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Editorial

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Editorial

Jerry Shen MSc, PhD

Senior Bridge Engineer - Seismic Specialist, Federal Highway
Administration, Washington, DC, USA

Masato Abé MSc, PhD

Director, Department of Research and Development, BMC Corporation,
Chiba, Japan

Bridges form vital links in transportation networks and represent the quintessence of structural engineering with a large variety in size, structural type and materials, subject to severe environmental and loading conditions. Experience and knowledge accumulated through failures and forensic investigations have driven advances in bridge engineering. For example, the Tay Bridge disaster of 1879 and the Tacoma Narrows Bridge collapse of 1940 triggered advancement of wind engineering and led to development of more aerodynamically stable long-span bridges. The sudden collapse of Silver Bridge in Point Pleasant, WV, USA in 1967 due to stress corrosion and corrosion fatigue (NTSB, 1970) motivated the establishment of the National Bridge Inspection Program in the USA. Lateral vibration observed at the Millennium Bridge in London in 2000 highlighted the importance of the resonance effect caused by pedestrians.

A variety of loadings and environmental effects potentially accelerate deterioration and may cause severe damage. Application of countermeasures is subject to significant constraint from the requirements of minimising service disruption. Detailed scientific forensic analysis is critical to identify causes and make rational and optimal decisions to immediately address the safety and functional needs. On the other hand, the aggregated knowledge from a collection of deterioration cases can offer valuable information in improving design and construction techniques that promote durability of bridge elements and long-term performance of bridge systems.

Bridge failure may result from internal causes, which may be further subdivided into inadequate design, construction, materials and maintenance. Bridge failure may also result from external causes, such as scour, flood, earthquake, fire, collision, wind, overload, settlement and environmental degradation of members (Lee *et al.*, 2013). Bridges are predominantly owned by government agencies, toll authorities or railroad network operation companies (ownership model varies by country/region). Each bridge does not function alone. They have unique roles that support the performance of the transportation network. Bridge owners have a strong desire to use a consistent forensic study approach and maintain complete records of the entire bridge population. In the USA, major bridge accidents are investigated by the National Transportation Safety Board (NTSB). Records of these investigations are maintained by NTSB. Specialised organisations often contribute to the effort of investigating bridge damage caused by natural disasters. For example, the Multidisciplinary Center for Earthquake Engineering Research (MCEER) has organised detailed investigation of bridge damages from earthquakes and hurricanes in the past three

decades. Because of the organisational approach, bridge failure investigations often lead to profound changes in practice as shown in some of the examples mentioned above.

Because of the high stakes in terms of the effect on public safety, economic growth and community development, bridge forensic investigations often employ all the techniques that can offer help, which include but are not limited to field investigation, large-scale experimental testing, refined numerical analysis/simulation, non-destructive evaluation, long-term monitoring and remote sensing. Proper usage of each method and careful interpretation of the results need to be supported by expertise in each specialised field. With a relatively small number of papers, this themed issue intends to showcase a few different combinations of bridge forensic techniques.

In the first paper in this themed issue on bridges, Nagatani and Tajiri (2019) introduce detailed study and repair of damage of slabs of continuous prestressed girders. Forensic study on slabs revealed serious corrosion and a high level of salinity, which would eventually cause rupture of prestressed cables in the slabs of the negative bending zone around intermediate piers. Slabs around the intermediate piers were replaced and outer cables were added to change the load-bearing system and eliminate this risk.

Chun *et al.* (2019) studied the buckling of steel pile bent piers. Density measurement of the remaining thickness of cross-section of steel piers using a new ultrasensitive magnetic non-destructive device revealed detailed distribution of thickness, indicating fluid, sediment and structure interaction, which reveals the abrasive characteristics of sediment-laden stream flow and the locations on the bridge substructure that are most vulnerable to the abrasion. This reliable measurement also eliminated unnecessary repair for piers with minor damage.

Long-term monitoring of a damaged prestressed concrete bridge is reported in the third paper, by Nishio and Abé (2019). Severe damage was observed at a prestressed concrete bridge, and emergency repair was conducted. Nevertheless, future replacement is planned because of the severity of damage, and a monitoring system was introduced to ensure safety of service until replacement. A risk-management strategy using monitoring as well as statistical analyses are reported.

Flood and scour are among the most common external causes of bridge failure. The development of rational scour equations that predict scour depth with greater confidence is in great demand.

Kerenyi and Flora (2019) devised an experimental study and used three-dimensional computational fluid dynamics (CFD) to investigate the formation process of the scour observed at a bridge. This is a rare opportunity where both forensic data and laboratory experiment offer high-resolution measurements that can be used to validate the CFD simulation. The CFD simulation allows the development of the decay function, which is a significant step forward that makes scour evaluation better reflect the specific site conditions and the stream bed material properties. It also enables scour evaluation for both granular and cohesive bed materials.

The panel of *Proceedings of the Institution of Civil Engineers – Forensic Engineering* is planning on publishing a themed issue on the role of water in structural failure. The scour at bridges is expected to be a significant topic in the discussion (see https://www.icevirtuallibrary.com/pb-assets/Call%20for%20Papers/FOEN_The_role_of_water_in_structural_failure_cfp_ext-1564479228093.pdf).

A wide variety of both risk and methodology for management are reported, reflecting the variety of phenomena associated with bridges. Demand for forensic studies is increasing, because the stock of bridges ages and matures and the risks due to natural/man-made disasters are increasing. The papers included in this themed issue present samples of several types of forensic study on bridge damages. Nagatani and Tajiri (2019) show a severe deterioration from extreme chemical environment. Chun *et al.* (2019) give an example of collapse due to a loss of capacity from physical abrasion and the use of a non-destructive approach in identifying the cause. Nishio and Abé (2019) demonstrate

the special need of monitoring in addition to the one-time forensic study in some cases. Kerenyi and Flora (2019) introduce modern technology that helps in finding solutions for problems previously difficult or impossible to solve. While still limited in coverage, we hope this themed issue contributes to the field of bridge forensic engineering by stimulating more innovative ideas that promote further advancement in the subject area.

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