

Lecture Notes in Civil Engineering

Volume 356

Series Editors

Marco di Prisco, Politecnico di Milano, Milano, Italy

Sheng-Hong Chen, School of Water Resources and Hydropower Engineering,
Wuhan University, Wuhan, China

Ioannis Vayas, Institute of Steel Structures, National Technical University of
Athens, Athens, Greece

Sanjay Kumar Shukla, School of Engineering, Edith Cowan University, Joondalup,
WA, Australia

Anuj Sharma, Iowa State University, Ames, IA, USA

Nagesh Kumar, Department of Civil Engineering, Indian Institute of Science
Bangalore, Bengaluru, Karnataka, India

Chien Ming Wang, School of Civil Engineering, The University of Queensland,
Brisbane, QLD, Australia

Lecture Notes in Civil Engineering (LNCE) publishes the latest developments in Civil Engineering—quickly, informally and in top quality. Though original research reported in proceedings and post-proceedings represents the core of LNCE, edited volumes of exceptionally high quality and interest may also be considered for publication. Volumes published in LNCE embrace all aspects and subfields of, as well as new challenges in, Civil Engineering. Topics in the series include:

- Construction and Structural Mechanics
- Building Materials
- Concrete, Steel and Timber Structures
- Geotechnical Engineering
- Earthquake Engineering
- Coastal Engineering
- Ocean and Offshore Engineering; Ships and Floating Structures
- Hydraulics, Hydrology and Water Resources Engineering
- Environmental Engineering and Sustainability
- Structural Health and Monitoring
- Surveying and Geographical Information Systems
- Indoor Environments
- Transportation and Traffic
- Risk Analysis
- Safety and Security

To submit a proposal or request further information, please contact the appropriate Springer Editor:

- Pierpaolo Riva at pierpaolo.riva@springer.com (Europe and Americas);
- Swati Meherishi at swati.meherishi@springer.com (Asia—except China, Australia, and New Zealand);
- Wayne Hu at wayne.hu@springer.com (China).

All books in the series now indexed by Scopus and EI Compendex database!

Wenhui Duan · Lihai Zhang · Surendra P. Shah
Editors

Nanotechnology in Construction for Circular Economy

Proceedings of NICOM7, 31 October–02
November, 2022, Melbourne, Australia

 Springer

Editors

Wenhui Duan
Department of Civil Engineering
Monash University
Clayton, VIC, Australia

Lihai Zhang
Department of Infrastructure Engineering
University of Melbourne
Parkville, VIC, Australia

Surendra P. Shah
Civil and Environmental Engineering
Northwestern University
Evanston, IL, USA



ISSN 2366-2557

ISSN 2366-2565 (electronic)

Lecture Notes in Civil Engineering

ISBN 978-981-99-3329-7

ISBN 978-981-99-3330-3 (eBook)

<https://doi.org/10.1007/978-981-99-3330-3>

© The Editor(s) (if applicable) and The Author(s) 2023. This book is an Open access publication.

Open Access This book is licensed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this book are included in the book's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the book's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

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 Singapore Pte Ltd. The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Organization

Advisory Committee

S. P. Shah
K. Wang
K. Sobolev
M. S. Konsta-Gdoutos
L. Ferrara

Scientific Advisory Committee

K. Wang (Chair)
S. Chen (Secretary)
L. Ferrara
G. A. Ferro
W. Young
A. Heidarpour
M. Yellishetty
P. Mendis
V. Sirivivatnanon
S. Setunge
C. Chen
B. Samali
D. Law
C. Li
Z. Tao
R. S. Nicolas
W. Li
L. Zhang

C. Caprani
H. Huang
D. Wu
B. Sainsbury
D. Robert
T. Yu
T. Ren
A. Remennikov
Y. Zhang
P. D. Silva
W. Gao
G. Li
X. Liu
K. Vessalas
R. Erkmén
R. Shrestha
J. Li
P. Thomas
N. Gowripalan
S. Nejadi
H. Wang
P. Mutton
R. Zou
Y. Huang
V. Tam
Y. Zhuge
M. Ghodrat
J. Zhao
Q. Zhang
M. M. Alam
K. Le

Local Organizing Committee

L. Zhang (Chair)
K. Sagoe-Crentsil (Co-Chair)
B. Chang (Secretary)
S. Miramini (Coordinator)
D. Chen (Coordinator)
S. Zhang
X. Yao
H. Sui
Y. Liu

F. Basquiroto

H. Nguyen

W. Wang

Award Committee

Y. Mai

D. Nethercot

J. Torero

S. T. Quek

R. Amal

M. Bradford

S. Kitipornchai

R. Kell

P. Phillip

A. Paradowska

R. Yeo

NICOM7 Preface

The Seventh International Symposium on Nanotechnology in Construction (NICOM7), with the theme of “Nanotechnology in Construction for Circular Economy”, provided a bridge between research advances and industry/commercial opportunities within the construction sector underpinned by nanoscience. To this end, NICOM7 showcased the latest developments across the entire supply chain involving researchers, manufacturers, suppliers, and end users.

NICOM7 was delivered via a hybrid mode (onsite & online) for a total of 8 plenary/keynote speeches and 12 parallel sessions containing 61 presentations and attracting nearly 100 attendees from Australia, China, Germany, Brazil, USA, India, UK, and Singapore. It was jointly hosted by Monash University and the University of Melbourne, Australia, and coordinated by an Advisory Committee (S. P. Shah, USA; K. Wang, USA; K. Sobolev, USA; M. S. Konsta-Gdoutos, Greece; L. Ferrara, Italy), Scientific Advisory Committee (49 members), Local Organising Committee (12 members), and Awards Committee (11 members). The editors acknowledge their excellent contributions that enabled successful delivery of NICOM7, as well as support from all reviewers, helpers, and conference organizers.

This proceeding volume is based on contributions presented at NICOM7. The 56 high-quality papers/extended abstracts cover a wide range of topics across nanotechnologies in concrete structures, structural health monitoring, nanocomposite cement replacements rails, pavements, AI and nanomodification of cementitious materials, the alkali–silica reaction, concrete durability, geopolymer concretes, etc. The focus of the proceedings is next-generation nanotechnologies for the broader construction sector. The editors sincerely thank the authors for their outstanding contributions, and hope the NICOM7 experience will promote innovation to enhance the rapid promotion and integration of nanoscience into mainstream construction practices. The editors also anticipate that the proceedings of NICOM7 will have great value

for both the research and engineering communities by advancing nanotechnology initiatives towards a globally sustainable and innovative construction sector.

Clayton, Australia

Surendra P. Shah
Honorary Chair

Parkville, Australia

Wenhui Duan
Conference Chair

Evanston, USA

Lihai Zhang
Conference Co-Chair

Contents

Nonlinear Wind-Induced Vibration Behaviors of Multi-tower Suspension Bridges Under Strong Wind Conditions	1
R. Zhou, Y. J. Ge, Y. Yang, Y. D. Du, and L. H. Zhang	
Thermal Transfer Effects of CRTS II Slab Track Under Various Meteorological Conditions	11
R. Zhou, W. H. Yuan, Y. D. Du, H. L. Liu, and L. H. Zhang	
Investigation on Superhydrophobicity and Piezoresistivity of Self-sensing Cement-Based Sensors Using Silane Surface Treatment	17
W. K. Dong, W. G. Li, X. Q. Lin, and S. P. Shah	
Use of Brown Coal Ash as a Replacement of Cement in Concrete Masonry Bricks	23
D. W. Law, C. Gunasekara, and S. Setunge	
Composition of Alkali–Silica Reaction Products in Laboratory and Field Concrete	27
M. J. Tapas, K. Vessalas, P. Thomas, N. Gowripalan, and V. Sirivivatnanon	
Behavior of Hybrid Engineered Cementitious Composites Containing Nanocellulose	37
H. Withana and Y. X. Zhang	
Investigation of ASR Effects on the Load-Carrying Capacity of Reinforced Concrete Elements by Ultra-Accelerated Laboratory Test	43
J. Cao, N. Gowripalan, V. Sirivivatnanon, and J. Nairn	
3D printed Ultra-High Performance Concrete: Preparation, Application, and Challenges	53
G. Bai, G. Chen, R. Li, L. Wang, and G. Ma	

Nanosilica-Modified Hydrogels Encapsulating Bacterial Spores for Self-healing Concrete 67
J. Feng and S. Qian

Reusing Alum Sludge as Cement Replacement to Develop Eco-Friendly Concrete Products 75
Y. Liu, Y. Zhuge, and W. Duan

Role of Aggregate Reactivity, Binder Composition, and Curing Temperature on the Delayed Ettringite Formation and Associated Durability Loss in Concrete 83
L. Martin, P. Thomas, P. De Silva, and V. Sirivivatnanon

Effect of Blending Alum Sludge and Ground Granulated Blast-Furnace Slag as Cement Replacement to Mitigate Alkali-Silica Reaction 93
W. Duan, Y. Zhuge, and Y. Liu

Optimisation of Limestone Calcined Clay Cement Based on Response Surface Method 103
G. Huang, Y. Zhuge, T. Benn, and Y. Liu

Designing Waterborne Protective Coatings Through Manipulating the Nanostructure of Acrylic-Based Nanocomposites 113
S. Ji, H. Gui, G. Guan, M. Zhou, Q. Guo, and M. Y. J. Tan

Analysis of Categories That Delay Global Construction Projects 127
M. Abonassrya, M. Alam, and A. Saifullah

Chloride Penetration in Low-Carbon Concrete with High Volume of SCM: A Review Study 141
C. Xue and V. Sirivivatnanon

A Compact Review on the Waste-Based Lightweight Concrete: Advancement and Possibilities 151
M. M. U. Islam, J. Li, R. Roychand, and M. Saberian

Influence of Reinforcement on the Loading Capacity of Geopolymer Concrete Pipe 165
S. Dangol, J. Li, V. Sirivivatnanon, and P. Kidd

Creep of Slag Blended Cement Concrete with and Without Activator 177
H. T. Thanh, M. J. Tapas, J. Chandler, and V. Sirivivatnanon

Partially-Unzipped Carbon Nanotubes as Low-Concentration Amendment for Cement Paste 187
S. Iffat, F. Matta, J. Gaillard, M. Elvington, M. Sikder, M. Baalousha, S. Tinkey, and J. Meany

Effect of Fine Aggregates and Test Settings on the Self-sensing Response of Cement-Based Composites with Carbon Nanotubes as Conductive Filler 197
 T. C. dos Santos, P. A. Carísio, A. P. S. Martins, M. D. M. Paiva, F. M. P. Gomes, O. A. M. Reales, and R. D. Toledo Filho

Effect of Carbonation on the Microstructure and Phase Development of High-Slag Binders 213
 M. J. Tapas, A. Yan, P. Thomas, C. Holt, and V. Sirivivatnanon

A New Dispersion Strategy to Achieve High Performance Graphene-Based Cement Material 223
 Z. Zhang, Y. Yao, H. Liu, Y. Zhuge, and D. Zhang

Accelerated Mortar Bar Test to Assess the Effect of Alkali Concentration on the Alkali–Silica Reaction 233
 B. Boyd-Weetman, P. Thomas, P. DeSilva, and V. Sirivivatnanon

Development of High-Strength Light-Weight Cementitious Composites with Hollow Glass Microspheres 241
 X. Li, Y. Yao, D. Zhang, Z. Zhang, and Y. Zhuge

Co-effects of Graphene Oxide and Silica Fume on the Rheological Properties of Cement Paste 251
 D. Lu, Z. Sheng, B. Yan, and Z. Jiang

Automated 3D-Printer Maintenance and Part Removal by Robotic Arms 259
 K. Andrews, K. Granland, Z. Chen, Y. Tang, and C. Chen

Machine Vision-Based Scanning Strategy for Defect Detection in Post-Additive Manufacturing 271
 S. Zhang, Z. Chen, K. Granland, Y. Tang, and C. Chen

Electrical and Sulfate-Sensing Properties of Alkali-Activated Nanocomposites 285
 Maliheh Davoodabadi, Marco Liebscher, Massimo Sgarzi, Leif Riemenschneider, Daniel Wolf, Silke Hampel, Gianaurelio Cuniberti, and Viktor Mechtcherine

Advances in Characterization of Carbonation Behavior in Slag-Based Concrete Using Nanotomography 297
 B. Mehdizadeh, K. Vessalas, B. Ben, A. Castel, S. Deilami, and H. Asadi

Application of Surface-Modified Nanosilica for Performance Enhancement of Asphalt Pavement 309
 D. He, H. H. Chan, Z. H. Xiao, T. Wu, L. M. Leung, M. Sham, B. Chen, S. F. S. Lee, and C. K. K. Kwan

Effect of Different Additives on the Compressive Strength of Very High-Volume Fly Ash Cement Composites 313
R. Roychand, J. Li, M. Saberian, S. Kilmartin-Lynch, M. M. Ul Islam, M. Maghfouri, and F. Chen

Spalling Resistance of Hybrid Polyethylene and Steel Fiber-Reinforced High-Strength Engineered Cementitious Composite 321
S. Rawat, Y. X. Zhang, and C. K. Lee

Roads Issues and the Social License to Operate 327
W. Young and M. Shackleton

An Intelligent Multi-objective Design Optimization Method for Nanographite-Based Electrically Conductive Cementitious Composites 339
W. Dong, Y. Huang, B. Lehane, and G. Ma

Machine Learning-Aided Nonlinear Dynamic Analysis of Engineering Structures 347
Y. Feng, Q. Wang, D. Wu, and W. Gao

Insights into the Size Effect of the Dynamic Characteristics of the Perovskite Solar Cell 353
Q. Li, D. Wu, and W. Gao

Non-probabilistic Informed Structural Health Assessment with Virtual Modelling Technique 359
Q. Wang, Y. Feng, D. Wu, and W. Gao

Modeling the Alkali-Silica Reaction and Its Impact on the Load-Carrying Capacity of Reinforced Concrete Beams 365
T. N. Nguyen, J. Li, V. Sirivivatnanon, and L. Sanchez

Guidelines for Enzymatic Soil Stabilization 373
B. O’Donnell, A. Swarup, A. Sidiq, D. Robert, and S. Setunge

Deterioration Modeling of Concrete Bridges and Potential Nanotechnology Application 399
H. Tran and S. Setunge

Transfer and Substrate Effects on 2D Materials for Their Sensing and Energy Applications in Civil Engineering 409
Q. Zhang, C. Zheng, K. Sagoe-Crentsil, and W. Duan

Experimental and Numerical Studies on the In-Plane Shear Behavior of PVC-Encased Concrete Walls 421
Kamyar Kildashti and Bijan Samali

Recycled Glass-Based Capping Layer for Foundations in Expansive Soils 431
 H. Karami, D. Robert, S. Costa, J. Li, S. Setunge, and S. Venkatesan

Submicroscopic Evaluation Studies to Minimize Delayed Ettringite Formation in Concrete for a Sustainable Industry and Circular Economy 445
 Yogesh Kumar Ramu, Paul Stephen Thomas, Kirk Vessalas, and Vute Sirivivatnanon

A Novel Concrete Mix Design Methodology 457
 D. Kumar, M. Alam, and J. Sanjayan

Characterization of the Nano- and Microscale Deterioration Mechanism of the Alkali–Silica Reaction in Concrete Using Neutron and X-ray Scattering Techniques: A Review 469
 E. Nsiah-Baafi, M. J. Tapas, K. Vessalas, P. Thomas, and V. Sirivivatnanon

Life Cycle Assessment of the Environmental Impacts of Virgin Concrete Replacement by CO₂ Concrete in a Residential Building 479
 M. Ma, Y. Zhou, V. W. Y. Tam, and K. N. Le

Economic Impacts of Environmentally Friendly Blocks: The Case of Nu-Rock Blocks 483
 V. W. Y. Tam, K. N. Le, I. M. C. S. Illankoon, C. N. N. Tran, D. Rahme, and L. Liu

Life Cycle Assessment (LCA) of Recycled Concrete Incorporating Recycled Aggregate and Nanomaterials 491
 W. Xing, V. Tam, K. Le, J. L. Hao, J. Wang, and P. Yang

Analysis of the Compressive Strength of CO₂ Concrete While Eliminating Overshadowing Concrete Variables 495
 V. W. Y. Tam, A. Butera, K. N. Le, and L. Liu

Harmonic Vibration of Inclined Porous Nanocomposite Beams 497
 D. Chen and L. Zhang

Influence of Carbon Nanotubes on the Fracture Surface Characteristics of Cementitious Composites Under the Brazilian Split Test 503
 Y. Gao, J. Xiang, Z. Yu, G. Han, and H. Jing

Effect of Carbon Nanotubes on the Acoustic Emission Characteristics of Cemented Rockfill 513
 Z. Yu, H. Jing, Y. Gao, X. Wei, and A. Wang

Effects of Graphene Oxide Content on the Reinforcing Efficiency of C–S–H Composites: A Molecular Dynamics Study 521
W. Chen, J. Xiang, Y. Gao, and Z. Zhang

Graphene-Induced Nano- and Microscale Modification of Polymer Structures in Cement Composite Systems 527
Z. Naseem, K. Sagoe-Crentsil, and W. Duan