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# Special Issue on Research and Enhancement of Mechanical Properties of Cementitious Materials

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Concrete is the most-produced product on the planet. In the journey toward more sustainable construction materials, recent research has sought to (1) enhance materials' sustainability using diverse natural and artificial resources, (2) enhance mechanical performances, (3) develop accurate models, and (4) ensure long-lasting performance.

The Special Issue aimed to present six original technical articles to cover the mechanical and durability properties of the construction materials used in various structures. Most papers utilized partially recycled waste materials (e.g., rice straw, plastics, slags, fly ash) for supplementary cementitious materials (SCMs) and fillers. Structures and construction materials exposed to harsh conditions (soil, backfill, pipe, etc.) were especially highlighted in this Special Issue. For example, one study optimized the mixture proportions to stabilize the soil's mechanical properties. Another study repurposed rice straw for backfill materials, while plastics were used for replacing natural aggregates. This exemplary research showed that natural and artificial waste materials are emerging resources for developing sustainable cementitious materials in underground structures. Researchers also used nontraditional approaches, such as vacuuming and electromagnetic radiation, on the materials. The experimental methods utilized in the papers in this Special Issue included standard mechanical tests, creep, shrinkage, and freeze–thaw resistance; authors used various microstructure analyses to confirm their findings. The findings of each paper are presented as follows.

Wu et al. [1] reported an optimum proportion for stabilized ordinary Portland cement (OPC)-based sandy silt using a pozzolanic reaction of fly ash along with three types of additives (gypsum, lime, clay particles). Within the mass fractions in the range of 0~4%, the optimal contents of additive gypsum, clay particles, and fly ash are identified as 2%, 4%, and 4%, respectively. Each additive improves chemical (secondary hydration) and physical properties (gradation of particles). However, the addition of lime was not suggested in this study due to mechanical strength degradation.

Lee et al. [2] proposed the blended mixture proportions using two different water-cooled slag (WC) and air-cooled (AC) slag to improve the freeze–thaw resistance of OPC concrete. Air-void systems and microstructure were investigated to confirm the benefits and mechanisms of WC and AC for frost resistance. Altering air-void systems (spacing factors with low air content) and the increase in hydration for blended cement concrete have positive impacts on both the mechanical and the durability properties.

Assad and Morcous [3] reported time-dependent properties (i.e., creep and drying shrinkage) of self-consolidating concrete (SCC). The study focuses on the applicability of the existing five models, including several U.S. and European design codes and benchmark models for estimating volume changes in various mixture proportions over time. The robustness of each model was evaluated with different SCMs and additives such as fly ash (class C and F), ground-granulated blast-furnace slag, and limestone powder. All models provided a lower prediction of drying shrinkage of SCC than measured data, indicating the need for modification of factors in prediction models.

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Yang et al. [4] reported a crack-repairing technique using bio-coating of Rhodobacter capsualtus based on bacteria immobilization. The negative-pressure method allows for improvement in bacteria immobilization, enhancing durability and mechanical properties. It was found that the immobilization rate using this method was 2.2–3.3 times that derived using the conventional approach (simple soaking method).

Shi et al. [5] reported findings that the application of rice straw (RS) improved the tensile strength of the cemented paste backfill. By focusing on attaining tensile strength, the varied fiber content (1, 2, 3 $kg/m^3$) and fiber length (0.8~1, 1~3, 3~5 cm) were used to improve tensile strength. Generally, the RS-reinforced concrete exhibited superior performance to conventional cemented paste backfill. RS improved the elastic modulus but exhibited a brittle failure mode under low tensile strains.

Lee et al. [6] presented some enhanced plastic aggregates to replace fine aggregates. By radiating gamma rays on plastics, their physical and chemical properties are changed. By performing scanning electron microscopy (SEM) and Fourier-transform infrared spectroscopy (FTIR) analyses, the strength enhancement mechanism is identified for two reasons: (1) the densification of crosslinking and (2) the improvement of the bonding strength with the cement matrix. Finally, the change in the chemical structure of plastic aggregates leads to an improvement in the interfacial bonding properties between aggregates and cement paste.

Finally, the Special Issue provides some insights into the recent approaches toward more sustainable construction materials in various applications.

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