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Carbonation Behavior of Powdered Cement-Based Materials Under Different Relative Humidities and CO_2 Concentrations

Kiyofumi Nakada[1], Katsuhito Komiya[2], Hikaru Fumino[2], Yuhei Nishio[2], Manabu Kanematsu[2] and Takafumi Noguchi[3]

[1] Department of Building Materials and Components, Building Research Institute, 1 Tachihara, Tsukuba-shi, Ibaraki-ken 305-0802, Japan, nakada@kenken.go.jp

[2] Department of Architecture, Graduate School of Science and Technology, Tokyo University of Science, 2641 Yamazaki, Noda-shi, Chiba-ken 278-8510, Japan, manabu@rs.tus.ac.jp

[3] Department of Architecture, Graduate School of Engineering, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, Japan, noguchi@bme.arch.t.u-tokyo.ac.jp

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1 Introduction

Carbonation reaction of cement hydrates governs the property changes of carbonated concrete, and carbonation behavior of cement hydrates is strongly affected by external environment (Castellote *et al*., 2009; Galan *et al*., 2013). The aim of the current study is to investigate the carbonation behavior of cement pastes at different humidity and CO_2 concentration. In order to obtain direct relationship between the carbonation degree and external environments, powdered samples are employed in this study.

2 Materials and Experiments

3 types of cement pastes are prepared using OPC (water to binder ratio is 0.45 and 0.60) and BFS (water to binder ratio is 0.60 and OPC: BFS is 50:50). After 91-day of water curing, the samples are crushed into ~90μm powder. The powder samples are carbonated under 4 different environments (Relative humidity are 60/85% and CO_2 concentration are 5/20%). TGA and XRD tests are conducted before and after carbonation for the purpose of determining carbonation degree of cement hydrates and types of calcium carbonates. Also, phenolphthalein test is also carried out and color change during the test is determined by means of color difference meter.

3 Results and Discussions

Based on the obtained results (Figure 1.), carbonation behavior of cement hydrates and their impact on concrete properties are discussed. Regarding to carbonation behavior of CH and other hydrates, the impact of relative humidity is clearly observed. As has been pointed out (Kim *et al.*, 1995), CH carbonation is promoted at higher relative humidity (85%RH) and less amount of CH remain uncarbonated. Compared to the results of phenolphthalein test (Figure 2.), the amount of residual CH can be related to color change of phenolphthalein. On the other hand, other hydrates carbonation is promoted at lower relative humidity (60%RH). As a result, at 60%RH, other hydrates carbonation proceeds without enough CH carbonation. Because other hydrates carbonation is more responsible for pore structure changes and carbonation shrinkage, changes in cement paste properties can occur without color change of phenolphthalein in such environments.

Carbonation occurs during drying process. Especially around surface of bulk samples or in small samples, drying proceeds immediately. In such situation, carbonation reaction proceeds under lower relative humidity, which leads to other hydrate carbonation without CH carbonation. In the previous research, CO_2 concentration is main factor for CSH carbonation and decomposition (Castellote *et al*., 2009). Relative humidity also affects CSH carbonation, and this factor should be taken into account when estimating long-term performance of carbonated concretes.

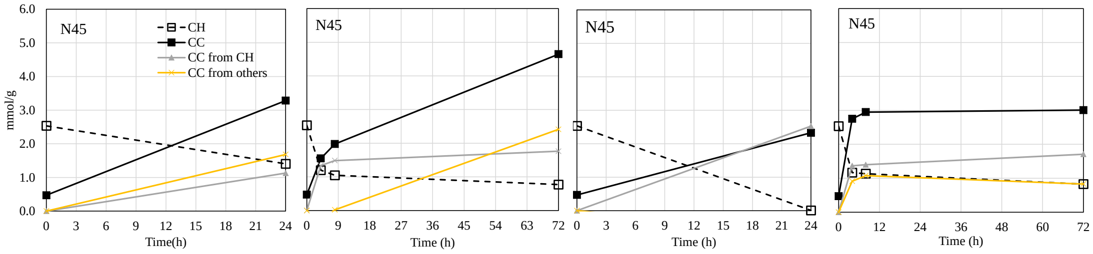

Figure 1. Changes in the amount CH and CĈ. The amounts of CĈ coming from CH carbonation and other hydrates carbonation are also illustrated in grey and yellow lines.

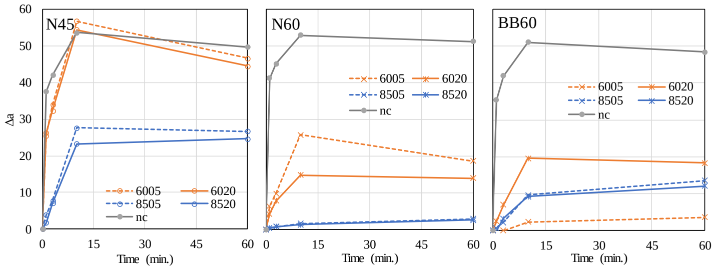

Figure 2. Changes in Δa* after phenolphthalein indicator was dropped. Non-carbonated (nc), carbonated at 60%RH and carbonated at 85%RH are illustrated as grey, orange and blue lines respectively.

ORCID

Kiyofumi Nakada: https://orcid.org/0000-0003-2744-1669
Katsuhito Komiya: https://orcid.org/0000-0001-8331-677X
Yuhei Nishio: https://orcid.org/0000-0002-9865-8606
Hikaru Fumino: https://orcid.org/0000-0001-9394-7372
Manabu Kanematsu: https://orcid.org/0000-0003-2473-0625
Takafumi Noguchi: https://orcid.org/0000-0001-6115-2292

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