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Cover

The 60-story Kitahama building in Osaka, Japan uses ECC in the building core. Coupling beam and Reinforced core wall structure shown as an inset image.

Cover image source:
Wikipedia and Victor C. Li, James R. Rice
Distinguished University Professor of
Engineering E. Benjamin Wylie Collegiate
Professor of Civil Engineering University
of Michigan, Ann Arbor, MI USA

02 EDITORIAL

PART I : FEATURES

04 NEWS and EVENTS

PART II : TECHNICAL PAPERS

05 Behavior of Engineered Cementitious Composite Structural Elements – A Review

Preethy Mary Arulanandam, S. B. Singh,
Toshiyuki Kanakubo, Madappa V. R. Sivasubramanian

29 Effect of Fiber Content on the ECC Bridging Stress-crack Opening Behavior and Flexural Strain Hardening Properties

Rongxin Guo, Chaoshu Fu, Yang Yang, Feng Yan

39 Optimization of Low-Cost Polyvinyl Alcohol (PVA) Fiber Reinforced Engineered Cementitious Composites (ECC) for Practical Applications

K. A. Shan D. Ratnayake, Jing Yu, Dhanada K. Mishra,
Christopher K. Y. Leung

49 Experimental Behaviour of Hybrid Fiber Reinforced Engineered Cementitious Composites for Concrete Pads Supporting Joint Strike Fighter F35-B

Ezgi Gurbuz, Savas Erdem

56 Correlation of Dynamic and Static Modulus of Elasticity of UHPC

Bharathi Ganesh, Ramesh M. N.,
Santhosh K., Manoj V.

66 Performance Characteristics of ECC using Micro Fibers in Hybridization

Maninder Singh, Babita Saini, H. D. Chalak

PART III : BOOK REVIEW

74 Engineered Cementitious Composites (ECC): Bendable Concrete for Sustainable and Resilient Infrastructure

Shamsher Bahadur Singh

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Dear Readers,

Focussed on the built environment, our need is more durable infrastructure that requires less frequent repair, and more resilient infrastructure that minimize disruption of life in a major load event. To that extent, with research papers on Concrete that is ductile, and with autogenous crack width control capability, generally known as Engineered Cementitious Composites (ECC) or Strain-Hardening Cementitious Composites (SHCC), Prof. Dhanda K. Mishra brings to you the present edition.

Prof. Dhanada K. Mishra has rich academic and professional experience. He 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 and has researched under the guidance of Prof. (Dr.) Victor C. Li. 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.

We thank our vibrant and committed team of Reviewers and Guest Editors for extending their exemplary support in these unusual times. We hope you enjoy reading this edition. Please do share your comments and feedback with us.

I am pleased to share the level of interest in our digital platforms has increased. The ICJ website (www.icjonline.com) has attracted a three-fold increase in the traffic to its monthly edition pages and on open access content pages over the last year. We will continue to upload more open access articles for our readers through this month.

I do hope we can all keep positive in these unusual times. Please continue to stay safe and healthy!

Production Editor
Indian Concrete Journal



Dear Colleagues,

The construction industry contributed to 6% of global GDP as per the Boston Consulting Group (BCG) report for the World Economic Forum (WEF) published in 2017¹. The threat of climate change, rapid demographic shifts and growing demand for resilient and sustainable infrastructure would enhance its importance even further. It is estimated that a global infrastructure investment of 3.3 trillion US dollars per year is needed in the years from 2016 through 2030². The construction industry also accounts for 25-40% of the carbon emissions and is the largest user of raw materials¹. To meet these challenges, there is an urgent need for high-performance construction materials with high strength and ductility, lightweight, excellent durability, good constructability, as well as low cost and minimum environmental impact. WEF has captured some of these trends in a Construction Industry Transformation Framework³. It emphasizes the opportunities for significant gains in areas of new material technologies. Unfortunately, the development of innovative material technology in construction has been infrequent and takes a long time to the market compared to other fields. 3D printing,

third generation construction chemicals, low carbon cements such as Limestone Calcined Clay Cement (LC³), Building Information Modelling (BIM), construction automation, self-sensing and self-healing materials are some examples of such innovations that are transforming the construction sector. Engineered Cementitious Composites (ECC) is one such novel material technology, which is also known as Strain Hardening Cementitious Composites (SHCC). ECC is part of the High Performance Cement Composites (HPCC) that helps converting a brittle material like concrete into a ductile material – popularly known as ‘Bendable Concrete’.

The current issue focuses on the topic of ‘Fiber Reinforced Cementitious Composites’ or FRCC, which is the broad class of materials that includes ECC.

The first paper by Prof. Sivasubramaniam from National Institute of Technology (NIT) Puducherry and his multi-institutional team of co-authors is a comprehensive literature review of structural application of ECC. It summarizes the important research work done on a range of topics from shear and flexural behavior of structural components to seismic performance of ECC structures.

In the second paper of this issue, Prof. Rongxin Guo and his colleagues from the Kunming University of Science and Technology in China have proposed an interesting approach to the micromechanics-based design of ECC using the flexural test method. They have measured the bridging stress versus crack opening relationship in notched tension samples to determine the effect of fiber volume fraction on the composite properties. This in turn helps determining the optimum fiber content for a given combination of matrix, fiber and interface that meets the conditions of strain hardening.

The third paper from the ECC research group at Hong Kong University of Science and Technology led by Prof. Christopher K. Y. Leung illustrates a real life case study in which a practical ECC mix has been designed for a specific structural application. The innate crack width control ability of ECC is used to design an improved water-tight structure. It uses a new lower cost Chinese PVA fiber as opposed to the commonly used Kuraray fiber from Japan and crushed rock fines as aggregate to make ECC commercially competitive.

The fourth paper by Prof. Savas Erdem and his colleague from the University of Istanbul reports a piece of very interesting work on the fire resistance of fiber reinforced composite pavement designed for high heating rate from the exhaust of a fighter jet. It reveals the importance of using mineral fibers like basalt and metallic fiber like steel together with the polymeric fiber like PVA, in order to retain required strength and impact energy at high temperature.

The fifth paper from Dr. Bharati Ganesh and colleagues from NITTE-MIT demonstrates the correlation between static and dynamic measurement of elastic modulus of Ultra High Performance Concrete (UHPC).

The sixth paper by Maninder Singh et al. from National Institute of Technology (NIT) Kurukshetra deals with flexural performance and durability characteristics of hybrid fiber reinforced ECC where the commonly used PVA fiber is partially replaced by PET and steel fibers. Certain advantages including lower cost were observed which may help promote use of ECC in real life applications.

Finally, we have also included a short review of the book titled Engineered Cementitious Composites authored by

Prof. Victor C. Li and published by Springer last year. This review has been contributed by Prof. S. B. Singh.

We hope this issue will be a stimulating read for undergraduate and post-graduate students, researchers, faculty members and practicing engineers. While India has a long and rich tradition of research in the field of concrete science and technology including fiber reinforced concrete, much remains to be done in the fields of advanced cement based composites such as ECC. We hope the December 2019 issue and the current issue will provide some much needed encouragement to researchers, particularly in India, in taking up explorations in these exciting new areas.

I would like to express my sincere gratitude to my Ph.D. supervisor and guide Prof. (Dr.) Victor C. Li for his constant mentoring, my host at HKUST Prof. Christopher K. Y. Leung for his support and specifically Assistant Professor Dr. Jing Yu for his prompt assistance in making this issue possible. We thank all our reviewers for their valuable support in enhancing the quality of the publication. I would also like to thank Sri Soumya Ranjan Patnaik, Chairman KMBB College of Engineering and Technology for having permitted my sabbatical at HKUST.

As the world grapples with the unprecedented Covid19 pandemic, I hope you are staying safe and healthy. I join you in looking forward to a brighter future as humanity learns the right lessons and rebuilds a climate-resistant and equitable new world.

Dhanada K. Mishra*

Guest Editor, ICJ

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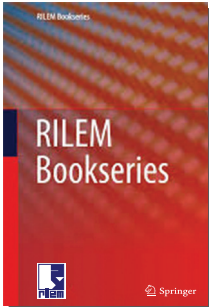
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RILEM UPDATE

The International Union of Laboratories and Experts in Construction Materials, Systems and Structures

NEW PUBLICATIONS

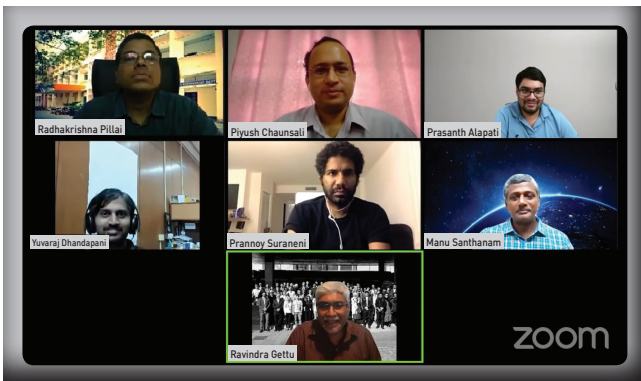


RILEM is glad to announce the recent publication of two new proceedings:

- Proceedings of the 3rd International Conference on Calcined Clays for Sustainable Concrete (S. Bishnoi)
- Proceedings of ConcreteLife'20 - Concrete Durability and Service Life Planning (K. Kovler)

More info can be found here: <https://www.rilem.net/news/395>

RILEM EVENT REPORT



Online Workshop on "Recent Advances in Science and Technology of Concrete"

*RILEM Online Conferences & Transfer of Knowledge (ROC&TOK)
Saturday 2nd May*

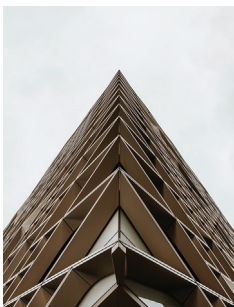
The first (of many more to come!!!) workshop of the brand-new series of ONLINE events called RILEM Online Conferences & Transfer of Knowledge (ROC&TOK) successfully took place in May 2020. The workshop, titled "Recent Advances in Science and Technology of Concrete", was organised by the Indian Institute of Technology Madras, Chennai, India, with the co-sponsorship of RILEM in partnership with the Indian Concrete Institute. More than 9,600

people registered, mostly from India and 30+ other countries, to view the event that was streamed live on YouTube. The video of the workshop is still available here <https://www.youtube.com/watch?v=gKZn2aaujHQ&feature=youtu.be>.

Although the benefits of conventional conferences, such as networking, social interactions and collateral visits, are appreciated and not to be discouraged, the workshop organisers ably showed that online seminars could provide an adequate solution in situations such as those imposed by the COVID-19 pandemic, when conventional gatherings are not feasible. After the positive experience of this first workshop, the ROC&TOK can build on its attributes to reach its primary goal, i.e. to continue having scientific discussions and dissemination of new research.

More information about the speakers and the content of each of the seven presentations can be found here: www.bit.ly/2W05n5i

UPCOMING RILEM EVENTS



74th RILEM Annual Week and 40th Cement and Concrete Science Conference

31 August-4 September 2020, Sheffield, UK

Due to the current COVID-19 pandemic and to ensure that all conference delegates are able to gain the maximum possible benefit from the meetings, sessions and presentations, the conference organisers have taken the decision to move the conference and all associated committee meetings into an **online format**.

Further information will be made available through the conference website <https://www.sheffield.ac.uk/materials/rilem2020>