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Editorial

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Editorial

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In accordance with current standards, UK bridges are designed to have a working life of 120 years (BSI, 2005). Owing to their replacement costs in terms of economic, environmental and societal impacts, it is likely that much of the existing bridge stock will need to survive for longer periods of time than this. There are many examples of considerably older bridges, both within the UK and from around the world. One example is the nearly-two-millennia-old Pont du Gard aqueduct that crosses the River Gardon near Nîmes, France. Although historians believe that the bridge ceased functioning as an aqueduct in the sixth century, it continued to be used as a toll bridge until the eighteenth/nineteenth century, when its increasing importance as a tourist attraction was recognised. A key reason that the Pont du Gard still survives is that it has been, sometimes erratically, maintained throughout its existence. This means that while individual components of the bridge have been repaired or replaced over the centuries, the bridge itself continues to fulfil its primary role – a transportation link across the River Gardon.

Pearson and Patel (2002) noted that there was a long-held belief among the designers and owners of reinforced-concrete bridges that their assets would require little or no maintenance during their 120 year working lives. It is now recognised that this notion was optimistic, and that maintenance is essential for ensuring that all types of structures, including bridges, achieve their full lifespans. Despite this knowledge, there are occurrences of major incidents resulting from the deterioration of the structure related to inspection/maintenance. One example was the bridge collapse near Stewarton (Ayrshire, UK) in 2009. This accident was caused by long-term corrosion to the main girders, which could not be readily accessed for inspection or maintenance (RAIB, 2010).

This special issue on bridge maintenance, which will be continued in a 2020 issue of *Bridge Engineering* with more papers, provides a range of views and case studies in this vital area. In his foreword, Richard Fish (2019) frames this area further, identifying some of the contemporary challenges that exist.

We recommend reading the foreword carefully, reflecting on its challenges and considering how they could affect your work with bridges.

There are many different types of maintenance activities carried out on bridges and the papers in this themed issue of the journal reflect that. The first paper from Colford *et al.* (2019) considers the different perspectives that are held by UK and US bridge designers regarding the inspection and maintenance of their bridges. Since the introduction of the Construction (Design and Management) Regulations 1994 (HMG, 1994), UK designers have held defined responsibilities for managing the whole-life risks associated with their designs, including those associated with its in-service performance. There are, however, no equivalent duties for their American counterparts. The paper covers issues such as how we define the lifespan of bridges, the durability of different forms of bridge construction, how access for inspections and maintenance can be integrated into the designs of future bridges, and how new technologies may change these activities in the future.

Based on the papers in this issue, a common maintenance activity for bridges involves preventing or repairing environmental damage. For example, chlorides in de-icing salt can accelerate corrosion of steel embedded in concrete bridges. In their paper, Christodoulou *et al.* (2019) describe how they managed this problem for two strategically important motorway bridges in Auckland, New Zealand. The bridges are both prestressed concrete structures located in marine environments. The solution involved the installation of a hybrid corrosion protection system. It was the first time that this technology had been used in New Zealand and it is thought that it may be the first time that it has been installed on a prestressed concrete bridge in tidal waters.

Simpkins and Cole (2019) also report on repairs to a prestressed concrete bridge. The Northam River Bridge in Southampton, UK, was the first major prestressed concrete bridge in the UK. The bridge was repaired and refurbished

after corrosion due to water seepage was found in the post-tensioning elements. As they could not be accessed beforehand, a further inspection of the post-tensioned elements was carried out during the works. This identified additional problems with the transverse tensioning, which resulted in an extension to the original works.

Steel bridges also require regular maintenance to prevent their deterioration. A relatively common remedy for this involves (re)applying a protective overcoat of paint to the steelwork. In their paper, El Sarraf and Barker (2019) report on the development of a coating management plan for the Auckland Harbour Bridge, New Zealand. The plan considered two alternative approaches and their work included the development of whole-life costings. The final decision between the two methods was based on which method would provide the required amount of protection to the steelwork at the lowest cost. Based on their findings, El Sarraf and Barker predict that the preferred solution could save NZ\$12 million over 40 years.

A number of the other papers in this issue also describe the use of future costing models to aid the decision-making process. In their paper, O'Connor *et al.* (2019) explain how costings were included in the development of an asset management plan for five reinforced-concrete bridges in Aberdeenshire, Scotland. At the start of the work, a comprehensive programme of assessment was undertaken to determine the current conditions of the bridges. These data were then used to build deterioration models that predicted the timings of significant events, such as the need to place weight restrictions on the bridges, together with the optimal intervention times to prevent the occurrence of the event.

The paper by Baron *et al.* (2019) also includes details about how financial planning models are an integral part of a long-term asset management plan for the Tamar Bridge in Plymouth, UK. The paper describes four major programmes of maintenance that have been carried out on the bridge over the last decade. Although the activities are typical of those required for a nearly-60-year-old suspension bridge, the ethos behind the running of the bridge is, perhaps, atypical. The Tamar Bridge is one of only nine toll bridges on a motorway or major road in the UK (RAC, 2019). The bridge is run through a joint committee, who decided to adopt a proactive approach to maintenance that involved keeping the bridge in a good state of repair. This process includes the use of a programme of planned replacement instead of reacting to problems as they are discovered. The committee anticipates that this approach will minimise future cost increases.

At the start of their paper on the Tamar Bridge, Baron *et al.* (2019) note that the bridge underwent a major refurbishment nearly two decades ago, which included strengthening works.

This is a further type of maintenance that is semi-regularly carried out on UK bridges so that they remain fit for purpose. Over the last three decades, a number of UK bridges have required this work as the maximum allowable normal loading on UK roads increased from 32.5 t before 1982 to 44 t in 2001 (Butcher, 2009).

The next contribution by Grubb *et al.* (2019) describes a scheme to strengthen and refurbish the Old Tweed Bridge; a three-span masonry arch bridge in Peebles, Scotland. A previous survey had identified several issues with the main structure of the bridge, which resulted in it being closed to the public and temporarily propped. The works on site included the installation of concrete saddles over the arches and an innovative method for reattaching voussoirs to the arch barrels. In addition to the technical challenges of the project, the team also had to pay special consideration to the impact of the works on the local wildlife. These included measures to relocate bats to new sites and placing restrictions on working practices and levels of pollution so that salmon in the River Tweed were unharmed.

In the final paper of this issue, De'Ath and Heap (2019) write about the reconstruction of a steel railway bridge over the River Witham in Lincoln, UK. Although it had not previously been identified as such, Network Rail found that the bridge was in a poor condition when they took over its ownership from Railtrack in 2002. After a new assessment, the bridge was assessed as having inadequate capacity for current rail traffic. As a result, an immediate speed restriction was imposed on the bridge while Network Rail investigated how to repair the Grade II-listed bridge. The reconstruction work took place in 2017 and, where possible, any structurally-sound elements of the original bridge were incorporated into the new structure.

We hope that the readership finds these first eight papers of the themed issue on bridge maintenance as interesting and informative as we did. Please do let us know what you think and if you have particular thoughts on a paper worthy of wider discussion, do submit them as a discussion piece for possible future publication in the journal. We would like to take this opportunity to thank all of the authors and reviewers of the papers for all of their efforts, as without them it would not have been possible to produce this issue of the journal. We would also like to express our gratitude to Richard Fish for writing the foreword to this issue.

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