Editorial

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This themed issue investigates the current and future hazards associated with global warming. Engineers now have the most extraordinary challenge: to start taking reasonable and considered approaches to making society more resilient, while limiting ‘carbon footprints’ that add to the warming.

This themed issue presents the opinions and data sought from engineers and experts worldwide. Papers, briefings and interviews have been arranged in a coherent order rather than the normal segregated format. Articles are so relevant and contemporary that they are being previewed by newspapers while topics raised by the scientists are being discussed in *New Scientist* (Ananthaswamy, 2015). Moreover, other recent articles in scientific journals indicate that world warming is 1.3°C rather than 0.8°C and that sea-level rise is also higher than previously reported, so the challenges may be even more urgent than indicated.

The first paper by Tye *et al.* (2015), ‘Rethinking failure: time for engineer–scientist collaborations on design’, sets the tone of the themed issue. It makes a number of significant points

- despite new extremes in weather, design approaches have remained largely static
- previous design was based on observed extremes in the historic record
- recent and future changes in extremes have been ignored
- other countries will usually have had experience of the new conditions
- scientific knowledge needs to be fed into engineering design, which will entail direct communications with climate scientists.

Many of these key points are taken further in subsequent papers.

The briefing by Thorne (2015), ‘Briefing: How do we know the globe has warmed? What do we know about why?’, sets the current scene. The briefing considers a suite of different indicators that lead to the unequivocal finding that the world has warmed. It illustrates a key subject of several papers: how the new range of local ‘normal’ will affect planning needs for changes in extremes. Thorne suggests that the current new conditions need to be studied by engineers to gain an understanding of both the present parameters and as an initial

indicator of the expected short-term future rate of change. While 2014 was another ‘hottest year on record’, graphs indicate why rapid rises in near-surfaces are expected in the next few years.

In another briefing paper, ‘Briefing: Discussions with scientific experts on defining the risks from climate change’ (Thorniley-Walker, 2015a), the editor acts on the communication recommendation made in the first paper (Tye *et al.*, 2015).

- Professor Peter Wadhams, who has spent many years studying the polar regions, warns that the probability associated with a catastrophic methane event may be as high as 50%. He suggests that IPCC AR5 (2014) does not give adequate guidance.
- Professor Reto Knutti was a leading player in the preparation of the latest IPCC AR5. He asserts that it is dangerous for engineers to plan for only the optimistic scenarios and suggests that engineers should be anticipating 80 or 90% of all plausible cases, which would indicate preparing for 4°C of warming. He recommends that adaptation and mitigation need to go hand-in-hand to reduce the risk that even higher temperatures will make large areas of the planet uninhabitable. On the issue of timescale, he suggests a 50% chance of reaching 3°C of warming before the end of the century as things stand.
- Dr James Hansen, the effective godfather of climate science, suggests that even for 2°C of warming, civil engineers should be preparing for 6–8 m of sea-level rise. The subject of impacts and ratios between incremental carbon emissions from projects and species loss or human casualties is broached.

The briefing paper by Abraham *et al.* (2015), ‘Briefing: Extreme weather: observed precipitation changes in the USA’, addresses new conditions and reports that all regions of the USA apart from Hawaii suffer more intense precipitation, regardless of any mean changes or droughts. They outline close links between predicted and manifested trends, although loss of Arctic sea ice contributes further change. Study of both recent observations and future projections for coming years and decades will be needed for design of robust infrastructure.

The paper by Tye (2015), ‘Understanding the risks from extreme rainfall’, explains several complex issues associated

with climate modelling, climate change and weather extremes. It covers key differences between the traditional 'resistant design', which may fail in an unsafe manner, and the need for new 'resilient design', which accepts that failure will occur and considers the consequences. Tye provides an overview and explanation of extreme weather conditions that result in flooding and summarises changes in patterns over the UK. The UK has poor awareness of climate-related risks but the UN believes that 6.5 billion people will be vulnerable to natural hazards by 2050.

A briefing by Scambos and Abraham (2015), 'Briefing: Antarctic ice sheet mass loss and future sea-level rise', considers the need for resilience of coastal communities and economic infrastructure. The authors explain that the steady increase of energy (between 0.5 and 1.0 W/m²) reaching the Earth would result in almost 1 m sea-level rise by 2100, but this would increase significantly if there are collapses or partial collapses to the great Arctic ice sheets in the manner of the Antarctic Peninsular, which disintegrated over a matter of weeks. Models indicate that one glacial area alone would contribute between 1 m and 3 m of sea-level rise. While this will take 200–500 years at current temperatures, any temperature increase will cut the time frame, and other glacier systems have similar ice offloading runaway potential.

The briefing by Jonkman and Schweckendiek (2015), 'Briefing: Lessons learned from failures of flood defences', investigates failures of a sample of flood defences and the resulting loss of life and enormous prolonged damage; New Orleans 2005 is one of the samples. The authors discuss failures from geotechnical mechanisms, overloading, vulnerability at transitions and simple lack of design/misunderstanding of requirements. The authors think it is crucial to analyse failures for both strengthening and to extrapolate performance for the more extreme loadings that are expected.

In 'Briefing: Carbon footprint and risk assessments', Thorniley-Walker (2015b) updates data and perceptions from a previous paper (Thorniley-Walker, 2011). While other papers in the issue are generally based on observations, this briefing is based on the opinions of interested engineer peers. The opinions have so far proved enlightening and surprisingly accurate. Moreover, opinions such as '50% of the world population will die with a 5°C warming' reflect the scale of disasters raised by experts in other papers of this issue. The percentage and the ratios allow a risk assessment to be based on a 'very high' probability of a death for annual carbon emissions of 11 t. It is also noted that engineers think that 80% of codes of practice need to be updated, but the confidence that engineers should take a lead on climate change dropped from 88% in 2008 to just 15% in 2013/14 (rebounded to 80% in 2015).

The final paper 'Resilient design of landslip measures: a case study' (Mickovski, 2015) illustrates problems faced by a practising civil engineer. Stabilisation of a slope with hazards from erosion, shallow landslips, overall stability, current and future hydrology and drainage require a risk-based approach that also ties into the carbon footprint of the works. The paper discusses the dilemma of how much effort should be expended now to reduce hazards from future expected changes to conditions.

Summary

The risks identified by these collected briefings and papers warrant radical action and new approaches. It appears that mean temperatures and sea levels are now likely to be rising at a faster rate, with associated extreme conditions that are beyond current design codes. Discussions with experts and feedback from opinions of peers indicate that, depending on risk assessments, designs may need to be resilient for conditions very different from previous decades. This will affect new designs and assessment of existing infrastructure.

The subjects covered by this themed issue are novel, so the editorial panel would particularly encourage discussion pieces or further papers on this theme.

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