sustainability

Editorial

The Sustainable Composite Materials in Civil and Architectural Engineering

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Citation: Li, Y.-F.; Chen, W.; Cheng, T.-W. The Sustainable Composite Materials in Civil and Architectural Engineering. *Sustainability* **2022**, *14*, 2134. https://doi.org/10.3390/su14042134

Received: 7 February 2022
Accepted: 10 February 2022
Published: 13 February 2022

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Sustainability is a central value in the United Nations' 17 sustainable development goals (SDGs), which include no poverty, zero hunger, good health and well-being, quality education, gender equality, clean water and sanitation, affordable and clean energy, decent work and economic growth, industry innovation and infrastructure, reduced inequalities, sustainable cities and communities, responsible consumption and production, climate action, life below water, and life on land. The use of sustainable composite materials in civil and architectural engineering, which is the theme of this Special Issue, is particularly related to SDG #9 (building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation) and SDG #11 (making cities and human settlements inclusive, safe, resilient, and sustainable). We believe that, of all feasible solutions, the use of sustainable composite materials is critical to accomplishing these aims.

However, when the *Sustainability* journal approached us to launch this Special Issue, the world was facing an unknown infectious epidemic and quickly fell into a state of uncertainty as a result of the COVID-19 pandemic's rapid spread. Two years into the outbreak, there appears to be no end in sight. We cannot help but wonder what lies ahead. Everything has altered as a result of the unexpected pandemic, from how we keep ourselves safe to how we connect with others. It is difficult for people from all walks of life, not just academics. According to the United Nations, the epidemic has exacerbated poverty and weakened our ability to respond to long-term sustainability challenges. It is a sobering reminder that even in the face of a pandemic, we cannot abandon environmental protection. This is why the Special Issue "Sustainable Composite Materials in Civil and Architectural Engineering" was initiated. To act even in the midst of a disaster, we encourage researchers to continue their work during this trying period and invite them to submit new work on the experiment, analysis, inspection, and repair of a variety of infrastructures and engineering structures to us. Additionally, we purposefully broadened the scope. The composite material does not have to be of a certain type, such as fiber-reinforced plastic (FRP) and geopolymer, but may be composed of recycled and reused waste materials. Furthermore, the contribution may focus on any aspect of sustainable composite materials in civil and architectural engineering, such as carbon emissions, cost analysis, experimental verification, flame retardance, reinforcement, and energy consumption.

As a result, we received 18 submitted manuscripts that covered a broad range of subjects and were excellent pieces of work. However, only ten manuscripts were accepted following a rigorous peer-review procedure. Three of the manuscripts were published in 2020, six in 2021, and the final article was published in 2022. The following is an overview of these works.

Lee et al. [1] conducted a study on oxygen furnace slag, a significant waste by-product of steel manufacturing that can be used as a natural aggregate. To minimize undesirable expansion, the authors applied novel geopolymer technology to capture free CaO and

MgO and build a stable silicate composite. The laboratory- and plant-scale experiments showed that expansion might be controlled to less than 0.5 percent while increasing the compressive strength of the specimens.

Focusing on a different material and application, Cheng et al. [2] detailed the development of conductive films using silver (Ag) flake powder and a multiwall carbon nanotube (MWCNT) hybrid grid on a polytetrafluoroethylene (PTFE) film for applications that require both electromagnetic shielding (EMS) and a conductive film. The suggested conductive film exhibited superior electromagnetic shielding effectiveness (EMSE) and conductivity compared to materials containing varying quantities of MWCNT. Additionally, the film was more stretchable, with a 10% elongation at a 29% resistivity change rate.

In the context of recycling materials, Lin et al. [3] investigated and tested the usage of SiC sludge as a geopolymer material in place of metakaolin. The mass ratio of Na_2SiO_3 and NaOH solutions (NS/SS ratio) was experimented with, as well as the influence of SiC sludge content on metakaolin geopolymers. The results indicated that the geopolymer with the ideal SiC sludge replacement level and NS/SS ratio possessed a high heat evolution value, superior flexural strength, and high Q4 silicate deconvolution percentages, which is due to a synergistic effect, increasing both the reactivity and strength of metakaolin-based geopolymers. As a result, SiC sludge qualifies as a potentially useful ingredient in the production of geopolymers containing metakaolin.

The following article by Shen et al. [4] contributes to the conversation regarding an eco-friendly polyurethane hyperbranched hybrid made through the sol–gel process. The organic–inorganic hybrid material was created by introducing a non-halogenated, hyperbranched flame retardant containing nitrogen, phosphorus, and silicon to a polyurethane (PU) matrix. Using a variety of instruments, the study examined the organic and inorganic dispersity, morphology, and flame retardance mechanism of the hybrid material. The hybrid material not only had a high condensation density, but it also had outstanding organic–inorganic phase compatibility. Finally, the hybrid material passed the burning test and demonstrated outstanding flame-retardant properties.

Shen et al. [5] investigated two dispersion methods (planetary centrifugal mixing and three-roll milling) to minimize the time required to disperse graphene nanoplatelets into a polymer matrix for graphene nanoplatelet-reinforced epoxy nanocomposites. Ultimate tensile strength, flexural strength, and flexural modulus were used to evaluate the procedures. The results revealed that planetary centrifugal mixing is more effective. It not only took less time to complete, but it also produced a more uniform dispersion of graphene nanoplatelets than three-roll milling and other traditional dispersal methods.

Wang et al. [6] investigated the effect of nano-MgO content and carbonization time on nano-MgO-modified cement soil utilizing mechanical characteristics as well. The results revealed that by adding 1.0 percent nano-MgO to the modified cement soil and carbonizing it for one day, the compressive strength of the modified cement soil may be greatly increased. The energy dissipation rate of the modified cement soil after 1-day carbonization achieved its maximum, and the peak strain of the modified cement soil after 2-day carbonization reached its highest value, both with the same nano-MgO concentration.

Returning to the topic of furnace slag, Li et al. [7] investigated the radiation cooling effect of substituting basic oxygen furnace slag (BOFS) on asphalt concrete pavement. Thermal conductivity, emissivity, and indoor and outdoor temperature measurements were used to compare the thermal performances of varied proportions of 45 wt%, 55 wt%, and 75 wt%. The specimen with the BOFS substitution of 75 wt% absorbed the most heat inside the body, resulting in less heat being released into the environment as a result of this. After making the appropriate BOFS substitution, the specimen's stability value, indirect tensile strength, and British pendulum number (BPN) all met the criteria for each parameter. Finally, because of its thermal performance, BOFS offers a wide range of potential benefits in pavements, particularly for the purpose of achieving the goal of urban heat island mitigation by radiation cooling.

Carbon-fiber-reinforced plastic (CFRP) has been widely employed in civil and architectural engineering to repair or replace deteriorated or damaged engineering structures such as bridge decks, concrete beams, walls, slabs, and columns. Its adaptability has sparked a wave of invention and several technological advancements. Li et al. [8] employed microwave-assisted pyrolysis (MAP) to remove the resin from a CFRP bicycle frame in order to recycle waste carbon fiber. They analyzed the mechanical properties of carbon-fiber-reinforced concrete (CFRC) in static and dynamic testing using three distinct types of carbon fiber, which are conventional carbon fiber, carbon fiber without a coupling agent, and recycled carbon fiber. The mechanical performance of recycled carbon fiber was found to be superior to that of normal carbon fiber and practically identical to that of carbon fiber without a coupling agent.

Li et al. [9] studied the influence of a next-generation colored inorganic geopolymer material (IGM) paint on an insulating concrete building shell for another geopolymer use. Five insulating IGM paints, white, red, green, blue, and yellow, were applied to the top surface of a concrete slab to determine their ability to reflect heat and to reduce a building's cooling requirements during hot summer seasons. The results indicated that IGM paints significantly reduced the surface temperature and heat flow of the upper and lower surfaces of concrete slabs, with the white IGM paint had the best performance of the five colors.

Chin et al. [10] closed the Special Issue with another investigation on waste CFRP. The authors investigated the undesirable silane residue on recovered carbon fibers (rCF) that was applied as a coupling agent during the commercial CFRP manufacturing process. The surface morphologies and elements present on the rCF were studied using the microwave pyrolysis method. It was discovered that increasing the pyrolysis temperature results in a greater reduction in silicon content. Due to the uniformity of microwave pyrolysis recycle treatment, this is a viable alternative to traditional furnace technology.

Author Contributions: Conceptualization and writing, Y.-F.L., W.C. and T.-W.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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