applied sciences

Editorial

Special Issue on Advances in High-Performance Fiber-Reinforced Concrete

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With the advancement of science and technology, scholars have developed a cement composite material with tensile strain hardening, called high-performance fiber-reinforced concrete (HPFRC). In fact, HPFRC is different from traditional high-strength concrete and steel-fiber-reinforced concrete. It is not a high-strength "high-performance concrete" in the traditional sense but a new variety of cement-based structural engineering materials with clear performance indicators. UHPC has been applied in many products, in structure maintenance, and in new constructions with good results. It is expected that with the establishment of the use of HPFRC, the improvement in design methods and specifications, further progress in production and construction technology, and large-scale applications, the costs of construction materials will be gradually reduced. Therefore, HPFRC has considerable development potential and room for improvement.

This Special Issue aimed to collect and present all breakthrough research in HPFRC, including innovative concepts to improve mechanical properties, the development of new fiber technologies to improve the performance of HPFRC, engineering applications of HPFRC, reducing the negative impact of fibers on certain properties of concrete, mixture designs of HPFRC, the bond behavior of HPFRC, the thermal and fire performance of HPFRC, the durability of HPFRC, etc.

A total of 15 papers in various fields of HPFRC research are presented in this Special Issue. Lanwer et al. [1] presents an innovative approach to the performance-based design of high-strength micro-steel fibers for ultra-high-performance concrete (UHPC). The effects of fiber layout, fiber orientation, and loading type (quasi-static and cyclic) are mainly considered, and the current method is extended with empirical and applicability test results. The fiber's design is based on the so-called utilization rate, which is determined by pull-out testing of high-strength micro-steel fibers in UHPC under quasi-static and high cyclic loads with different directions and embedment depths. Matos [2] evaluated the durability of non-property and more environmentally friendly UHPCs involving expansive reactions, alkali-silicon reactions, and external sulfate-induced expansion through a comprehensive study at the macro- and micro-scales. At the macro-level, no deleterious expansion due to ASR or external sulfates occurred. However, SEM analysis revealed the reaction products of ASR and sulfate attacks in the UHPC specimens, namely, ASR gel and ettringite, respectively. Huang et al. [3] conducted a test of the heat absorption and deicing effect of carbon-fiber-modified concrete (CFMC) under the action of multiple factors. They found that the law of heat absorption and deicing of CFMC was affected by the coupling effect of fiber length and dosage, height (straight-line distance between the microwave receiving surface and bell component), initial temperature, and ice cover. Yao et al. [4] explored the influence of different contents of aluminum oxide fiber on the impact compression performance of the concrete matrix and optimized and established a constitutive model based on damage theory and stress residue. The results showed that

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Citation: Tang, C.-W. Special Issue on Advances in High-Performance Fiber-Reinforced Concrete. *Appl. Sci.* **2022**, *12*, 8723. https://doi.org/10.3390/app12178723

Received: 28 August 2022
Accepted: 29 August 2022
Published: 31 August 2022

adding alumina short-cut fiber to concrete changed the impact compression mechanical properties of concrete to a certain extent. Li et al. [5] established a dynamic damage constitutive model of polypropylene concrete under real-time high-temperature conditions and compared the model with the experimental data. The results showed that thermal conditions affected the chemical composition and microstructure of polypropylene fiber concrete, which was why the high temperature had a great influence on the dynamic mechanical properties of polypropylene concrete. Lim et al. [6] used multiwalled carbon nanotubes (MWCNTs) and graphene nanoplatelets (GNPs) to enhance the electrical conductivity and mechanical properties of cement-based composites. In this study, MWCNTs and GNPs were non-covalently functionalized using melamine and ball milling. Furthermore, MWCNTs and GNPs with one- and two-dimensional shapes were mixed with the cement paste to examine their effects on electrical conductivity and compressive strength. Tang et al. [7] investigated the mix design and performance of fiber-reinforced pervious concrete using lightweight coarse aggregates instead of ordinary coarse aggregates. The properties of the matrix were tested by rheological tests, and then different amounts of lightweight coarse and fine aggregates were added to the matrix to measure the properties of the obtained lightweight pervious concrete (LPC). The results of the study confirmed that the use of suitable materials and optimal mixing ratios are key factors for improving the mechanical properties of LPC. Lei et al. [8] conducted a series of experiments on polypropylene-fiber-reinforced, high-performance concrete (HPC) to obtain its mechanical and thermal properties. Dynamic tests of HPC at different loading rates were performed using a split Hopkinson pressure bar (SHPB). Then, the HPC specimens were heated to various high temperatures. It was found that at temperatures below 100 °C, the HPC specimens remained intact despite numerous fractures under dynamic loading conditions. However, it was found that at temperatures above 200 °C, all the HPC samples were shattered into pieces. Niu et al. [9] conducted a series of tests on the mechanical behavior of recycled concrete, focusing on the cubic, flexural, and uniaxial compression mechanical properties of steel–polyvinyl alcohol fiber-reinforced recycled concrete specimens. Based on the test results, the elastic modulus, the Poisson's ratio, and the uniaxial compression toughness were digitized to derive mathematical expressions that provided a theoretical understanding of the mechanical properties of steel–polyvinyl alcohol fiber-reinforced recycled concrete. Łach et al. [10] explored the effect of adding different types of reinforcing fibers on the strength properties of geopolymers. The reinforcing fibers used include glass, carbon and basalt fibers. Additionally, composites with these fibers were produced not only in the matrix of pure geopolymers but also as a hybrid variant with the addition of cement. Karimipour et al. [11] investigated the effect of steel fibers (SF) and polypropylene fibers (PPF) on the hardened and fresh state properties of high-strength concrete (HSC). For this purpose, 99 concrete mixtures were designed and applied. The concrete specimens were tested for slump, compressive and tensile strength, elastic modulus, water absorption, and resistivity. Lanwer et al. [12] investigated the material behavior of ultra-high-performance fiber-reinforced concrete (UHPFRC), especially the tensile fatigue behavior and the bond behavior between these fibers and plain UHPC. According to the test results, an S/N curve of the characteristic values was established. In addition, the test program included pull-out testing of fiber groups of different embedded lengths and orientations under monotonic and cyclic loading. An et al. [13] studied the mechanical and thermal properties of basalt-fiber-reinforced concrete. The differences between basalt-fiber-reinforced concrete and ordinary concrete were compared by determination of the physical parameters, static compressive tests, and dynamic compressive tests. The strength of basalt-fiber-reinforced concrete was greater than that of ordinary concrete in both the static compressive tests and the dynamic compressive tests. Zhang et al. [14] proposed an experimental study on the mechanical properties of steel–polypropylene hybrid fiber-reinforced concrete (HFRC) for shaft lining. The static mechanical properties, dynamic mechanical properties, and crack failure characteristics of HFRC were experimentally studied. The test results show that HFRC had significantly higher dynamic splitting tensile strength and compressive deformation resistance, as well as a certain anti-disturbance effect. Kim et al. [15] used newly developed arched steel fibers to evaluate the shrinkage properties of steel-fiber-reinforced concrete (SFRC) and scaled-down deck members, including free drying shrinkage and restricted drying shrinkage. They compared the measured drying shrinkage test results with predictions obtained from models found in the literature. Overall, the number, width, and length of cracks on the surface of the SFRC slabs were significantly reduced when a 0.2% volume fraction of arched steel fibers was included in the mixture.

Funding: This research received no external funding.

Acknowledgments: Thanks to all the authors and peer reviewers for their valuable contributions to this Special Issue 'Advances in High-Performance Fiber-Reinforced Concrete'. I would also like to express my gratitude to all the staff and people involved in this Special Issue.

Conflicts of Interest: The author declares no conflict of interest.

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