

RILEM Bookseries

Freek P. Bos  
Sandra S. Lucas  
Rob J. M. Wolfs  
Theo A. M. Salet *Editors*

# Second RILEM International Conference on Concrete and Digital Fabrication

Digital Concrete 2020



 Springer

The Springer logo features a stylized white chess knight piece on a red background, positioned to the left of the word "Springer" in a white, serif font.

# **Second RILEM International Conference on Concrete and Digital Fabrication**

## **RILEM BOOKSERIES**

### **Volume 28**

RILEM, The International Union of Laboratories and Experts in Construction Materials, Systems and Structures, founded in 1947, is a non-governmental scientific association whose goal is to contribute to progress in the construction sciences, techniques and industries, essentially by means of the communication it fosters between research and practice. RILEM's focus is on construction materials and their use in building and civil engineering structures, covering all phases of the building process from manufacture to use and recycling of materials. More information on RILEM and its previous publications can be found on [www.RILEM.net](http://www.RILEM.net). Indexed in SCOPUS, Google Scholar and SpringerLink.



More information about this series at <http://www.springer.com/series/8781>

Freek P. Bos · Sandra S. Lucas ·  
Rob J. M. Wolfs · Theo A. M. Salet  
Editors

# Second RILEM International Conference on Concrete and Digital Fabrication

Digital Concrete 2020

 Springer

*Editors*

Freek P. Bos  
Built Environment  
Eindhoven University of Technology  
Eindhoven, The Netherlands

Sandra S. Lucas  
Built Environment  
Eindhoven University of Technology  
Eindhoven, The Netherlands

Rob J. M. Wolfs  
Built Environment  
Eindhoven University of Technology  
Eindhoven, The Netherlands

Theo A. M. Salet  
Built Environment  
Eindhoven University of Technology  
Eindhoven, The Netherlands

ISSN 2211-0844

ISSN 2211-0852 (electronic)

RILEM Bookseries

ISBN 978-3-030-49915-0

ISBN 978-3-030-49916-7 (eBook)

<https://doi.org/10.1007/978-3-030-49916-7>

© RILEM 2020

No part of this work may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, microfilming, recording or otherwise, without written permission from the Publisher, with the exception of any material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work. Permission for use must always be obtained from the owner of the copyright: RILEM.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG  
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

# Preface

It is our great pride and pleasure to present to you the proceedings of *Digital Concrete 2020*, the 2nd RILEM International Conference on Concrete and Digital Fabrication. More than 100 papers await you, collected from around the globe.

*Digital Concrete* was initiated by the RILEM Technical Committee 276 Digital Fabrication with cement-based materials. Starting in 2016, this committee has stood at the cradle of an impetuously growing field of technologies and associated research. Driven by the promise of increased productivity and speed, reduced material use and cost, and enhanced geometrical freedom, digital fabrication methods with cement-based materials have taken a flight. The number of papers has tripled since the first *Digital Concrete* conference, held in September of 2018 at the ETH Zurich, Switzerland. Distinctive areas of research within the field are becoming discernable, such as mixture design, rheology & fresh state behaviour, hardened properties, and structural engineering. Technology, equipment and digital design strategies, is a particular field of research that more than ever plays a key role in the development of cement-based manufacturing. It builds new collaborations between previously unrelated fields of expertise. A significant number of contributions in each of these areas can be found in these proceedings. In addition, we also find papers aimed at applications, as well as studies on the impact of these technologies, such as life cycle and economic analyses. This mirrors the expansive growth of ‘real’ applications.

Professional associations are setting up and expanding working groups. Figuratively speaking, we are moving from childhood into adolescence. This means our capabilities are growing rapidly, and every day we can do more—better, faster, and higher. This brings joy and excitement. However, whilst our capabilities are growing, so are our responsibilities. Digital fabrication with cement-based materials will need to provide quality, safety, and sustainability. Academics and professionals need to reach out to make sure that scientific results, ranging from the quantification of ‘printability’ to shrinkage control, from low-emission binders to reinforcement, from interface properties to design methodology and many more, find their way into practice. Vice versa, lessons and needs from industry should guide research directions and priorities. *Digital Concrete* is the platform where this synergy is

forged. We extend a virtual warm welcome to you, as this 2020 edition proceeds online in tumultuous times when the COVID-19 virus shakes our world. In addition, we hope to see you in person too at the on-location *Digital Concrete 2020 (re) visited workshop* in Eindhoven in 2021.

*Digital Concrete 2020* presents an outstanding line-up of keynote speakers that represent the state-of-the-art of research across the globe. Once again, *Digital Concrete* has teamed up with *Cement & Concrete Research* to deliver a dedicated special issue containing 13 papers from renowned experts in the field, including the keynote speakers. Furthermore, the Dutch magazine *Cement* publishes a theme issue in Dutch with selected proceedings papers, for the local professional market.

We would like to thank all the authors for their contributions: their excellent work provides the backbone of the conference and allows the world to learn and grow. We thank the keynote speakers and gratefully acknowledge the support of RILEM and the Scientific and Organizing Committees. A special word of gratitude goes to our sponsors, which at the time of writing included Saint Gobain Weber Beamix, Sika, and Twente Additive Manufacturing (platinum), Bekaert (gold), and BASF and Dow (Silver).

Finally, we thank you, reader and conference participant, and hope you will enjoy an inspiring conference.

July 2020

Freek Bos  
Rob Wolfs  
Sandra Lucas  
Theo Salet

# Organization

## Conference Committees

### Conference Chair

Theo A. M. Salet  
Eindhoven University of Technology,  
The Netherlands

### Conference Vice Chair

Freek P. Bos  
Eindhoven University of Technology,  
The Netherlands

## International Scientific Committee

Nicolas Roussel (Chair)	IFSTTAR, France
Alexandre Pierre	University of Cergy-Pontoise, France
Alper Yıkıcı	MEF University, Turkey
Arnaud Perrot	University of Southern Brittany, France
Asko Fromm	University of Wismar, Germany
Behzad Nematollahi	Swinburne University of Technology, Australia
Chalermwut Snguanvat	SCG Cement-Building Materials Co., Ltd., Thailand
Christoph Gehlen	Technical University of Munich, Germany
Costantino Menna	University of Naples “Federico II”, Italy
Dietmar Stephan	Technical University of Berlin, Germany
Dirk Lowke	TU Braunschweig, Germany
Domenico Asprone	University of Naples “Federico II”, Italy
Fabrice Toussaint	LafargeHolcim, France
Freek Bos	Eindhoven University of Technology, The Netherlands
Geert De Schutter	Ghent University, Belgium
Giovanni Volpatti	CEMEX Research Group AG, Switzerland



Harald Kloft	TU Braunschweig, Germany
Hélène Lombois-Burger	LafargeHolcim Ltd, France
Jaime Mata-Falcón	ETH Zurich, Switzerland
Jay Sanjayan	Swinburne University of Technology, Australia
Kim Van Tittelboom	Ghent University, Belgium
Ksenija Vasilic	German Society for Concrete and Construction Technology, Germany
Liberato Ferrara	Politecnico di Milano, Italy
Miguel Azenha	University of Minho, Portugal
Mohammed Sonebi	Queen's University Belfast, UK
Nathan Tregger	GCP Applied Technologies, USA
Philippe Leblond	University of Paris-Est, France
Richard Buswell	Loughborough University, UK
Rob Wolfs	Eindhoven University of Technology, The Netherlands
Robert Flatt	ETH Zurich, Switzerland
Roel Schipper	TU Delft, The Netherlands
Rolands Cepuritis	Norwegian University of Science and Technology, Norway
Sandra Lucas	Eindhoven University of Technology, The Netherlands
Sandra Nunes	University of Porto, Portugal
Sandro Moro	BASF Construction Chemicals Italia Spa, Italy
Scott Z. Jones	National Institute of Standards and Technology, USA
Sébastien Rémond	University of Orléans, France
Shiho Kawashima	Columbia University, USA
Steffen Grunewald	Ghent University, Belgium
Theo Salet	Eindhoven University of Technology, The Netherlands
Timothy Wangler	ETH Zurich, Switzerland
Venkatesh Naidu Nerella	TU Dresden, Germany
Viktor Mechtcherine	TU Dresden, Germany
Vítor Cunha	University of Minho, Portugal
Wilson Leal da Silva	Danish Technological Institute, Denmark
Xiangming Zhou	Brunel University London, UK
Zhendi Wang	Brunel University London, UK

## **Local Organizing Committee**

Freek P. Bos (Chair)  
 Theo A. M. Salet  
 Rob J. M. Wolfs  
 Sandra S. Lucas

Lauri Hass  
Karsten Nefs  
Derk Bos  
Zeeshan Y. Ahmed  
Stefan Chaves Figueiredo  
Naomi van Hierden  
Monique van Gaalen  
Ginny Vissers  
Department of the Built Environment  
Eindhoven University of Technology  
Eindhoven, the Netherlands

# Contents

<b>Mixture Design, Admixtures and Alternative Binder</b>	
<b>An Fe-Rich Slag-Based Mortar for 3D Printing</b> . . . . .	3
Glenn Beersaerts, Sandra S. Lucas, and Yiannis Pontikes	
<b>Enhancing Buildability of 3D Printable Concrete by Spraying of Accelerating Admixture on Surface</b> . . . . .	13
Shantanu Bhattacharjee and Manu Santhanam	
<b>Effect of Wollastonite Micro-Fiber Addition on Properties of 3D-Printable ‘Just-Add-Water’ Geopolymers</b> . . . . .	23
Shin Hau Bong, Behzad Nematollahi, Arun R. Arunothayan, Ming Xia, and Jay Sanjayan	
<b>Synthesis of Hybridized Rheological Modifiers for 3D Concrete Printing</b> . . . . .	32
AlaEddin Douba, Clare Chan, Stephanie Berrios, and Shiho Kawashima	
<b>Control of Strand Properties Produced with Shotcrete 3D Printing by Accelerator Dosage and Process Parameters</b> . . . . .	42
Inka Dressler, Niklas Freund, and Dirk Lowke	
<b>Comparison of Printable Inorganic Binders - Key Properties for 3D Printable Materials</b> . . . . .	53
Tamino Hirsch, Tobias Dorn, Clemens Ehm, and Dietmar Stephan	
<b>Design of Energy-Efficient White Portland Cement Mortars for Digital Fabrication</b> . . . . .	64
Sibel Kurt, Yiğit A. Atalay, Ozan E. Aydın, Berrak Avcıoğlu, Tayfun Yıldırım, Gizem B. Göktepe, Sedat Emir, Zeynep B. Bundur, and Halime Ö. Paksoy	

<b>Use of the Chemical and Mineral Admixtures to Tailor the Rheology and the Green Strength of 3D Printing Cementitious Mixtures</b> . . . . .	73
Mohammad Amin Moeini, Masoud Hosseinpoor, and Ammar Yahia	
<b>Characterising Concrete Mixes for 3D Printing</b> . . . . .	83
Atteyeh S. Natanzi and Ciaran McNally	
<b>Digital Fabrication of ‘Just-Add-Water’ Geopolymers: Effects of Curing Condition and Print-Time Interval</b> . . . . .	93
Behzad Nematollahi, Shin Hau Bong, Ming Xia, and Jay Sanjayan	
<b>Advances in Binder-Jet 3D Printing of Non-cementitious Materials</b> . . . . .	103
Pietro Odaglia, Vera Voney, Benjamin Dillenburger, and Guillaume Habert	
<b>Rubber-Cement Composites for Additive Manufacturing: Physical, Mechanical and Thermo-Acoustic Characterization</b> . . . . .	113
Matteo Sambucci, Marco Valente, Abbas Sibai, Danilo Marini, Alessia Quitadamo, and Ettore Musacchi	
<b>Properties of Composite Modified with Limestone Powder for 3D Concrete Printing</b> . . . . .	125
Szymon Skibicki, Maria Kaszyńska, Nawid Wahib, Mateusz Techman, Karol Federowicz, Adam Zieliński, Tomasz Wróblewski, Norbert Olczyk, and Marcin Hoffmann	
<b>Effect of Limestone Powder Substitution on Fresh and Hardened Properties of 3D Printable Mortar</b> . . . . .	135
Yaxin Tao, Karel Lesage, Kim Van Tittelboom, Yong Yuan, and Geert De Schutter	
<b>Rheology Evaluation of Cement Paste with Nanoclays, Nanosilica and Polymeric Admixtures for Digital Fabrication</b> . . . . .	144
Hugo Varela, Gonzalo Barluenga, and Irene Palomar	
<b>Geopolymer Formulation for Binder Jet 3D Printing</b> . . . . .	153
Vera Voney, Pietro Odaglia, Coralie Brumaud, Benjamin Dillenburger, and Guillaume Habert	
<b>Lightweight Concrete 3D Printing by Selective Cement Activation – Investigation of Thermal Conductivity, Strength and Water Distribution</b> . . . . .	162
Daniel Weger, Heejeong Kim, Daniel Talke, Klaudius Henke, Thomas Kränkel, and Christoph Gehlen	

**Rheology and Fresh State Behaviour**

**Numerical Model Describing the Early Age Behavior of 3D Printed Concrete – Work in Progress** . . . . . 175  
 Sebastian Andersen, Wilson Ricardo Leal da Silva, Ieva Paegle, and Jens Henrik Nielsen

**Characterisation of the Layer Pressing Strategy for Concrete 3D Printing** . . . . . 185  
 Paul Carneau, Romain Mesnil, Nicolas Ducoulombier, Nicolas Roussel, and Olivier Baverel

**A Compendious Rheo-Mechanical Test for Printability Assessment of 3D Printable Concrete** . . . . . 196  
 Seung Cho, Jacques Kruger, Frederick Bester, Marchant van den Heever, Algurnon van Rooyen, and Gideon van Zijl

**Effect of Metakaolin, Fly Ash and Polypropylene Fibres on Fresh and Rheological Properties of 3D Printing Based Cement Materials** . . . . . 206  
 M. Dedenis, M. Sonebi, S. Amziane, A. Perrot, and G. Amato

**“The Slug Test”: Inline Assessment of Yield Stress for Extrusion-Based Additive Manufacturing** . . . . . 216  
 Nicolas Ducoulombier, Paul Carneau, Romain Mesnil, Léo Demont, Jean-François Caron, and Nicolas Roussel

**Fresh and Hardened Properties of 3D-Printed Concrete Made with Dune Sand** . . . . . 225  
 Hilal El-Hassan, Fady Alnajjar, Hamad Al Jassmi, and Waleed Ahmed

**An Experimental Testing Procedure to Assess the Buildability Performance of 3D Printed Concrete Elements** . . . . . 235  
 Laura Esposito, Costantino Menna, Domenico Asprone, Chiara Rossino, and Maurizio Marchi

**Investigation on the Rheological Behavior of Lightweight Foamed Concrete for 3D Printing Applications** . . . . . 246  
 Devid Falliano, Giuseppe Crupi, Dario De Domenico, Giuseppe Ricciardi, Luciana Restuccia, Giuseppe Ferro, and Ernesto Gugliandolo

**Experimental Investigation on the Early Age Tensile Strength of Fiber Reinforced Mortar Used in 3D Concrete Printing** . . . . . 255  
 Marta Fioretti, K. Sriram Kompella, Francesco Lo Monte, Laura Esposito, Costantino Menna, Sandro Moro, Domenico Asprone, and Liberato Ferrara

**Transition from Fluid to Solid Concrete in the Flexible Mould Process** . . . . . 262  
 Steffen Grünewald and Roel Schipper

<b>Physico-Chemical Characterization at Early-Age of 3D Printed Mortar</b> . . . . .	272
Ilhame Harbouz, Emmanuel Roziere, Ammar Yahia, and Ahmed Loukili	
<b>Gravity Driven Tests to Assess Mechanical Properties of Printable Cement-Based Materials at Fresh State</b> . . . . .	280
Yohan Jacquet, Vincent Picandet, Damien Rangeard, and Arnaud Perrot	
<b>Characterizing Extrudability for 3D Concrete Printing Using Discrete Element Simulations</b> . . . . .	290
Roshan Jayathilakage, Jay Sanjayan, and Pathmanathan Rajeev	
<b>Investigation on Structural Build-Up of 3D Printable Foam Concrete</b> . . . . .	301
Viacheslav Markin, Irina Ivanova, Shirin Fataei, Silvia Reißig, and Viktor Mechtcherine	
<b>Effect of Cement Type and Limestone Powder Content on Extrudability of Lightweight Concrete</b> . . . . .	312
Carla Matthäus, Daniel Back, Daniel Weger, Thomas Kränkel, Jennifer Scheydt, and Christoph Gehlen	
<b>Numerical Modeling of an Extrusion-Based 3D Concrete Printing Process Considering a Spatially Varying Pseudo-Density Approach</b> . . . . .	323
Meron Mengesha, Albrecht Schmidt, Luise Göbel, and Tom Lahmer	
<b>Evaluating the Influence of Aggregate Content on Pumpability of 3D Printable Concrete</b> . . . . .	333
Manu K. Mohan, A. V. Rahul, Kim Van Tittelboom, and Geert De Schutter	
<b>2D Numerical Modelling of Particle-Bed 3D Printing by Selective Paste Intrusion</b> . . . . .	342
Alexandre Pierre, Daniel Weger, Arnaud Perrot, and Dirk Lowke	
<b>Effect of Vibration on the Rheology of Concrete for 3D Printing</b> . . . . .	353
K. Pattaje Sooryanarayana, P. Stynoski, and D. Lange	
<b>Prediction of the Yield Stress of Printing Mortar Ink</b> . . . . .	360
Sergis Vasileios, Malo Charrier, and Claudiane M. Ouellet-Plamondon	
<b>Dynamic and Static Yield Stress Determination of Cementitious Paste with Admixtures</b> . . . . .	370
Karim Zongo, Malo Charrier, Corentin Duval, and Claudiane M. Ouellet-Plamondon	
<b>Penetration Study of Liquid in Powder Bed for 3D Powder-Bed Printing</b> . . . . .	379
Wenqiang Zuo, Chenghao Dong, Emmanuel Keita, and Nicolas Roussel	

**Mechanical Performance**

**Quantitative Evaluation of Orientation of Steel Fibers in 3D-Printed Ultra-High Performance Concrete** . . . . . 389  
 Arun R. Arunothayan, Behzad Nematollahi, Jay Sanjayan, Ravi Ranade, Shin Hau Bong, and Kamal Khayat

**Steel Fiber Links in 3D Printed Concrete** . . . . . 398  
 Frederick Bester, Marchant van den Heever, Jacques Kruger, Seung Cho, and Gideon van Zijl

**Mechanical Characterization of Cement-Based Mortar Used in 3DCP Including Early-Age Creep Effects**. . . . . 407  
 Lorenzo Casagrande, Laura Esposito, Costantino Menna, Domenico Asprone, and Ferdinando Auricchio

**Influence of Pumping/Extrusion on the Air-Void System of 3D Printed Concrete** . . . . . 417  
 Arnesh Das, Yu Song, Sara Mantellato, Timothy Wangler, Robert J. Flatt, and David A. Lange

**Fire Behavior of a Printed Sample for Building** . . . . . 428  
 Melody D’Hondt, Sébastien Rémond, Philippe Leblond, Bunthan Iea, Estelle Hynek, and Nicolas Pinoteau

**Effect of Metallic Fibers on the Print Quality and Strength of 3D Printed Concrete** . . . . . 439  
 Rashid Hameed, Aurélie Papon, Arnaud Perrot, and Damien Rängeard

**Facilitating Ductile Failure of 3D Printed Concrete Elements in Fire** . . . . . 449  
 Jacques Kruger, Antonio Cicione, Frederick Bester, Marchant van den Heever, Seung Cho, Richard Walls, and Gideon van Zijl

**High-Performance Light-Weight Concrete for 3D Printing** . . . . . 459  
 Malek Mohammad, Eyad Masad, Thomas Seers, and Sami G. Al-Ghamdi

**Mechanical Characterization of Layer-by-Layer Interface in Concrete Elements Obtained by Additive Manufacturing** . . . . . 468  
 Rosanna Napolitano, Costantino Menna, Domenico Asprone, and Lorenzo Del Giudice

**Dynamic Behaviour of Layered 3D Printed Concrete Elements** . . . . . 478  
 Rosanna Napolitano, Costantino Menna, Daniele Forni, Domenico Asprone, and Ezio Cadoni

<b>Characterizing the Fissility of 3D Concrete Printed Elements via the Cohesive Zone Method . . . . .</b>	<b>489</b>
Marchant van den Heever, Frederick Bester, Mohammad Pourbehi, Jacques Kruger, Seung Cho, and Gideon van Zijl	
<b>3D Printing of Concrete: The Influence on Chloride Penetration . . . . .</b>	<b>500</b>
Jolien Van Der Putten, Melissa De Volder, Philip Van den Heede, Geert De Schutter, and Kim Van Tittelboom	
<b>Effect of Heat Curing and E6-Glass Fibre Reinforcement Addition on Powder-Based 3DP Cement Mortar . . . . .</b>	<b>508</b>
Pshtivan Shakor, Shami Nejadi, and Nadarajah Gowripalan	
<b>Effect of Polypropylene Fibres on the Mechanical Properties of Extrudable Cementitious Material . . . . .</b>	<b>516</b>
Thadshajini Suntharalingam, Brabha Nagaratnam, Keerthan Poologanathan, Phil Hackney, and Jeffri Ramli	
<b>Improving the Bonding Adhesion of the Cold Joints of Normal and Lightweight 3D Printing Mortars . . . . .</b>	<b>527</b>
Kho P. Verian, Jarron Ashcroft, Matthew D. Carli, Randall P. Bright, Eriek Maandi, Avak Avakian, and Edouard Baaklini	
<b>Interlayer Effect on Fracture Behavior of 3D Printing Concrete . . . . .</b>	<b>537</b>
Yun-Chen Wu, Jason Cotrell, and Mo Li	
<b>Auxetic Behavior of Cementitious Cellular Composites Under Uniaxial Compression and Cyclic Loading . . . . .</b>	<b>547</b>
Yading Xu, Erik Schlangen, and Branko Šavija	
<b>Impact of Particle Size and Grading on Aggregate-Bed 3D Concrete Printing . . . . .</b>	<b>557</b>
Shiwei Yu, Jay Sanjayan, and Hongjian Du	
<b>Drying of 3D Printed Mortar Filaments at Early Age Assessed by X-Ray Computed Tomography . . . . .</b>	<b>564</b>
Wenqiang Zuo, Emmanuel Keita, Michel Bornert, and Nicolas Roussel	
<b>Structural Engineering and Reinforcement</b>	
<b>Printed Concrete as Formwork Material: A Preliminary Study . . . . .</b>	<b>575</b>
Michiel Bekaert, Kim Van Tittelboom, and Geert De Schutter	
<b>Bond of Reinforcement Cable in 3D Printed Concrete . . . . .</b>	<b>584</b>
Freek Bos, Steven Dezaire, Zeeshan Ahmed, Anne Hoekstra, and Theo Salet	



**Experimental Investigation of Topology-Optimized Deep Reinforced Concrete Beams with Reduced Concrete Volume** . . . . . 601  
 Yan Liu, Jackson L. Jewett, and Josephine V. Carstensen

**Studying the Bond Properties of Vertical Integrated Short Reinforcement in the Shotcrete 3D Printing Process** . . . . . 612  
 Niklas Freund, Inka Dressler, and Dirk Lowke

**Aligned Interlayer Fibre Reinforcement and Post-tensioning as a Reinforcement Strategy for Digital Fabrication** . . . . . 622  
 Lukas Gebhard, Jaime Mata-Falcón, Ana Anton, Joris Burger, Ena Lloret-Fritschi, Lex Reiter, Benjamin Dillenburger, Fabio Gramazio, Matthias Kohler, Robert Flatt, and Walter Kaufmann

**Bending and Pull-Out Tests on a Novel Screw Type Reinforcement for Extrusion-Based 3D Printed Concrete** . . . . . 632  
 Lauri Hass and Freek Bos

**Load Carrying Capacity and Failure Mode of 3D Printing Mortar Wall Panel Under Axial Compression Loading** . . . . . 646  
 Patiphat Jiramarootapong, Lapyote Prasittisopin, Chalermwut Snguanay, Ganchai Tanapornraweekit, and Somnuk Tangtermsirikul

**Application of 3D Printed Segments Designed by Topology Optimization Analysis to a Practical Scale Prestressed Pedestrian Bridge** . . . . . 658  
 Koji Kinomura, Satoshi Murata, Yujin Yamamoto, Hirotochi Obi, and Akihito Hata

**Potential Approaches for Reinforcing Complex Concrete Structures with Integrated Flexible Formwork** . . . . . 669  
 Minu Lee, Jaime Mata-Falcón, Mariana Popescu, Philippe Block, and Walter Kaufmann

**Penetration Reinforcing Method for 3D Concrete Printing** . . . . . 680  
 Taylor Marchment and Jay Sanjayan

**Combining Multiple Loads in a Topology Optimization Framework for Digitally Fabricated Concrete Structures** . . . . . 691  
 Tommaso Pastore, Costantino Menna, and Domenico Asprone

**Potential for the Integration of Continuous Fiber-Based Reinforcements in Digital Concrete Production** . . . . . 701  
 Martin Scheurer, Gözdem Dittel, and Thomas Gries

**3D Concrete Printing on Site: A Novel Way of Building Houses?** . . . . . 712  
 Jolien Van Der Putten, Alex Van Olmen, Marijke Aerts, Emiel Ascione, Joeri Beneens, Jan Blaakmeer, Geert De Schutter, and Kim Van Tittelboom

<b>Design Optimization for 3D Concrete Printing: Improving Structural and Thermal Performances</b> . . . . .	720
Gieljan Vantghem, Marijke Steeman, Wouter De Corte, and Veerle Boel	
<b>Flexural Behaviour of AR-Glass Textile Reinforced 3D Printed Concrete Beams</b> . . . . .	728
Weiqiang Wang, Nikolaos Konstantinidis, Simon A. Austin, Richard A. Buswell, Sergio Cavalaro, and Domenico Cecinia	
<b>Digital design, Technologies and Industrialization</b>	
<b>3D Concrete Printing - Free Form Geometries with Improved Ductility and Strength</b> . . . . .	741
Zeeshan Ahmed, Alessia Biffi, Lauri Hass, Freek Bos, and Theo Salet	
<b>Print-Cast Concrete: Additive Manufacturing for 3D Printing Mortar in Robotically Fabricated Green Sand Molds</b> . . . . .	757
Christopher A. Battaglia, Martin F. Miller, and Kho P. Verian	
<b>3D Printing of a Cement-Based Mortar in a Complex Fluid Suspension: Analytical Modeling and Experimental Tests</b> . . . . .	768
Abdeslam Benamara, Alexandre Pierre, Abdelhak Kaci, and Yannick Meline	
<b>Experimental Study on 3D Printing of Concrete with Overhangs</b> . . . . .	778
Francis Brun, Florindo Gaspar, Artur Mateus, João Vitorino, and Francisco Diz	
<b>Inspection Methods for 3D Concrete Printing</b> . . . . .	790
Richard Buswell, Peter Kinnell, Jie Xu, Norman Hack, Harald Kloft, Mehdi Maboudi, Markus Gerke, Peter Massin, Georg Grasser, Rob Wolfs, and Freek Bos	
<b>DIGITAL CONSTRUCTION: 3D Printing for Performative Houses</b> . . .	804
Paolo Cascone, Maddalena Laddaga, and Federico Forestiero	
<b>Extended Lattice Model to Simulate the Printing Process of 3D Printed Cementitious Materials</b> . . . . .	814
Ze Chang, Erik Schlangen, and Branko Šavija	
<b>Quality Assessment of Printable Strain Hardening Cementitious Composites Manufactured in Two Different Printing Facilities</b> . . . . .	824
Stefan C. Figueiredo, Anne L. van Overmeir, Karsten Nefs, Erik Schlangen, Theo A. M. Salet, Branko Šavija, Akke S. J. Suiker, and Freek P. Bos	
<b>More Than Meets the Eye? Robotisation and Normativity in the Dutch Construction Industry</b> . . . . .	839
Chantal E. Muishout, Tom N. Coggins, and H. Roel Schipper	

<b>Influence of Processing Parameters on the Layer Geometry in 3D Concrete Printing: Experiments and Modelling</b> . . . . .	852
Raphael Comminal, Wilson Ricardo Leal da Silva, Thomas Juul Andersen, Henrik Stang, and Jon Spangenberg	
<b>Automating Concrete Construction: Digital Design of Non-prismatic Reinforced Concrete Beams</b> . . . . .	863
Eduardo Costa, Paul Shepherd, John Orr, Tim Ibell, and Robin Oval	
<b>Free Deposition Printing for Space Truss Structures</b> . . . . .	873
Romain Duballet, Romain Mesnil, Nicolas Ducoulombier, Paul Carneau, Leo Demont, Mahan Motamedi, Olivier Baverel, Jean-François Caron, and Justin Dirrenberger	
<b>Rapid Composite Formwork: An Automated and Customizable Process for Freeform Concrete Through Computational Design and Robotic Fabrication</b> . . . . .	883
Guy E. Gardner, Kristen Forward, Kim Tse, and Karan Sharma	
<b>Simultaneous Reinforcement of Concrete While 3D Printing</b> . . . . .	895
Omar Geneidy, Sujay Kumarji, Alexandre Dubor, and Aldo Sollazzo	
<b>Additive Manufacturing by Extrusion of Lightweight Concrete - Strand Geometry, Nozzle Design and Layer Layout</b> . . . . .	906
Klaudius Henke, Daniel Talke, and Carla Matthäus	
<b>Extrusion Nozzle Shaping for Improved 3DP of Engineered Cementitious Composites (ECC/SHCC)</b> . . . . .	916
Wes McGee, Tsz Yan Ng, Kequan Yu, and Victor C. Li	
<b>Buildability of Geopolymer Concrete for 3D Printing with Microwave Heating</b> . . . . .	926
Shravan Muthukrishnan, Sayanthan Ramakrishnan, and Jay Sanjayan	
<b>High-Resolution Additive Formwork for Building-Scale Concrete Panels</b> . . . . .	936
Roberto Naboni and Luca Breseghello	
<b>Architectural Applications and Workflows for Additive Fabrication with Concrete</b> . . . . .	946
Pfeiffer Sven, Tobias Dorn, Tamino Hirsch, Clemens Ehm, Dietmar Stephan, and Dimitrios Vassiliadis	
<b>ACDC: The Admixture Controlled Digital Casting and Its Application to Thin Folded Concrete Structures</b> . . . . .	956
Anna Szabo, Lex Reiter, Ena Lloret-Fritschi, Timothy Wangler, Fabio Gramazio, Matthias Kohler, and Robert J. Flatt	

**Robot-Controlled Fabrication of Sprayed Concrete Elements as a Cyber-Physical-System** ..... 967  
Ilija Vukorep, Gregor Zimmermann, and Tino Sablotny

**Reinforced Particle-Bed Printing by Combination of the Selective Paste Intrusion Method with Wire and Arc Additive Manufacturing – A First Feasibility Study** ..... 978  
Daniel Weger, Daniel Baier, Alexander Straßer, Sophia Protting, Thomas Kränkel, Andreas Bachmann, Christoph Gehlen, and Michael Zäh

**Knitting Concrete** ..... 988  
Helena Westerlind and José Hernández

**Concrete 3D Printing: System Development, Process Planning and Experimental Results** ..... 998  
Yu Wang, Shuaishuai Li, Tian Qin, Ying Yu, and Jianzhuang Xiao

**Shape Accuracy Evaluation of Geopolymer Specimens Made Using Particle-Bed 3D Printing** ..... 1011  
Ming Xia, Behzad Nematollahi, and Jay Sanjayan

**Sustainability, LCA and Economical Analyses**

**Environmental Impacts of 6-Axes Robotic Arm for 3D Concrete Printing** ..... 1023  
Kateryna Kuzmenko, Adélaïde Feraille, Olivier Baverel, and Nicolas Roussel

**Preliminary Productivity Analysis of Conventional, Precast and 3D Printing Production Techniques for Concrete Columns with Simple Geometry** ..... 1031  
Raitis Pekuss and Borja García de Soto

**Preliminary Study of the Implications of 3D Printing on the Construction Supply Chain** ..... 1051  
Ayyagari Ramani and Borja Garcia de Soto

**Applications and Case Studies**

**Fast Complexity: Additive Manufacturing for Prefabricated Concrete Slabs** ..... 1067  
Ana Anton, Andrei Jipa, Lex Reiter, and Benjamin Dillenburger

**Architectonic Explorations of the Possibilities of 3D Concrete Printing: The Historic Building Fragment as Inspiration for New Applications with 3D Concrete Printing in Architecture** ..... 1078  
Juliette Bekkering, Barbara Kuit, Alessia Biffi, and Zeeshan Yunus Ahmed

**A Robust Mortar and Printing System** . . . . . 1091  
 J. Blaakmeer and B. Lobo

**Design and Fabrication of a Non-standard, Structural Concrete Column Using Eggshell: Ultra-Thin, 3D Printed Formwork** . . . 1104  
 Joris Burger, Ena Lloret-Fritschi, Nizar Taha, Fabio Scotto, Thibault Demoulin, Jaime Mata-Falcón, Fabio Gramazio, Matthias Kohler, and Robert J. Flatt

**Complex Architecture in Printed Concrete: The Case of the Innsbruck University 350<sup>th</sup> Anniversary Pavilion COHESION** . . . . . 1116  
 G. Grasser, L. Pammer, H. Köll, E. Werner, and F. P. Bos

**Shotcrete 3D Printing Technology for the Fabrication of Slender Fully Reinforced Freeform Concrete Elements with High Surface Quality: A Real-Scale Demonstrator** . . . . . 1128  
 Norman Hack and Harald Kloft

**UHPRC Pavilion of 3-Dimensional Pentagon Tiling** . . . . . 1138  
 Sung-Gul Hong, John Juhyung Chun, Sung-Hoon Kang, and Minsoo Kim

**Field Considerations for Deploying Additive Construction** . . . . . 1147  
 Eric Kreiger, Brandy Diggs-McGee, Tanner Wood, Bruce MacAllister, and Megan Kreiger

**Sustainable Reinforced Concrete Beams: Mechanical Optimisation and 3D-Printed Formwork** . . . . . 1164  
 Sébastien Maitenaz, Romain Mesnil, Paul Onfroy, Nicolas Metge, and Jean-François Caron

**Thermal and Sound Insulation of Large-Scale 3D Extrusion Printing Wall Panel** . . . . . 1174  
 Lapyote Prasittisopin, Kittisak Pongpaisanseree, Patiphat Jiramarootapong, and Chalermwut Snguanyat

**Author Index** . . . . . 1183

# RILEM Publications

The following list is presenting the global offer of RILEM Publications, sorted by series. Each publication is available in printed version and/or in online version.

## RILEM Proceedings (PRO)

**PRO 1:** Durability of High Performance Concrete (ISBN: 2-912143-03-9; e-ISBN: 2-351580-12-5; e-ISBN: 2351580125); *Ed. H. Sommer*

**PRO 2:** Chloride Penetration into Concrete (ISBN: 2-912143-00-04; e-ISBN: 2912143454); *Eds. L.-O. Nilsson and J.-P. Ollivier*

**PRO 3:** Evaluation and Strengthening of Existing Masonry Structures (ISBN: 2-912143-02-0; e-ISBN: 2351580141); *Eds. L. Binda and C. Modena*

**PRO 4:** Concrete: From Material to Structure (ISBN: 2-912143-04-7; e-ISBN: 2351580206); *Eds. J.-P. Bournazel and Y. Malier*

**PRO 5:** The Role of Admixtures in High Performance Concrete (ISBN: 2-912143-05-5; e-ISBN: 2351580214); *Eds. J. G. Cabrera and R. Rivera-Villarreal*

**PRO 6:** High Performance Fiber Reinforced Cement Composites - HPRCC 3 (ISBN: 2-912143-06-3; e-ISBN: 2351580222); *Eds. H. W. Reinhardt and A. E. Naaman*

**PRO 7:** 1st International RILEM Symposium on Self-Compacting Concrete (ISBN: 2-912143-09-8; e-ISBN: 2912143721); *Eds. Å. Skarendahl and Ö. Petersson*

**PRO 8:** International RILEM Symposium on Timber Engineering (ISBN: 2-912143-10-1; e-ISBN: 2351580230); *Ed. L. Boström*

**PRO 9:** 2nd International RILEM Symposium on Adhesion between Polymers and Concrete ISAP '99 (ISBN: 2-912143-11-X; e-ISBN: 2351580249); *Eds. Y. Ohama and M. Puterman*

**PRO 10:** 3rd International RILEM Symposium on Durability of Building and Construction Sealants (ISBN: 2-912143-13-6; e-ISBN: 2351580257); *Eds. A. T. Wolf*

**PRO 11:** 4th International RILEM Conference on Reflective Cracking in Pavements (ISBN: 2-912143-14-4; e-ISBN: 2351580265); *Eds. A. O. Abd El Halim, D. A. Taylor and El H. H. Mohamed*

**PRO 12:** International RILEM Workshop on Historic Mortars: Characteristics and Tests (ISBN: 2-912143-15-2; e-ISBN: 2351580273); *Eds. P. Bartos, C. Groot and J. J. Hughes*

**PRO 13:** 2nd International RILEM Symposium on Hydration and Setting (ISBN: 2-912143-16-0; e-ISBN: 2351580281); *Ed. A. Nonat*

**PRO 14:** Integrated Life-Cycle Design of Materials and Structures - ILCDES 2000 (ISBN: 951-758-408-3; e-ISBN: 235158029X); (ISSN: 0356-9403); *Ed. S. Sarja*

**PRO 15:** Fifth RILEM Symposium on Fibre-Reinforced Concretes (FRC) - BEFIB'2000 (ISBN: 2-912143-18-7; e-ISBN: 291214373X); *Eds. P. Rossi and G. Chanvillard*

**PRO 16:** Life Prediction and Management of Concrete Structures (ISBN: 2-912143-19-5; e-ISBN: 2351580303); *Ed. D. Naus*

**PRO 17:** Shrinkage of Concrete – Shrinkage 2000 (ISBN: 2-912143-20-9; e-ISBN: 2351580311); *Eds. V. Baroghel-Bouny and P.-C. Aïtcin*

**PRO 18:** Measurement and Interpretation of the On-Site Corrosion Rate (ISBN: 2-912143-21-7; e-ISBN: 235158032X); *Eds. C. Andrade, C. Alonso, J. Fullea, J. Polimon and J. Rodriguez*

**PRO 19:** Testing and Modelling the Chloride Ingress into Concrete (ISBN: 2-912143-22-5; e-ISBN: 2351580338); *Eds. C. Andrade and J. Kropp*

**PRO 20:** 1st International RILEM Workshop on Microbial Impacts on Building Materials (CD 02) (e-ISBN 978-2-35158-013-4); *Ed. M. Ribas Silva*

**PRO 21:** International RILEM Symposium on Connections between Steel and Concrete (ISBN: 2-912143-25-X; e-ISBN: 2351580346); *Ed. R. Eligehausen*

**PRO 22:** International RILEM Symposium on Joints in Timber Structures (ISBN: 2-912143-28-4; e-ISBN: 2351580354); *Eds. S. Aicher and H.-W. Reinhardt*

**PRO 23:** International RILEM Conference on Early Age Cracking in Cementitious Systems (ISBN: 2-912143-29-2; e-ISBN: 2351580362); *Eds. K. Kovler and A. Bentur*

**PRO 24:** 2nd International RILEM Workshop on Frost Resistance of Concrete (ISBN: 2-912143-30-6; e-ISBN: 2351580370); *Eds. M. J. Setzer, R. Auberg and H.-J. Keck*

**PRO 25:** International RILEM Workshop on Frost Damage in Concrete (ISBN: 2-912143-31-4; e-ISBN: 2351580389); *Eds. D. J. Janssen, M. J. Setzer and M. B. Snyder*

**PRO 26:** International RILEM Workshop on On-Site Control and Evaluation of Masonry Structures (ISBN: 2-912143-34-9; e-ISBN: 2351580141); *Eds. L. Binda and R. C. de Vekey*

**PRO 27:** International RILEM Symposium on Building Joint Sealants (CD03; e-ISBN: 235158015X); *Ed. A. T. Wolf*

**PRO 28:** 6th International RILEM Symposium on Performance Testing and Evaluation of Bituminous Materials - PTEBM'03 (ISBN: 2-912143-35-7; e-ISBN: 978-2-912143-77-8); *Ed. M. N. Partl*

**PRO 29:** 2nd International RILEM Workshop on Life Prediction and Ageing Management of Concrete Structures (ISBN: 2-912143-36-5; e-ISBN: 2912143780); *Ed. D. J. Naus*

**PRO 30:** 4th International RILEM Workshop on High Performance Fiber Reinforced Cement Composites - HPFRCC 4 (ISBN: 2-912143-37-3; e-ISBN: 2912143799); *Eds. A. E. Naaman and H. W. Reinhardt*

**PRO 31:** International RILEM Workshop on Test and Design Methods for Steel Fibre Reinforced Concrete: Background and Experiences (ISBN: 2-912143-38-1; e-ISBN: 2351580168); *Eds. B. Schnütgen and L. Vandewalle*

**PRO 32:** International Conference on Advances in Concrete and Structures 2 vol. (ISBN (set): 2-912143-41-1; e-ISBN: 2351580176); *Eds. Ying-shu Yuan, Surendra P. Shah and Heng-lin Lü*

**PRO 33:** 3rd International Symposium on Self-Compacting Concrete (ISBN: 2-912143-42-X; e-ISBN: 2912143713); *Eds. Ó. Wallevik and I. Nielsson*

**PRO 34:** International RILEM Conference on Microbial Impact on Building Materials (ISBN: 2-912143-43-8; e-ISBN: 2351580184); *Ed. M. Ribas Silva*

**PRO 35:** International RILEM TC 186-ISA on Internal Sulfate Attack and Delayed Ettringite Formation (ISBN: 2-912143-44-6; e-ISBN: 2912143802); *Eds. K. Scrivener and J. Skalny*

**PRO 36:** International RILEM Symposium on Concrete Science and Engineering – A Tribute to Arnon Bentur (ISBN: 2-912143-46-2; e-ISBN: 2912143586); *Eds. K. Kovler, J. Marchand, S. Mindess and J. Weiss*

**PRO 37:** 5th International RILEM Conference on Cracking in Pavements – Mitigation, Risk Assessment and Prevention (ISBN: 2-912143-47-0; e-ISBN: 2912143764); *Eds. C. Petit, I. Al-Qadi and A. Millien*



**PRO 38:** 3rd International RILEM Workshop on Testing and Modelling the Chloride Ingress into Concrete (ISBN: 2-912143-48-9; e-ISBN: 2912143578); *Eds. C. Andrade and J. Kropp*

**PRO 39:** 6th International RILEM Symposium on Fibre-Reinforced Concretes - BEFIB 2004 (ISBN: 2-912143-51-9; e-ISBN: 2912143748); *Eds. M. Di Prisco, R. Felicetti and G. A. Plizzari*

**PRO 40:** International RILEM Conference on the Use of Recycled Materials in Buildings and Structures (ISBN: 2-912143-52-7; e-ISBN: 2912143756); *Eds. E. Vázquez, Ch. F. Hendriks and G. M. T. Janssen*

**PRO 41:** RILEM International Symposium on Environment-Conscious Materials and Systems for Sustainable Development (ISBN: 2-912143-55-1; e-ISBN: 2912143640); *Eds. N. Kashino and Y. Ohama*

**PRO 42:** SCC'2005 - China: 1st International Symposium on Design, Performance and Use of Self-Consolidating Concrete (ISBN: 2-912143-61-6; e-ISBN: 2912143624); *Eds. Zhiwu Yu, Caijun Shi, Kamal Henri Khayat and Youjun Xie*

**PRO 43:** International RILEM Workshop on Bonded Concrete Overlays (e-ISBN: 2-912143-83-7); *Eds. J. L. Granju and J. Silfwerbrand*

**PRO 44:** 2nd International RILEM Workshop on Microbial Impacts on Building Materials (CD11) (e-ISBN: 2-912143-84-5); *Ed. M. Ribas Silva*

**PRO 45:** 2nd International Symposium on Nanotechnology in Construction, Bilbao (ISBN: 2-912143-87-X; e-ISBN: 2912143888); *Eds. Peter J. M. Bartos, Yolanda de Miguel and Antonio Porro*

**PRO 46:** ConcreteLife'06 - International RILEM-JCI Seminar on Concrete Durability and Service Life Planning: Curing, Crack Control, Performance in Harsh Environments (ISBN: 2-912143-89-6; e-ISBN: 291214390X); *Ed. K. Kovler*

**PRO 47:** International RILEM Workshop on Performance Based Evaluation and Indicators for Concrete Durability (ISBN: 978-2-912143-95-2; e-ISBN: 9782912143969); *Eds. V. Baroghel-Bouny, C. Andrade, R. Torrent and K. Scrivener*

**PRO 48:** 1st International RILEM Symposium on Advances in Concrete through Science and Engineering (e-ISBN: 2-912143-92-6); *Eds. J. Weiss, K. Kovler, J. Marchand, and S. Mindess*

**PRO 49:** International RILEM Workshop on High Performance Fiber Reinforced Cementitious Composites in Structural Applications (ISBN: 2-912143-93-4; e-ISBN: 2912143942); *Eds. G. Fischer and V. C. Li*

**PRO 50:** 1st International RILEM Symposium on Textile Reinforced Concrete (ISBN: 2-912143-97-7; e-ISBN: 2351580087); *Eds. Josef Hegger, Wolfgang Brameshuber and Norbert Will*

**PRO 51:** 2nd International Symposium on Advances in Concrete through Science and Engineering (ISBN: 2-35158-003-6; e-ISBN: 2-35158-002-8); *Eds. J. Marchand, B. Bissonnette, R. Gagné, M. Jolin and F. Paradis*

**PRO 52:** Volume Changes of Hardening Concrete: Testing and Mitigation (ISBN: 2-35158-004-4; e-ISBN: 2-35158-005-2); *Eds. O. M. Jensen, P. Lura and K. Kovler*

**PRO 53:** High Performance Fiber Reinforced Cement Composites - HPRCC5 (ISBN: 978-2-35158-046-2; e-ISBN: 978-2-35158-089-9); *Eds. H. W. Reinhardt and A. E. Naaman*

**PRO 54:** 5th International RILEM Symposium on Self-Compacting Concrete (ISBN: 978-2-35158-047-9; e-ISBN: 978-2-35158-088-2); *Eds. G. De Schutter and V. Boel*

**PRO 55:** International RILEM Symposium Photocatalysis, Environment and Construction Materials (ISBN: 978-2-35158-056-1; e-ISBN: 978-2-35158-057-8); *Eds. P. Baglioni and L. Cassar*

**PRO 56:** International RILEM Workshop on Integral Service Life Modelling of Concrete Structures (ISBN 978-2-35158-058-5; e-ISBN: 978-2-35158-090-5); *Eds. R. M. Ferreira, J. Gulikers and C. Andrade*

**PRO 57:** RILEM Workshop on Performance of cement-based materials in aggressive aqueous environments (e-ISBN: 978-2-35158-059-2); *Ed. N. De Belie*

**PRO 58:** International RILEM Symposium on Concrete Modelling - CONMOD'08 (ISBN: 978-2-35158-060-8; e-ISBN: 978-2-35158-076-9); *Eds. E. Schlangen and G. De Schutter*

**PRO 59:** International RILEM Conference on On Site Assessment of Concrete, Masonry and Timber Structures - SACoMaTiS 2008 (ISBN set: 978-2-35158-061-5; e-ISBN: 978-2-35158-075-2); *Eds. L. Binda, M. di Prisco and R. Felicetti*

**PRO 60:** Seventh RILEM International Symposium on Fibre Reinforced Concrete: Design and Applications - BEFIB 2008 (ISBN: 978-2-35158-064-6; e-ISBN: 978-2-35158-086-8); *Ed. R. Gettu*

**PRO 61:** 1st International Conference on Microstructure Related Durability of Cementitious Composites 2 vol., (ISBN: 978-2-35158-065-3; e-ISBN: 978-2-35158-084-4); *Eds. W. Sun, K. van Breugel, C. Miao, G. Ye and H. Chen*

**PRO 62:** NSF/ RILEM Workshop: In-situ Evaluation of Historic Wood and Masonry Structures (e-ISBN: 978-2-35158-068-4); *Eds. B. Kasal, R. Anthony and M. Drdácáký*

**PRO 63:** Concrete in Aggressive Aqueous Environments: Performance, Testing and Modelling, 2 vol., (ISBN: 978-2-35158-071-4; e-ISBN: 978-2-35158-082-0); *Eds. M. G. Alexander and A. Bertron*

**PRO 64:** Long Term Performance of Cementitious Barriers and Reinforced Concrete in Nuclear Power Plants and Waste Management - NUCPERF 2009 (ISBN: 978-2-35158-072-1; e-ISBN: 978-2-35158-087-5); *Eds. V. L'Hostis, R. Gens, C. Gallé*

**PRO 65:** Design Performance and Use of Self-consolidating Concrete - SCC'2009 (ISBN: 978-2-35158-073-8; e-ISBN: 978-2-35158-093-6); *Eds. C. Shi, Z. Yu, K. H. Khayat and P. Yan*

**PRO 66:** 2nd International RILEM Workshop on Concrete Durability and Service Life Planning - ConcreteLife'09 (ISBN: 978-2-35158-074-5; ISBN: 978-2-35158-074-5); *Ed. K. Kovler*

**PRO 67:** Repairs Mortars for Historic Masonry (e-ISBN: 978-2-35158-083-7); *Ed. C. Groot*

**PRO 68:** Proceedings of the 3rd International RILEM Symposium on 'Rheology of Cement Suspensions such as Fresh Concrete (ISBN 978-2-35158-091-2; e-ISBN: 978-2-35158-092-9); *Eds. O. H. Wallevik, S. Kubens and S. Oesterheld*

**PRO 69:** 3rd International PhD Student Workshop on 'Modelling the Durability of Reinforced Concrete (ISBN: 978-2-35158-095-0); *Eds. R. M. Ferreira, J. Gulikers and C. Andrade*

**PRO 70:** 2nd International Conference on 'Service Life Design for Infrastructure' (ISBN set: 978-2-35158-096-7, e-ISBN: 978-2-35158-097-4); *Ed. K. van Breugel, G. Ye and Y. Yuan*

**PRO 71:** Advances in Civil Engineering Materials - The 50-year Teaching Anniversary of Prof. Sun Wei' (ISBN: 978-2-35158-098-1; e-ISBN: 978-2-35158-099-8); *Eds. C. Miao, G. Ye, and H. Chen*

**PRO 72:** First International Conference on 'Advances in Chemically-Activated Materials – CAM'2010' (2010), 264 pp, ISBN: 978-2-35158-101-8; e-ISBN: 978-2-35158-115-5, *Eds. Caijun Shi and Xiaodong Shen*

**PRO 73:** 2nd International Conference on 'Waste Engineering and Management - ICWEM 2010' (2010), 894 pp, ISBN: 978-2-35158-102-5; e-ISBN: 978-2-35158-103-2, *Eds. J. Zh. Xiao, Y. Zhang, M. S. Cheung and R. Chu*

**PRO 74:** International RILEM Conference on 'Use of Superabsorbent Polymers and Other New Additives in Concrete' (2010) 374 pp., ISBN: 978-2-35158-104-9; e-ISBN: 978-2-35158-105-6; *Eds. O. M. Jensen, M. T. Hasholt, and S. Laustsen*

**PRO 75:** International Conference on 'Material Science - 2nd ICTRC - Textile Reinforced Concrete - Theme 1' (2010) 436 pp., ISBN: 978-2-35158-106-3; e-ISBN: 978-2-35158-107-0; *Ed. W. Brameshuber*

**PRO 76:** International Conference on 'Material Science - HetMat - Modelling of Heterogeneous Materials - Theme 2' (2010) 255 pp., ISBN: 978-2-35158-108-7; e-ISBN: 978-2-35158-109-4; *Ed. W. Brameshuber*

**PRO 77:** International Conference on ‘Material Science - AdIPoC - Additions Improving Properties of Concrete - Theme 3’ (2010) 459 pp., ISBN: 978-2-35158-110-0; e-ISBN: 978-2-35158-111-7; *Ed. W. Brameshuber*

**PRO 78:** 2nd Historic Mortars Conference and RILEM TC 203-RHM Final Workshop – HMC2010 (2010) 1416 pp., e-ISBN: 978-2-35158-112-4; *Eds. J. Válek, C. Groot, and J. J. Hughes*

**PRO 79:** International RILEM Conference on Advances in Construction Materials Through Science and Engineering (2011) 213 pp., ISBN: 978-2-35158-116-2, e-ISBN: 978-2-35158-117-9; *Eds. Christopher Leung and K. T. Wan*

**PRO 80:** 2nd International RILEM Conference on Concrete Spalling due to Fire Exposure (2011) 453 pp., ISBN: 978-2-35158-118-6, e-ISBN: 978-2-35158-119-3; *Eds. E. A. B. Koenders and F. Dehn*

**PRO 81:** 2nd International RILEM Conference on Strain Hardening Cementitious Composites (SHCC2-Rio) (2011) 451 pp., ISBN: 978-2-35158-120-9, e-ISBN: 978-2-35158-121-6; *Eds. R. D. Toledo Filho, F. A. Silva, E. A. B. Koenders and E. M. R. Fairbairn*

**PRO 82:** 2nd International RILEM Conference on Progress of Recycling in the Built Environment (2011) 507 pp., e-ISBN: 978-2-35158-122-3; *Eds. V. M. John, E. Vazquez, S. C. Angulo and C. Ulsen*

**PRO 83:** 2nd International Conference on Microstructural-related Durability of Cementitious Composites (2012) 250 pp., ISBN: 978-2-35158-129-2; e-ISBN: 978-2-35158-123-0; *Eds. G. Ye, K. van Breugel, W. Sun and C. Miao*

**PRO 84:** CONSEC13 - Seventh International Conference on Concrete under Severe Conditions – Environment and Loading (2013) 1930 pp., ISBN: 978-2-35158-124-7; e-ISBN: 978-2-35158-134-6; *Eds. Z. J. Li, W. Sun, C. W. Miao, K. Sakai, O. E. Gjorv & N. Banthia*

**PRO 85:** RILEM-JCI International Workshop on Crack Control of Mass Concrete and Related issues concerning Early-Age of Concrete Structures – ConCrack 3 – Control of Cracking in Concrete Structures 3 (2012) 237 pp., ISBN: 978-2-35158-125-4; e-ISBN: 978-2-35158-126-1; *Eds. F. Toutlemonde and J.-M. Torrenti*

**PRO 86:** International Symposium on Life Cycle Assessment and Construction (2012) 414 pp., ISBN: 978-2-35158-127-8, e-ISBN: 978-2-35158-128-5; *Eds. A. Ventura and C. de la Roche*

**PRO 87:** UHPFRC 2013 – RILEM-fib-AFGC International Symposium on Ultra-High Performance Fibre-Reinforced Concrete (2013), ISBN: 978-2-35158-130-8, e-ISBN: 978-2-35158-131-5; *Eds. F. Toutlemonde*

**PRO 88:** 8th RILEM International Symposium on Fibre Reinforced Concrete (2012) 344 pp., ISBN: 978-2-35158-132-2, e-ISBN: 978-2-35158-133-9; *Eds. Joaquim A. O. Barros*

**PRO 89:** RILEM International workshop on performance-based specification and control of concrete durability (2014) 678 pp, ISBN: 978-2-35158-135-3, e-ISBN: 978-2-35158-136-0; *Eds. D. Bjegović, H. Beushausen and M. Serdar*

**PRO 90:** 7th RILEM International Conference on Self-Compacting Concrete and of the 1<sup>st</sup> RILEM International Conference on Rheology and Processing of Construction Materials (2013) 396 pp, ISBN: 978-2-35158-137-7, e-ISBN: 978-2-35158-138-4; *Eds. Nicolas Roussel and Hela Bessaies-Bey*

**PRO 91:** CONMOD 2014 - RILEM International Symposium on Concrete Modelling (2014), ISBN: 978-2-35158-139-1; e-ISBN: 978-2-35158-140-7; *Eds. Kefei Li, Peiyu Yan and Rongwei Yang*

**PRO 92:** CAM 2014 - 2nd International Conference on advances in chemically-activated materials (2014) 392 pp., ISBN: 978-2-35158-141-4; e-ISBN: 978-2-35158-142-1; *Eds. Caijun Shi and Xiadong Shen*

**PRO 93:** SCC 2014 - 3rd International Symposium on Design, Performance and Use of Self-Consolidating Concrete (2014) 438 pp., ISBN: 978-2-35158-143-8; e-ISBN: 978-2-35158-144-5; *Eds. Caijun Shi, Zhihua Ou, Kamal H. Khayat*

**PRO 94 (online version):** HPRCC-7 - 7th RILEM conference on High performance fiber reinforced cement composites (2015), e-ISBN: 978-2-35158-146-9; *Eds. H. W. Reinhardt, G. J. Parra-Montesinos, H. Garrecht*

**PRO 95:** International RILEM Conference on Application of superabsorbent polymers and other new admixtures in concrete construction (2014), ISBN: 978-2-35158-147-6; e-ISBN: 978-2-35158-148-3; *Eds. Viktor Mechtcherine, Christof Schroeff*

**PRO 96 (online version):** XIII DBMC: XIII International Conference on Durability of Building Materials and Components(2015), e-ISBN: 978-2-35158-149-0; *Eds. M. Quattrone, V. M. John*

**PRO 97:** SHCC3 – 3rd International RILEM Conference on Strain Hardening Cementitious Composites (2014), ISBN: 978-2-35158-150-6; e-ISBN: 978-2-35158-151-3; *Eds. E. Schlagen, M. G. Sierra Beltran, M. Lukovic, G. Ye*

**PRO 98:** FERRO-11 – 11th International Symposium on Ferrocement and 3rd ICTRC - International Conference on Textile Reinforced Concrete (2015), ISBN: 978-2-35158-152-0; e-ISBN: 978-2-35158-153-7; *Ed. W. Brameshuber*

**PRO 99 (online version):** ICBBM 2015 - 1st International Conference on Bio-Based Building Materials (2015), e-ISBN: 978-2-35158-154-4; *Eds. S. Amziane, M. Sonebi*

**PRO 100:** SCC16 - RILEM Self-Consolidating Concrete Conference (2016), ISBN: 978-2-35158-156-8; e-ISBN: 978-2-35158-157-5; *Ed. Kamal H. Kayat*

**PRO 101 (online version):** III Progress of Recycling in the Built Environment (2015), e-ISBN: 978-2-35158-158-2; *Eds I. Martins, C. Ulsen and S. C. Angulo*

**PRO 102 (online version):** RILEM Conference on Microorganisms-Cementitious Materials Interactions (2016), e-ISBN: 978-2-35158-160-5; *Eds. Alexandra Bertron, Henk Jonkers, Virginie Wiktor*

**PRO 103 (online version):** ACESC'16 - Advances in Civil Engineering and Sustainable Construction (2016), e-ISBN: 978-2-35158-161-2; *Eds. T.Ch. Madhavi, G. Prabhakar, Santhosh Ram and P. M. Rameshwaran*

**PRO 104 (online version):** SSCS'2015 - Numerical Modeling - Strategies for Sustainable Concrete Structures (2015), e-ISBN: 978-2-35158-162-9

**PRO 105:** 1st International Conference on UHPC Materials and Structures (2016), ISBN: 978-2-35158-164-3, e-ISBN: 978-2-35158-165-0

**PRO 106:** AFGC-ACI-fib-RILEM International Conference on Ultra-High-Performance Fibre-Reinforced Concrete – UHPFRC 2017 (2017), ISBN: 978-2-35158-166-7, e-ISBN: 978-2-35158-167-4; *Eds. François Toutlemonde & Jacques Resplendino*

**PRO 107 (online version):** XIV DBMC – 14th International Conference on Durability of Building Materials and Components (2017), e-ISBN: 978-2-35158-159-9; *Eds. Geert De Schutter, Nele De Belie, Arnold Janssens, Nathan Van Den Bossche*

**PRO 108:** 28MSSCE 2016 - Innovation of Teaching in Materials and Structures (2016), ISBN: 978-2-35158-178-0, e-ISBN: 978-2-35158-179-7; *Ed. Per Goltermann*

**PRO 109 (2 volumes):** MSSCE 2016 - Service Life of Cement-Based Materials and Structures (2016), ISBN Vol. 1: 978-2-35158-170-4, Vol. 2: 978-2-35158-171-4, Set Vol. 1&2: 978-2-35158-172-8, e-ISBN : 978-2-35158-173-5; *Eds. Miguel Azenha, Ivan Gabrijel, Dirk Schlicke, Terje Kanstad and Ole Mejlhede Jensen*

**PRO 110:** MSSCE 2016 - Historical Masonry (2016), ISBN: 978-2-35158-178-0, e-ISBN: 978-2-35158-179-7; *Eds. Inge Rörig-Dalgaard and Ioannis Ioannou*

**PRO 111:** MSSCE 2016 - Electrochemistry in Civil Engineering (2016), ISBN: 978-2-35158-176-6, e-ISBN: 978-2-35158-177-3; *Ed. Lisbeth M. Ottosen*

**PRO 112:** MSSCE 2016 - Moisture in Materials and Structures (2016), ISBN: 978-2-35158-178-0, e-ISBN: 978-2-35158-179-7; *Eds. Kurt Kielsgaard Hansen, Carsten Rode and Lars-Olof Nilsson*

**PRO 113:** MSSCE 2016 - Concrete with Supplementary Cementitious Materials (2016), ISBN: 978-2-35158-178-0, e-ISBN: 978-2-35158-179-7; *Eds. Ole Mejlhede Jensen, Konstantin Kovler and Nele De Belie*