Editorial

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1. Summary of forensic themed issues on climate resilience

This second themed issue of *Forensic Engineering* on resilience for climate change has been prepared at an extraordinary time of real change. Both this 2017 issue and the previous 2015 edition (Thorniley-Walker, 2015a) cover subjects associated with safety of society and infrastructure, using briefing articles to review current and predicted conditions that will be shocking to many

- global temperatures started to reach 1.5°C of warming above pre-industrial levels in 2016, just months after the Twenty-first Session of the Conference of the Parties (COP21) in Paris adopted that temperature as one of its targets
- after a 3-year reprieve, the summer Arctic sea ice is once again heading towards zero volume around 2021
- the best estimate is that temperatures will reach 5°C above pre-industrial levels by 2100
- civil engineers are warned that they need to consider the possible effects of 4°C of warming above pre-industrial levels by 2040.

Against that background, engineering recommendations for resilience in these papers suggest useful and reasonable cost-effective short-term measures. The engineering papers cover codes of practice for hurricane conditions, defence against scour, cost-effective solutions to scoured watercourses and lessons to be learnt for resilient electrical power.

2. Forward-looking forensic approach to codes of practice

For civil engineers, many projects now seek to rectify environmental problems from climate change such as flood damage. At the April 2017 Institution of Civil Engineers (ICE) North East regional dinner, for example, 80% of award nominations related to such projects. The guest speaker suggested that this was creating a new definition for civil engineering!

The new Climate Change Task Force (Kermode, 2017) has pointed out that the science and advice have not significantly changed since 1994 (Engineering Council, 1994); only the timings and the extent of current and projected warming has sharpened considerably after decades of inaction. At this late stage, engineers who generally

prepare for events with probabilities of around 0.2%, now face an overwhelming task with a ridiculous timescale.

As outlined in several papers and briefings in the first themed issue (Thorniley-Walker, 2015a), most current codes of practice are generally inadequate as they are based on studies of previous expectations and have no concerns over carbon dioxide emissions. Conversely, newer sustainability codes are often predicated on long-term whole-life benefits that appear equally remote. For appropriate engineering approaches to improve the resilience of infrastructure, engineers need to establish

- the current conditions of the environment
- the current rates of change and the forecast conditions
- hazards that most need to be addressed for reasonable resilience
- new approaches that will enable designs to be resilient
- new philosophies for resilience.

For the fast-moving news on the climate, engineers must communicate with climate scientists (Tye, 2015). For that purpose, a collection of briefing articles has again been sought from climate scientists alongside engineering views.

3. Current and future conditions

In the first briefing article by an academic, 'Global surface temperature records: an update', Professor Peter Thorne (2017) reviews current temperatures and reveals the news that we have already started to reach 1.5°C of temperature rise above pre-industrial levels. He also gives a forensic explanation of how it was possible for temperatures to appear to have almost stopped rising in 2013 and 2014.

Professor Thorne's warning should be extremely newsworthy and significant to engineers, as well as the wider public. The 1.5°C and 2°C targets were only set in December 2015 by world leaders at COP21 in Paris, with implementation by 2020. Unfortunately, this is just the first piece that indicates how the laws of physics are not influenced by public wishful thinking.

In the second briefing article by university-based climate scientists, 'Future climate projections allow engineering planning' (Abraham

et al., 2017), Drs John Abraham from St Paul in Maine, Lijing Cheng from Beijing and Michael Mann from Pennsylvania have collaborated to advise civil engineers on likely conditions for the future. Starting from current temperatures, they succinctly assess the accuracy of various computer models to identify the best estimate for future projections, assuming steady conditions without tipping points. The resultant best estimate is a rise of 5°C above pre-industrial levels by 2100.

Engineers will then need to assess even worse consequential dangers that such a steady-state projection poses as discussed in the 2015 themed issue

- engineering opinions indicate that only half of the world population can survive 5°C of warming (Thorniley-Walker, 2015b)
- a risk that Arctic sea ice loss will exacerbate conditions as discussed below
- a 50% chance that methane releases will create a tipping point once the Arctic ice melts (Thorniley-Walker, 2015c)
- the effect that with Moroccan-style temperatures in the UK, many other areas will fare even worse.

The editor, who is also an engineer on the ICE Climate Task Force, has provided the third briefing paper (Thorniley-Walker, 2017). This provides an update from the 2015 issue (Thorniley-Walker, 2015c) on current loss of area and volume of the summer Arctic sea ice. A similar decline in the winter sea ice has now been added. The trend lines still suggest that 2021 may be the first time that the human race will have the globe without a cooling and reflective sun hat.

There are many alarming aspects of the imminent ice exit from the Arctic

- the official and general expectations that summer loss is still decades away
- the lack of research and information on the global consequences of the globe suddenly having no block of ice to influence ocean drifts and jet streams, which makes engineering recommendations difficult
- alarming optimism that loss of ice is initially unlikely to be significant for the planet.

A previous briefing (Thorniley-Walker, 2015b) suggested how engineers should be compiling risk assessments for the carbon dioxide emissions from projects. The data in the two themed issues could also be useful when preparing for risks to projects within their lifetime.

The fourth briefing article, 'Should engineers be allowing for a potential 4°C rise by 2040 and how?', is by John Parry (2017) who is also from the ICE Climate Task Force. He suggests reasonable conditions and a timescale that diligent engineers should be addressing in their risk assessments. Drawing from a wide range of previous presentations and papers, he reviews some of the principal issues that engineers face.

Parry also considers the *UK Climate Change Risk Assessment 2017* (HMG, 2017), which works to different probabilities from those accepted for civil engineering design. As current carbon dioxide emissions were previously predicted to raise temperatures between 1.1°C (cf Thorne (2017) for 1.5°C in 2016) and 5.4°C (cf Abraham *et al.* (2017) for 5.0°C in 2100 without tipping points), Parry suggests the reasonable 4°C figure for which civil engineers need to prepare by 2040. In addressing the implications of this rise, Parry points out that the effects will be so much worse than current short- and medium-term precipitation, sea level rise and heatwaves that are already stretching current budgets.

4. Resilient infrastructure

'Are building codes keeping up? A case study on hurricanes in the Caribbean' by Ester Calavia Garsaball and Hristo Markov (Garsaball and Markov, 2017) is the first full technical paper in this series on change and resilience, with particular emphasis on problems for working engineers between

- projected conditions
- actual current conditions
- current design codes of practice.

For hurricanes in the Caribbean, Garsaball and Markov research and compare engineering guidance on wind or hurricane conditions and the physical conditions recorded on the ground along with 'near misses'.

Like several aspects of climate change, this is particularly relevant to islands and areas that have so far escaped violent conditions. Garsaball and Markov point out that the timing is just a matter of probability, so this should be reflected in the codes. This paper is likely to have relevance to engineers beyond the Caribbean, as the intensity and the distribution of hurricanes have started to spread beyond the traditionally prone parts of the world.

The paper 'Bamboo structures as a resilient erosion control measure' by Dr Guillermo Tardio, Dr Slobodan Mickovski, Dr Alexia Stokes and Sanjaya Devkota addresses another common manifestation of climate change and poor land-use: the devastated landscape after a destructive torrential flood (Tardio *et al.*, 2017). Once a violent flood has washed out the bed and meanders of a stream, it is difficult to imagine how an engineer can reinstate resilient pools, bogs and banks in a short period and in a cost-effective manner that can resist subsequent storms and help attenuate the flow.

Tardio *et al.*'s paper gives new engineering solutions and practical guidance for the engineering/landscape design for both cut and living bamboo to create living dams. Such water retaining and flood attenuation structures are likely to be both efficient and practical. This paper should also be highly influential to areas around the world where bamboo does not flourish but where species such as alder, hazel and especially willow would be effective substitutes.

'A review of approaches to assessing scour current velocity around existing structures' by Adeniyi Aje and Ahmad Khattab is a paper

that covers an aspect of infrastructure that has already proved critical as weather patterns have changed (Aje and Khattab, 2017). The lifespan of many bridges has already been defined by the capacity to resist scour so the design of cost-effective protection is a key issue.

With a case study of a bridge affected by floods in the Somerset Levels in 2013/2014, Aje and Khattab review current engineering guidance covering analysis approaches that range from the too simple to the too complicated yet fail to indicate adequately the impact that the bridge substructure has on the flow. They suggest straightforward practical approaches to help define the size of stones needed for protection.

The last paper 'Electrical system resilience: a forensic analysis of the blackout in Lancaster, UK' by Professor Roger Kemp (2017) describes the consequence of a flood-hit power supply in December 2015. He suggests that the need for resilience involves assessing both the likelihood of failure and the consequence.

After many years of a continuous uninterrupted supply of electric power, some of the results were almost laughable. Issues ranged from effective imprisonment for homeowners with entirely electric gates, to an extraordinary total collapse in most methods of communications, which prevented residents being able to hear important news from the authorities. Professor Kemp then goes on to discuss opportunities and vulnerabilities posed by 'decarbonisation' and climate change. His additional comments on the reliance on computer software for power distribution appear particularly prescient and relevant for 2017.

5. Reality of denial

Notwithstanding the clarity of the above-mentioned briefings and papers, in 2017 it is unfortunately still usually professionally unacceptable for engineers to consider the threats of climate change as real. For example, the following ridiculous and worrying exclusion clause needed to be inserted into his recent forensic report on a coastal bridge by the editor.

'This report has been based on the common engineering assumptions that climate change is irrelevant and that environmental conditions at the site will be those expected in the codes of practice. Beneficial or destructive effects related to exceptional conditions over recent decades, current conditions and likely future conditions have been excluded from this report covering the 120-year life of the bridge.'

Looking at the themed issue as a whole

- it is very clear that the scale, timescale and effects of global warming pose credible and imminent threats that need to be taken seriously
- there appears to be a major gap in the credibility between the current extraordinary rates of change in our environment and the optimistic models and reassuring promises of long timescales

- a primary purpose of current engineering design therefore needs to involve providing infrastructure that is resilient to at least the short-term changes that are now unsafe to ignore
- amendments are needed to nearly all codes of practice
- drastic changes in attitudes are needed to cut carbon dioxide emissions, while there is still scope to act positively
- the civil engineering profession needs to be able to discuss and address what is currently still regarded as unspeakable.

REFERENCES

- Abraham J, Cheng L and Mann ME (2017) Future climate projections allow engineering planning. *Proceedings of the Institution of Civil Engineers – Forensic Engineering* **170(2)**: 54–57, <http://dx.doi.org/10.1680/jfoen.17.00002>.
- Aje A and Khattab A (2017) A review of approaches to assessing scour current velocity around existing structures. *Proceedings of the Institution of Civil Engineers – Forensic Engineering* **170(2)**: 84–99, <http://dx.doi.org/10.1680/jfoen.16.00035>.
- Engineering Council (1994) *Guidelines on Environmental Issues*. Engineering Council, London, UK.
- Garsaball EC and Markov H (2017) Climate change: are building codes keeping up? A case study on hurricanes in the Caribbean. *Proceedings of the Institution of Civil Engineers – Forensic Engineering* **170(2)**: 67–71, <http://dx.doi.org/10.1680/jfoen.16.00034>.
- HMG (Her Majesty's Government) (2017) *UK Climate Change Risk Assessment 2017*. The Stationery Office, London, UK.
- Kemp R (2017) Electrical system resilience: a forensic analysis of the blackout in Lancaster, UK. *Proceedings of the Institution of Civil Engineers – Forensic Engineering* **170(2)**: 100–109, <http://dx.doi.org/10.1680/jfoen.16.00030>.
- Kermode T (2017) ICE recognises the role of civil engineers in adapting to climate change. *Proceedings of the Institution of Civil Engineers – Forensic Engineering* **170(1)**: 3–5, <http://dx.doi.org/10.1680/jfoen.16.00036>.
- Parry J (2017) Should engineers be allowing for a potential 4°C rise by 2040 and how? *Proceedings of the Institution of Civil Engineers – Forensic Engineering* **170(2)**: 61–66, <http://dx.doi.org/10.1680/jfoen.17.00016>.
- Tardio G, Mickovski SB, Stokes A and Devkota S (2017) Bamboo structures as a resilient erosion control measure. *Proceedings of the Institution of Civil Engineers – Forensic Engineering* **170(2)**: 72–83, <http://dx.doi.org/10.1680/jfoen.16.00033>.
- Thorne P (2017) Global surface temperature records: an update. *Proceedings of the Institution of Civil Engineers – Forensic Engineering* **170(2)**: 50–53, <http://dx.doi.org/10.1680/jfoen.17.00001>.
- Thorniley-Walker R (2015a) Editorial. *Proceedings of the Institution of Civil Engineers – Forensic Engineering* **168(2)**: 46–48 <http://dx.doi.org/10.1680/feng.2015.168.2.46>.
- Thorniley-Walker R (2015b) Discussions with scientific experts on defining the risks from climate change. *Proceedings of the Institution of Civil Engineers – Forensic Engineering* **168(2)**: 65–67, <http://dx.doi.org/10.1680/feng.15.00006>.
- Thorniley-Walker R (2015c) 'Carbon footprint' and risk assessments. *Proceedings of the Institution of Civil Engineers – Forensic Engineering* **168(2)**: 89–95, <http://dx.doi.org/10.1680/feng.15.00005>.
- Thorniley-Walker R (2017) Updates on Arctic Ocean ice graphs for 2016/2017 indicate very short timescales. *Proceedings of the Institution of Civil Engineers – Forensic Engineering* **170(2)**: 58–60, <http://dx.doi.org/10.1680/jfoen.17.00014>.
- Tye MR (2015) Understanding the risks from extreme rainfall. *Proceedings of the Institution of Civil Engineers – Forensic Engineering* **168(2)**: 71–80, <http://dx.doi.org/10.1680/feng.14.00002>.