Dear Readers,

We are pleased to present this edition guest edited by Prof. Dr. Victor C. Li, who led the research team that invented Engineering Cementitious Composites (ECC), popularly known as "bendable concrete." Prof. Dr. Victor C. Li is the James R. Rice Distinguished University Professor of Engineering and the E.B. Wylie Collegiate Professor of Civil and Environmental Engineering at the University of Michigan, Ann Arbor. His research interest is in multifunctional materials targeted at enhancing civil infrastructure sustainability and resilience. Prof. Li was awarded the International Grand Prize for Innovation by the Construction Industry Council and the Life-time Achievement Award by RILEM in 2016. He has multiple patents to his credit and is a recipient of distinguished awards and recognition from the University of Michigan, Technical University of Denmark.

Best Regards,
Production Editor

Dear Colleagues,

The invention of Portland Cement in Britain in the 18th century laid the foundation for modern civil infrastructure. Over the past two hundred years, the invention of steel reinforced concrete and the continuous enhancement of concrete compressive strength have allowed the construction of taller buildings and longer bridges. Today, we have built up deep knowledge in concrete and global applications of concrete buildings and civil infrastructure. Consuming at the annual rate of 2 tonnes per person, concrete has become the ubiquitous material in modern cities around the world.

Despite the significant advancement of concrete and concrete infrastructures the built environment and the natural environment are both in a less than desirable state. For the built environment, we need more durable infrastructure that require less frequent repair, and more resilient infrastructure that minimize disruption of life in a major load event. Traditionally, such major load event is often associated with earthquakes, but today, this major load event may more often than not come from climate change, including wide-spread fire, extreme hurricane forces, and wide-area flooding. These events will likely arrive at increasing frequencies and is in fact affecting many coastal urban communities. In other words, there is a need to build and retrofit our built environment for enhanced resilience to extreme loads, adapting to climate change.

Climate scientists tell us that there may be just fifteen to thirty years when the tipping point of wide-spread disaster of broad magnitude will occur – the average surface temperature of the earth reaching 1.5°C above the pre-industrial level. The only approach to avoid this calamity is to dramatically reduce emissions, not only at the materials production phase, but also at the building/infrastructure design phase, the use/operations phase, and the end-of-life phase of the infrastructure life-cycle. Mitigating climate change is critical to reducing the chance or at least delaying the reaching of the 1.5°C critical temperature. The built environment must play a big role in climate mitigation due to the fact that it is responsible for over 60% of all carbon emissions.

Can concrete simultaneously contribute to climate change adaptation and mitigation through enhanced infrastructure durability, resilience, and sustainability? I believe we can if we think out of the box. The traditional approach to increasing the compressive strength or densifying concrete has proven inadequate. This is because most of the problems infrastructure experiences results from cracks, a phenomenon associated with tensile stress. Further, controlling the width of cracks in concrete using steel reinforcement has been found to be notoriously unreliable. It is necessary to create concrete that is ductile, and with autogenous crack width control capability. Such concrete is available today – generally known as Engineered Cementitious Composites (ECC) or Strain-Hardening Cementitious Composites (SHCC).

India has the second largest population in the world. The need for new infrastructure to support its economic growth in the coming decades is large. This gives rise to the potential and opportunity that India can lead the world in creating infrastructure designed for adaptation and mitigation of climate change. It is therefore appropriate for Indian academia, industry, and Government to join forces to accelerate this process. A number of institutions have initiated activities towards this end. I applaud the efforts by the Indian Concrete Journal to organize this Special Issue on ECC. The building and infrastructure industries are generally conservative, and often with good reasons. However, it is critical to balance conservativeness and innovation, especially when the time left for innovation is only a short fifteen to thirty years away. In many coastal cities in India and elsewhere, the impact of climate change is already here. There is no time to wait.

Victor C. Li
Chief Advisor,
Guest Editorial Group, ICJ

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CHRISTOPHER K.Y. LEUNG received his B.Sc. degree in Civil Engineering from the University of Hong Kong, his M.S. degree in Structural Engineering from the University of California, Berkeley and his Ph.D. degree in Civil Engineering from Massachusetts Institute of Technology (MIT). He has rich academic experience and is presently the Head of the Civil and Environmental Engineering Department, Hong Kong University of Science and Technology (HKUST).

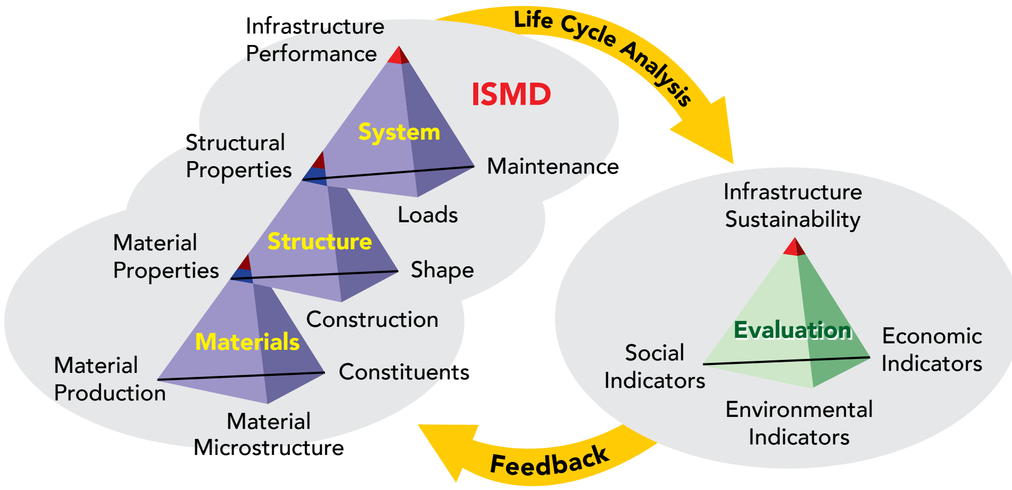
Prof. Leung's research interests are in the general field of construction materials, which include composite mechanics, application of fibre composites in civil engineering, fracture mechanics of cementitious materials as well as the mechanics-based design of fibre optic sensors. He is a two time recipient of the Teaching Excellence Appreciation Award from the School of Engineering at HKUST. He is a recipient of Year 2007 Best Applied Research Paper from the ASCE Journal of Composites for Construction. He has co-authored a textbook on Renovation Engineering, the first of its kind in the literature. Prof. Leung is the Fellow of Hong Kong Institute of Engineers (HKIE) and RILEM (International Union of Laboratories and Experts in Construction Materials, Systems and Structures). He chairs the RILEM Technical Committee on Optical Fibre Sensors for Civil Engineering Applications, and was the Honorary President of RILEM in the past. He has been on the Editorial board of many reputed international journals including Journal of Materials in Civil Engineering, RILEM Materials and Structures as well as Construction and Building Materials. He is presently the Chair of the Hong Kong Accreditation Service Working Party on Construction Materials Testing, and member of the HKIE Accreditation Board.

DHANADA K. MISHRA is a visiting Research Scholar at Hong Kong University of Science and Technology (HKUST). He has received his Ph.D. degree in Civil Engineering from the University of Michigan, Ann Arbor. His research topic under the guidance of Prof. Victor C. Li focused on application of Engineered Cementitious Composites (ECC) in plastic hinge region of beam-column joints in earthquake resistant buildings. He has rich academic and professional experience. He has served at the Kalinga Institute of Industrial Technology (KIIT) University as its first Dean of Research and as the Principal of the Jagannath Institute of Technology and Management (JITM), during its transformation to become the Centurion University. Currently he is on sabbatical leave from his position as Director KMBB Engineering College, Biju Patnaik University of Technology (BPUT). His research interests include low cost housing, compressed earth construction, fly ash and other industrial waste utilisation and advanced concrete technology.

JING YU is a Research Assistant Professor in the Department of Civil and Environmental Engineering at the Hong Kong University of Science and Technology (HKUST). He has B.E. degree from Zhejiang University and his Ph.D. degree from HKUST. He has received various awards and scholarships during his undergraduate and graduate studies including the Fulbright-RGC Hong Kong Research Scholar Award and the National Outstanding Graduate Award by the China Civil Engineering Society. His research mainly focuses on sustainable and advanced cement-based materials.

DUO ZHANG is a Research Scientist in the Department of Civil and Environmental Engineering at the University of Michigan. He received his B.Sc. and M.Sc. degrees from Southwest Jiaotong University, China, and his Ph.D. degree from McGill University, Canada. Dr. Zhang has been focusing on sustainable developments of cementitious materials, with an emphasis on CO_2 utilization and sequestration to develop carbon-negative ECC and concrete. His research also includes reuse of waste streams as well as mitigating life-cycle emissions of civil infrastructure.

GREEN AND SUSTAINABLE ENGINEERED CEMENTITIOUS COMPOSITES (ECC)



DUCTILE ECC

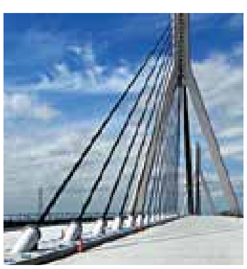

Normal concrete


ECC

COUPLING BEAMS FOR TALL BUILDINGS

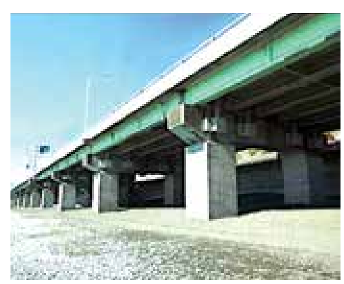

The Kitahama building – 60 story residential tower in Osaka, Japan uses ECC in the building core

ECC BRIDGE DECK FOR CABLE-STAYED BRIDGE




Mihara bridge in Hokkaido with ECC bridge deck

ECC DAMPERS

Seisho Bypass viaduct, Odawara city, Japan retrofitted with ECC dampers

Images courtesy Prof. Victor C. Li

Dear Colleagues,

We are pleased to bring to you the first ever special issue of the ICJ exclusively focused on Engineered Cementitious Composites (ECC) with an objective to introduce and encourage more research and application in this field.

A book authored by Prof. Victor C. Li titled Engineered Cementitious Composites (ECC): Bendable Concrete for Sustainable and Resilient Infrastructure has been recently published by Springer. A detailed book review that familiarises with this new material is included. Further, readers can gather more detailed insight from various research papers included in this edition.

Prof. En-Hua Yang and his team at Nanyang Technological University, Singapore present their investigations on the effect of passive confinement provided from ECC cover on corrosion of steel reinforcing bars. Specimen with ECC cover showed significant performance improvement with reduced mass loss as well as mass loss rate of steel reinforcement while increasing residual flexural load capacity. The change of failure mode of cover material from brittle to ductile is the key to enhanced corrosion resistance which would help improve service life and make for sustainable reinforced concrete infrastructure.

ECC has been recognized as an advanced and resilient alternative to conventional concrete materials. However, the high cost of the constituents limits the wide application. To improve the sustainability and reduce the material cost, efforts were made by applying green binders with industrial wastes and/or recycled fibres. Dr Yao and team from China focus on the potential use of Industrial Solid Wastes (ISWs) such as Silica Fume (SF), Fly Ash (FA) and Ground Granulated Blast Furnace Slag (GGBFS), and low cost PVA fibres produced by local synthetic fibre factory. The mechanical properties show that even when upto 50% of Portland Cement is replaced with ISWs, ECC with local PVA fibres still maintains Strain-Hardening and multiple cracking behaviours accompanied by a tensile strain capacity upto 1.0%. Such improvement may significantly reduce the environmental impact and material cost, and is expected to greatly promote the field applications of ECC with local ingredients.

Prof. Ravi Ranade and his co-authors from University of Buffalo discuss influence of fibre length on the mechanical behaviour of Steel-PVA Hybrid Fibre Reinforced Strain Hardening Cementitious Composites at high temperatures. Residual mechanical properties of Hybrid Fibre Reinforced Strain-Hardening Cementitious Composites (HFR-SHCCs), after exposure to temperatures of up to 800°C are reported in this article utilizing steel and polyvinyl alcohol (PVA) fibres. While the HFR-SHCC with 13 mm steel fibres exhibits lesser micro-cracking and greater compressive strength at room temperature than that of the HFR-SHCC with 25 mm steel, the latter material shows better tensile performance at high temperatures than the former material due to higher aspect ratio of the steel fibres.

ECC is regarded as a multifunctional smart material due to its intrinsic autogenous self-healing and self-sensing attributes. Paper by Prof Sahmaran and his co-workers discuss their recent findings related to the utilization of electrical measurements in analysing combined effectiveness of these attributes in ECC. It is concluded that electrical testing which are already widely used for self-sensing, can also be used successfully in estimating the autogenous self-healing efficiency in ECC. This adds to the great prospects of such smart materials in structural health monitoring and preventive maintenance applications.

Dr. Ohno and Prof. Victor Li report on sulphuric acid resistance of a Strain Hardening Fibre Reinforced geopolymer composite, named Engineered Geopolymer Composite (EGC). EGC is a promising new material for durable and resilient wastewater infrastructure applications due to its acid-resistant geopolymer matrix and high tensile ductility along with self-controlled microcracking. In the present study, the weight loss, residual compressive and flexural strengths, and deflection capacity of acid-exposed. EGC specimens are experimentally investigated. In comparison with normal cement concrete and ECC, EGC exhibited a three times slower rate of weight loss and no significant degradation in mechanical performances.

Er. V. V. Arora and his co-workers from the National Council of Cement and Building Materials report their results of measurement of compressive stress-strain behaviour of steel fibre reinforced high strength concrete for application in hydraulic structures. The results so improved performance of such composites with steel fibre increasing the compressive strain capacity, post-peak ductility and abrasion resistance significantly.

This special issue has brought together the latest research in the field of ECC from around the world. We received an overwhelming response to the call for papers and have included the first set of papers that completed the double-blind peer-review process in this edition. A sequel edition in the second half of 2020 will include contribution of other authors. The editorial team is grateful to all the authors for sharing their contributions and to all the reviewers who helped us enhance these contributions with their valuable feedback and comments, overall enhancing the quality of this edition.

Prof. Dhanada K. Mishra
Associate Guest Editor for the Special Issue, ICJ