Tianzi Mountains, China

Αρ. 84 – ΝΟΕΜΒΡΙΟΣ 2015

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Τα Νέα της Ε Ε Ε Ε Γ Μ

84

Συγκρότηση σε σώμα της νέας Εκτελεστικής Επιτροπής

Σε συνέχεια των αρχαιρεσιών της 21ης Οκτωβρίου 2015 το αρχαιότερο στην ΕΕΕΕΓΜ εκλεγέν μέλος της ΕΕ Ανδρέας Αναγνωστόπουλος συγκάλεσε σε συνεδρίαση τα μέλη της ΕΕ προκειμένου να συγκροτηθούν σε σώμα. Τα μέλη της ΕΕ αποφάσισαν ομόφωνα την ακόλουθη συγκρότηση της ΕΕ:

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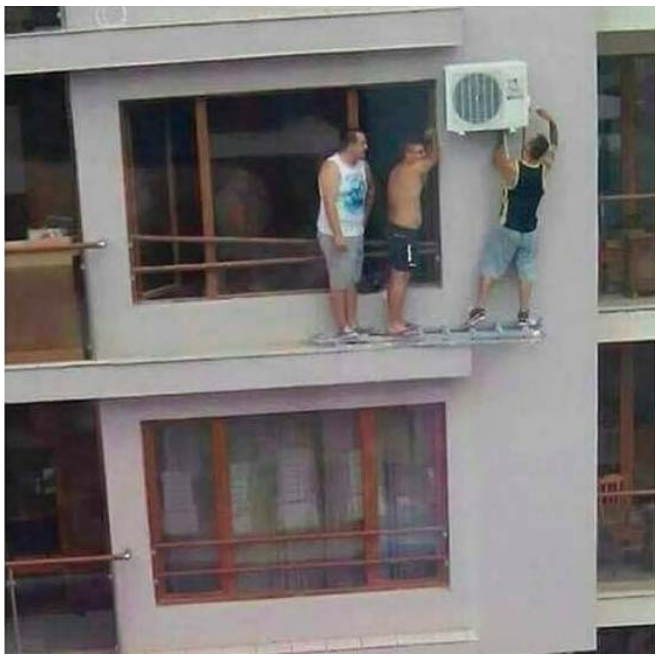

Χωρίς Λόγια

ΑΡΘΡΑ

Παρουσίαση άρθρων, στην συγγραφή των οποίων μετείχαν Έλληνες, στο XVI European Conference on Soil Mechanics and Geotechnical Engineering, Edinburgh, 13-17 September 2015 (κατ' αλφαβητική σειρά, στα ελληνικά, του ονόματος του πρώτου συγγραφέα).

A landslide's restoration in a highway of southwest Greece

Restauration de glissement du terrain d'une autoroute de la Grèce sud-ouest

G. J. Vlavianos

ABSTRACT The Tsakona landslide occurred in 2003, disrupting completely the traffic in the highway between Tripoli and Kalamata, and constitutes one of the larger road landslides. In a few words, the main objectives of the present study are the following: (a) A brief description of the area and the circumstances under which the landslide happened. (b) A brief presentation of the geological and geotechnical investigations carried out after the landslide. (c) A reference of the various proposals for the confinement of the landslide and the long term restoration of traffic movement, followed by a small review of similar phenomena in the national road network of Greece and the experience from their confrontation. (d) A presentation of the technical solution which was adapted. (e) A technical report of the foundation type of the bridge's piers and abutments. (f) A brief report of the construction progress of the bridge.

RÉSUMÉ Le glissement du terrain de Tsakona a eu lieu à 2003 et a perturbé complètement le trafic de l'autoroute reliant Tripoli à Kalamata et constitue un de plus grands glissements du terrain. Dans quelques mots les objectifs principaux de la présente étude sont les suivants : (a) Une courte description de la région et des circonstances sous lesquelles le glissement du terrain a eu lieu. (b) Une présentation brève des investigations géologiques et géotechniques qui ont été effectuées après le glissement du terrain. (c) Une référence des diverses proposition pour le contrôle du glissement du terrain et la restauration à long terme du mouvement du trafic. Il s'ensuit une petite revue des phénomènes similaires qui ont été produites dans le réseau routier national de la Grèce et de l'expérience de leur confrontation. (d) Une présentation de la solution technique qui a été adoptée. (e) Un report technique concernant la forme de la fondation (piliers et butées) du pont. (f) Finalement un report court de progrès de la construction du pont.

1 THE LANDSLIDE

The Tsakona landslide (8th of February 2003) cut off the National Highway between Tripoli and Kalamata and constitutes one of the largest road landslides that have ever taken place in Greece (Figure 1). The phenomenon was initially evident by small cracks on the road surface, during the wet season, and two weeks before the main event (January 2003) by a big hole with dimensions 3 x 3 x 2 m (w x l x d). The interaction of certain physical aspects such as the lithology of the flysch formations at Pindos area and the tectonic strain that these have undergone, the hydrogeological conditions as a result of tectonically emplaced limestone as well as the morphology, all contributed to the formation of an unstable site with notable landslide occurrence during its recent geological history. Human activity, due to construction of the National Highway, played its part towards the site's recent activation, while the final occurrence was triggered by heavy rainfalls during 2003's autumn and winter.

The findings and results of older and more recent geotechnical studies as well were used in order to monitor the landslide mass, i.e. data from twelve (12) older and nine (9) more recent drillings, data from older drillings included inclinometer measurements and findings from monitoring changes in the water table level. In conclusion, the geological factors that make the structure of this narrow region glide and influenced the event are the following:

Figure 1. The Tsakona landslide.

a) The morphology characterized by a recess (pelvis) where a large amount of scree overlying limestone mass was accumulated.

b) The geological structure of the area where very weak geoengineering formations exist, such as those of "flyschoeidous." The surface disintegrated portion, into which the shear zone of the landslide is activated, is a clay zone with very low strength.

c) The tectonic structure of the region which is characterized by two event tectonic phases, an older in the alpine orogenesis and a subsequent which caused severe fragmentation and crimping the background formations with consequent deterioration of mechanical characteristics. Furthermore, the development of a weak tectonic discontinuity in the south end of the landslide, which additionally defines it, constituting the largest tectonic line in the narrow region, contributes significantly to the downward movement of the landslide's mass.

d) The hydrogeological behavior of the region's formations is a very important factor for the landslide's manifestation. The existence of limestone that form an upstream huge water tank, and their contact with the underlying impermeable flysch formation, creates favorable conditions for the development of contact sources of significant provision, which are discharged into the area of the landslide. The transmittance, together with the loosely accumulated scree and the hydrostatic pressure developed at the base contacting the flysch, creates very favourable conditions for the activation of landslides. Also, the conjuncture of the sources with the weak Geoengineering horizons of the "flyschoeidous" creates instability, causing failures in the mass and the undermining of overlying limestone. It was found that the rise in piezometric level in the extreme hydrological year of 2003 is the main reason that led to the large activation of the landslide.

e) The human interference occurred with the construction of the New National Road in the position of the fault, implemented on unstable materials by combining upstream trench and downstream embankment. Although the materials obtained from the trenches contained a large proportion of silt-clay, they were used for the construction of embankments without prior consolidation of the background.

f) The heavy rainfall that occurred during the fall and winter of 2003 together with the geological conditions and human intervention accelerated the development of the landslide (Sotiropoulos et all. 2004)

1.1. Highlights of geotechnical assessment

The landslide occurred within scree which resulted from the disintegration of the overlying limestone and underlying siltstone, chert and flysch. Limestone scree is dominant at sites where permeability and durability are increased, while elsewhere scree flysch with less permeability and durability are dominant.

The landslide triggered by feeding large quantities of water from the overlying limestone. The morphology and testimonies clearly indicate that this is an ancient landslide. The earthworks of the National Road probably adversely affected the drainage conditions of the slopes and the overall balance, but the huge movement took place due to the excessively wet 2002-2003 winter season. Checking the inclinometers showed that after the completion of large displacements (of the order of 80m) there was a period of several years during which there was no measurable movement. Creep landslide was observed again in 2008 and gave movements of the order of 3cm by 2010.

2. RESTORATION SOLUTIONS

A wide range of solutions, including stabilization of the landslide, slight movement of the shaft upstream, crossing with a bridge of 200m central span and a bypass tunnel of 1km, were examined. The various alternatives were briefly the following (Dounias & Belokas 2006):

- Earthwork (excavation-weights)
- Humiliation of the aquifer - Drainage
- Pile wall for the National Road
- General stabilizing using piles
- Small moving of the axis of National Road with anchored pile wall
- Bridging
- Bypass tunnel

The examination of the solutions above was operated by a study group and crossing with a bridge or bypassing with a tunnel were adopted as the two (2) more appropriate.

2.1. Small review of similar severe landslide phenomena in the national road network of Greece.

a) On the 25th of April 1971 a major landslide occurred in the area of Panagopoula, uphill of the Corinth-Patras National Road in Greece. The landslide happened during the wet season following the excavation of the slope for the construction of the New National Road (NNR). The soil masses reached the sea level and covered the NNR, the old national road and the rail tracks (Figure 2). The transportation between East and West Greece was carried out by small ferries for at least one week after the landslide.

As it was derived from the geotechnical calculations, the optimum temporary support system was a diaphragm made of piles. With the data available to date the widening of the NNR either with a cut or with a half-bridge is not permitted, so the reconstructed road and rail tracks should pass using a tunnel (Vlavianos & Cathreptis 1998).

b) On the 18th of February 1995 an extended landslide took place on the slope of a cut on the New National Road between Athens and Lamia, at Malakasa. The slide mass was of about 1,5 million m^3. The landslide disrupted the NNR and the main railway between south and north Greece (Figure 3).

The investigation that followed revealed the decisive role that the high pore water pressures played in the manifestation of instability. Thus the excess pore pressures of the soil material were faced by pumping. A network of vertical pumping wells along with a set of sub-horizontal drains was constructed and operated successfully for many months helping the stabilization of the slope (Marinos et all. 1997).

Figure 2. The Panagopoula landslide.

c) On the 8th of February 2003 an important landslide of 220m width, at the area of the 123rd km of the New National Road Korinthos-Tripolis, took place. The sliding caused a traffic interruption on the national road for two months. The service was restored after the development of a bypass road on the same position with the sliding. The geomorphologic features of the area indicate that in the past there were sliding problems which became serious after the construction of the New National Road by the additional load of the embankment of the road and the increased infiltrations.

Figure 3. The Malakasa landslide.

The main remedial work was the toe buttress of the unstable slope by constructing a 15m high fence in the valley and appropriate drainage on the foot of the sliding, and at the same time the riverbed was re-arranged through the development of a sewer along with the use of a drainage network (Marinos et all. 2004). (Figure 4)

2.2. Crossing with a bridge

The axis of the NNR displaced downstream so it can construct the bridge in alignment. The possible positions of bridge piers were examined with the following basic criteria:

a. The piers lie outside the main landslide to avoid the risk of possible future activation.

b. The piers are seated in bedrock at a sufficient distance from the strongly disturb ant zones or faults.

c. The excavation required for their manufacture can be supported permanently.

Figure 4. The landslide of the 123km Korinthos-Tripoli NNR.

b. The piers are seated in bedrock at a sufficient distance from the strongly disturb ant zones or faults.

c. The excavation required for their manufacture can be supported permanently.

d. The northern pier is not compromised by minor slips of the overlying soil mantle.

e. The fault bounding the landslide towards Kalamata is not active. If it is active, any movement should be safely undertaken from the vector of the bridge.

The main ancillary works required in the case of bridge construction are plainly the following:

- Restoration works of runoff in the region
- Excavation for the foundation piers, the stabilization of the slopes upstream the piers and the arrangement of bad body slope landslide
- Permanent retaining of rocky slopes with permanent rock anchors and drainage boreholes
- Works of underground drainage of the landslide in the area upstream the NNR to prevent new very large landslide movement

Assuming a total bridge length of 400m from concrete, a rough approximate cost is estimated to be 50.000.000 €

2.3. Bypassing with a tunnel

In this case you will be bypassing the landslide with a tunnel whose length will be about 900m. Due to strong inclination, it is not appropriate to use a single two-lane tunnel that will serve both directions. Subsequently, there must be a twin tunnel construction.

Exactly after the tunnel, a new road section of approximately 600m will be constructed using an embankment with a maximum height of about 12m.

The solution of the tunnel is considered to be advantageous in that it requires no intervention in the landslide and therefore it does not involve uncertainties that may increase costs due to any additional slope stabilization works and drainage.

From the environmental point of view it was more acceptable as a solution. On the other hand, it was a difficult tunnel - about half way along the rock mass to be drilled in a very low profile.

It was estimated that the twin tunnel with the outdoor road will cost 55.000.000 €.

2.4. Final decision

The solution of the bridge compared to this of a tunnel was preferable due to cost. (Figure 5)

Before taking the final decision on the choice of the bridge, a seism tectonic-seismic hazard study was elaborated (Pavlidis 2004) that generated the following, as far as the seismic hazard assessment of the wider area of the study project is concerned:

- There is no documented existence of possible active tectonic structures in the construction site.
- Based on geological, morph tectonic and seismological data, there were established the main active and potentially active faults in the region which could possibly affect the technical work, if activated.
- The maximum earthquake design size is estimated at M s = 6.5 and the maximum expected intensity in the area of the project at VII - VIII (7-8 in the MM scale). Based on the expected size of this maximum design earthquake, the acceleration was calculated at PGA = 0,24 g with a project importance factor of 0,31 g. As standard seismic design there can be used the fully studied earthquake of Kalamata in 1986.

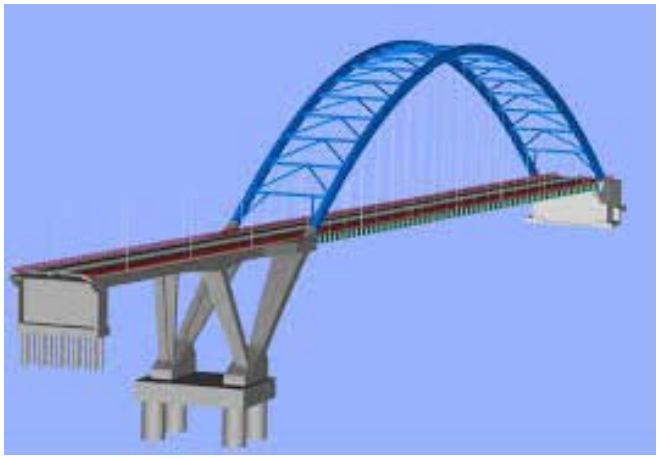

Figure 5. The bridge solution.

3. THE BRIDGE FOUNDATION

Regarding the design of the foundation, the geological and geotechnical study and research, carried out in several stages, were taken into account. The bridge consists of two openings with a total length of 390m. The second aperture length of 300m bridges the great landslide.

3.1. Abutment A0 (North)

The foundation of the abutment A0 is a group (3X6) of piles Ø120, 15m deep each. The piles are connected with a 2.0m-thick pile cap (9X21m). According to data from the geotechnical investigations the foundation material is siltstone with sandstone intercalations (Fikiris et all. 2011).

3.2. Pier M1

The pier will be based on four shafts (caissons) 6m in diameter and 15m in depth which are connected with a 5m thick rectangular 23X31m reinforced concrete raft. The pier is founded on bedrock. According to survey data, in the worst case the material foundation is in full depth siltstone with sandstone intercalations at variable rates.

The type of foundation is the largest built in Greece followed by the foundation of the isthmus bridge of Corinth at 6m diameter shaft framed by two rows of sand piles (Vlavianos & Constantinidis 2000).

3.3. Abutment A2 (South)

The abutment A2 sits directly in the fixed background. The seating is on two levels. The upper level is at an altitude of 355,8 m and has dimensions of 6.5X28, 7m. The lower level is at an altitude of 352m and its dimensions are 9.5 X28, 7m. The abutment is founded entirely in sandstone.

4. CONCLUSIONS

In Greece, the morphology of the landscape, the geological structure of specific areas and the hydro geological behaviour of formations, combined with the human activity and excessive wet seasons, activate minor or major landslides. It's a big challenge to find- from an economic-technical point of view- the appropriate restoration solution. In the case of Tsakona landslide, the bridge solution was selected after a big study and research.

At the time of writing this paper the construction of the bridge has advanced greatly. The abutments and the pier have already been constructed, followed by the construction of the arch of the bridge. Finally, when the deck gets posted, the construction of one of the longest bridges of this type in Greece (second in particular) will have been completed. (Figure 6)

Figure 6. The bridge under construction.

ACKNOWLEDGEMENTS

The design of the bridge is being supervised by the authority of the Ministry of Infrastructure, Tranports and Networks (DMEO). The co-operation of my colleagues is greatly acknowledged.

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The mechanical behaviour of a clean sand stabilized with colloidal silica

Le comportement mécanique du sable propre stabilisé à l'aide de silice colloïdale

A.D. Vranna and Th. Tika

ABSTRACT This paper presents a laboratory investigation into passive site stabilization of liquefiable sands by means of colloidal silica, CS. In order to examine the improvement of the mechanical behaviour of liquefiable sands stabilized with CS, an extensive laboratory testing program comprising monotonic and cyclic triaxial tests was performed on a clean quartz sand stabilized with CS. The stabilized sample preparation method adopted in the tests is initially described and then results from the above tests conducted on treated and untreated specimens are presented. It is shown that stabilization of the sand with CS significantly improves both the undrained monotonic and cyclic resistance strength. Furthermore, the development of double amplitude axial strain of at least 5% during cyclic loading does not influence the undrained shear strength of the stabilized sand.

RÉSUMÉ Cet article présente une recherche de laboratoire sur la stabilisation passive de sites de sables liquéfiables à l'aide silice colloïdale (SC). Afin d'étudier l'amélioration du comportement mécanique des sables liquéfiables stabilisés à l'aide de SC, nous avons mis en oeuvre un programme complet d'essais de laboratoire incluant des essais monotones et cycliques triaxiaux. Ces essais ont été réalisés sur du sable propre de quartz stabilisé à la SC. Nous commençons par décrire la méthode de préparation des échantillons stabilisés adoptée pour les essais et, ensuite, nous présentons les résultats des essais précités obtenus sur des échantillons traités et non traités. Il est montré que la stabilisation des sables à l'aide de SC améliore significativement la résistance tant monotone que cyclique non drainée. En outre, le développement d'une déformation axiale de double amplitude d'au moins 5% en charge cyclique n'affecte pas la résistance au cisaillement non drainée du sable stabilisé.

1 INTRODUCTION

Passive site stabilization is a relatively new method proposed for non-disruptive mitigation of liquefaction risk at developed sites susceptible to liquefaction. It involves slow injection of a stabilizing material at the up-gradient edge of a site and delivery of the stabilizer to the target location, by means of natural or augmented groundwater flow. Colloidal silica, CS, has been identified as a potentially suitable stabilizer by researchers in the past few years. CS is an aqueous suspension of microscopic silica particles produced from saturated solutions of silicic acid, H_4SiO_4 (Iler 1979). In dilute solutions, CS has a density and viscosity similar to water and can be made to gel by adjusting the ionic strength or pH of the given solution. This property allows it to be injected or mixed with soil, so that after gelling colloidal silica blocks the void space in the soil and therefore alters its mechanical behaviour. The principal advantages of CS over other potential stabilizers are its excellent durability characteristics, its initial low viscosity and the ability to attain low permeability in grouted soils, long controllable and reproducible gel times, nontoxicity and its low cost.

Previous studies on the mechanical behaviour of sands stabilized with CS, mainly involve unconfined compressive strength tests and physical modeling tests. Monotonic and cyclic triaxial testing on sands stabilized with CS are reported in literature among a few others by Kabashima & Towhata (2000), Gallagher (2000), Gallagher & Mitchell (2002), Díaz-Rodriguez et al. (2008) and Mollamahmutoglu & Yilmaz (2010).

With increasing application of passive site stabilization, there is need to better understand the behavior of sand stabilized with CS under different loading conditions. The need also for the development of standard testing methods calls for the expansion of the existing database of test results on these soils. To this extent, a series of monotonic and cyclic tests was performed on a clean sand, stabilized with CS. To assess the effectiveness of the CS stabilization, a series of monotonic and cyclic tests on untreated sand samples was also conducted. The results from the two series of tests are presented and discussed.

2 EXPERIMENTAL PROCEDURE

2.1 Tested materials

The soil used in this study is a natural clean quartz sand (M31) with grains of variable roundness and sphericity. It has a specific gravity G_s =2.655, maximum and minimum void ratios of e_{max} = 0.805 and e_{min} = 0.558 respectively, a mean diameter D_{50} = 0.31mm and a uniformity coefficient of C_u = 1.5. Its gradation curve lies within the bound gradation curves, suggested for liquefiable soils.

Ludox SM-30 was selected as the stabilizing agent of sand specimens, supplied as a 30% by weight silica solution with a viscosity of 5.5cP, a pH of 10 and an average particle size of 7nm. Distilled water was added to the initial solution in order to obtain a concentration of 10% CS. Gel times of the studied solution were investigated by conducting viscosity measurement tests by means of a rotating Brookfield viscometer. Typical test results for CS = 10% solutions with the same pH value and different salinity are presented in Figure 1. It is noted that gel time was defined as the elapsed time for which the tested solution viscosity is equal to η = 3.5cP. Beyond that value, viscosity increases rapidly and eventually the solution transforms into a rigid gel.

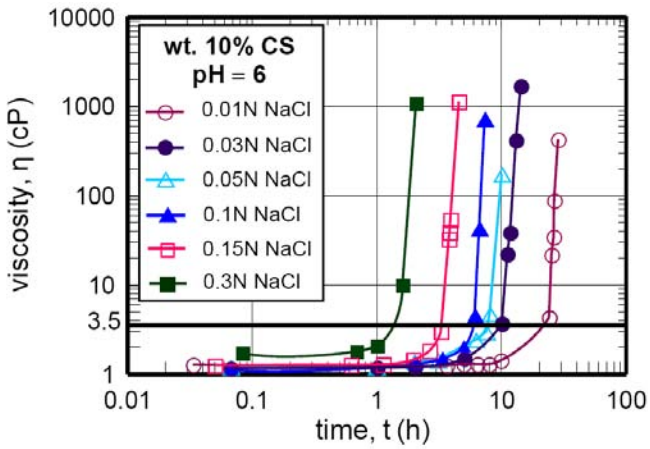

Figure 1. Variation of viscosity, η, with time, t, for CS = 10% solutions with pH = 6.00 and different NaCl concentrations.

It was decided to employ a CS gel time equal to 10 hours, which was determined by adjusting the pH value to pH = 6.0, as well as the NaCl concentration of the solution to 0.03N.

2.2 Testing programme

Cylindrical specimens (height/diameter ≈ 100mm / 50mm) were prepared at various densities, using the undercompaction method, as proposed by Ladd (1978), both for the untreated and treated sand. Saturation was achieved by percolating throughout the specimen, first carbon dioxide gas (CO_2) and then deaired water. Following, the CS solution was likewise injected into the specimens until it filled the soil voids. The procedure was assumed complete when a solution volume equal to four times the soil specimen volume was extracted from the top of the specimen. The vis-

cosity of the CS solution remained low (η < 3.5cP) throughout the specimen percolation process.

After the setting of CS, samples were placed in a constant temperature and humidity chamber for a curing time of five times the CS gel time. Saturation of specimens prior to testing would damage the formed CS bonds and hence was not performed. Furthermore, the measurement of any excess pore water pressure would be unreliable, due to lack of pore water inside the treated specimens.

The monotonic testing programme consisted of undrained isotropically consolidated tests on untreated sand specimens and unconfined compression, as well as undrained consolidated tests on treated specimens. All types of tests were performed using a closed-loop automatic cyclic triaxial apparatus (M.T.S. Systems Corporation) (Papadopoulou 2008; Vranna 2014).

In the monotonic tests, specimens were subjected to undrained compression at a constant strain rate of 0.1%/min. In the cyclic triaxial tests, a sinusoidally varying axial stress (±σd) was applied at a frequency of f = 0.1Hz, under undrained conditions. In this work, the occurrence of double amplitude axial strain, ε_{DA} = 5% is used as a reference point to define cyclic softening of both treated and untreated specimens. For this reason, a series of cyclic triaxial tests with different cyclic stress ratios, CSR = σ_d / 2σ'_0, was carried out in order to determine the number of load cycles, N, required for the development of ε_{DA} = 5% both for the treated and untreated specimens. In view of the typical number of load cycles of actual earthquakes (10 to 20 for an earthquake of M7.5 magnitude), in this work the onset of liquefaction and thus the cyclic resistance ratio, CRR_{15}, is considered as the cyclic stress ratio, CSR = σ_d / 2σ'_0, required to produce ε_{DA} = 5% in 15 load cycles. Confining stresses of either 100kPa or 300kPa were used in the tests.

3 TEST RESULTS

3.1 Monotonic response

Figure 2 presents the Mohr-Coulomb peak shear strength envelopes of the treated and untreated sand samples at a relative density, D_r = 25.8-29.2%. It is shown that the increase in strength of the treated samples over that of the untreated occurs mainly as a cohesion intercept. This indicates that introduction of CS into the sand induces a cohesion factor by infilling the voids and creating bonds among the sand grains.

Figure 3 presents the variation of the undrained shear strength, s_u, with void ratio of treated and untreated sand samples. The undrained shear strength, $s_{u,max}$ = $q_{u,max}$ / 2, of the treated specimens was determined at the point of the maximum deviatoric stress, $q_{u,max}$, which corresponds to an axial strain, ε_a = 5.0 - 8.0%. For comparison reasons, in the case of untreated samples, the undrained shear strength at the phase transformation state, $s_{u,PT}$ = q_{PT}/2, was used (point of transition from a contractive to a dilative response, that takes place at a minimum effective mean stress), since it was triggered at a comparable range of ε_a = 1.1 - 4.6%. It is noted that the undrained shear strength of the untreated samples at critical state was triggered at larger values of ε_a, ε_a = 10 - 30%. It is again shown that the undrained shear strength for the treated sand samples is considerably larger than the corresponding of the untreated samples, under the same effective stress. Moreover, the undrained shear strength of the treated sand increases with increasing confining stress. For the studied density range, it doubles when σ'_0 increases from 100kPa to 300kPa.

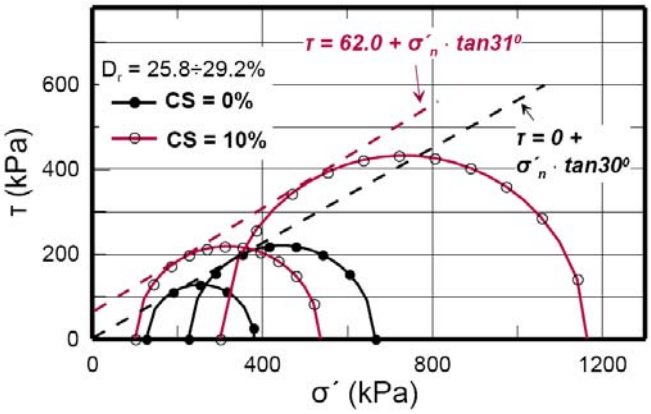

Figure 2. Peak shear strength envelopes for treated and untreated samples of D_r = 25.8-29.2%.

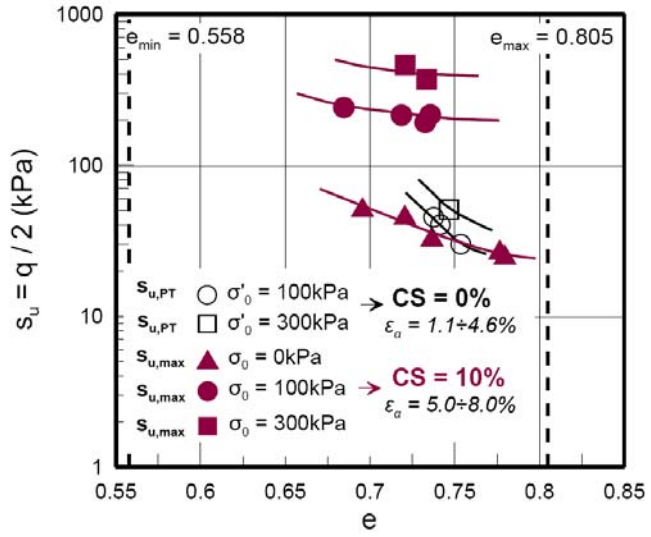

Figure 3. Variation of the undrained shear strength, s_u with void ratio, e for the treated sand samples, at σ'_0 = 0kPa, 100kPa and 300kPa, as well as the untreated samples, at σ'_0 = 100kPa and 300kPa.

3.2 Cyclic response

Figure 4 compares the cyclic response of medium dense untreated and treated specimens, subjected to CSR = 0.40-0.45 under $\sigma'0$ = 100kPa. It is indicated that the untreated sand samples experience much larger strain in fewer loading cycles, N, than the corresponding treated samples. Whereas the values of N for ε_{DA} = 1, 2.5 and 5% are very close for the untreated specimen, for the treated specimen there is a distinct difference between N for ε_{DA} = 2.5 and 5%. For the untreated sample, as seen in Figure 4b, ε_{DA} increases rapidly and complete liquefaction is reached ($\Delta u/\sigma'_0$ = 98% at ε_{DA} = 5.6%), whereas for the treated sample, ε_{DA} increases gradually during cyclic loading. The same pattern of behaviour was also observed at different CSR and void ratios.

Figure 5 presents the variation of cyclic stress ratio, CSR, with N required to reach three levels of ε_{DA} = 1, 2.5 and 5% for the treated specimens under σ'_0 = 100kPa, at a loose and a medium dense state. The numbers of cycles required to reach ε_{DA} = 1, 2.5 and 5% are considerably different from each other, especially at lower CSR values.

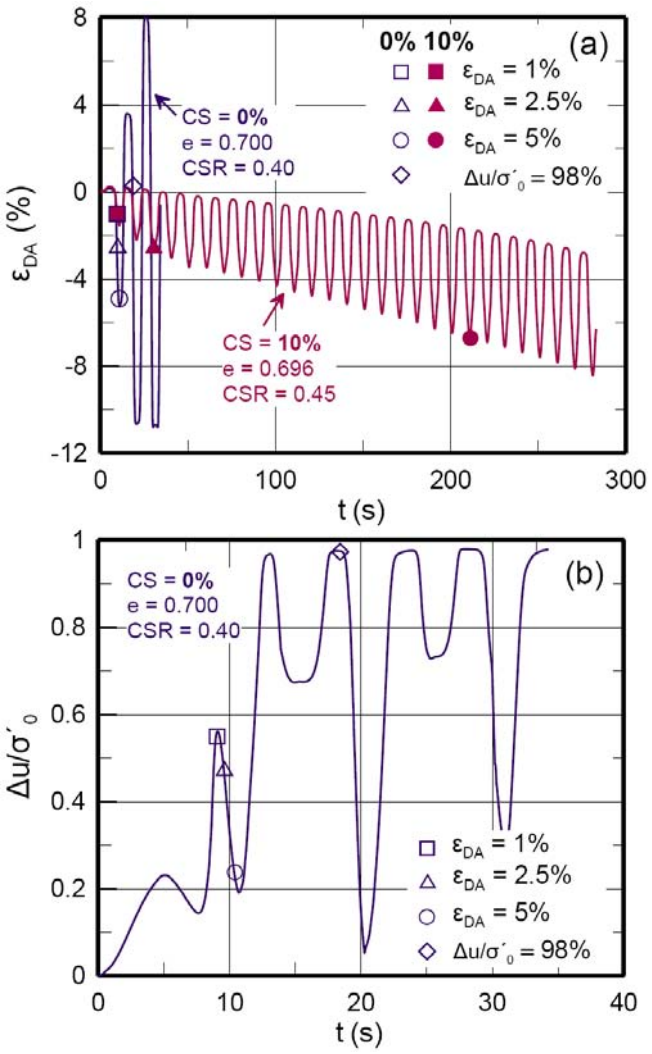

Figure 4. (a) Variation of double amplitude axial strain, ε_{DA} with time, t, for treated and untreated sands, for e = 0.696-0.700 and CSR ≈ 0.43 under σ'_0 = 100kPa. (b) Variation of normalized excess pore water pressure, $\Delta u/\sigma'_0$, with time, t, for the untreated sample of Fig. 4a.

Figure 6 presents the variation of CSR with number N_l for ε_{DA} = 5%, for treated and untreated specimens, at two different ranges of void ratio and σ'_0 = 100kPa. There is a remarkable increase of N_l for loose, as well as moderately dense treated samples, as compared to the corresponding of the untreated samples.

The variation of liquefaction resistance, CRR_{15}, with void ratio, e, for untreated and treated sands at σ'_0 = 100kPa, is presented in Figure 7. It is shown that treated sands possess at least double the liquefaction resistance of untreated sands, under σ'_0 = 100kPa, for the studied densities.

To examine the possibility of particle bonding breakage during cyclic loading of the treated samples, undrained monotonic compression tests were performed on treated samples after their cyclic loading to at least ε_{DA} = 5%. The number of preceding loading cycles was N = 7÷628 and the preceding accumulated strain was ε_{DA} = 5÷10%. The test results for this post-cycling shear strength are shown in Figure 8, in which they are also compared with the corresponding shear strength of treated samples not subjected previously to cyclic loading. It is shown that the loss in shear strength during cyclic loading is insignificant. It may be concluded therefore that no degradation in shear strength of treated samples subjected to cyclic loading takes place. This conclusion agrees with previous studies on the post-cycling shear strength of sand stabilized with CS (Mollamahmutoglu & Yilmaz 2010), indicating that no deterioration of sand improvement occurs during cyclic loading.

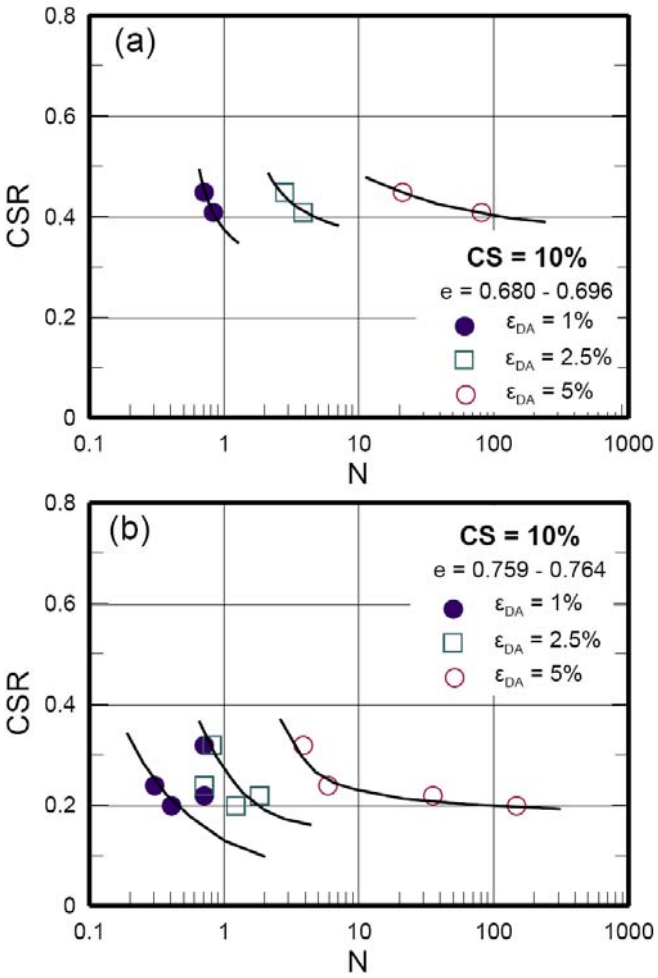

Figure 5. Variation of CSR, with number of cycles N, for treated sands, at σ'_0 = 100kPa and at different values of ε_{DA}, for (a) e = 0.680-0.696 (D_r ≈ 47.3%) and (b) e = 0.759-0.764 (D_r ≈ 17.7%).

4 CONCLUSIONS

According to the test results, stabilization of loose to moderately dense sands with 10% CS significantly improves their monotonic and cyclic response and thus greatly reduces liquefaction risk. In particular, the following conclusions can be drawn from the work presented:

a) The increase of the Mohr-Coulomb peak shear strength of treated samples over the corresponding of the untreated samples, occurs mainly as an increase of the cohesion intercept.

b) The undrained monotonic shear strength of the treated samples is significantly larger than the corresponding of untreated samples at comparable strains. It also increases with increasing effective stress up to 300kPa.

c) For the materials tested at the studied density range, treated sands possess approximately double the liquefaction resistance of untreated sands, under σ'_0 = 100kPa.

d) The treated samples exhibit increased deformation resistance to cyclic loading, as compared to the untreated samples which experience much larger ε_{DA} in fewer cycles.

e) Post-cycling undrained monotonic shear strength of treated samples is not affected by the accumulated strains (at least ε_{DA} ≈ 5%) during the preceding cyclic

loading, indicating that no deterioration of sand improvement occurs during cyclic loading.

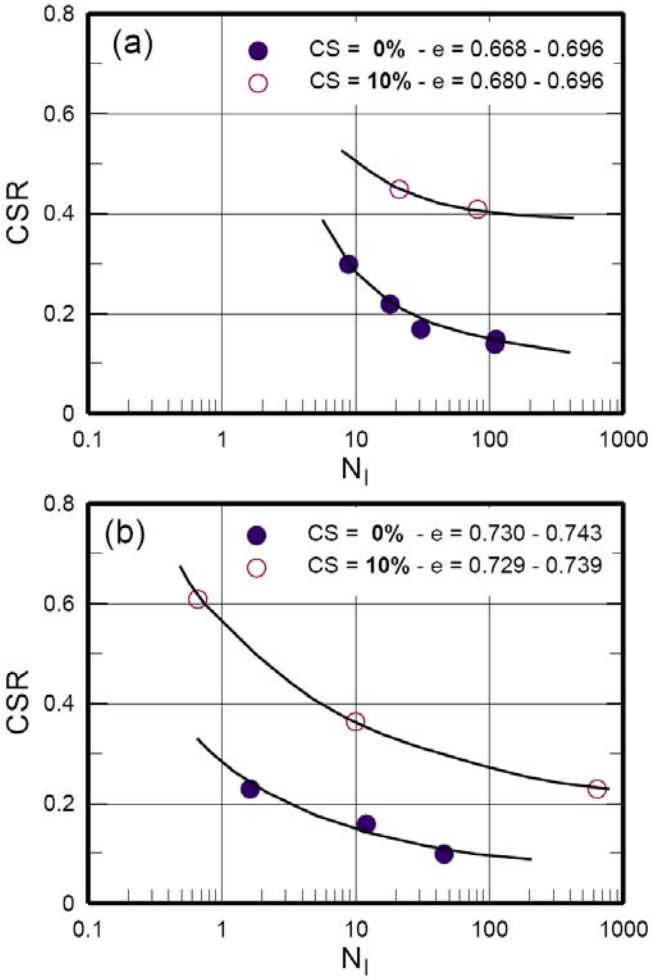

Figure 6. Variation of CSR, with number of cycles N_l required for ε_{DA} = 5%, for sands with CS = 0% and 10%, for (a) e = 0.668-0.696 ($D_r \approx$ 49.8%) and (b) e = 0.735-0.743 ($D_r \approx$ 26.6%), at σ'_0 = 100kPa.

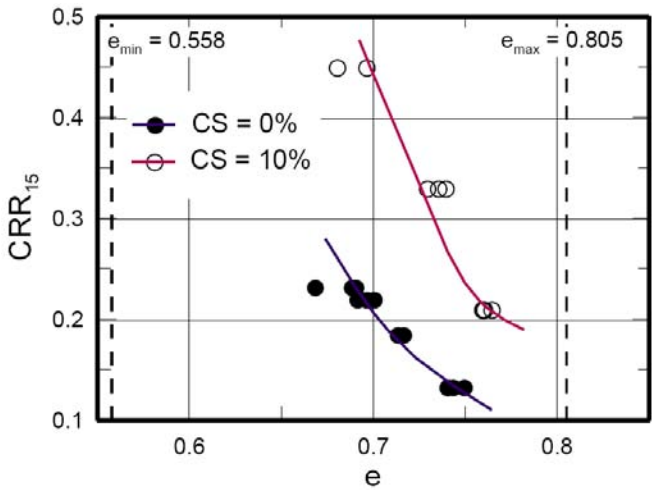

Figure 7. Variation of CRR15 with void ratio, e, for soils with CS = 0% and 10% at σ'_0 = 100kPa.

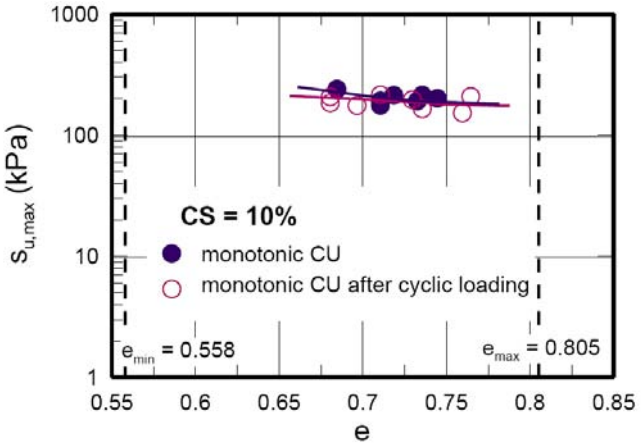

Figure 8. Variation of the undrained shear strength, $s_{u,max}$ with void ratio, e, for treated sands at σ'_0 = 100kPa, after monotonic loading and after monotonic loading that followed liquefaction reached by cyclic loading.

ACKNOWLEDGEMENT

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Estimation of elastic and non-linear stiffness coefficients for suction caisson foundations

Estimation des coefficients de rigidité élastique et non-linéaire pour des fondations de caissons à succion

F.M. Gelagoti, P.P. Lekkakis, R.S. Kourkoulis and G. Gazetas

ABSTRACT This paper investigates the stiffness of suction caisson foundations both in the elastic domain and when considering material and interface nonlinearities. First, at small strains, expressions from the literature are used to identify the stiffness matrix of a solid embedded foundation. Following, expressions for the stiffness components of flexible skirted foundations are engendered for variations in the characteristics of the system normalized by a parameter that produces unique stiffness values. The second part of the paper involves the investigation of the stiffness of the system in the large-strain domain. Both full contact conditions as well as the assumption of interfaces are examined and corresponding charts are produced that allow the calculation of the reduction in the stiffness components with increasing rotation and displacement.

RÉSUMÉ Cet article étudie la rigidité des fondations caissons à succion à la fois dans le domaine élastique et lors de l'examen des nonlinéarités de matériel et d'interface. Tout d'abord, en petites déformations, des expressions de la littérature sont utilisées pour identifier la matrice de rigidité d'une fondation solide encastrée. À la suite, des expressions pour les composantes de rigidité de fondations flexibles de caissons sont engendrées pour des variations dans les caractéristiques du système. Les expressions sont normalisées par un paramètre qui produit des valeurs de rigidité unique. La deuxième partie de l'article implique l'examen de la rigidité du système dans le domaine de grandes déformations. Des conditions de contact complet sont examinées et des graphiques correspondants sont réalisés permettant le calcul de la réduction des composants de rigidité avec l'augmentation de la rotation et du déplacement.

1 PREFACE

Various publications in the past decades have tackled the subject of elastic static or dynamic stiffnesses for various foundation shapes and types [i.e. Poulos & Davis, 1974; Gazetas, 1983, 1987, 1991; Roesset, 1980; Doherty & Deeks, 2003, 2005; Doherty et al., 2005]. Recently, a methodology including the geometrical and material nonlinearities for the case of a surface footing lying on an undrained soil stratum was introduced by Gazetas et al. [2012], in which the effective nonlinear rocking stiffness of the system is estimated. Through an iterative procedure, the proposed method provides an accurate prediction of the foundation response in the large strain domain.

Far more little work has been conducted to define the elastic let alone the nonlinear stiffness coefficients of a suction caisson. Just recently, Doherty et al. [2005] estimated the purely elastic stiffness coefficients for various cases of skirt embedment, Poisson's ratio as well as skirt flexibility.

2 ELASTIC STIFFNESSES OF A SUCTION CAISSON

2.1 Modified elastic stiffness coefficients for Circular Solid Embedded Foundations

The expressions that have been formed in previous works for embedded foundations are all for a reference point at the bottom of the foundation. In producing relationships between embedded and skirted foundations, this would be inconvenient since the skirts are also flexible and the relative position of the reference point (with the exception of fully rigid skirts) would change depending on the degree of flexibility. Thus, the first step in deducing these expressions must be the translation of the load reference point to the top of the foundation, which is rigid in all cases.

In Figure 1, the absolute displacement of the reference point at the top as well as the transformed moment is shown for small rotations of the solid foundation.

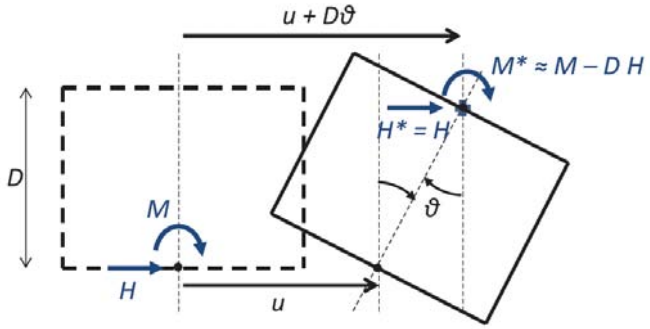

Figure 1. Change in absolute displacement and moment if the load reference point is taken at the top of the foundation

Below, expressions of the stiffness matrix will be used in conjunction with the moment and displacement definitions from **Figure 1** to deduce the same expressions for a change in the load reference point to the top of the foundation. The subscript *b* denotes that the variable refers to the bottom of the foundation, whereas the subscript *t* refers to the top. Since the vertical stiffness clearly remains the same wherever the reference point is taken, it will not be added to the operations below.

$$M_b = K_{R_b}\theta + K_{C_b}u \quad (1)$$

$$H_b = K_{C_b}\theta + K_{H_b}u \quad (2)$$

$$M_t = K_{R_t}\theta - K_{C_t}(u + D\theta) \quad (3)$$

$$H_t = -K_{C_t}\theta + K_{H_t}(u + D\theta) \quad (4)$$

The signs of the cross-coupling stiffness coefficients have been chosen so as to ensure that the coupling terms will have a positive value. Therefore, when referring to the top, when a horizontal force acts on it, the foundation tends to rotate and an opposite-direction moment must be applied to resist this rotation; thus the coupling term will have a negative sign. In the same manner the positive sign was taken for the coupling term at the base of the foundation. Three additional equations are needed to define the horizontal and rocking stiffness coefficients as well as the coupling term at the top of the caisson; one equation that can help in this transformation is that relating the moment at the top (Mt) to the moment (Mb) and shear force (H_b) at the bottom of the foundation:

$$M_t \approx M_b - H_b D \quad (5)$$

The second equation is the equality of the horizontal forces, for any reference point taken at the foundation:

$$H_t = H_b \quad (6)$$

Only one equation remains to make the system determinate. This can be given by any of the two cases shown in Figure 2, where either the horizontal displacement (2 a) or the rotation (2 b) of the foundation is constrained ($u = 0$ or $\theta = 0$ respectively). The solution of the system is given below:

$$\begin{Bmatrix} K_{H_t} \\ K_{R_t} \\ K_{C_t} \end{Bmatrix} = \begin{Bmatrix} K_{H_b} \\ K_{R_b} + \left(K_{H_b} D - 2K_{C_b}\right) D \\ K_{H_b} D - K_{C_b} \end{Bmatrix} \quad (7)$$

The vertical stiffness of the foundation obviously remains the same. Thus, with (7) the equations that have been derived for the base of the embedded foundations can be easily translated to the top of the foundation.

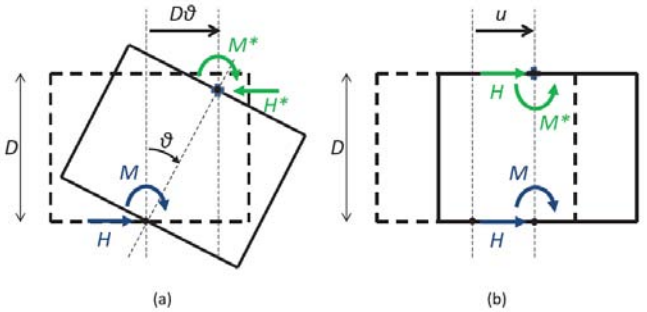

Figure 2. Sub-cases of Figure 1: (a) imposed rotation at the base with constrained displacement and (b) imposed horizontal displacement with constrained rotation.

The transformed expressions calculating the stiffness for the reference point at the top of the foundation, according to Gazetas

$$K_V = \frac{4GR}{1-\nu}\left(1 + 1.3\frac{R}{H}\right)\left(1 + 0.55\frac{D}{R}\right)\left[1 + \left(0.85 - 0.28\frac{D}{R}\right)\frac{D}{H-D}\right] \quad (8)$$

$$K_H = \frac{8GR}{2-\nu}\left(1 + 0.5\frac{R}{H}\right)\left(1 + \frac{D}{R}\right)\left(1 + 1.25\frac{D}{H}\right) \quad (9)$$

$$K_R = \frac{8GR^3}{3(1-\nu)}\left(1 + 0.17\frac{R}{H}\right)\left(1 + 2\frac{D}{R}\right)\left(1 + 0.65\frac{D}{H}\right) + \frac{1}{3}K_H D^2 \quad (10)$$

$$K_C = \frac{2}{3}K_H D \quad (11)$$

2.2 *Elastic Stiffnesses of Circular Flexible Skirted Foundations*

Having defined suitable expressions for the elastic stiffness coefficients of cylindrical solid caissons, the second part of the process of deriving expressions for skirted foundations is to find a dimensionless parameter that will be able to produce unique stiffness values for differing soil conditions and skirt flexibility. The lid of the suction caisson is considered rigid; thence, if the skirts have a very small thickness or elastic modulus, the foundation will behave like a surface footing.

Similar to the dimensionless parameter *J* defined by Doherty et al. [2005], a new parameter is introduced as follows:

$$\mathcal{P} = \frac{E_{steel}\, t}{E_{soil}\, B} \quad (12)$$

where E_{steel} the elastic modulus for steel (usually 210 GPa), t the skirt thickness, E_{soil} Young's modulus for the soil and B the foundation diameter. By conducting several analyses where one of the above parameters was varied while the rest remained constant, it was found that indeed unique stiffnesses were defined by the value of *P* (deviation of 2% at most).

Also, for very small values of *P* the stiffness coefficients reduced to those for a surface foundation. Conversely, for very large values of *P*, the stiffness coefficients are practically equal (difference of 3-4% for large embedment ratios) with those of an equivalent solid embedded foundation.

The purpose is to elicit a "reduction" factor which when multiplied with the stiffness of the solid foundation would yield the stiffness of the equivalent skirted foundation. Therefore, the results presented are in the form of fractions of the stiffness of the solid foundation in percentile form. The variation of these results with *P* for each type of stiffness is plotted in Figures 3 to 6.

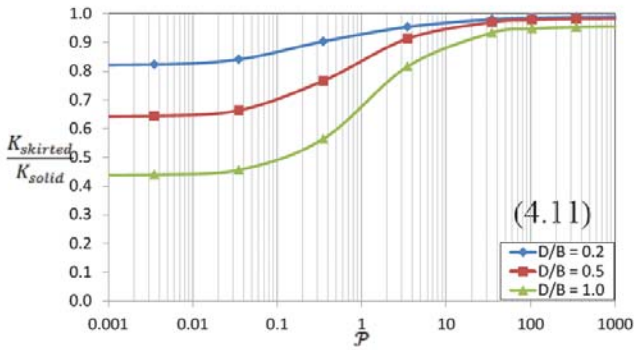

Figure 3. Ratio of the vertical stiffness of a skirted foundation over the stiffness of the equivalent solid foundation versus *P*.

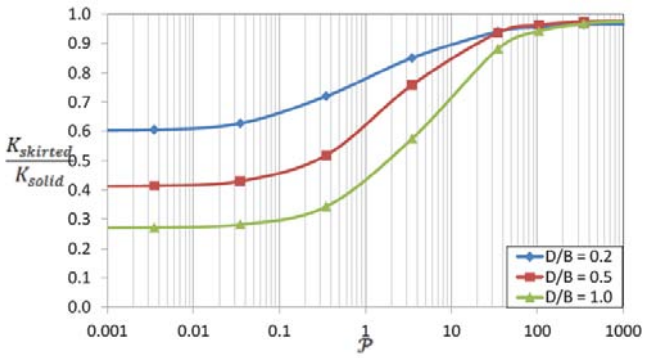

Figure 4. Ratio of the horizontal stiffness of a skirted foundation over the stiffness of the equivalent solid foundation versus *P*.

It was found that the curves produced can be approximated by the following function:

$$\mathcal{S}(p) = \frac{K_{surf}}{K_{solid}} + \frac{p\,\frac{K_{rigid} - K_{surf}}{K_{solid}}}{1+p} \quad (13)$$

where:

$$p\left(\mathcal{P}, \frac{D}{B}\right) = a\left(\frac{D}{B}\right)^{-b}\mathcal{P}^{c} \quad (14)$$

a, b, c : factors varying for each type of stiffness.

K_{surf} : stiffness of the equivalent surface foundation.

K_{solid} : stiffness of the equivalent solid embedded foundation.

K_{rigid} : stiffness of the equivalent rigid skirted foundation.

K_{rigid} is given by multiplying K_{solid} with the appropriate factor from Table 1.

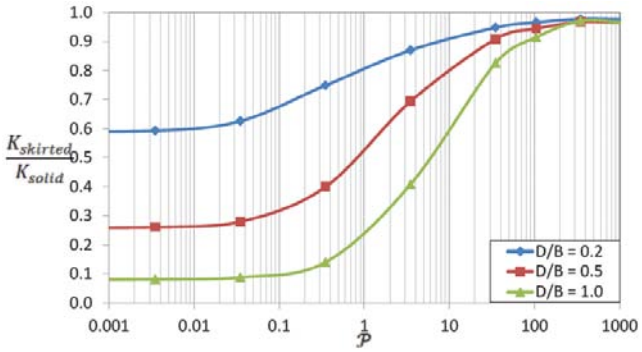

Figure 5. Ratio of rocking stiffness of a skirted foundation over the stiffness of the equivalent solid foundation vs *P*.

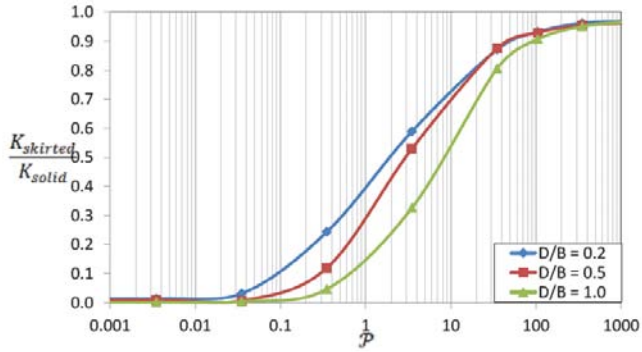

Figure 6. Ratio of the coupled swaying-rocking stiffness of a skirted foundation over the stiffness of the equivalent solid foundation plotted against *P*.

Table 1. Reduction factors for K_{rigid}

	Vertical	Horizontal	Rocking	Swayed - Rocking
K_{rigid}/K_{solid}	1 -0.04 D/B	1 -0.03 D/B	1 -0.035 D/B	1 -0.04 D/B

It can be considered as a simplification for the embedment values of interest (D/B ≤ 1) that $K_{rigid} \approx K_{solid}$. Table 2 presents the values for factors *a, b* and *c* for each type of stiffness as well as the maximum error between (13) and the finite element analysis results.

Table 2 Coefficient Values and maximum Error for Equation (13)

Stiffness	a	b	c	Error
K_V	0.9	0.5	0.85	1.4%
K_H	0.3	0.75	0.8	1.8%
K_R	0.25	1	0.8	3.4%
K_C	0.2	0.7	0.85	5.6%

3 NONLINEAR STIFFNESS COEFFICIENTS

3.1 Generalities

The elastic stiffness coefficients may only be considered approximately correct in the small-strain domain. For large displacements or rotations, geometric and material nonlinearities start to affect the response of the system and the expressions derived previously are no longer applicable. Thus, it is important that the behavior of the system be investigated as it enters the plastic domain and soil yielding, sliding, detachment and even uplift govern its response.

In order to reduce complexity of this strongly nonlinear problem, the skirts are initially considered rigid while "full contact" conditions are assumed at the soil-foundation interface. Again, three embedment ratios (D/B = 0.2, 0.5 and 1) will be the subjects of investigation for this section. Only results for the horizontal, rocking and cross-coupling stiffness coefficients will be presented.

3.2 Nonlinear Stiffness for very high FSV values

Following Gazetas et al. [2012] recommendation, the effective rocking stiffness degradation is defined as a function of the initial Factor of Safety against vertical loading (FS) and the level of imposed deformation u [K(u,FS) / (K(0,FS)]. In this study the stiffness degradation coefficient is examined only for very high factors of safety (i.e. FS ≈ 97) - a quite typical loading condition for offshore wind-turbines. For such high values of FS the K (0, FS) term is practically the elastic term defined in the previous paragraph.

Results are shown for the horizontal and coupled swaying-rocking stiffness in Figures 7 and 8. The cross-coupling term of Figure 8 has been derived from analyses with imposed zero rotation and horizontal displacement to failure. Note that in Figure 7 the imposed displacement u is divided by the term u_t (to produce the nondimensional term u/u_t) where:

$$u_t = B\left(1 + 0.8\left(\frac{D}{B}\right)^{0.7}\right) \quad (15)$$

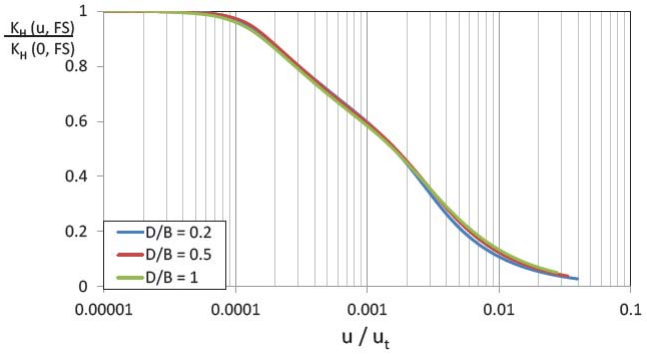

Figure 7. Dimensionless chart of the reduction in the horizontal stiffness with increasing horizontal displacement, under zero rotation and full contact conditions.

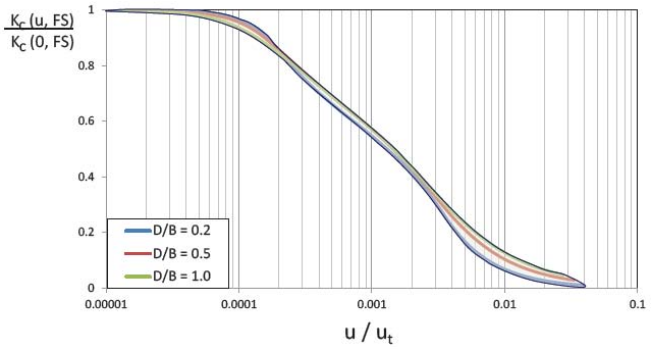

Figure 8. Dimensionless chart of the reduction in the coupled swaying-rocking stiffness with increasing horizontal displacement, under zero rotation and full contact conditions.

With this operation all curves (irrespectively of the embedment depth of the suction caisson) fall practically within a unique line (maximum deviation for horizontal stiffness less than 2% and for crosscoupling stiffness less than 7%). The "bumps" present in the curves reflect the shaping of new failure zones beneath, around and within the skirts as they temporarily relieve the ones already formed due to excess displacements/rotations.

The same procedure as above is carried out for the rocking stiffness and cross-coupling stiffness derived from imposed rotation with zero horizontal displacement. Figures 9 and 10

represent dimensionless charts where the reduction in the rocking stiffness and cross-coupling term with increasing rotation is plotted against the angle of rotation normalized by a parameter similar to u_t, namely θ_t, which is equal to:

$$\vartheta_t = \left(1 - 0.2\left(\frac{D}{B}\right)^2\right) \qquad (4.19) \qquad (16)$$

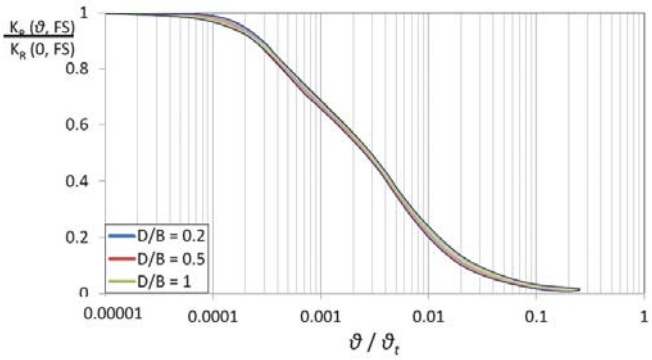

Figure 9. Dimensionless chart of the reduction in the rocking stiffness with increasing rotation, for zero displacement and full contact conditions.

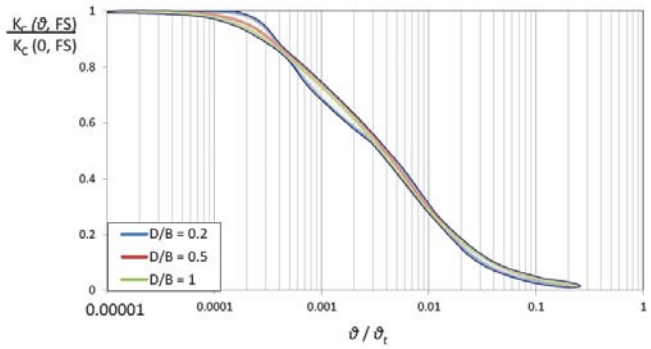

Figure 10. Dimensionless chart of the reduction in the coupled swaying-rocking stiffness with increasing rotation, for zero displacement and full contact conditions.

4 CONCLUSIONS

The stiffness of the soil-foundation system was investigated both in the elastic domain and when nonlinearities are considered. Expressions from the literature were used to identify the stiffness matrix of a solid embedded foundation with the load reference point at its top.

Following, expressions for the stiffness components of flexible skirted foundations were engendered for variations in the characteristics of the system normalized by a parameter that produced unique stiffness values. These were evaluated with other methodologies in the literature and their difference was considered within reasonable limits.

The second part of this paper involved the investigation of the stiffness of the system in the large-strain domain. Full contact was examined and corresponding charts were produced that showed the reduction in the stiffness components with increasing rotations and displacements, giving the ability of estimating with an iterative procedure the true displacement and rotation of the foundation for imposed horizontal and moment loading.

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Pumped storage hydropower round-up

The benefits pumped storage has to offer are such that its value is soaring as energy systems move toward cleaner forms of electricity generation. Pumped hydro is consequently attracting significant global investment.

David Appleyard
Chief Editor of HRW – Hydro Review Worldwide magazine

In May this year the International Hydropower Association (IHA) released its 2015 Key Trends in Hydropower report, showing that 1.46 GW of new pumped storage capacity was put into operation in 2014.

It is clear that the advantages of pumped hydro in terms of voltage and frequency regulation of the grid and reserve capacity capabilities make the technology increasingly attractive, particularly in the face of the increasing influence of variable output renewables such as wind and solar.

The IHA says in Europe, pumped storage continues to be a focus, with new facilities totalling 8,600 MW in the planning and construction stages.

Developments in variable-speed technology are expected to be a key component of this new capacity, the IHA adds.

Europe is pushing forward with a swathe of new pumped storage projects with new build and refurbishment and replacement of electromechanicals and uprating civils.

For example, global technology manufacturer Alstom recently received an order from Vattenfall Europe Generation AG for the overhaul of a synchronous generator at the 1,050 MW Markersbach pumped-storage plant on Germany's Mittweida River.

A contractual option covers the overhaul of Markersbach's four remaining generators at a rate of one unit per year.

Markersbach was commissioned in 1979 and is the second-largest pumped-storage project in Germany.

Vattenfall Europe Generation, the German unit of Sweden-based Vattenfall AB, has performed numerous modifications to Markersbach since it was put into operation. In 2013, it took bids to expand the upper and lower reservoirs of the project. In 2012, the utility took bids for concrete work at 11 hydro projects including Markersbach. Most recently, Vattenfall sought bids to upgrade and repair pump-turbines and other equipment in March 2014.

Elsewhere in Germany, March saw a unit of European utility Statkraft invite applications to expand the water storage capacity of the 200 MW Erzhausen Pumped-Storage project in Germany, built in 1964.

Work would involve the crest of the ring dam and intake structure of the upper reservoir, the overflow threshold at the pumping station and the water side embankment slope of the lower reservoir's main dam.

In 2014, Voith announced that it had been awarded a contract by E.ON Kraftwerke GmbH involving the replacement, assembly and commissioning of the stator and rotor of the generator in unit 6 at the Waldeck 2 pumped storage power plant, in North Hesse, Germany. The contract includes an option for the modernization of a further machine. Construction of the original power plant took place in 1970.

The project should ensure an increase of about 10% in efficiency of the machine unit.

This year Voith has also been commissioned to modernize four motor-generators at the 1,290 MW Vianden pumped storage plant in Luxemburg. The project includes design, construction and installation of four rotors.

Vianden is located close to the border between with Germany and feeds directly into the German power network. The plant is owned by Societé Electrique de l'Our S.A. and is marketed and used by RWE Generation.

A swathe of new pumped storage development is underway. Source: Vattenfall

The plant was first set into operation in 1964. After expansions in 1976 and 2014, the total installed pump capacity is 1045 MW.

Germany's pumped-storage power plants have a combined capacity of about 7 GW, but a recent study by the Rheinisch-Westfälische Technische Hochschule (RWTH) Aachen University and Voith indicates there is potential to add to nearly 24 GW of new pumped-storage capacity in the states of Baden-Württemberg and Thuringia.

Dr. Andreas Schäfer, chief engineer at the Institute for Electric Plants and Energy at RWTH Aachen, commented: "Pumped-storage plants would offer important systems services, especially for control reserves, but also for the provision of secured outputs. In this way, pumped-storage systems can make a contribution to the success of the energy transition."

The study shows that with a 60% share of renewables, about 2 TWh of renewable electricity can be additionally utilized if pump storage capacity in Germany is increased to a total capacity of 15 GW.

Stephan Kohler, Chairman of the Board of Deutsche Energie-Agentur (dena), argues that more should be done to recognise the ancillary services potential of pumped hydro: "Pumped storage power plants should be given first priority, because they are the only existing industrial-scale power storage systems and, beyond that, also make many valuable contributions to the power grid. We have to adapt the framework conditions in such a way, that this added value is also adequately remunerated."

In neighbouring Austria, this year saw the civil engineering contract for a new 940 MW pumped-storage plant.

Pumpspeicherkraftwerk Koralm GmbH has selected ILF Consulting Engineers and AF-Consult to provide engineering services for the Koralm project in Austria.

The Koralm plant will include an upper and lower reservoir, headrace, penstock and tailrace, surge tank, cavern powerhouse and access tunnel, transmission line and switchyard. The plant is expected to have a head of about 650 m and will the largest hydroelectric plant in Austria upon its completion.

Austria is also home to the new Ober-vermuntwerk II and Rellswerk pumped storage projects, which are located in Montafon, Vorarlberg. Voith will supply the energy provider

Vorarlberger Ill-were AG with two pumps and a pump turbine for the two projects under the terms of a contract announced in December 2014. The Obervermuntwerk II pumped-storage power plant is being constructed between the Silvretta and Vermunt reservoirs at an altitude of around 1700 m.

For the Obervermuntwerk II, Voith is to supply, assemble and commission two 170 MW storage pumps. For the new Rellswerk project, Voith Hydro will supply a 13 MW, 3-stage pump turbine.

Over in Portugal EDP – Gestão da Produção de Energia, S.A., awarded an ANDRITZ HYDRO-led consortium an order for the supply and erection of the complete electromechanical equipment for the pumped storage project Foz Tua.

The contract includes two reversible pump turbines of 120 MW each and the station will be erected on the river Tua, a tributary of the Douro River in the north of Portugal.

Portuguese pumped storage also got a boost in 2015 with the delivery of a spherical valve to be installed at the 383 MW Frades 2 pumped-storage hydro plant. The 170 tonne component is one of two that will control flows through the Frades 2 plant's pair of reversible pump turbines on the left bank of the Cavado River.

Refurbishment of pumped storage can significantly increase capacity. Source: Vattenfall.

The Americas

Although only Argentina is the only South American country to have installed significant pump storage capacity to date, the technology is certainly under consideration. In a novel application, for example, proposals have been put forward that would see a 600 MW solar plant coupled with a 300 MW pump-storage facility in Chile. According to the proposals from developer Valhalla Energy and submitted to Chile's environmental regulatory authorities (Servicio de Evaluación Ambiental, SEIA), the hydroelectric pumped-storage plant set for the northern Tarapaca region will use seawater.

The so-called 'Mirror of Tarapaca' project is expected to require an investment of some US$1 billion.

While South America has seen very limited pumped-storage development to date, North America is on a roll, with a raft of announcements suggestive of a buoyant market for additional pumped storage capacity.

In September, for example, GB Energy Park LLC and Alstom announced an agreement for equipment supply for the 400 MW Gordon Butte project.

A closed-loop pumped storage facility in south central Montana, it will consist of upper and lower reservoirs connected by an underground concrete and steel-lined hydraulic shaft. The head between the two reservoirs if 1,025 feet. The powerhouse will contain four pump-turbine units with total installed capacity of 400 MW and expected annual energy generation of 1,300 GWh.

This followed news that San Diego is to pursue a two-year, $900,000 study of the proposed San Vicente pumped-storage hydropower project that would involve the construction of a 240 to 500 MW hydroelectric plant using the existing San Vicente Dam and reservoir.

This year also saw United Power Corp. file an application to study development of the 30 MW South Maui Pumped-Storage project on the south coast of Maui Island, Hawaii. This project would also use seawater from the Pacific Ocean.

The proposed project includes an upper reservoir composed of four concrete storage tanks and a powerhouse containing three 10 MW variable-speed pumps and two 15 MW variable-speed Pelton turbine-generators. Estimated annual generation is 5.2 GWh.

And, in a recent development, an affiliate of Eagle Crest Energy has agreed to buy the Kaiser Eagle Mountain mine near Desert Center, California, as part of a plan to create a new pumped storage hydropower plant from two of the iron ore mine's vacant pits.

The project is expected to have a capacity of up to 1,300 MW.

Africa's pumped hydro ambitions

Although a vast tranche of Africa's conventional hydropower potential has yet to be developed, pumped storage projects are nonetheless underway.

In South Africa, incumbent utility Eskom is increasing its pumped storage capacity with a new project set to be commissioned this year. Eskom's operational pumped-storage schemes include the 1,000 MW Drakensberg in the mountains of the Northern Drakensberg of KwaZulu-Natal and the 400 MW Palmiet, 2 km upstream of Kogelberg Dam on the Palmiet River near Cape Town.

A third pumped-storage site, the 1,332 MW Ingula project, is being constructed 55 km from Ladysmith, within the Drakensberg range, on the border between the Free State and KwaZulu-Natal provinces. The scheme is being built on a 9,000 ha site at a cost of RND8.9 billion.

Development of the pumped storage scheme was first proposed in 2002. Construction encompasses two dams for the upper and lower reservoirs; a powerhouse, two tunnels, access roads and transmission lines. The underground powerhouse contains four 333 MW pump turbines.

And, in July this year, the Lesotho Highlands Development Authority (LHDA) issued a tender call for economic studies and development arrangements for the 1200 MW Kobong Pumped-Storage project.

South Africa's Cabinet agreed in 2008 to invest US$712 million in the Lesotho Highlands Water Project (LHWP) Phase 2, which includes construction of Kobong Pumped-Storage project, Polihali Dam as upper reservoir for Kobong, a Polihali-Katse transfer tunnel, roads and associated environmental and social programs.

A contract was recently awarded to Maleka, Ntshihlele, Putsoa Joint Venture for 8 million maloti (US$648,397) for demarcation of Polihali Reservoir.

Asia expands PS projects

Asia, too, is seeing its share of development. Recently, a consortium led by South Korean builder Daelim Industrial Co., was selected to build the 1040 MW Upper Cisokan pumped storage hydropower plant in Indonesia's West Java province.

The consortium also includes Italian construction firm Astaldi SpA and Indonesia's Wijaya Karya (WIKA). Being developed on behalf of Indonesian utility PLN, the deal is worth about US$323 million.

Financing for the project is coming in large part from the World Bank.

In July, Nepal advanced the development of its first pumped storage hydro project, as Tanahu Hydropower Ltd awarded contracts to engineering firm Lahmeyer International GmbH and sub-consultant Manitoba Hydro International. The contracts relate to the development of the 140 MW Tanahu pumped-storage project.

Tanahu will be located on the Seti River about 100 km from Kathmandu. The project's upper reservoir will be impounded by a 140-meter-tall gravity dam.

More recently, in September, Voith was awarded a new contract to supply electromechanical equipment for a pumped storage plant in Thailand. The order is for the extension of the Lam Ta Khong plant and includes the supply of two motor-generators and two 255 MW vertical pump turbines.

Located on the Lam Ta Khong River 200 km northeast of Bangkok, the extension project will double the capacity to a total of 1000 MW.

Australia, too, is looking to expand its pumped storage capacity as Genex Power has appointed consulting firm Entura to provide a feasibility study for the 330 MW Kidston pumped-storage hydropower plant, proposed for construction in North Queensland, Australia, at the site of the Kidston Gold Mine. The project includes two large adjacent pits that would act as the plant's upper and lower reservoirs [see box panel].

In a nod to further development in the eastern hemisphere, August saw Russia's PJSC RusHydro and the Korean Water Resources Corp. jointly look to develop a pumped-storage hydroelectric plant in Russia's Far East.

RusHydro and K-Water will create a working group to study the feasibility of the Primorsky Energy and Water Resources Complex (PEWC), including the Primorskaya pumped storage plant.

Of course, China cannot be ignored when it comes to pumped storage. Last year Hainan Pumped Storage Power Generation Co. Ltd. awarded a US$71.14 million contract to Alstom to equip the 600 MW Hainan Qiongzhong pumped-storage plant.

Hainan Province's first pumped-storage project operations are due in December 2017.

Under the terms of the deal, Alstom will provide three 200 MW turbine units, including pump turbines, motor generators and other equipment.

Outlook for pumped storage hydro

According to the IHA, the world's total pumped storage capacity now stands at some 142 GW, increasing by something north of 10% during 2014 alone. Clearly, there is a strong appetite not just for new build pumped storage, but also refurbishment and rehabilitation. This push for additional pumped storage capacity has a number of drivers, but chief among them is the headlong rush for more solar and wind power, renewable energy technologies that require back-up if security of energy supply is to be maintained. Pumped storage is an ideal solution, if not the only realistically economical one. As such, demand for its ample utility in service is likely to grow in the coming decades as the global economy inexorably shifts toward a clean energy system.

Glyn Rhonwy quarry pumped storage

Although the nearby 1800 MW pumped storage plant Dinorwig has been operating since the 1980s, development of pumped storage capacity is still being actively pursued in Snowdonia, the mountainous region of north Wales, in the UK.

If plans proceed to construction, two abandoned slate quarries, Glyn Rhonwy and Chwarel Fawr, are set to be the basis of the UK's first new pumped storage capacity for several decades.

First mooted in 2012, in April this year, the UK's Crown Estate agreed to lease 13 Ha of land to Snowdonia Pumped Hydro for its £100 million (US$155 million) project. This followed the granting of planning permission in September 2013.

The project includes the construction of a 20-metre-high dam on the upper reservoir at Chwarel Fawr and a 15-metre-high dam on the lower reservoir at Glyn Rhonwy.

Originally, the Glyn Rhonwy plant had been planned as a 49.9 MW capacity installation, that proposal was increased by a further 50 MW in December last year, pushing the application to the UK Planning Inspectorate.

The proposed change in output, involves installing larger turbines and associated equipment within the powerhouse, now expected to be operational by 2019.

Snowdonia Pumped Hydro is a subsidiary of Quarry Battery Company, which together with AECOM developed a preferred design, including the dams and a cut and fill pen stock.

Construction is anticipated to take 3 to 5 years with the upper reservoir holding some 1.1 billion litres.

The developers see a strong business case for a multitude of such brownfield sites, with their relatively low additional infrastructure costs and minimal visual and environmental impact.

"By continuing to utilize unconventional sites such as the abandoned quarry on The Crown Estate's land, Britain can realize an additional 15 GW of grid-scale storage using pumped hydro technology alone," said Peter Taylor, chairman of Quarry Battery.

The company is proposing a new generation of small-scale pumped storage facilities, arguing that they are economically viable and environmentally more acceptable.

Last year it secured a further £3 million (US$4.8 million) in private funding for initial work at the site, near Llanberis and it is in negotiations to secure five further sites from a short list of 30 identified potentials.

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www.hydroworld.com

ΝΕΑ ΑΠΟ ΤΙΣ ΕΛΛΗΝΙΚΕΣ ΚΑΙ ΔΙΕΘΝΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΝΩΣΕΙΣ

ISSMGE Webinars
(www.issmge.org)

Samuel I.K Ampadu (Ghana)
December 2015
Characterizing lateritic soils

Serge Leroueil (Canada)
January 2016
Consolidation and creep

Announcing the Publication of the 2015 Geotechnical Business Directory in print, as e-book and as an online platform. Preparations ongoing for the 2016 Geotechnical Directory

GeoWorld is excited to announce the publication of the inaugural 2015 Geotechnical Business Directory! The directory that was announced to the 80+ member countries of ISSMGE in September in the Edinburgh, during the European Conference on Soil Mechanics and Geotechnical Engineering, is now widely available. This truly unique directory is available in three formats as:

- an Online Interactive Platform
- an e-book
- in-print through Amazon

The 2015 directory includes 5000+ individuals, and 300+ geo-companies and geo-organizations from 135 countries. The online platform allow visitors to search the membership database based on location, technical expertise, and qualifications. It is expected to reach more than 50,000 professionals.

The Geotechnical Business Directory is continuously updated. The e-book and in-print version is going to be circulated annually. Preparations are already ongoing for the publication of the 2016 Business Directory that is expected to include 6000+ individuals and 500+ companies in the geo-profession, and have increased functionalities.

Please visit this page to update your professional information so that your professional record is accurate!

Individuals who are not yet members of GeoWorld are encouraged to see the Individual and join GeoWorld here.

Also, encourage your company to establish a GeoWorld profile so that it can be included in the business directory. See our 2016 Advertising Media Kit!

Note that as an individual member of GeoWorld, you will be included in the directory, unless you choose to opt-out.

On behalf of GeoWorld team.

Research study on Dams

We would like to draw your attention to a research project by scholars from the University of Cambridge and University of Oxford in the UK, looking at current trends and developments in the global dam industry. They are seeking to gather data on **cost and time overruns of dam projects completed since 2000**, and have asked for our help to reach the survey's **target group** of **dam developers /owners and engineers**. If you have information about any dam project(s) completed since 2000, we hope that you might assist by answering a few survey questions (it is quick to complete); all the responses will be anonymized in the statistical results.

Here is a link to the survey. The intention is for the results gathered via this survey to be presented at next year's HYDRO 2016 conference in Montreux.

2015 ITA TUNNELLING AWARDS WINNERS

MAJOR PROJECT OF THE YEAR (OVER €500M)

Eurasia Tunnel Project

The Eurasia Tunnel Project (Istanbul Strait Road Tube Crossing Project) will connect the Asian and European sides via a highway tunnel going underneath the Bosphorus. The project is being constructed by a Joint Venture (YMSK-JV) formed under the leadership of Turkish firm Yapı Merkezi and South Korean firm SK E&C. 5.4 kilometers of the project will comprise a twostory tunnel to be constructed underneath the seabed using special technology To successfully deal with the complex challenges at the Istanbul Strait Road Tube Crossing Project, the 13.7m Mixshield from Herrenknecht was designed exclusively for the construction joint venture and included a number of specially developed features such as 19' disc cutters with internal pressure compensation device or a hyperbaric transfer shuttle Specifically innovated, developed and designed seismic joints that can resist under 12 bar pressure were installed to accommodate differential displacements at proper locations at the transition zones between rock and soft soils.

TUNNELLING PROJECT OF THE YEAR (BETWEEN €50M AND €500M)

1st Phase of Low and Intermediate Level Radioactive Waste Disposal Facility Construction

The chosen site can hold 800,000 drums (160,000m3) of LILW. In this project, which is the 1st Phase of LILW Disposal Facility Construction, a disposal facility was constructed to store 100,000 drums (20,000m3) of LILW. A disposal facility consists of six silos storing LILW and a 3.9km access tunnel. For the geometrical shape of silos, the shape of a dome and a cylinder was chosen to ensure both the mechanical stability and the maximum storage space with less excavation. Such deep underground space for a disposal facility of LILW was constructed solely in Finland and Sweden where geotechnical condition is relatively good compared to Korea's. It is believed that the technology acquired from the construction of a disposal facility for radioactive waste will be a good example of the construction of a disposal facility for 98 nuclear plants located in Korea, China, and Japan.

OUTSTANDING PROJECT OF THE YEAR (UP TO €50M)

Norsborg Metro Depot

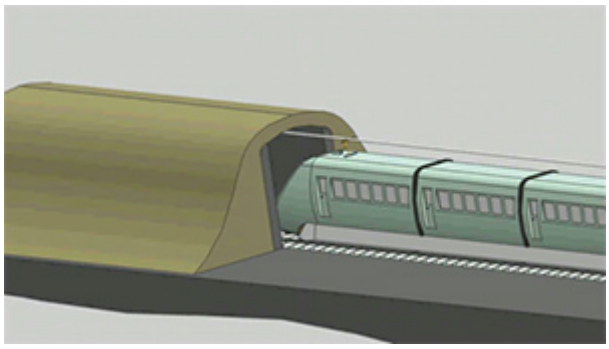
The Norsborg Metro Depot is an important part of the development of the Stockholm metro system. The depot will provide storage, train wash and service areas for 17 trains and will also be a working place for 100 employees. The depot is located underground in hard rock. It consists of three rock caverns, 300 by 24 meters each, connecting tunnels and areas for technical equipment. Conventional drill and blast method with top modern equipment was used. The total rock volume is 320 000 cubic meters and the total length of the tunnels and caverns is 3000 meter. The scope of the project led to the division into two contracts:

- one consisting in the excavation and the waterproofing of the tunnels and caverns
- one consisting of the buildings, installations and the tracks.

Between 2013 and 2015 Skanska excavated the tunnels and caverns that will serve as storage for the metro depot. The complete depot is to be finished in 2017.

TECHNICAL INNOVATION OF THE YEAR

Innovative Vehicle-mounted GPR Technique for Fast and Efficient Monitoring of Tunnel Lining Structure Conditions



A noncontact nondestructive testing technique in the field of operation tunnel health status evaluation, whose air-

launched antennas can detect linings and surrounding rock conditions at 0.9~2.25m distance between the antenna away from the tunnel walls. We have completed the inspection of 91 tunnels with a total 122 km by Railway vehicle-mounted GPR technique. The test tunnels are located in the Baoji-Zhongwei line, Xiangfan-Chongqing line under the jurisdiction of Xi'an Railway Bureau. Just as the old line of Xiangfan-Chongqing line, where the tunnels approaching to the design life, aging problem is particularly prominent Railway vehicle-mounted GPR technique for tunnel detection can detect the tunnel linings of national railway network and complete the tunnel defect census in a short time. This technique solves the major problems on national railway network tunnel safety inspection and has obvious social benefits.

ENVIRONMENTAL INITIATIVE OF THE YEAR

The Corrib Tunnel Project - tunnelling in environmentally sensitive area

Construction of 4.9km TBM tunnel incl. the fit-out with a gas pipeline and the backfilling of the tunnel. The client SEPIL decided to install the 20' gas pipeline with all its relevant accessory components in this sensitive nature reserve in a tunnel. The tunnel was to be driven in advance by mechanized means with the residual tunnel cross-section subsequently being backfilled. The final alignment of the onshore pipeline section was the result of an intensive development process with the aim to minimise and mitigate the potential for impact of the proposed route on the receiving environment. The key criterion in the identification of the modified route, underpassing the Sruwaddacon Bay between Glengad and Aughoose, was the trenchless underground construction of a 4.9 km long section due to the environmental impact of its location.

SAFETY INITIATIVE OF THE YEAR

MineARC Systems Compressed Air Management Solution

Emergency refuge forms an integral part of a tunnelling project's wider Emergency Response Plan (ERP). In an emergency situation (such as a tunnel fire), when evacuation is no-longer safe or practical, a refuge chamber is designed to provide a safe and secure 'go-to' area for personnel to gather and await extraction. In looking for a solution to the ITA Guideline's requirement for the use of compressed air and to maintain positive pressure to refuge chambers to avoid ingress of toxins, MineARC's engineering team developed a breathable air system that is unique to the market; offering a range of new features aimed at reducing running costs and improving operational safety during an emergency. This system is called the Compressed Air Management System or CAMS.

INNOVATIVE USE OF UNDERGROUND SPACE

Toledo Metro Station on Line 1 in Naples

The Toledo Station is a unique example of a decentralised museum, offering dynamic fruition of the artists' creations, as the citizens have the possibility to travel an open artistic itinerary. Building the station has involved the re-systemisation of the surrounding urban context. In fact, the underground works include a long pedestrian passageway starting from the service tunnel, and linking the pedestrian platforms to the secondary exit in Piazzetta Montecalvario, a square that has been regenerated and re-qualified with positive effects for the surrounding Spanish Quarters (built in the sixteenth century under the Spanish Viceroy). In addition to the underground works, part of the Via Diaz above the main shaft, has now become a broad pedestrian square. Trees were planted in the narrow area whilst along the southern perimeter, parasols have been arranged to protect the street stalls that were formerly scattered over the pavement in Vesuvian basalt, lending grace and comfort to the area.

YOUNG TUNNELLER OF THE YEAR

Karlovsek Jurij

Jurij is a Civil Engineer, specialising in Geotechnical Engineering, and Tunnelling in particular. His philosophy is grounded in the belief that industry and academia should work together in the pursuit of excellence and innovation. He currently works as a Postdoctoral Research Fellow at The

University of Queensland, Australia where he recently obtained his PhD in the field of TBM segmental lining integrity detection. Jurij's professional career to date spans three continents, with experience in both academia and industry Jurij's latest achievement is his position as founding Chair of the International Tunnelling Association and Underground Space Young Members' Group.

(σ.ε. Στον «μικρό κατάλογο» των υποψηφίων για το βραβείο είχε επιλεγεί και το μέλος της ΕΕΕΕΓΜ Δρ. Πέτρος Φορτσάκης)

CONTRACTOR OF THE YEAR

Salini Impregilo is operative in over 50 countries with roughly 34,400 employees and a turnover of about € 4.2 billion (as at 31-12-2014). The Group is a pure player in the construction sector, with 110 years of experience, focusing on complex and large civil engineering projects: dams and hydroelectric plants, railways and subways, roads and highways, civil, industrial construction and airports. The Group track-record includes:

- 230 dams and hydroelectric plants;
- 1,350 km of underground works;
- 6,730 km of railways;
- 375 km of metro systems;
- 36,500 km of roads and motorways;
- 330 km of bridges and viaducts.

The management and the entire Group are committed to operating in accordance with environmental, ethical and professional principles, which comply with the highest international criteria for corporategovernance and citizenship.

ENGINEERING OF THE YEAR

WSP and Parsons Brinckerhoff have combined and are now one of the world's leading engineering professional services consulting firms. Together we provide services to transform the built environment and restore the natural environment, and our expertise ranges from environmental remediation to urban planning, from engineering iconic buildings to designing sustainable transport networks, and from developing the energy sources of the future to enabling new ways of extracting essential resources. We have approximately 34,500 employees, including engineers, technicians, scientists, architects, planners, surveyors, program and construction management professionals, and various environmental experts. We are based in more than 500 offices across 40 countries worldwide. www.wspgroup.com www.pbworld.com.

LIFETIME ACHIEVEMENT

Prof. Dr. Eng. Sebastiano PELIZZA

Degree in Mining Engineering, 1961 Politecnico di Torino (University of Technology)

Full Professor at the University of Technology of Turin on "Tunnel Construction"

Head of TUSC - Tunneling and Underground-Space Center, Turin University of Technology

Scientific Director and teacher of the one year post-graduate Master Course on "Tunnelling and Tunnel Boring Machines", Turin University of Technology

Coordinator of 2 PhD works (2003-2005) to study EPB machines face stability and ground conditioning.

Since 2010 – Member of the Committee of Surayors of ITA/AITES

Academic Carrier

Courses, Seminars and Special Conferences on tunneling and underground works

1995 KTA Seoul
1995 Perhapi, Jakarta
1995-1997 Ecole Polytechnique Fédérale de Lausanne
1996 Sinotech, Taipei
1996 RTA, Brashov
1996 SPEA, Rome
1997 Railway Communication University, Saint Petersburg
1997 CBIP, New Delhi
1997 IAEG, Athens
1998 Workshop on Selection of Tunneling Methods, Sao Paulo
1999 Seminar Special Geotechnical Problems, Melbourne
2000 Long TBM Driven Tunnels, Institution of Engineers of Malaysia
2001 International Center for Geotechnics and Underground Construction (Sargan –CH)
2001 Keynote Speach Workshop "Tunnel Boring Machines and Related Engineering Practice", Beijng
2005 Lesson on "Tunnel design", Training course of ITA/AITES, Istanbul
2006 Inaugural Lecture of the Academic Year 2006-2007 of the Politecnico di Torino

Awards

1983 Eurotunel, Basel
1996 Doctor Honoris Causa in Tunneling, Technical University of Civil Engineering, Bucharest
1998 Honorary Doctor of Railway Communication University of Saint Petersburg
Since 2001 Member of the Accademy of Science in Turin
2009 Professor Emeritus at the Politecnico di Torino

Professional Associations and Offices

Since 1995 ITA/AITES, President 1995/1998
Since 1995 SIG Società Italiana Gallerie, President 1996/1998
Since 1994 Member of the CETU Scientific Committee, Centre d'Etude des Tunnels, France
1997-2004 Editor of the Italian Journal "Tunnelling and underground construction"
Since 2000 Member of the "Dispute Resolution Board Foundation",Seattle

Since 2007 Member of the advisory board of the RMZ- Materials and Geoenvironment journal
Since 2008 Member of the Editorial Board of Journal of China University of Mining & Technology

Fields of Specialization

Engineer specialized in underground construction, soil and rock improvement and reinforcement; construcion methods and TBM tunnelling Consultant, designer and supervisor for construction of more than 100 tunnels (road, railway, subway, hydraulic) for a length of hundreds of kilometers in Italy and abroad (Turkey, Saudi Arabia, Algeria, Morocco, Venezuela, Brazil, France, Cyprus, Greece, Taiwan, Norway, India, Russia, Tunisia, Spain, USA, Hong Kong, Portugal, Santo Domingo)

Publications

Over 210 technical and scientific articles on underground constructions.

ΑΝΑΣΚΟΠΗΣΗ ΓΕΓΟΝΟΤΩΝ ΓΕΩΤΕΧΝΙΚΟΥ ΕΝΔΙΑΦΕΡΟΝΤΟΣ

ΠΑΘΗΤΙΚΗ ΣΤΑΘΕΡΟΠΟΙΗΣΗ
Μια νέα τεχνική βελτίωσης εδαφών έναντι σεισμικής ρευστοποίησης

Διεξήχθη την Παρασκευή 27 Νοεμβρίου 2015, στην Αίθουσα Εκδηλώσεων Τ.Ε.Ε., ημερίδα για την παρουσίαση των αποτελεσμάτων του ερευνητικού προγράμματος

NANO-LIQ
Mitigation of Seismic Liquefaction in the Foundation Soil of Existing Structures via Pore Fluid Enrichment with Environmentally Safe Nano-Particles
(http://nanoliq.org).

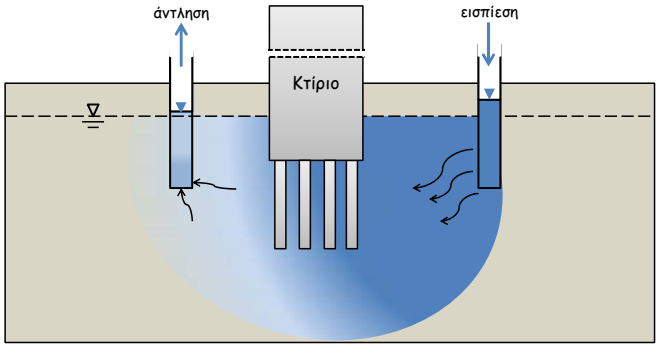
Άποψη της αίθουσας ΤΕΕ. Στο βήμα βρίσκεται ο κ. Αχιλλέας Παπαδημητρίου, Επικ. Καθηγητής ΕΜΠ και ερευνητικός υπεύθυνος του προγράμματος NANOLIQ

Ρευστοποίηση: Ένα από τα επακόλουθα ισχυρών σεισμικών διεγέρσεων, που επιφέρει παγκόσμια μεγάλες καταστροφές σε κτίρια και έργα υποδομής, όταν αυτά θεμελιώνονται σε κορεσμένα χαλαρά κοκκώδη εδάφη.

Διακριβώθηκε ως φαινόμενο τη δεκαετία του 1970, και συνεπώς ένα μεγάλο μέρος του παράλιου δομικού ιστού (και στη χώρα μας) δεν το έλαβε υπόψη του κατά το σχεδιασμό και την κατασκευή.

Το τεχνικό πρόβλημα: Σε θέσεις υφισταμένων κατασκευών θεμελιωμένων επί ρευστοποιήσιμου (χαλαρού μη συνεκτικού) εδάφους, η χρήση των περισσοτέρων από τις υπάρχουσες μεθοδολογίες βελτίωσης του εδάφους είναι είτε δυσχερής (π.χ. λόγω λειτουργίας της κατασκευής) ή αδύνατη (π.χ. λόγω των δομικών ζημιών που μπορούν να προκληθούν). Έτσι, για τη βελτίωση του εδάφους σε τέτοιες θέσεις συνήθως χρησιμοποιούνται μικροπάσσαλοι, εισπίεση ενεμάτων υψηλού ιξώδους και η έμπηξη πλαστικών στραγγιστηρίων. Όμως, οι μεθοδολογίες αυτές δεν μπορούν ευχερώς να βελτιώσουν το έδαφος σε ολόκληρη την κάτοψη του κτηρίου, ενώ μπορούν να δημιουργήσουν και προβλήματα (π.χ. η εισπίεση ενεμάτων μπορεί να προκαλέσει ανασήκωμα θεμελίων). Επιπλέον, κατά τη διάρκεια των εργασιών της βελτίωσης προκαλούνται δυσχέρειες στην κανονική λειτουργία της κατασκευής και η βελτίωση μεγάλων περιοχών αποδεικνύεται σχετικά υψηλού κόστους.

Η προτεινόμενη λύση: Μια νέα τεχνική βελτίωσης του εδάφους που δεν έχει τα ανωτέρω μειονεκτήματα και μπορεί να χρησιμοποιηθεί ευχερώς στο έδαφος θεμελίωσης υφισταμένων κατασκευών είναι η **παθητική σταθεροποίηση.** Η διήθηση του σταθεροποιητή μπορεί να γίνει με τη χρήση γεωτρήσεων υψηλού και χαμηλού υδραυλικού ύψους εκατέρωθεν της κατασκευής.



Σύμφωνα με αυτή, ο εμπλουτισμός του υγρού των πόρων του ρευστοποιήσιμου εδάφους με έναν σταθεροποιητή (περιβαλλοντικώς ασφαλή νανο-σωματίδια, π.χ. κολλοειδής πυριτία) αλλάζει τη μηχανική συμπεριφορά του συστήματος εδαφικού σκελετού – υγρού πόρων, καθιστώντας το λιγότερο ευάλωτο σε συσσώρευση διατμητικών πραμορφώσεων που σχετίζονται με τη ρευστοποίηση, και των καταστροφικών συνεπειών που έχουν αυτές για την κατασκευή..

Σκοπός του ερευνητικού προγράμματος NANO-LIQ: Δεδομένου ότι η παθητική σταθεροποίηση βρίσκεται την παρούσα χρονική στιγμή σε πειραματικό στάδιο διεθνώς, ο σκοπός της έρευνας να **διατυπώσει μια ολοκληρωμένη μεθοδολογία σχεδιασμού** για την παθητική σταθεροποίηση ρευστοποιήσιμων εδαφών, και να **την καταστήσει εφαρμόσιμη** για πρακτικές εφαρμογές μέσω διαγραμμάτων σχεδιασμού και προδιαγραφών, λαμβάνοντας υπόψη θέματα διασφάλισης ποιότητας υλικών και διαδικασιών, κόστους, διάρκειας ζωής και περιβαλλοντικών επιπτώσεων

Στη συνέχεια παραθέτουμε τα στοιχεία του προγράμματος (από τον σχετικό ιστότοπο)

Work Plan

WP1: Literature review: Material Selection – Procedures

WP2: Preliminary testing: Rheology, permeability, permeation, unconfined compression

WP3: Numerical analyses: Simulation of stabilizer delivery via groundwater flow (permeation)

WP4: Element testing: Monotonic response of stabilized-soil

WP5: Element testing: Dynamic and Cyclic response of stabilized-soil

WP6: Constitutive modeling of the mechanical response of stabilized-soil

WP7: Implementation of new constitutive model(s) in finite element FE or finite difference FD codes

WP8: Numerical analyses of boundary value problems involving stabilized-soil: Seismic response, design spectra (FE/FD) – Micromechanical response (DEM)

WP9: Seismic Soil-Structure-Interaction: Springs and dashpots (Winkler) for stabilized-soil

WP10: Design charts and Specifications for the application of passive stabilization in practice

Research Group

The combined experimental and numerical research effort is being materialized by bringing together researchers from 4 different Universities in Greece [University of Thessaly (UTh), Aristotle University of Thessaloniki (AUTh), National Technical University of Athens (NTUA), University of Patras (UP)] and an invited researcher from the USA (CalTech). They are organized in 3 distinct Research Teams, with different (but complementary) objectives and expertise, and are assisted by a select External Research Team.

Research Team 1 : Earthquake Geotechnical Engineering & Seismic Soil-Structure Interaction

Leader **Panos Dakoulas**, Professor, Department of Civil Engineering, University of Thessaly (UTh)

Panos Tsopelas, Professor, Department of Civil Engineering, University of Thessaly (UTh)

Achilleas Papadimitriou, Assistant Professor, School of Civil Engineering, National Technical University of Athens (NTUA)

Dominic Assimaki *(invited researcher)*, Professor, Division of Engineering and Applied Science, California Institute of Technology (CalTech)

Research Team 2 : Experimental Geotechnics & Nano-Material Science

Leader **Theodora Tika**, Professor, Department of Civil Engineering, Aristotle University of Thessaloniki (AUTh)

George Athanasopoulos, Professor, Department of Civil Engineering, University of Patras (UP)

Vassiliki Georgiannou, Associate Professor, School of Civil Engineering, National Technical University of Athens (NTUA)

Dimitrios Achilias, Associate Professor, Department of Chemistry, Aristotle University of Thessaloniki (AUTh)

Research Team 3 : Computational Geomechanics & Geo-enviromental Engineering

Leader **George Bouckovalas**, Professor, School of Civil Engineering, National Technical University of Athens (NTUA)

Michael Kavvadas, Associate Professor, School of Civil Engineering, National Technical University of Athens (NTUA)

George Mylonakis, Professor, Department of Civil Engineering, University of Patras

Marina Pantazidou, Associate Professor, School of Civil Engineering, National Technical University of Athens

Members of External Research Team:

A total of fifteen (15) members of an External Research Team are being employed in the project. They include 4 Post-Doctoral Researchers, 9 PhD Candidates and/or MSc holders and 2 BSc holders working in close cooperation with the 12 (faculty) members of the 3 Research Teams.

Results

The results of this project are presented in thirteen (13) Deliverables, i.e. mostly technical reports and software. These are outlined below, with reference to the WP from which they originate. They are (mostly) written in Greek, and may become available upon request (fill in the Contact form):

D1: Technical Report on the properties and specifications of selected materials (sand, silt, stabilizer), as well as the preparation method for the soil samples and the stabilizer solutions [from WP1]

D2: Technical Report on experimental data for the (chemical, rheological and mechanical) properties of the stabilizer solutions, the permeation/injection potential of the stabilizer in soil samples and the unconfined compression strength of stabilized-soils [from WP2]

D3: Technical Report on numerical analyses for permeation/injection of stabilizer solutions in granular soil using multi-phase flow software [from WP3]

D4: Technical Report on monotonic (triaxial) test data under usual and high stress levels, including reference tests on untreated samples [from WP4]

D5: Technical Report on dynamic (resonant column, bender elements) and cyclic (triaxial and simple shear) test data, including reference tests on untreated samples [from WP5]

D6: Technical Report on constitutive modeling of stabilized sand, on the basis of project test data and the literature [from WP6]

D7: Technical Report on constitutive model implementation in FE/FD numerical code(s) via User-Defined-Model routine(s) [from WP7]

D8: Software related to the executable file(s) of the User-Defined-Model routine(s) for use in boundary value problem analyses with FE/FD code(s) [from WP7]

D9: Technical Report on seismic (stabilized) ground response analyses, performed by employing D8 in FE/FD codes(s) [from WP8]

D10: Technical Report on DEM analyses of stabilized soil response simulating macroscopic test data [from WP8]

D11: Technical Report on proposed categories and related (elastic) design spectra for structures on stabilized-soil, in the spirit of EC8 [from WP8]

D12: Technical Report on spring and dashpot (Winkler) constants for strip footing on stabilized soil layer over bedrock [from WP9]

D13: Technical Report on design charts and (quality control and assurance) specifications for the design and application of passive stabilization in practice [from WP10]

Documents

21 journal or conference papers or theses have originated from research performed during this project.

Χρηματοδότηση: ΕΣΠΑ 2014 – 2020.

ΣΧΕΔΙΑΣΜΟΣ ΒΑΘΡΩΝ ΓΕΦΥΡΩΝ (και όχι μόνον) σε ΡΕΥΣΤΟΠΟΙΗΣΙΜΟ Έδαφος με ΕΠΙΦΑΝΕΙΑΚΗ ΘΕΜΕΛΙΩΣΗ και ΦΥΣΙΚΗ ΣΕΙΣΜΙΚΗ ΜΟΝΩΣΗ

Ημερίδα που διεξήχθη την Δευτέρα 30 Νοεμβρίου 2015 στο Αμφιθέατρο Πολυμέσων του ΕΜΠ ημερίδα παρουσίασης των αποτελεσμάτων του 4-ετούς ερευνητικού προγράμματος:

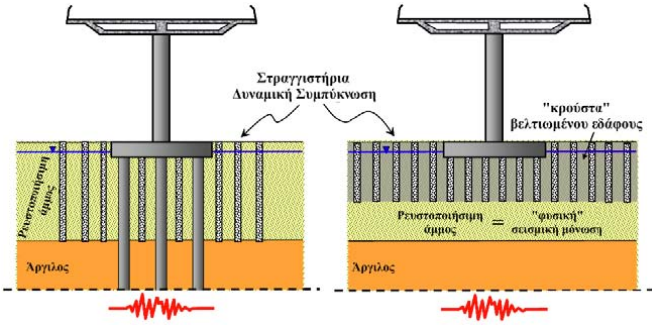
ΘΑΛΗΣ-ΕΜΠ (MIS 380043): NAT-SEI-ISO

(Χρηματοδότηση : ΕΣΠΑ 2007 – 2013**)**

με συμμετοχή συναδέλφων από τον ακαδημαϊκό και τον επαγγελματικό χώρο. Όλες οι παρουσιάσεις έχουν αναρτηθεί στην ιστοσελίδα του Ερευνητικού Υπεύθυνου του έργου, καθ. **Γ. Μπουκοβάλα** (***georgebouckovalas.com***)

ΑΝΤΙΚΕΙΜΕΝΟ

Ο έλεγχος σεισμικής επάρκειας αποτελεί κομβικό στοιχείο του σχεδιασμού γεφυρών στην χώρα μας, για δύο κυρίως λόγους: την αναμφίβολα υψηλή σεισμικότητα της ευρύτερης περιοχής αλλά και τον σημαντικό κίνδυνο ρευστοποίησης λόγω σεισμού που διατρέχουν οι πρόσφατες αλλουβιακές εδαφικές αποθέσεις που συναντώνται συνηθέστατα στις θέσεις κατασκευής των γεφυρών (διασταυρώσεις με ποταμούς, παράκτιες περιοχές, κλπ.). Κατ' επιταγή των ελληνικών, αλλά και των διεθνών αντισεισμικών κανονισμών, αποτελεί πρακτικά πάγια πρακτική σήμερα η θεμελίωση των βάθρων γεφυρών υπό τις ανωτέρω αντίξοες συνθήκες να γίνεται με χρήση πασσάλων που μεταφέρουν τα φορτία της ανωδομής στο μη ρευστοποιήσιμο υπόβαθρο, σε συνδυασμό με καθολική (κατά το βάθος) βελτίωση της ρευστοποιήσιμης στρώσης (Σχήμα Α, αριστερά).



Με αφετηρία ενθαρρυντικά ευρήματα από πρόσφατους σεισμούς (Luzon 1990, Tohoku 2011, Christchurch 2011), για την συμπεριφορά κτιρίων με επιφανειακή θεμελίωση σε ρευστοποιήσιμα εδάφη, στο ερευνητικό πρόγραμμα που παρουσιάσθηκε εξετάσθηκε διεξοδικά η ακόλουθη εναλλακτική μέθοδος θεμελίωσης, η οποία αποσκοπεί στην μείωση του κόστους κατασκευής εξασφαλίζοντας παράλληλα τα κριτήρια επιτελεστικότητας του έργου (Σχήμα Β, δεξιά):

(α) Η θεμελίωση του βάθρου γίνεται επιφανειακά, σε πλάκα έδρασης, χωρίς την χρήση πασσάλων.

(β) Το έδαφος θεμελίωσης βελτιώνεται σε περιορισμένο βάθος και πλάτος, έτσι ώστε να δημιουργηθεί μια μη ρευστοποιήσιμη επιφανειακή "κρούστα" η οποία θα προστατεύσει την πλάκα έδρασης ακόμη και μετά την εκδήλωση ρευστοποίησης στο ελεύθερο πεδίο.

(γ) Επιδιώκεται η ρευστοποίηση του εδάφους υπό την επιφανειακή βελτιωμένη "κρούστα" προκειμένου να αναπτυχθεί έτσι μηχανισμός "φυσικής σεισμικής μόνωσης" και να μειωθούν αδρανειακές δυνάμεις που ασκούνται στην ανωδομή.

ΔΡΑΣΕΙΣ & ΑΠΟΤΕΛΕΣΜΑΤΑ

Κατ' επέκταση των ανωτέρω, οι βασικοί στόχοι της έρευνας που πραγματοποιήθηκε ήταν δύο. Στο πρώτο στάδιο, διατυπώθηκε μια ολοκληρωμένη μεθοδολογία αντισεισμικού σχεδιασμού βάθρων γεφυρών σε ρευστοποιήσιμα εδάφη, με επιφανειακή θεμελίωση επί (φυσικής ή τεχνητής) «κρούστας» μη ρευστοποιήσιμου εδάφους. Ακολούθως, πραγματοποιήθηκε πιλοτική εφαρμογή της ανωτέρω μεθοδολογίας σε τυπικές περιπτώσεις γεφυρών (από Ο.Σ., μεταλλικές), και σύγκριση με τις συμβατικές μεθόδους σχεδιασμού, ώστε να αποτιμηθούν τα τεχνικο-οικονομικά οφέλη και να προκύψουν παραδείγματα εφαρμογής.

Πιο συγκεκριμένα, πραγματοποιήθηκαν οι ακόλουθες επιμέρους "δράσεις", τα αποτελέσματα των οποίων παρουσιάσθηκαν συνοπτικά και σχολιάσθηκαν κατά την ημερίδα:

ΕΔ1. Ανάπτυξη λογισμικού για την αριθμητική ανάλυση της συζευγμένης σεισμικής απόκρισης ρευστοποιημένου εδάφους - θεμελίου - βάθρου γέφυρας.

ΕΔ2. Αναλυτική μεθοδολογία σχεδιασμού επιφανειακών θεμελιώσεων σε ρευστοποιημένο έδαφος.

ΕΔ3. Ελαστικά φάσματα σχεδιασμού για ρευστοποιήσιμα εδάφη.

ΕΔ4. Ελατήρια και αποσβεστήρες Winkler για θεμέλια σε ρευστοποιήσιμο έδαφος.

ΕΔ5. Εφαρμογή σε Στατικώς Ορισμένη Γέφυρα Ο.Σ.

(α) Κριτήρια Επιτελεστικότητας για Στατικώς Ορισμένη Γεφυρα Ο.Σ.

(β) Συγκριτική μελέτη Συμβατικού και Πρωτότυπου Σχεδιασμού για Στατικώς Ορισμένη Γέφυρα Ο.Σ.

ΕΔ6. Εφαρμογή σε Στατικώς Αόριστη Γέφυρα Ο.Σ.

(α) Κριτήρια Επιτελεστικότητας για Στατικώς Αόριστη Γέφυρα Ο.Σ.

(β) Πιλοτικός σχεδιασμός με χρήση "φυσικής" σεισμικής μόνωσης

ΕΔ7. Εφαρμογή σε Χαλύβδινη Καλωδιωτή Γέφυρα

(α) Κριτήρια Επιτελεστικότητας για Χαλύβδινη Καλωδιωτή Γέφυρα

(β) Πρότυπη Μελέτη για Χαλύβδινη Καλωδιωτή Γέφυρα. Συγκριτική αξιολόγηση έναντι συμβατικής μεθολογίας σχεδιασμού

"ΑΡΙΣΤΕΙΑ" & "ΔΙ-ΕΠΙΣΤΗΜΟΝΙΚΗ ΣΥΝΕΡΓΑΣΙΑ"

Σύμφωνα με την πρόσκληση υποβολής ερευνητικών προτάσεων, απώτερος στόχος των Πράξεων "ΘΑΛΗΣ" είναι η ενίσχυση της "αριστείας" και της "δι-επιστημονικής ή/και δι-ιδρυματικής έρευνας".

Προς ικανοποίηση του στόχου της *Αριστείας*, παρήχθησαν 25 δημοσιεύσεις σε επιστημονικά περιοδικά και συνέδρια, αρκετές εκ των οποίων κατόπιν προσκλήσεως. Επιπλέον, χρηματοδοτήθηκε η έρευνα έντεκα (11) υποψηφίων διδακτόρων (ΥΔ) και πέντε (5) μετα-διδακτόρων ερευνητών σε θέματα συναφή προς το αντικείμενο του Έργου.

Ικανοποιητική θα πρέπει να θεωρείται επίσης η ανταπόκριση ως προς τους στόχους της *διεπιστημονικής έρευνας* και *συνέργειας* δεδομένου ότι:

(α) Στις επιμέρους δράσεις του Έργου είχαν αποκλειστική ή κύρια συμμετοχή επτά (7) Εργαστήρια από πέντε (5) ΑΕΙ της Ελλάδας και της Κύπρου: **ΕΜΠ**, **ΑΠΘ**, **Πανεπιστήμιο Πατρών**, **Πανεπιστήμιο Θεσσαλίας**, **Πανεπιστήμιο Κύπρου**.

(β) Τα μέλη της **Κύριας Ερευνητικής Ομάδας** (ΚΕΟ) δραστηριοποιούνται σε πέντε (5) διαφορετικά γνωστικά αντικεί-

μενα, συγκεκριμένα: Μηχανική & Καταστατικές σχέσεις εδαφών (**Αχ. Παπαδημητρίου**, **Δ. Λουκίδης**), Γεωτεχνική Σεισμική Μηχανική (**Γ. Μπουκοβάλας**), Δυναμική Αλληλεπίδραση Εδάφους-Θεμελίωσης-Κατασκευής (**Γ. Μυλωνάκης**), Αντισεισμικός Σχεδιασμός Κατασκευών από Ο.Σ.

(**Ι. Ψυχάρης, Α. Κάππος, Αν. Σέξτος, Χ. Μουζάκης**) και Σχεδιασμός Μεταλλικών Κατασκευών (**Χ. Γαντές, Ι. Ερμόπουλος**).

Επιπλέον, την Εξωτερική Αξιολόγηση του ερευνητικού προγράμματος ανέλαβε ο έμπειρος συνάδελφος **Βασ. Παπαδόπουλος**, Αν. καθηγητής ΕΜΠ.

(γ) Καθ' όλη την διάρκεια προγραμματισμού και υλοποίησης του Έργου **συνεργάσθηκαν** δύο βασικές ειδικότητες, του **Γεωτεχνικού** και του **Δομοστατικού Πολιτικού Μηχανικού**, οι οποίες παραδοσιακά λειτουργούν ανεξάρτητα (και ενίοτε ομιλούν "διαφορετική γλώσσα") κατά την ανάλυση-μελέτη-κατασκευή έργων υποδομής.

ΣΤΙΓΜΙΟΤΥΠΑ της ΗΜΕΡΙΔΑΣ

Απόψεις του ακροατηρίου της ημερίδας

Σύνοψη τελικών συμπερασμάτων ερευνητικού προγράμματος από τον Καθηγητή Γ. Μπουκοβάλα.

Συζήτηση με τους Καθηγητές (από αριστερά):
Γ. Μπουκοβάλα, Α. Σέξτο, Ι. Ψυχάρη, Γ. Μυλωνάκη & Χ. Γαντέ

Χρηματοδότηση : ΕΣΠΑ 2007 – 2013

ΠΡΟΣΕΧΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΚΔΗΛΩΣΕΙΣ

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

Southern African Rock Engineering Symposium an ISRM Regional Symposium, 5 January 2016, Cape Town, South Africa, http://10times.com/southern-african-rock

Environmental Connection Conference, February 16–19, 2016, San Antonio, Texas, USA, www.ieca.org/conference/annual/ec.asp

ASIA 2016 - Sixth International Conference on Water Resources and Hydropower Development in Asia, 1-3 March 2016, Vientiane, Lao PDR, www.hydropower-dams.com/pdfs/asia20161.pdf

GROUND ENGINEERING INSTRUMENTATION AND MONITORING 2016 | 15 - 16 March 2016 | Immarsat, London

https://monitoring.geplus.co.uk

Ground Engineering is delighted to bring you the seventh annual **Instrumentation and Monitoring** conference: an essential gathering for anyone involved in monitoring and looking for up-to-date insight into projects, technologies and strategy. In the **2016 Instrumentation and Monitoring** event you can hear industry leaders, innovators and major clients outline the challenges and opportunities facing the sector over the next five years.

Instrumentation and Monitoring is an essential event for everyone involved in the sector from industry leaders to newcomers, and will give insight into the latest technological advances and best practice being employed across construction and asset management projects.

Draft Programme
file:///C:/Documents%20and%20Settings/pan54/My%20Documents/Downloads/Draft%20programme%20v1.pdf

GeoAmericas 2016 3rd Panamerican Conference on Geosynthetics, 11 – 14 April 2016, Miami Beach, USA, www.geoamericas2016.org

International Symposium on Submerged Floating Tunnels and Underwater Structures (SUFTUS-2016), 20-22 April 2016, Chongqing, China, www.cmct.cn/suftus

World Tunnel Congress 2016 "Uniting the Industry", April 22-28, 2016, San Francisco, USA, http://www.wtc2016.us

International Symposium "Design of piles in Europe - How did EC7 change daily practice?", 28-29 April 2016, Leuven, Belgium, www.etc3.be/symposium2016

7th In-Situ Rock Stress Symposium 2016 - An ISRM Specialised Conference, 10-12 May 2016, Tampere, Finland, www.rs2016.org

84th ICOLD Annual Meeting, 16-20 May 2016, Johannesburg, South Africa, www.icold2016.org

2nd International Conference on Rock Dynamics and Applications (RocDyn-2), 18 – 20 May 2016, Suzhou, China http://rocdyn.org

5th International Conference on Geofoam Blocks in Construction Applications
May 22 – 24, 2017, Istanbul, Turkey
http://geofoam2017.org/en

The organizing committee is pleased to invite you to the

5th International Conference on Geofoam Blocks in Construction Applications (EPS'17) which will be held in **Istanbul, Turkey on May 22 – 24, 2017**.

Geofoam researchers, consultants, molders, contractors and practitioners from all around the world will be meeting in Istanbul to discuss the recent developments and future trends of the expanded polystyrene (EPS)-block geofoam technology and its construction applications. EPS'17 will continue to contribute to the development of the geofoam applications after successful Oslo (1985), Tokyo (1996), Salt Lake City (2001) and Oslo (2011) conferences.

We are honored to dedicate the proceedings of EPS'17 to Mr. **Tor Erik Frydenlund** and Mr. **Geir Refsdal** who were the pioneers of the development of geofoam technology. They have implemented the use of geofoam as a lightweight fill material in Norway and also involve in the dissemination of the technology to other countries.

The conference program will be a combination of technical papers and group discussions regarding the use, new development and implementation of geofoam technology. The conference theme will cover but not limited to the present use of geofoam, design specifications, applications, new concepts, material properties, modeling and special topics of geofoam blocks in construction applications.

CONFERENCE THEMES

Dedication:

Papers about Tor Erik Freydlund and Geir Refsdal's achievements on the development of geofoam technology

Present use of Geofoam:

Reports by members of the International Organizing Committee on known applications, type of projects and volumes.

Expanded Polystyrene:

Chemical composition and production process
Index properties
Product control
Durability

Material properties and modeling:

Model studies
Dynamic properties
Fatigue

Design specifications:

International standards
National specifications
Seismic design

Construction applications:

Roads, Railroads and Airports
Buildings and Industrial plants
Landscaping
Settlement mitigation
Load reduction on buried culverts
Failures

New concepts and special topics:

Innovative use of Geofoam blocks
Avalanche protection
Disaster prevention - climate change
Re-use/recycling of Geofoam blocks

Organizing Secretariat

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E-mail: secretariat@geofoam2017.org
Visit www.dekon.com.tr for more information

13th International Conference Underground Construction Prague 2016 and 3rd Eastern European Tunnelling Conference (EETC 2016), 23 to 25 May 2016, Prague, Czech Republic, www.ucprague.com

GEOSAFE: 1st International Symposium on Reducing Risks in Site Investigation, Modelling and Construction for Rock Engineering - an ISRM Specialized Conference, 25 – 27 May 2016, Xi'an, China, www.geosafe2016.org/dct/page/1

14th International Conference of the Geological Society of Greece, 25-27 May, Thessaloniki, Greece, www.ege2016.gr

NGM 2016 - The Nordic Geotechnical Meeting, 25 - 28 May 2016, Reykjavik, Iceland, www.ngm2016.com

International Mini Symposium Chubu (IMS-Chubu) New concepts and new developments in soil mechanics and geotechnical engineering, 26 - 28 May 2016, Nagoya, Aichi, Japan, www.jiban.or.jp/index.php?option=com_content&view=article&id=1737:2016052628&catid=16:2008-09-10-05-02-09&Itemid

19SEAGC – 2AGSSEAC Young Geotechnical Engineers Conference, 30th May 2016, Petaling Jaya, Selangor, Malaysia, seagc2016@gmail.com

19th Southeast Asian Geotechnical Conference & 2nd AGSSEA Conference Deep Excavation and Ground Improvement, 31 May – 3 June 2016, Subang Jaya, Malaysia, seagc2016@gmail.com

ISSMGE TC211 Conference Session within the framework of the 19th Southeast Asian Geotechnical Conference "GROUND IMPROVEMENT works: Recent advances in R&D, design and QC/QA"

ISL 2016 12th International Symposium on Landslides Experience, Theory, Practice, Napoli, June 12th-19th, 2016, www.isl2016.it

25th European Young Geotechnical Engineers Conference
21 – 24 June 2016, Sibiu, Romania
http://25eygec.srgf.ro

The Romanian Society for Geotechnical and Foundation Engineering (RoSGFE) was invested by the International Society for Soil Mechanics and Geotechnical Engineering, through the Vice-President for Europe, Professor Antonio Gens, to organize **the 25th European Young Geotechnical Engineers Conference.**

The organising committee is delighted to invite you in Sibiu, Romania from 21st to 24th of June, 2016 to attend, what we are sure will be, an outstanding conference.

Proud to be **GEOTECHNICAL ENGINEER** is not only the motto of the conference, is the expression of a future career, full of challenges and also achievements.

Young researchers under the age of 35 years are invited to attend the conference.

Participants' selection is the responsibility of the European Member Societies of ISSMGE that will appoint maximum 2 "nominated participants". If a country does not send representatives to the conference, they can be replaced with "nonnominated participants" from other countries.

All participants must submit a paper and deliver an oral presentation of 8-10 minutes.

The organising committee invited several geotechnical engineering professionals to deliver keynote and invited lectures.

The official language of the conference is English.

CONTACT

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124 Lacul Tei Bvd., Bucharest
e-mail: ernest@utcb.ro, 25eygec@srgf.ro

1st International Conference on Natural Hazards and Infrastructure: Protection, Design, Rehabilitation, 28-30 June 2016, Chania, Greece, http://iconhic2016.com

4th GeoChina International Conference Sustainable Civil Infrastructures: Innovative Technologies for Severe Weathers and Climate Changes, July 25-27, 2016, Shandong, China, http://geochina2016.geoconf.org

6th International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics August 1-6, 2016, Greater Noida (NCR), India, www.6icragee.com

EUROC 2016 - ISRM European Regional Symposium Rock Mechanics & Rock Engineering: From Past to the Future, 29-31 August 2016, Ürgüp-Nevşehir, Cappadocia, Turkey http://eurock2016.org

3rd ICTG – 3rd International Conference on Transportation Geotechnics 4 - 7 September 2016, Guimaraes, Portugal, www.civil.uminho.pt/3rd-ICTG2016

IAS'5 5th International Conference on Geotechnical and Geophysical Site Characterisation, 5-9 September 2016, Gold Coast, Queensland, Australia, http://www.isc5.com.au

The World Multidisciplinary Earth Sciences Symposium– WMESS 2016, 5-9 September 2016, Prague, Czech Republic www.mess-earth.org

http://acuus.primexpo.ru/en

The ACUUS conference 2016 is organised on behalf of Associated research Centers for the Urban Underground Space, one of the leading organisations involved into underground space development of the modern metropolises.

The ACUUS conference series has been held previously in Sydney (Australia, 1983), Minneapolis (USA, 1986), Shanghai (China, 1988), Tokyo (Japan, 1991), Delft (The Netherlands, 1992) , Paris (France, 1995), Montreal (Canada, 1997), Xi'an (China, 1999), Turin (Italy, 2002), Moscow (Russia, 2005), Athens (Greece, 2007), Shenzhen (China, 2009), Singapore (2012), Seoul (2014).

The Conference in Singapore, ACUUS 2012, welcomed more than 370 participants from 35 countries and numerous guests. More than 350 papers from 30 countries were received. The Scientific Committee, including world leading specialists, selected 159 papers from 26 countries for presentation. These papers made together 26 parallel sessions on planning, architecture, safety, sustainable development. The programme of the conference included training seminars on planning and safety. There were 5 technical tours.

ACUUS 2012 Singapore was organized by the Society for Rock Mechanics and Engineering Geology Singapore, and supported by the Ministry of National Development Singapore and the Singapore Exhibition and Convention Bureau.

ACUUS 2014 Seoul was supported by the Ministry of Construction and Transportation of Korea, the Seoul Metropolitan Government and Korea Tourism Office. The Russian delegation took part in the conference and presented the next ACUUS destination – St. Petersburg.

This represents the growing importance and use of underground space in world wide economic development and the increasing interest and investment in research and development effort in this area.

We truly believe that the World Conference ACUUS 2016 in St. Petersburg will be a highly rewarding international event for everyone and will bring enhancement of the academic level and industrial development, which will contribute to improving quality of life in urban areas.

Themes & Topics

1. Urban planning of underground space for comfort living, historic centers preserving, improving environmental situation.

2. Progress of geotechnical surveys for planning underground space development, importance of geotechnics and hydrotechnics for the choice of engineering and design solutions

3. Symbiotic relation between ground urban development, underground infrastructure and nature for creation of a single landscape, aesthetic and comfort of underground structures.

4. Underground metro systems, transport tunnels, integrated interchange hub as a prerequisite for regional development and securing comfort and safe conditions.

5. Underground structures in permafrost, shelf zone development. Energy efficiency of underground structures.

6. Advantages of underground construction for safety and preventive measures from natural disasters. Environmental management and improvement of the environmental quality.

7. Trenchless technology, the role of the underground utility lines in integrated urban underground space development.

8. Strengthening the investment appeal of underground structures by improving legislation and public-private partnership principles and harmonizing technical regulations.

9. State-of-art technologies, equipment and construction materials that are currently in use for underground infrastructure development.

CONTACTS
Association of Underground Builders
Tel.: +7 812 325 05 65
info@acuus2016.com, www.metrotunnel.ru

SAHC 2016 - 10th international Conference on Structural Analysis of Historical Constructions 13-15 September 2016, Leuven, Belgium, www.sahc2016.be

13 Baltic States Geotechnical Conference Historical Experiences and Challenges of Geotechnical Problems in Baltic Sea Region, 15 - 17 September 2016, Vilnius, Lithuania, http://www.13bsgc.lt

EuroGeo 6 – European Regional Conference on Geosynthetics, 25 – 29 Sep 2016, Istanbul, Turkey, www.eurogeo6.org

5th International Scientific Conference on Industrial and Hazardous Waste Management, 27 - 30 September 2016, Chania, Crete, Greece, http://hwm-conferences.tuc.gr

2nd International Specialized Conference on Soft Rocks
29-30 September 2016, Cartagena, Colombia

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Achievements, opportunities and challenges
10-12 October 2016, Montreux, Switzerland

With 33 hydro and pumped-storage schemes under construction (new and major upgrade projects), which will provide more than 2100 MW of capacity, Switzerland is one of Europe's most active countries for hydropower at present.

The beautiful town of Montreux, overlooking Lake Geneva, will provide a perfect setting for the world hydro community to meet next year, to discuss topical aspects of global hydropower development.

There will be opportunities to visit major projects under construction in the region.

Further details and a Call for Papers will be issued shortly.

http://www.hydropower-dams.com/hydro-2016.php?c_id=88

ARMS 9, 9th Asian Rock Mechanics Symposium, ISRM Regional Symposium, 18-20 October 2016, Bali, Indonesia, http://arms9.com

SFGE 2016 Shaping the Future of Geotechnical Education International Conference on Geo-Engineering Education 20 - 22 October 2016, Minascentro, Belo Horizonte, MG, Brazil, http://cobramseg2016.com.br/index.php/sfge-sobre/?lang=en

25-30 October 2016, Antalya, Turkey
www.trcold.com

It is a pleasure to invite you to the **10th ICOLD European Club International Symposium : Dams and HEPPs for Sustainable Development** scheduled from 25-30 October 2016 in Antalya, Turkey. The Symposium will be a joint effort of the Turkish National Committee on Large Dams (TRCOLD) and the General Directorate of State Hydraulic Works (DSI).

The Honorable President of TRCOLD, His Excellency, Prof. Dr. Veysel EROGLU, will inaugurate the Conference and the President of TRCOLD, Mr. Ali Riza DINIZ, will address the Closing Ceremony.

The Symposium will examine the state-of-the-art regarding the design and construction of Dams & HEPPs both locally and internationally on the following themes:

I. Dam Safety, Rehabilitation and Surveillance

II. Financing of Dam Projects

III. Managing Risks in Dam and HEPP Projects (Climate Change, Socio-economic and Environmental Aspects)

IV. Design and Construction of Dams and HEPPs

A. Types of Dams: RCC, CFRD, ECRD, ACRD, Tailings, Hardfill, Concrete Arch, etc.

B. Auxiliary Structures: Spillways, Diversion and Energy Tunnels, Bottom Outlets, Hydromechanical and Electrical Equipment

C. Modern Structural and Technical Solutions (Geomembranes, etc.)

For more information please visit TRCOLD web site at www.trcold.com.

GeoAsia 6 - 6th Asian Regional Conference on Geosynthetics 8-11 November 2016, New Delhi, India, http://seags.ait.asia/news-announcements/11704

RARE 2016 Recent Advances in Rock Engineering 16-18 November 2016, Bangalore, India, www.rare2016.in

AfriRock 2017, 1st African Regional Rock Mechanics Symposium, 12 – 17 February 2017, Cape Town, South Africa, www.saimm.co.za/saimm-events/upcoming-events

International Conference and Exhibition
WATER STORAGE AND HYDROPOWER DEVELOPMENT FOR AFRICA
14 to 16 March 2017, Marrakech, Morocco

International Commission on Large Dams, and with the strong support of the Government of Morocco, is pleased to reconvene the next regional conference for Africa, AFRICA 2017, which will take place in Marrakech. This follows the unfortunate need to postpone AFRICA 2015, at the time of the tragic ebola outbreak, on the advice of various relevant authorities.

In view of the postponement of the 2015 event, we produced a special publication for Africa, also working in collaboration with the African Union and ICOLD. This has been widely disseminated, and proceeds from advertising in the publication were donated to Médecins Sans Frontières, the organization which played the greatest role in bringing the ebola outbreak under control.

The first conference in this series, AFRICA 2013, took place in Addis Ababa, when practical aspects of advancing hydropower and water resources development in Africa were discussed by more than 600 participants from 67 countries. The conference brought together utility CEOs, officers of UNECA, leading experts from the IFIs, Presidents, Vice-Presidents and Secretaries of the water- and energy-related professional associations, eminent engineering consultants, researchers, leading contractors and equipment suppliers. Outcomes made a practical contribution to the Programme for Infrastructure Development in Africa. A Final Declaration was widely disseminated globally.

Conference Themes

Major multipurpose water resources schemes, including many large regional hydro projects, are moving ahead in Africa at an unprecedented rate. A status update, potential and development opportunities, as well as technical, environmental and financial challenges, covering all regions of the African continent, will be the focus of the presentations and discussions.

- Potential and planned developments in Africa
- African multipurpose water storage including hydropower, irrigation, water supply, navigation and fisheries
- Quantifying and qualifying the benefits of water infrastructure
- African small dams for irrigation
- Role of storage in river basin management for sustainable development
- The role of risk mitigation in making hydro more competitive
- Concession agreements and construction contracts
- Finance options including resource mobilization and the Africa 50 fund
- Implementation and review of dam safety legislation in Africa
- Monitoring the safety of dams, gates and powerplants
- Public safety around dams
- Dam engineering: design and construction
- Institutions and institutional arrangements
- Case studies from the 'Water Towers': the Congo Basin, the Ethiopian Highlands, the Fouta Djallon and the Lesotho Highlands
- Effects of climate change in Africa: adaptation and mitigation
- Flood control
- The role of hydro in African regional development
- Update on the PIDA Energy Priority Action Plan
- Pumped storage; hydro in synergy with other renewables
- Hydro's role in electrical system stability in Africa
- Small hydro in Africa
- Rural electrification in Africa
- Hydro machinery: research and operational issues and, practical examples of innovative low cost technologies
- Environmental and social aspects of African schemes, including water conservation and transfer, and social challenges of transboundary projects
- Reservoir sedimentation mitigation
- Operation, maintenance and rehabilitation challenges; obstacles and solutions

For further information, please either contact Margaret Bourke, Conference Project Manager (africa2017@hydropower-dams.com) or follow announcements at: www.hydropower-dams.com and www.icold-cigb.org.

World Tunnel Congress 2017
Surface problems – Underground solutions
9 to 16 June 2017, Bergen, Norway
www.wtc2017.no

"Surface problems – Underground solutions" is more than a slogan; for ITA-AITES and its members it is a challenge and commitment to contribute to sustainable development. The challenges are numerous and the availability of space for necessary infrastructure ends up being the key to good solutions. The underground is at present only marginally uti-

lized. The potential for extended and improved utilization is enormous.

EUROCK 2017
13-15 June 2017, Ostrava, Czech Republic

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19th International Conference on Soil Mechanics and Geotechnical Engineering, 17 - 22 September 2017, Seoul, Korea, www.icsmge2017.org

GeoAfrica 2017
3rd African Regional Conference on Geosynthetics
9 – 13 October 2017, Morocco

11th International Conference on Geosynthetics (11ICG)
16 - 20 Sep 2018, Seoul South Korea
csyoo@skku.edu

10th Asian Rock mechanics Symposium - ARMS10
October 2018, Singapore

Prof. Yingxin Zhou
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Fax: (+65) 627 35754
E-mail: zyingxin@dsta.gov.sg

AFTES International Congress
"The value is Underground"
13-16 November 2017, Paris, France

World Tunnel Congress 2018
20-26 April 2018, Dubai, United Arab Emirates

UNSAT2018 The 7th International Conference on Unsaturated Soils, 3 - 5 August 2018, Hong Kong, China, www.unsat2018.org

14th ISRM International Congress
2019, Foz de Iguaçu, Brazil

Contact Person: Prof. Sergio A. B. da Fontoura **E-mail:** fontoura@puc-rio.b

ΕΝΔΙΑΦΕΡΟΝΤΑ ΓΕΩΤΕΧΝΙΚΑ ΝΕΑ

Video: Scary landslide in Pakistan

The slope of a mountain in Hunza Valley (σ.ε. στην ορεσειρά Gilgit-Baltistan στο Βόρειο Πακιστάν) collapsed after the deadly earthquake (σ.ε. μεγέθους 7.5 στις 26 Οκτωβρίου 2015) that has killed nearly 266 people while levelling thousands of homes and forcing many to camp out in the open. The landslide brought up massive amounts of dust and blocked a road next to the valley.

About 11,000 houses were damaged in northwestern Pakistan.

According to the US Geological Survey, the initial quake was followed by seven aftershocks, with intensity of 4.8.

Watch the video provided under media below!

https://www.youtube.com/watch?v=y4crGbZFn6g

Related Geotechnical Papers

- Springman, S. Kienzler, P. Casini, F. Askarinejad, A., 2009, Landslide triggering experiment in a steep forested slope in Switzerland ,Proceedings of the 17th International Conference on Soil Mechanics and Geotechnical Engineering (ICSMGE 2009)
- Vaniček, I. Vaniček, M. Zalesky, J., 2009, Monitoring of tunnel lining deformation and deterioration ,Proceedings of the 17th International Conference on Soil Mechanics and Geotechnical Engineering (ICSMGE 2009)
- Huang, C.C., 2009, Failures of soil structures during the 1999 Taiwan Chi-Chi earthquake ,Earthquake geotechnical case histories for performance-based design
- Bandeira, A.P.N. Coutinho, R.Q., 2008, Landslide risk management: Experiences in the metropolitan area of Recife ? Pernambuco, Brazil ,Landslides and Engineered Slopes: From the Past to the Future.

(Geoengineer.org / Friday, 30 October 2015)

Exploration of an Ancient Mayan Sinkhole in Mexico

A difficult but extremely interesting mission undertook the American photographer and diving instructor Troy Iloski, attempting to explore and photograph the Ancient Mayan sinkhole deep in the Mexican jungle.

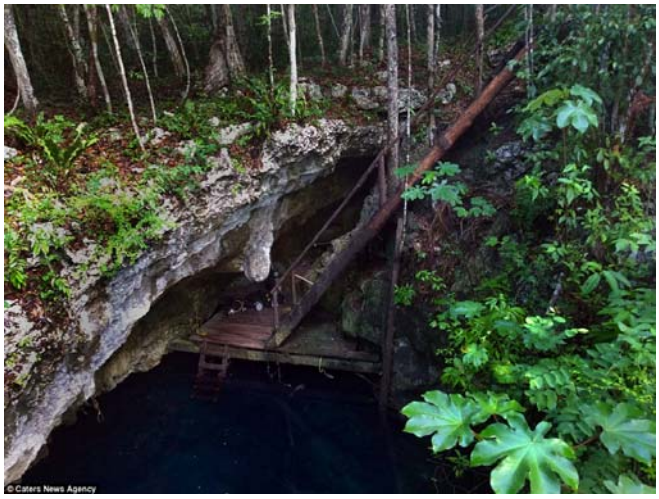
A difficult but extremely interesting mission undertook the American photographer and diving instructor Troy Iloski, attempting to explore and photograph the Ancient Mayan sinkhole deep in the Mexican jungle.

The underwater cave at a depth of 122 meters in Quintana Roo of Mexico is believed that it was a place of sacrifice for the Mayans, and it is full of bones of animals and humans.

"I think the ancient Mayans use this giant hole for sacrifice or burial", describes the photographer.

It is believed that there are over 6000 sinkholes which were created naturally in Mexico, but less than half of them have been explored.

Enjoy the photos below!

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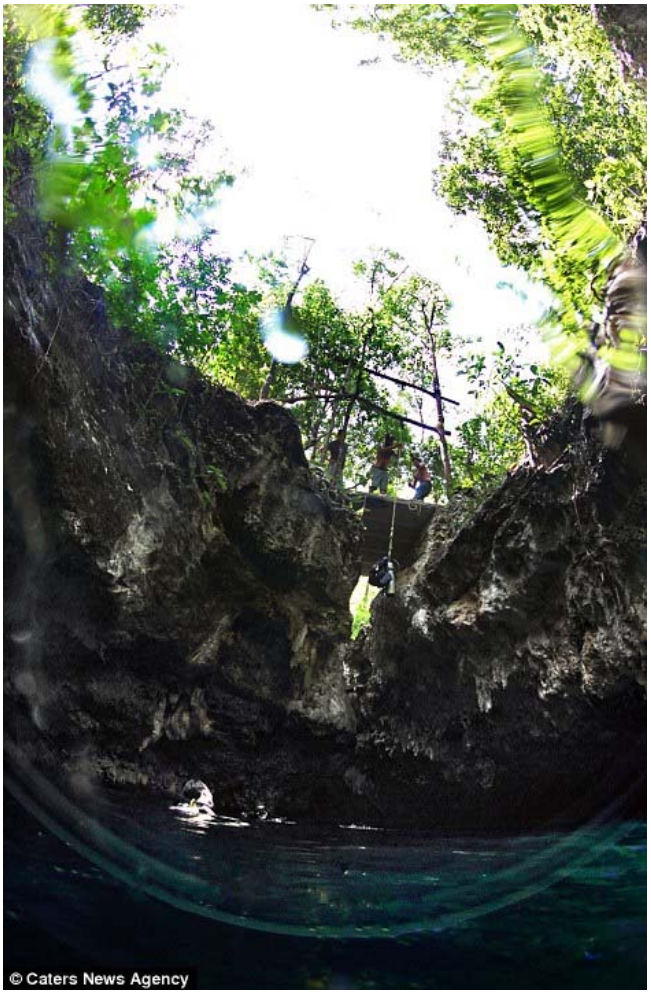
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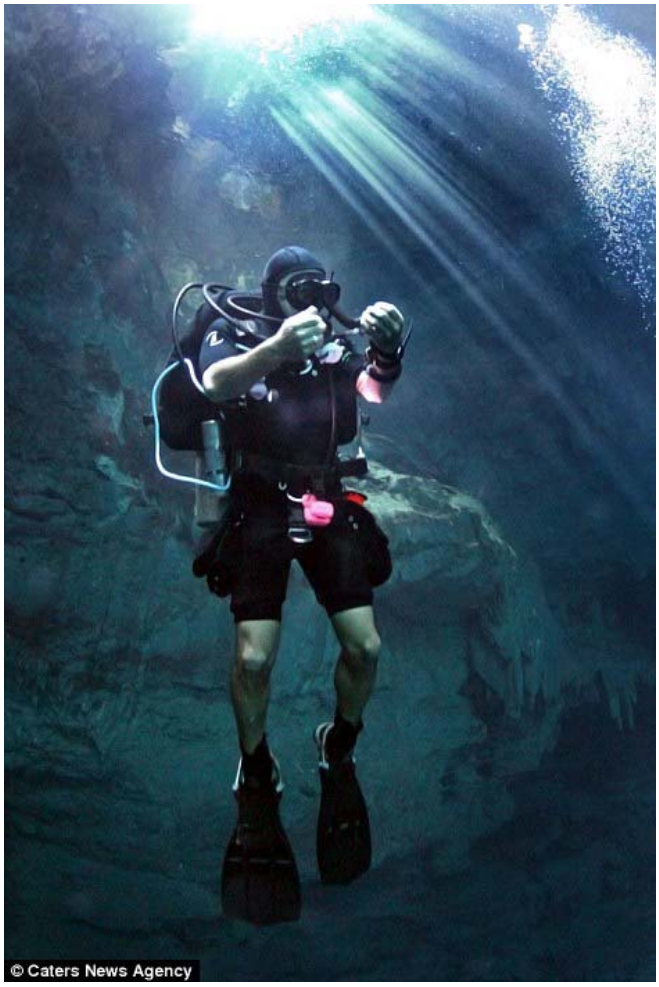
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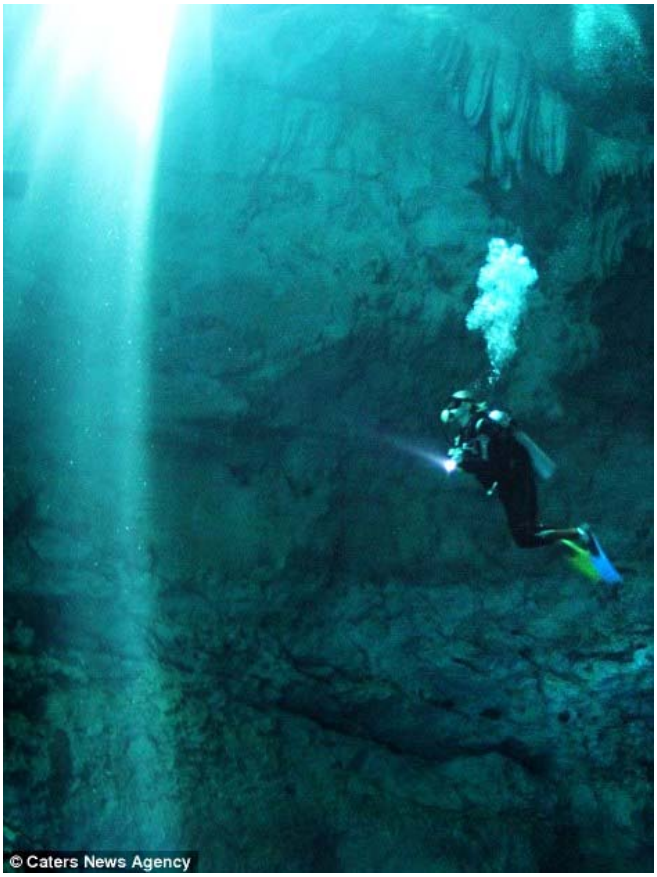
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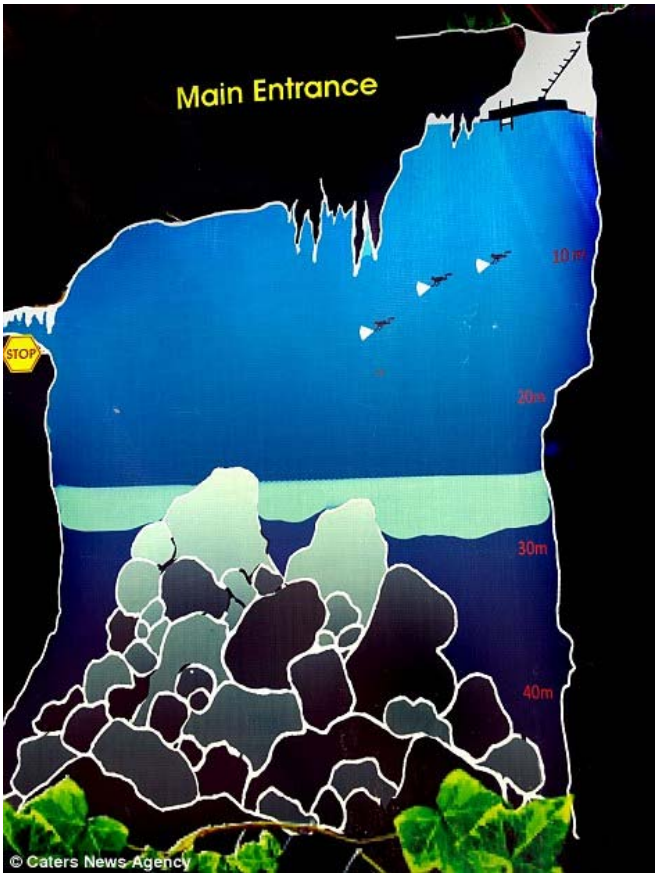


Source: dailymail.co.uk, news.com.au

Related Geotechnical Papers

- Mendez, B. Botero, E. Romo, M.P. Marengo, H., 2009, Three-dimensional numerical modelling of a high slope cut in a rock mass having complex geological formations, Proceedings of the 17th International Conference on Soil Mechanics and Geotechnical Engineering (ICSMGE 2009)
- Garcia, S. Romo, M., 2009, Treatment of geoseismic data as a non-stationary process, Proceedings of the 17th International Conference on Soil Mechanics and Geotechnical Engineering (ICSMGE 2009)
- Chiu, S.L. Lam, T.S. Yu, H.W.P., 2009, Application of Computed Tomography technology for exploration of deep underground cavities and solution features ,Proceedings of the 17th International Conference on Soil Mechanics and Geotechnical Engineering (ICSMGE 2009)
- Whiteley, R.J. Stewart, S.B., 2009, Enhanced site characterization of covered karst with surface and borehole seismic imaging ,Proceedings of the 17th International Conference on Soil Mechanics and Geotechnical Engineering (ICSMGE 2009)

(Geoengineer.org / Tuesday, 03 November 2015)

Brazil dam burst: Rivers of thick red mud (video)

A dam holding back water from an iron ore mine near Mariana, Brazil, has burst.

Officials say one person is confirmed dead. But there are reports that up to 16 have died and others are missing.

Authorities have warned that the water mixed with residue from mining operations could be toxic.

(Julia Carneiro / EIB, 6 November 2015, http://world.einnews.com/article/295568013/mmoKku508g7ZtDNy)

Dam Breach of Toxic Sludge

A mudslide unleased at Bento Rodrigues in southeastern Brazil, when a dam broke at a mining deposit site. At least 17 people died and 40 people are missing.

A mudslide unleased at Bento Rodrigues in southeastern Brazil, when a dam broke at a mining deposit site. At least 17 people died and 40 people are missing.

A torrent of thick red mud destroyed houses and cars.

Bento Rodrigues, with 600 inhabitants who mostly work in the mining company Samarco, buried under a river of mud.

Residents of Mariana donated mattresses and mineral water for those affected.

The Fundao dam in which 25 people were working, restrained toxic mud from mining waste on an area equivalent to 10 football fields. For a reason which is still unknown, the dam fell is releasing a torrent of mud that was spread over an area of two kilometers.

The alarm sounded and the neighboring cities sent immediately firefighters and ambulances, helping residents of Bento Rodrigues to be removed from the place of destruction and take refuge in the nearby hills.

Source: dw.com, malaysiandigest.com

(Geoengineer.org / Saturday, 07 November 2015)

Video: Meridian "Sinkhole"

A sinkhole which is about 50 feet wide and 600 feet long, opened up in Meridian, Mississippi, USA.

A sinkhole which is about 50 feet wide and 600 feet long, opened up in Meridian, Mississippi, USA. The causes of the phenomenon are still unknown.

The huge cave-in opened up in an IHOP parking and shallowed 15 cars causing terror!

Local authorities blocked the area in order to keep people away because nobody knows the progress of the phenomenon.

Meridian Fire Department Chief Battalion Wayne Cook said "Upon arrival, we found multiple vehicles in the ditch. At this time, we are trying to stabilize this and keep everyone away."

Meridian Public Safety Director Buck Roberts said ''he collapse was not technically a sinkhole, which is usually the result of an underground water aquifer that dries and leaves a void in the ground. You can call it what you want, a cave-in or whatever, but it is not a sinkhole,"

Engineers and contractors are currently studying the site.

Some people believe that the phenomenon is caused by a collapse of a subterranean cave.

Video https://www.youtube.com/watch?v=lfh3p_FTy28

Source: usatoday.com

(Geoengineer.org / Monday, 09 November 2015)

Σημείωση Εκδότη

Προφανώς δεν πρόκειται για sinkhole, ούτε για την κατάρρευση «υπογείου»!!! σπηλαίου. Όπως και το συνοδευτικό κείμενο του video αναφέρει (It is apparently not really a sinkhole but some kind of underground drainage collapse), η αστοχία οφείλεται στην κατάρρευση αποχετευτικού αγωγού από κυματοδειδή λαμαρίνα (Corrugated Steel Culvert), η έξοδος του οποίου φαίνεται στην φωτογραφία και η έξοδός του, κάτω από τον δρόμο, φαίνεται στο video.

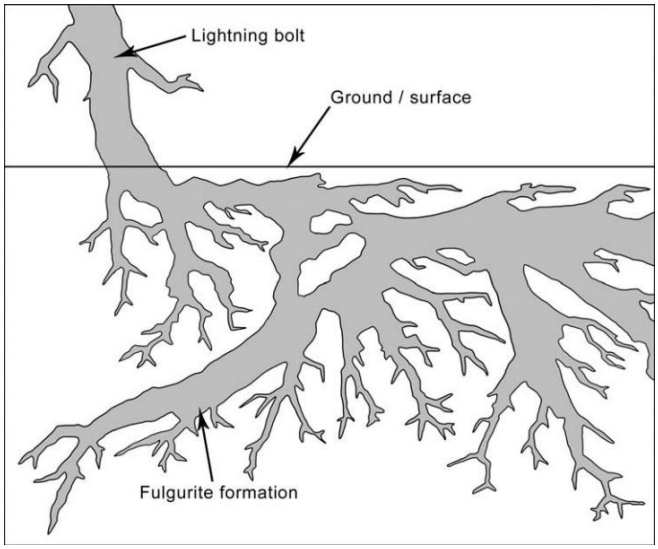
Fulgurite: A rare phenomenon

A bolt of lightning is able to deliver up to 5 gigajoule of energy (energy that can power a house in the US for over a month). When such a powerful lightning strikes a sandy area, then under special conditions, the sand particles can melt and fuse in less than a second. It is known that the sand melts at about 1,800 degrees Celsius, and the temperature of a bolt can reach 30,000 degrees Celsius.

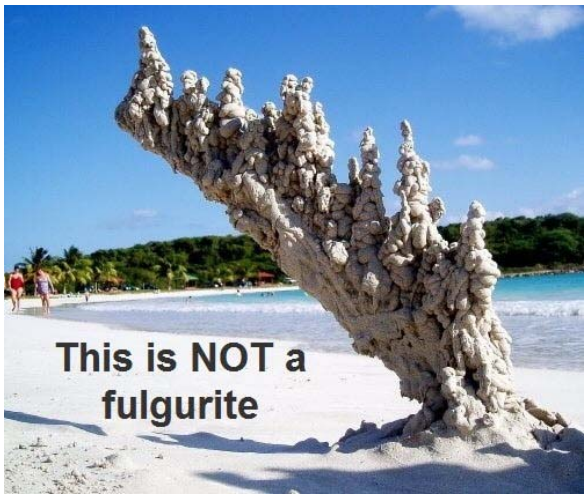
So, sometimes when a bolt of lightning strikes sandy areas, tubes of sand that are called fulgurites are created. Despite the fact that there are over one million lightning that strike Earth every day, the fulgurites are rare.

Fulgurites are usually occurring beneath the surface of the sand and their shape reflects the way that makes lightning as it dispersed into the ground.

Fulgurites resemble roots with rough surface. However, the inner surface is smooth and glassy, because of the fact that the sand cools rapidly and solidifies. Their size is based on the strength of the lightning and the thickness of the sand bed. There are some occasions that fulgurites can penetrate deep into the soil, up to 15 meters below the surface.



The fulgurites are known since 1711 and they are appreciated for their scientific value. A fulgurite that is 250 million years old found in the Sahara, has confirmed that the desert was a fertile area where the storms were frequent.



Some people claim that this image is an example of fulgurite. In fact, it is a sculpture (wood from the beach that is covered with sand) creation of "Sandcastle Matt".

As the Museum of Hoaxes rightly observes, "A fulgurite of that size would be extremely valuable, and most likely would already have been carted away to a museum. It wouldn't be sitting on a beach surrounded by holiday-goers, any one of whom could potentially break it."

Source: amusingplanet.com, geology.utah.gov

(Geoengineer.org / Wednesday, 11 November 2015)

Total immersion: the world's longest immersed tunnel

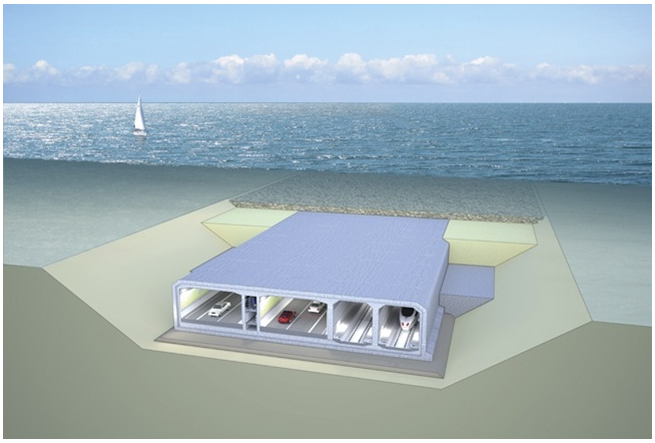
Danish engineers are poised to begin construction of the world's longest immersed tunnel

Denmark is no stranger to challenging infrastructure projects. Over the years – primarily in an effort to improve the transport links between the country's mainland and its largest islands – it has built a host of record-breaking bridges and tunnels that have cemented its reputation as a global centre of structural engineering excellence.

But now, its civil engineers are poised to begin a construction project that could be the country's most challenging yet: an 18km-long sub-sea tunnel that will link the German island of Fehmarn with the Danish island of Lolland. Its proponents claim that it will fundamentally transform transport in the region, replacing around two million ferry journeys annually, and slashing rail travel time between Copenhagen and Hamburg by more than 25 per cent.

Dubbed the Fehmarn Belt Fixed Link (after the Baltic strait separating the two islands), the new link will be the longest immersed tunnel ever built and will be five times longer than the current record-holder, the Øresund tunnel, which is also in Denmark. Constructed from vast pre-fabricated concrete sections that will be installed in a trench on the seabed up to 35m beneath the surface, the tunnel will comprise twin railway lines, four motorway lanes and a separate emergency tube.

Kim Smedegaard Andersen is the technical director for Femern A/S, the Danish government-owned organisation responsible for building the tunnel.



The tunnel will be installed in a trench on the seabed

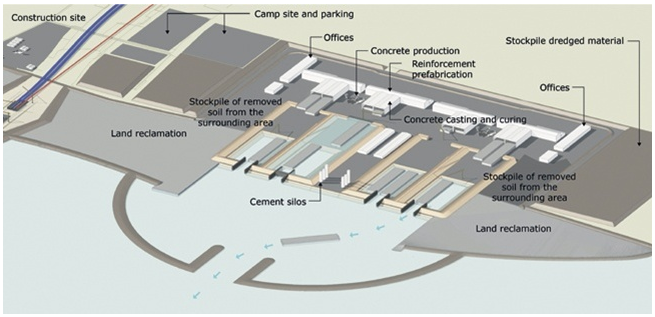
He explained to *The Engineer* that a direct link across the Fehmarn Belt has been under discussion for a number of years, but that a tunnel was chosen as the preferred solution primarily because of the distance of the link, the water depth in the Fehmarn belt and a host of environmental factors. "A tunnel below the seabed will cause some environmental disruption during construction," he said, "but once in place it will be neutral, while a bridge, which would have giant pillars would constantly impact on the environment."

The decision to build an immersed tunnel rather than a bored tunnel such as those recently excavated for London's Crossrail project was, he added, driven by both the desired size of the tunnel (it would require the largest tunnel-boring machine ever built) and the complex geology of the region. "We don't have a uniform soil type, there are some very plastic clays and some very hard marine clays with a lot of flint and it can be a very complicated to construct machinery which can cope with material changing from sand and silt to clay and so forth."

The project has been formally approved in Denmark, and the team is now waiting for it to be signed off by the German government. Once this happens, a mammoth manufacturing and engineering operation will begin.

The first step will be the construction of a giant purpose-built manufacturing facility and harbour near Rødbyhavn, on the south coast of the Danish island of Lolland.

Here, eight identical production lines will be set up for the continuous casting of the huge reinforced concrete elements that will form the structure of tunnel.



A giant factory and harbour will be built specially for the project

Made from a series of nine identical segments that are joined together during the manufacturing process, each element will weigh approximately 73,000 tonnes and will be 217m long, 9m high and 42m wide. A total of 89 separate elements will be produced for the tunnel. Ten of these will feature a special additional deck beneath the traffic tube that will be used to carry out maintenance work once the tunnel is operational. This, said Andersen is a completely new innovation in immersed tunnel design that has been necessitated by the distance of the crossing. "Most tunnels are so short you are only operating from the poles," he added.

Once an element has been cast, watertight steel bulkheads will be added to each end of element to ensure that it floats and it will be pushed into a basin and towed to a holding area near the trench.

The element will then be connected to advanced pontoons that will be used to carefully guide it to the immersion site.

Once positioned directly above the trench, cables anchored to the seabed will hold the element in position, and its ballast tanks will be filled with water to enable it to sink to the seabed. Its descent to the immersion site will be carefully controlled by cables attached to the immersion pontoon while a combination of GPS and sonar will help guide the giant structure to its final resting place.

The tunnel sections lowered into place; the voids will house two railway lines and four motorwat lanes

The next challenge is connecting the separate elements together on the seabed in order to form the tunnel, and this is achieved using an elegant process that Andersen likens to "a great big kiss". When the tunnel element has been placed in the tunnel trench and lined up with the previous one, a hydraulic arm will be used to haul the new element right up to the existing one.

As the elements are brought together, huge rubber gaskets mounted on their ends will form a watertight chamber between the steel bulkheads. Water is then pumped out of this chamber, until it's at normal atmospheric pressure, and the considerably higher water pressure on the free end will force the elements close together creating a watertight seal.

This will continue until all the elements are in place. They'll then be secured in the tunnel trench with gravel and sand, and covered with a protective layer of stone. The top layer of stone will be level with the existing seabed and the tunnel itself will be safely below the seabed, protected against ship anchors and other collisions.

Once that process is complete, the engineering team can then set about installing the road and rail infrastructure that will, says Andersen, make the Fehmarn tunnel one of the most advanced links of its kind in the world.

Much of the technology that will be deployed in the tunnel is, he said, still to be decided. Safety and traffic management systems are evolving rapidly and with the project expected to take around eight years to complete, he and his team are watching developments around the world with interest.

In the meantime, with the Danish parliament giving the scheme the go-ahead earlier this summer, Andersen and his team are anxiously awaiting a similar vote of confidence from the German federal government.

(Jon Excell / the engineer, 13 November 2015, http://www.theengineer.co.uk/in-depth/analysis/total-immersion-the-worlds-longest-immersed-tunnel/1021406.article?cmpid=tenews_1750541)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΣΕΙΣΜΟΙ

Συσκευή προειδοποίησης για τσουνάμι θα εγκατασταθεί στον Κορινθιακό

Μία νέα πειραματική συσκευή χαμηλού κόστους για την καταγραφή της στάθμης της θάλασσας, που θα προειδοποιεί έγκαιρα για επερχόμενο τσουνάμι, ανέπτυξαν επιστήμονες του Κοινού Ερευνητικού Κέντρου (Joint Research Center-JRC) της Ευρωπαϊκής Ένωσης.

Οι πρώτες τέσσερις συσκευές εγκαταστάθηκαν ήδη τον Οκτώβριο στην Ισπανία και στην Πορτογαλία (από δύο σε κάθε χώρα), ενώ άλλες 16 θα εγκατασταθούν στη Μεσόγειο. Σύμφωνα με το JRC, μία από αυτές θα τοποθετηθεί σύντομα στον Δυτικό Κορινθιακό Κόλπο, σε συνεργασία με το Εθνικό Αστεροσκοπείο Αθηνών.

Τα συστήματα έγκαιρης προειδοποίησης για τσουνάμι βασίζονται τόσο σε σεισμογράφους, όσο και σε σταθμούς μετρησης της στάθμης των υδάτων. Οι σταθμοί αυτοί εγκαθίστανται συνήθως κατά μήκος των ακτών.

Η νέα συσκευή Inexpensive Device for Sea Level Measurement (IDSL) μετρά τη στάθμη του νερού σε πραγματικό χρόνο. Η μέτρηση γίνεται κάθε πέντε δευτερόλεπτα και τα στοιχεία μεταδίδονται στους κεντρικούς υπολογιστές του JRC. Τα δεδομένα είναι άμεσα διαθέσιμα για ανάλυση και πρόσβαση σε αυτά από μια ειδική ιστοσελίδα.

Εκτός από τον Κορινθιακό, τέτοιες συσκευές θα τοποθετηθούν στην Ιταλία, στο Λίβανο, στο Μαρόκο, στη Ρουμανία, στην Τυνησία και στην Τουρκία. Το όλο δίκτυο θα ενταχθεί στο ευρύτερο Σύστημα Προειδοποίησης για Τσουνάμι σε Βόρειο Ατλαντικό και Μεσόγειο (NEAMTWS), που έχει στήσει η διακυβερνητική ωκεανογραφική επιτροπή της Unesco.

(Η ΚΑΘΗΜΕΡΙΝΗ / ΑΠΕ-ΜΠΕ, 16.11.2015,
http://www.kathimerini.gr/838766/article/epikairothta/episthmh/syskeyh-proeidopoihshs-gia-tsoynami-8a-egkatasta8ei-ston-korin8iako)

Σ.Ε. Πόσος χρόνος εννοείται με τον όρο «Έγκαιρη Προειδοποίηση»; Για την περίπτωση του Κορινθιακού Κόλπου ο χρόνος «ταξιδιού» του tsumani ανέρχεται σε μερικά δευτερόλεπτα!

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΠΕΡΙΒΑΛΛΟΝ

Τέως θάλασσα
Όταν η Μεσόγειος στέγνωσε

Για σχεδόν 300.000 χρόνια, η Μεσόγειος ήταν μια έρημος από αλάτι

Υπήρξε μια εποχή που η Μεσόγειος έπαψε για λίγο να είναι θάλασσα -μετατράπηκε σε μια απέραντη έρημο από αλάτι πάχους εκατοντάδων ή χιλιάδων μέτρων. Τα αίτια αυτής της γεωλογικής κρίσης παραμένουν εν πολλοίς αδιευκρίνιστα, όπως φαίνεται όμως σχετίζονται με τους πάγους της Ανταρκτικής.

Ο θάνατος της Μεσογείου πριν από 5,6 εκατομμύρια χρόνια επιβεβαιώθηκε ως συμβάν τη δεκαετία του 1970, και οι γεωλόγοι το ονομάζουν σήμερα «κρίση αλατότητας του Μεσσηνίου», από το όνομα της γεωλογικής περιόδου κατά την οποία συνέβη.

Η αιτία της εξάτμισης παραμένει σήμερα αντικείμενο επιστημονικής διαμάχης: άλλοι πιστεύουν ότι η Μεσόγειος απομονώθηκε από τον Ατλαντικό λόγω μιας λωρίδας ξηράς που σχηματίστηκε από τη μετακίνηση των τεκτονικών πλακών στην περιοχή του Γιβραλτάρ. Άλλοι, πάλι, αποδίδουν το συμβάν σε μεγάλη υποχώρηση της στάθμης του ωκεανού, η οποία σταμάτησε τη ροή νερού προς τη λεκάνη της Μεσογείου.

Νέα δεδομένα που δείχνουν να ενισχύουν τη δεύτερη αυτή θεωρία δημοσιεύονται τώρα από διεθνή ερευνητική ομάδα στην επιθεώρηση Nature Communications.

Με επικεφαλής τον Δρ Κρίστιαν Ονέιζερ του Πανεπιστημίου του Οτάγκο στη Νέα Ζηλανδία, οι ερευνητές εξέτασαν δείγματα από 60 σημεία του πυθμένα γύρω από την Ανταρκτική. Πράγματι, η ανάλυση έδειξε ότι η ήπειρος συσσώρευε πάγο περίπου την εποχή που η Μεσόγειος νεκρώθηκε.

Αυτό δείχνει ότι η κρίση αλατότητας του Μεσσηνίου περίπου συμπίπτει χρονικά με μια πτώση της στάθμης σε παγκόσμιο επίπεδο -το νερό των ωκεανών μετατράπηκε σε πάγο που συσσωρεύθηκε στην ξηρά της Ανταρκτικής.

Στην επόμενη φάση της μελέτης, οι ερευνητές χρησιμοποίησαν υπολογιστικά μοντέλα για να προσομοιώσουν πώς η επέκταση του παγοκαλύμματος της Ανταρκτικής θα επηρέαζε τη γεωλογία ολόκληρου του πλανήτη.

Το μοντέλο έδειξε ότι η πτώση της στάθμης δεν ήταν ομοιόμορφη σε όλη τη Γη λόγω μιας «περίπλοκης αλληλεπίδρασης ανάμεσα στη βαρύτητα, την περιστροφή του πλανήτη και τις παραμορφώσεις του γήινου φλοιού από την επέκταση και την υποχώρηση των πάγων» λέει ο Δρ Ονέιζερ.

Στην περιοχή της Μεσογείου, η πτώση της στάθμης οδήγησε σε μείωση της πίεσης που ασκούσε το νερό στο βυθό της θάλασσας. Και όταν το βάρος του νερού μειώθηκε, ο βυθός γύρω από το Στενό του Γιβραλτάρ ανυψώθηκε.

«Αυτό κράτησε τη Μεσόγειο απομονωμένη από τον Ατλαντικό μέχρι που ο γήινος φλοιός χαλάρωσε και άρχισε να βυθίζεται. Την ίδια εποχή, οι πάγοι της Ανταρκτικής άρχισαν να λιώνουν, ανεβάζοντας και πάλι τη στάθμη της θάλασσας».

Σχεδόν 300.000 χρόνια μετά την απονέκρωση της Μεσογείου, πριν από 5,33 εκατ. χρόνια, η στάθμη ήταν αρκετά υψηλή για να μπορέσουν τα νερά του Ατλαντικού να διαλύσουν τη στενή λωρίδα ξηράς στο Γιβραλτάρ.

Αυτό που ακολούθησε ήταν μια πλημμύρα βιβλικών διαστάσεων που γέμισε ξανά τη μεσογειακή λεκάνη.

Οι εκτιμήσεις για το πόσος χρόνος χρειάστηκε μέχρι να αναστηθεί η Μεσόγειος ποικίλουν. Σύμφωνα πάντως με μελέτη που δημοσιεύτηκε στο Nature το 2009, η ροή ήταν τόσο μεγάλη ώστε ολόκληρη η μεσογειακή λεκάνη ξαναγέμισε σε λιγότερο από δύο χρόνια (Κατακλυσμιαία πλημμύρα γέμισε τη Μεσόγειο σε μήνες, http://news.in.gr/science-technology/article/?aid=1084327).

Σήμερα, μάρτυρας αυτού του θανάτου και της ανάστασης της Μεσογείου είναι ένα παχύ στρώμα αλατιού που κρύβεται σήμερα μερικές εκατοντάδες μέτρα κάτω από τον βυθό -το αλάτι μιας αρχαίας Μεσογείου που ξεράθηκε.

(Βαγγέλης Πρατικάκης / Newsroom ΔΟΛ, 11 Νοε. 2015, http://news.in.gr/science-technology/article/?aid=1500038730&ref=newsletter)

Antarctic glacio-eustatic contributions to late Miocene Mediterranean desiccation and reflooding

Christian Ohneiser, Fabio Florindo, Paolo Stocchi, Andrew P. Roberts, Robert M. DeConto & David Pollard

Abstract

The Messinian Salinity Crisis (MSC) was a marked late Neogene oceanographic event during which the Mediterranean Sea evaporated. Its causes remain unresolved, with tectonic restrictions to the Atlantic Ocean or glacio-eustatic restriction of flow during sea-level lowstands, or a mixture of the two mechanisms, being proposed. Here we present the first direct geological evidence of Antarctic ice-sheet (AIS) expansion at the MSC onset and use a $\delta^{18}O$ record to model relative sea-level changes. Antarctic sedimentary successions indicate AIS expansion at 6 Ma coincident with major MSC desiccation; relative sea-level modelling indicates a prolonged ~50 m lowstand at the Strait of Gibraltar, which resulted from AIS expansion and local evaporation of sea water in concert with evaporite precipitation that caused lithospheric deformation. Our results reconcile MSC events and demonstrate that desiccation and refilling were timed by the interplay between glacio-eustatic sea-level variations, glacial isostatic adjustment and mantle deformation in response to changing water and evaporite loads.

(Nature Communications 6, Article number: 8765, doi:10.1038/ncomms9765, http://www.nature.com/ncomms/2015/151110/ncomms9765/full/ncomms9765.html#affil-auth)

Όταν άνοιξε το Γιβραλτάρ

Κατακλυσμιαία πλημμύρα γέμισε τη Μεσόγειο σε μήνες

Η πλημμύρα που γέμισε τη Μεσόγειο πριν από 5,33 εκατομμύρια χρόνια ήταν τόσο σφοδρή ώστε η όλη διαδικασία ολοκληρώθηκε σε διάστημα από λίγους μήνες μέχρι δύο χρόνια, μαρτυρούν τα ίχνη ενός υποβρύχιου καναλιού στην περιοχή του Γιβραλτάρ.

Πριν από περίπου 5,6 εκατομμύρια χρόνια υπήρχε στο Γιβραλτάρ ένας ισθμός που ένωνε την Ισπανία με την Αφρική και απέκοπτε τη Μεσόγειο από τον Ατλαντικό. Η θάλασσα σταδιακά εξατμιζόταν, μέχρι που η στάθμη της έπεσε 1.500 με 2.700 μέτρα κάτω από το επίπεδο του γειτονικού ωκεανού.

Και καθώς η αλατότητα της Μεσογείου αυξανόταν, τα νερά της σταδιακά απονεκρώνονταν.

Προηγούμενες μελέτες υποδείκνυαν ότι η πλημμύρα που ξαναγέμισε τελικά τη Μεσόγειο διήρκεσε από 10 έως αρκετές χιλιάδες χρόνια, αναφέρει το Γαλλικό Πρακτορείο Ειδήσεων.

Η νέα έρευνα, που βασίστηκε σε δεδομένα από γεωτρήσεις και σεισμικές μετρήσεις, δείχνει ότι η πλημμύρα ήταν πολύ πιο απότομη από ό,τι νόμιζαν οι επιστήμονες, και εξελίχθηκε με διαφορετικό μηχανισμό.

«Δεν φανταζόμαστε έναν καταρράκτη, όπως συνήθως απεικονίζεται [στα σχέδια άλλων επιστημόνων]. Τα γεωφυσικά δεδομένα υποδηλώνουν την ύπαρξη μιας τεράστιας ράμπας, πλάτους αρκετών χιλιομέτρων, που κατηφόριζε από τον Ατλαντικό στην αποξηραμένη Μεσόγειο» γράφουν οι Ισπανοί ερευνητές στο περιοδικό Nature.

Η μελέτη αποκάλυψε μάλιστα ένα κανάλι 200 χλμ, το οποίο διανοίχτηκε στο βυθό από νερά που κυλούσαν με ταχύτητα 300 χιλιομέτρων την ώρα.

Η απότομη πλημμύρα ανέβαζε τη στάθμη της Μεσογείου έως και κατά 10 μέτρα την ημέρα, εκτιμά η ομάδα του Ντανιέλ Γκαρθία-Καστελάνος στο Ινστιτούτο Γεωεπιστημών της Βαρκελόνης.

Η ροή ήταν τριπλάσια από του Αμαζόνιου.

Μαζί με τα τρεχούμενα νερά φαίνεται ότι επέστρεψαν στη Μεσόγειο και διάφοροι θαλάσσιοι οργανισμοί που είχαν εξαφανιστεί λόγω της υψηλής αλατότητας, όταν η θάλασσα ακόμα εξατμιζόταν, έχουν δείξει παλαιότερες μελέτες σε ιζήματα.

Όσον αφορά την αιτία αυτού του κατακλυσμιαίου συμβάντος, το πιθανότερο είναι ότι πυροδοτήθηκε από υποχώρηση των τεκτονικών πλακών.

(Newsroom ΔΟΛ, 10 Δεκ. 2009, http://news.in.gr/science-technology/article/?aid=1084327)

ΕΝΔΙΑΦΕΡΟΝΤΑ – ΛΟΙΠΑ

Όμορφες πεζογέφυρες στον κόσμο!

Κάποιες αποτελούν θαύματα αρχιτεκτονικής, άλλες χρωστούν στη φύση την ύπαρξή τους! Κάποιες αποτελούν θαύματα αρχιτεκτονικής, άλλες χρωστούν στη φύση την ύπαρξή τους!

Μερικές γέφυρες είναι πολύ πιο εντυπωσιακές τη νύχτα. Σε αυτή την κατηγορία ανήκει η μήκους 240 μέτρων πεζογέφυρα πάνω από τον ποταμό Tees στη βορειοανατολική Αγγλία. Το είδωλο της γέφυρας αντικατοπτρίζεται στο νερό ενώ τα φώτα κατά μήκος της αλλάζουν όταν περπατούν πεζοί πάνω της καθοδηγώντας τους στην απέναντι όχθη.

Moses Bridge, Ολλανδία

Είναι η πιο κομψή πεζογέφυρα της λίστας μας αφού δεν βρίσκεται πάνω από το νερό αλλά μέσα σε αυτό. Συνδέει τις δύο όχθες της τάφρου στο φρούριο Fort de Roovere της πόλης Halsteren στα νοτιοδυτικά της χώρας. Είναι κατασκευασμένη από ένα high-tech ξύλο, το Accoya ενώ το όνομά της είναι εμπνευσμένο από το Μωυσή που σύμφωνα με τη Βίβλο διέσχισε την Ερυθρά Θάλασσα χωρίζοντάς τη στη μέση.

Iya Valley, Ιαπωνία

Σε αυτή την απομακρυσμένη και δυσπρόσιτη περιοχή της Ιαπωνίας έβρισκαν πάντα καταφύγιο οι παράνομοι και καταζητούμενοι της χώρας. Έτσι, εκατοντάδες χρόνια πριν, χρησιμοποίησαν δύο αναρριχητικά φυτά, που φύτρωναν στις όχθες του ποταμού, και τα έπλεξαν μεταξύ τους δημιουργώντας την μήκους 45 μέτρων γέφυρα. Αρχικά υπήρχαν μόνο σανίδες πλεγμένες μαζί με τα κλαδιά αλλά πλέον η γέφυρα έχει ενισχυθεί με σύρμα και πλαϊνά προστατευτικά.

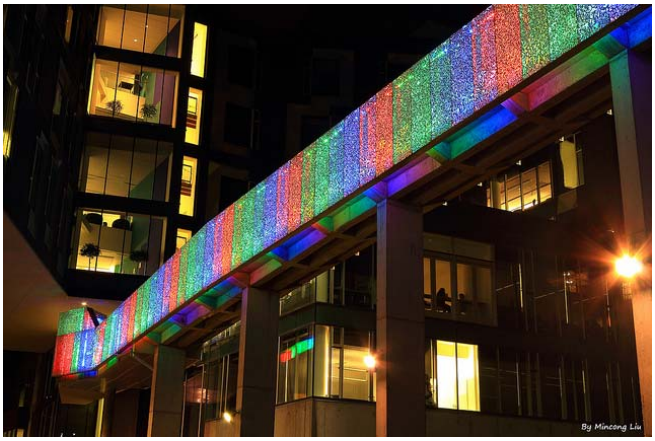
Trift Bridge, Ελβετία

Η μεγαλύτερη πεζογέφυρα στις Ελβετικές Άλπεις έχει μήκος 170 μέτρων και κρέμεται σε ύψος 100 μέτρων πάνω από τη λίμνη Triftsee. Δέχεται κάθε χρόνο χιλιάδες επισκέπτες που τολμούν να τη διασχίσουν.

Festina Lente, Βοσνία & Ερζεγοβίνη

"Σπεύδε βραδέως" είναι η μετάφραση του λατινικού ονόματος της γέφυρας που διασχίζει τον ποταμό Miljaka στο Σαράγιεβο και οδηγεί στην εκκλησία της πόλης. Σχεδιάστηκε από τρεις φοιτητές της Σχολής Καλών Τεχνών της πόλης, είναι κατασκευασμένη από ατσάλι με μήκος 38 μέτρων και εγκαινιάστηκε μόλις το καλοκαίρι του 2012.

Randy Pausch Memorial Footbridge, ΗΠΑ



Η πεζογέφυρα εγκαινιάστηκε το 2009 προς τιμήν του καθηγητή της Επιστήμης των Υπολογιστών Randy Pausch, ο οποίος είχε χάσει τη μάχη με τον καρκίνο ένα χρόνο νωρίτερα. Η γέφυρα συνδέει τα κτίρια του πανεπιστημίου Carnegie Mellon University και έχει πάνω από 7.000 φώτα LED τα οποία δημιουργούν μοτίβα εμπνευσμένα από τις ομιλίες του καθηγητή. Για παράδειγμα, στο "σόου" που διαρκεί 15 λεπτά και επαναλαμβάνεται όλη μέρα, θα δείτε φωτισμένες φιγούρες πιγκουίνων να βουτούν στο νερό. Ο Pausch συνήθιζε να λέει πως ακόμα και στα πιο επικίνδυνα νερά ένας πιγκουίνος θα έπρεπε να είναι ο πιο γενναίος για να κάνει την πρώτη βουτιά.

War-Khasis Bridge, Ινδία

Πρόκειται για "ζωντανές" γέφυρες που δεν κατασκευάζονται αλλά μεγαλώνουν με το πέρασμα του χρόνου. Την ιδέα συνέλαβαν πριν αρκετούς αιώνες τα μέλη της φυλής War-Khasis στην βορειοανατολική Ινδία, ένα από τα πιο υγρά μέρη στον κόσμο. Καθοδήγησαν τις ρίζες του καουτσοκόδεντρου από τη μία όχθη του ποταμού στην άλλη, οι οποίες δημιούργησαν τελικά τη γέφυρα. Χρειάζονται περίπου 15 χρόνια για να ολοκληρωθεί αυτή η διαδικασία αλλά οι γέφυρες όσο περνάει ο καιρός γίνονται πιο γερές και μπορούν να αντέξουν το βάρος μέχρι και 50 ανθρώπων.

Reiman Bridge, ΗΠΑ

Η καλωδιωτή γέφυρα συνδέει την πόλη του Μιλγουόκι με το μουσείο τέχνης που μοιάζει με καθεδρικό στην άκρη της λίμνης Μίσιγκαν. Το φουτουριστικό design που θυμίζει πουλί υπογράφει ο Καλατράβα, ο οποίος σχεδίασε και το μουσείο. Η γέφυρα εγκαινιάστηκε το 2001.

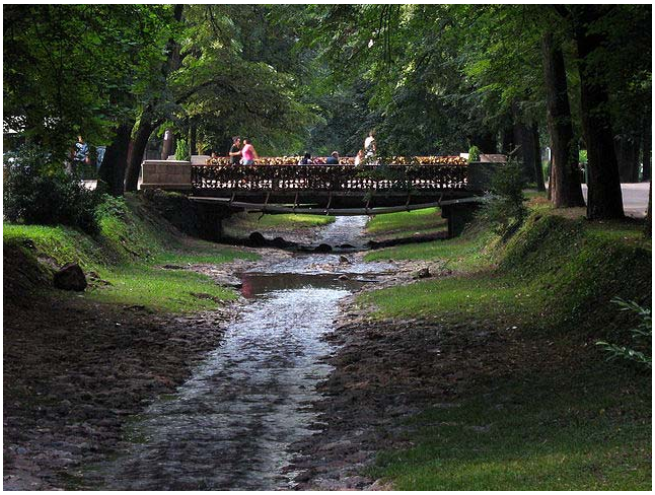
Bridge of Flowers, ΗΠΑ

Η τσιμεντένια γέφυρα κατασκευάστηκε το 1908 για να συνδέει με τρόλεϊ τις πόλεις Shelburne και Buckland της Μασαχουσέτης. Ως το 1927 οι μεταφορές γίνονταν πλέον με φορτηγά κι έτσι η γραμμή καταργήθηκε και η γέφυρα γέμισε χορτάρια. Τότε, δύο γυναίκες, η Clara S. C. Barnard και η Antoinette Burnham είχαν την ιδέα να μετατρέψουν τη γέφυρα σε κήπο που διατηρείται εντυπωσιακός ως σήμερα.

Benson Footbridge, ΗΠΑ

Κρεμασμένη σε ύψος 32 μέτρων πάνω από τα νερά του καταρράκτη Multnomah στο Όρεγκον, η μήκους 14 μέτρων γέφυρα χτίστηκε το 1914 από Ιταλούς τεχνίτες της πέτρας με χρηματοδότηση του επιχειρηματία και φιλάνθρωπου Simon Benson.

Most Ljubavi, Σερβία



Η Γέφυρα της Αγάπης είναι η πιο γνωστή από τις 15 γέφυρες της πόλης Vrnjačka Banja και είναι γνωστή για τα αμέτρητα λουκέτα με ονόματα ερωτευμένων ζευγαριών κλειδωμένα στα κάγκελά της ως σύμβολο αιώνιας αγάπης. Η ιστορία έχει ως εξής: κατά τη διάρκεια του Α' Παγκοσμίου Πολέμου, η Nada, μια ντόπια δασκάλα ερωτεύτηκε τον στρατιώτη Relja, ο οποίος αφού αρραβωνιάστηκαν, έφυγε για να πολεμήσει στην Ελλάδα. Στη χώρα μας όμως ερωτεύτηκε μια νεαρή από την Κέρκυρα και διέλυσε τον αρραβώνα του με τη Nada, η οποία πέθανε από τη στενοχώρια της.

(5 Νοεμβρίου 2015)

Βγαλμένο από παραμύθι
Το μυστηριώδες δάσος με τους καμπυλωτούς κορμούς στην Πολωνία

Μοιάζει σαν ένα μέρος που έχει βγει από τα παραμύθια. Κι όμως υπάρχει στην πραγματικότητα.

Πρόκειται για το λεγόμενο «Στραβό Δάσος» που βρίσκεται στην Πολωνία και έχει ένα ιδιαίτερο χαρακτηριστικό. Όλα τα δέντρα έχουν μια περίεργη καμπύλη στην βάση του κορμού τους.

Πάνω από 400 πεύκα που έχουν φυτευτεί περίπου στη δεκαετία του '30, έχουν αυτή την ιδιαιτερότητα στον κορμό τους, σχηματίζοντας το γράμμα C. Τα δέντρα μεγαλώνουν κανονικά χωρίς να επηρεάζονται από την ιδιομορφία αυτή.

(Newsroom ΔΟΛ, 18 Νοεμ. 2015, http://news.in.gr/perierga/article/?aid=1500040175)

ΝΕΕΣ ΕΚΔΟΣΕΙΣ ΣΤΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΠΙΣΤΗΜΕΣ

Γεωλογία της Ελλάδας

Δημήτρης Παπανικολάου

Η Ελλάδα αποτελεί ένα φυσικό εργαστήριο γεωλογίας, που δίνει τη δυνατότητα να αντιληφθούμε τη σημερινή ενεργό γεωδυναμική διεργασία του ελληνικού ορογενετικού τόξου, που περιλαμβάνει τους σεισμούς, τα ηφαίστεια, τις μετακινήσεις ακτών και τις άλλες γεωλογικές διεργασίες ανυψώσεων και βυθίσεων διαφόρων περιοχών, καθώς και της έντονης διάβρωσης, μεταφοράς και απόθεσης ιζημάτων. Ταυτόχρονα αποτελεί ένα σπουδαίο γεωλογικό μουσείο, που αποκαλύπτει την πολύπλοκη ιστορία της περιοχής κατά τη διάρκεια των τελευταίων 300 εκατομμυρίων ετών της ύπαρξης του πλανήτη μας. Μέσα από τη μελέτη των πετρωμάτων της Ελλάδας μπορούν να ανιχνευθούν παλιές ωκεάνιες λεκάνες, όπως στη Βόρεια Πίνδο και την Όρθρυ, παλιά κρυσταλλικά πετρώματα του Παλαιοζωικού αιώνα, παλιά γρανιτικά και ηφαιστειακά πετρώματα, καθώς και χαρακτηριστικές φάσεις ασβεστολίθων και άλλων ιζηματογενών πετρωμάτων, τα οποία περιέχουν απολιθώματα τόσο παράκτιας νηριτικής φάσης, όσο και πελαγικής ή και αβυσσικής φάσης. Τα νεότερα ιζήματα αποκαλύπτουν τη συνεχή αλλαγή της παλαιογεωγραφίας της Ελλάδας, με περιοχές λιμνών, οροπεδίων, κόλπων που μεταβάλλονται σε νέες μορφές νησιών, χερσονήσων ή ψηλών βουνών κτλ. Όλα τα προηγούμενα περιέχονται στο βιβλίο που περιγράφει την τεκτονική δομή των γεωλογικών στρωμάτων και των λοιπών πετρωμάτων της Ελλάδας, καθώς και τα διαδοχικά στάδια εξέλιξης της παλαιογεωγραφίας και της γεωδυναμικής στον ευρύτερο χώρο της Μεσογείου.

(Εκδόσεις ΠΑΤΑΚΗ, Οκτώβριος 2015)

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