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GUEST EDITORIAL

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Life-cycle, reliability and sustainability of civil infrastructure

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The International Association for Life-Cycle Civil Engineering (IALCCE) was founded in 2006 to create a fertile ground for promoting the study, research, and applications in the design, assessment, prediction, and optimal management of life-cycle performance, safety, reliability and risk of civil structures and infrastructure systems (http://www.ialcce.org). To accomplish this mission and following a series of International Workshops on Life-Cycle Cost Analysis and Design of Civil Infrastructure Systems held in Honolulu, Hawaii (LCC1, 2000), Ube, Yamaguchi (LCC2, 2001), Lausanne (LCC3, 2003), Cocoa Beach, Florida (LCC4, 2005), and Seoul (LCC5, 2006), it was decided to bring together the main advances on life-cycle civil engineering and related topics at the First International Symposium on Life-Cycle Civil Engineering (IALCCE'08) held in Varenna, Lake Como, 10–14 June, 2008 (http://www.ialcce08.org), and afterwards at the Second International Symposium on Life-Cycle Civil Engineering (IALCCE 2010) held in Taipei, 27–31 October, 2010 (http://www.ialcce2010.ntust.edu.tw), the Third International Symposium on Life-Cycle Civil Engineering (IALCCE 2012) held at the Hofburg Palace in Vienna, 3–6 October, 2012 (https://ialcce2012.boku.ac.at/index.htm) the Fourth International Symposium on Life-Cycle Civil Engineering (IALCCE 2014) held in Tokyo, 16–19 November, 2014 (http://www.ialcce2014.org), the Fifth International Symposium on Life-Cycle Civil Engineering (IALCCE 2016) held in Delft, 16–19 October, 2016 (http://www.ialcce2016.org), the Sixth International Symposium on Life-Cycle Civil Engineering (IALCCE 2018) held in Ghent, 28-31 October, 2018 (http://www.ialcce2018.org), and the Seventh International Symposium on Life-Cycle Civil Engineering (IALCCE 2020) held in Shanghai, 27-30 October, 2020 (http://www.ialcce2020.org).

IALCCE 2020 has been organized on behalf of the IALCCE under the auspices of Tongji University. The interest of the international civil engineering community in areas covered by the IALCCE has been confirmed by the significant response to the IALCCE 2020 call for papers. Overall, more than 400 abstracts from many countries were received by the Symposium Secretariat, and approximately 60% of them were selected for publication. Contributions presented at IALCCE 2020 included state-of-the-art as well as emerging applications related to key aspects of life-cycle civil engineering. The extended versions of selected papers presented at IALCCE 2020 and invited contributions are included in this special issue of *Structure and Infrastructure Engineering*.

The main aim of the article by *Sarkisian* is to present the impact of Jin Mao Tower in China on life-cycle civil engineering of tall buildings. The World Green Building Council has put forth a challenge that all buildings shall be designed for net zero operational carbon by 2030 and net zero embodied carbon by 2050. This challenge is even more pronounced for tall buildings. The construction of the Jin Mao Tower 20 years ago was unique for several reasons, and ideas have resulted in progress towards these goals.

To perform in-service assessment of reinforced concrete transportation infrastructure *Wang and Maekawa* propose a multi-scale simulation, which has been improved with an integrated hygro-thermal-chemo-electrical-mechanistic approach. Various durability issues are successfully evaluated in conjunction with the long-term performance evaluation influenced by the drying shrinkage. Furthermore, the multi-scale integrated approach is coupled with neural networks and data assimilation techniques.

Sanchez-Silva and Calderon-Guevara discuss key elements of the decision-making process and assess the value of incorporating flexibility in the design and management of large-scale infrastructure. The emphasis is given on the nature of flexibility, the complexities of integrating it within a project, and the gains of adopting this approach for both stakeholders and users. The proposed approach for incorporating flexibility in infrastructure design and management is illustrated with the case study of an airport design and expansion.

In recent years, the interest in the effect of the spatial variability associated with steel corrosion on the safety and reliability of reinforced concrete structures in harsh environments has increased. In order to reduce the epistemic uncertainty associated with structural performance assessment, *Srivaranun, Akiyama, Masuda, Frangopol and Maruyama* developed an efficient random field-based reliability updating framework for existing reinforced concrete structures by incorporating the effect of spatial steel corrosion distribution.

Offshore wind structures are exposed to the cyclic action of wind and waves, thus, they are subject to fatigue deterioration processes throughout their operational life. *Hlaing, Morato, Nielsen, Amirafshari, Kolios and Rigo* presented a detailed study on inspection and maintenance planning of offshore wind structural components. For this purpose, fatigue failure criteria with Bayesian networks and Markov decision processes have been integrated.

The paper by *Xin, Akiyama, Frangopol and Zhang* describes the development of a multi-objective maintenance optimization formulation, which is applied for in-service asphalt pavement considering system reliability estimated via long short-term memory neural networks. Tri-objective optimization processes are investigated by maximizing user benefits (i.e., improved system reliability) and agency benefits (i.e., extended service life), while minimizing the associated life-cycle cost (LCC) (i.e., user and agency costs) via multi-objective genetic algorithms.

Wang, Zhang, Wu, Li and Wang focus on fatigue damage evaluation of steel bridges considering thermal effect. Two fatigue evaluation methods are proposed considering the coupling effects of traffic load and thermal load based either on vehicular and thermal fatigue load models, or on measurements of thermal and traffic loads. The proposed methodologies have been successfully tested by conducting monitoring and analysis for an in-service steel bridge.

The corrosion of reinforcements induces the concrete cracks and the reduction of structural capacity. The complex durability deterioration at the material scale is commonly oversimplified in the structural analysis, and the influence of reinforcement corrosion distribution is not realisticaly evaluated. The work of *Li, Ruan, Zhang and Dou* aims at determining an efficient method for the probabilistic life-cycle evaluation of reinforced concrete structures under chloride ingress, by considering mesoscopic material uncertainty.

In order to improve the safety management at large-scale construction sites, the paper by *Yang, Zhang, Zhang, Wang, Dong and Fang* establishes a specialized fall hazard management system. More specifically, automatic detection of falling hazard from surveillance videos is enabled, utilizing advanced computer vision and building information modeling computational tools. In this manner, an efficient bi-directional coordination can be achieved between the digital and the physical levels, providing a basis for "smart" and safe construction sites.

The objective of the paper by *He, Castoro, Aloisio, Zhang, Marano, Gregori, Deng and Briseghella* is the development of an efficient methodology for the dynamic assessment, numerical modelling and parametric updating of a special type of pedestrian bridge. The elaborate finite element model that has been developed can serve as a baseline for long-term monitoring of a bridge during its life-cycle, and also provides recommendations to practitioners and researchers for the modelling and analysis of this particular type of footbridges.

The fatigue crack at a rib-to-deck joint that is initiated at the weld root and propagated through the deck plate is one of the most common and unfavorable crack type on orthotropic steel decks. The contribution by *Xiang, Wang, Wang, Chen and Ma* deals with a realistic numerical simulation of root-deck crack propagation of an orthotropic steel bridge deck, based on linear elastic fracture mechanics. Important factors that may affect the crack propagation are analyzed, including the lack of penetration defects, initial crack depth, crack aspect ratio and crack angle.

The guest editors wish to thank the authors and the reviewers for contributing to this special issue and hope that this collection of papers will represent a useful reference for researchers, students, and practitioners to promote and advance research and applications in the field of life-cycle civil engineering.