that the distribution of landslide presences and absences across the geographic space can be explained according to a Bernoulli exponential distribution. The influence of the covariates is then captured *via* linear relationships. This is usually implemented in a frequentist approach with good performances (*e.g.* Yesilnacar and Topal, 2005; Nefeslioglu et al., 2008; Rossi et al., 2010), which justifies the use of such a relatively simple model. Nevertheless, more complex statistical models are available nowadays, and they allow one to explore whether nonlinear relations between landslides and landscape characteristics exist. This is the case of the most common extension of the GLM framework, the Generalized Additive Model (GAM), already appeared in a number of applications (Goetz et al., 2011; Petschko et al., 2012; Goetz et al., 2021). However, even in such case, the frequentist framework does not allow to naturally account for uncertainties, which instead is an essential part of a Bayesian counterpart (Korup, 2021; Lombardo and Tanyas, 2021).

Few landslide susceptibility studies feature a Bayesian implementation. Das et al. (2012) show one example of Bayesian GLM to assess the landslide susceptibility in the proximity of roads in a Indian case study. Analogous examples can be found more recently at catchment (Lombardo et al., 2020b; Luo et al., 2021) and regional scale assessments (Tanyas et al., 2021; Loche et al., 2022a). Moreover, Lombardo et al., 2018a, Lombardo et al., 2019 proposed an extension of the Bayesian workflow pursued by the authors mentioned above by using a Log–Gaussian Cox Process to predict landslide counts per mapping unit, this being implemented in R–INLA (Lindgren and Rue, 2015; Bakka et al., 2018).

Ultimately, another non–standardized approach in landslide science pertains to the way the space is partitioned *i.e.*, which mapping unit is adopted. The vast majority of literature contributions opt for a regular mesh or grid–cell based subdivision (Sala et al., 2021; Arnone et al., 2016; Huang et al., 2017) whereas other researchers use Slope-Units (SU, Schlögel et al., 2018; Tanyas et al., 2019a, Tanyas et al., 2019b; Alvioli et al., 2021, Alvioli et al., 2022) or in fewer cases for other terrain unit subdivisions (Zêzere et al., 2004); Zêzere et al., 2017). Even more rarely, the differences induced by one or the other spatial partition are discussed (Erener and Düzgün, 2012; Alvioli et al., 2018; Ba et al., 2018; Jacobs et al., 2020; Doménech et al., 2020).

The grid cell–based partition type is regular, easy–to–use, and it usually subdivides the landscape at a fine to very fine resolution. It is convenient because its resolution often coincides with satellite–derived data, but it leads to some operational issues. For instance, when a susceptible grid cell is surrounded by non–susceptible ones (Doménech et al., 2020), it is not straightforward to make decisions for landslide risk reduction nor for structural slope design. Conversely, SU result from geomorphological processes which shape the landscape as much as the landslides, and have a physical correspondence on the terrain. Being medium–coarse in resolution, they require an aggregation step of the quantities one usually derives from satellite data. Moreover, they intrinsically express the morphodynamic behavior of a failing slope, thus SU can be easily interpreted for master planning purposes. As a result of these advantages, although grid cells are still predominant in the literature, the number of SU–based applications has seen a constant increase in recent years, especially after automated and open access tools for SU delineation have been made available to the community (see, Alvioli et al., 2016). Considerations on the advantage of SU over grid-cells have been extensively discussed in Reichenbach et al. (2018).

In this work, we investigate the landslide susceptibility of the Italian territory considering the three aspects mentioned above: spatial homogeneity/heterogeneity of landslide inventories, a solid approach to the susceptibility estimation, and the use of SU as geomorphologically–sound mapping units. Specifically, we focus on examining possibly incomplete landslide inventories and develop a selection procedure to ensure that the bias they may generate would not propagate onto the final susceptibility maps. We do so within a GAM–type model built over a SU partition of Italy. In doing so, we examine the (linear/nonlinear) covariate effects out of a suite of models that also feature an uncertainty estimation phase.

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6. Conclusions

The strategy proposed here is currently the most comprehend-sive example of landslide susceptibility analysis, in a situation where incomplete landslide inventories may affect the model estimates over multiple landslide types. It consists in a continuation of the research started with Steger et al. (2016a) and continued until (Steger et al., 2021). It resulted in the first bias-free landslide susceptibility model for the whole Italian territory and for each landslide type reported in the IFFI inventory. Overall, we consider the eight susceptibility maps to be a complete tool for experts in the administrations to improve landscape management practices but also simply to make better decisions on which solution can become operational to reduce landslide risk, with an approach that can be tailored to the probabilistic expectation of a specific landslide type to occur at a given location.

Aside from these aspects, a number of extensions of the framework we propose can already be envisioned. First of all, we tested the effect of biased landslide inventories onto the susceptibility because the latter is the most common result sought through data-driven models. However, a more informative data-driven framework can lead to estimate the landslide intensity instead (here interpreted as number or size of landslides per mapping unit). In the context of landslide intensity no study is available so far to elucidate on what implications the use of biased inventories may lead to. Thus, we consider a worthy venue for future scientific studies to elaborate on what partial landslide information can induce in the estimation of landslide counts or sizes.

These susceptibility and intensity models separately constitute two fundamental elements of the hazard definition. Thus, an important extension to the framework we propose here also includes the assessment of what biased inventories can induce over the hazard definition. Along the same direction, even the temporal aspect of the hazard notion can exhibit strong biases. For instance, landslides area obviously being mapped better and more frequently now as compared to the past, because the resolution of the satellite scenes is higher and their acquisition frequency has also increased. However, no study so far has explored what a temporally biased model can induce over dynamic susceptibility models or just rainfall threshold estimates in early warning systems.

Overall, data quality and inequality is still an issue in data-driven models applied to the landslide context. We believe this to be a problem that will decrease with time, as automated landslide mapping procedures are becoming increasingly common and more importantly reliable. Until these automated tools will become the standard though, analogous problems to the one we faced in this article will still affect most of the landslide predictive models. This will be especially valid for models built on the basis of a collection of different inventories, from different sources, for different purposes and with different thematic supports. In all these cases, we suggest a similar solution to the one presented here, in the hope of removing negative effects from the model outcomes.

Before concluding, we stress again that to promote reproducible results and to allow any reader to access the susceptibility patterns we produced in their raw form, we are sharing the eight mean susceptibility maps and their uncertainty at this link: https://geomorphology.irpi.cnr.it/tools/slope-units.

https://www.sciencedirect.com/science/article/pii/S0012825222002094?via%3Dihub
https://doi.org/10.1016/j.earscirev.2022.104125

An investigation of the combined effect of rainfall and road cut on landsliding

Samprada Pradhan, David G.Toll, Nick J.Rosser, Matthew J.Brain

Highlights

- Combined effect of rainfall and road cut on landsliding was investigated.
- Integrated methodology with field and laboratory testing and numerical modelling was adopted.
- Reliability of numerical modelling was improved by calibration against field measurements.
- Two ways by which road cuts promote rainfall-induced landslides were identified.

Abstract

The reduction of soil suction and consequent loss of shear strength due to infiltration is known to trigger shallow landslides during periods of concentrated rainfall. In the mountainous terrain of Nepal, the risk of shallow rainfall-induced landsliding is further exacerbated by non-engineered hillslope excavation for local roads construction. To better understand the combined effect of rainfall and road cutting on landsliding, a detailed investigation of a shallow landslide was conducted, on a site with a steep road cut that failed due to rainfall infiltration in July 2018. An integrated investigation approach was adopted, combining field and laboratory testing and field monitoring with a series of coupled hydro-mechanical analyses with the finite element code PLAXIS 2D. The field and laboratory tests were performed to characterise the subsoil condition and determine the soil parameters for the hydro-mechanical analyses. The field monitoring program was set up to obtain real-time measurements of rainfall and volumetric water content of the soil. The monitored data was used to calibrate the numerical model and assess the reliability of its predictions. Results of the numerical back-analysis suggest that the investigated landslide was triggered by rainfall infiltration causing a gradual reduction of soil suction at shallow depths of ≤1.7 m and the presence of the steep road cut promoted slope failure by allowing larger displacements to occur in the hillslope. Without the road cut, the slope was found to have ~35% greater initial factor of safety and under the landslide-triggering rainfall, the undisturbed slope was found to remain stable with ~170% greater factor of safety than that in the slope with the road cut. This indicates that the presence of a road cut increases the likelihood of landslide during rainfall and lowers the minimum level of rainfall needed for landslide initiation. Hence, rainfall-induced roadside slope failures could become more frequent and extensive if roads continue to be built by informal slope excavation, without adopting suitable interventions, some examples of which are presented in this study.

1. Introduction

Rainfall-induced landslides pose a serious threat to lives and properties around the world. The mountainous country Nepal experiences widespread landslides every year triggered by the concentrated monsoonal rainfall between June and September (Dahal and Hasegawa, 2008; Petley et al., 2007; Upreti and Dhital, 1996). The monsoonal rainfall constitutes ~80% of the total annual rainfall and studies show that >90% of the fatal landslides in Nepal occur during this period (Froude and Petley, 2018; NDRRMA, 2021; Petley et al., 2007). In the last decade, landslides caused the loss of over 1200 lives and economic damage of more than $14 million in Nepal (NDRRMA, 2021).

The proliferation of informal local roads in Nepal has further increased the risk of rainfall-induced landsliding (Dahal et al., 2010; Devkota et al., 2014; Froude and Petley, 2018; Mcadoo et al., 2018; Petley et al., 2007; Vuillez et al., 2018), and this has been attributed to the non-engineered or informal method of slope excavation for road construction, often crossing terrain with steep angles, without suitable planning, design and drainage and protection measures (Dixit et al., 2021; Hearn and Shakya, 2017; Robson et al., 2021; UNDP, 2011; World Bank, 2012). The study by Mcadoo et al. (2018) found that the rainfall-triggered landslides could occur with approximately twice the frequency in areas with poorly constructed roads than in those without, based on the spatial distribution analysis of landslides and roads in Sindhupalchok district, Nepal. Vuillez et al. (2018) also found that within the Phewa watershed in western Nepal, the occurrence of landslides during extreme rainfall events was more prominent in areas intersected by or in close vicinity of the roads.

Although the association between rainfall, road construction and landslides in Nepal has been recognised anecdotally (Dahal et al., 2010; Rosser et al., 2021) and broadly correlated statistically by previous studies (Petley et al., 2007), there is limited understanding related to the physical process by which road cuts influence slope stability during rainfall. The necessity to model this physical process to better understand the combined road-rainfall effect on landsliding has also been emphasised by Mcadoo et al. (2018). Moreover, the need to address landslides related to roads and rainfall extends beyond Nepal to other low- and middle-income countries, where the construction of non-engineered steep slopes as part of road building is common and is known to be a dominant driver of instability (Haigh and Rawat, 2012; Holcombe et al., 2016; Sati et al., 2011; Sidle et al., 2014; UNDP, 2011; Sidle and Ziegler, 2012).

Assessing the physical process of the rainfall-triggered landslides requires understanding how the transient atmospheric process like rainfall influences the unsaturated soil behaviour near the ground surface (Fredlund and Rahardjo, 1993). Rainfall infiltration into the unsaturated zone is known to cause an increase in the soil water content, and reductions in soil suction and shear strength (Brand, 1981; Fredlund, 1987; Godt et al., 2009; Lumb, 1975; Rahardjo et al., 2019; Springman et al., 2003; Tsaparas et al., 2002). The infiltration-induced pore water pressure changes modify the soil stresses, which causes soil deformation, and soil deformation, in turn, modifies the seepage process because the key hydraulic properties like permeability, porosity, and water retention capacity of soil change with the changes in stresses (Song and Borja, 2014; Zhang et al., 2018). Hence, the analysis of the physical process of rainfall-triggered landslides requires powerful numerical modelling methods that can model not only the transient atmospheric conditions but also the interdependence between seepage and stress-deformation in unsaturated soils.

The coupled hydro-mechanical analysis effectively captures this interdependence by allowing simultaneous computation of both hydraulic and mechanical responses of variably saturated soils, which is necessary for the accurate assessment of rainfall-induced landslides (Chen et al., 2018; Hamdhan and Schweiger, 2013; Laloui et al., 2016; Md Rahim and Toll, 2014; Qi and Vanapalli, 2015; Yang et al., 2017; Yang et al., 2019; Yubonchit et al., 2017). Compared to the uncoupled analyses, where the hydraulic and mechanical aspects of soil behaviour are treated separately, the coupled hydro-mechanical analyses have been reported to provide a better prediction of factor of safety and the pore water pressure predictions from coupled analyses have been found to be in good agreement with field-measured pore water pressures (Hamdhan and Schweiger, 2013; Toll et al., 2019). Studies have also shown that the coupled analyses can closely predict actual failure times, in addition to providing a better prediction of seepage and stress distribution (Rahim, 2016; Oh and Lu, 2015; Yang et al., 2017, Yang et al., 2020, Yang et al., 2019).

Thus, addressing the need to understand the physical process of landslides triggered by the combined effect of rainfall and road cut in Nepal, and considering the advantages of the coupled hydro-mechanical analyses, this study utilises the hydro-mechanical approach to investigate a case study of a rainfall-induced landslide on a road cut slope in Sindhupalchok district, Nepal. Using this case study, this paper aims to 1) back-analyse the landslide to understand the underlying mechanism and physical processes involved in the failure and 2) quantitatively assess the effect of the road cut on the occurrence of the landslide during rainfall. Through a series of numerical analyses, this study also attempts to demonstrate the viability of coupled hydro-mechanical analyses to capture the hydrological changes in unsaturated soils due to soil-atmospheric interaction and to predict the occurrence of slope failures. As hydro-mechanical modelling requires a good understanding of the relevant physical, mechanical, and hydraulic soil parameters, comprehensive field and laboratory testing of the soils were conducted during this study. The field and laboratory data were used to define the input material properties for numerical modelling. A field hydrological monitoring program was also undertaken at the study site after the landslide, and the monitored data was utilised to calibrate the numerical model.

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9. Discussion

In low- and middle-income countries like Nepal, roads are considered fundamental infrastructures, expected to contribute to the socio-economic development of local communities. When the poorly constructed roads become one of the landslide causative factors, the consequences present a contradiction to the primary objective of building the roads. In developing parts of the world, hillslope excavation for roads or for creating flatter sites for urbanisation has been associated with significant landslide and erosion problems (Haigh and Rawat, 2012; Holcombe et al., 2016; Sidle and Ochiai, 2006; Sidle and Ziegler, 2012). While the road networks continue to proliferate across many countries to meet the developmental goals, the need to acknowledge and address the adverse impacts of poorly constructed roads becomes more necessary than ever.

Using a case study of a typical landslide that occurred following a non-engineered slope excavation, the numerical analyses presented in this paper demonstrate how such activities can contribute to landsliding during rainfall. The back-analysis of the investigated landslide showed that when the failure occurred in July 2018, the rainfall infiltration in the unsaturated ground caused a gradual reduction of soil suction at shallow depths (≤1.7 m), but not to a point where the suction dissipated completely or positive pore water pressures started to build up. Despite this the landslide occurred, which to a large extent was promoted by the presence of the road cut that allowed the weaker upslope materials with low suctions to slide, resulting in large displacements at the road cut.

Although the consequences of steep slope cutting for road construction on the occurrence of rainfall-induced landslides are generally well understood and there are both supporting anecdotal and statistical evidence, the results of this study provide a valuable reference that quantifies this effect. More specifically, results show that the presence of a steep road cut on a natural hillslope could reduce the initial factor of safety by ~35%, thereby increasing the susceptibility to landsliding during rainfall. Further, the stability of the undisturbed hillslope (without road cut) under the same rainfall conditions that triggered the investigated landslide (with road cut) shows that the presence of a single road cut can lower the level of minimum rainfall needed to initiate slope failure. It is critical to recognise that a significant proportion of landslides in Nepal occurs during the monsoon when almost 80% of the annual rainfall is expected to occur. The lowering of the minimum landslide-triggering rainfall for slopes modified by road construction means that the rainfall-induced roadside slope failures will become more frequent and extensive during the monsoon if the hillslopes continue to be informally excavated without suitable engineering interventions. The proposed empirical relationship between rainfall duration and percentage decrease in factor of safety further suggests that the reduction of the factor of safety or the risk of slope failure is greater during longer duration rainfall events in modified natural hillslopes with similar soil properties as was encountered at the investigated site. The relevance of the findings of this study extends beyond the presented case study to other developing regions globally, where the road infrastructures need to be better planned and constructed, with a particular focus on minimising the risk of slope instabilities that have both short- and long-term cumulative impacts on lives, infrastructures and the environment in general.

Where economic constraints prevent the adoption of engineering design-based slope protection measures, cost-effective retaining structures such as dry stone and mortared masonry walls, gabion walls and crib walls that utilise locally available materials, can help prevent or mitigate roadside slope failures during rainfall (Hearn, 2011). Bio-engineering techniques such as plantation of deep-rooted plant species, turfing and jute netting are other cost-effective slope protection measures (Devkota et al., 2014). Constructing gentler roadside slopes with angles lower than the angle of shearing resistance of the soil, while adhering to the road construction guidelines e.g. DoR (2003), TRL (1997) is another simple approach that can help prevent rainfall-induced roadside slope failures.

On the slopes that have a high landslide potential during rainfall and pose a greater risk to lives and infrastructures, landslide prediction can prevent disasters from occurring. This study demonstrates the abilities of the coupled hydro-mechanical analysis, with Bishop's effective stress and single wetting SWRC to simulate the long-term hydrological changes in the unsaturated soils and most importantly, to predict the failure timing and failure mechanism of slopes under transient wetting and drying conditions. Application of this approach requires comprehensive site-specific field study, laboratory testing of (un)saturated soil properties and meteorological data, acquiring which may not be feasible in all conditions. This also underlines the need for quality geotechnical and meteorological data in developing countries for the prediction, prevention and mitigation of rainfall-induced landslides. Nonetheless, the lack of geotechnical data could be tackled by obtaining information through empirical estimations, published scientific literature or by utilising community knowledge and participation, as employed by Anderson and Holcombe (2013).

10. Conclusions

This paper presented a case study of a typical roadside slope failure (Kanglang landslide) located in Sindhupalchok district in Nepal that was triggered by the monsoon rainfall in July 2018. An integrated approach combining detailed field investigation, laboratory testing, field monitoring and coupled flow-deformation analyses in PLAXIS 2D was used to understand the failure mechanism of the landslide and to assess the role of rainfall and road cut in inducing this failure. From the work presented in this study, the following conclusions can be drawn:

1.

The back-analysis results showed that the Kanglang landslide occurred during a low intensity (4.4 mm/h), long duration (10 h) rainfall event on 12 July 2018, which agrees with the landowner's testimony that the failure occurred before 16

July 2018. The landslide was caused by a combined effect of rainfall and road cut where the infiltration of rainwater created a weaker zone with low suction at shallow depths of (≤1.7 m) and the presence of the road cut promoted the failure by allowing the upslope materials to slide, resulting in large displacements of ~200 mm at the road cut.

2.

Comparison between the two slope models representing the actual slope (with the road cut) and the idealised undisturbed slope (without the road) showed that the presence of a single steep road cut can increase the susceptibility of slope failure in two ways: first, by reducing the initial factor of safety by over 30%; and second, by lowering the minimum level of rainfall needed to initiate slope failure. This implies that the rainfall-induced roadside slope failures will become more frequent and extensive in the future if the slopes continue to be informally excavated for constructing roads or for other developmental activities.

3.

A statistically significant correlation was found between rainfall duration and percentage decrease in the factor of safety. This relationship suggests that in the informally excavated steep road cut slopes underlain by lower permeability SILTS and Sandy SILTS, as encountered at the investigated site, a greater reduction of the factor of safety can be expected during longer duration rainfall events; an increase in the rainfall duration from 5 to 17 h could cause an additional ~10% decrease in the factor of safety.

4.

Using the measured soil properties, site geometry and rainfall records, this study demonstrates the viability of the coupled hydro-mechanical analysis to effectively capture the hydrologic changes in the soil in response to transient atmospheric conditions, and most importantly, to predict the timing of slope failure and to assess the failure mechanism of rainfall-induced slope failure. For slopes with high rainfall-induced landslide susceptibility that pose a serious risk to lives and infrastructures, landslide prediction using this approach can prevent disasters from occurring. Where hydraulic hysteresis cannot be taken into consideration in the hydro-mechanical analysis, this study also shows that the wetting soil-water retention curve can be suitably adopted to model the hydraulic behaviour of unsaturated soils.

The results from this study provide a reference for recognising the detrimental impact of informal slope cutting for road construction on the occurrence of rainfall-induced landsliding. This should be taken into consideration in future disaster mitigation and reduction strategies in areas where increasing rural access through road construction is also a priority.

https://doi.org/10.1016/j.enggeo.2022.106787Get rights and content

Engineering Geology, Volume 307, 20 September 2022, 106787, https://www.sciencedirect.com/science/article/pii/S0013795222002721

4 Benefits of Hydropower

The Foundation for Water and Energy Education's (FWEE) Hydropower Appreciation campaign, which aims to spread awareness of hydropower's renewable and carbonfree benefits. Check out their excellent videos to learn more: https://bit.ly/3Xt1If6

https://www.youtube.com/watch?v=9RJSUxByo7c&t=30s

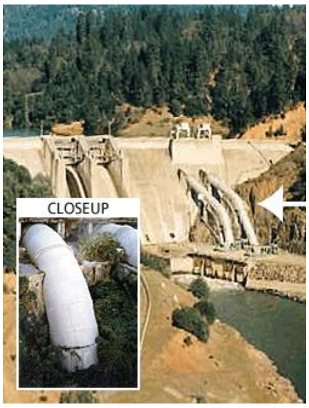
Walk Through a Hydroelectric Project

Introduction

HYDROPOWER is a clean, low cost and renewable energy source that takes an unpredictable resource — rainfall and snowpack — and turn it into a reliable source of electricity. Hydroelectric projects can support recreation, irrigation, -flood control, transportation and habitat needs.

https://www.youtube.com/watch?v=Em63Nl74UQ8

1. The Penstock

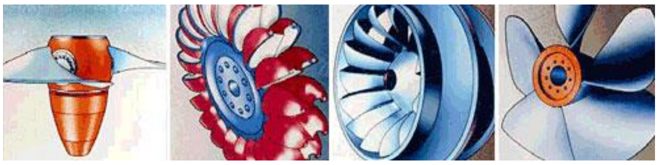


WATER FROM A river or reservoir flows into the powerhouse. Commonly a penstock, a large pipe that can be above or below ground, is used to direct the water flow.

https://www.youtube.com/watch?v=EnOx6MIw0vY

2. Turbine Blades

TURBINE BLADES are pushed by flowing water from the penstock, causing them to rotate.



THE SHAPE AND ANGLE of the turbine blades transfers the energy of falling water to rotate the shaft.

https://www.youtube.com/watch?v=XNc3YKCHyIU&t=2s

3. Turbine Shaft

THE SHAFT connects the turbine to the generator, turning at the same speed as the turbine.

https://www.youtube.com/watch?v=mEXXd1XyTcw

4. Generator (Rotor)

INSIDE THE GENERATOR the spinning shaft turns magnets inside a stationary ring of copper, moving electrons to produce electricity.

https://www.youtube.com/watch?v=s_3rJPa2f1c

5. Step Up Transformer

STEP UP TRANSFORMERS increase the voltage of electricity produced by the generator.

https://www.youtube.com/watch?v=Y9HkdR19bFk

6. Transmission Lines

TRANSMISSON LINES carry high voltage electricity to substations in our communities.

https://www.youtube.com/watch?v=Oido65mv0LI

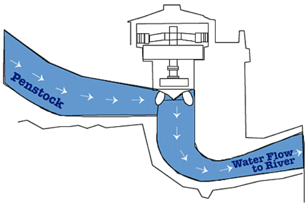
7. Substations

AT SUBSTATIONS the voltage is decreased and the power is distributed to homes and businesses.

8. Homes & Businesses

SUBSTATIONS Before reaching our home or business from substations, voltage is again decreased at transformers. As shown in the picture, transformers are often seen at the top of power poles.

9. Water Flow



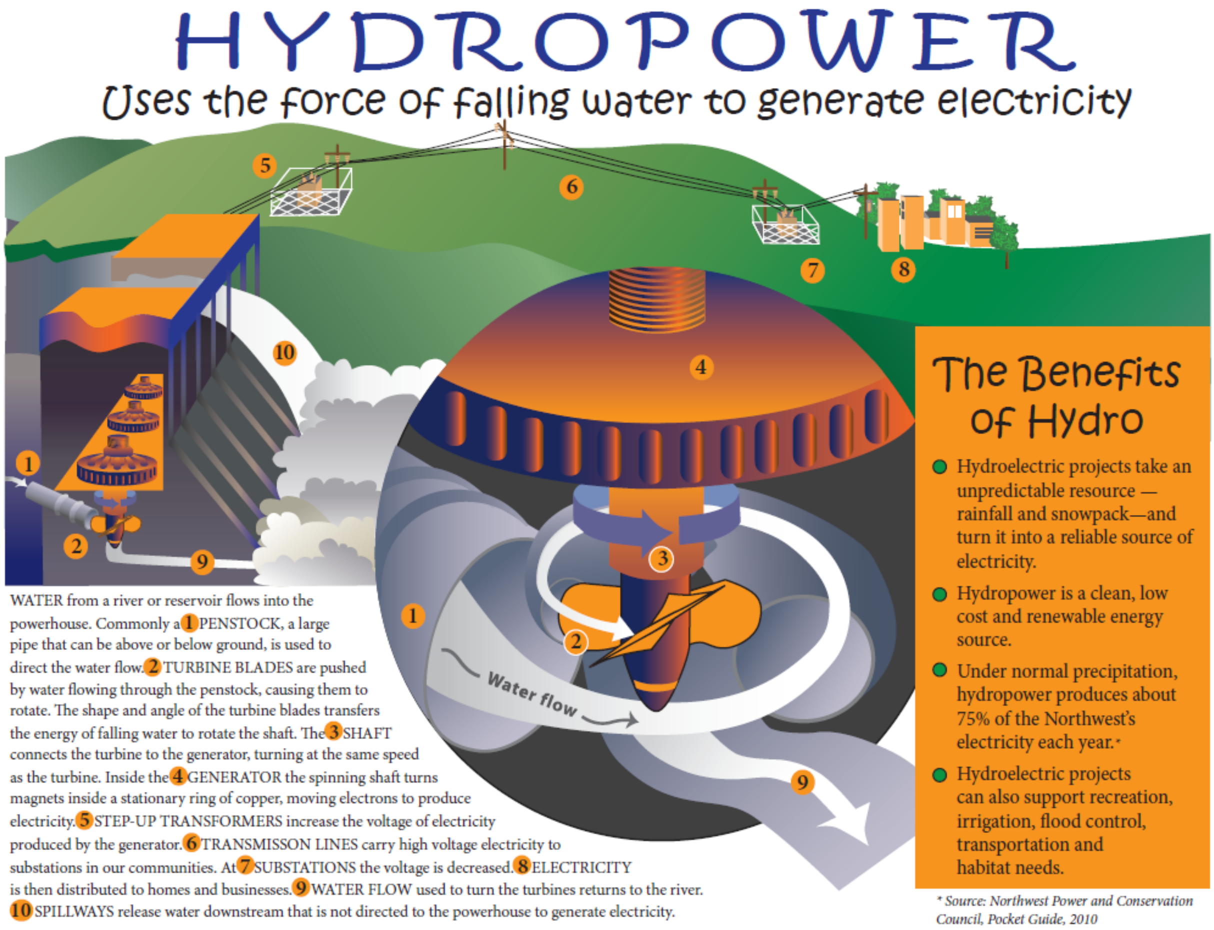
WATER FLOW is used to turn turbines returns to the river.

https://www.youtube.com/watch?v=lPQXWxbw1Ng

10. Spillway

SPILLWAYS release water downstream that is not directed to the powerhouse to generate electricity.

https://www.youtube.com/watch?v=jS26RoYHfk4



March 1876: Building a Channel Tunnel

Andrew Wade

The UK's relationship with the continental mainland has always been fraught, and conflict between the major powers has punctuated European history, from the Spanish Armada and Napoleon to the Great War and the rise of fascism.

Despite the almost ever-present tension, plans to connect the UK to mainland Europe have been around for centuries. In March 1876, *The Engineer* compiled an extensive roundup of the various means that could be employed to accomplish the task, including tunnels, tubes, and bridges. According to that same edition of the publication, proposals to create a link between Britain and France go as far back as 1802, just as the Napoleonic Wars were getting underway.

"Ever since the commencement of the present century there has been evinced a very firmly rooted conviction that there ought to be a line of communication established between England and the Continent of Europe other than that afforded by the passage of steamships between shore and shore," our predecessors wrote in 1876.

"The first proposition to unite England and France was made in 1802, by Monsieur Mathieu, whose plans were laid before the First Napoleon, then First Consul, and were afterwards exhibited at the Luxembourg and public galleries in Paris. They have, however, long since been lost, and with them the proposed method of carrying out the work."

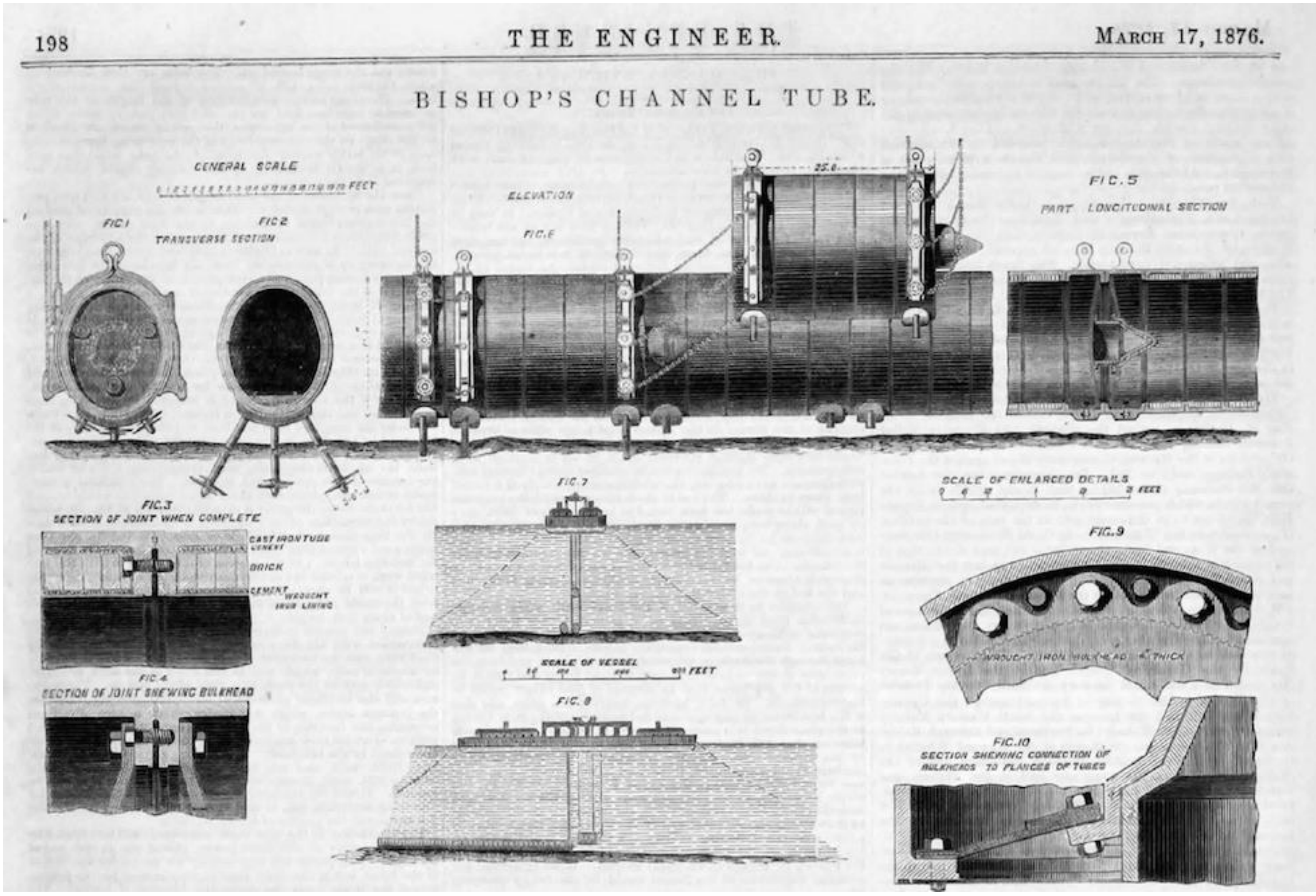
Another Frenchman is singled out for special praise by *The Engineer* for his lifelong dedication to the project. Known to day as the "father of the tunnel", Monsiuer Thomé de Gamond died just a month prior to the 1876 article's publication. He devoted more than 40 years of his engineering career to researching a tunnel under the Straits of Dover, his "scientific attainments" and "irreproachable character" winning him "the love of many and the regard of all."

Throughout the course of his work M. de Gamond made over 1,500 experimental borings in France and England to examine the strata, as well as carrying out three dives to the bottom of the channel to examine the contents of its bed. The last of these dives saw him "attacked by conger eels or dogfish", resulting in serious injuries. Though he didn't get to witness his vision become reality, M. de Gamond did live to see his idea for a channel tunnel be "adopted by eminent engineers in both countries, and supported by financial authorities."

Those eminent engineers would include Sir John Hawkshaw and Sir James Brunlees, founders of the original Channel Tunnel Company in 1872. They proposed a tunnel of 31 miles between St Margaret's Bay in England to a point on the French coast roughly midway between Calais and Sangatte.

This line was chosen to take the tunnel entirely through the lower chalk, assumed at the time to be homogenous. Although undoubtedly a serious challenge, it was certainly one that was technically possible, according to *The Engineer.*

"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."



The Bishop's Channel Tunnel Tube, made from cast-iron sections lined with bricks and cement, was designed to sit on the seabed's surface

“The tunnel will be a single one of circular or of the ordinary tunnel section, the chalk boring being 36ft in diameter at the arch springing, and when lined with brickwork in cement it will have an interior diameter of 30ft.”

While our predecessors declared that “preliminary operations will shortly be commenced,” we of course know now that Brunlees and Hawkshaw’s particular endeavour would never be attempted, and the Channel Tunnel would not be completed until over a century later.

Another intriguing concept from the time that never came to fruition was Bishop’s Channel Tube. As the name suggests, this was a railway tube that sat on top of the seabed rather than boring beneath it. Sections of cast iron lined with bricks and cement, each measuring 25ft and weighing 273 tons, would be lowered to the seabed from a floating pontoon 400ft long by 100ft wide.

Workers on the pontoon would be in electronic communication with those working in the slowly advancing tube. Using glass sight-holes in the tube’s bulkhead, the workers could help guide the iron sections into position. The structure would be protected from the “injurious” effects of the seawater through the application of Calley’s Torbay oxide paint. Looking back, it was certainly an innovative approach, but probably not one that would’ve passed the EU health and safety checks of today. A reminder, perhaps, that Brussels has given rise to good ideas as well as bad.

(THE ENGINEER, 09 Mar 2016, https://www.theengineer.co.uk/content/news/march-1876-building-a-channel-tunnel)

La Fibre Optique pour la Surveillance des Structures Souterraines en Béton

Photographie de l'équipement d'une paroi moulée.

Les ouvrages de soutènement, dont les dimensions sont de plus en plus importantes, nécessitent une surveillance étroite de la part de leurs exploitants. Ceux-ci sont utilisés principalement pour construire des enceintes souterraines relativement étanches, mais également dans les cas de fortes contraintes environnementales. Ils sont en effet soumis à de nombreux risques naturels ou liés à l'activité humaine. Des mesures de température et de déformation sont donc régulièrement nécessaires, en de nombreuses zones, afin de contrôler la santé de ces ouvrages. Cet article porte sur le retour de mesures collectées en continu durant 5 jours sur des parois moulées instrumentées par fibres optiques.

Depuis ces 50 dernières années, les structures du génie civil ont vu leurs nombres et leurs dimensions augmenter, exigeant une réglementation très stricte du point de vue de leur surveillance.

Compte tenu de la profondeur des éléments de soutènement, tels que les parois moulées et les pieux en cours de construction, ainsi que des questions de développement durable et de préservation des ressources, l'intégrité de ces éléments est une préoccupation essentielle en géotechnique. Elle permet de réduire les dommages probables pendant les périodes de construction et de service.

Pour répondre aux exigences réglementaires de surveillance, Cementys, entreprise française spécialisée dans l'auscultation et le suivi du comportement des infrastructures et des ouvrages, propose la technologie très innovante des capteurs à fibres optiques répartis (CFOR). Elle regroupe plusieurs techniques de mesure et constitue un outil majeur des stratégies de surveillance de la santé des constructions du génie civil.

Dans les méthodes d'auscultation conventionnelles, un grand nombre de capteurs ponctuels, tels que des jauges de contrainte ou des sondes de température, sont installés pour mesurer les profils de contrainte et de température de la structure pendant le bétonnage ou le durcissement. Ces méthodes présentent deux limitations majeures : tout d'abord, elles sont ponctuelles (limitée à l'emplacement et au nombre des capteurs), là où la fibre et donc les CFOR sont continus : ensuite, pour réaliser des mesures en profondeur et sur une distance importante, le déploiement des capteurs conventionnels est coûteux et parfois même impossible là où les CFOR sont moins limités.

Principe des Capteurs à Fibre Optique Répartis

D'une manière générale, dans le cas des CFOR, la fibre constitue sur toute sa longueur l'élément sensible du capteur, ce qui permet de réaliser des mesures réparties d'un bout à l'autre de celleci, qui seront par la suite appliquées à la détection et à la localisation. Concernant le système en tant que tel, une impulsion laser infrarouge est lancée depuis une extrémité de la fibre optique grâce à un interrogateur optique. Une petite fraction de cette impulsion est renvoyée, ou rétrodiffusée successivement tout au long du parcours de l'impulsion. (Figure 1).

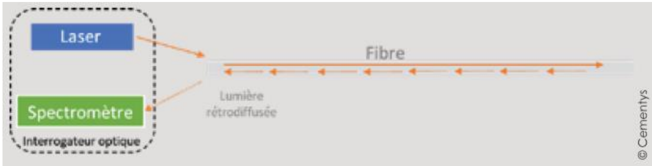


Figure 1 : configuration standard d'un système de capteur à fibre optique.

À un instant donné, l'information rétrodiffusée depuis un point donné de la fibre est collectée à l'extrémité de la fibre, et est analysée par l'interrogateur optique. La fibre optique est le seul élément sensible où les variations de la propagation guidée de la lumière sont exploitées. Il n'y a pas de signal électrique qui la traverse.

Trois types de rétrodiffusions de la lumière se créent lors de la propagation de l'impulsion dans la fibre. Les caractéristiques de chacune d'entre elles peuvent être exploitées pour effectuer différentes mesures. (Figure 2).

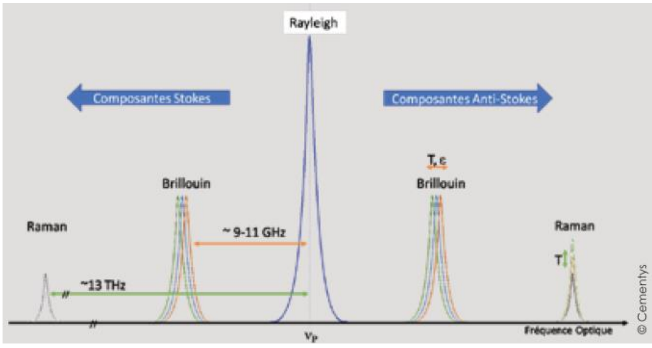


Figure 2 : spectre de rétrodiffusion dans une fibre optique en silice.

Les capteurs de température répartis (DTS – Distributed Temperature Sensing) sont des fibres optiques qui fournissent des mesures de température tout au long du parcours de l'impulsion laser, et à tout moment. Elle est basée sur le phénomène de diffusion Raman qui se produit à l'intérieur de la fibre. La mesure du signal rétrodiffusé Brillouin quant à lui (DTSS – Distributed Temperature and Strain Sensing), nous renseigne simultanément sur les variations en température et en déformation. Enfin, les capteurs acoustiques répartis (DAS – Distributed Acoustique Sensing) fournissent des mesures acoustiques et de température en se basant sur le phénomène de diffusion Rayleigh. Toutes ces mesures peuvent être réalisées sur une seule et même fibre optique, ce qui ne fait qu'accroître l'intérêt de l'utilisation de cette technologie dans le suivi de la pérennité des infrastructures du génie civil.

Installation de l'instrumentation par Capteurs à Fibre Optique Répartis

Parmi les applications des capteurs à fibres optiques répartis pour la surveillance du processus de production des structures souterraines en béton, un essai sur le terrain a été réalisé sur le chantier d'une future gare ferroviaire d'Île-de-France pendant la construction d'une paroi moulée de près de 50 m de profondeur. L'évaluation de l'intégrité d'un des éléments de cage de la paroi est basée sur l'installation de boucles de câble à fibre optique (CFOR). Pour cela, le capteur SensoLux TMA de la société Cementys a été utilisé (Figure 3). Réalisé autour d'une fibre optique standard utilisée dans le domaine des télécommunications, il profite de ses propriétés de transmission du signal et de sa grande sensibilité intrinsèque à la température (diffusion Raman) et aux déformations (diffusion Brillouin). Le capteur optique SensoLux TMA est immunisé contre les surtensions (foudres) ou autres perturbations électromagnétiques. Elle est constituée de 2 types de fibres à l'intérieur. 2 fibres multimodes (MM) et 2 fibres monomodes (SM) permettant les mesures Brillouin et Raman sur le même câble. De plus, les fibres sont collées à l'intérieur du revêtement, ce qui permet un bon transfert des déformations et de la température.

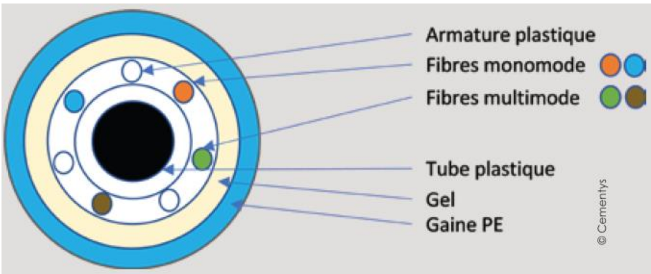


Figure 3 : coupe transversale du capteur de SensoLux TMA Cementys.

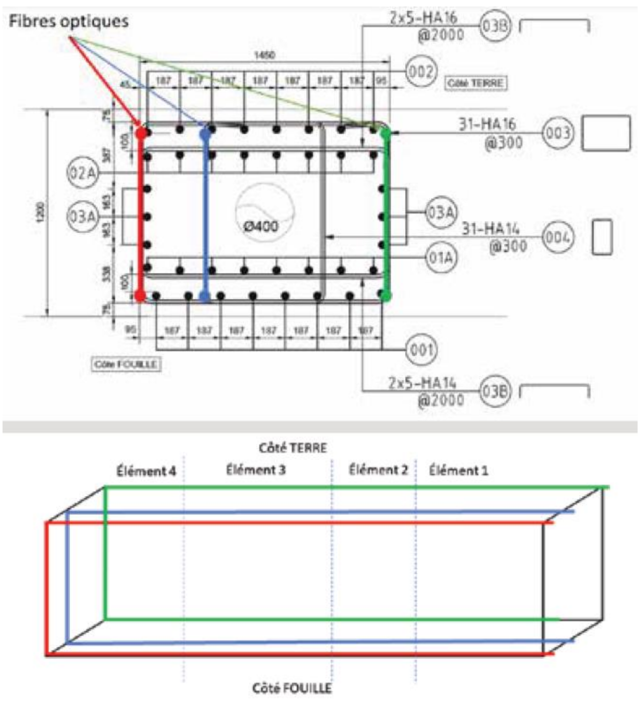


Figure 4 : plan d'installation de fibre optique.

En raison de la profondeur de la paroi moulée, la cage d'armature est constituée de 4 éléments, qui doivent être connectés en série pendant l'installation. (Figure 4).

Il était donc impossible de fixer préalablement le câble à l'armature de la cage. Le câble a alors été fixé aux barres d'armature des cages par des liens autobloquants et du ruban adhésif tous les mètres au moment de sa descente dans la fosse.

Ensuite, les bobines de câble ont été déroulées d'un seul tenant depuis l'élément de cage ausculté le plus en profondeur jusqu'à la surface.

Température

Ce système de surveillance a permis de surveiller la fondation en temps réel durant 5 jours, et de collecter les variations de température pendant la phase de bétonnage avec une résolution spatiale métrique. Les variations de température en fonction du temps et de la distance (figure 5) nous renseignent sur les différentes sections de fibre utilisées.

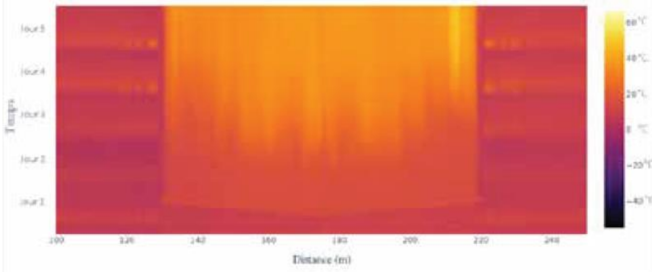


Figure 5 : spectrogramme de la température mesurée par capteur à fibre optique.

Les valeurs de température comprises entre 100 et 130 m et entre 220 et 250 m correspondent aux températures extérieures relevées par le CFOR DTS, tandis que les valeurs de température comprises entre 130 et 220 m correspondent aux températures mesurées dans la paroi moulée. Nous pouvons y observer l'augmentation de la température dans la paroi moulée de 10 °C à 14,5 °C lors de la phase de bétonnage au jour 1. À partir du jour 2, la température augmente sensiblement en fonction du temps de durcissement du béton jusqu'à atteindre une température maximale relevée de 37,14 °C à la fin des mesures.

Photographie de l'instrumentation d'une cage d'armature de paroi moulée.

Le relevé de l'évolution de la température par capteurs à fibre optique répartis, sur la longueur totale de la paroi moulée, nous permet alors d'observer l'activation de la prise et du durcissement du béton à différents niveaux, visible par une augmentation prononcée de la température. Ces types de données peuvent nous renseigner par la suite sur la détection d'éventuels défauts de remplissage, puis l'évolution de la paroi en phase de travaux de terrassement et d'excavation de la future gare.

Miyassa Salhi, ingénieur optique
Emmanuel Mengue, ingénieur R&D géotechnique
Aymen Gargouri, ingénieur auscultation et géotechnique
CEMENTYS

SOLSCOPEMAG, No 18, Juin 2021

(16/07/2021, https://www.solscope.fr/zoom-technique-la-fibre-optique-pour-la-surveillance-des-structures-souterraines-en-beton,b18-792.htm#:~:text=Le%20relev%C3%A9%20de%20l'%C3%A9volution,augmentation%20prononc%C3%A9e%20de%20la%20temp%C3%A9rature.)

Animation of where the largest earthquakes of the past 100 years have struck

The US Geological Survey (USGS) estimates that millions of earthquakes occur every year, but only one of them will be a "great earthquake" — that is, one with a magnitude of 8.0 or above. Here are where all the "great earthquakes" since 1900 have struck.

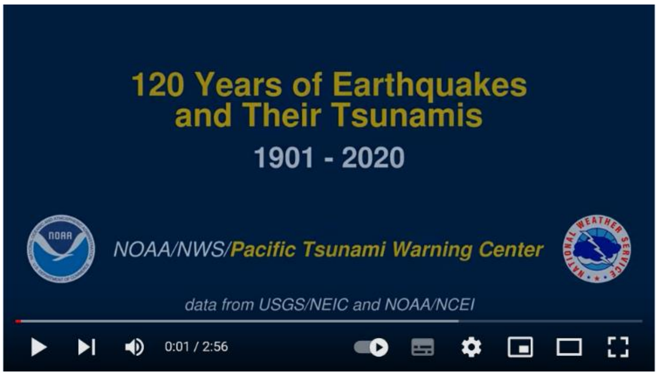
https://www.youtube.com/watch?v=HSeO_tHNn-I

Animated map: all earthquakes of the past 15 years

This animated map created from the NOAA, NWS, and PTWC shows every recorded earthquake in chronological order from January 1, 2001 to December 31, 2015. The size of the circle shows the magnitude of the earthquakes in relation to each other. The color represents the earthquake depth.

https://www.youtube.com/watch?v=Ed0tGlfJHiY

120 Years of Earthquakes and Their Tsunamis: 1901-2020



https://www.youtube.com/watch?v=ilFEKSZQv5o

This animation shows every recorded earthquake in sequence as they occurred from January 1, 1901, through December 31, 2020, at a rate of 1 year per second. The earthquake hypocenters first appear as flashes then remain as colored circles before shrinking with time so as not to obscure subsequent earthquakes. The size of each circle represents the earthquake's magnitude while the color represents its depth within the earth. This animation also highlights significant tsunamis generated by some of these earthquakes. When the following earthquakes appear they will also have their tsunami's "energy map" that shows each tsunami's maximum modeled wave heights on the open ocean:

8.8 — Ecuador-Columbia — 31 January 1906
8.5 — Atacama, Chile — 11 November 1922
8.4 — Kamchatka, Russia — 3 February 1923
8.4 — Sanriku, Japan — 2 March 1933
8.6 — Unimak Island, Aleutian Islands — 1 April 1946*
9.0 — Kamchatka, Russia — 4 November 1952
8.6 — Andreanof Islands, Aleutian Islands — 9 March 1957*
9.5 — Valdivia, Chile — 22 May 1960*
9.2 — Prince William Sound, Alaska — 28 March 1964*
8.7 — Rat Islands, Aleutian Islands — 4 February 1965
7.7 — Kalapana, Hawaii — 29 November 1975*
8.4 — Southern Peru — 23 June 2001
9.1 — Sumatra, Indonesia — 26 December 2004*
8.1 — Samoan Islands — 29 September 2009*
8.8 — Maule, Chile — 27 February 2010*
9.0 — Tohoku, Japan — 11 March 2011*
7.9 — Haida Gwaii, Canada — 28 October 2012*

(*tsunami animation also available on this YouTube channel)

Note that while the great majority of all earthquakes occur at plate boundaries, these tsunami-causing earthquakes mostly occur at convergent plate boundaries. These boundaries, also called "subduction zones," are where tectonic plates collide to produce megathrust earthquakes and are the regions where we expect future devastating tsunamis to come from. Other, much smaller earthquakes also occur away from plate boundaries such as those related to volcanic activity in Hawaii or those related to wastewater injection wells in Oklahoma.

The animation concludes with a series of summary maps. The first one shows all of the earthquakes in this 120-year period. The next map shows only those earthquakes known to have produced a tsunami, and the map after that shows only those earthquakes that produced damaging tsunamis. The final map shows the plate boundary faults responsible for the majority of these earthquakes.

The era of modern seismology—the scientific study of earthquakes—began with the invention of the seismograph in the late 19th Century and its deployment in instrument networks in the early 20th Century to record and measure earthquakes as they occur. Therefore, when the animation begins only the largest earthquakes will appear. They were the only ones that could be detected at great distances with the few instruments available at the time. But as time progressed, more and more seismographs were deployed and smaller and smaller earthquakes could be recorded. For example, the installation of these instruments in California in the 1930s creates the illusion of new earthquake activity there. Likewise, there appears to be a jump in the number of earthquakes globally in the 1970's when seismology took another leap forward with advances in telecommunications and digital signal processing, a trend that continues today. -----

Earthquakes from the USGS/NEIC Earthquake Catalog: https://earthquake.usgs.gov/earthquak...

Tsunami sources from the NOAA/NCEI Tsunami Database: https://www.ngdc.noaa.gov/hazel/view/...

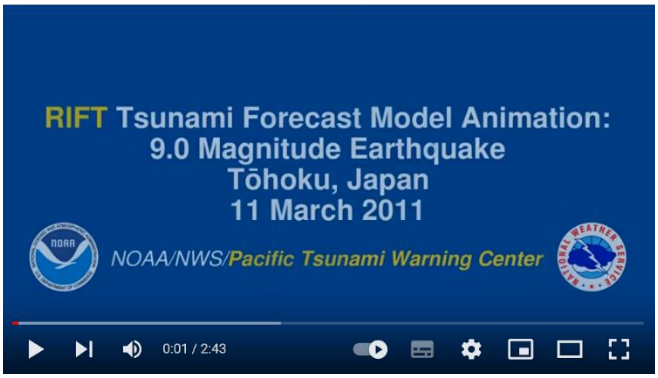
Tsunami Animation: Tohoku, Japan 2011 (rotating globe)

This animation shows how PTWC's real-time tsunami forecast model, RIFT, predicts the behavior of the tsunami following the 9.0 magnitude earthquake offshore of the Tōhoku-Oki region, Japan, on 11 March 2011. This version uses the USGS finite fault model (link below) as the source mechanism for the tsunami model, therefore the animation begins in "slow motion" to show the details of how the tsunami starts. The animation covers a 48-hour period finishing with an "energy map" showing the forecasted maximum heights of open-ocean tsunami waves over that time period, followed with the forecasted tsunami runup on the coasts. If you look carefully you will see not only the waves leaving Japan, but also the reflected waves leaving South America after about 23 hours.

For a "flat earth" version, please see: Tsunami Animation...

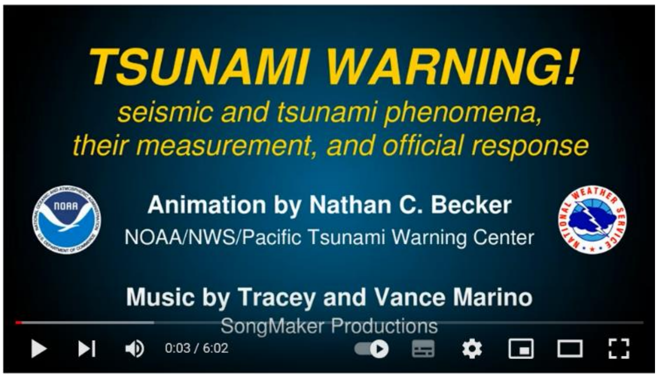
For the earthquake and its aftershocks, please see:
The Great Tōhoku-...

Finite fault model: http://earthquake.usgs.gov/earthquake...



https://www.youtube.com/watch?v=feBtPsJH25c

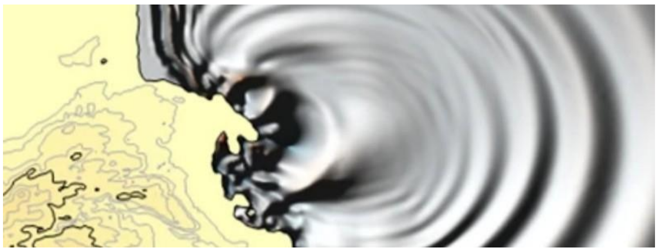
Tsunami Warning!



https://www.youtube.com/watch?v=r3ZCOnDa2Uk

Since an earthquake's fastest wave, its primary or P-wave, travels about 50 times faster than the fastest tsunami waves, a tsunami warning center will issue its initial tsunami warning based on seismic data alone. This animation uses the 9.1 magnitude Great Tohoku-Oki Earthquake and its tsunami to illustrate how the Pacific Tsunami Warning Center (PTWC) issued its first warning message less than 9 minutes after the earthquake and 19 minutes before the tsunami reached the first sea-level sensor not damaged by the earthquake, a deep-ocean or DART instrument. After the P-wave sequence the animation will then speed up to show the tsunami spreading through the world's oceans over a 48 hour period and highlight tsunami measurements by coastal and DART sensors.

New insights into the enigmatic 1693 AD tsunami in the eastern Mediterranean Sea

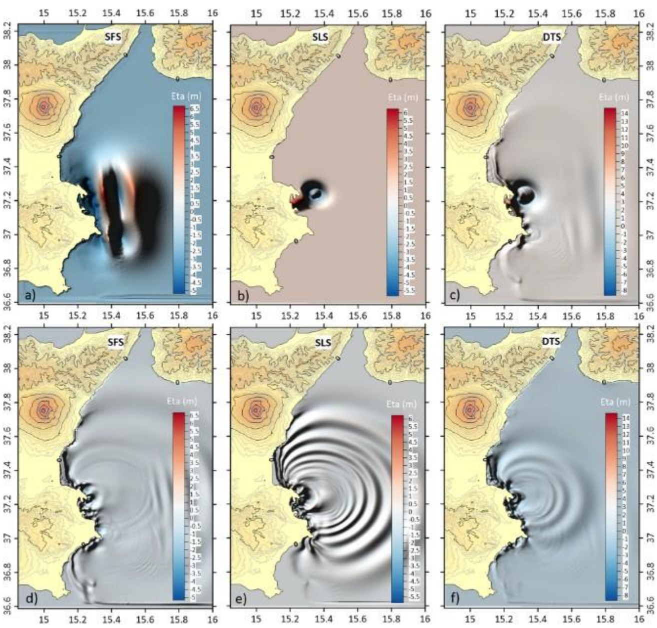


A new study published in Nature provides new insights into the triggering mechanisms and propagation dynamics of the enigmatic 1693 tsunami in the eastern Mediterranean Sea.

The disastrous earthquake of 1693 AD caused over 60 000 causalities and the total destruction of several villages and towns in south-eastern Sicily, Italy. Immediately after the earthquake, a tsunami struck the Ionian coasts of Sicily and the Messina Strait and was probably recorded even in the Aeolian Islands and Malta.

Over the last few decades, the event has been much debated regarding the location of the seismogenic source and the possible cause of the associated tsunami. The marine event has been related to both a submarine landslide and a coseismic displacement at the seafloor.

To better define the most reliable sources and dynamics of the tsunami, a team of researchers coupled high-resolution marine seismic survey data with hydrodynamic modeling to simulate various scenarios of tsunami generation and propagation. Results from the simulations were compared with geomorphological evidence of past tsunami impacts, described in previous work along the coast of south-eastern Sicily, and within historical chronicles and reports.



Initial sea-surface elevation (m) and wave impacting the coast under different scenarios. Simulations after 60 s of the starting event: (a) SFS—earthquake-generated tsunami; (b) SLS—submarine landslide-generated tsunami; (c) DTS—dual mechanism due to earthquake and submarine landslide. Simulations after 9 min of the starting event: (d) SFS—earthquake-generated tsunami; (e) SLS—submarine land-slide-generated tsunami; (f) DTS—dual mechanism due to earthquake and submarine landslide. The maps were obtained by co-authors through QGIS—software (version 3.14.16); https://www.qgis.org/it/site/, license Creative Commons. Attribution-Share Alike 3.0 license (CC BY-SA) integrated with ESRI World Imagery.

The most reliable scenario considers the 1693 event was composed by two different tsunami waves: a first wave generated by the coseismic fault displacement at the seafloor and a second wave generated by a submarine landslide, triggered by the earthquake shaking.

Tsunami modeling shows that a simultaneous movement between fault displacement and submarine mass movement could determine a destructive interference on the tsunami waves, resulting in a reduction in wave height.

For this reason, the second tsunami wave probably occurred with a maximum delay of a few minutes after the one generated by the earthquake and induced greater flooding.

The double-source model could explain the observation because in the course of other destructive earthquakes in south-eastern Sicily, such as that of 1169 AD, the associated tsunami caused less damage.

References:

The enigmatic 1693 AD tsunami in the eastern Mediterranean Sea: new insights on the triggering mechanisms and propagation dynamics – Scicchitano, G., Gambino, S., Scardino, G. *et al.* – *Sci Rep* **12,** 9573 (2022). https://doi.org/10.1038/s41598-022-13538-x

(THE WATCHERS, Saturday, July 16, 2022, https://watchers.news/2022/07/16/new-insights-into-the-enigmatic-1693-ad-tsunami-in-the-eastern-mediterranean-sea)

The enigmatic 1693 AD tsunami in the eastern Mediterranean Sea: new insights on the triggering mechanisms and propagation dynamics

Giovanni Scicchitano, Salvatore Gambino, Giovanni Scardino, Giovanni Barreca, Felix Gross, Giuseppe Mastronuzzi & Carmelo Monaco

Abstract

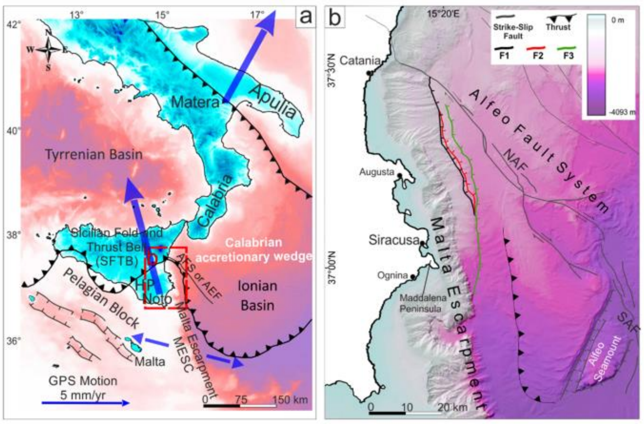
The disastrous earthquake of 1693 AD caused over 60,000 causalities and the total destruction of several villages and towns in south-eastern Sicily. Immediately after the earthquake, a tsunami struck the Ionian coasts of Sicily and the Messina Strait and was probably recorded even in the Aeolian Islands and Malta. Over the last few decades, the event has been much debated regarding the location of the seismogenic source and the possible cause of the associated tsunami. The marine event has been related to both a submarine landslide and a coseismic displacement at the seafloor. To better define the most reliable sources and dynamics of the tsunami, we couple high-resolution marine seismic survey data with hydrodynamic modelling to simulate various scenarios of tsunami generation and propagation. Results from the simulations are compared with geomorphological evidence of past tsunami impacts, described in previous work along the coast of south-eastern Sicily, and within historical chronicles and reports. The most reliable scenario considers the 1693 event composed by two different tsunami waves: a first wave generated by the coseismic fault displacement at the seafloor and a second wave generated by a submarine landslide, triggered by the earthquake shaking. Tsunami modelling shows that a simultaneous movement between fault displacement and submarine mass movement could determine a destruc-

tive interference on the tsunami waves, resulting in a reduction in wave height. For this reason, the second tsunami wave probably occurred with a maximum delay of few minutes after the one generated by the earthquake and induced a greater flooding. The double-source model could explain the observation because in the course of other destructive earthquakes in south-eastern Sicily, such as that of 1169 AD, the associated tsunami caused less damages. This implies the need to better map, define and assess the hazard responsible for this type of tsunami events.

Introduction

The Mediterranean Sea experienced several tsunami events, as testified by historical records and geological evidence. The geodynamic activity of the Mediterranean basin has determined the occurrences of tsunami that have been related to seismic and non-seismic sources[1,2,3]. The non-seismic or mixed seismic/non-seismic sources have also recently generated significant tsunamis in the Mediterranean, such as that generated by a landslide at Stromboli in 2002[4,5,6,7,8], and that related to the Mw 7.1 earthquake and submarine landslide of the Strait of Messina in 1908[9,10,11,12]. The Western Ionian basin (eastern Sicily and southern Calabria in particular—Fig. 1) is one of the most seismically active sectors of the Italian peninsula and within the central Mediterranean. Several seismic events with estimated moment magnitude greater than 7 have struck eastern Sicily. Most of these have been associated with tsunami generation (e.g. the 1169, 1542, 1693, 1818, 1908, 1990 events—ITC, Italian Tsunami Catalogue[13]). Excluding the 1908 event, the seismogenic sources of these large earthquakes have been located in the Hyblean Plateau or in neighboring areas (south-eastern Sicily, Fig. 2).

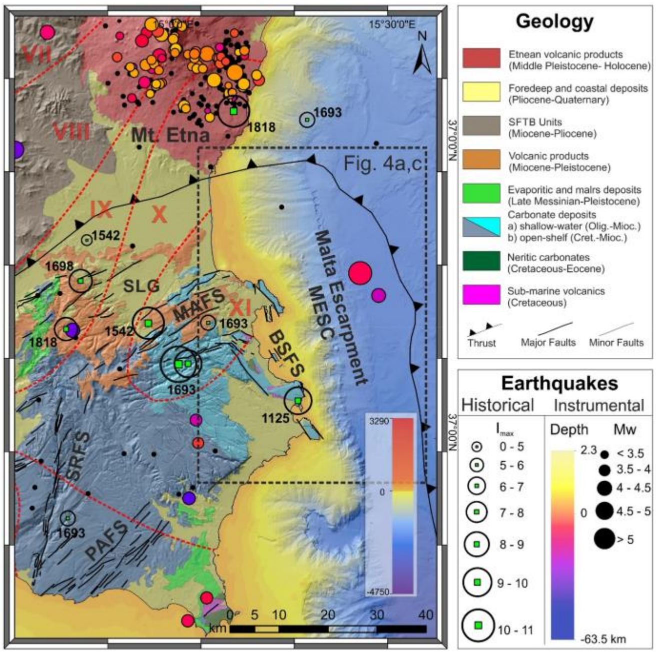
Figure 1



(**a**) Tectonic sketch map of southern Italy. Large blue arrows indicate the GPS vectors (see[14,15,16], modified after Gambino et al.[26]) in the lower plate of the collisional system whereas small blue arrows is the resultant extension in the Western Ionian Basin. AFS, Alfeo Fault System[17,18]; AEF, Alfeo-Etna Fault[19]; (**b**) main tectonic structures of Western Ionian basin. NAF, North Alfeo Fault; SAF, South Alfeo Fault (modified after Gambino et al.[20]). The maps were obtained by co-authors through QGIS—software (version 3.14.16); https://www.qgis.org/it/site/, license Creative Commons. Attribution-Share Alike 3.0 licence (CC BY-SA) integrated with ESRI World Imagery.

The strongest tsunami described in the Mediterranean was associated with the January 11, 1693 seismic event (M ≈ 7.3), whose source is still a matter of debate. Some authors proposed an offshore fault displacement on the seafloor as the most plausible source of the tsunami and identified, through marine geophysical campaigns, distinct possible causative tectonic structures[24,25,26]. Recently, tsunami propagation and impact on the coast of Ognina, an area located 30 km south of the town of Siracusa (Fig. 1), was modelled by Scardino et al.[27], considering distinct seismic events, including that of 1693, and distinct fault scarps on the seafloor as the source of the tsunami waves. According to these authors, the fault proposed by Gambino et al.[26] is the most plausible for the generation of tsunamis with associated waves able to reach the southern coastal sector of south-eastern Sicily. Other authors instead considered a marine landslide triggered by the earthquake as a possible source of the 1693 tsunami[28,29,30].

Figure 2



Structural setting of the Hyblean Plateau with major faults system (MAFS, Monterosso–Agnone Faults System; SRFS, Scicli–Ragusa Faults System; PAFS, Pozzallo–Avola Faults System; BSFS, Brucoli–Siracusa Faults Systems; SLG, Scordia Lentini Graben) with the location (empty circles) of Historical earthquakes (from CPTI 15[21]), and instrumental seismicity with M > 2.5 events in the period 1981–2014 (from http://istituto.ingv.it/index.php/it/archivi-e-banche-dati—see also Scarfi et al.[22]). Red dashed lines refer to the isoseismal map proposed by Barbano[23] for the January 11, 1693 earthquake. The map was obtained by co-authors through QGIS—software (version 3.14.16); https://www.qgis.org/it/site/, license Creative Commons. Attribution-Share Alike 3.0 licence (CC BY-SA) integrated with ESRI World Imagery.

However, dynamics related to the propagation of two distinct tsunamis, one generated by a fault displacement and the other one generated by a submarine landslide, have never been considered and modelled.

Geological settings

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Scientific Reports **volume 12**, Article number: 9573 (2022)

(https://www.nature.com/articles/s41598-022-13538-x)

ΝΕΑ ΑΠΟ ΤΙΣ ΕΛΛΗΝΙΚΕΣ ΚΑΙ ΔΙΕΘΝΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΝΩΣΕΙΣ

ΕΛΛΗΝΙΚΗ ΕΠΙΣΤΗΜΟΝΙΚΗ ΕΤΑΙΡΕΙΑ ΕΔΑΦΟΜΗΧΑΝΙΚΗΣ & ΓΕΩΤΕΧΝΙΚΗΣ ΜΗΧΑΝΙΚΗΣ

SIMSG ISSMGE

Geotechnical Engineering for the Preservation of Monuments and Historic Sites

The third International Symposium of TC301 on "Geotechnical Engineering for the Preservation of Monuments and Historic Sites" was held in Napoli, Italy on 22 – 24 June 2022.

Prof. Em. Carlo Viggianni, Italy, delivered the opening address and prof. Alessandro Flora, Italy, gave the 3rd Kerisel lecture entitled "Taking care of heritage, a challenge for geotechnical engineers".

From Greece, invited speaker was Dr. Dimitris Egglezos, who talked about "Understanding the mechanical history of the burial monument of the Kasta tumulus at Amphipolis, Greece: A tool for documentation and design of restoration strategy".

The organization of the next (4th) International Conference of TC301 in 2026, was claimed by both the French and the Greek delegation. The French proposal was presented by Dr. Jean-David Vernhes (Paris) and the Greek by Dr. Christos Tsatsanifos (Athens). After a vote it was decided that the conference should take place in Athens.

Δημήτρης Εγγλέζος

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SIMSG ISSMGE

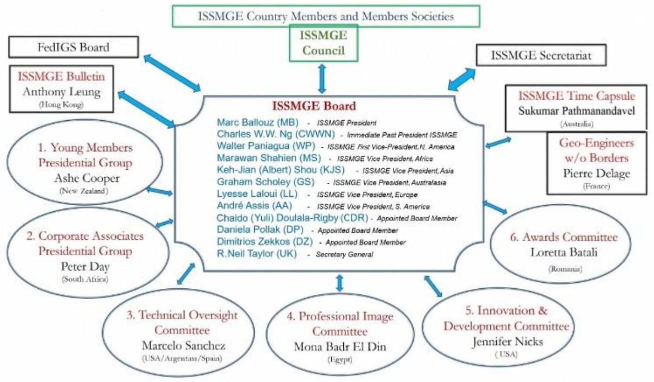
International Society for Soil Mechanics and Geotechnical Engineering

ISSMGE News & Information Circular July 2022

www.issmge.org/news/issmge-news-and-information-circular-July-2022

1. NEW ISSMGE WORKING STRUCTURE

The President, Marc Ballouz, is pleased to announce the new working structure of ISSMGE



2. CAPG HAS A GREAT TIME IN SYDNEY!

The Corporate Associates Presidential Group extends its sincere thanks and congratulations to Australian Geomechanics Society, the Organising Committee and the Conference Organisers (ICMS Australia) on a highly successful 20th International Conference on Soil Mechanics and Geotechnical Engineering held in Sydney in early May this year. It was a remarkable achievement under very difficult and changeable circumstances. Well done to all.

For the full report on the CAPG activity during the Sydney conference please click **here**

3. ISSMGE BULLETIN

The latest edition of the ISSMGE Bulletin (Volume 16, Issue 3, June 2022) is available from the **website**.

4. ISSMGE FOUNDATION

The next deadline for receipt of applications for awards from the ISSMGE Foundation is the 30th September 2022. Click **here** for further information on the ISSMGE Foundation.

5. 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

II CONFERENCE ON SLOPE REPAIR AND REMEDIATION // II CONFERENCE OF MOUNTAIN ROADS - 06-10-2022 - 07-10-2022 Radisson Hotel + virtual, San Jose, Costa Rica; Language: Spanish; Organiser: Asociación Costarricense de Geotecnia; Contact person: Adrián Fernández Castro; Address: SAN JOSÉ; Phone: (506) 8816 7313; Email: afernandezcastro80@gmail.com; info4@geotecniacr.com; Website: https://www.geotecniacr.com/seminario/index.html

4TH INTERNATIONAL SYMPOSIUM OF MACHINE LEARNING AND BIG DATA IN GEOSCIENCE - 29-08-2023 - 01-09-2023 Cork, Ireland; Language: English; Organiser: University College Cork & TC309 Machine Learning and Big Data; Contact person: Abbey Conference & Events; Email: ismlg2023@abbey.ie; zili.li@ucc.ie; Website: https://www.ismlg2023.com

XVIII EUROPEAN CONFERENCE ON SOIL MECHANICS AND GEOTECHNICAL ENGINEERING - 25-08-2024 - 30-08-2024 Lisbon, Portugal; Language: English; Organiser: SPG; Contact person: SPG; Address: Av. BRASIL, 101 ; Phone: 218443859 ; Fax: (351) 218443021 ; Email: spg@lnec.pt; Website : https://www.ecsmge-2024.com/

21ST INTERNATIONAL CONFERENCE ON SOIL MECHANICS AND GEOTECHNICAL ENGINEERING - 14-06-2026 - 19-06-2026 Austria Center Vienna, Austria; Language: English; Organiser: Austrian Geotechnical Society and Austrian Society for Geomechanics; Contact person: Prof. Helmut F. Schweiger; Email: helmut.schweiger@tugraz.at

NON-ISSMGE EVENTS

WORKSHOP ON THE GEOTECHNICAL CHALLENGES POSED BY HIGH PLASTICITY CLAYS - 11-07-2022 - 12-07-2022 Building 07, Room 010, University of Cyprus Campus, Nicosia, Cyprus; Language: English; Organiser: University of Cyprus / Cyprus Scientific and Technical Chamber (); Contact person: Dimitrios Loukidis Address: Kallipoleos 75; Phone: +357 22892192; Email: loukidis@ucy.ac.cy; Website:https://newdev.ucy.ac.cy/cee/workshop-on-the-geotechnical-challenges-posed-by-high-plasticity-clays/

11th International Conference on Scour and Erosion (ICSE 11): Call for Abstracts

The abstract submission for the 11th International Conference on Scour and Erosion (ICSE 11) that will take place in Copenhagen, Denmark on September 17-21, 2023 is now open at https://icse11.org/abstract-submission.

Shinji Sassa, TC213, 07-07-2022

ISSMGE Interactive Technical Talks: A new educational initiative by the president of ISSMGE

President of ISSMGE Dr. Marc Ballouz has just launched a new educational initiative titled ISSMGE Interactive Technical Talks (IITT). It represents a series of technical talks to bring together geo professionals from around the world, young and renowned, from both the academia and the industry, to discuss a certain subject of geotechnical engineering.

The president of ISSMGE is the moderator and the main speaker would be a renowned geotechnical engineer, usually a leader from the corresponding ISSMGE Technical Committee. Any young engineer could ask to be part of this series by emailing directly to the president (president.ISSMGE@gmail.com) , mentioning his field of expertise, the corresponding TC number, and be ready to prepare 3 or 4 slides presenting his know how in the subject with the challenges that he is facing in his geographical are or environment.

You can watch all ISSMGE Interactive Technical Talks at: https://www.issmge.org/education/interactive-technical-talks

The 1st episode of this new initiative has just been launched and is supported by TC 221: Tailings and Mine Waste. Prof. Roberto Cudmani (Germany), Dr. Assile Diab (Canada) and Ms. Bridget Lokoe (Ghana) are discussing with Dr. Ballouz about tailings and materials and the challenges of dealing with such materials.

Proceedings from the 6th International Conference on Geotechnical and Geophysical Site Characterisation available in open access

The Innovation and Development Committee of ISSMGE is pleased to announce that through the initiative of Tamas Huszak, Andras Mahler and the Hungarian Geotechnical Society, the 288 papers from the proceedings of the 6th International Conference on Geotechnical and Geophysical Site Characterisation (ISC'6) are available in the ISSMGE Online Library here:

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

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

Furthermore, ISSMGE issued a DOI for all 288 newly indexed papers.

ISC'6 was originally scheduled to be held in Budapest, Hungary in 2020, but due to the COVID-19 pandemic, it was held online from September 26th to September 29th 2021.

Acknowledgements for ISC'6 can be found at the ISSMGE online library acknowledgements section.

☙ ❧

International Society for Rock Mechanics and Rock Engineering

ISRM

News

https://www.isrm.net

7th ISRM Young Members' Seminar (YMS) on 29 July
2022-07-19

The ISRM Young Members' Seminar (YMS) Series is a new ISRM Young Members Group initiative. It consists of a series of virtual events to provide a global platform for ISRM young members to share knowledge, experiences, and ideas. More details on the YMS are available on this page.

After six very successful editions, the 7th ISRM Young Members' Seminar will take place on 29 July at 12 P.M. GMT, with speakers from China and Canada:

- Innovation of giant NPR cable and its advantages in critical slip warning for landslide disaster - Dr. Chun Zhu (Hohai University - China)
- Reconciliation between Laboratory and In-situ Measurements of Elastic Stiffness for Opalinus Clay - Dr Lang Liu, (University of Alberta - Canada)

You can join using the Zoom link created for each Seminar and participate in the question and answers period. The Seminars will also be live-streamed to the ISRM YM's YouTube channel, where they will be stored. **Click here to download the flyer**.

Stay tuned for details on the 8th edition from the YMS organising committee.

Sevda Dehkhoda
Chair of the ISRM Young Members Committee

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

Scooped by ITA-AITES #71, 5 July 2022

First tunnel boring machine for Metro's phase II project arrives from China | India

United Utilities starts tendering for mega aqueduct scheme | UK

Preferred option chosen for New Zealand's LGWM

First five disposal tunnels excavated at Finnish repository | Finland

National Grid celebrates first London Power Tunnel breakthrough | UK

How contractors are gearing up to build record breaking Fehmarnbelt immersed tube | Denmark - Germany

Updates on Naples-Bari High Speed/High Capacity line: the Monte Aglio tunnel's last diaphragm wall comes down | Italy

New underground routes for Toronto's light rail system | Canada

Revealing what's underground

Helsinki's energy utility to build a €400m tunnel to use seawater to heat homes | Finland

Scooped by ITA-AITES #72, 19 July 2022

Kanpur Metro: Tunnel construction work for Chunniganj-Nayaganj underground section begins from Bada Chauraha | India

HS2 timeline of major events to 2025 revealed | UK

Azerbaijan to build Murovdag tunnel in Kalbajar region

Gateway tunnel project: New York and New Jersey sign deal to split cost | United States of America

Kolkata gearing for a deep dive Indias first underwater train to begin next year | India

Tunnel boring machine Hazel will keep Alexandria's waterways clean | United States of America

CRL's second tunnel breakthrough at Karanga a Hape Station | New Zealand

Switzerland's autonomous underground cargo system aims for 2031 debut

Operating a data center from a subterranean biosphere | United States of America

The REM tunnel boring machine crosses the finish line at the airport | Canada

ΠΡΟΣΕΧΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΚΔΗΛΩΣΕΙΣ

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

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

WTC 2022 World Tunnel Congress 2022 - Underground solutions for a world in change, 2-8 September 2022, Copenhagen, Denmark, www.wtc2021.dk

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

3rd European Conference on Earthquake Engineering & Seismology, September 4 – September 9, 2022, Bucarest, Romania, https://3ecees.ro

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/?

International Workshop on Advances in Laboratory Testing of Liquefiable Soils, 17 September 2022, Kyrenia, North Cyprus, https://nce2022.ktimo.org

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/

Smart Geotechnics 2022, 6 October 2022, London UK, https://smartgeotechnics.geplus.co.uk/smartgeotechnics/en/page/home

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

5ο Πανελλήνιο Συνέδριο Αντισεισμικής Μηχανικής και Τεχνικής Σεισμολογίας, 20-22 Οκτωβρίου 2022, Αθήνα, https://5psamts.eltam.org

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

CouFrac 2022 - 3rd International Conference on Coupled Processes in Fractured Geological Media: Observation, Modeling, and Application, November 14-16, 2022, Berkeley, California, USA, https://coufrac2022.org

Piling & Ground Improvement Conference 2022, November 16-18, 2022, Sydney, Australia, https://events.americantradeshow.com/pilingconference2022

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/

16th ICGE 2022 – 16th International Conference on eotechnical Engineering, Lahore, Pakistan, 8-9 December, 2022, https://16icge.uet.edu.pk/

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

ASIA 2023, 14 - 16 March 2023, Kuala Lumpur, Malaysia, www.hydropower-dams.com/asia-2023

3rd International Conference TMM_CH "Transdisciplinary Multispectral Modelling and Cooperation for the Preservation of Cultural Heritage: Recapturing the World in Conflict through Culture, promoting mutual understanding and Peace", 20-23 March 2023, Athens, Greece, www.tmm-ch.com

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

UNSAT 2023 - 8th International Conference on Unsaturated Soils, 2-5 May 2023, Milos island, Greece, www.unsat2023.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

NROCK2022 - The IV Nordic Symposium on Rock Mechanics and Rock Engineering, 24 – 25 May 2023, Reykjavic, Iceland, www.nrock2023.com

3rd JTC1 Workshop on "Impact of global changes on landslide risk",7 – 10 June 2023, Oslo, Norway, https://jtc1-2023.com

9th International Congress on Environmental Geotechnics Highlighting the role of Environmental Geotechnics in Addressing Global Grand Challenges, 25-28 June 2023, Chania, Crete island, Greece, www.iceg2022.org

17ARC 17th Asian Regional Geotechnical Engineering Conference, 14-18 August 2023, Nur-Sultan, Kazakhstan, https://17arc.org

IS-PORTO 2023 8th International Symposium on Deformation Characteristics of Geomaterials, 3rd - 6th September 2023, Porto, Portugal, www.fe.up.pt/is-porto2023

Innovative Geotechnologies for Energy Transition, 12-14 September 2023, London, UK, www.osig2023.com

SAHC 2023 13th International Conference on Structural Analysis of Historical Constructions "Heritage conservation across boundaries", 12-15 September 2023, Kyoto, Japan, https://sahc2023.org/

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

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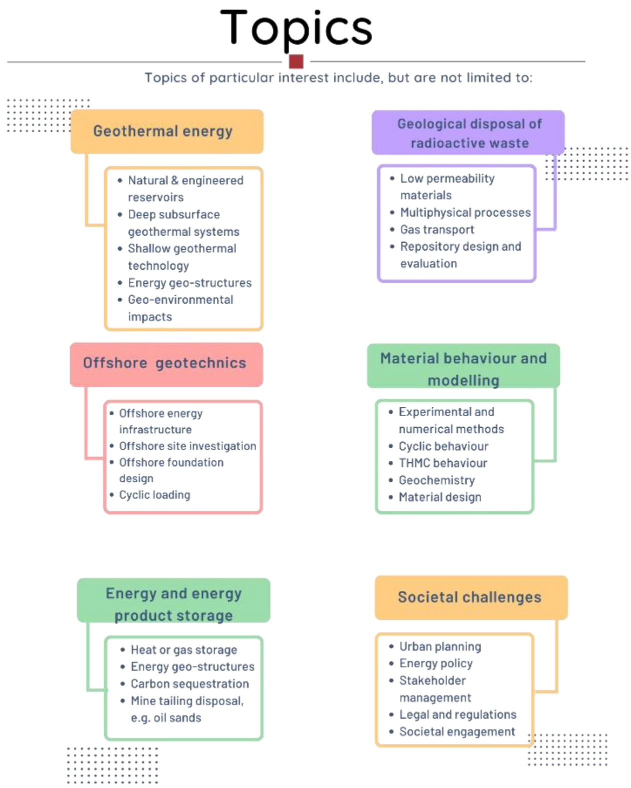
SEG23 Symposium on Energy Geotechnics
3-5 October 2023, Netherlands
https://seg23.dryfta.com

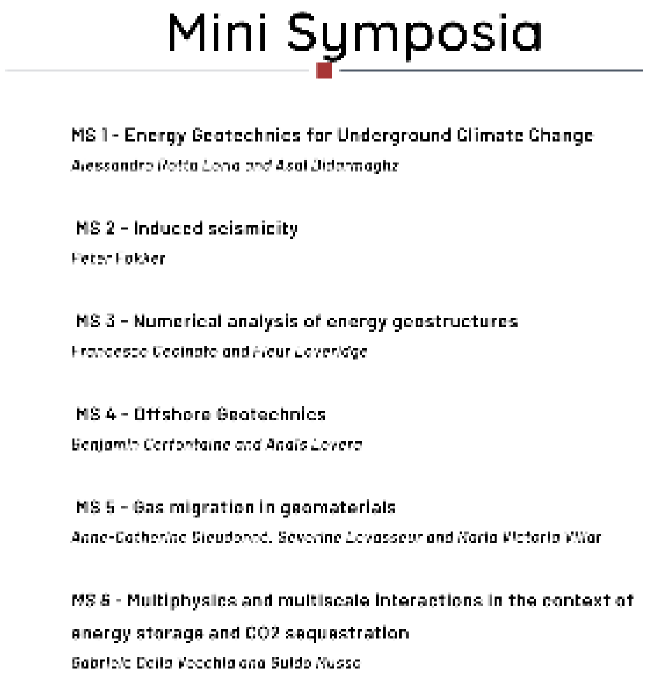
The upcoming edition of the symposium series on Energy Geotechnics, SEG23, held under the auspices of the ISSMGE Technical Committee 308 on Energy Geotechnics, will be held on 3-5 October 2023 in Delft. Keynote lectures from prominent researchers and practitioners in the field of energy geotechnics, state-of-the-art lectures and technical sessions focusing on the task force of TC-308 will be a part of SE23. We warmly welcome you to contribute and attend and look forward to an exciting scientific exchange.

Contributions on various topics related to the energy geotechnics field, including geothermal energy, energy geostructures, energy storage, carbon sequestration, radioactive waste disposal and induced seismicity, are encouraged in the scope of SEG23.

Researchers working on these challenging topics are invited to present the most recent advances. Practitioners are invited to share their experience on various topics of energy geotechnics where presentations of case studies are highly encouraged. Moreover, SEG23 will put emphasis on discussing innovative ideas and highly encourages the presentation of patents and start-ups in the broad spectrum of energy geotechnics.

Symposium topics & Mini Symposia (MS)





Contact

BlueBox Events | Technische Universiteit Delft
P.O. Box 5048 | 2600 GA Delft
Stevinweg 1 | 2628CN Delft
+31 (0)15 278 4915 | blueboxevents@tudelft.nl

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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/

18th Conference of the Associated Research Centers for the Urban Underground Space
"Underground Space – the Next Frontier"
1 - 4 Nov 2023, Singapore
www.acuus2023.com

On behalf of the Organising Committee and ACUUS, it is our pleasure to invite you to Singapore in 2023 for the 18th Conference of the Associated Research Centers for the Urban Underground Space (ACUUS 2023 Singapore). ACUUS 2023 combines with the 2nd International Conference on the Exploration and Utilisation of Underground Space (EUUS-2). The EUUS conference series is an ACUUS initiative with a focus on urban geology and underground resources.

Worldwide, the use of underground space has been increasingly recognised as part of the solutions for sustainable urban development. In Singapore, underground space has been elevated to a strategic level and economic imperative when the government announced that underground space development will form part of the economic strategies for Singapore's future development. For the first time, underground space was included as part of Singapore's Master Plan 2019. Special legislations have been enacted on the ownership and acquisition of underground space. There has also been a paradigm shift towards the underground as a default option for major infrastructure development.

The main theme for ACUUS 2023 Singapore is "Underground Space – the Next Frontier." This theme was chosen to focus on the new opportunities and challenges in underground space use amid a re-focus on exploring and developing the underground space as a strategic resource and part of sustainable development. The new frontier presents unprecedented opportunities for simultaneously improving urban infrastructure, urban livability, and resilience. At the same time, special challenges exist in developing underground space – both from a human design perspective and in terms of complexity, 3D planning, system integration, technical, and life cycle costs. Equally important is the need to move from the creation of underground space as a haphazard, last resort solution to a well-planned, and integrated use of underground space that can serve the needs of society for future generations as well as our own.

As the world emerges from the COVID-19 pandemic and is faced with the many challenges in climate resilience, ACUUS 2023 Singapore will provide a timely opportunity and an excellent forum for engaging discussions and exchanges among planners, designers, engineers, researchers, and policy makers. We look forward to welcoming you to Singapore on 1 -4 Nov 2023.

Conference Themes

- Architecture
- Case studies
- Combined resource extraction and space creation
- Deep underground engineering
- Elevated City
- Energy and carbon storage
- Geospatial and digital technologies
- Maintenance and repair
- Planning
- Resilience and Sustainability
- Risk management & legal matters
- Safety & Underground Environment
- Underground infrastructure
- Underground logistics
- Urban geology and Urban geophysics
- Underwater Space

6th World Landslide Forum "Landslides Science for sustanaible development", 14 to 17 November 2023, Florence, Italy, https://wlf6.org

World Tunnel Congress 2024
19 to 25, April, 2024, Shenzhen, China
www.wtc2024.cn

The 2024 World Tunnel Congress (WTC2024), the world's top tunnel and underground engineering industry congress, will be held in Shenzhen, China from 19 to 25, April, 2024. This congress will focus on the latest trends and sustainable development trends in tunnel and underground engineering. In order to promote the development of the industry and the progress of society, we advocate energy-saving, environmenttally friendly, green and low-carbon, intelligent and safe solutions.

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

Tunnel-Related Topics of WTC2024

1. Planning
2. Survey
3. Design
4. Ground Stability
5. Support and Lining
6. Conventional Tunnelling
7. Mechanized Tunneling (TBM, shield)
8. Waterproofing and Drainage
9. Geological Prediction and Geophysical Prospecting
10. Instrumentation and Monitoring/Testing and Inspection
11. Ventilation and Aerodynamics
12. Maintenance and Repair

13. Operational Safety
14. Tunnel Renovation and Upgrading
15. Occupational Health and Safety
16. New Materials
17. Digital and Information Technology
18. Immersed/Floating Tunnels
19. Shafts
20. Underground Caverns/Underground Space Use
21. Contractual Practices and Risk Management

8th International Conference on Earthquake Geotechnical Engineering (8ICEGE)

7-10 May, 2024 Osaka, Japan

https://confit.atlas.jp/guide/event/icege8/top?lang=en

It is a great pleasure and an honor for us to extend a warm invitation to all of you to attend the 8th International Conference on Earthquake Geotechnical Engineering (8ICEGE) that will take place in Osaka, Japan, on 7-10 May, 2024.

Following the highly successful conferences of this series held in Tokyo 1995, Lisbon 1999, Berkeley 2004, Thessaloniki 2007, Santiago 2011, Christchurch 2015, and Roma 2019, the Japanese Geotechnical Society (JGS) on appointment by the ISSMGE Technical Committee 203 ('Earthquake Geotechnical Engineering and associated problems') is delighted to announce that Osaka will host the 8th International Conference on Earthquake Geotechnical Engineering (8ICEGE) from 7 to 10 in May 2024.

The 8ICEGE offers an outstanding technical program on a range of earthquake geotechnical engineering topics, which will be presented in the published proceedings as well as in the oral and poster sessions. We believe that the 8ICEGE will provide an excellent opportunity for earthquake and geotechnical engineers, geologists and seismologists, consulting engineers, public and private contractors, regional and national authorities, and all those involved in engineering projects and research related to earthquake geotechnical engineering, to exchange ideas and present their recent experience and developments. We hope that you will find the 8ICEGE professionally rewarding, scientifically stimulating, and personally enjoyable as were the previous ICEGEs.

Last but not least, as well as the central business hub in western Japan, Osaka has been at the heart of Japan's cultural and economic developments for hundreds of years with a perfect mix of traditional and modern cultures. The 8ICEGE will also provide you with a great opportunity to enjoy the many charms of Osaka.

Topics

1. Seismic hazard, ground motion records and prediction
2. Surface fault rupture and near-fault effects
3. Field and laboratory testing on soils and rocks
4. Physical modelling, shaking table and centrifuge tests
5. Seismic site characterization
6. Constitutive and numerical models for dynamic analyses
7. Seismic response analysis, site amplification and micro-zonation
8. Liquefaction, lateral spreading and their impacts
9. Stability of natural slopes, cavities and mining digs
10. Embankments, levees and dams
11. Landfills and waste repositories
12. Ground improvement, reinforced soil structures and geosynthetics
13. Waterfront and offshore structures
14. Earth-retaining structures
15. Tunnels and underground structures
16. Lifeline earthquake engineering
17. Shallow and deep foundations
18. Soil-foundation-structure interaction
19. Case histories and instrumented test sites
20. Safeguard of monuments and cultural heritage
21. Lessons learned from recent and past earthquakes
22. Developments in performance-based design, codes and standards of practice
23. Metamaterials and other innovative technologies for seismic protection
24. Emergency, urban systems and resilient communities
25. Risk management and insurance issues
26. Multi-hazards, tsunamis and induced earthquakes
27. Education and preparedness

Sessions

1. Ground motions
2. Seismic site characterization and dynamic soil modeling
3. Site effects and micro-zonation
4. Numerical and constitutive models for dynamic analyses
5. Field testing
6. Laboratory testing
7. Liquefaction assessment
8. Liquefaction and lateral spreading
9. Liquefaction impact on buildings and infrastructure
10. Liquefaction modelling
11. Liquefaction mitigation
12. Shallow and deep foundations
13. Ground improvement, reinforced soil structure and geosynthetics
14. Retaining and waterfront structures
15. Slope, embankment, dams and landfills
16. Tunnels and lifelines
17. Soil-structure interaction
18. Performance-based design and codes
19. Seismic hazard assessment
20. Risk assessment
21. Case histories, observations & lessons from recent/past earthquakes
22. Special Session
23. Others

Contact

Secretariat of 8th International Conference on Earthquake Geotechnical Engineering

Please email us for inquiries regarding,
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others: Info8ICEGE@gmail.com

XVIII European Conference on Soil Mechanics and Geotechnical Engineering
26-30 August 2024, Lisbon, Portugal
www.ecsmge-2024.com

The Portuguese Geotechnical Society (SPG) is pleased to welcome you to the XVIII European Conference on Soil Mechanics and Geotechnical Engineering in Lisbon, Portugal, from August 26th to August 30th 2024.

The theme of the Conference is CHALLENGES OF GEOTECHNICAL ENGINEERING TO MEET CURRENT AND EMERGING SOCIETY NEEDS.

The five-day conference will be held in the heart of Lisbon, with a view to the Tagus River.

We look forward to welcoming you to Lisbon in August 2024.

Conference Theme

The geotechnical challenges that the world faces are getting increasingly complex and interrelated.

In order to develop a renewed commitment with the engineering core values and ethics in this time of rapid and defying changes, the title of the Conference is:

CHALLENGES OF GEOTECHNICAL ENGINEERING TO MEET CURRENT AND EMERGING SOCIETY NEEDS

We are having a glimpse of the New Engineering age, which demands a better knowledge of problems and solutions and imposes a more proficient management of natural resources.

Case Histories, that always give us an opportunity to learn from success and failure, are welcome to foster the synergy between Academicians and Practitioners. The intellect of Man is forced to choose perfection in both life and work.

Main Topics

The main topics are divided in following six main categories:

A - New developments on structural design
B - Geohazards
C - Risk analysis and safety evaluation
D - Current and new construction methods
E - Environment, water and energy
F - Future city world vision
G - Others

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ΕΝΔΙΑΦΕΡΟΝΤΑ ΓΕΩΤΕΧΝΙΚΑ ΝΕΑ

The Tupul landslide: understanding the site

Recovery works continue at the site of the 30 June 2022 Tupul landslide in Manipur, India. News reports at the end of 4 July 2022 indicate that the bodies of 47 victims have now been recovered, with a further 14 people missing, two of whom are soldiers.

Meanwhile, my post yesterday has prompted the unearthing of some further videos of interest. Loyal reader Ryukai has highlighted a video collected immediately after the landslide that captures the start of water flow over the landslide dam:-

https://www.youtube.com/watch?v=I2E3wntdeBI

A second video was captured by one of the first news teams on the site, including initial attempts to rescue victims of the landslide:-

https://www.youtube.com/watch?v=sU73GnFctRU

A third video captures small collapses occurring in the head scarp area:-

https://www.youtube.com/watch?v=Vlr8OyxI0vE

Inevitably, questions are now being asked about the degree to which this landslide should have been anticipated and could have been prevented. For example, the Times of India has an article that points out details from Geological Survey of India report about landslides in the Tupul area, completed in 2018-19:-

While it may take some time to pinpoint the exact cause of the Tupul incident, the GSI had found that out of 170 landslides that occurred between 2011 and 2017, "most have occurred in extensive slope cut during construction of road/railway line. Out of 170 recorded slides, only 30 slides were on natural slopes and the rest were of anthropogenic origin… The GSI report said even "railway is at risk" on NH37, Imphal-Jiribun highway, because of "cutting of slope for railway line and increase in pore water pressure reducing the conhesive strength of the overburden materials".

Whilst one might quibble at some of the detail here, the overall message is absolutely clear. This is landslide-prone territory, and slope cutting is exacerbating the situation. Back in 2020, concerns about this project were raised by the Centre for Financial Accountability, again citing the GSI report:

"A geotechnical assessment of landslides along the Jiribam-Imphal Broad Gauge Line, between Barak and Tupul, was undertaken by the Geological Survey of India, North East Region. In their report, they noted: "The unauthorised and unscientific dumping of excavated earth and disposal of chemical and solid wastes must be strictly checked in the proximity of the villages to avoid loss of property and life including aquatic life in future."

The assessment report further stated that uncontrolled sudden increase in the discharge of major rivers – including Ejei – had caused severe erosion of the rivers and their tributaries, which would pose a danger to nearby villages. "Change in existing land use, uncontrolled cutting and excavation of critical slopes during construction of new approach road, particularly close to habituation, makes the area vulnerable to landslides."

So what of the specific site of the Tupul landslide? As I indicated yesterday, I believe that there were good reasons to be concerned about this site prior to the events of 30 June 2022. The image below is the 3D view of the slope complex in 2009, prior to construction. The location of Tupul railway station is marked – this is where the camp that was destroyed was located:-

The site of the 30 June 2022 Tupul landslide in Manipur, India. Google Earth image from 2009.

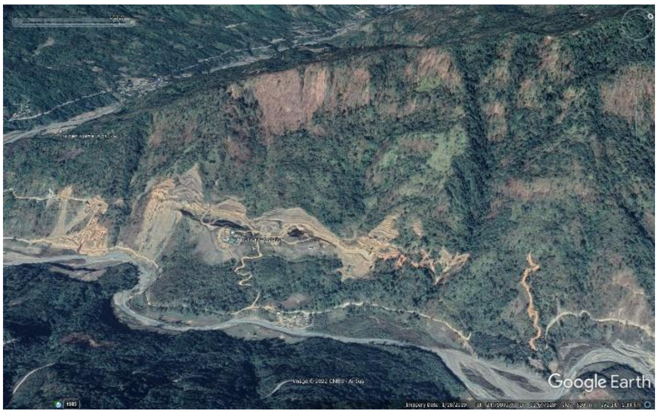
I was a student of the wonderful Professor Denys Brunsden, a pioneer of applied geomorphology. He encouraged us to learn to read the landscape as the landforms indicate past and ongoing processes. At this site, there are multiple elements that to me indicate the likelihood that this slope is a relict (ancient) landslide. For instance, I would worry a great deal about those very steep slopes near to the ridge – does this indicate that material has slipped to expose them? Look at the uneven topography on the midslopes – could that be an indication of material deposited in a previous landslide? Why does the river have that sharp pair of bends on the left side of the image? Is this an indication that it has been pushed over by a landslide? Indeed, doesn't the section of slope on which Tupul railway station is located look like an earthflow?

Is there a sign of a secondary failure in the slopes above the railway station – possible an arcuate but vegetated scarp?

If this is true then the slope on the left of the section is of particular concern. The river is actively eroding the toe and it is steeper than the adjoining slopes. There may be some signs of instability on the lower slope.

Of course all of this needed to be confirmed with detailed mapping from aerial photographs and on the ground, including analysis of the materials. Was that analysis undertaken, I wonder?

But once you are sensitised to the possible landforms at this site the construction approaches start to look somewhat courageous:-



The site of the 30 June 2022 Tupul landslide in Manipur, India. Google Earth image from January 2019.

Look in particular at the area around Tupul railway station, where the landslide occurred, this time from an overhead view:-

The site of Tupul railway station, part of the 30 June 2022 Tupul landslide in Manipur, India. Google Earth image from January 2019.

The lobe that I identified as a potential earthflow has been cut, and the slope has been benched. Downslope, spoil has been tipped to create a bench, loading the lower slope. If this location was an ancient landslide then both of these acts could have potentially destabilised the slopes.

Of course once again this is speculation, and a proper investigation is needed. The Print reports that the Chief Minister of Manipur, N. Biren Singh, has indicated that *"the tragedy necessitated a "relook" at the railway project."*

"The Manipur hill soil is very soft, the railway people have the expertise, but unfortunately this kind of incident has taken place and they need to relook… this target of railway reaching Imphal by December 2023 will be delayed," he had said.

I am unsure what a "relook" actually means. I hope it indicates a detailed investigation as to what caused the Tupul landslide, and a lessons learnt for the remainder of the railway alignment. Time will tell.

(Dave Petley / THE LANDSLIDE BLOG, 5 July 2022, https://blogs.agu.org/landslideblog/2022/07/05/tupul-landslide-2)

Shifting the blame for the deadly landslide at Tupul in India

Recovery operations continue at the site of the 30 June 2022 landslide at Tupul in Northern India. The latest news is that 49 bodies have been recovered, whilst a further 12 people remain missing. The likelihood of recovering their remains is probably diminishing with time. In total, 29 of the victims were soldiers billeted on the landslide site, who were reportedly providing security to the project.

Inevitably, attempts are now being made to shift the blame for the disaster. The New Indian Express provides two perspectives. First, they report the words of an anonymous senior geologist from the Oil and Natural Gas Corporation:-

"We have loose soil here. The rocks are hard only in the deeper portions. So when it rains incessantly or heavily, chances are that the soil will erode," the geologist, who has worked in the region, said requesting anonymity…"To avoid such incidents where development projects are coming up, we must ensure maximum plantations. Only the plants with roots that can reach the sub-surface should be planted in consultations with experts," he said, adding that in Uttarakhand, which has hard rocks, the retaining walls should have steel nets to keep the earth stable.

Vegetation is of course important in landslide management, and it brings many other benefits. But there is no evidence that vegetation, or lack thereof, was the cause of the landslide at Tupul. Indeed, the deep-seated nature of the failure indicates that vegetation was probably essentially irrelevant. The clear evidence of slope cutting is likely to have been far more significant, although as I noted previously this needs to be investigated properly.

Secondly, the article quotes one or more railway officials in relation to the landslide:-

"When a hill is cut for a project, the angle and the slope need to be maintained. It was adhered to," he said … A railway official blamed jhum cultivation for the recent incident.

"Rainwater had got accumulated at the site, rendering the soil soft. That place is not a natural basin," he said.

Jhum cultivation is a shifting form of agriculture in which the forest is cut down and burnt, and the land is then farmed for a small number of years before being abandoned. In the traditional form the land is allowed to recover, but a shift to more intensive land use means that the time period between cycles has often been reduced. The consequences can be extremely environmentally destructive.

There is little doubt that jhum cultivation can be have adverse outcomes for the land, and there may be some evidence that it has been practised in the Tupul area. However, I will leave it to readers to consider whether this is the probable cause of a deep-seated landslide at this site:-

A Google Earth image of the site of the 30 June 2022 landslide at Tupul in northern India.

If losses from these types of landslides are to be reduced then there is a need for an honest conversation about the likely causes.

(Dave Petley / THE LANDSLIDE BLOG, 8 July 2022, https://blogs.agu.org/landslideblog/2022/07/08/tupul-3)

Naina in Khaptad, Nepal: the terrible impacts of low quality road construction

The Nepali newspaper Nagarik News carried an article last week, in Nepali, about the impacts of low cost road construction on an isolated mountain community. The hamlet in question in Nainam located in the area of Chhededaha village in Khaptad. The article includes this image of the location:-

The village of Naina in Khaptad, showing the destabilising effect of low cost road construction.

As the image shows, a so called bulldozer road has been constructed on the slopes below the community. As is so often the case, the slope has been cut to create a road bench, with the spoil being dumped haphazardly on the downslope side. The material is likely to be colluvium sitting at its angle of repose, so steepening induces instability. The lack of drainage has of course exacerbated the problems.

In locations in which there are concentrations of water, the slope is destabilising at paces and there is active gully formation. On other sections of the road there is the potential for deeper-seated landsliding. The downslope side of the road is very badly damaged.

The article articulates the hazards faced by the community:-

Landslides have been reported day and night. A 12-meter road has been constructed below the settlement. Landslides have been raging in the village since the year the dozer built the road. There is no alternative to relocating an entire settlement. Since there is no open space nearby for comfortable accommodation, they spend the night on the roof of the local house.

In total, 25 families are being affected by these landslides. This pattern is common in Nepal, but road construction continues at a pace. Nepal is now in the middle of the summer monsoon, when these problems come home to roost.

(Dave Petley / THE LANDSLIDE BLOG, 11 July 2022, https://blogs.agu.org/landslideblog/2022/07/11/naina-khaptad-1)

New peat landslides in Shetland (including a very interesting landslide video)

The Shetland islands, off the far north coast of Scotland, are covered with large amounts of blanket bog. In such settings, exceptional rainfall and/or disturbance of the peat by human activity can trigger peat landslides – there was for example a large failure at Scalloway in Shetland in 2012 and there were multiple peat landslides in a heavy rainfall event in Shetland in September 2003 (Dykes and Warburton 2008).

On 4 July 2022 a landslide was triggered on the Mid Kames Ridge in Shetland. There is a Youtube video of the setting of the Mid Kames Ridge taken from a drone, including views of the access roads and pads for a large windfarm, which includes 103 turbines across several sites, and which is under construction by Viking Energy. There seems to be little dispute that the peat landslide was associated with the windfarm construction.

The Shetland News has posted an article about the landslide, which includes a remarkable video posted to Facebook by the Stop Viking Energy Windfarm group. This video shows the landslide in motion, carrying an area of crushed rock, presumably a part of the windfarm infrastructure. This still from the video shows the material that failed:-

The 4 July 2022 landslide on the Kames Ridge in Shetland.

[The video is also on Youtube](https://www.youtube.com/watch?v=FXf72vuRfVE&t=1s) and should be visible below: https://www.youtube.com/watch?v=FXf72vuRfVE&t=1s

This is a remarkable example of a peat slide in action – there are few such videos around. The Shetland News reports that the area has been stabilised and some reinforcement has been placed to prevent a recurrence. However, experience says that remediating the site of such landslides is very difficult. The scar from another peat landslide on the Kames Ridge, which occurred in 2015, remains visible.

On 23 June 2022, less than two weeks prior to the landslide Mid Kames Ridge, I published an article in Ground Engineering warning of the risk of peat landslides associated with windfarm development. I said:

"Onshore wind development can pose a real threat to peatlands. If poor ground engineering practices are deployed, large-scale failures can occur, causing massive peat degradation and inflicting a high environmental cost downstream. The development of new wind farms in peatland areas will pose substantial ground engineering challenges."

Meanwhile, yesterday another landslide occurred on Shetland, triggered by heavy rainfall. Again, it seems likely that this is a peat landslide, although on this occasion it does not seem to have been related to a windfarm. It partially blocked a road at Vidlin Junction. The Shetland News has a photograph:-

The 24 July 2022 landslide at Vidlin Junction in Shetland.

Reference

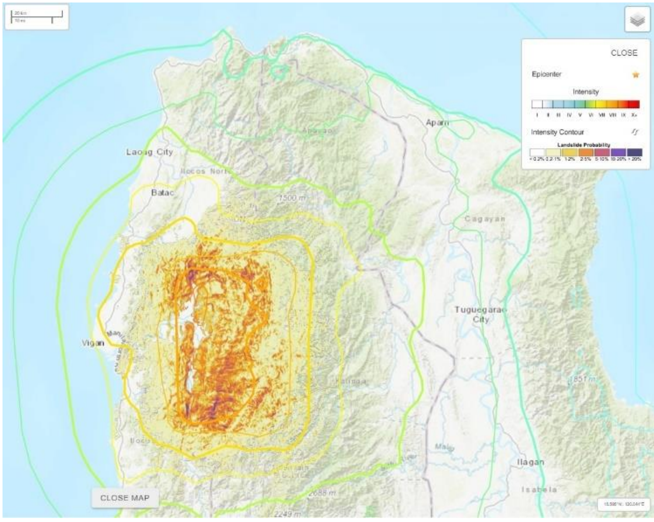
Dykes, A.P. and Warburton, J. 2008. Characteristics of the Shetland Islands (UK) peat slides of 19 September 2003. *Landslides* **5,** 213–226 (2008). https://doi.org/10.1007/s10346-008-0114-7

(Dave Petley / THE LANDSLIDE BLOG / 25 July 2022, https://blogs.agu.org/landslideblog/2022/07/25/shetland-1)

Landslides from the 27 July 2022 M=7.0 earthquake in Abra, Philippines

On 27 July 2022 a M=7.0 earthquake struck Abra Province in the northern part of Philippines, with the epicentre being located close to Tayum. Fortunately, this is a lightly populated part of the country, but the Manilla Times is reporting at least five fatalities. The shallow depth of this earthquake (the USGS reports it as 10 km) and the hilly terrain means that landslides are inevitable, and indeed have been widely reported.

The USGS attempts to model likely landslide probability from large earthquakes. Their simulation appears to estimate an extensive area with high landslide probability:-



A USGS estimate of landslide probability from the 27 July 2022 earthquake in the Philippines.

Some reports of landslides have already emerged. The Manila Times reports two fatalities from landslides:-

"[A] person was killed when boulders smashed into the building site where he was working in Kalinga province, police said. Six other workers were injured. Police said an elderly woman in Suyo municipality in Ilocos Sur province suffered fatal injuries after she was buried by a landslide while out walking."

Meanwhile, the Manila Bulletin reports a further fatal landslide in Benguet:–

"A 32-year old laborer died after he was buried in a landslide that was triggered by the 7.0 magnitude earthquake in Tuba, Benguet. The victim was identified as Resty Emperador Tavas, a native of Pugo La Union, and a stay-in Laborer at M.A. Camilo Construction, Sitio Bayacsan, Taloy Sur, Tuba. Police Capt. Marnie Abellanida, spokesperson of the Police Regional Office-Cordillera Administrative Region, said Tavas' coworkers survived the landslide that occurred at around 8:45 a.m. on Wednesday, July 27."

Meanwhile, some images of landslides have emerged:-

A landslide blocking a road on the Halsema Highway near to Bontoc.

AP has released this very dramatic image of a rockfall in Bauko, Mountain Province:-

A landslide occurring at Bauko in the aftermath of the 27 July 2022 earthquake in Philippines.

It is likely that there will be many more landslides in the upland areas, and that a further round of landslides will be triggered in the first heavy rainfall event following the earthquake.

(Dave Petley / THE LANDSLIBE BLOG, 28 July 2022, https://blogs.agu.org/landslideblog/2022/07/28/abra-earthquake-1)

Trapped Cattle: Positive and Negative Geodisasters

Top: On a positive spot left after the devastating 2010 earthquake in NZ (courtesy 11th IAEG Congress, Auckland) Bottom: In a sinkhole of the karst area 1994 near the City of Bad Pyrmont / Germany (courtesy Geol. Survey North-Rhine-Westphalia)

IAEG Connector E-News, 13.07.2022

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΓΕΩΛΟΓΙΑ

1.2 billion-year-old groundwater is some of the oldest on Earth

The abundance of hydrogen and helium make it a possible energy source.

Researchers discovered 1.2 billion-year-old groundwater inside a mine in South Africa.

Groundwater that was recently discovered deep underground in a mine in South Africa is estimated to be 1.2 billion years old. Researchers suspect that the groundwater is some of the oldest on the planet, and its chemical interactions with the surrounding rock could offer new insights about energy production and storage in Earth's crust.

In fact, Oliver Warr, a research associate in the department of Earth sciences at the University of Toronto in Canada and lead author of a new study about the groundwater discovery, described the location in a statement as a "Pandora's box of helium-and-hydrogen-producing power."

The South African groundwater was also enriched in the highest concentration of radiogenic products — elements produced by radioactivity — yet discovered in fluids, according to the study, demonstrating that ancient groundwater sites may one day potentially serve as energy sources.

The gold and uranium mine, known as Moab Khotsong, sits about 100 miles (161 kilometers) southwest of Johannesburg and is home to one of the world's deepest mine shafts, plunging to depths of 1.86 miles (3 km) below the surface at its deepest, according to the mine (opens in new tab).

The new find follows the prior discovery of approximately 1.8 billion-year-old groundwater made during a 2013 research expedition (also led by Warr). That finding occurred at Kidd Creek Mine in Ontario, which lies beneath the Canadian Shield, a geologic structure comprised of igneous and metamorphic rock dating to the precambrian supereon (4.5 billion to 541 million years ago). The Canadian Shield spans 3 million square miles (nearly 8 million square km), and Warr referred to it as a "hidden hydrogeosphere" — an abundance of hydrogen — in a blog post (opens in new tab) published July 5.

"One of the most exciting parts about this new discovery is that at first we thought the groundwater at Kidd Creek was an outlier," Warr told Live Science. "But now we have this brand-new site located somewhere different with a completely different geologic history that also preserves fluid on a billion-year timescale. It looks like this is a feature of these environments, which represent about 72% of the total continental crust by surface area."

Until now, "We only had one data point, and it's pretty hard to say that, yes, this is applicable to the entire world," Warr said. "But this new site reaffirmed what we considered to be true: that these systems trap water over extremely long time spans."

Warr described the way that rocks release this billion-year-old groundwater as similar to the way that liquid escapes from a water balloon.

"These deep mines are the perfect location for what we do, since, as researchers, we don't have the time or the money to put a hole in the ground, but that's what a mine does. When they drill bore holes, the water that has been trapped inside the rock starts gushing out — it's like piercing a water balloon — and we're able to capture it."

After collecting the samples at Moab Khotsong, Warr and his team of international researchers examined their contents and found that the water contained properties that resembled those of water at Kidd Creek.

"In these deep settings, water is held in cracks in the rock and, over time, they interact, resulting in uranium, which then decays over millions, and even billions, of years, creating noble gases," Warr said. As these noble gases accumulate in the water, researchers can measure their concentrations and how long they were present within the rock.

Warr explained that the samples collected contained high salt content — about eight times more than that of seawater — as well as concentrations of uranium, radiogenic helium, neon, argon, xenon and krypton. They also found the presence of hydrogen and helium, both of which are important energy sources. This finding offers a previously unseen glimpse of helium diffusion from deep within the planet, an important process to consider as we face an ongoing helium shortage, and could hint at energy production under the surface of other planets, too, according to the study.

"As long as there is water and rock, you'll see the production of helium and hydrogen — and that doesn't necessarily mean this has to be taking place only on Earth," Warr said. "If there is water on the subsurface of Mars or any other rocky planet, helium and hydrogen could be generated there too, leading to yet another energy source."

The findings were published June 30 in the journal (opens in new tab)Nature Communications (opens in new tab).

(Jennifer Nalewicki / LIVE SCIENCE, 15.07.2022, https://www.livescience.com/ancient-groundwater-mine-south-africa)

^{86}Kr excess and other noble gases identify a billion-year-old radiogenically-enriched groundwater system

O. Warr, C. J. Ballentine, T. C. Onstott, D. M. Nisson, T. L. Kieft, D. J. Hillegonds & B. Sherwood Lollar

Abstract

Deep within the Precambrian basement rocks of the Earth, groundwaters can sustain subsurface microbial communities, and are targets of investigation both for geologic storage of carbon and/or nuclear waste, and for new reservoirs of rapidly depleting resources of helium. Noble gas-derived resi-

dence times have revealed deep hydrological settings where groundwaters are preserved on millions to billion-year timescales. Here we report groundwaters enriched in the highest concentrations of radiogenic products yet discovered in fluids, with an associated ^{86}Kr excess in the free fluid, and residence times >1 billion years. This brine, from a South African gold mine 3 km below surface, demonstrates that ancient groundwaters preserved in the deep continental crust on billion-year geologic timescales may be more widespread than previously understood. The findings have implications beyond Earth, where on rocky planets such as Mars, subsurface water may persist on long timescales despite surface conditions that no longer provide a habitable zone.

Nature Communications **volume 13**, Article number: 3768 (2022), https://doi.org/10.1038/s41467-022-31412-2, https://www.nature.com/articles/s41467-022-31412-2

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΠΕΡΙΒΑΛΛΟΝ

Contractor reuses site spoil for sustainable bricks

Contractor Volker Fitzpatrick has utilised clay excavated from the basement perimeter of a site in Camden to make bricks for the project.

Working with client Reef and architecture practice Bennetts Associates, Volker Fitzpatrick combined traditional construction methods with the sustainability agenda to scoop subsoil from the site before transporting it to a brickmaker's in Buckinghamshire.

At brickmaker HG Matthews the clay was then mixed with sand and straw to create the unfired bricks, which are known as earth blocks. A total of 14,000 earth blocks will be laid for the project covering $90m^3$.

According to Volker Fitzpatrick, the earth blocks, which are tested to British standards, regulations and strengths, are then being sent back to site to be used to create the perimeter walls in the basement of the new buildings, which when complete, will include a mixed-use development with a state-of-the-art laboratory and office space.

Known as the Apex, the project in Camden will be the first building of its scale to make use of site subsoil as a construction material, and the aim is to set a pioneering precedent on using earth blocks for the construction industry. Unlike standard blockwork, which has limited recycling potential, earth blocks can be broken down and reused, or returned to nature at the end of their lifespan.

As such, the earth block can store the building resource within the walls of the development throughout the lifetime of the building. This natural material also brings climatic benefits to buildings – it regulates indoor temperature and humidity levels and purifies the air by trapping airborne pollutants.

Rakesh Chavda, senior project manager at the Apex, said: "The earth blocks will undergo a unique lifecycle in which they are able to end up exactly where they started from and we hope this technique can be applied to other large scale developments in future."

(Tim Clark / GROUND ENGINEERING, 21 July, 2022, https://www.geplus.co.uk/news/contractor-reuses-site-spoil-for-sustainable-bricks-21-07-2022)

Amazing Waterfalls from Around the World

TreeHugger has been writing about various aspects of the worldwide water crisis for the past few weeks, so it seems appropriate to highlight some of the great water wonders of the world. From New Zealand to Africa to the United States, these nine amazing waterfalls will make you want to appreciate them in person.

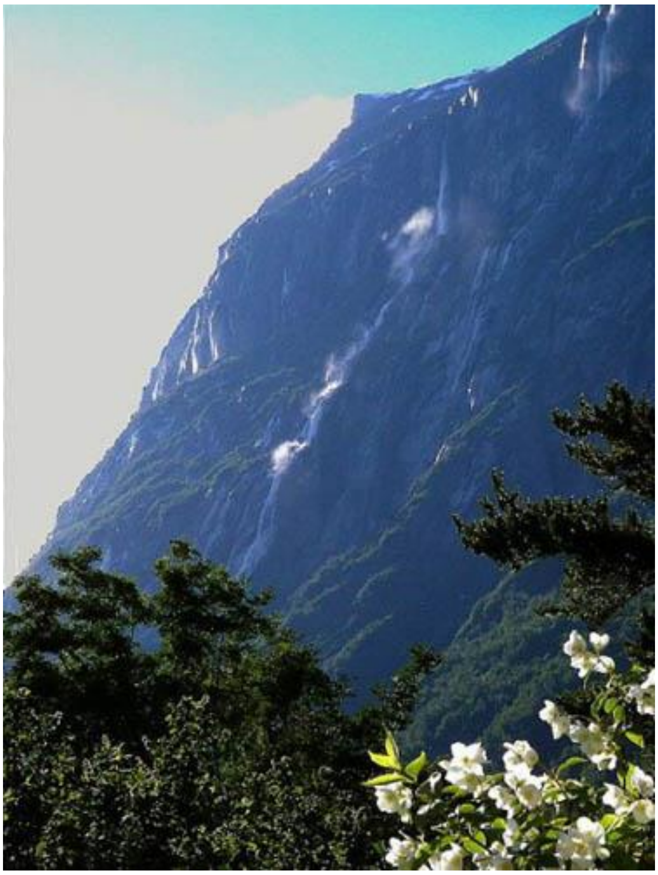
Tugela Falls, South Africa Located in South Africa, Tugela Falls is the second tallest waterfall in the world with a total height of 3,110 feet. It drops in five different tiers, making it a spectacular view.

Rhine Falls, Switzerland Rhine Falls is the largest waterfall in Europe. Located in Switzerland, it is just a few miles from the German border. Though it is not that tall, at 79 feet, the volume of water that flows through Rhine Falls is what makes it the largest.

Angel Falls, Venezuela As the world's tallest waterfall Angel Falls is located in Canaima National Park in Venezuela. It has a 2,648 foot plunge and a total height of 3,212 feet.

Yosemite Falls, United States Located in Yosemite National Park in California, the Yosemite Falls reach a height of 2,425 feet. It has three separate drops, which contains three different types of waterfalls: a horsetail, a plunge, and a cascade.

Iguacu Falls, Argentina/Brazil While the majority of Iguacu Falls is on the Argentina side, this waterfall borders Brazil as well. A portion of this enormous waterfall is a single plunge that flows deep into a gorge known as the "Devil's Throat."



Vinnufossen, Norway Located in Norway, Vinnufossen is a small-stream waterfall yet boasts four drops and is 2,822 feet tall. The stream flows all year round, creating significant volume, and the tallest drop is 1,378 feet.

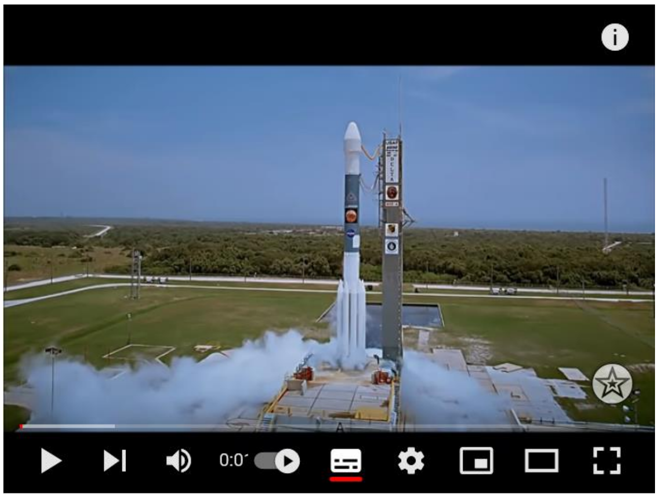
Victoria Falls, Africa The Victoria Falls, located in Victoria National Park in Africa, are some of the most well-known in the world. Although they are only 350 feet high, they are a whopping 5,700 feet wide and have been described as a "falling sheet of water."

Gocta, Peru As the fifth highest waterfall in the world, Gocta is located in Peru and just recently emerged as an attraction. Stefan Ziemendorff is thought to be responsible for this and bringing the falls to the attention of the Peruvian government in 2002. He further participated in documenting, constructing a trail to and measuring the falls.

Sutherland Falls, New Zealand The Sutherland Falls is one of the most well-known in New Zealand at 1,904 feet. The tiered waterfall drops directly from Lake Quill, which is in turn fed by several glaciers producing their own waterfalls.

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΛΟΙΠΑ

How to Get to Mars



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

"How To get to Mars" is a clip from the IMAX documentary "Roving Mars" from 2006. This is an edited short version.

From Wiki : Spirit, MER-A (Mars Exploration Rover -- A), is a robotic rover on Mars, active from 2004 to 2010. It was one of two rovers of NASA's ongoing Mars Exploration Rover Mission. It landed successfully on Mars at 04:35 Ground UTC on January 4, 2004, three weeks before its twin, Opportunity (MER-B), landed on the other side of the planet. Its name was chosen through a NASA-sponsored student essay competition. The rover became stuck in late 2009, and its last communication with Earth was sent on March 22, 2010.

The rover completed its planned 90-sol mission. Aided by cleaning events that resulted in higher power from its solar panels, Spirit went on to function effectively over twenty times longer than NASA planners expected following mission completion. Spirit also logged 7.73 km (4.8 mi) of driving instead of the planned 600 m (0.4 mi), allowing more extensive geological analysis of Martian rocks and planetary surface features. Initial scientific results from the first phase of the mission (the 90-sol prime mission) were published in a special issue of the journal Science.

On May 1, 2009 (5 years, 3 months, 27 Earth days after landing; 21.6 times the planned mission duration), Spirit became stuck in soft soil. This was not the first of the mission's "embedding events" and for the following eight months NASA carefully analyzed the situation, running Earth-based theoretical and practical simulations, and finally programming the rover to make extrication drives in an attempt to free itself. These efforts continued until January 26, 2010 when NASA officials announced that the rover was likely irrecoverably obstructed by its location in soft soil, though it continued to perform scientific research from its current location.

The rover continued in a stationary science platform role until communication with Spirit stopped on sol 2210 (March 22, 2010). JPL continued to attempt to regain contact until May 24, 2011, when NASA announced that efforts to communicate with the unresponsive rover had ended. A formal farewell was planned at NASA headquarters after the Memorial Day holiday and was televised on NASA TV.

The Monster's Fin, Lake Baikal in Russia

In the southern part of the Russian region of remote, frigid and untamed cold known as Siberia lies a lake unlike any other on Earth. Lying nestled within the rugged Siberian wilderness is the enormous Lake Baikal, the deepest and most ancient lake on the planet, and so renowned for its beauty that it is sometimes referred to as "The Pearl of Russia." It is a majestic place not only remarkable for its deep water, but also for its deep mysteries, for Lake Baikal has long been the epicenter for a wide variety of weird happenings and high strangeness.

Lake Baikal is a rift lake, meaning it was formed within a deep rift created by tectonic movement along fault lines, and lies in the Russian region of Siberia, between the Irkutsk Oblast to the northwest and the Buryat Republic to the southeast. At 5,387 feet (1,642 meters) deep and with a surface area of 12,248 square miles (31,722 square kilometers) it is the deepest lake in the world and the seventh largest by surface area. The lake is so large and so deep that it is estimated to hold 20% of the world's unfrozen fresh water. At an estimated 25 million years old, Lake Baikal is also considered to be the oldest existing lake in the world as well. The lake is known for not only its size, but also its remarkably crystal clear water and biodiversity. Lake Baikal is home to a large variety of species found nowhere else on earth and this rich ecology and biodiversity has earned it the nickname “The Galapagos of Russia,” and helped it to be designated as a UNESCO World Heritage Site in 1996.

Το πτερύγιο του τέρατος, η λίμνη Βαϊκάλη στη Ρωσία

Στο νότιο τμήμα της ρωσικής περιοχής του απομακρυσμένου, ψυχρού και αδάμαστου ψυχρού γνωστού ως Σιβηρία βρίσκεται μια λίμνη που δεν μοιάζει με καμία άλλη στη Γη. Κείτεται φωλιασμένη μέσα στην άγρια έρημο της Σιβηρίας είναι η τεράστια λίμνη Βαϊκάλη, η βαθύτερη και πιο αρχαία λίμνη στον πλανήτη, και τόσο γνωστή για την ομορφιά της που μερικές φορές αναφέρεται ως «Το Μαργαριτάρι της Ρωσίας». Είναι ένα μαγευτικό μέρος όχι μόνο αξιοσημείωτο για τα βαθιά νερά του, αλλά και για τα βαθιά μυστήρια του, γιατί η λίμνη Βαϊκάλη αποτελεί εδώ και καιρό το επίκεντρο μιας μεγάλης ποικιλίας περίεργων συμβάντων και υψηλής παραξενιάς.

Η λίμνη Βαϊκάλη είναι μια ρήξη λίμνη, που σημαίνει ότι σχηματίστηκε μέσα σε ένα βαθύ ρήγμα που δημιουργήθηκε από τεκτονική κίνηση κατά μήκος των γραμμών, και βρίσκεται στη ρωσική περιοχή της Σιβηρίας, μεταξύ της Περιφέρειας Ιρκούτσκ στα βορειοδυτικά και της Δημοκρατίας Μπουριάτ στα νοτιοανατολικά. Σε βάθος 5.387 πόδια (1.642 μέτρα) και με επιφάνεια 12.248 τετραγωνικά μίλια (31.722 τετραγωνικά χιλιόμετρα) είναι η βαθύτερη λίμνη στον κόσμο και η έβδομη μεγαλύτερη ανά επιφάνεια. Η λίμνη είναι τόσο μεγάλη και τοσο βαθιά που εκτιμάται ότι χωράει το 20% του παγκοσμίως μη παγωμένου γλυκού νερού. Σε ηλικία περίπου 25 εκατομμυρίων ετών, η λίμνη Βαϊκάλη θεωρείται επίσης η παλαιότερη υπάρχουσα λίμνη στον κόσμο. Η λίμνη είναι γνωστή όχι μόνο για το μέγεθός της, αλλά και για το εξαιρετικά πεντακάθαρο νερό και τη βιοποικιλότητα της Η λίμνη Βαϊκάλη φιλοξενεί μια μεγάλη ποικιλία ειδών που δεν υπάρχουν πουθενά αλλού στη γη και αυτή η πλούσια οικολογία και βιοποικιλότητα της απέκτησαν το παρατσούκλι «Τα Γκαλαπάγκος της Ρωσίας» και τη βοήθησε να χαρακτηριστεί ως Μνημείο Παγκόσμιας Κληρονομιάς της UNESCO το 1996.

ΝΕΕΣ ΕΚΔΟΣΕΙΣ ΣΤΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΠΙΣΤΗΜΕΣ

BIM IN Tunnelling

Guideline for Bored Tunnels - Vol 1

Working Group 22 ITA

(https://about.ita-aites.org/publications/wg-publications/content/208-working-group-22-information-modelling-in-tunnelling)

ΗΛΕΚΤΡΟΝΙΚΑ ΠΕΡΙΟΔΙΚΑ

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

IGS NEWSLETTER – July 2022

Helping the world understand the appropriate value and use of geosynthetics

www.geosyntheticssociety.org/newsletters

- IGS Elections Results Announced! READ MORE
- READ ELECTED MEMBER BIOS
- Did You Know?… Life Cycle Assessment tools (LCAs) show geosynthetics as the greener choice READ MORE
- Discounted flights to EuroGeo7 on LOT Polish Airlines. For more details contact info@eurogeo7.org
- Spotlight On The IGS Technical Committees: Barrier Systems READ MORE
- Record Number Of Abstracts Received For 12th ICG READ MORE
- IGS Young Members Photo Contest – Open Now! READ MORE
- 10 Questions With… Eric Blond READ MORE
- My Engineer Life With… Luke Sutton READ MORE
- IGSF Helps Harness The Power Of Virtual Education READ MORE
- IGS Awards: Call for Nominations 2018 – 2021 READ MORE
- Upcoming Webinars
  - Landfill final covers: field hydrology, in-situ hydraulic properties and long-term performance. July 20, repeated on July 26. Presented by Prof. Craig h. Benson REGISTRATION INFORMATION
  - Geomembranas en Obras Civiles : Conceptos de Diseño y Construcción (*Geomembranes in Civil Works: Concepts of Design and Construction)*. July 21. Presented by Ing. Gustavo Fierro in Spanish REGISTRATION INFORMATION

ITACET Foundation

Foundation for Education and Training on Tunnelling and Underground Space Use

Newsletter #35
July 2022

www.itacet.org/newsletter-35-july-2022

Κυκλοφόρησε το Τεύχος 35, Ιουλίου 2022 του ITACET Foundation με τα ακόλουθα περιεχόμενα:

- President's address
- Training session reports
  - LUNCHTIME LECTURE SERIES - #10 Date: 14/12/2021 Location: Mechanized Tunnelling
  - LUNCHTIME LECTURE SERIES - #11 Date: 11/01/2022 Location: Fires in tunnels
  - ADVANCES IN DESIGN AND CONSTRUCTIONOF TUNNELS Date: 01/02/2022 to 04/02/2022 Location: Pune, India
  - LUNCHTIME LECTURE SERIES - #12 Date: 08/02/2022 Location: Planning, Modelling and use of the subsurface
  - LUNCHTIME LECTURE SERIES - #13 Date: 08/03/2022 Location: Site Investigations in underground projects
  - LUNCHTIME LECTURE SERIES - #14 Date: 02/04/2022 Location: Immersed and floating tunnels
  - LUNCHTIME LECTURE SERIES - #15 Date: 10/05/2022 Location: BIM
  - LUNCHTIME LECTURE SERIES - #16 Date: 14/06/2022 Location: Robots & data processing
- Forthcoming sessions

  LUNCHTIME LECTURE SERIES - #17 Date: 12/07/2022 Location: Online This seventeenth instalment of the Lunchtime Lecture series will focus on 'Build sustainable Precast Segment Lining with Fibre Reinforced Concrete'.

- Other events in preparation
  - Don't miss the ITACET training course at the WTC in Copenhagen! https://www.itacet.org/session/sustainability-underground-design-practical-implementations
  - MEXICO - Conventional and mechanized tunnelling in soil and rock https://www.itacet.org/session/conventional-and-mechanized-tunnelling-soil-and-rock-0
- Scholarschips

ΕΚΤΕΛΕΣΤΙΚΗ ΕΠΙΤΡΟΠΗ ΕΕΕΕΓΜ (2019 – 2023)

ΕΕΕΕΓΜ

Τομέας Γεωτεχνικής
ΣΧΟΛΗ ΠΟΛΙΤΙΚΩΝ ΜΗΧΑΝΙΚΩΝ
ΕΘΝΙΚΟΥ ΜΕΤΣΟΒΙΟΥ ΠΟΛΥΤΕΧΝΕΙΟΥ
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