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Editorial

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Although I was brought up in a family with a rich engineering tradition, I am myself unable to claim anything more than associate membership of the engineering community. If truth be told, a growing concern with how engineering and engineers fitted into a wider picture of social benefit rather distracted me from the study of stresses and structures which was the daily fare of my undergraduate courses. These concerns have been gradually eroded over the years as I spent more time with practising engineers . . . but they have not been put to rest. My anxiety spans both faces of the engineering–society relationship; why is engineering so bad at serving society, and why is society so poor at exploiting the potential of engineering? It is one aspect of the second of these (perhaps over-simplistically stated) queries that I wish to address here.

The challenges that face modern-day engineering are characterised by a need to understand, and design solutions that are sensitive to, the long-term impacts of implemented interventions on communities, the environment and the economy. Such understandings necessarily involve consideration of a much wider set of phenomena and processes than that which previously fell under the engineer's remit. Engineers are urged to think holistically, engage with interdisciplinary teams and consider whole life cycle features of materials and structures. At times the route to more sustainable communities can appear daunting as it seems to necessitate knowledge of all possible impacts and influences across space and time.

While the capacity to know all things will doubtless remain an attribute exclusive to omniscient deities, a perspective that focuses on connections, extended chains of cause–effect, and how parts are organised into wholes has significant consequences for engineering practice. For example, although cause–effect chains manifest themselves at all spatial scales from the sub-atomic to the global, it is the large scale processes that tend to generate most concern. The Stern Review on *The Economics of Climate Change*, published at the end of October, clearly illustrates the enormous diversity and complexity of connections between different elements of the global system.[1] Increasing incidence and intensity of floods, droughts, crop failures, forest fires and human migration are just some of the consequences of climate change itemised in the report. A colleague noted that engineers would no doubt now be called on to not only alleviate those processes which drive the problem (climate change) but also provide options to mitigate the undesirable impacts.

So how can civil engineers and civil engineering contribute to a more sustainable future? This query has been the subject of much reflection and self-questioning on the part of engineers over the last few decades and this journal has published several papers which address the future role of the profession (see, for example, the contributions by Sebastian Wood[2] and Paul Jowitt[3]). I don't wish to restate or challenge these positions but I would like to emphasise two often overlooked features of civil engineering as an activity which might help explain how engineers could play a more central role in a sustainable future.

Civil engineers, like all professionals, come in many guises. But whether constructing a bridge, a building, a pier, a road or a sewer, all civil engineers are concerned with how function relates to form and how both function and form relate to setting or circumstance. The design and construction of physical artefacts would be senseless without a strong and meaningful rationale for favouring one design option over another. Debate and analysis over which design is 'best' cannot be conducted without reference to how the artefact relates to the environment, community and economy in which it is to be located. Articulating the trade-offs between performance (often against multiple criteria), aesthetics, costs, robustness, and so on, comes as second nature to most engineers as they negotiate their way through what the client wants, what she can afford and what is feasible in engineering terms. Although not formally incorporated as part of degree course curricula, this (innate?) understanding of the significance of composition, arrangement and configuration permeates the profession's thinking and practice.

The second attribute of engineers which makes them particularly suited to meet the challenges of sustainable development is their ability to map abstract concepts, theories and ideas across the practice gap. With one eye constantly on the question 'how will this look on the ground?' engineers contrast and compare new ideas and options with their own knowledge, learning and experience to 'ground truth' solutions. This is not to suggest that engineers should have ultimate control over option generation and selection. However, engineers are perhaps best placed to conduct early screening of options; one suspects that much time and effort could be saved if greater use was made of the proverbial 'back of a fag packet' calculation at an early stage of project design.

These two vital skills, the ability to function professionally at the intersection of theory and practice, and an understanding of cross-phenomena relationships, are, for most engineers, founded on tacit knowledge which is difficult to codify and share. It is 'know how' in contrast to 'know why' (the remit of the sciences) and 'know what' (the world of facts). Consequently, exploiting these characteristics (over and above the traditional role of engineering) for the benefit of our communities is not straightforward. A renegotiation of the remit of engineers may be required and those who specify and define problems will need to learn to ask different questions of the profession if they are to receive innovative options for action. Engineers are too often shackled by a solution rather than empowered by a problem. Additionally, engineers need to be encouraged to view their skills and knowledge base in a more generic sense. I often find engineers to be full of innovative ideas and sharp insights in the company of their disciplinary colleagues but reticent to speak out in a more interdisciplinary setting.

Interestingly, although evidence for the attributes discussed above has all but disappeared in the Western tradition, their significance can still be discriminated in evidence from other cultures. For example, the etymology of the English words 'engineering' and 'engineer' points to an original meaning related to design or construction. However, the word for engineer in the Semitic languages (e.g. *muhandis* in Arabic) originally referred to someone engaged in geometry; the root of the word having come from the Arabic for 'India', a source of much early middle Eastern knowledge in mathematics. Geometry, of course, is concerned with dimensions, shape, form and relations between objects, and often embraces abstract models (such as calculus) to support solution generation. Proficiency in abstract thinking and its application to practical problems as well as in how elements of a problem relate to each other make for both an effective geometrician and, I would argue, an effective engineer. European science already owes a huge scholastic and cultural debt to Arab civilisations for preserving key texts from the Greek intellectual tradition, including much of its medical and mathematical thinking. This knowledge, embellished with contemporary developments, was available to Europeans when they emerged from what is popularly called the Dark Ages (the latter half of the first millennium). Is it time to rediscover the abstract and relational skills which lie at the very heart of the word that these civilisations use for engineering?

This issue of *Engineering Sustainability* carries four full papers on diverse aspects of creating and managing sustainable responses to development. Each of them demonstrates something about the ability of engineers to manipulate configuration and abstraction. In the opening paper, Tom Shaw reviews 'run-of-river' hydroelectric schemes which do not rely on storage reservoirs for source water. These types of hydropower scheme have seen a gradual increase in popularity over recent years. Compared with larger-scale reservoir-based schemes, their environmental impacts are both less extensive and more manageable at local scales.

Our second paper comes from a team of authors well placed to comment on the complexity of sustainable development as noted above. Collectively, Richard Fenner, Charles Ainger, Heather Cruickshank and Peter Guthrie have huge experience in the field and write convincingly on extending the problem boundary that is typically adopted by engineers. Using a wastewater treatment plant as case history, they neatly demonstrate how many of the dimensions of sustainability which civil engineers should be engaged with are effectively hidden within the rules, norms and guidance which characterise organisational processes and behaviour.

Demonstrating the breadth of assessment that can be delivered when engineers are given a liberal remit (i.e. allowed to ask the big questions), Dexter Hunt, Ian Jefferson, Lubo Jankovic and Kevin Hunot report on a total energy demand balance for an area of Birmingham undergoing significant regeneration and redevelopment. Drawing on information from what will be a mixed-use development, the authors move from scoping the energy demand to exploring the feasibility of different renewable supply options and finally applying a cost model to support decision making.

Finally, Te Kipa Kepa Brian Morgan describes an approach to ensuring that indigenous values and beliefs are incorporated into sustainability decision making. Culturally sensitive development has been a central feature of debates on sustainability in many countries with significant indigenous populations (e.g. Canada and Peru) as well as within the corridors of global institutions such as UNESCO. The involvement of indigenous peoples in dialogue on sustainable development is well advanced in many contexts, but the incorporation of indigenous norms, understandings and aspirations into evaluation frameworks which have been independently developed has proved a significant challenge. Despite the author's reserved opinion of this paper's relevance outside New Zealand, I hope that it will be widely read and the ideas given substantive consideration.

These four papers demonstrate the breadth and depth of sustainability-relevant thinking and practice within the civil engineering community. My aim at the start of this editorial was to advocate an expanded role for engineers and I feel that the papers in this issue suitably illustrate the skills which form the basis for that proposition. Indeed, I can but echo the words of Gordon Masterton (outgoing ICE President) writing in the introduction to the ICE *State of the Nation* report 2006, who asserted that 'we have the engineering skills, experience and resources in the UK to achieve everything envisaged in this report'.[4] My only concern is that some of the most important skills may be both unrecognised and under-valued.

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