Carbon Curing of concrete – effect on hydration

Master's thesis project in Chemistry (cement/ inorganic chemistry)

Background

Carbonation is normally considered to be detrimental to concrete as it may increase the risk of reinforcement corrosion. However, carbon curing (with CO_2) have for a long time been known to have a positive effect on e.g. lime mortar. In 1972 Klemm & Berger[1] presented results using high pressure CO_2 which showed that it was possible to achieve compressive strengths after 5 min curing similar to what was achieved after 1 day normal curing. Later development have looked into the possibility of adding liquid CO_2 to fresh concrete[2]. The CO_2 dissolves quickly to generate carbonic acid in the mix water, and then a "forced" hydration of C_3S (and/or C_2S) almost immediately occurs, to produce intermingled $CaCO_3$ (which acts as nucleation sites) and some version of C-S-H. This has been found to improve strength and reduce porosity. This beneficial effect can then be used to reduce the cement content and thus two positive effects are achieved, CO_2 is sequestered and the carbon-footprint of the concrete is reduced. However, there are several aspects of the hydration process which is not fully understood, or documented. Moreover, it has also been seen that when ground granulated blast-furnace slag is used there is an additional boost of the CO_2, which could be due to that the aluminium in the slag reacts with the precipitated calcium carbonate.

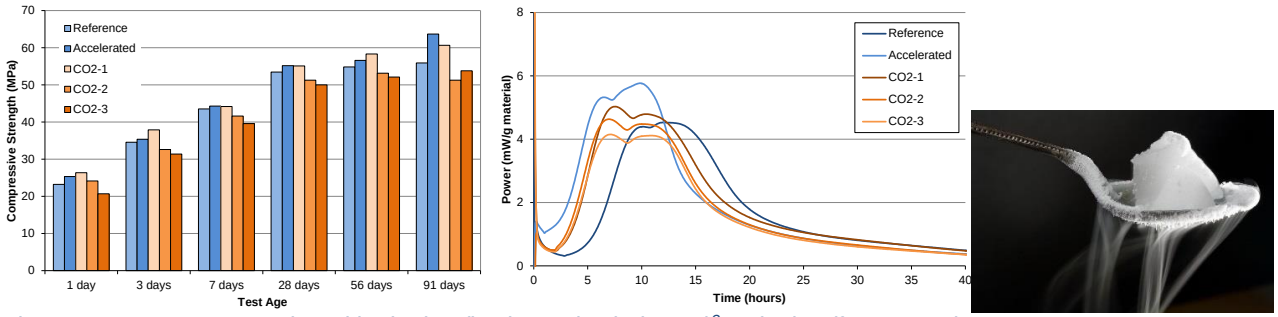

Figure 1. Impact on strength and hydration (isothermal calorimetry)[3] & dry ice (frozen CO_2).

Purpose/Method

This master thesis proposal aims to investigate how CO_2 injected into fresh cement paste influences the hydration process and hydration reactions, i.e. kinetics and hydrate phases. The investigation will be carried out by examining and monitoring early hydration of cement by Ex Situ and In Situ ATR-FTIR, Infrared Spectroscopy, Thermal Gravimetric Analysis (TGA), XRD and isothermal calorimetry. The effect of CO_2 will be examined for different binder compositions; pure Portland cement as well as addition off supplementary cementitious materials (ground granulated blast-furnace slag and fly ash).

Thesis setup information

The master thesis will be carried at Chalmers University of Technology together with Thomas Concrete Group (http://thomasconcretegroup.com/) and AGA (http://www.aga.se). This Master Thesis is suitable for students interested in experimental work and cement chemistry.

Supervisors

PhD Rikard Ylmén (main supervisor & examiner), (rikard.ylmen@chalmers.se), Docent Helén Jansson (helen.jansson@chalmers.se), and adj. prof. PhD Ingemar Löfgren, (Ingemar.lofgren@thomasconcretegroup.com).

[1] W. A. Klemm and R. L. Berger, Accelerated Curing of Cementitious Systems by Carbon Dioxide, Part 1, Cem. & Concrete Research 2 (5) 567-576 (1972).
[2] Using Carbon Dioxide as a Beneficial Admixture in Ready-Mixed Concrete: http://downloads.calmetrix.com/Downloads/Monkman-MacDonald-Hooton-NRMCA-2015.pdf
[3] S. Monkman, M. MacDonald, R.D. Hooton, P. Sandberg, Properties and durability of concrete produced using CO2 as an accelerating admixture, Cement and Concrete Composites (2016), doi: 10.1016/j.cemconcomp.2016.10.007