2030, The Structural Engineer's Role In Beating Professor Beddington's Perfect Storm Prescriptions

Michael Smales, February 2010

Young structural engineers like myself, currently pondering the title of this paper, will be faced with the Perfect Storm scenario laid out by Professor Beddington covering issues as diverse as the future of energy generation and the challenges facing global agriculture. Many of these issues will seem, at first glance, to be completely unrelated to structural engineering. However, it will be precisely these engineers who will see the effect of changes in our society and environment on their careers and personal lives as 2030 approaches. It will be these engineers who will be called upon as professionals to lead the solutions to the Perfect Storm.

So what is the structural engineer's role in beating the Perfect Storm? The answer is, in fact, contained within Professor Beddington's paper, where he recognises that beating the Perfect Storm requires a focus on "facilitating the real world deployment of existing and emergent technologies". This is the core of what structural engineers do, and what we will have to continue to do in a future similar to the Perfect Storm scenario. Taking the case of existing technologies we will have to learn to design around new constraints and ensure at the same time that the construction of our designs will not continue to add to problems such as CO_2 emissions[1]. In the case of emergent technologies we will have the chance to turn the ideas for beating the Perfect Storm, which might at first seem unrealistic, into a feasible, affordable and practical reality.

The Perfect Storm prescriptions – insurmountable challenges or challenging brief?

We don't know how the world and society will develop over the next twenty years, but there is increasing consensus that we can look forward to a future similar to that described by Professor Beddington[2]. Unless, that is, we act now to prevent and mitigate against it. These predictions cover the full range of the most fundamental needs of humanity: food and water supply, housing, energy demand and the quality of our natural environment. For the structural engineer, young or otherwise, this scenario covers such a bewilderingly broad range of topics it is difficult to see where they tie in to our professional remit. However, there are several underlying, interlinked themes running through Professor Beddington's paper which affect, and are affected by, the everyday work of structural engineers.

Pressure on land use. As the Earth's population continues to grow there will be an increasing competition for land use from three main sources. Firstly there will be the need for more developed land to provide housing and services as the population expands and continues to urbanise. There will also be an increased demand for food, and a more affluent population will require more land-intensive foodstuffs such as meat and dairy. Finally, energy generation facilities will take up much larger areas as an increasing electricity demand is met, whilst moving from fossil-fuel based generation to more sustainable methods. Renewable forms of energy generation are diffuse and require more land than their conventional predecessors, whether this energy generation is in the form of solar power, biofuel crops, wave power generation or wind farms[3]. For a simple example, the UK's largest coal-fired power station at Drax produces some 4000MW of electricity[4] on a site of less than 2 square kilometres[5]. In contrast, Europe's largest onshore windfarm at Whitelee near Glasgow produces 322MW of electricity on a 55 square kilometre site[6]. As a result of these pressures, construction will have to deliver more whilst making use of smaller areas of land in inhospitable environments.

Pressure on resources. A larger, more affluent, more urbanised population will put greater demand on all of our natural resources, from fossil fuels, to steel, to water. The last of these will, perhaps, be the most pronounced as we switch from a world where water is generally freely available, for the developed world at least, to a scenario with limited water. The structural engineer, however, will be affected most by the need to limit the use of primary raw materials such as steel, aggregate and cement. It is also worth noting that in a world where energy supply becomes more restricted and expensive, the production of many basic construction materials is very energy intensive.

The effects of climate change. Finally, as a backdrop to these pressures, are the effects of climate change. As we strive to make do with the limited land we have, rising sea levels and change to local climates will further reduce the land we have available. As the world's engineers work to meet the growing demand for electricity, buildings and infrastructure we will have to simultaneously reduce our emissions of greenhouse gasses.

These predictions may make for grim reading for the designer tasked to solve these problems. Or perhaps they read like a particularly challenging design brief on a global scale: we have the deliverables (food, water, energy and housing), a limited time-frame (by 2030) with limited resources (land and raw materials) and some other constraints thrown in for good measure (a drastic reduction in fossil fuels). As engineers we deal with problems framed in this manner daily, albeit on a smaller scale. Should we not be, therefore, well suited to deal with the problems posed by the Perfect Storm?

Facilitating existing technologies – the need for efficiency.

The first of the structural engineer's roles will be to improve on how we deliver existing technology. The demand for the buildings and infrastructure we create will continue to increase, but the resources we have to deliver this demand, resources such as the land we have to build on and the materials available to use, will simultaneously decrease. This increase in demand coupled with diminishing resources will mean that efficiency will become paramount. Designing structures which use a minimum of resources has, fortunately, always been a key competence of structural engineers, but if we are to address Professor Beddington's predictions we will no longer be able to judge efficiency solely in terms of financial cost. Designers of structures will have to consider efficiency in terms of embodied energy, CO_2 emissions and the use and re-use of materials. Of course, if international negotiators succeed in establishing legislation which drives a price for CO_2 emissions, we may find that the cost of a project will naturally come to incorporate sustainability considerations[7].

Minimising the embodied CO_2 of a building, designing buildings for adaptability, designing for recycling of the constituent materials and becoming increasingly involved in decommissioning to ensure that recycling takes place - there are many aspects to sustainable, efficient construction which can be lead by structural engineers. Designs will also have to account for increasing use of brownfield sites and constraints on buildable land. There are, in addition, areas where we will simply need to continue to accommodate other members of the design team, allowing them to make their own contributions to sustainable design, like the in-use energy efficiency driven by building services engineers.

Efficient, sustainable engineering? Timber-framed buildings like the Open Academy, Norwich can be treated like biomass and burned for energy after decommissioning, effectively recycling the building.

Economical offshore wind turbines are only made possible by the design of structural engineers. Each wind turbine structure must be uniquely designed because of varying water depth and soil conditions.

Facilitating emerging technologies – delivering the unfeasible?

The second major role of structural engineers will be to ensure that new technology is realised. Increasing the efficiency of the way we build at the moment is, in effect, ensuring that we keep our contribution to the problems to a minimum whilst adapting to new constraints. This is extremely important, but must not eclipse how we can play a pivotal role in creating the solutions to the Perfect Storm. The ideas which ultimately become the solutions to the food, water and energy problems we face may not originate with structural engineers, but with problems on a global scale the solutions will, necessarily, be on a grand scale. As new and untested technologies, these ideas will initially seem to be unfeasible, uneconomical and un-buildable. Surely this is where engineers are needed, and where we can find our most rewarding challenges – in taking the seemingly impossible and making it reality.

Revisiting the example given above of energy and electricity production, as we try to implement new, more sustainable electricity generation methods these will need proportionally more land than previous fossil-fuel-based generation. As agriculture and urbanisation take up the prime land, these solutions will be pushed into ever-more inhospitable locations. This is already being seen with the wind power industry in the UK, where the public's objections to having vast tracts of land covered in wind turbines has forced wind farm developments into the harsh environments of the coastal waters around the UK. Each and every one of these turbines needs to be designed affordably to survive the rigours of consistent, dynamic wind and wave loading. This has been made possible so far by structural engineers, and with plans for the construction of several thousand offshore turbines over the next ten years[8] this presents a situation where structural designers are key in implementing direct solutions to the Perfect Storm.

Taking transport as a further example, in the UK a national high-speed rail network is currently being discussed as a lower-emission alternative to short-haul aviation[9]. An expansion to the rail network will inevitably require redevelopment and construction of stations and bridges as critical components – components which require the design skills of structural engineers. Similar arguments follow for the construction of rail-based public transport networks as lower-emission alternatives to travel by car, such as the proposed Crossrail development in London.

Arguably neither of these examples is led by the structural engineer, but nor would they be possible without our contribution. These examples show a precedent; that structural engineers can be essential for success in deploying new technology in industries with which we are not usually associated. The same can be said for the future challenges like building a new generation of nuclear power plants, with four currently awaiting planning permission in the UK[10] despite the fact that a nuclear power station has not been commissioned in the UK since 1995[11]. We will also have to play our part in upgrading the national grid to handle renewables[12], delivering more sustainable cities[13] and realising other, as-yet unconceived technologies which are needed to beat the Perfect Storm.

Public transport networks such as Crossrail have many aspects requiring structural design, such as the development of Paddington Station, pictured[14].

Conclusion

There is no shortage of ways in which structural engineers can continue to improve how we design to adapt to the Perfect Storm. Our designs must be more efficient in terms of embodied CO_2, land-use, energy and raw materials. We must design our structures to be adaptable, avoiding the need to rebuild them after a short life. We must also design buildings and bridges which can be recycled, and become more involved in the decommissioning process to facilitate this. In doing so we will both be ensuring that we do not contribute to the problems, as well as coping with new constraints imposed by changes to the society we live in.

However, we should not limit ourselves to simply reducing our own contributions to the Perfect Storm. By deploying new technologies in the real world, we can make contributions to solutions in many other fields, whether they are needed in tackling water scarcity, transport or energy production. We should not expect the structural engineer to be the protagonist in every solution to the Perfect Storm – the range of issues involved is simply too large. But we will still have to play a key role in every solution if they are to become reality. Large-scale construction is the specialism of structural engineers, and with problems on a global scale the solutions will have to both large and widespread. If you still feel unconvinced read Professor Beddington's paper once again, but this time ask yourself how we might find solutions *without* the role of the structural engineer.

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[1] The term 'CO_2 emissions' is used throughout to mean emissions of carbon dioxide and equivalent greenhouse gasses.
[2] Beddington, J., 2009. Food, Energy, Water and the Climate: A Perfect Storm of Global Events? *Sustainable Development UK 09*, London 19 March 2009. Available at: http://www.dius.gov.uk/news_and_speeches/speeches/john_beddington
[3] MacKay, D. J. C., 2008. *Without the Hot Air* UIC
[4]Drax Group plc, *Our Business.* Available at: www.draxpower.com
[5] Measured directly from national maps
[6]Whitelee Windfarm, *About the Windfarm*. Available at: www.whiteleewindfarm.co.uk
[7] Institution of Structural Engineer's Sustainable Construction Panel, 2010. Sustainability Briefing Issue No. 8: The Copenhagen Accord. *The Structural Engineer,* 88(2), pp10-13
[8] Based on Data from BWEA, 2010. *What Does the Round 3 Announcement Mean?* Available at: http://www.bwea.com/ref/reports-and-studies.html
[9] Greengauge 21, *The Case for High Speed Rail.* Available at: www.greengauge21.net
[10] Infrastructure Planning Commission, *Programme of Anticipated Projects February 2010.* Available at: http://infrastructure.independent.gov.uk/
[11] British Energy Group plc, *Sizewell B*. Available at: www.british-energy.com
[12] National Grid plc., *'Gone Green': A Scenario for 2020*. Available at: http://www.nationalgrid.com/uk/Media+Centre/Documents/
[13]Campbell, A. & Head, P. R., 2008. Structural Engineering in the Ecological Age of Civilisation. *The Structural Engineer*, 86(14), pp130-135.
[14] Image available at: www.crossrail.co.uk/library#asset/4965