Engineering 5 (2019) 197–198

Contents lists available at ScienceDirect

Engineering

journal homepage: www.elsevier.com/locate/eng

Topic Insights

Sustainable High-Performance Resilient Structures

Hong Hao [a], Jun Li [b]

[a] ARC Laureate Fellow, John Curtin Distinguished Professor, School of Civil and Mechanical Engineering, Curtin University, WA 6102, Australia
[b] Senior Lecturer, School of Civil and Mechanical Engineering, Curtin University, WA 6102, Australia

Natural and human-made disasters such as earthquakes, tsunamis, typhoons, floods, blasts, and impacts have resulted in more than 1.1 million deaths, affected the lives of more than 2 billion people, and caused an estimated 1.5 trillion USD in damage worldwide between 2003 and 2013. The 2008 Wenchuan earthquake killed 69226 people and left 17923 unaccounted for, it caused a direct loss of 140 billion USD. The 9/11 terrorist attack on the World Trade Center killed 2996 people and resulted in an estimated loss of 135 billion USD. The accidental explosion in Tianjin in 2015 killed 173 people and caused a great economic loss. The Tohoku earthquake and tsunami in 2011 killed nearly 20 000 people and caused an economic loss of 300 billion USD. It also initiated the accident at the Fukushima Daiichi Nuclear Power Plant, which was the most catastrophic nuclear event since the 1986 Chernobyl disaster; this event resulted in the leakage of radioactive materials from containment vessels into the ocean, causing severe environmental contamination. These modern examples demonstrate that the development of sustainable high-performance resilient structures against extreme dynamic loads is imperative for the protection of life and economy. Similarly, the increasing number of extreme weather events, heat waves, and high wind speed events due to climate change imposes new demands on effective and economic engineering adaptations of infrastructure design, construction, and maintenance, and encourages the exploration of green construction technologies to minimize carbon dioxide (CO_2) emissions.

To address these challenges, the structural engineering community is making continual advances in technology, with the development of new materials and new structural forms for the construction of sustainable high-performance resilient structures. These efforts include: the development of green materials such as geopolymers and limestone-calcined-clay cement (LC3), which make use of sustainable materials and industrial wastes in construction to reduce greenhouse gas emission; new structural forms and designs to control structural vibrations and mitigate loading effects for effective structural protection against multi-dynamic loads; new prefabrication technologies using three-dimensional (3D) printing and modular and segmental construction to minimize construction-site disruption and provide better construction quality control; and new design and construction concepts such as metaconcrete, metastructures, origami and kirigami structures, deployable structures, and sacrificial structures to improve the resilience of structures and their capacity to resist extreme loads.

Furthermore, advanced techniques are being explored to provide quantitative data for effective structural condition monitoring for engineering asset management. These techniques include the use of cameras and computer-vision techniques to collect data, bio-inspired methods such as deep learning techniques for effective processing of large volumes of data, and new signal-processing techniques and damage indices to improve the capability to detect minor structural damage from uncertain and noisy data.

This issue presents reviews and discussions on various aspects of sustainable high-performance resilient structures, including new construction materials, new structural forms and analysis methods, and new structural health monitoring techniques.

Ueda discusses various materials and their mechanical properties for strengthening concrete structures to enhance structural capacity. Li considers the characteristics of high-performance and multifunctional cement-based composite materials for the construction of durable, resilient, and sustainable structures with self-healing, self-sensing, self-thermal adapting, self-cleaning, and air-purification abilities. Rezakhani et al. present the theory and numerical implementation of the multiscale homogenization analysis of the alkali-silica-reaction (ASR) effect in concrete. This developed multiscale framework can accurately reproduce the expansion curves obtained from experiments and full fine-scale analysis.

Takagi and Wada discuss and propose a new structural design that separates the primary structure from a seismic structure for structure protection. The seismic structure is designed to carry earthquake loads with passive control, base isolation, and replaceable components to absorb seismic energy. Gardner et al. present a steel design method based on advanced analysis to simulate local buckling in beam elements. The proposed method is shown to be more accurate than the current Eurocode 3 design approach. Lam et al. report on their testing of full-scale composite floor plates to investigate the flexural behavior and in-plane effect of the floor slab in a grillage of composite beams designed to reduce the longitudinal splitting of the concrete slab and increase the load capacity of the structural system. Zhou and Zhang present their thoughts on the development of bridge technology in China, including construction efficiency, management effectiveness, and

https://doi.org/10.1016/j.eng.2019.02.001
2095-8099/

long-term service. Challenges in the development of new materials, design and analysis software, construction technology, and monitoring techniques are discussed.

Fujino et al. share experiences in monitoring bridge and building structures in Japan, with an emphasis on types and strategies of monitoring systems, and effective utilization of monitored data. Spencer et al. present advances in computer-vision-based civil infrastructure inspection monitoring techniques, in conjunction with acquisition through remote cameras and unmanned aerial vehicles (UAVs). Rapid advances in research on computer-vision-based inspection and monitoring of civil infrastructure will change how infrastructure is monitored, leading to safer and more resilient structures. Bao et al. present a review on the development and application of recent techniques in data science and engineering for structural health monitoring. Compressive sampling-based data acquisition algorithms, an anomaly data diagnosis approach using deep learning algorithms, crack identification using computer-vision techniques, and the condition assessment of bridges using machine learning algorithms are presented in this paper.

In summary, this issue presents and reviews recent advances in new construction materials, structural forms, and design and analysis methods for the construction of sustainable high-performance structures, along with experiences with and new techniques for effective structural condition monitoring.