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11th ACI/RILEM INTERNATIONAL CONFERENCE ON CEMENTITIOUS MATERIALS AND ALTERNATIVE BINDERS FOR SUSTAINABLE CONCRETE

SP-349

Editor:
Arezki Tagnit-Hamou

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American Concrete Institute
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PREFACE

In July 1983, the Canada Centre for Mineral and Energy Technology (CANMET) of Natural Resources Canada, in association with the American Concrete Institute (ACI) and the U.S. Army Corps of Engineers, sponsored a five-day international conference at Montebello, Quebec, Canada, on the use of fly ash, silica fume, slag and other mineral by-products in concrete. The conference brought together representatives from industry, academia, and government agencies to present the latest information on these materials and to explore new areas of needed research. Since then, eight other such conferences have taken place around the world (Madrid, Trondheim, Istanbul, Milwaukee, Bangkok, Madras, Las Vegas, and Warsaw).
The 2007 Warsaw conference was the last in this series.

In 2017, due to renewed interest in alternative and sustainable binders and supplementary cementitious materials, a new series was launched by the Université de Sherbrooke (UdeS); ACI; and the International Union of Laboratories and Experts in Construction materials, Systems, and Structures (RILEM). They, in association with a number of other organizations in Canada, the United States, and the Caribbean, sponsored the 10th ACI/RILEM International Conference on Cementitious Materials and Alternative Binders for Sustainable Concrete (ICCM2017). The conference was held in Montréal, QB, Canada, from October 2 to 4, 2017. The conference proceedings, containing 50 refereed papers from more than 33 countries, were published as ACI SP-320.

In 2021, the UdeS, ACI, and RILEM, in association with Université de Toulouse and a number of other organizations in Canada, the United States, and Europe, sponsored the 11th ACI/RILEM International Conference on Cementitious Materials and Alternative Binders for Sustainable Concrete (ICCM2021). The conference was held online from June 7 to 10, 2021. The conference proceedings, containing 53 peer reviewed papers from more than 14 countries, are published as ACI SP-349.

The purpose of this international conference was to present the latest scientific and technical information in the field of supplementary cementitious materials and novel binders for use in concrete. The conference highlights recent advances in the field of alternative and sustainable binders and supplementary cementitious materials, which are receiving increasing attention from the research community.

To all those whose submissions could not be included in the conference proceedings, the Institute and the Conference Organizing Committee extend their appreciation for their interest and hard work.

Thanks are extended to the members of the international scientific committee to review the papers. Without their dedicated efforts, the proceedings could not have been published for distribution at the conference. The cooperation of the authors in accepting reviewers' suggestions and revising their manuscripts accordingly is greatly appreciated.

The assistance of Ms. Chantal Brien, Secretary of ICCM2021, at the Université de Sherbrooke is greatly acknowledged for the administrative work associated with the conference and for processing the manuscripts, both ACI SP and supplementary volume.

Arezki Tagnit Hamou, Editor

Chairman, eleventh ACI/RILEM International Conference on Cementitious Materials and Alternative Binders for Sustainable Concrete (ICCM2021).
Sherbrooke, Canada
2021

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EFFECT OF MINERAL ADDITIONS ON THE SELF-HEALING ABILITY OF CEMENTITIOUS MATERIALS

Carol Namnoum, Benoît Hilloulin,Maxime Robira, Frédéric Grondin, Ahmed Loukili.

Synopsis: The production of cement by calcination of limestone releases large amounts of carbon dioxide. Development of concrete quality lead to optimize the sustainability and maintenance phases of concrete structures, so, using supplementary cementitious materials (SCM) is one of the methods adapted to reduce the environmental impact of cement production. In addition, self-healing of concrete appears as a process to considerably improve the durability of a damaged structure [1]. As revealed by most analyses, mineral additions can be used to improve the autogenous healing ability of cementitious materials [2].

In this study, the influence of using a combination of SCMs, such as ground granulated blast furnace slag and metakaolin, on the mechanism of autogenous crack healing was assessed in ternary formula. Self-healing evolution was characterised by means of mechanical tests carried out on notched mortar samples with different substitution ratios. The mechanical recovery was investigated after the healing period. Moreover, the micro-chemical structure of the healing products was determined using various techniques (TGA, SEM/EDS and XRD). The primary results showed that using metakaolin and ground granulated blast furnace slag together greatly improve the healing efficiency.

Keywords: Autogenous self-healing, ground granulated blast furnace slag, metakaolin, mechanical properties, SEM/EDX, TGA, XRD.

Carol Youssef Namnoum is a PhD student at GeM laboratory, Ecole Centrale de Nantes (ECN). This study has been carried out during her thesis about the study of the healing of cracks in concrete subjected to creep.

Benoît Hilloulin is an Assistant Professor at GeM Laboratory, Ecole Centrale de Nantes, France. He completed his joint PhD in 2015 about natural self-healing characterization and modelling in collaboration with Prof. Nele De Belie research group at Ghent University, Belgium. His main research interests are micromechanical characterization of cementitious materials and nondestructive testing.

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Fréderic Grondin is Full Professor at GeM Laboratory, Ecole Centrale de Nantes, France. He completed his PhD in 2005 at Pierre et Marie Curie University, France. His main research interests are durability of cementitious materials and characterization of the visco-elastic behavior of concrete.

Ahmed Loukili is Full Professor in the Department of Civil Engineering, GeM, Ecole Centrale de Nantes (ECN), from which he received his PhD in 1996. He is the head of ECN-Edycem Chair. He is a RILEM Member. His research interests include durability mechanics of cementitious materials.

INTRODUCTION

Around the world, the concern for sustainable development is present in every field of civil engineering, because cement is qualified as a major source of carbon. The valorization of secondary materials is the one of the methods to be followed to reduce the harmful emissions attributed to the process of portland cement production. Incorporation of mineral additions such as fly ash, silica fume, ground granulated blast furnace slag and metakaolin can improve permeability and strength of structures only over the long term, compared to portland cement that has better mechanical properties at early age. On the other hand, self-healing appears as a promising phenomenon to the durability of structures by blocking the penetration of aggressive agents and restoring the original mechanical properties of the structure. The intrinsic ability of concrete to heal is described by the continuous hydration of unhydrated cementitious particles and/or the precipitation of calcium carbonate [3]. Autogenous healing process is observed when unhydrated particles of clinker react with water to form secondary hydration products like portlandite and C-S-H, which can fill the crack and lead to mechanical recovery like strength and stiffness recovery. Different studies involve that autogenous healing potential is restricted to small crack and it requires the presence of water [4]. This type of healing depends on the cracking age, the presence of sustained mechanical load and the type of cementitious material [4] [5].

The intrinsic healing capacity of cement-based materials can be improved by mineral additions. From different research studies, the chemical reaction of minerals can form products that fill and heal cracks [4]. Through hydration reaction of slag with water in the presence of portlandite Ca $(OH)_2$, additional hydration products like C-S-H gel were formed at the crack surface. Their latent hydraulic properties explain their significant role in self-healing processing [5]. As found in several studies, the mineralogy of reaction products formed in cracks is obviously different from the hydration products in bulk matrix. Self-healing in SCM cement paste lead to complex mineralogy of healing products in cracks compared to self-healing in