Recent Advances in Concrete Technology and Sustainability Issues

Proceedings
Fourteenth International Conference
Beijing, China

October-November 2018

Tongbo Sui
Terence C. Holland
Ziming Wang
Xiaolong Zhao

American Concrete Institute

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Editorial production:
Carl R. Bischof
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Tiesha Elam
Kelli R. Slayden

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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 30 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

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Degradation Process of Cementitious Materials with Copper Slag Subjected to Sodium Sulfate Attack under Drying-Wetting Cycles

by Huashan Yang and Yujun Che

This paper presents an experimental study on the degradation process of cementitious materials with copper slag subjected to sodium sulfate attack under drying-wetting cycles. The cement pastes with 30% of copper slag (CS) were prepared by using water to binder ratio of 0.4. The degradation process of cementitious materials with copper slag immersed in 5% sodium sulfate solution under drying-wetting cycles were studied. X-ray diffraction (XRD) and backscattered electron image (BSE) were used to investigate microstructure changing. The research results indicate that the newly formed hydration products of partially reacted clinker increase the compactness of the hardened cementitious materials and increase the concentration of calcium hydroxide in the pore solution, thereby retarding the decomposition of C-S-H.

Keywords: cementitious materials; copper slag; sodium sulfate; hydration products; pore structure.

INTRODUCTION

Sulfate attack on cementitious materials has been a key durability issue and a subject of extensive investigation. It was established that sulfate attack on cementitious materials is generally attributed to the reaction of sulfate ions with calcium hydroxide and calcium aluminate hydrate to form gypsum and ettringite,[1-4] which can cause expansion, cracking, and deterioration of concrete exposed to sulfate environment. Mehta[5] pointed out that the decomposition of hydration products such as calcium hydroxide and C-S-H gel, should also be considered an integral part of the sulfate attack. For cementitious materials in splash and tidal zone, drying-wetting cycles tend to severely accelerate the sulfate attack, because drying–wetting cycle could make the sulfate accumulation and crystallization in concrete through cycled moisture gradient and capillarity absorption.[6-8] For example, the conversion of anhydrous sodium sulfate (Na_2SO_4) to the hydrous ($Na_2SO_4 \cdot 10H_2O$) form is associated with 314% volumetric expansion.[9] Thus, the degradation of concrete due to sulfate attack