NEW ACCELERATED TEST METHOD FOR DETERMINATION OF CHLORIDE THRESHOLD VALUES FOR CORROSION INITIATION IN REINFORCED CONCRETE

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Project description

Introduction

This on-going research project is concerned with the challenge of measuring the chloride threshold value for initiation of reinforcement corrosion in concrete. The chloride threshold value is an essential input parameter for the modelling of service life for reinforced concrete structures exposed to chlorides, e.g. structures located in marine environments or near roads regularly exposed to de-icing salts during winter seasons. The chloride threshold value may be described as the minimum concentration of chloride at the depth of the embedded reinforcing steel in a concrete structure, which is able to initiate corrosion. Unfortunately, a commonly accepted method for measuring this important value is still not available. For instance, the effort of the RILEM committee TC 235-CTC recently failed to provide such a method.

In the project presented here, we attempt to develop a new accelerated test method for measuring chloride threshold values under laboratory conditions.

Principles of test method

The principle of the method is to accelerate the ingress of chloride ions from an exposure solution into concrete specimens by applying an external electrical field (6 V) (Fig. 1). The electrochemical potential of steel bars embedded in the specimens is continuously measured during the testing and corrosion initiation is detected by a significant electrochemical potential drop. After registration of corrosion initiation, specimens are removed from the test setup and the chloride threshold value is determined by measuring the chloride concentration at the depth of the reinforcing steel.

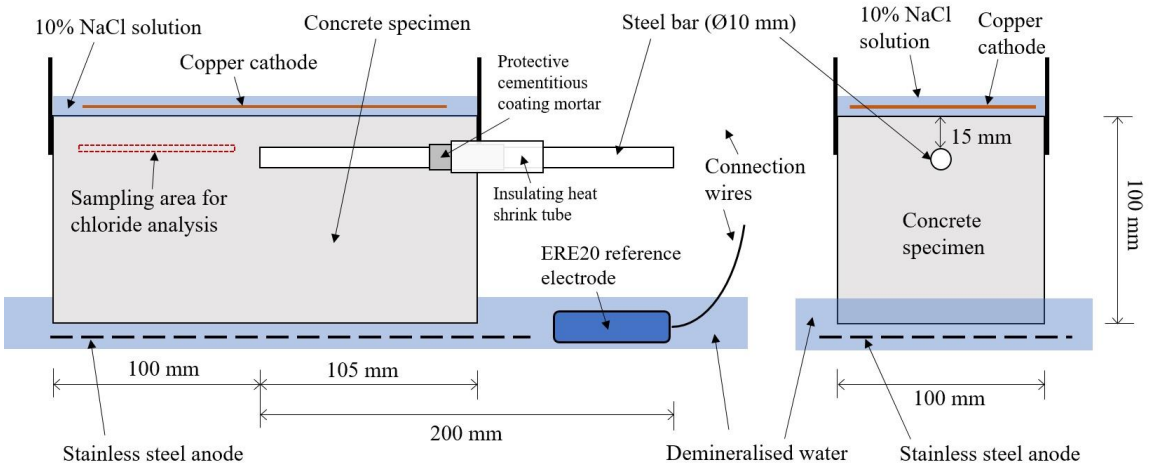

Figure 1. Schematic illustration of concrete specimen and the experimental setup used for determination of chloride threshold values.

The experimental approached used in this project is based on previous work carried out by Castellote, Andrade & Alonso (2002), Andrade & Rebolledo (2012), Yang (2015) and Yang et al. (2017), and most recently, Polder, Put & Peelen (2018), who employed a similar experimental approach to determine the chloride threshold values for mortar specimens with embedded steel bars. In our project, we use a slightly altered version of the method presented by Polder, Put & Peelen (2018) and apply it to a series of specimens prepared using concrete rather than mortar.

Preliminary results

The applicability of the test method is presently being examined in an on-going series of experiments with test specimens produced using concrete with a binder of 100% sulphate-resistant low-alkali Portland cement (CEM I 42.5 N – SR 5) and a water/cement ratio of 0.50 (Poulsen & Sørensen, in press). Until now, chloride threshold values have been determined for four test specimens, and the duration of the testing period has been approximately 14 days for each of the four specimens. Identification of corrosion onset was in each case confirmed by visual inspection of the embedded steel bar. The measured chloride threshold values vary from 1.34 to 1.98 wt.% of cement with an average value of 1.64 wt% of cement. These results are in good agreement with data from a marine field exposure site in Rødbyhavn, Denmark, where the chloride threshold value was found to be in the range between 1.4 and 1.7 wt% of cement for a concrete with a composition comparable to the one use in this project (Sørensen, Poulsen, & Jönsson 2016).

Conclusions and further investigations

The results obtained in the project so far suggest that the applied test method can be utilized as an effective tool for fast determination of chloride threshold values for corrosion initiation in concrete. The validity and applicability of the proposed test method will be further examined through continued laboratory experiments, e.g. experiments with test specimens produced with other types of concrete. Ultimately, our aim is to develop a test method that can be used to determine the chloride threshold value for any type of concrete.

We also plan to carry out experiments, which will clarify whether the accelerated nature of the chloride ingress affects the magnitude of the chloride threshold values being measured, e.g. due to insufficient time for achieving an equilibrium between “free” and “bound” chloride ions in the cement paste.

References

Andrade, C. & Rebolledo, N. (2012), Accelerated evaluation of corrosion inhibition by means of the integral corrosion test. Proceedings of the ICCRRR - 3rd International conference on concrete repair, rehabilitation and retrofitting, Alexander, M.G., Beushausen, H-D., Dehn, F., & Moyo, P. (Eds.), Cape Town, South Africa, pp. 132-133.

Castellote, M., Andrade, C. & Alonso, C. (2002), Accelerated simultaneous determination of the chloride depassivation threshold and of the non-stationary diffusion coefficient values. Corros. Sci., 44(11), pp. 2409-2424.

Polder, R.B., Put, M.v. & Peelen, W.H.A. (2018), Accelerated Testing for Chloride Threshold of Reinforcing Steel in Concrete. Proceedings of the 2017 fib Symposium: High Tech Concrete: Where Technology and Engineering Meet, Hordijk, D.A. & Luković, M. (Eds.), Maastricht, The Netherlands, pp. 2066-2073.

Poulsen, S.L. & Sørensen, H.E. (in press), Testing of new accelerated method for determination of chloride threshold values for corrosion initiation in reinforced concrete. Proceedings of RILEM International Conference on Sustainable Materials, Systems and Structures (SMSS2019), Rovinj, Croatia.

Sørensen, H.E., Poulsen, S.L. & Jönsson, U. (2016), Chloride threshold values from concrete blocks exposed at Rødbyhavn marine field exposure site. Proceedings of fib Symposium 2016 on Performance-Based Approaches for Concrete Structures, Beushausen, H. (Ed.), Cape Town, South Africa.

Yang, Z. (2015), Modified hydrotalcites as smart additives for improved corrosion protection of reinforced concrete. PhD. Thesis, Delft University of Technology.

Yang, Z., Polder, R.B., Mol, J.M.C. & Andrade C. (2017), The effect of two types of modified Mg-Al hydrotalcites on reinforcement corrosion in cement mortar. Cem. Conc. Res., 100, pp. 186-202.