New conceptual approach to assess steel corrosion in carbonated concrete

Projektdauer: 18 Monate

Forschungsstelle: ETH Zürich, Institut für Baustoffe (IfB)

Projektteam: Prof. Dr. Ueli Angst, Dr. Zhidong Zhang, Thilo Schmid, Cristhiana Albert

Abstract

Background and objectives

To reduce greenhouse gas (GHG) emissions of cement production, the traditional Portland cement clinker is suggested to be replaced with other low-carbon cementitious materials. However, this leads to the reduction of alkalinity in concrete which may cause carbonation related durability problems. Therefore, the concept of the current European (and Swiss) standards ensuring durability to avoid corrosion damage is not appropriate. Current norms are conservative and lead to unequal treatment of the different cements [1]. The clinker-reduced cements tend to be disadvantaged because they carbonate faster. In terms of sustainability, it is therefore central to consider reinforcement corrosion in service life design using reliable, quantitative approaches. Moreover, we consider it fundamental to abandon the current concept of focusing on the carbonation resistance alone. Instead, other more relevant parameters and criteria should be taken into account for the design and evaluation of cement types. For a long time, laboratory experiments and practical experience have shown that moisture condition in carbonated concrete might be the controlling factor for corrosion damage. If the moisture content in the concrete is below a certain threshold, steel corrosion in carbonated concrete occurs at a negligible rate. As has been shown in Cemsuisse project 202004, temporary wetting events play a major role (exposure class XC4), namely moisture transport through the cover concrete and the interaction with the electrochemical corrosion processes on the reinforcing steel. Thus, there are large opportunities in considering the moisture state and moisture transport through the (carbonated) concrete cover, and especially the effect of this on the corrosion behavior, as more relevant design parameters than the carbonation resistance. Embracing properties different from the carbonation resistance to ensure the durability of reinforced concrete in XC exposure classes offers opportunities to depart from the current concept that disadvantages cements with reduced GHG emissions.

The aim of this project is to develop a new concept of ensuring the durability of reinforced concrete in XC exposure, capable of paying more attention to sustainability than the current normative approach that is almost exclusively based on the carbonation resistance and thus tends to disadvantage cements with low GHG emissions. So far, available methods to determine moisture state and moisture transport property of concrete have been critically reviewed. The focus was on methods feasible for implementation in a material testing laboratory on a routine basis. To support the interpretation and to establish criteria for these test methods, additional detailed characterization are carried out. On this basis, it is recommended that water absorption is conducted by the method recommended by RILEM CPC11.2 and SIA 262-1 “Wasserleitfähigkeit” and water permeability is measured by the bulk permeation methods or the indirect methods, such as the inverse method using a moisture transport so it can provide additional information about transport properties. By the end of 2023, the reviews of moisture transport models and moisture transport and state measurement methods have been completed, and sample preparation and conditioning (curing, hydration, carbonation) has been almost completed. Selected moisture transport and moisture state measurements have started; most of the planned experiments will be performed in 2024.

[1] U.M. Angst, Steel corrosion in concrete – Achilles' heel for sustainable concrete?, Cement and Concrete Research, 172 (2023) 107239.