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Editorial

Editorial on Special Issue "Performance Prediction, Durability and Modelling of Concrete Materials and Structures"

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Concrete is one of the construction industry's most essential and commonly used materials. The construction industry plays a significant role in supporting the global economy and human activities; moreover, it is among the most important industries on the front line of changes to adapt to and fulfill the requirements of environmental policies and future sustainability. Many problems arise from extracting, producing, and utilizing this material. To date, many studies have been conducted in the fields of concrete materials and concrete structures, to promote practical applications toward a more sustainable environment. However, many challenges still exist, and the contribution of research to the analysis of materials and structural behaviors due to aging, external loads, and environmental factors is of paramount interest.

The emerging subjects are related to non-destructive tests, making the prediction of material behavior more reliable and practical. Accordingly, this Special Issue gathers fifteen outstanding contributions of up-to-date advances and developments in the durability, structural performance, service-life prediction, and modeling of concrete materials and structures. Due to the diversity of the papers in this issue, many aspects of the topic are discussed. They can roughly be grouped into four categories based on their similarities.

Of the papers featured in this issue, the prediction of modeling and concrete material parameters are discussed in [1–5], wherein advanced numerical simulations are used to model the permeability, compressive strength, porosity, neutralization depth, etc.

The permeability of concrete is considered a primary indicator of its durability. Wang et al. [1] proposed a simple model to predict the permeability of engineered cementitious composites (ECC). The required microstructure information of cement paste was obtained from a simulated microstructure. The calculated permeability of ECC was verified using the results from water permeability tests, and the model accuracy was acceptable for cement-based materials.

Alam and Nassar highlighted, in their research [2], that the traditional approach to the optimization problem—based on the maximum-likelihood theory to obtain estimates for the targeted parameters, and then, estimate the reliability—might become more robust under irregular situations, such as in the case of data contamination. The authors proposed the use of Laplace Birnbaum–Saunders distribution to overcome this aspect. An extensive set of simulations was carried out in this research to prove the highlighted issues and the benefits of the proposed approach.

Ngo et al. [3] proposed using artificial intelligence to estimate concrete strength. By implementing artificial intelligence (AI), the authors explored the relationship between the rebound hammer (RH) test, the ultrasonic-pulse velocity (UPV) test, and compressive

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strength. The analysis results showed that AI prediction models provide more accurate estimations when compared to statistical regression models.

Machine-learning techniques have become a popular solution to prediction problems and are gaining attention, especially in the construction industry. The papers of Duan et al. [4] and Amin et al. [5] used the machine-learning technique to estimate the neutralization depth of concrete bridges and the compressive strength of rice-husk-ash-blended concrete, respectively. In these studies, advanced machine-learning techniques were implemented. It was observed that the performance of machine-learning methods was superior to traditional methods.

Lightweight concrete is studied in two papers in this Special Issue, [6,7]. So-called bubble concrete is a new type of lightweight concrete obtained by mixing concrete with random high-strength hollow bodies, which provides overall benefits to its material and mechanical properties. Yan et al. [6] conducted a study with concave and spherical steel hollow bodies, embodied in concrete to form multiple cavities, and also to transfer internal stresses. Through compression tests, the shape effects and distribution effects of the hollow bodies on the strength and Young's modulus of the concrete were investigated. An advanced study of the mechanical characteristics of the bubble concrete were simulated via nonlinear elastoplastic finite-element analysis. The results indicated that with the proper combination, bubble concrete can reduce its density and maintain relevant compressive strength. Yan et al. [7] extended their research on the roles of different hollow bodies (steel spheres, sand-bonded stainless-steel spheres, and ceramic spheres) in bubble concrete (BC)'s mechanical properties. A comparative study was carried out using advanced FEA analyses. The results showed that the difference in the elastic modulus of hollow bodies and concrete is the primary reason for the inhomogeneous stress distribution inside the concrete. The interface between the hollow body and hardened concrete could be increased using epoxy resin, thus enhancing the compressive strength of BC specimens.

The following papers discuss different aspects of concrete components and their influence on the concrete's physical and mechanical parameters. The request for specific properties requires the addition of other materials to the mixture along with traditional concrete materials, or their replacement. To improve the thermal insulation properties and toughness of concrete, the paper by Dai et al. [8] added glazed hollow bead (GHB) and polyvinyl alcohol (PVA). The authors investigated the influence of GHB and PVA on the thermal insulation parameters and tensile strength by considering a variety of mixtures.

Mára et al. [9] investigated the possibility of increasing ballistic resistance by adding different corundum and basalt aggregate percentages. Ultra-high-performance steel-fiber-reinforced concrete (UHP-SFRC) is a technologically advanced composite with a high ability to absorb and dissipate mechanical energy. The experimental campaign showed that the addition of basalt, and especially corundum aggregates had a positive effect on ballistic resistance. In particular, an increase in compressive strength and a slight decrease in depth of penetration (DOP) was observed with the use of of corundum aggregate.

Steel fibers are known to improve the mechanical parameters of concrete. In addition, their combination with Nano-SiO2 materials could significantly increase the flexural capacity of reinforced concrete elements. A very good contribution on this topic can be found in the paper of Shi et al. [10]. The failure mode was discussed in detail, and the specimens all behaved in a ductile fashion. Furthermore, the test results indicated that bending cracks and concrete crushing occurred in the compression zone of all specimens.

The paper by Lu et al. [11] numerically investigated the relationships in a composite section between ductility, strength, and hysteretic behavior under cyclic loading. The simulations were carried out by modifying many involved parameters.

Rahman et al. [12] present an experimental investigation on geopolymer cement formulations for enhancing oil-well integrity. Fresh slurry properties, mixability, density, free water, and rheology were determined for possible field applications. The compressive strength and expansion characteristics were studied for the durability and integrity of the well system.

Modified cement-based materials obtained using industrial waste present robust engineering properties that can lead to sustainable development. Anuar et al. [13] evaluated the capacity of oil palm boiler clinker (OPBC) waste, which is produced during the palm oil extraction process, as partial and complete substitutions for natural sand to produce cement mortar. The changes in the forms of color, weight, compressive strength, microstructure, mineralogical composition, and thermal conductivity were investigated. The test results showed that the compressive strength of OPBC mortars was generally higher than the strength of the control mortar after heat exposure, and water-cooling exerted less damage to the samples compared to air-cooling.

Two papers by Haufe et al. [14,15] addressed the sulfate resistance of concrete, which is essential for the use of concrete in sulfate-rich environments. In [14], the authors highlighted that the standard EN 206-1 contains descriptive requirements for the concrete to withstand a sulfate attack and limits the use of feasible concrete mixtures that do not comply with these requirements. The authors proposed a new approach to test the performance of concrete during a sulfate attack under practical conditions, based on the residual tensile strength of concrete briquet specimens, according to ASTM C307. The approach, tested on a variety of binders, seems to be effective. The authors completed their research by providing the specifications and conditions for a Sulfate-Resistance Performance test [15].

As guest editors, we deeply thank all of the contributors to this Special Issue. Their excellent works are of great value to the research community and to practitioner engineers who deal with concrete materials and construction in their daily practice. The need for new concrete, with different properties that we have dealt with in the past, is emerging very fast. All fifteen contributions to this Special Issue discuss very common and quite different concerns which we have to face. Therefore, we believe the vast majority of the issues discussed are essential contributions to a sustainable future.

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