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12th ACI/RILEM International Conference on Cementitious Materials and Alternative Binders for Sustainable Concrete

Editor:
Arezki Tagnit-Hamou

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American Concrete Institute
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12th ACI/RILEM International Conference on Cementitious Materials and Alternative Binders for Sustainable Concrete (ICCM2024)

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PREFACE

In July of 1983, the Canada Centre for Mineral and Energy Technology of Natural Resources Canada (CANMET), in association with the American Concrete Institute (ACI) and the U.S. Army Corps of Engineers, sponsored a 5-day international conference in 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 been held 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 the renewed interest in alternative and sustainable binders and supplementary cementitious materials, a new series was launched by Sherbrooke University (Professor Arezki Tagnit-Hamou), American Concrete Institute (ACI), and the International Union of Laboratories and Experts in Construction Materials, Systems and Structures (RILEM)—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 October 2-4, 2017, in Montréal, Canada. The conference proceedings, containing 50 reviewed papers from more than 33 countries, were published as ACI SP-320.

In 2021, 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 scheduled to take place in Toulouse, but due to COVID, it was held online June 7-10, 2021. The conference proceedings, containing 53 reviewed papers from more than 21 countries, were published as ACI SP-349.

In 2024, the conference was finally held in-person in Toulouse from June 23 to 26, 2024, with the support of UdeS, ACI, and RILEM in association with Université de Toulouse (Martin Cyr) and a number of other organizations in Canada, the United States, and Europe. 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 new aspect of this conference is to highlight advances in the field of alternative and sustainable binders and supplementary cementitious materials for the transition to low carbon concrete. The conference proceedings, containing 78 reviewed papers from more than 25 countries, have been published as ACI SP-362.

Thanks are extended to the members of the International Scientific Committee who reviewed the papers. The cooperation of the authors in accepting the reviewers' suggestions and revising their manuscripts accordingly is greatly appreciated. The involvement of the steering committee and the organizing committee is gratefully acknowledged. Special thanks go to Chantal Brien (Université de Sherbrooke) for the administrative work associated with the conference and for processing the manuscripts for both the ACI proceedings and the supplementary volume.

Arezki Tagnit Hamou, Editor
Chairman, 12th ACI/RILEM International Conference on Cementitious Materials and Alternative Binders for Sustainable Concrete (ICCM2024).
Sherbrooke, Canada, 2024

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Interface Properties Between Reactive Magnesia Cement Matrix and GFRP Rebar

Bo Wu and Jishen Qiu

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Bo Wu is a PhD candidate at the Department of Civil and Environmental Engineering, Hong Kong University of Science and Technology. He received his BS from Hunan University of Science and Technology, and MS form Shenzhen University. His research interests include fiber-reinforced cementitious composites, fiber surface modification, fiber-matrix interface properties, self-healing, and reactive magnesium cement.

ABSTRACT

Reactive magnesia cement (RMC) is an emerging class of low-alkaline and CO_2-sequestering binder, which can mitigate the deterioration of GFRP reinforcements induced by a high-alkaline environment, e.g., in Portland cement. This study investigated the slip behavior of GFRP rebar embedded in RMC composite, which varies with carbonation depth significantly. The variation of the interfacial bond was determined by a specially designed push-out test of the GFRP core; the variation of the carbonation degree and microstructure was examined by SEM-EDX, XRD, TGA, and acid digestion tests. Both properties demonstrated a similar trend, decreasing rapidly with increasing depth. A new finite element model that considers the depth-dependency of the matrix compositions and the rebar-to-matrix interfacial bond is established. It can predict the constitutive bond-slip behavior of a long GFRP rebar embedded in an RMC composite with non-uniform carbonation.

Keywords: glass fiber reinforced polymer (GFRP), reactive magnesia cement (RMC), bond-slip behavior, non-uniform carbonation, CO_2 sequestration.

INTRODUCTION

Reactive magnesia cement (RMC) is low-carbon binder, which can be manufactured by calcining minerals at a lower temperature than Portland cement (PC) (700-1000 °C vs. 1450 °C) [1]; it can chemically sequester CO_2 from the ambient air in two steps – first the cement grains react with water to form Brucite ($Mg(OH)_2$), which contributes little to strength development; second, the Brucite further react with the extra water and the dissolved CO_2 to form various hydrated magnesium carbonates (HMCs) [2, 3]. The formation of HMCs is essentially a process of solid volume expansion, which densifies the microstructure and provides a high strength of RMC matrix [1, 4, 5]. Furthermore, at a low calcination temperature (700 °C), the HMCs have the potential to be fully decomposed into RMC, which can be used for making new concretes [6, 7]. However, the RMC-based composites have an intrinsic problem, i.e., their relatively low alkalinity (pH = 9 to 10 after carbonation [8]) does not allow the steel bars to be used as internal reinforcement. This is because under a pH lower than 11.5, the passive layer of the steel rebar will be consumed quickly, and early-age rebar corrosion will appear [9, 10].

Glass fiber-reinforced polymer (GFRP) is a class of high-strength composites that are widely used in structural strengthening and retrofitting; it is promising to use the GFRP bars as the internal reinforcements for the RMC-based concrete, because it contains no metal elements and can be free from corrosion [11]. A recent study has demonstrated that the mechanical degradation of GFRP rebar is indeed largely alleviated when the high-pH PC is replaced by the more neutral RMC [12]. After being exposed to hot water (40 °C) for 90 days, the strength retention is 73.6% in the PC concrete, while it is 90.4% in the RMC-based composites. However, RMC-based composites are heterogeneous – the microstructure and strength vary significantly with the carbonation degree, which is governed by CO_2 diffusion and decreases with the increasing distance to the surface [13, 14]. Such heterogeneity suggests that the rebar-to-matrix interfacial strength is likely to vary with the depth, especially when the rebars are aligned perpendicular to the surface (e.g., the anchorage rebars for slope stability). As a result, the traditional pull-out test [15, 16] is unable to characterize the interface properties between RMC and GFRP at varying depths.

This work investigated the effect of depth-dependent carbonation on the bond-slip behavior of a GFRP rebar embedded in RMC-based composites. Besides the traditional long-rebar pull-out test to characterize the overall interfacial behavior, a new push-out test was carried out to the GFRP-RMC discs sliced from different depths to characterize the local interfacial behavior. The microstructure and chemical composition of the RMC discs were analyzed with various material characterization technologies to study the carbonation dependency on depth. Finite element (FE) models, which use the depth-dependent local interfacial properties as input, were developed to predict the overall bond-slip curve of GFRP-RMC composites. The models were validated by the experimental results.