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Editorial

Emerging Construction Materials and Sustainable Infrastructure

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As well reported, ordinary Portland cement (OPC) production causes between 0.8 and 1 tons of carbon dioxide (CO_2) emission for every ton of cement produced which corresponds to 5%–10% global CO_2 emissions [1]. However, reinforced concrete is still the most common material used in the construction of roads, bridges, buildings and other infrastructures. The demand for this material is expected to increase in the future due to the rise of infrastructure needs in developing and industrial countries. In addition, ageing and deterioration of reinforced concrete infrastructure due to degradation of materials, harsh environmental conditions, seismic excitations, overloading, inadequate maintenance and lack of frequent inspections are worldwide problems that pose serious risks to structural and life safety [2]. Most of this deterioration is the result of corrosion of the steel in steel structures [3–5] or the steel reinforcing bars (rebars) embedded in the concrete structures [6–8]. Due to the repair and rehabilitation of deteriorated reinforced concrete infrastructure and the sustainability issues owing to the extremely resources- and energy-intensive process of producing steel and cement materials, researchers and engineers have sought some alternative construction materials [9,10].

To answer the challenge of deterioration of those aging concrete structures and the demand for low carbon-footprint and durable infrastructure, the study of sustainable construction is developed by academics and engineers standing on a basis of emerging low-energy construction materials together with structural design optimisation [11]. Nowadays, innovative "green" construction materials can be designed or tailored to different requirements by controlling their microstructure, and have been proposed as alternatives for the substitution of the conventional construction materials [12,13]. In addition, smart materials, such as PZT (Lead Zirconate Titanate), are increasingly integrated with structures [14,15] to form intelligent structures that possess structural health monitoring and damage detection capacities [16–19]. Therefore, infrastructural behaviours can be improved by using those materials and the related design and construction solutions in terms of durability and safety. These emerging construction materials are extending the frontiers of design and construction of highly sustainable infrastructure, and allow significant enhancement in response to environmental impact. However, the properties of those construction materials and the behaviours of structures constructed with the related materials, such as durability, time-dependent behaviour and mechanical properties, have not been fully explored. Those properties should be well-understood in practical construction application.

This issue focuses on the latest development in "Emerging Construction Materials and Sustainable Infrastructure". In the study of properties of sustainable construction materials, "green" concrete materials [20–23], composite materials [24,25], recycled materials [26–28], soil/rock materials [29,30] and other novel environmentally friendly construction materials [31,32] are reported in this issue. The investigations of the behaviours of structures constructed with different materials include demolished concrete structures [33,34], high-performance concrete structures [35], steel structures [36,37], steel–concrete composite structures [38,39] and fiber-reinforced polymer (FRP)-concrete hybrid structures [40–43]. In addition, seismic behaviour and the interaction behaviour between superstructure and substructure are discussed in two papers [44,45]. In this special issue, four papers investigate the behaviours of novel prefabricated structures using experimental and numerical approaches [46–49]. On the other hand, several innovative structural forms are invented and the behaviours of those structures are presented and discussed in four other papers [50–53]. Two structural strengthening techniques using composite and shape memory alloy materials for the reinforced concrete structures are proposed and studied [54,55].

Though tremendous progress has been achieved in developing new construction materials and sustainable structures, many challenges remain. With the use of new reinforcing materials, such as various FRPs [56–59], the bonding behaviour between the new reinforcing materials and the traditional material, such as cement, should be better understood analytically and numerically with experimental verifications. As a form of sustainable structure, prefabricated structures that can be quick assembled and also dissembled for re-use have found increasing applications. Often the joints that enable the assembling of these prefabricated structures experience stress concentration and effective methods of monitoring of these joints, including bolted joints [60,61], welded joints [62,63], and epoxied joints [64], should be developed.

In summary, the development and application of emerging construction materials, including recycled materials, together with innovative structures and structural design optimization, results in lower energy and durable products in civil infrastructure [65–68]. The need for this field is significantly high and the related innovative research will be a foundation of sustainable construction in infrastructure.

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