Advanced Cementitious Materials: Mechanical Behavior, Durability, and Volume Stability

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Several types of advanced cementitious materials, including fiber-reinforced cement composite, eco-friendly concrete including supplementary cementitious materials (i.e., fly ash, ground granulated blast furnace slag, and silica fume), geopolymers, high-performance concrete, and self-consolidating concrete, have been developed worldwide since the 1960s. Fiber-reinforced cement composite is suited for structures under flexure or tension due to its inhibition of crack propagation and widening through fiber bridging. Eco-friendly/geopolymer concrete became very important in construction technology after the UN Climate Change Conference held in 2015, since it can reduce carbon dioxide emissions from cement production. (Ultra)high-performance concrete may improve several shortcomings of ordinary concrete in terms of strength-to-weight ratio, ductility, durability, workability, and so forth, and also self-consolidating concrete is an example of high-performance concrete improving workability.

This special issue aimed to provide a comprehensive overview on cementitious materials, including aspects related to mechanical behavior, durability, and time-dependent volume changes such as shrinkage and creep. Authoritative review articles and original research papers describing recent findings in the field of advanced cementitious materials successfully covered the above topics. This special issue was also very competitive. In total, 58 scientific papers were submitted, and among them, only 14 papers were finally accepted for publication. Acceptance rate was approximately 24%.

Several experimental and numerical papers addressed new research findings with regard to durability properties of concrete. K. Y. Ann et al. examined the effect of frost damage on the rate of chloride transport in ordinary concrete subjected to a rapid freeze-thaw cyclic environment. In their study, the chloride transport was accelerated by frost damage and it was more obvious at a lower cement content. The freezing conditions increased the volume of large capillary pores in ordinary concrete. K.-B. Park et al. numerically simulated the time-dependent chloride diffusion coefficients of concrete including ground granulated blast furnace slag. With an addition of the slag, the changes of total porosity, pore refinement on macro- and microscales due to filling effect, latent-hydraulic properties, and pozzolanic reaction were also analyzed. By comparing the numerical and experimental data, it was concluded that the proposed model is valid for concrete with different water-to-binder ratios, slag replacement ratios, and curing ages. H. J. Yang et al. evaluated the chloride transport in various types of high alumina cement mortar. An increase of Al₂O₃ content in the high alumina cement clinker led to an increase of diffusion.
coefficient and concentration of surface chloride due to
the increase of chloride binding. But the pore distribution
in the cement matrix was not influenced by the types of
high alumina cement, except for macropores. An extensive
literature review was also conducted by P. Azarsa and R.
Gupta for a connection between the electrical resistivity of
concrete and the deterioration processes like increase in
permeability and corrosion of embedded steel.

The volume stability of cement paste and concrete was
investigated by several researchers. B. Kucharczyková et al.
introduced an advanced measurement equipment and proce-
dure for simultaneous measurement of length changes, mass
losses, acoustic responses, and temperature development.
The cement composite's setting and hardening characteristics
were evaluated by the continuous measurements of the
relative length changes and mass losses. In addition, the
formation of microcracks during the setting and hardening
of the composites, substantially affecting the final mechanical
properties, was possible to be determined using acoustic
emission method. Y. Chen et al. examined the effects of
amorphous nano-SiO$_2$ on the early-age properties, such as
consistency, setting time, strength, and chemical/autogenous
shrinkages. The addition of nano-SiO$_2$ resulted in higher
consistency, significant reductions in setting times, higher
early-age strength, and higher chemical/autogenous shrink-
ages. The implications of concrete age and creep on the
ultimate load carrying capacity of concrete-filled steel tube
columns were also reported by H. Y. Wang et al. based on both
experimental tests and numerical analyses. H. Xiong et al.
investigated the strain behavior of external thermal insulation
cladding systems with Glazed Hollow Beads thermal insu-
lation mortar under hygrothermal cycles. Their test results
indicated that the finishing coat shrank at early stage, while
the finishing coat tended to expand and became damaged at
later stage. The crack length and width on the finishing coat
increased with age, but the cracks stopped growing around 70
cycles.

Some other properties, including mechanical property,
rheological property, hydration activity, and pore struc-
ture, of cement paste and concrete were also reported. R.
Chakravarthy et al. tried to develop ductile high volume
fly ash concrete including steel, polypropylene (PP), and
basalt fibers. In their study, a significant improvement of
mechanical properties of high volume fly ash concrete was
obtained by including hybrid fibers (i.e., 1% steel fiber, 0.75%
PP fiber, and 0.75% basalt fiber). A limiting combination of
3% overall fibers was determined based on the workability of
concrete. K.-K. Yun et al. mainly evaluated the pumpability
of wet-mix shotcrete including various admixtures, that is,
silica fume, fly ash, ground granulated blast furnace slag,
metakaolin, and steel fibers based on rheological properties.
The addition of silica fume and metakaolin led to satisfactory
pumpability, whereas those of fly ash and steel fibers failed
to meet the pumping criteria at normal pump pressure. On
the other hand, the use of ground granulated blast furnace
slag had no significant effect on the pumpability. J. H. Kim
et al. introduced the alpha test to examine the performance of
polycarboxylate-based high-range water-reducing admix-
ture. To overcome some drawbacks of the mini-slump flow
test, the channel flow test was proposed. The final spread and
the time to get the stoppage of the spread were measured,
and a model converting them into rheological properties was
developed. Y. Gao et al. modeled a pore structure in cement
paste by means of the recently proposed solid mass fractal
model and an enhanced Maxwell homogenization method to
determine the associated ionic diffusivity. They verified the
developed model by comparing it with experimental results,
that is, mercury intrusion porosimetry and rapid chloride
migration. S. K. Kim et al. suggested a method for sustainable
development of cement industry as well as waste recycling on
a national scale that was replacing a portion of cement with
a high quality liquid crystal display (LCD) processing waste
glass (LPWG) powder. For this, they investigated both fresh
and hardened properties of concrete with various amounts
of the LPWG powder. Lastly, the reasons why f-CaO in basic
oxygen furnace slag is expanded and shows slow hydration
activity were studied by R. Jia and J. Liu based on simulated
experiments.

The guest editors hope that readers of this special issue
can obtain useful experimental and numerical results and
discover recent research trends regarding advanced cemen-
titious materials. Furthermore, we wish that their academic
curiosities and difficulties can be solved by investigating the
valuable research results in this special issue containing both
experimental and numerical developments. This publication
considers a wide range of disciplines, including civil, archi-
tectural, and chemical engineering, and may appeal to the
scientists and engineers.

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