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Educating engineers to embrace complexity and context

Edmond P. Byrne and Gerard Mullally

Education represents a key intervention point in encouraging the emergence of a professional engineering ethos informed by a sustainability ethic. In terms of establishing an appropriate relationship between sustainability and education, many would contend that incorporating sustainability as merely add-on material to already overcrowded curricula is insufficient. Instead sustainability should actually be a leading principle for curricula. Traditional reductionist models of engineering education seek to extinguish context and uncertainty and reduce complexity across socio-economic and ecological domains. They therefore constitute a wholly inadequate response to the need for fit-for-purpose, twenty-first century graduates required to address broader sustainability issues. This paper presents research from an undergraduate module at University College Cork, Ireland. The module is aimed at developing students' conceptions of complexity, uncertainty, risk, context and ethics as foundational bases for productively engaging with sustainability. The paper also highlights some problematic issues.

(συνέχεια στην σελίδα 3)

Π Ε Ρ Ι Ε Χ Ο Μ Ε Ν Α

The **Giant's Causeway** is an area of about 40,000 interlocking basalt columns, the result of an ancient volcanic eruption. It is also known as *Clochán an Aifir* or *Clochán na bhFomhórach* in Irish and *tha Giant's Causey* in Ulster-Scots. It is located in County Antrim on the northeast coast of Northern Ireland.

The **Cliffs of Moher** (Irish: *Aillte an Mhothair*) are located at the southwestern edge of the Burren region in County Clare, Ireland. They rise 120 metres above the Atlantic Ocean at Hag's Head, and reach their maximum height of 214 metres just north of O'Brien's Tower.

Whiterocks Beach, forming the eastern end of the East Strand/Curran Strand beach, Northern Irelend and within walking distance of the busy resort of Portrush, is famous for its white chalk cliffs.

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Education represents a key intervention point in encouraging the emergence of a professional engineering ethos informed by a sustainability ethic. In terms of establishing an appropriate relationship between sustainability and education, many would contend that incorporating sustainability as merely add-on material to already overcrowded curricula is insufficient. Instead sustainability should actually be a leading principle for curricula. Traditional reductionist models of engineering education seek to extinguish context and uncertainty and reduce complexity across socio-economic and ecological domains. They therefore constitute a wholly inadequate response to the need for fit-for-purpose, twenty-first century graduates required to address broader sustainability issues. This paper presents research from an undergraduate module at University College Cork, Ireland. The module is aimed at developing students' conceptions of complexity, uncertainty, risk, context and ethics as foundational bases for productively engaging with sustainability. The paper also highlights some problematic issues.

1. Introduction

There is a realisation that what has been called a 'new engineer' is required for fit-for-purpose twenty-first century engineering in order to address the attendant challenges and crises around (un)sustainability that face contemporary society (Beder, 1998). This is a professional who recognises that values and ethics pervade all engineering practice, leaves hubristic illusions of control aside and embraces context, complexity, inherent uncertainty and risk (Bucciarelli, 2008). S/he recognises the 'deep sociotechnical complexities that are often at the heart of [engineering] ''Grand Challenges''' while making 'explicit the social and ethical responsibilities of engineers' (Herkert and Banks, 2012). Moreover, while they recognise the value of scientific and technological approaches in relation to contemporary societal challenges, the 'new engineer' acknowledges that technocentric approaches alone are incapable of achieving progress towards sustainable outcomes among inter-related complex social, techno-economic and ecological systems (Conlon, 2008). Such approaches need to be complemented by recognition of the importance of context and the presence of contingency and indeterminacy in these complex systems, and hence value the additional knowledge that can be provided by experiential and local knowledge and intuition.

This is a view consistent with one proposed across the domain of engineering education for sustainable development (EESD) over the past two decades. Such a view proposes the incorporation of sustainability within and across engineering programmes as a 'leading principle for curricula' to elicit a broader conception of the engineer (in contrast to incorporating content merely as 'add on' material to an already overcrowded curriculum) (Mulder et al., 2012). It also aligns with contemporary directions in the sociology of sustainable development (e.g. Baillie et al., 2013) and with education and pedagogical theory (e.g. Boud, 2000).

2. Module description

This paper reflects on the experiences of a first-year module on a (four-year) undergraduate engineering programme at University College Cork (UCC), Ireland which seeks to help facilitate the development of a fit-for-purpose twenty-first century engineer. The module (PE1006: professional engineering communication and ethics) is taken by engineering students across all four engineering programmes at UCC (civil and environmental, electrical and electronic, energy, and process and chemical). The four programmes incorporate varying degrees of material and ethos associated with sustainability across the respective programmes, with, for example, the chemical engineering students taking a 'Sustainability in process engineering' module in the third year, two 'Safety and environmental protection' modules in the third and fourth years and a final year capstone design project module in the fourth year, which entails a significant sustainability component (Fitzpatrick et al., 2013). The module includes contributions from academics across the school, including the lead author who is module coordinator and teaches half the module. The following learning outcomes are associated with this part of the module:

- relate professional engineering practice to the ethics and ethos of the profession and the role of engineering in society
- understand the nature of complex, wicked problems and apply appropriate strategies for resolving such problems.

Class contact time with the lead author comprises 12 teaching hours, eight hours of design/tutorial sessions and four hours of student assignment presentations around the following topics

- role of engineering in society
- wicked problems
- philosophy of engineering (historical and current philosophies and trends)
- professional engineering ethics and ethos
- micro and macro ethical frameworks
- complex problems; risk and uncertainty
- the new engineer and post-normal science.

2.1 Wicked problem

The principal assessment for this part of the module comprised a group assignment on a 'wicked problem'. The assignment aims to address the material covered in the module and the claim that artificial, oversimplified, well-defined problems and case studies often neglect 'the social complexities of engineering practice' (Bucciarelli, 2008).

The term 'wicked problem' was coined by Horst Rittel and Melvin Webber in a seminal paper where they described these as complex, messy problems where there is potential for disagreement in terms of their framing as well as around any proposed solutions (Rittel and Webber, 1973). Indeed, they suggest that 'it makes no sense to talk about ''optimal solutions''' as 'there are no ''solutions'' in the sense of definitive and objective answers' for a wicked problem. Nor can any proposed 'solution' to a wicked problem be tested, except through a pragmatic approach where interventions are made contingently and iteratively and experiential knowledge is gained. As such, wicked problems involve more than just the purely technical; they involve some societal aspect or interaction with people whereby context is fundamentally important. Technical solutions alone are therefore usually insufficient in tackling wicked problems; nontechnical and policy/value-based approaches are also required. Tackling them also requires collaboration, usually between stakeholders with different backgrounds, disciplines and experience, to help understand each others' positions or 'object worldviews' well enough to have intelligent dialogue about the different interpretations of the problem. This requires a new type of engineer, one who demonstrates 'increased reflexivity and broadened participation in how engineers define problems and attempt to solve them' and one who is equipped 'to deal with the dimensions of these challenges that are considered outside the ''technical'' realm' (Cech, 2012).

Two iterations of the wicked problem assignment form the basis of this study during successive years 2012–2013 and 2013–2014. Students were assigned to groups of five and invited to collectively choose a wicked problem from a list of about 30. These include for example, problems on energy provision, water quality and provision, nanotechnology and nano-particles, traffic, sea level/flood protection, geoengineering, plastics, hazardous waste, food production, atmospheric carbon levels, local flooding events, chemical plant safety, nuclear power, road safety, artificial intelligence and electric power transmission.

They then are required to research the problem, consider the perspectives of different stakeholders and see how each might contribute to both the problem specification/description/framing and how they might contribute to appropriate responses. Groups are also required to nominate a designated person whose formal role is to 'institutionalise doubt', a 'yes, but…' person who must act as a 'devil's advocate' and hence speak up, point out problems, critique suggestions, generate discussion, get the group to consider how worst-case scenarios might be dealt with, or consider different perspectives or (perhaps larger) windows on the world (Ulanowicz, 2009). Groups were then invited to produce a report on their work and prepare a short (7 min) presentation to peers and the lecturing team, followed by a brief question and answer session.

3. Student learning experiences and feedback

The student learning experience and success in meeting the goals of the module were assessed through

- reflective surveys
- module feedback
- student material presented as part of the wicked problem assignment.

3.1 Reflective survey

In 2012–2013 the survey was carried out after the module's completion. Of 125 students taking the module during 2012–2013, 73 responded, representing a 58% response rate (Table 1; 13a). Part 1 of the survey sought to ascertain to what extent students embraced ideas presented in the module. To do this, students were asked which of two statements they most closely agreed with from each of seven statement pairs. The first of each pair represents a viewpoint that aligns with the dominant societal paradigm (seeking reduction, separation and control), which has characterised modern engineering (Herkert and Banks, 2012; Riley, 2008). The latter statement more closely aligns with what has been called a paradigm of complexity (Morin, 2008), and embraces inherent uncertainty, context and a broader macro-ethical framework (i.e. a focus on the broader context, e.g. the social, economic and political structures that engineering operates within, as well as values held by/across the profession) (Byrne, 2012a; Herkert, 2005) as permeates this part of the module. In 2012–2013 students were also asked to reflect and indicate whether (in their opinions, retrospectively) the statement they supported represents a change from the view they held before they took the module. Of the 73 respondents, 53 indicated whether or not the module helped precipitate a change in their outlook (Table 1, 13b), with the remainder not indicating either way. In 2013–2014 students were surveyed on two separate occasions: just before the commencement of the module (Table 1; 14b) and upon its completion (14a). A total of 78 students responded to the first survey out of a cohort of 114 (a 68% response rate), while 70 responded to the latter (61%). Any deviations from the above sum totals resulted from incomplete filling in of the forms.

Results of part 1 of the survey are presented in Table 1. A striking aspect of the results is the strong support for the second statement across each of the pairs of statements after the completion of the module (columns 13a, 14a). Another striking aspect is the degree to which students of the module over respective years came to very similar aggregated conclusions. In particular there was very strong support for the contention that different possible legitimate truths can exist within different frameworks, that values are inherent in engineering practice, and that engineers should be committed to social good. Intellectually at least, it would appear there is strong support among students of the module for the conception of engineering presented and a strong sense of social responsibility prevalent among first-year engineers. The module itself appears to have helped reinforce this significantly – as might be expected, given the tendency for intrinsic (greater than self) values, to be strengthened by exposure to them, and for the opposite to occur when extrinsic (selfish) values are portrayed (Burgoyne and Lea, 2006; Maio et al., 2009).

This is in fact strongest for the pair of statements which generated most division. Initially, a good majority of students each year would have at first agreed that efficiency was 'the key feature to good engineering', although this flipped around, particularly among the 2013–2014 cohort, who having taken the module were willing to adopt the more nuanced view which holds that while efficiency is important for engineering practice, a singular emphasis on this particular ratio means that system resilience and redundancy is reduced, while tight coupling and risk increases (i.e. essentially a singular focus on efficiency is potentially catastrophic as it reduces redundancy and resilience, hence curtailing system sustainability (Leach et al., 2010; Ulanowicz, 2009)). There were also large shifts in students' perceptions of risk, regarding it more as a social phenomenon (as opposed to an objectively quantifiable entity), and also on the basis for technological innovation, as well as on 'truth' as a function of framing and on public opinion being primarily based on inherent values rather than scientific ignorance. Taken together, these perceptions appear to indicate that students generally show a very positive disposition towards the ideas associated with the 'new engineer' whereby context, contingency and uncertainty are embraced. This resonates with a complexity/contingent-based conception of sustainability (Ulanowicz et al., 2009), as opposed to a linear reductionist conception that more often pertains. While the latter envisages progress as a linear march towards some unique optimisation point through ever greater systemic order, control and efficiency, the former would conceive of progress as an emergent process emanating from a necessary contingent- and context-dependent dialectic balance between, on the one hand order and control, and on the other hand freedom, creativity and autonomy. This is essentially a worldview that envisages sustainability itself as

> a discursively constructed concept without any stable definition and interpretation … a heterogeneous and contested set of perspectives that are continually defined and redefined through social, cultural, and political practices. A central implication of this perspective is that sustainability cannot be viewed as a finite goal or destination we can work towards as a global community. Like the pot of gold at the end of the rainbow, sustainability is more of a moving target never quite to be reached. Using a navigational metaphor thus captures the concept more comfortably: sustainability discourses help us steer in a sea of future challenges and navigate around

Table 1. PE1006 reflective survey results (2012–2013 and 2013–2014)

	13b	13a	14b	14a
Because engineers like to gather the facts from which the truth can be logically determined, they are best positioned to solve many problems.	17	6	43	4
The 'truth' cannot be achieved through facts and logic alone; in fact, there are many possible legitimate truths within given frameworks – for example, different disciplines hold different perspectives and hence different truths.	36	67	35	66

	13b	13a	14b	14a
Engineering is largely (or exclusively) a value-free endeavour.	14	6	14	2
Values are inherent in all engineering practice.	43	67	64	68

	13b	13a	14b	14a
Improving efficiency is the key feature of good engineering – continually increasing both technological efficiency and human productivity towards system optimisation.	39	27	48	10
While efficiency is important for engineering, a sole focus on improving efficiency represents poor engineering practice, as it reduces system resilience and redundancy while increasing tight coupling and risk	14	46	30	59

	13b	13a	14b	14a
Basic scientific research is required as a precursor to technological innovation.* (*e.g. as practised by engineers)	38	20	30	18
Technological innovation* is often largely experiential and pragmatic and emanates from ideas and creativity. Basic scientific knowledge, while potentially useful to this process is not necessarily a prerequisite (*e.g. as practised by engineers).	25	53	48	52

	13b	13a	14b	14a
Engineers should be considered value-neutral 'guns for hire' or 'paid hands'.	15	8	17	2
Engineers should be committed to social good, thus bestowing privilege in some ways, while also conferring a level of responsibility for their work and its consequences.	38	65	61	68

	13b	13a	14b	14a
Risk can be represented by objectively quantifying the likelihood of an incident occurring.	34	21	53	14
Risk is a social phenomenon and is culturally constructed; the likelihood of an incident occurring is inherently subjective and thus in turn influences both the approach taken towards a risk and the risk level.	18	51	25	55

	13b	13a	14b	14a
When the general public oppose engineering projects, it is often due to scientific or technical ignorance. It is therefore a key role of the engineer as experts to better inform the public; we need to improve our communications.	23	22	26	22
When the general public oppose engineering projects, it is often not due to inherent scientific or technical ignorance, but because the project conflicts with inherent values, for example around ideas of wellbeing, community, acceptable risk. This requires a broader more participatory conception of engineering (the 'new' engineer).	29	50	51	48

> the rocky patches of undesirable solutions. (Petersen, 2013)

This approach is actually undertaken by many professional engineering practitioners who grapple with sustainability in the field, where by necessity 'more conflicted and complex' learning occurs amid 'contradictions and conflicts', as engineers

> engage fellow stakeholders in the effort to give shape to sustainability in practice. The challenges involved reach beyond the technical to intrinsically human dimensions of sustainability that, in practice, become questions about issues such as organizing stakeholder involvement, managing knowledge and negotiating commitments on action. (Laws and Loeber, 2011)

They also reject as inadequate the traditionally dominant approach to engineering education which seeks to strip away context. As Buch and Bucciarelli (2013) proclaim

> the system is deficient. It is deficient because it ignores context – the context of practice, the context of use, the context of the individual psyche and the context that our culture provides – barely acknowledged in the teaching of engineering. We rarely explore or show how social and political interests contribute in important ways to the forms of technologies we produce.

A couple of points are pertinent in considering student responses. The module has no end-of-term exams (only continuous assessment exercises) and questionnaires were administered anonymously. Therefore, there was no compulsion on students to be coerced into new or different ways of thinking or to provide answers that they might think would impress the lecturer. On the other hand, the reality of the power structure inherent in the system, whereby the lecturer may be viewed as a sort of fount of definitive knowledge is unavoidable. Even if/when other lecturers propose other potentially antagonising versions of 'definitive knowledge', this may be worn lightly by students as they can pragmatically flip-flop between different conceptions of reality, particularly given the structure of their programme is generally reductionist in the sense that it comprises a number of separate modules which combine to produce the degree, and apart from perhaps final-year capstone design or research projects, neither promotes nor requires an integrative approach to learning and teaching. One interpretation of this therefore might be that students, by virtue of the fact that they appear to be adept at accepting and wearing quite lightly whatever cluster of values are presented to them, may actually be less disposed to critical or independent thinking than they claim (see Section 3.2).

The second part of the survey was designed to see how students understood what had been covered in the module and see how their conception of the role of an engineer might now be, having just completed the module. It asked the following pair of open-ended questions (followed by a selection of responses).

Question 1. What is the single most relevant thing you have learned as part of this part of the module PE1006?

- That ethics and values are an inherent part of engineering and cannot be ignored. The concept of the 'new engineer'.
- Values are essential in the lives of engineers. Choices that engineers make cannot be based on scientific knowledge alone but also based on social, ethical and economic values.
- Engineering isn't just about thinking in a linear, mathematical way about problems. It must take social (and other) aspects into consideration.
- I have learned to look at problems in many different ways (i.e. there are very few problems with one specific solution. Each solution has problems within.)
- How risk can be thought of as a social phenomenon and how a perceived risk can affect people's actions.
- A wider range of thinking and consideration when seeking solutions to problems. There is no perfect solution to most engineering obstacles.

Question 2. What is the role of the engineer?

- Help solve problems in society by innovative solutions, while taking into consideration society and likely reactions to such a solution.
- To utilise the resources available to man for the betterment of mankind.
- To provide a clear and logical solution to a posed problem.
- The role of the engineer is to use the forces of nature to better human life.
- Apply technical knowledge to solve social problems. While engineers work largely in a technical context, there is also a social responsibility.
- To improve quality of life through science and technology, to innovate to find answers to modern-day problems and to bring solutions to life.

The responses to question 1 suggest that students took on board and saw as relevant many of the concepts covered as part of the module on issues around context, values, ethics, risk and the relationship between social and technical aspects of engineering. Question 2 on the role of the engineer elicited a more mixed response, however. Students appeared to struggle with incorporating the concepts they expressed in the previous question and in the earlier part of the survey into their conception of the role of the engineer. The responses shown above, which are representative of those presented, reverts to a conception of engineering that either mirrors the traditional self-perception of the engineer (deterministically controlling by way of technological solutions) or presents some muddled synthesis of the above alongside the ethos presented through the module. Thus, we get an engineer who is obliged to coerce all (sorts of) problems into a framework which will allow these to be heroically 'solved' using a toolbox that contains only technological tools: 'apply technical knowledge to solve social problems'. An hubristic notion that engineers can single-handedly solve problems – even 'social' ones – and do this through science and technology appears to be prevalent. Moreover echoes of the modern Cartesian philosophy ('It is possible to reach a kind of knowledge which will be of the utmost use to men and thereby make ourselves the lords and possessors of nature' (Descartes, 1638)) abound: 'utilise the resources available to man for the betterment of mankind'; 'use the forces of nature to better human life'. Only the first response, which presents the role of the engineer in a broader, and more tentative and contingent light, appears to begin to grasp the import of the 'new engineer'. There thus appears to be a discontinuity of sorts; while formative engineers are prepared intellectually to accept a new and broader conception of engineering, they struggle to apply this meaningfully in terms of how this might affect the role of the engineer and in the practical application of engineering.

3.2 Module feedback

Feedback on the principal author's section of the module was garnered both electronically through UCC's Quality Promotion Unit (QPU) (2012–2013) and by hard copy, by way of the lecturer (2013–2014) following module completion. This survey elicited response rates of 48% (60/125) (2012–2013) and 61% (70/114) (2013–2014). While questions on the respective surveys differed, each survey had at least one question that related to how this part of the module stimulated students' own perceived critical thinking and deeper learning/understanding (Table 2). Between three-quarters and fivesixths of respondents agreed that the module precipitated enhanced stimulation of their thinking to an 'above average' extent or better; this result aligns with the relatively high proportion of students who claimed to have changed their perspectives by way of the module.

3.3 Practical implementation by way of a wicked problem assignment

The wicked problem assignment afforded students the opportunity to demonstrate the extent to which they could incorporate, in a practical way, many of the aspects covered in the module, and to which they generally claimed to ascribe. However, this proved to be a difficult exercise. One

Table 2. Post-module survey results on PE1006 (E. Byrne's section)

	Excellent	Above average	Average	Below average
2012–2013 cohort (n=125)				
The stimulation to my thinking provided by this lecturer is:	21 (35%)	23 (39%)	11 (18%)	5 (8%)
2013–2014 cohort (n=114)				
To what extent did this part of the module:				
…help you develop new and deeper understandings you'd previously overlooked or help broaden your perspectives?	25 (35%)	33 (48%)	12 (17%)	0 (0%)
…help make you think more critically?	23 (34%)	34 (49%)	12 (17%)	0 (0%)

student alluded to this on the QPU survey when they commented: 'Very interesting, but also complex. It is just difficult to figure out how to EXACTLY start approaching wicked problems, but the principles and methods were made clear enough.' The student presentations appeared to reflect this,as students struggled to integrate the concepts they claimed to uphold in addressing reallife wicked problems. This resulted in a general lack of coherence and contradictory proposals, while in most cases groups ultimately proposed traditional reductionist 'solutions' to their respective problems, typically characterised by a singular drive towards ever greater efficiency. For example, one group in 2012–2013 looked at the problem of traffic and proposed that it could be solved by bigger, straighter and 'better' designed roads through signage, road markings, surface quality, flyovers and so on. At the same time, they recognised in their presentation that this approach does not look at 'the bigger picture' and may ultimately lead to increased traffic volumes. However, they offered no further or alternative proposals or insights. These findings are consistent with observations of Petersen (2013) in the context of developing a complexity informed 'contested discourses' view of sustainability, who suggests that

> from this perspective it is no surprise that engineers have been struggling to deal with issues of sustainability. The traditional engineering approaches of setting up finite sets of goals or measures in order to develop tangible technologies to meet these goals are bound to fall short. Finite goals have no value when the desired destination is constantly changing – they will only result in redundant technological fixes without any significantly positive impact.

To try to address this issue, the 2013–2014 module iteration incorporated the aforementioned 2012–2103 student traffic presentation as a case study, whereby students were invited themselves to critique it and, in doing so, to reflect on how broader contextualised approaches might be applied. This was aimed at precipitating greater student reflections on the social complexities of traffic and attendant problem framings, such as by considering, for example, urban and suburban planning, the status of pedestrians, cyclist and public transport as well as other broader issues such as health and well-being, obesity, energy and fuel consumption. They were also asked to consider what are the ethical issues around their selected wicked problems as part of the assignment and hence to facilitate reflection more generally on 'what the social and ethical commitments of engineering are and ought to be' (Herkert and Banks, 2012).

While this may have improved students' engagement with the material, the 2013–2014 group presentations still suffered from a largely linear reductionist mindset where students still sought a unique optimisation. Moreover, and despite the formal imposition of a contrarian 'yes, but…' group member, most of the ultimate reports and presentations appeared to converge around some agreed group position. A lowest common denominator effect still seemed to be occurring, with little of the hoped-for creative tension or vision in evidence. This is problematic, in particular if one accepts that in relation to sustainability 'the power of the concept does not reside within such a shared understanding, but rather across the discursive field surrounding it' (Petersen, 2013). In response to this, the present authors suggest a greater emphasis might be placed on problem framing during future iterations, since this is a process which both opens up and closes down response possibilities (Leach et al., 2010).

Ideally, this would involve incorporating other disciplinary object world perspectives, such as for example, through engineers working with groups of social scientists to facilitate authentic trans-disciplinary creative tensions from which might emerge multi-scale, multi-faceted and/or multiple problem conceptions with resultant possible (albeit contingent and pragmatic) interventions. While this is not easily facilitated with a large group of first-year engineers, the authors have in fact initiated such collaborations at another level through bringing together students of respective third-year engineering and sociology modules around a common meta-theme of sustainability.

4. Reflection

Contemporary theories of learning support the idea that learning represents a personal journey whereby learners can be helped to continuously (re)construct their emergent conceptions of reality (Osberg and Biesta, 2007). In this context, engineers can be exposed to opportunities to explicitly (re)envisage their roles and responsibilities, including some of the dominant 'truths' that underlie engineering practice and contemporary society. However, even though people may intellectually accept certain values, paradigms or worldviews, this does not necessarily imply they will change their behaviour instantaneously, or even at all. There may be other conflicting values that are stronger and/or structural barriers to change in a wholly interconnected society (Hannan and Freeman, 1984). Peer pressure, groupthink and the desire to fit in too are extremely powerful human drivers. But to paraphrase the oft-quoted economist Rudiger Dornbusch, change, just like 'crisis takes a much longer time coming than you think, and then it happens much faster than you would have thought' (Dornbusch, 1995).

The experience with this module is that while students are willing to explicitly accept a worldview which recognises indeterminacy and complexity, and while they claim to recognise the professional importance of understanding concepts such as context, uncertainty, complexity and ethical sensitivity (Byrne, 2012b), they nevertheless struggle to implement this in practice, as they operate within a world(view) which consistently and determinedly tells them otherwise. Students clearly struggled to 'join the dots' when faced with the key but difficult task of practical implementation. This is perhaps unsurprising as, when faced with a challenge of implementation in any learning process, it is easier to revert to type (i.e. previously held, more deeply embedded constructs of reality) on being presented with a new and significant challenge. Moreover behavioural change in response to changes in people's environmental circumstances is typically non-linear, often following a non-linear 'zigzag course' (Hernes, 2012).

5. Conclusion

A new kind of engineer is required if engineering is to be fit-for-purpose to address twenty-first century sustainability-related challenges. Such an engineer challenges current paradigmatic reductionist thinking (Ehrenfeld, 2008; Ulanowicz, 2009) and requires a broader, more contingent view of professional engineering roles and responsibilities while taking a broader (context and complexity informed) view that embraces the transdisciplinary approach necessary to address emergent 'grand challenges' pertaining to issues around sustainability which straddle multiple interconnected (environmental, social, economic) domains (Reid et al., 2010). The self-perception of such an engineer goes well beyond one whose only tool in their toolbox is technology and whose default approach is to seek increased control through enhanced efficiency and productivity. Communications and transportation system design, for example, need to utilise technology efficiently, but a one-dimensional engineer who cannot relate to the social implications is one who merely serves to contribute to deeper and more widespread 'unintended' consequential problems associated with and driven by emergent technologies. A key intervention point in the precipitation of a broader fit-for-purpose profession is through its formative professional education. Undergraduate engineers require exposure to contemporary knowledge and research around the nature of complexity, uncertainty and ethics to provide them with the opportunities to be equipped with the necessary tools to embrace and facilitate meaningful societal transformation, and to be equipped to do so in concert with other disciplines and extended peer groups. This work has examined a module which has sought to help develop such an approach, reflected on some challenges that arose, and has proposed some suggestions that can assist in meeting these challenges.

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Introducing sustainable development with a mathematical model

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The role of the professional engineer has shifted over time from the application of narrowly defined technical expertise to a more holistic contribution to the betterment of society. However, as the profession has sought to develop these 'habits of mind' in engineering students, it has become apparent that both students and faculty find it difficult to transition from traditional technical subjects to the often nebulous realm of sustainability. This paper introduces a simple mathematical model based on a Cobb–Douglas production function to show how key principles of sustainable development can be introduced to students in a familiar setting. Examples are provided of how the model might be incorporated into an overall sustainability curriculum, emphasising the model's role not as a predictive calculating tool but as a conceptual framework through which sustainability can be explored and better understood.

Notation

a	constant
D	level of development
E	environmental capital
E	environment
E	fossil fuel energy resources
E	land area
f	unknown function
H_{NI}	human needs
I	environmental impact
K	economic capital
P	population
S	social capital
S(t)	sustainable development at time t
T	level of technology
T_{max}	maximum time
t	time
X	vector of factors that affect development
α, β, γ	model-fit parameters

1. Introduction

In a survey of the history of civil engineering, Jowitt (2004) remarked upon the discipline's transition from one that thrived on local problems tackled with 'technical rationality' to one that is increasingly asked to deal with systemic 'wicked' problems. These large-scale multi-disciplinary challenges, like climate change or urbanisation, defy narrow technical solutions and consequently require engineers 'to be more fully aware of the economic, social and environmental dimensions of their activities and more skilled inmeeting their objectives' (Jowitt, 2004: p. 87). Jowitt emphasised the need to reform engineering education so that the concept of sustainable development was integrated into mainstream training in order to develop 'an appropriate habit of mind, attitudes, systems, skills and domains of knowledge to enable the engineers of the future to better contribute to society'. These recommendations, arising from an Institution of Civil Engineers task group, have since been widely adopted by the engineering profession, both in the UK and overseas (e.g. Engineering Council, 2013; JBM, 2013; RAE, 2005).

However, it remains an open question how best to translate these ambitions into practice. The Joint Board of Moderators (JBM), responsible for accrediting engineering education in the UK, has provided a number of recommendations in this regard, for example, asking that an explicit sustainability thread run through degree programmes with an increased focus on related coursework and the economic and social aspects of sustainability (JBM, 2011). Furthermore, the JBM and Royal Academy of Engineering (RAE) have initiated an exercise to produce guidance for lecturers on embedding sustainability in undergraduate engineering courses. This has led to a brief report that outlines nine core principles that lecturers can incorporate into their own teaching, along with examples of best practice (Broadbent, 2012). Alongside these changes in the undergraduate curriculum, a number of universities also offer specialised sustainable development programmes for engineers, particularly at post-graduate level (Fenner et al., 2005; Fisk and Ahearn, 2006; Kamp, 2006; Perdan et al., 2000).

Arguably the biggest challenge for those seeking to teach engineers about sustainable development is to persuade both students and faculty that it belongs alongside more traditional curriculum. As Jowitt (2004: p. 79) says, 'Engineers are not comfortable – and rightly so – with the idea of a profession which eschews rigour'. Having been trained in this way, how are engineers supposed to respond when presented with 'sustainable development', a concept that – with apologies to the Brundtland commission – is widely critiqued for lacking a clear definition (Hopwood et al., 2005)? A worldwide survey of engineering students indeed confirms that they have difficulty making links between general sustainability theory and the detail of engineering practice (Azapagic et al., 2005). Even textbooks that emphasise the softer sides of sustainability seem to struggle with clearly communicating the practice of sustainable development (Fisk, 2011) and those with an engineering focus rely primarily on text-based narratives to develop key concepts, which are arguably off-putting for those more at home with equations (Allenby, 2011).

This paper therefore explores one potential strategy to ease the transition from core engineering disciplines to the messy world of sustainable development: the use of a simple mathematical model that captures core concepts. While engineers may tend to think of mathematical models as codifications of immutable natural laws, other disciplines – in particular, economics – use mathematical models extensively as conceptual models, as ways of thinking about problems that are significantly messier than a neat equation might initially suggest. As a starting point, it is assumed that the students of interest here are upper year undergraduates or graduate students; that is, engineers with a good grounding in the basic technical subjects of the discipline and beginning to encounter sustainability either through dedicated taught modules, problem-based learning or their own reading and experience.

2. The pedagogical value of mathematical models

An important feature of an undergraduate engineering degree is an increased maturity and confidence with mathematical modelling. Whereas a final year school student might be expected to memorise an equation like F5ma, undergraduates are gradually taught to derive such models from first principles, experimental data and a growing body of experience. For example, this might mean writing and solving the balance of forces in a static structure, where the geometry of the particular system will vary from problem to problem. However, the theory underlying such models is still presented essentially as a fact to be memorised: it is only much later in post-graduate education that a student is expected to derive equations based on new theoretical understandings of a physical system.

While this serves the 'technical rationality' of basic engineering practice well, it does stand in stark contrast to the mathematical models used in other disciplines, notably economics. As Gilboa et al. (2011) note, economic models are often highly stylized representations of a system that draw heavily on theoretical innovation. In other words, the heavy lifting of economic models is not in the mathematics per se but in the framing of the problem, formalised by mathematical equations (see Arrow et al. (2011) for a selection of such models). This tradition has of course led to substantial critiques of economic models – that they yield poor predictions, that they are just as likely to reflect the modeller's political and other interests rather than any 'objective' description of the problem, that they adopt assumptions that have been empirically shown to be false. However, Gilboa et al. argue that this is largely a misunderstanding, that good economists recognise these limitations but use mathematical models in a perfectly valid manner as

> 'theoretical cases', which help understand economic problems by drawing analogies between the model and the problem… economic models, empirical data, experimental results and other sources of knowledge are all on equal footing, that is, they all provide cases to which a given problem can be compared (Gilboa et al., 2011: p. 1).

This kind of mathematical modelling is not uncommon in the wider sustainability literature. Consider the IPAT framework, which decomposes environmental impact I into the product of three drivers: population P, affluence A and level of technology T (Commoner, 1972; Ehrlich and Holdren, 1972). The Kaya identity is a similar well-known expression for decomposing global carbon dioxide emissions into the product of population, affluence, energy intensity and carbon intensity.

These particular equations are restricted to environmental impacts and therefore they lack generality when dealing with sustainable development overall. In contrast, Phillips (2009) offers a more elaborate model of sustainability grounded in earth systems science

1. $$S(t) = E(t) - H_{NI}(t)$$

where S(t) is sustainable development at time t, E is the environment and HNI represents human needs. Each term of the model is duly expanded and differential equations are used to examine the dynamic relationships between human society and the environment. The model offers insight on potential sustainable 'operating' strategies for the global environment and was applied in a detailed analysis of Bangalore metro system. However, the model is strongly linked with the notion of environmental carrying capacity, and does not include social or economic influences.

3. The model

The above literature suggests that a simple mathematical model could be a valuable tool for providing a theoretical understanding of sustainable development using a rigorous language familiar to undergraduate engineers. The model that follows therefore emphasises pedagogy over calculation and, to that end, three specific sustainable development concepts are prioritised

- the question of what development is and how it can be measured
- the three capitals (i.e. social, economic and environmental) and their role in development
- choosing system boundaries and the role of innovation, as illustrated by efficient resource use.

3.1 What is development?

We start with a basic equation and a question. The equation is

2. $$D = f(X)$$

in which D is development and X is a vector of factors that affect development through some unknown function f(.). The question is simple: what is development? This can be used to stimulate a discussion that, in the author's teaching experience, tends to elicit widely differing views about what should be prioritised. For example, those from a developed country background may emphasise the importance of environmental protection, whereas those from a developing country often stress the need for basic human and economic development. This approach introduces two of the nine principles of sustainable development described by Broadbent (2012): an emphasis on learning from other stakeholders and understanding different perspectives. The conversation can also be steered to engage with the eighth principle 'Emphasise a commitment to professional values', as students can be presented with alternative definitions of the engineering profession and asked to decide how their definitions of development fit with that professional duty.

A related question prompted by the mathematical formulation is how to measure development. This can stimulate a review of existing development metrics, such as the United Nations' human development index or the Stiglitz report on the efficacy of gross domestic product (GDP) as a measure of social progress (Stiglitz et al., 2009). Related indicator techniques, such as multicriteria decision analysis, can also be introduced at this point.

Note that we have not yet said anything about sustainable development. However, with the further assumption that D is a function of time, we can write a simple zero-order differential equation to define sustainable development, which of course is reminiscent of the Brundtland definition

3. $$(dD / dt) \geq 0$$

Hopefully by now the brighter students in the class should be asking whether D is a per capita quantity or an aggregate measure. This is an excellent opportunity to reflect on classical sustainability concepts such as inter-generational (or even inter-species) equity (Haughton, 1999) since we should be interested in neither the total nor the mean level of development, but its distribution. For simplicity, the model adopts the assumption that D is an aggregate metric, although exercises can be introduced to illustrate how the properties of a distributed variable might be summarised (e.g. calculating the Gini coefficient).

3.2 The three capitals

With the left-hand side of Equation 2 sorted out, the next question is the mystery function f. The goal here is to choose a functional form that is both plausible and instructive. To this end, the Cobb–Douglas production function is an ideal solution, such that

4. $$D = a.S^{\alpha}.K^{\beta}.E^{\gamma}$$

where a is a constant (Equation 4 could be written as a proportional statement omitting this constant to avoid confusion), α, β and γ are model-fit parameters (ignored at present) and S, K and E represent social, economic and environmental capital stocks respectively (these can also be treated as functions of time, like D). This particular formulation satisfies the plausibility criteria as it has been experimentally validated in a range of economic applications and the simple multiplicative relationship is easy to understand.

The instructive value of the Cobb–Douglas formulation primarily comes by allowing one to explicitly highlight the potential roles of social, economic and environmental capital in delivering development. For example, one can introduce general notions of a capital stock as a pool of resource from which flows can be added or subtracted, flows that facilitate desired outcomes. Starting with a simple one-capital stock model for example, one could again differentiate with respect to time to see how satisfying the sustainable development condition (Equation 3) requires increasing or maintaining the level of these capital stocks. Furthermore, by introducing multiple forms of capital, one can begin to discuss the complex trade-offs and substitution effects that exist between capital stocks. For example, one can explore notions of 'strong' against 'weak' sustainability (Neumayer, 2003). These trade-offs encourage students to assess their own values and beliefs about what is truly important and worth sustaining and, if illustrated with practical examples (e.g. contrasting the UK and Norwegian allocation of North Sea oil revenues), enable students to practice Broadbent's seventh principle 'Apply judgement to real problems.'

3.3 System boundaries and innovation

Sustainable development is largely about taking a systems view of an engineering problem and trying to anticipate how an initially attractive technical solution might be undermined by liabilities displaced beyond the original temporal or spatial boundaries of the analysis. Using the model, this can be illustrated with the example of resource depletion.

Using a simplified version of Equation 4, we could write that development depends solely on the consumption of an environmental capital stock DE, rather than the total stock E

5. $$D = a.D.E^{\gamma}$$

E might therefore represent fossil fuel energy resources or land area. If we assume that there exists some finite amount of this resource E_0 available at time t=0, then the following constraint can be written

6. $$\int_{t=0}^{T_{max}} \Delta E(t)\, dt \leq E_0$$

Students can be prompted to ask about what is an appropriate choice for the system boundary, in this case the maximum time T_{max}. Historical examples can help to illustrate the consequences of such constraints, such as the way in which the depletion of England's forests in the seventeenth century led to a spatial expansion of the system boundary through increased timber trade with the Baltic region and the Americas, and the substitution of charcoal by newly discovered fossil fuel reserves. The role of engineers can be developed further by exploring how they might intervene in this stylised system to ensure continued performance for t.Tmax. With a few additional manipulations, the importance of continual innovation can be highlighted. This is often one of the most difficult things for students to appreciate, although recent examples like the shale gas revolution in the USA help to illustrate the point that, while resource depletion often looks inevitable under current circumstances. The real question is whether rates of innovation and the flexibility of system boundaries will be sufficient to avoid these constraints. Similar points are made with a simple mathematical model by Bettencourt et al. (2007) and in Tainter's well-known studies of collapse in complex civilisations (Tainter, 1988).

4. Applying the model in curriculum design

To reiterate, the goal of this model is not perfect representational accuracy, but to provide a framework that uses rigorous methods familiar to engineering students as a way of gradually introducing sustainable development. Clearly, at some point, trying to shoehorn additional concepts into this model will become unwieldy and so this section provides a number of curriculum design recommendations for its effective use within a broader course of study.

4.1 Learning objectives

Learning objectives are statements of what a student is expected to have accomplished or what skills they should have acquired following a learning programme. It is suggested that the model should be introduced as part of the learning objectives, explicitly noting its value as a conceptual framework for thinking about sustainability. For example, an overall module objective might be 'At the end of this module, students should be able to apply a simple mathematical model of development to critically assess the sustainability of an engineering project'. Equally for a single lesson, 'At the end of this lecture, students should be able to explain the concept of the 'three capitals' in words and mathematically'.

These objectives should, of course, align with the overall aims of the module, which are likely to remain high-level, as in the Engineering Council's guidance that chartered engineers should 'undertake engineering work in a way that contributes to sustainable development' (Engineering Council, 2013).

4.2 Syllabus and recommended reading

The JBM (2013) provides a number of specific recommendations for the syllabus of the sustainability components of engineering degree programmes, including specific topics such as energy, waste and water management, life-cycle assessment methods, carbon accounting and options assessment. As illustrated above, the model provides a framework through which many of these concepts and methods can be introduced. Perhaps the most significant change to the syllabus of a sustainability programme that is suggested by the model is a greater emphasis on economics, in particular notions of substitution and innovation. There is a wide literature available from which examples can be drawn, including William Nordhaus's work on resource economics and critiques of the limits to growth model (Nordhaus, 1973, 1992) and Eric Neumayer's work on indicators of sustainable development (Neumayer, 2003; Neumayer et al., 2005). Encouraging students to investigate this literature explicitly addresses two of the principles of Broadbent (2012): to take learners out of their comfort zones and to learn from other disciplines.

4.3 Learning and teaching methods

Use of the model is compatible with traditional engineering learning and teaching methods such as lecturing, tutorials and self-study problem sheets. To aid the transition from traditional analysis to sustainability analysis, one might therefore design a series of tutorials in which the learner starts out performing fairly standard manipulations of the model (e.g. fitting it to data, making simple predictions of future behaviour with a given functional form, etc.) and then complications are gradually introduced (e.g. using the model to perform a calculation based on a case study that is then contradicted by some real-life factors not in the model). Ultimately, the students should engage in problem-based learning, applying the model as they see fit to understand the problem and assess potential solutions.

4.4 Assessment

Assessment should reflect the learning objectives and therefore it is suggested that examinations or other assessed work should focus more on use of the model as a conceptual model rather than evaluating mathematical skill. In the sample learning objective provided earlier, it was suggested that students use the model to 'critically assess' a project's sustainability. This is a very open-ended question and gives the student a chance to draw in complementary material they have explored elsewhere in the curriculum.

5. Conclusion

Engineering students at both undergraduate and postgraduate level are increasingly asked to learn about sustainable development, both as a guiding principle for professional practice and as an umbrella term for a set of specific analytical tools such as life-cycle assessment. However, as the profession has sought to introduce these changes, it has become apparent that one of the greatest challenges is to introduce students trained in rigorous technical disciplines to the rather subjective notion of sustainability.

This paper has sought to overcome this problem by drawing on the use of mathematical models in economics, where such models are used primarily as theoretical tools to build understanding of complex problems. Using a standard Cobb–Douglas production function and basic calculus, it was demonstrated that a number of core sustainable development principles such as the goal of development, three capitals analysis and system boundaries can be explored. Recommendations were also provided for how the model can be incorporated into different stages of a curriculum to ease the tradition from 'hard' engineering to the 'softer' science of sustainability.

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Electro-Kinetic Geosynthetics (EKG) and Electro-Osmosis Theory

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Introduction

Increasing environmental concerns as well as land demands has led to a growth of reclamation. Hydraulic filling has become an important method for land reclamation. For these hydraulic-filled areas, surcharging and vacuum preloading are currently major methods for consolidation. Usage of PVD in China tops up 30 billion RMB (~5 billion USD) per year. However, methods of surcharging and vacuum have similar limitations when it comes to sludge. It takes long time for consolidation to complete and effect of treatment for deep soft ground is poor.

Electro-osmotic consolidation can be an alternative method which can provide quicker and better effect of consolidation for soft ground with high water content and low hydraulic permeability. Electro-osmosis is a kind of electrokinetic phenomenon that moisture in the soil migrates from anode to cathode under DC field. This phenomenon has been discovered for over 200 years (Reuss, 1809). People have seen great potential of its application in geotechnical engineering. However, this technique has been restrained by corrosion of electrode and deficiency of electro-osmosis theory. The author's work is to remove these barriers for the application of electro-osmosis. There is still lots of inspiring work to do in this area and major contributions up to now are presented in the following.

Novel EKG product

Concept of EKG was presented around 20 years ago by Prof. C.J.F.P. Jones et al. However, ability of mass production of EKG was just recently (Zhuang et al. 2012a). Once the challenge was to find a suitable electric conductive polymer as source material for EKG. Analysis shows that the electric resistivity of EKG should not be higher than 10-3 Ω·m (Zhuang 2005; Zhuang et al. 2012b) and it shall have enough strength and flexibility at the same time. This challenge has been overcome after numerous times of trials. Some trial samples are shown in Fig.1~3 and Fig.4 presents the final patented EKG product (Zhuang et al. 2006; Zhuang et al. 2012a; Zhuang et al. 2013).

The novel EKG product is like classical PVD in appearance. It is made from conductive polymer with resistivity of 10-3 Ω·m. Two copper wires of Φ 1 mm are embedded inside the polymer for better distribution of electric current and for convenience of wiring. With the help from geosynthetics industry, this EKG product can now be massproduced in China.

Fig.1 EKG sample in 2004

Fig.2 EKG with conductivity of 10^0 S/m

Fig.3 EKG with conductivity of 10^1 S/m

Fig.4 EKG product patented in 2012

The EKG product solved the problem of electrode corrosion. With high conductive and corrosion-proof polymer the energy consumption of electro-osmotic consolidation is within 10 kwh/m3 only, which is similar to that of vacuum consolidation.

Electro-osmosis theory

Current theory for electro-osmotic consolidation is based on Esrig's theory proposed in 1968. This theory is deficient for design in geotechnical engineering. Firstly, it provides no information on electric current and power, which are very important issues for design. Secondly, Esrig's theory is inconsistent with some experimental results. For example, it cannot explain current variation pattern after current intermittence or polar reversion.

To improve this deficiency, energy analysis model and electric charge accumulation theory was developed (Zhuang et al. 2004; Zhuang et al. 2005a; Zhuang et al. 2005b; Zhuang et al. 2008; Zhuang et al. 2011 and Zhuang et al. 2012c). These two theories bridge the gap between micro-mechanism and macro-behavior of electro-osmotic consolidation. They describe the pattern of current variation, which provides a basis for power source selection and circuit configuration in electro-osmotic consolidation design.

Dewatering process predicted by these theories provides an estimation of consolidation effect and time required for the consolidation to complete.

Automatic DC power source

According to the electro-osmosis theories proposed, electric field has to be adjusted flexibly both in direction and intensity during electro-osmotic consolidation. For this purpose, a novel automated electric power source was de-veloped (see Fig.5). The power source is able to work under constant-current mode and constant-voltage mode. It can be manually controlled and program controlled. The open programming interface allows people to customize their program so that to adjust the electric field as they want during the electro-osmosis process, including switching between constant-current and constant-voltage mode, polar reversion quickly (once per second for maxima) and alteration of electric field intensity. A control program based on new electro-osmosis theories is provided as well (see Fig.6).

Fig.5 Automatic DC power source

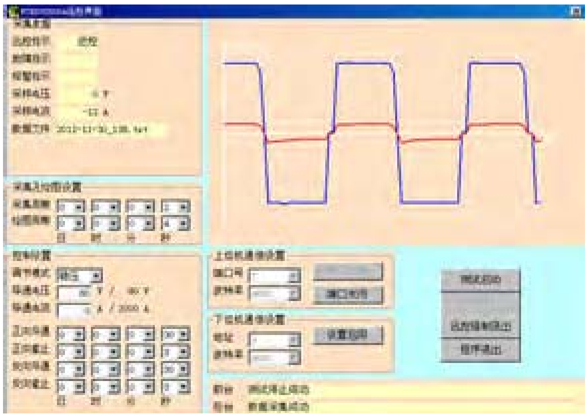
Fig.6 Control panel of program for power source

Field application

A 19 m × 15 m hydraulic-filled area was treated with electro-osmosis technique using EKG. The area was filled with 5.8 m thick of dredged pool sludge. After 36 days of treatment, including 16 days of intermittence, the average water content of dredged sludge was decreased from 62% to 36% and the soft ground was improved from a fluid-like status to a bearing capacity of 70kPa. The average energy consumption for this treatment was 5.6kwh/m3. Comparison of the soft ground before and after E-treatment is shown in Fig.7 and Fig.8.

As a comparison, the same consolidation effect achieved by using the preloading method was analyzed. The soil had a coefficient of consolidation CV=0.0029cm2/s and a compression index CC=0.3611. In order to achieve the same effect of consolidation (to reduce water content from 62% to 36%), there should be 132 kPa of preloading (around 6~7 m high soil surcharge); and it would take 1139 days, which is more than 3 years, to achieve 90% of consolidation (Zhuang et al. 2014). However, electro-osmotic consolidation took only 36 days, including 16 days of intermittence.


Fig.7 Soft ground before consolidation


Fig.8 Soft ground after consolidation

For vacuum consolidation, theoretic limit of bearing capacity is 1 atm (~100kPa) and practical limit is around 80kPa considering the vacuum loss. Therefore, practically vacuum consolidation can achieve bearing capacity of 50~60kPa for maxima and it would take 3~6 months or even longer for the vacuum consolidation to complete.

Comparisons above shows that electro-osmotic consolidation is much quicker and can achieve better consolidation effect.

Potential market of EKG and challenge of large scale application

The innovation of EKG and development of electro-osmosis theory are inspiring enthusiasms now in China for re-search on electro-osmotic consolidation. Land reclamation often produces tens of thousands square meters of soft ground to be consolidated. Therefore, potential opportunity for EKG is huge.

Challenges for large scale application lie in the following aspects (Zhuang 2015).

1) Electric conductive filter and carbon migration from EKG

In order to provide a channel for dewatering, a filter is necessary for EKG. Ordinary geotextile filter will affect the conductivity of EKG board, so electric conductive geotextile was developed as a filter for EKG. It is a woven geo-textile and made from the same conductive polymer as EKG board. The deficiency of this filter is that it is too think that under high lateral earth pressure the hydraulic conductivity is poor.

Another potential problem is the migration and loss of carbon from EKG electrode during electro-osmosis. This phenomenon has been reported by several researchers and it may affect long term effect of electro-osmotic consolidation. However, the author's latest in-situ experiment shew that EKG electrode lasts at least 2 months, which is much longer than other researchers' report. And 2 months is pretty acceptable for electro-osmotic consolidation.

2) Voltage loss along depth

Resistivity of EKG electrode is not negligible, so there is voltage loss along depth. Experiments show that consolidation effect is very good in 1 meter depth; effect is fair within 5 meters depth. For sludge deeper than 5 meters, electro-osmotic consolidation is still a challenge. For this challenge, new catalog of EKG, which is E-tube, is under developing.

3) Power source

Energy consumption of electro-osmotic consolidation is within 10kwh/m3, which is similar to that of vacuum consol-idation. However, electro-osmotic consolidation is much quicker than vacuum consolidation and this indicates that energy input should be much quicker. Therefore, we can expect that electric power required for electro-osmotic consolidation is much higher. As a comparison, for hydraulic-filled sludge of 5m deep, electric power required for vacuum consolidation is around 10 watt/m2 only, while 100 watt/m2 is required for electro-osmotic consolidation.

This situation presents a challenge for design of electric power source. A DC power source of 80V/2000A for large scale application is big, heavy and expensive. The weight of power source topped up 1 ton (See Fig. 9). One pos-sible solution is to use many small power sources, but number of power source is huge for large scale application and configuration and management of these power sources are still a problem.

Fig.9 DC power source for large scale application

4) Bearing capacity and cost

The cost of electro-osmotic consolidation is much higher than the cost of consolidation using PVD. The high cost is mainly due to the price of EKG. The price of EKG is 20RMB/m (~3USD/m), while the price of PVD is 1RMB/m (0.2USD/m) only. On this price, EKG is difficult to compete with PVD and electro-osmotic consolidation is suitable for urgent project under this situation.

There are two potential ways that EKG can com-pete with PVD. The first way is to lower the price of EKG and the second way is to further improve the effect of electro-osmotic consolidation. For deep hydraulic-filled sludge, secondary treatment after vacuum or surcharging consolidation is usually required. Using piles is the most popular way for the secondary treatment and piles are very expen-sive. If bearing capacity after electro-osmotic consolidation can be improved to over 80kPa, so that the secondary treatment can be omitted then EKG would be very competitive.

Conclusions

The author's main contributions in research field of electro-osmosis are

1) Advance of electro-osmosis theory from both micro and macro perspectives (electric charge accumulation theoryand energy analysis model), which provides a basis for design of electro-osmotic consolidation.

2) A patented novel EKG product that solved the problems of electrode corrosion and high electric energy consumption at the same time.

3) A specially designed automatic DC power source according to the new electro-osmosis theory that can help toachieve better electro-osmotic consolidation effect.

Acknowledgements

This work was supported by research grants from the National Natural Science Foundation of China (NSFC Grant No. 41472039 and 51109168) and the Ministry of Education of China (Ph.D. Programs Foundation of Ministry of Education of China Grant No. 20100141120016).

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ΝΕΑ ΑΠΟ ΤΙΣ ΕΛΛΗΝΙΚΕΣ ΚΑΙ ΔΙΕΘΝΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΝΩΣΕΙΣ

Online Rock Mechanics Glossary is now on the ISRM website

Following an initiative of the ISRM Board, supported by the Chinese National Group, a Glossary with rock mechanics terminology in different languages has been compiled during the past few months and has now been made available on the ISRM website. This is hoped to be an important contribution for practitioners that have to deal with technical literature in different languages.

An initial list of 1000 English rock mechanics terms were selected. This list was sent for translation to several Board Members and National Groups. So far, translation into the following languages have been received and are are available in the Glossary: Chinese, English, Korean, Italian, Japanese, Persian, Russian and Turkish. Translations in other languages are arriving to the Secretariat and they will be added. We hope that the number of languages available will be increase considerably before the Montréal Congress, next May.

A dedicated platform was implemented on the website for the Rock Mechanics Glossary. To search, choose the original language and insert the term. If a correspondence is found, click on the adequate term to see its translation in the available languages.

Follow this link to test the glossary and leave your feedback https://www.isrm.net/gca/?id=1189.

Volume 17 - December 2014 of the ISRM News Journal is now online

The December 2014 issue of the ISRM News Journal is now available. It includes the ISRM activities in 2014, the Board and Council meetings, an article by the ISRM President on the accomplishments of the 2011–2015 Board, a report of the Technical Oversight Committee on the work done by the Commissions, information on the publication of the "Orange Book" with the Suggested Methods 2007-2014, announcements of futures events, reports of the Vice Presidents and many other articles of interest for the rock mechanics fraternity.

Prof. John Hudson announced in the Editor's Introduction to this Volume of the News Journal that this is his last volume as Editor of the News Journal, after having edited it for eight years, 2007–2015. The ISRM owes him tremendouly for more this excellent contribution that he gave to the Society.

The ISRM News Journal is distributed to all members in electronic version. We still print a few copies of the News Journal, which are available at our sponsored symposia. Click here to read it directly on our website or download it https://www.isrm.net/gca/?id=206.

Seven countries from south-eastern Europe joined the ISRM

Since 2011, the ISRM family has been growing with a total of seven new National Groups from south-eastern Europe: Albania, Bosnia and Herzegovina, Bulgaria, Hungary, Romania, Serbia and Ukraine. Bulgaria, Romania and Ukraine joined ISRM during the last few months. The new National Groups are:

- The Scientific and Technical Union of Mining, Geology and Metallurgy (STUMGM) in Bulgaria.
- The Romanian National Group of the International Society for Rock Mechanics (RONGISRM) in Romania.
- The Ukrainian Geotechnical Society (UGS) in Ukraine.

You can read a complete report on these new ISRM National groups by clicking here (https://www.isrm.net/fotos/editor2/nl29/vrkljan_report.pdf).

Journal of the ISRM National Group of India

The ISRM (India) Journal was launched in 2012. It is a half yearly technical journal of the Indian National Group of the ISRM, which is involved in dissemination of information on rock mechanics and its related activities in the field of foundation and abutments of dams, tunnel engineering, mining, underground works, rock slope stability, road works, etc.

The 6th issue of the journal, Vol. 4, N. 1, January 2015 can be downloaded here (https://www.isrm.net/fotos/editor2/nl29/isrm_india__january_2015.pdf).

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Introduction to special issue on geosynthetic clay liners II

Volume 22, No. 1, of *Geosynthetics International* is a special issue devoted to geosynthetic clay liners (GCLs). GCLs are manufactured products consisting of bentonite clay bonded to a layer, or between layers, of geosynthetic material. In the 33 years since the GCL was invented, acceptance of these products has grown to the point where they are now commonly specified in the design of waste disposal facilities and other facilities requiring hydraulic barriers. Acceptance has been rapid because GCLs offer many advantages over compacted soil liners, not the least of which is a lower cost for many applications. Equally rapid developments in manufacturing, testing, design, construction, and the regulatory environment have sparked research on various issues related to GCL perfor-mance. This special issue contains some of the latest research on the engineering behavior and performance of these unique barrier materials.

The *Special Issue on Geosynthetic Clay Liners II* represents a 10 year update to the original *Special Issue on Geosynthetic Clay Liners* organized by Dr Fox as guest editor in 2004. For this current effort, we decided to team as guest editors and then jointly invited submission of papers from leading international experts. These invitations produced 10 submitted manuscripts from which eight technical papers were ultimately accepted for publication. Each paper received rigorous peer review by two or more anonymous reviewers. This special issue provides our readers with coverage of a wide range of topics including: shear strength, hydraulic performance, chemico-osmotic behavior, internal erosion, bentonite migration, and thermal exposure conditions. The scope and content of some papers go beyond that typical for a journal article as the intent was to provide contributing authors with the flexibility to submit comprehensive papers if desired. The electronic format allows this impressive collection of papers to be published together as a single issue of *Geosynthetics International*.

This special issue of *Geosynthetics International* would not be possible without the high-level contributions of the contributing authors. We would also like to gratefully acknowledge the assistance of the Editor, R. J. Bathurst, and the Chair of the Editorial Board, J. P. Giroud, and the many reviewers who ensured that each paper met the high technical standards of *Geosynthetics International*.

ΔΙΑΚΡΙΣΕΙΣ ΕΛΛΗΝΩΝ ΓΕΩΜΗΧΑΝΙΚΩΝ ΚΑΙ ΜΕΛΩΝ ΤΗΣ ΕΕΕΕΓΜ

Τακτικό Μέλος στην Ευρωπαϊκή Ακαδημία Επιστημών και Τεχνών (**Academia Scientiarum et Artium Europaea**) είναι πλέον ο Καθηγητής του Τμήματος Γεωλογίας του Αριστοτέλειου Πανεπιστημίου Θεσσαλονίκης (ΑΠΘ) **Βασίλης Χρηστάρας**.

Ο Καθηγητής Βασίλης Χρηστάρας εκλέχτηκε στον **Τομέα Τεχνικών και Περιβαλλοντικών Επιστημών** της Ακαδημίας. Η εκλογή έγινε στις 14 Νοεμβρίου 2014 και η επίσημη εισδοχή του στην Ακαδημία πραγματοποιήθηκε στις 7 Μαρτίου 2015, στο Salzburg της **Αυστρίας**.

Η Ακαδημία Επιστημών και Τεχνών ιδρύθηκε το 1985, έχει 1500 τακτικά και αντεπιστέλλοντα μέλη, στα οποία συμπεριλαμβάνονται 29 κάτοχοι βραβείου Νόμπελ. Στο πλαί-σιο της Ακαδημίας λειτουργεί το Ευρωπαϊκό Πανεπιστήμι-ο *«Alma Mater Europaea»*. Η έδρα της Ακαδημίας είναι στο Salzburg της Αυστρίας και τελεί υπό την αιγίδα της Προεδρί-ας 12 ευρωπαϊκών κρατών, μεταξύ των οποίων και η Ελλά-δα.

Ο Καθηγητής Βασίλης Χρηστάρας σπούδασε στη Θεσσαλονίκη και το Παρίσι. Είναι Καθηγητής Τεχνικής Γεωλογίας στο Τμήμα Γεωλογίας του Α.Π.Θ., Διευθυντής του Εργαστηρίου Τεχνικής Γεωλογίας και Υδρογεωλογίας και του Τομέα Γεωλογίας και -μεταξύ άλλων- διετέλεσε, κατά το 1998-2000, Πρόεδρος του ΔΣ του ΙΓΜΕ.

(ΕΡΤ, 12 Μαρτίου 2015, http://www.ert.gr/o-kathigitis-v-christaras-melos-tis-evropaikis-akadimias-epistimon-ke-technon)

ΠΡΟΣΕΧΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΚΔΗΛΩΣΕΙΣ

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

ICGE 2015 International Conference in Geotechnical Engineering – Colombo-2015, 10 - 11 August 2015, Colombo, Colombo, Sri Lanka, http://www.slgs.lk/?p=564

Numerical Analysis in Geotechnics, 20 August 2015, Hanoi, Vietnam, nag2015secretariat@gmail.com

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2-3 September 2015, COEX, Seoul, Korea

2-3 September 2015, Seoul, Korea
www.tu-seoul2015.org

On behalf of the Korean Tunnelling and Underground Space Association (KTA), I would like to invite you to join the International Forum on Subsea Tunnels (TU-Seoul 2015) to be held on Seoul COEX, Korea from September 2 to 3, 2015. It will be an intellectually challenging program especially focused on the subsea tunnel in the aspects of design, construction and maintenance.

Construction of a subsea tunnel is not simply building a tunnel under the sea, but a generation of the linkage between the continents and the isolated lands to flourish economic and regional activities. The tunnel will drastically changes social and economic conditions to the both ends of the tunnel with initiation of traffic and cultural flows. Especially in East Asia region, rampant demand on the construction of subsea tunnel is raised such as linkage between Korea-China, Korea-Japan, Seoul-Jeju, and Jiaozhou Bay tunnels. Therefore, it must be an appropriate time and environment to open a forum for subsea tunnel.

This forum is jointly organized by the Korean Tunnelling and Underground Space Association (KTA) and the Subsea Tunnelling Technology Centre. The research center fully funded by the Korean Government develops core techniques and devises key components essential for the plan, design, construction and maintenance of long subsea tunnels. As the Director of the Subsea Tunnelling Technology Centre, I hope that the forum will provide an excellent communication platform among engineers, scientist, entrepreneurs, decision makers and tunnelling professionals to exchange invaluable information and brilliant ideas worthwhile to share and promote.

The technical contents of the forum are rich and diverse with 14 invited speeches and panel discussions. The themes of the speeches will cover various aspects of subsea tunnelling including design, construction and maintenance of subsea tunnels for bored and immersed tunnels constructed at various continents.

Theme

"Future of subsea tunnels as transnational and transregional passages"

Topics

- Challenges in deep subsea tunnels
- Consideration of high-water pressure in deep subsea tunnels
- Mechanized and conventional tunneling in subsea tunnels
- Design and Construction of immersed tunnels
- Operation and maintenance of subsea tunnels

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SICAT 2015

Symposium on Innovation and Challenges in Asian Tunnelling 2015
2 to 3 September 2015, Singapore

The quest for knowledge to meet the challenges faced by the growing Asian tunnelling and underground construction industry has led the Tunnelling and Underground Construction Society (Singapore), TUCSS, to organise this Symposium. It aims to share the valuable experiences gained from the recent underground infrastructural projects in Singapore and other Asian countries such as Malaysia, Thailand, Korea & China.

To overcome the challenges faced by the industry, we require creative and innovative solutions. The symposium seeks to bring together prominent experts and specialists to share their visions and experiences on a variety of relevant topics through keynote addresses and talks. This will be relevant for all Clients, Professionals, Project Managers and Engineers who are involved in the tunnelling and underground construction industry, including Government Agencies, Consultants, Specialist Suppliers and Contractors.

The two-days symposium will have eight excellent keynote lectures delivered by well-regarded experts from all over Asia in their respective fields. It will also include twelve excellent presentations by Specialist Suppliers and Manufacturers who will be showcasing their latest technologies at their exhibition booths during the symposium.

For more information, please contact:

TUCSS Secretariat @ 1 Liang Seah Street #02-11 Liang Seah Place Singapore 189022 Tel: 6336 2328 Fax: 6336 2583 Email: tucss@cma.sg, Website: www.tucss.org.sg.

China Shale Gas 2015 - an ISRM Specialized Conference, 6-8 September 2015, Wuhan, China, http://english.whrsm.cas.cn/ic/ic/201405/t20140509_120692.html

"Underground Construction" Conference, 8-9 September 2015, Krakow, Poland, www.inzynieria.com

13th International Benchmark on the Numerical Analysis of Dams, 9 - 11 September 2015, Lausanne | Switzerland http://icold2015bmw.epfl.ch

International Symposium on Geohazards and Geomechanics 10-11 September, 2015, Coventry, U.K., www.warwick.ac.uk/isgg2015

24th European Young Geotechnical Engineers Conference in Durham, UK, 11-12 September, 2015, https://www.dur.ac.uk/conference.booking/details/?id=419

16th European Conference on Soil Mechanics and Geotechnical Engineering "Geotechnical Engineering for Infrastructure and Development", 13 - 17 September 2015, Edinburgh, UK, www.xvi-ecsmge-2015.org.uk

www.ucaofsmecuttingedge.com

The world is becoming more smaller every day, but people still need to get where they are going and we want our utilities wherever we are. With a limited amount of area above ground, tunneling in urban areas is becoming more important than ever. As Urban tunneling increases, new challenges and solutions are being discovered. This year's Cutting Edge conference will ensure that you are up to date on all of the latest trends worldwide.

Urban tunneling is a complex field of activity that has seen impressive technological changes and progress in recent years. From the planning of underground space, to excavation methods, and impacts on adjacent structures, Cutting Edge 2015 will take a detailed look at the current state of practice, and examine developments necessary to improve the issues facing urban tunnel projects.

Featuring subject-specific presentations that focus on innovations and practical experience, and extended in-depth industry discussion sessions – which have become a trademark of this conference – Cutting Edge 2015 will educate and inform attendees on recent developments in urban tunneling technology.

Cutting Edge is proud to present more than 50 technical sessions featuring the leading practitioners in underground construction, specifically focused on the important role urban tunnleing plays in developing and existing infrastructure. Session topics can be viewed below: *Please check back soon for a complete listing of available technical sessions.

- Long-Term Benefits of Underground Space in the Urban Environment
- Mitigating Adverse Impacts from Urban Tunneling
- Utility Tunneling in Urban Settings
- Innovations in Tunneling
- Environmental Challenges/Sustainability
- TBM Operation & Logistics in Urban Settings
- Caverns, Stations & Non-TBM Tunneling Under Major Cities
- Project Management of Urban Megaprojects

Workshop on Volcanic Rocks & Soils, 24 - 25 September 2015, Isle of Ischia, Italy, www.associazionegeotecnica.it

The 7th International Symposium on Roller Compacted Concrete (RCC) Dams, Chengdu, China, Sept. 24th-25th, 2015, www.chincold.org.cn

Athens 2015 International Landfill Mining Conference, September 24-25, 2015, Athens, http://www.erasmus.gr/microsites/1050/welcome-address

TranSoilCold 2015 - The 2nd International Symposium on Transportation Soil Engineering in Cold Regions, September 24-26, 2015, Novosibirsk, Russia, http://transoilcold2015.stu.ru/index.htm

International Conference on Landslides and Slope Stability (SLOPE 2015)
September 27-30, 2015, Bali, Indonesia
www.slope2015.com

International Conference on Landslides and Slope Stability (SLOPE 2015) cordially invite you to participate and contribute papers in the conference. The committee of SLOPE 2015 also warmly welcomes members of the Indonesian Geotechnical Society, the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE), the International Society of Rock Mechanics (ISRM), International Consortium on Landslides (ICL), geotechnical engineers, engineering geologists, environmental engineers and all interested parties to attend and share knowledge in this important conference.

Landslides have become a major threat and disasters at large scale residence area in urban as well as suburban area or villages. Our profession has important roles in public safety against landslides and man made slope failures and the potential of shaping the future of landslides risk management. The theme of the conference "ADVANCEMENT OF RESEARCH, PRACTICE, AND INTEGRATED SOLUTION ON LANDSLIDE" reflect the effort to synergize the academic research and findings and practical experience in facing climate change and human interference on the nature.

Engineering Geologists, Civil Engineers and Environtmental Engineers are concerned with the problems of debris flow, landslides and rockslides which may be caused by natural disasters, river erosion, climate change, human errors and geo-environtmental problems. Eventhough we have gained experience, knowledge and advanced technology, there are still numbers of deadly events that recently occured at many places in Indonesia such as in Padang Pariaman in Sumatera 2009 (more than 600 fatalities), South Cianjur 2009 (54 fatalities) and recently at one particular district area of Banjarnegara, Central Java with 351 fatalities (Legetang/Kepakisan, 16 April 1955), 90 fatalities (Sijeruk, 4 January 2006) and 108 fatalities (Jemblung, 12 December 2014) and also in many other countries as well.

Landslides Risk Reduction has become very important steps in every country. They require multi hazard approach including institutional capacities such as policy, legislation, education and training, community awarenes etc as an essential condition for its effectiveness. Many universities, research institutions, landslides centers and geological or geotechnical consultants have gained experience and knowledge which are of valuable importance. Case histories of landslides contribute to the state of the art for research and practice on landslides and rock slides. It is with the objectives of sharing knowledge, the conference has been aimed for the goals. Hence the conference is very important event for exchange of ideas and experience and for contribution among many countries all over the world.

SLOPE 2015 will present outstanding keynote speakers who are expert in their field, presentation of technical papers, pre-conference workshops, technical tour, photo contest, exhibition, social and networking opportunities for participants and sponsors, accompany program and amid of the activities, a chance to enjoy an elegant devdan show that tells you about the Indonesian cultures by performers and musical entertainment.

We would like to encourage you to explore the SLOPE 2015 website, to keep informed and update the program. Come and attend the conference in Bali, an exciting paradise in Indonesia.

Conference Themes

- Mechanism of Slope Failures in Soils and Rocks
- General Landslides Studies
- The importance of Geological Aspects on Landslide and Rockslides
- Behavior of Soil and Rock for Slope Stability Analysis
- Physical Modeling and Material Testing for Slope Stability Analysis
- Dynamic Behavior of Soils and Rock for Slope Stability Analysis
- Site Characterization for Slope Stability Study
- Insitu Testing and Monitoring for Identification and Study of Slope Movement
- Climate Change and Land Use Impact on Landslides
- Problems of Creeps Causing Slope Failures
- Case Histories of Natural and Man Made Slope Failures
- Earthquake and Liquefaction Induced Landslides
- Landslides in River, Coastal and Submarine Environments
- Stability of Dams and Landslides in Reservoirs
- Design Aspects for Slope Stability
- Slope Stability in Excavation and Embankment Works
- Use of Piles and Ground Anchor for Slope Stabilization
- Reinforced Earth Slopes Design, Analysis and Case Histories
- Ground Improvement for Slope Stabilization
- Outlook for New Technology in Slope Stabilization
- Analysis of Debris Flows and Mudflows
- Modeling of Slopes and Application and Development of Numerical Analysis
- Probabilistic Slope Stability
- The Use of Remote Sensing for Landslides Response, Monitoring and Mapping
- Landslides Inventory and Landslide Hazard Zonation
- Remedial Measures on Landslides and Risk Reduction Strategy
- Monitoring, Prediction and Warning of Landslides
- Risk Assessment and Control on Landslides and Urbanization
- Policy, Legislation and Guidelines on Landslides
- Capacity Development for Landslides Mitigation
- Education on Landslides

Two workshops prior to the conference are prepared for participants to enhance more understanding on landslides mechanism and landslides disaster risk reduction and management.

Workshop 1 :
"Landslide, Mud Flows and Their Counter Measures"

This workshop gives you insight on the mechanism of landslide, most important geotechnical and geological aspects, factors to be considered, and the technology for counter measures. This workshop is a must for engineers responsible in slope design and technology for counter measure.

Workshop 2 :
"Comprehensive Landslides Risk Reduction and Management"

This workshop focuses on the basic knowledge and skills needed by stakeholders in the field of landslide management. This workshop is a very important for the stake holders, engineers, policy makers, and government officials.

For further information, please contact us by email to:
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www.sardiniasymposium.it

The fifteenth edition of the Sardinia Symposium, organized by the IWWG, will be held in Forte Village, Santa Margherita di Pula, Italy, from October 5th to October 9th 2015.

The traditional issues of waste prevention, material and energy recovery, waste treatment and final disposal will be addressed in general sessions, specialized sessions, workshops and Italian sessions where new ideas and concepts will be presented and thoroughly discussed. Several workshops will be devoted to the presentation of innovative international projects.

Topics

The following topics, among others, will be extensively discussed:

A. Waste policy and legislation

International, national and regional guidelines; regulation and planning requirements; role of scientific and technical organizations; carbon tax.

B. Waste management strategies

Integrated waste management; national strategies; future perspectives, waste as a resource; public and private partnership.

C. Public concern and education

Public involvement and relationship; NGO`s activities; mediation; education; communication; training in waste management and operation.

D. Waste management assessment and decision tools

Life cycle analysis; risk assessment; environmental impact assessment; EMAS; quality control procedures; cost benefit analysis; multicriteria analysis; auditing; BAT-Best Available Technologies.

E. Waste characterization

Standardization; analytical procedures, sampling, production variations vs time and geographical areas.

F. Waste collection

Cost optimization; collection on demand; separate collection; case studies; subsurface systems; pneumatic collection; ergonomics of waste collection.

G. Waste minimisation and recycling

Waste avoidance; waste logistics and recycling; new recycling technologies; material quality after recycling; packaging material; electronic waste; construction and demolition waste; batteries; end of life vehicle; market waste.

H. Biological treatment

New developments in composting and anaerobic digestion; emissions from processing facilities; product quality; degradation and fate of emerging pollutants during biological treatment; biological treatment of special biowaste; challenges in using microbiology knowledge to explain biological process; assessment of indicators for evaluating product quality and humification.

I. Thermal treatment

Technologies and experiences; new technologies; production and use of RDF; emission control; treatment of residues; beneficial use of combustion ash.

L. Mechanical biological treatment prior to landfilling

Mechanical pretreatment (separation, shredding, RDF-production, etc.); technology and experience; new technology, testing and landfill acceptance; off gas treatment; emission control.

M. Sanitary landfilling

Sustainable landfill concepts for mechanically biologically pretreated municipal waste and special waste; processes and emissions; leachate and gas management; landfill design and construction; barrier design and performance; technologies for mitigation of landfill gas emission; waste mechanics; landfill operation; administrative and financial aspects; landfilling under specific conditions (tropics, islands, mountains, etc.); aftercare and reuse; waste disposal as final sinks for harmful substances; landfill remediation; case studies.

N. Integrated wastewater and solid waste management

Decentralized systems; closed substance cycles; future perspectives; cases.

O. Waste management and climate change

Minimisation of greenhouse gases from waste management activities and landfills, waste - CDM projects, minimisation of energy consuption, landfills as geological sinks for carbon and other elements.

P. Waste management in developing and low income countries

Appropriate technologies, experiences, international cooperation, financing, education.

Q. Special sessions

BAT - Best Available Technologies; IPPC regulations; fate of nanomaterials during waste management.

For any enquiries and information on registration, accommodation , etc., please contact the Organising Secretariat:

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GE Basements and Underground Structures Conference 2015, 6 - 7 October 2015, London, UK, http://basements.geplus.co.uk

EUROCK 15 ISRM European Regional Symposium & 64th Geomechanics Colloquy, 7 – 9 October 2015, Salzburg, Austria, www.eurock2015.com

Shotcrete for Underground Support XII New Developments in Rock Engineering, TBM tunnelling, Deep Excavation and Underground Space Technology, October 11-13, 2015, Singapore, www.engconf.org/conferences/civil-and-environmental-engineering/shot-crete-for-underground-support-xii

5th International Symposium on Geotechnical Safety and Risk (ISGSR 2015), 13-16 October 2015, Rotterdam, The Netherlands www.isgsr2015.org

International Workshop on Tsunamis in the World: from Source Understanding to Risk Mitigation, 14 to 16 October, 2015, Heraklion, Greece, www.gein.noa.gr/itw2015

HYDRO 2015, 26-28 October 2015, Bordeaux, France, www.hydropower-dams.com/pdfs/hydro2015.pdf

International Conference on Engineering Geology in New Millennium, 26-31 October 2015, New Delhi, India, http://isegindia.org/pdfs/1st%20circular-international-IAEG.pdf

6th International Conference on Earthquake Geotechnical Engineering, 2-4 November 2015, Christchurch, New Zealand, www.6icege.com

SEOUL 2015 - 25th World Road Congress Roads and Mobility – Creating New Value from Transport, 2–6 November, 2015, Seoul, Republic of Korea, http://www.aipcrseoul2015.org

4° Πανελλήνιο Συνέδριο Αναστηλώσεων, Νοέμβριος 2015, Θεσσαλονίκη, www.etepam.gr.

The 15th Asian Regional Conference on Soil Mechanics and Geotechnical Engineering, 9-13 November 2015, Fukuoka, Japan, http://www.15arc.org

11-13 November 2015, Žilina, Slovak Republic
www.tps2015.sk

Slovak Tunnelling Association is pleased to announce the conference on Tunnels and Underground Construction 2015. The aim of the conference is to inform the wide professional public about the latest news in the field of design, construction and operation of underground constructions.

The conference is held under the auspices of Ján Počiatek, the Minister of Transportation, Construction and Regional Development and Juraj Blanár, the chairman of the Žilina automonous region.

General Topics of the conference:

- Design and construction of underground structures
- Reconstruction and remediation of underground structures
- Geotechnical survey and monitoring
- Operational safety of tunnels including fire safety
- Contractual relations and the risk management

Contacts

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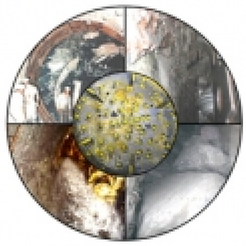
Technical Secretariat:
Guarant International spol.s.r.o., telefón: +421 948 490 765, e-mail: tps2015@guarant.sk

15th Pan-American Conference on Soil Mechanics and Geotechnical Engineering, 15 - 18 November 2015, Buenos Aires, Argentina, http://conferencesba2015.com.ar

GEOMATE, 16 -18 November 2015, Osaka, Japan, www.geomate.org

VIII South American Congress on Rocks Mechanics, 15 - 18 November 2015, Buenos Aires, Argentina, http://conferencesba2015.com.ar

Sixth International Conference on Deformation Characteristics of Geomaterials IS Buenos Aires 2015, November 15th to 18th 2015, www.saig.org.ar/ISDCG2015



TBM DiGs
Tunnel Boring Machines in Difficult Grounds
18-20 November 2015, Singapore
www.tbmdigs.org

Tunnel boring machines (TBM) are increasingly used for tunnelling with difficult and complex geological conditions, including rock and soil mixed and interfaced grounds, spalling and bursting rocks, squeezing and swelling grounds, blocky and highly fractured rocks, fault and shear zones, and grounds under high in situ stress and water pressure. Improvement and optimisation of TBM's performance in those difficult ground conditions require good scientific understanding, innovative technology development and good engineering practice, that involve tunnelling and geotechnical engineers, designers and contractors, TBM manufacturers and material suppliers, and researchers.

The tunnelling industry has been facing the challenges of TBM in difficult and complex geological conditions and working together to find solutions. For examples, the International Tunnelling and Underground Space Association (ITA) has a Working Group on "Mechanised Tunnelling", the European Commission sponsored R&D projects on "Technology Innovation in Underground Construction" (Framework Program 6) and "New Technologies for Tunnelling and Underground Works" (Framework Program 7). In China, a number of national key laboratories on TBM technologies have been established in the recent years.

TBM DiGs (Tunnel Boring Machines in Difficult Grounds) is planned to be an international conference series to provide a specialised technological forum discussing and exchanging knowledge related to TBM works in difficult grounds. The conference plans to cover a wide range including characterisation of difficult grounds, field observations and case studies, physical and laboratory tests, numerical modelling and techniques, treatments of difficult grounds, TBM design and installation, tunnel support design, monitoring and risk management.

TBM DiGs 2015 is to be held in Singapore, jointly organised by the universities and supported by the tunnelling community worldwide, interested in TBM tunnelling technologies. The Organisers would like to welcome researchers and practitioners involved with TBM tunnelling to the TBM DiGs 2015 conference to share, to cooperate, and to progress.

The objective of TBM DiGs conference is to discuss the various issues related to tunnel boring machines in complex and difficult ground conditions, focusing on engineering and technological solutions including planning, design, operation, monitoring, testing, modelling, research and development. Areas of interest include, but are not limited to, the following topics:

- Case studies of TBM in various difficult grounds and complex geology
- Characterisation of difficult grounds for TBM tunnelling
- Laboratory testing and physical modelling of TBM excavation
- Numerical modelling of TBM interaction with grounds
- Ground treatment for TBM in difficult grounds, and application of foam
- Support design for TBM tunnels in variable and complex grounds
- Monitoring and back analysis for TBM tunnels in difficult grounds
- Development of hybrid TBMs for difficult and varying grounds
- Use of TBM in mines and for other special applications
- TBM selection, performance assessment and operation management
- Decision aids for tunnelling and risk management of TBM in difficult grounds

For all queries regarding your submitted abstract and program queries please contact:

Conference Secretariat
Email: **contact@tbmdigs.org**

Post: TBM DiGs Conference Secretariat
C/O Nanyang Centre for Underground Space
School of Civil and Environmental Engineering
Block N1, Nanyang Avenue
Singapore, 639798

Arabian Tunnelling Conference & Exhibition: Innovative Underground Infrastructure - And Opportunities, 23-25 November 2015, Dubai, UAE, www.atcita.com

Geo-Environment and Construction, 26-28 November 2015, Tirana, Albania, Prof. Dr. Luljeta Bozo, lulibozo@gmail.com; luljeta_bozo@universitetipolis.edu.al

ICSGE 2015 - The International Conference on Soft Ground Engineering, 3-4 December 2015, Singapore, www.geoss.sg/icsge2015

The 1st International Conference on Geo-Energy and Geo-Environment (GeGe2015) 4th and 5th December 2015, Hong Kong, http://gege2015.ust.hk

2015 6th International Conference Recent Advances in Geotechnical Engineering and Soil Dynamics, December 7-11, 2015, New Delhi (NCR), India, wason2009@gmail.com; wasonfeq@iitr.ernet.in, sharmamukat@gmail.com; mukutfeq@iitr.ernet.in, gvramanaiitdelhi@gmail.com, ajaycbri@gmail.com

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

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

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

The Organizing Committee of SUFTUS -2016 is pleased to announce that the International Symposium on Submerged Floating Tunnels and Underwater Structures (SUFTUS-2016) will be held in Chongqing, China during 20—22 April 2016.

Submerged floating tunnel (SFT), also called Archimedes Bridge (AB), belonging to the category of underwater structure, is a kind of floating transportation passage which is submerged underwater to bridge water banks. As an innovative transportation technology, SFT will become attractive in competing with traditional techniques due to its economic and environmental advantages. However at the present time, there is still not an actual SFT being built in the World.

The First International Symposium on Archimedes Bridge (ISAB-2010) was held in Qiandao Lake, China during 17-20 October, 2010. In the past 6 years, new theory and new technology about SFT and underwater structure were developed. The aim of SUFTUS-2016 is to provide a global forum for scientists, engineers and technicians around the world, who are involved or interested in researches and developments on the innovative technologies of SFT and underwater structure, to share their research progresses and conceptual design advances, so that to discuss and improve the challenging issues of SFT and underwater structures.

Main Topics

- Conceptual design
- Prototype strategy and design
- Underwater tunnel
- Applicability and key technical indexes
- Dynamic response to hydrodynamic loads
- Dynamic response to seismic, tsunami and other accidental loads
- Connections and foundations
- Materials selection and resistance
- Structural analysis and safety assessment
- Environmental and economic assessment
- Construction and installation
- Lighting and ventilation
- Escape and rescue

- Other related topics

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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.sancold.org.za/index.php/activities/icold-annual-meeting-2016

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

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

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19SEAGC – 2AGSSEAC
Young Geotechnical Engineers Conference
30th May 2016, Petaling Jaya, Selangor, Malaysia

In conjunction with the 19th Southeast Asian Geotechnical Conference & 2nd Association of Geotechnical Societies in Southeast Asia Conference (19SEAGC-2AGSSEAC), which will be held in Petaing Jaya, Selangor, Malaysia from 31 May to 3 June 2016, a parallel Young Geotechnical Engineers Conference (YGEC) will be held on 30 May 2016 . YGEC participants are encouraged to attend the first day program of the main conference on 31 May 2016, which includes the Opening Keynote Address, Chin Fung Kee Lecture and Special Lectures to be delivered by distinguished geotechnical experts and eminent academicians.

The theme of the YGEC is "Contributions of Young Geotechnical Engineers to Nation Building", which acknowledges the valuable contributions of young, enterprising and energetic Geotechnical Engineers working in increasingly challenging projects.

Conference topics:

- Numerical Modelling (FEM, DEM etc.)
- Soil Characterization & Properties
- Ground Improvement & Stabilization
- Shallow and Deep Foundations
- Slope Stability, Excavations
- Retaining Structures
- Geosynthetics & Geo-Products
- Field Testing & Monitoring
- Engineering Geology
- Rock Mechanics
- Design Analysis & Modelling
- Embankments & Dams
- Tunnelling & Underground Space

Contact:

Young Geotechnical Engineers Conference

c/o SEAGC2016 Secretariat
IEM Training Centre Sdn. Bhd.
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Tel. No.: +(603) 7958 6851 Fax No.: +(603) 7958 2851 E-mail: seagc2016@gmail.com

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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

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

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

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

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

Recent Advances in Rock Engineering - RARE 2016 - an ISRM Specialised Conference
16-18 November 2016, Bangalore, India

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

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 utilized. 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

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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

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

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ΕΝΔΙΑΦΕΡΟΝΤΑ ΓΕΩΤΕΧΝΙΚΑ ΝΕΑ

Yeager airport – a massive, damaging fill slope landslide

Yeager Airport is located about 5 km east of downtown Charleston in West Virginia, USA. The airport is located on top of a hill, with steep slopes on several sides, including at the end of the main runway. In 2005 a project was initiated to increase safety at Yeager Airport by creating an overrun area at the end of the runway, including the installation of an EMAS, which is a concrete surface that is designed to bring aircraft to safe stop. In 2010 this successfully arrested an over-running regional jet:

The construction of the EMAS required that a new, large fill slope was built, retained by a reinforced slope. There is a very detailed and interesting presentation about the design and construction of the slope ([i]); at the time this was apparently the largest reinforced slope in the United States (I'm not sure if this is still the case). This images, from the presentation, shows the completed structure at the end of the runway at Yeager Airport:

In Wednesday the Charleston Daily Mail reported (http://www.charlestondailymail.com/article/20150311/DM05/150319745) that six residents had been moved out of their houses below the slope as movement of the slope had been detected in the EMAS. Yesterday this quickly developed into a very large-scale landslide. This image is from a gallery that is in a Charleston Daily Mail report from yesterday (http://www.charlestondailymail.com/article/20150312/DM05/150319672):

Charleston Daily Mail

This is a massive, very deep-seated and rather complex failure. The scale is somewhat impressive. The failure is surprising in so much as the conditions appear to be dry, a fact that is supported by this image of the rear scarp, although as the comment below notes, there has been significant rainfall and snowmelt in recent weeks:

Charleston Daily Mail

The slope reinforcement is clear to see in the image – the failure appears to have sliced through it. The images gives few indications as to what has gone wrong – whether this is a design failure or whether something happened at the toe of the slope to change the system. I do wonder if the rock below the reinforced slope has failed though – this might explain the interesting geometry of the collapse. Either way, this is going to be very expensive, and it will affect both the operations at Yeger Airport and the local residents for some time to come.

(dr-dave / AGU.Blogosphere, 13 March 2015, http://blogs.agu.org/landslideblog/2015/03/13/yeager-airport-1)

Bus falls through giant sinkhole in Brazil, gets swept away by floodwater

A bus fell through a massive crater on a Brazilian road Monday before it was washed away by intense floodwater, shocking video shows.

Passengers on a bus in Brazil escaped before the vechicle fell into a hole into a river.

The doomed tourist bus was quickly evacuated moments before it was swallowed up by the sinkhole, according to reports.

None of the passengers were injured. They are seen watching from a safe distance as the bus takes a nosedive into the crater and gets swept away into the water.

(Melissa Chan / NEW YORK DAILY NEWS, Wednesday, March 25, 2015, http://world.einnews.com/article/256650953/yUwJmF0ZdcT0gaOz)

ΕΝΔΙΑΦΕΡΟΝΤΑ - ΛΟΙΠΑ

Επισκευάστηκε και λειτουργεί ξανά
Ισπανία: Το πιο επικίνδυνο μονοπάτι περιμένει τους λάτρεις της αδρεναλίνης

Θεωρείται το πιο επικίνδυνο μονοπάτι του κόσμου αφού μοιάζει να κρέμεται στον αέρα. Το «Caminito del Rey» που διασχίζει το φαράγγι του Γκαϊτάνες στη νότια Ισπανία, επισκευάστηκε και περιμένει ξανά τους λάτρεις της πεζοπορίας, του κινδύνου και της αδρεναλίνης να το διασχίσουν.

Το μονοπάτι σταμάτησε να λειτουργεί το 2001, καθώς η έλλειψη συντήρησης οδήγησε στην κατάρρευση μεγάλων τμημάτων του.

Η αποκατάστασή του κράτησε αρκετά χρόνια και τώρα οι αρχές της Ισπανίας είναι έτοιμες να... δώσουν το μονοπάτι πίσω στους πεζοπόρους.

Το «Caminito Del Rey» βρίσκεται σε ύψος 100 μέτρων πάνω από τον ποταμό στο φαράγγι του Γκαϊτάνες.

Για την ιστορία κατασκευάστηκε στις αρχές του 20ού αιώνα για τη μεταφορά υλικού και τη συντήρηση δύο υδροηλεκτρικών σταθμών παραγωγής ενέργειας.

(Newsroom ΔΟΛ, 12 Μαρ. 2015, http://news.in.gr/perierga/article/?aid=1231392114#.VQG3WwNyeos.email)

Νέος Κόσμος, νέα περίοδος
Η γεωλογική εποχή του ανθρώπου «άρχισε το 1610 μΧ»

Το λεγόμενο «Ανθρωπόκαινο», η προτεινόμενη γεωλογική εποχή που διαμορφώνεται από την ανθρώπινη δραστηριότητα, πρέπει να άρχισε το 1610, όταν οι αλλαγές που έφερε η ανακάλυψη του Νέου Κόσμου άρχισαν να επηρεάζουν ολόκληρο τον πλανήτη, προτείνει μελέτη στο περιοδικό Nature (http://dx.doi.org.10.1038/nature14258).

Οι προηγούμενες γεωλογικές περίοδοι έληξαν έπειτα από δραματικά συμβάντα που άλλαξαν το πρόσωπο του πλανήτη, όπως προσκρούσεις μετεωριτών, μεγάλες ηφαιστειακές εκρήξεις και μετατοπίσεις των ηπείρων.

Σήμερα, όμως, ο πλανήτης αλλάζει λόγω της ανθρώπινης δραστηριότητας, και πολλοί γεωλόγοι πιστεύουν ότι ζούμε ήδη στην περίοδο του Ανθρωπόκαινου. Αυτό στο οποίο διαφωνούν, ωστόσο, είναι το πώς θα οριστεί αυτή η νέα εποχή.

Άλλοι πιστεύουν ότι άρχισε με τις πρώτες δοκιμές πυρηνικών όπλων, οι οποίες γέμισαν τον πλανήτη με ίχνη ραδιενεργών στοιχείων. Άλλοι πάλι εκτιμούν ότι η νέα περίοδος εγκαινιάστηκε με τη Βιομηχανική Επανάσταση, η οποία οδήγησε σε αύξηση του διοξειδίου του άνθρακα στην ατμόσφαιρα και προκάλεσε τελικά τη σημερινή κλιματική αλλαγή.

Η ανακάλυψη του Κολόμβου έφερε αλλαγές πλανητικής κλίμακας (Πορτραίτο από τον ιταλό ζωγράφο Sebastiano del Piombo)

Ερευνητές του University College του Λονδίνου προτείνουν τώρα ότι το Ανθρωπόκαινο ξεκίνησε το 1610, εκτιμώντας ότι ο δικός τους ορισμός πληρεί δύο βασικές προϋποθέσεις για την επίσημη αναγνώριση μιας γεωλογικής περιόδου: πρώτον, μακροχρόνιες μεταβολές σε πλανητική κλίμακα· και δεύτερον, την ύπαρξη ενός δείκτη που σημειώνει την έναρξη αυτών των μεταβολών σε φυσικά υλικά όπως τα πετρώματα και τα ιζήματα του ωκεάνιου πυθμένα.

Λίγο περισσότερο από έναν αιώνα μετά την άφιξη του Κολόμβου στην Αμερικής το 1492, δεκάδες είδη ζώων και φυτών είχαν ήδη μεταφερθεί από και προς τον Νέο Κόσμο, αλλάζοντας δραστικά την παγκόσμια βιογεωγραφία, αναφέρει η ερευνητική ομάδα. Γύρη από καλαμπόκι, ένα φυτό της Λατινικής Αμερικής, πρωτοεμφανίζονται σε θαλάσσια ιζήματα της Ευρώπης το 1600.

Το έτος 1610 σημειώνει επίσης μια δεύτερη μεγάλη αλλαγή, μια ξαφνική πτώση των επιπέδων διοξειδίου του άνθρακα στην ατμόσφαιρα. Ήταν συνέπεια του αποικισμού της Αμερικής, ο οποίος είχε ως αποτέλεσμα το θάνατο 50 εκατομμυρίων ανθρώπων, κυρίως λόγω της ασθένειας της ευλογιάς. Οι καλλιεργήσιμες εκτάσεις τους εγκαταλείφθηκαν και καλύφθηκαν σταδιακά από πυκνά δάση, τα οποία απορρόφησαν μεγάλες ποσότητες CO_2από την ατμόσφαιρα.

Η πτώση αυτή, επισημαίνουν οι ερευνητές, καταγράφηκε στους πάγους της Αρκτικής και μπορεί να θεωρηθεί γεωλογικός δείκτης για την έναρξη του Ανθρωπόκαινου.

Όσον αφορά άλλες προτάσεις για την έναρξη της νέας γεωλογικής εποχής, οι συντάκτες της μελέτης εξηγούν τις αντιρρήσεις τους. Η αύξηση των επιπέδων ραδιενέργειας που καταγράφηκε το 1964 λόγω των πυρηνικών δοκιμών δεν έφερε μείζονες αλλαγές στον πλανήτη όπως θα απαιτούσε ένας επίσημος ορισμός, λέει η ερευνητική ομάδα.

Αναφέρει ακόμα ότι ο ορισμός δεν μπορεί να βασιστεί στην έναρξη της Βιομηχανικής Επανάστασης, καθώς η αύξηση του ατμοσφαιρικό CO2 δεν ήταν αρκετά απότομη για να θεωρηθεί αξιόπιστος δείκτης.

«Από ιστορική άποψη, η "σύγκρουση" ανάμεσα στον Παλαιό και τον Νέο Κόσμο σημειώνει την αρχή της σύγχρονης εποχής» αναφέρει ο Δρ Σάιμον Λιούις, πρώτος συγγραφέας της μελέτης. «Πολλοί ιστορικοί θεωρούν τις εισαγωγές αγροτικών προϊόντων από τις αχανείς εκτάσεις της Αμερικής, σε συνδυασμό με τη διαθεσιμότητα του λιθάνθρακα, ως θεμελιώδεις προάγγελους της Βιομηχανικής Επανάστασης».

«Σε παγκόσμιο επίπεδο, το όριο αυτό σημειώνει την τελευταία δροσερή εποχή πριν από την έναρξη της μακροπρόθεσμης ζέστης του Ανθρωπόκαινου».

Άλλοι γεωλόγοι, όμως, διαφωνούν. Τον Ιανουάριο, τα 26 από τα 38 μέλη της Διεθνούς Ομάδας Εργασίας Ανθρωπόκαινου κατέληξαν στην άποψη ότι η νέα εποχή άρχισε με την πρώτη πυρηνική δοκιμή στις 16 Ιουλίου 1945 (http://news.in.gr/science-technology/article/?aid=1231378375).

Το θέμα θα συζητηθεί εκ νέου σε διεθνείς συνομιλίες που προγραμματίζονται για το 2016.

(Επιμέλεια: Βαγγέλης Πρατικάκης / Newsroom ΔΟΛ, 12 Μαρ. 2015, http://news.in.gr/science-technology/article/?aid=1231392277#.VQG3A_IOG9k.emai).

Ιάπωνες επιστήμονες πέτυχαν μετάδοση ρεύματος μέσω του αέρα

Ιάπωνες ερευνητές κατόρθωσαν να μεταφέρουν ηλεκτρική ενέργεια με ασύρματο τρόπο, μέσω του αέρα, καθιστώντας περιττά τα καλώδια.

Το επίτευγμα ανήκει στους επιστήμονες της Ιαπωνικής Υπηρεσίας Εξερεύνησης του Διαστήματος (JAXA), που, σύμφωνα με το Γαλλικό Πρακτορείο, χρησιμοποίησαν μικροκύματα για να κάνουν, από ένα πομπό σε ένα δέκτη, μετάδοση ρεύματος αρκετού ώστε να ζεστάνει μια κατσαρόλα.

Αν και η απόσταση ήταν μικρή, μόλις 55 μέτρα, και η ισχύς του ρεύματος επίσης μικρή, 1,8 κιλοβάτ, πρόκειται για ένα σημαντικό βήμα, που ανοίγει μεγάλες δυνατότητες για το μέλλον, μεταξύ άλλων την αξιοποίηση της ηλιακής ακτινοβολίας για την παραγωγή ηλεκτρισμού στο διάστημα και την ασύρματη μετάδοσή της στη Γη.

«Είναι η πρώτη φορά που κάποιος κατάφερε να στείλει σχεδόν δύο κιλοβάτ ηλεκτρικής ενέργειας μέσω μικροκυμάτων σε ένα μικρό στόχο, χρησιμοποιώντας μια συσκευή ελέγχου μεγάλης κατευθυντικότητας», δήλωσε εκπρόσωπος της JAXA, η οποία εδώ και χρόνια εργάζεται για τη δημιουργία διαστημικών σταθμών παραγωγής ρεύματος.

Η διαστημική παραγωγή ηλεκτρισμού έχει πολλά πλεονεκτήματα σε σχέση με την παραγωγή στη Γη, κυρίως ότι είναι πάντα διαθέσιμη, ανεξαρτήτως καιρού ή ώρας. Αν και οι δορυφόροι, καθώς και ο Διεθνής Διαστημικός Σταθμός χρησιμοποιούν την ηλιακή ενέργεια, την οποία μετατρέπουν σε ηλεκτρική για τις ανάγκες τους, η ασύρματη μετάδοση αυτού του ρεύματος στη Γη, ώστε να το χρησιμοποιούν ευρέως οι άνθρωποι, παραμένει επιστημονική φαντασία.

Όμως οι Ιάπωνες επιστήμονες επιμένουν πως είναι θέμα χρόνου κάτι τέτοιο να γίνει εφικτό. Η JAXA οραματίζεται ένα δίκτυο δορυφόρων με ηλιακούς συλλέκτες και αντένες, σε ύψος περίπου 36.000 χιλιομέτρων από την επιφάνεια του πλανήτη μας, που θα συλλέγουν το φως του Ήλιου, θα το μετατρέπουν σε ρεύμα και τελικά θα το «διακτινίζουν» στο έδαφος. Όπως είπε ο εκπρόσωπος της JAXA, μπορεί να περάσουν δεκαετίες, έως ότου υπάρξει πρακτική εφαρμογή της φιλόδοξης τεχνολογίας. Εκτίμησε ότι αυτό, στην καλύτερη περίπτωση, θα συμβεί στη δεκαετία του 2040.

Αν και η όλη ιδέα είχε ξεπηδήσει στους επιστημονικούς κύκλους των ΗΠΑ στη δεκαετία του ’60, ήταν η Ιαπωνία αυτή που πήρε ζεστά το ζήτημα, επειδή η νησιωτική χώρα εξαρτάται σε ανησυχητικό βαθμό από τις εισαγωγές πετρελαίου και άλλων πρώτων υλών, με συνέπεια να προσπαθεί εναγωνίως να αποκτήσει ενεργειακή αυτάρκεια – έστω και εξ ουρανού. Το σοβαρό πυρηνικό ατύχημα της Φουκουσίμα το 2011 έκανε την ανάγκη ακόμη πιο επείγουσα, καθώς έδειξε ότι η πυρηνική ενέργεια, στην οποία είχε «ποντάρει» η χώρα, δεν έχει αμελητέους κινδύνους.

(TechIT, 13 Μαρτίου 2015, http://techit.gr/2015/03/iapones-epistimones-petuchan-metadosh-reumatos-meso-tou-aera)

☙ ❧

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Όπως ξέρουμε στην Αμερική η σημερινή ημερομηνία 14 Μαρτίου γράφεται 3/14. Έτσι καθιερώθηκε να γιορτάζεται η 14η Μαρτίου σαν μέρα της τιμής του π = 3.141592653 …

Φέτος όμως, που έχουμε 3/14/15 (στην Αμερικανική μορφή), στην ώρα 9:26:53 είχαμε την τιμή του π με 10 ψηφία ακρίβεια. Αυτό θα συμβεί πάλι το 2115!

ΕΚΤΕΛΕΣΤΙΚΗ ΕΠΙΤΡΟΠΗ ΕΕΕΕΓΜ (2012 – 2015)

ΕΕΕΕΓΜ

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