REVIEW

New technology in the spotlight at annual bridges conference

Problem-solving through collaboration and preparing for a future coloured by climate change and the digital space were some of the key themes addressed by speakers at the annual *Bd&e* conference Bridges 2018 in the UK in March.

Cam Middleton, professor of construction engineering at the University of Cambridge, focussed on research that is driving the digital agenda as regards bridge design, build, operation and maintenance.

The UK is leading the digital construction arena assisted by government-mandated adoption of level two BIM on government-funded projects. Substantial amounts of funding in the area of research and innovation for the construction sector have also been made available, he revealed. "This is a complete game-changer and we need to use that to push the digital agenda," urged Middleton. A new approach is necessary because little has changed and standard bridges are still being designed and constructed in a bespoke way, he claimed. The 'Lego-isation' of bridges is a 'no-brainer' for simpler structures, Middleton suggested, and will free up engineers to address complex or large structures as well as their assessment

The digital concept should not, however, be regarded as a BIM model of components; it is an automated process where design is interlinked with libraries of construction components. The design model feeds directly to the manufacturer with all the details necessary to build the elements.

Research is also focussing on how the digital concept can be applied to progress monitoring and workforce productivity. Middleton illustrated the idea with an image showing the construction of the James Dyson Building in Cambridge overlaid with a BIM model. In future, software will match individual BIM elements with their real-life counterparts and assess construction progress automatically: "So the net outcome is I can walk round with these goggles and find green, [meaning] 'progress'; yellow, 'still working on it'; and red, 'we are behind schedule'."

The aim is that the research efforts will lead to so-called smart bridges fitted with sensors transmitting live data to their digital twins:

Right: David Collings presented on the effects of climate change on bridges

"In the long term we will end up, and need to end up, with a national bridge inventory with access to true performance data and ongoing behaviour of our structures," he concluded.

Also on the theme of the future, David Collings, technical director at Arcadis, explored how climate change would affect bridges and what steps might be necessary to increase their resilience. The current response to climate change revolves around reducing carbon dioxide emissions to limit temperature rise as well as ensuring that structures can withstand climate-related changes.

Even if CO_2 emissions are controlled, a rise in global temperatures and changes in weather patterns are predicted; existing infrastructure needs to be assessed to ensure it can accommodate a variable climate, he said. Given the 100-year or more life of bridges, it is particularly important that these are resilient, as they are likely to experience significant change over their useful lifetime.

"The UK Highways agency has said the UK could get three to seven degrees change, depending on where you are, and this temperature needs to be designed for. Generally it affects bearings and expansion joints," said Collings.

More frequent storms will bring increased precipitation intensity, and a consequent increase in river flows, flood risk and scour damage to bridges. "It is already being talked about and generally the advice is to design almost 30% above current river flows under our bridges," he added. Work currently being carried out at the University of Surrey indicates that the structures most at risk of climate change are the ones that are currently near to their limit, and it is these that will be pushed over their limits.

The melting of parts of the polar ice sheets is expected to raise sea levels between 250mm and 1.2m by the end of the century; while this doesn't affect most bridges, it will have some impact on structures over tidal waters such as in London. "The current proposal is for the flood walls to be raised by at least 1m in the near future. If you are putting a bridge above that, it can be an issue," said Collings. For example, a planned bridge across the River Thames between Rotherhithe and Canary Wharf, would have to take into account future sea level rises when considering navigation headroom for river traffic. "At high tide the headroom at Tower Bridge is only 8m, and there are around 12,000 vessels that pass there every month: a change of 1m headroom actually means that quite a few cannot get through and the bridge will need to open more often," he explained.

Other factors to consider are an increase in the frequency of high wind events, which will lead to major bridges being closed to traffic more often, as well as the effect of a higher rate of corrosion of steelwork and carbonation of concrete due to increased CO_2 levels. "But local factors come in. In cities where there is more pollution due to traffic, the effect of global warming will not be so great. It is bridges in rural areas that will be more affected, and where we will have to take into account the same factors as in industrial areas," said Collings.

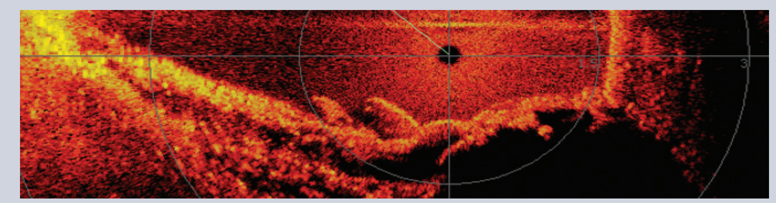
Industry should use quantitative estimates of the carbon footprint to reduce CO_2 emissions for new projects, he suggested, particularly where energy-intensive materials are transported significant distances. "And if we design to a code we must know that there needs to be some thought to these changes and to the fact that those [structures] most at risk of climate change are those currently near their limits when we assess them."

The issue of climate change is a very real one for bridge owners, as was highlighted by Cumbria County Council bridges & structures manager Martin Hardman, and Jenny Roberts, senior project manager at Gaist Solutions. They presented the results of a trial of Bridgecat, a new system for inspecting bridges during floods, which is intended to enable owners to make better-informed decisions about whether or not they need to be closed. The initiative came about as a direct result of Storm Desmond in December 2015, which not only broke national rainfall records but also resulted in the collapse of a number of structures including Bell Bridge and Pooley Bridge.

Gaist was approached in early 2017 and within six months the project went from paper to working prototype.

Bridgecat consists of a Unimog vehicle with a mounted crane fitted with a pan/tilt bracket, an underwater camera, an imaging sonar and an altimeter. The equipment has been trialled at seven bridge locations in Cumbria, said Roberts, and one of the main benefits of the system is the high reach and flexibility of the crane. It can be positioned on the structure for routine bridge inspections but it can also work from the riverbank when there is a flood and it is not safe to go on the bridge. "We can actually be quite a distance from the bridge and still carry out an inspection to make ▶

Bridgecat in action (above) and sonar image (below) showing cross-section between river bank and bridge abutment



▶ sure there is no significant scour," said Roberts.

Sonar images were compared with dive reports of the same structures to ensure that key points of interest had been captured. "If we've identified features with sonar that we are not sure of, we can get closer with the camera and see what is there," she explained.

Over the coming months, this technology will be used to gather a bank of evidential data that can be added to on future visits. "We will validate whether Bridgecat is good enough for principal inspections and, of course for flood response, when we'll take it to a site and test it," said Roberts.

Meanwhile at the other end of the scale, Rendel director of bridges and structures, Sam Khan, outlined some of the challenges posed by value engineering of the construction of the 270m-long cable stayed section of the 4.3km-long Sydney Metro Northwest viaduct in Australia The cable-stayed bridge is a precast glued segmental, three-span post-tensioned structure with steel-concrete composite towers. The cable-stayed section is on a curve with a single plane of cables down the centre of the deck.

Two identical overhead gantries were used for the project, each 150m long and 1,000t in weight; one for the viaduct section and another for the cable-stayed structure.

The gantries had previously been deployed on a viaduct project in the Middle East but had never been used for a cable-stayed bridge, recalled Khan. Although the contractor had been confident that the gantry had the capacity to construct the cable-stayed spans involved, once it was on its way to Australia, doubts set in. "We talked about it a lot and it seemed like a desperate situation," remembered Khan.

The initial suggestion had been that the gantry would work on a span-by-span basis, where all the precast segments would be erected below the gantry, and then be post-tensioned together. However, in this case the spans were so large and heavy that even with the temporary supports they could not all hang at the same time.

The solution arrived at was a combination of balanced cantilever and span-by-span construction methods, plus temporary supports. A certain number of segments were constructed using balanced cantilever on each side of the piers; after post-tensioning they became self-supporting and no longer needed the gantry. The next span would then be done in the same way, and then the central segments added in the conventional way, using the span-by-span method.

Khan emphasised that the success of any civil engineering project relied on collaboration and that the only winner in the end had to be the project.

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