

# Recent Advances in Concrete Technology and Sustainability Issues

Proceedings  
Fourteenth International Conference  
Beijing, China

October-November 2018

**Fengbo Sui**  
**Frederic C. Holland**  
**Ziming Wang**  
**Xiaolong Zhao**



American Concrete Institute

SP-330

# Recent Advances in Concrete Technology and Sustainability Issues

Proceedings  
Fourteenth International Conference  
Beijing, China  
October 30-November 2, 2018

Editors:

Tongbo Sui

Terence C. Holland

Ziming Wang

Xiaolong Zhao



American Concrete Institute  
*Always advancing*

SP-330

First printing, September 2018

Discussion is welcomed for all materials published in this issue and will appear ten months from this journal's date if the discussion is received within four months of the paper's print publication. Discussion of material received after specified dates will be considered individually for publication or private response. ACI Standards published in ACI Journals for public comment have discussion due dates printed with the Standard.

The Institute is not responsible for the statements or opinions expressed in its publications. Institute publications are not able to, nor intended to, supplant individual training, responsibility, or judgment of the user, or the supplier, of the information presented.

The papers in this volume have been reviewed under Institute publication procedures by individuals expert in the subject areas of the papers.

Copyright © 2018  
AMERICAN CONCRETE INSTITUTE  
38800 Country Club Dr.  
Farmington Hills, Michigan 48331

All rights reserved, including rights of reproduction and use in any form or by any means, including the making of copies by any photo process, or by any electronic or mechanical device, printer or written or oral, or recording for sound or visual reproduction or for use in any knowledge or retrieval system or device, unless permission in writing is obtained from the copyright proprietors.

Editorial production:  
Carl R. Bischof  
Kaitlyn J. Dobberteen  
Tiesha Elam  
Kelli R. Slayden

ISBN-13: 978-1-64195-030-5

# Preface

The Canada Centre for Mineral and Energy Technology (CANMET) of Natural Resources of Canada, Ottawa, has played a significant role for more than 40 years in the broad area of concrete technology in Canada. In recent years CANMET has become increasingly involved in research and development dealing with the supplementary cementing materials, high-performance normal weight and lightweight concretes, and alkali-aggregate reactions. As part of CANMET's technology transfer program, an international symposium on Advances in Concrete Technology was sponsored jointly with the American Concrete Institute (ACI) and other organizations in Athens, Greece in May 1992. In June 1995, CANMET, in association with the ACI and other organizations in Canada and the U.S.A., sponsored the Second CANMET/ACI International Symposium on Advances in Concrete Technology in Las Vegas, Nevada. For the Athens symposium, the CANMET publication "Advances in Concrete Technology," constituted the proceedings of the symposium. The proceedings from the Las Vegas symposium were published by the ACI as SP-154.

In August 1997, CANMET in association with the ACI and other organizations in Canada and New Zealand, sponsored the Third CANMET/ACI International Symposium on Advance in Concrete Technology in Auckland, New Zealand. The main purpose of the symposium was to bring together representatives from industry, universities, and government agencies to present the latest information on concrete technology, and to explore new areas of research and development. Thirty-three refereed papers from 15 countries were presented and distributed at the symposium. The proceedings were published as ACI SP-171.

In June 1998, CANMET, in association with ACI, Japan Concrete Institute (JCI), and several other organizations in Canada and Japan sponsored the Fourth CANMET/ACI International Conference on Recent Advances in Concrete Technology in Tokoshima, Japan. More than 80 papers from 20 countries were received and reviewed in accordance with the policies of the ACI. Sixty-one referred papers were accepted for presentation at the conference and for publication as ACI SP-179. In addition to the referred papers, more than 30 papers were presented and distributed at the conference.

In July-August 2001, CANMET in association with the ACI and several organizations in Singapore, sponsored the Fifth CANMET/ACI International Conference on Recent Advances in Concrete Technology in Singapore. More than 100 papers from 25 countries were received and reviewed in accordance with the policies of the ACI. Forty-six refereed and more than 25 additional papers were accepted for presentation at the conference. The proceedings of the conference were published as ACI SP-200. In JUNE 2003 CANMET, in association with the ACI and several organizations in Romania, sponsored the Sixth CANMET/ACI International Conference on Recent Advances in Concrete Technology in Bucharest, Romania. More than 40 papers presented at the conference were distributed "as received," and no formal ACI special publication was published.

In May 2004, CANMET, in association with the ACI and several other organizations in the U.S.A., sponsored the Seventh CANMET /ACI International Conference on Recent Advances in Concrete Technology in Las Vegas, Nevada. Seventeen refereed papers from more than 10 countries were presented and distributed at the conference. The proceedings, consisting of the refereed papers, were published as ACI SP-222. In addition to the refereed papers, 20 additional papers were presented and distributed at the conference.

In May 2006, CANMET, in association with the ACI and several other organizations in Canada and the U.S.A., sponsored the Eighth CANMET/ACI International Conference on Recent Advances in Concrete Technology in Montreal, Canada. The proceedings of the conference consisting of 17 refereed papers, were published as ACI SP-235. In addition to the refereed papers, more than 30 additional papers were presented and distributed at the conference.

In May 2007, CANMET, In association with the ACI and several other organizations in Canada, Europe, and the U.S.A., sponsored the Ninth CANMET/ACI International Conference on Recent Advances in Concrete Technology in Warsaw, Poland. The proceedings of the conference consisted of 10 refereed papers were published as ACI SP-243. More than 20 additional papers were presented and distributed at the conference.

In October 2009, ACI, in association with several organizations in Canada, Europe and the U.S.A., sponsored the Tenth ACI International Conference on Advances in Concrete Technology in Seville, Spain. The proceedings of the conference consisting of 20 refereed papers were published as ACI SP-261. In addition to the refereed papers, more than 20 additional papers were presented at the conference and published in a supplementary papers volume.

In May 2010, the Committee for the Organization of International Conferences (COIC) (formerly CANMET/ACI Conferences), in association with the Chinese Ceramics Society (CCS) and several other organizations in China, sponsored the Eleventh International Conference on Advances in Concrete Technology and Sustainability Issues in Jinan, China. More than 40 papers were presented at the conference. The proceedings of the conference were published by the CCS, Beijing, China.

In October 2012, the COIC, in association with the ACI, sponsored the Twelfth International Conference on Advances in Concrete Technology and Sustainability Issues in Prague, Czech Republic. The proceedings of the conference consisted of more than 30 refereed papers and were published as ACI SP-288. In addition to the refereed papers, more than 40 other papers were presented at the conference, and were published in a supplementary papers volume.

In July 2015, the COIC, in association with the ACI sponsored the Thirteenth International Conference on Advances in Concrete Technology and Sustainability Issues in Ottawa, Canada. The proceedings of the conference consisting of 28 refereed papers were published by the ACI as SP-303. In addition to the refereed papers, more than 40 other papers were presented at the conference, and were published in a supplementary papers volume.

In October 1 to November 2, 2018, the CCS and the China Academy of Building Research (CABR), Beijing China, in association with the COIC sponsored the Fourteenth International Conference on Recent Advances in Concrete Technology and Sustainable Issues in Beijing, China. The proceedings of the Conference consisting of 19 refereed papers were published by the ACI as SP 330. In addition to the refereed papers, more than 52 papers were presented at the conference, and these were published in the supplementary papers volume.

Thanks are extended to the members of the technical papers review panel that met in March 2018 in Hainan Island, China. The members of the review panel were selected from Canada, China, Italy, Norway Switzerland, the U.K, and the U.S.A. Without their dedicated efforts, it would not have been possible to have the proceedings ready for distribution

at the conference. The co-operation of the authors in accepting the reviewers' suggestions, and in revising the draft manuscripts accordingly is greatly appreciated.

The guidance and great support for organization of the conference from Dr. V.M. Malhotra, Prof. Changwen Miao, the Honorary Chairpersons of the conference, are sincerely appreciated.

The support of CABR for the administrative work associated with the review of the papers, and the conference is gratefully acknowledged. Also, acknowledged is their support for the publication of the proceedings (ACI SP 330).

*Dr. Tongbo Sui, Chairperson, Scientific Committee of the Conference*

*Dr. Terence C. Holland, Chairperson, Paper Review Panel*

*Prof. Ziming Wang, Secretary General of the Conference*

*Dr. Xiaolong Zhao, Vice Director of the Organizing Committee*

*Editors*

*Fourteenth International Conference on Advances in Concrete Technology and Sustainability Issues*

*October 30 to November 2, 2018,*

*Beijing, China*

# Contents

<b>Preface</b>	iii		
<b>SP-330-01</b>	1		
<b>Degradation Process of Cementitious Materials with Copper Slag Subjected to Sodium Sulfate Attack under Drying-Wetting Cycles</b>			
by Huashan Yang and Yujun Che			
<b>SP-330-02</b>	11		
<b>The Influence of Alkalinity on the Properties of the Accelerated Cement Pastes</b>			
by Zhenping Sun, Chao Chen, Yanliang Ji, Xu Yang, Yuansong Sun, and Lelin Wu			
<b>SP-330-03</b>	21		
<b>Absolute Volume Change of Portland Cement Studied by Helium Pycnometry</b>			
by Zhenping Sun, Xu Yang, Juntao Tian, Haijing Yang, Yanliang Ji, and Kuangyi Hu			
<b>SP-330-04</b>	31		
<b>Natural Rubber Latex as a Binder for Polymer Concrete</b>			
by My Linh Vo and Johannes Plank			
<b>SP-330-05</b>	43		
<b>Compressive Strength and Durability of Concrete Made with Combined Cementitious Materials</b>			
by Chienming Wu and Junqing Xin			
<b>SP-330-06</b>	55		
<b>Relationships of Diffusivities and Age Factors between Analytical and Empirical Chloride Models for Decreasing Diffusivities</b>			
by Shengjun Zhou			
<b>SP-330-07</b>	67		
<b>High-Performance Steel Fiber-Reinforced Concrete for Lining Construction of Mines Using Ground Freezing Method</b>			
by Qian Wang, Shaowei Yang, Lei Guo, and Chunzhen Li			
<b>SP-330-08</b>	77		
<b>Resistance of Hybrid Cement after 5 Years of Exposure to 5% <math>\text{Na}_2\text{SO}_4</math></b>			
by Ivan Janotka, Pavel Merta, and Michal Bacuvčík			
<b>SP-330-09</b>	93		
<b>Rapid Strength Concrete for Rehabilitation of Transportation Infrastructure</b>			
by B. Steffen, H. Ryan, Y. Bu, and K. Valions			
<b>SP-330-10</b>	107		
<b>One-Part Alkali-Activated Slag Cement for Conservation of Existing Structures</b>			
by Luigi Coppola, Denny Coffetti, and Elena Crotti			
<b>SP-330-11</b>	123		
<b>Research on the Use of MSWI Bottom Ash Mixed Sand in Concrete</b>			
by HU Hong-mei, LUO De-fu, WAN Hui-bao, FU Rong-xing, and Cheng Yao			
<b>SP-330-12</b>	135		
<b>Power Ultrasound-Assisted Concrete Production—Workability, Strength Development, and Durability</b>			
by Ricardo Remus, Christiane Roessler, and Horst-Michael Ludwig			

**SP-330-13** 151  
**Bacteria-Based Self-Healing Concrete: Effect of Bio-agents on the Cementitious Matrix**  
by Jianyun Wang, Nico Boon, and Nele De Belie

**SP-330-14** 163  
**Sustainable Ready Mixed Concrete Production Using Waste CO<sub>2</sub>: A Case Study**  
by Sean Monkman

**SP-330-15** 175  
**Mechanical and Durability Properties of Coral Aggregate Concrete**  
by Wen Zhou, Yongxiang Zhou, Peng Feng, Zuqi Wang, Jing Wang, and Putao Song

**SP-330-16** 189  
**Calcined Clay-Based Mineral Addition for the Production of Structural Concrete**  
by J. Fernando Martirena, Eilys Valdes, Adrian Alujas, and Karen Scrivener

**SP-330-17** 197  
**Effect of Si/Al on the Buildability of Geopolymer Printing** 197  
by Dongmin Wang and Dawang Zhang

**SP-330-18** 205  
**Sulfate Resistance and Hydration Products of Steam Cured GGBFS Blended Cement Mortar**  
by Baoliang Li, Binbin Huo, and Yamei Zhang

**SP-330-19** 219  
**A Dual-Functional Intervention Method for Sea-Sand Concrete Structure**  
by Ji-Hua Zhu, Zhi Wang, Wanqian Li, Hanshi Liang, Zhiwei Zeng, Mei-ni Su, Dawang Li, and Feng Xing