Effect of accelerated carbonation on the capillary absorption and gas permeability of high-volume fly ash (HVFA) mortar

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Abstract: To enable a fast assessment of a cementitious binder's resistance to carbonation, samples are often being exposed to CO$_2$ levels that highly exceed the atmospheric CO$_2$ concentration of around 0.04%. Experimental output obtained as such, is then used to predict the time to carbonation-induced steel depassivation of the studied binders for critical steel reinforced concrete infrastructure works. Previous research indicated that increasing the CO$_2$ level too much during laboratory experiments will have as consequence that the expected service life based on the resulting data will be substantially overestimated for binder systems consisting of 50% of pozzolanic fly ash from coal-fired electricity production. Among the possible reported causes for their overestimation in service life performance are carbonation-induced changes in microstructure and excess water production with a pore blocking effect at too high CO$_2$ levels. In this paper, HVFA mortar samples have been exposed to 0.04%, 1% and 10% CO$_2$, while maintaining temperature and relative humidity at 20°C and 60%, respectively. Once fully carbonated, they were subjected to capillary sorption tests. Samples carbonated at 10% were characterized by a significantly lower capillary water uptake than those carbonated at 0.04% and 1% CO$_2$. Effects on the gas permeability were examined as well in the well-known Cembureau permeater setup. Carbonation-induced changes in microstructure were evaluated indirectly by determining the differences in carbonation ratio for Ca(OH)$_2$ (CH) and the calcium-silicate-hydrates (C–S–H) for the three CO$_2$ concentrations considered using thermogravimetric analysis (TGA). Since a C–S–H carbonation coarsening of the pore structure normally tends to have the upper hand from a CO$_2$ concentration of 1% onwards, the mechanism of pore blocking excess water requires further attention as well. Nuclear magnetic resonance (NMR) measurements on the carbonated samples are an added value in that perspective.

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