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An Experimental Evaluation of the RCM-method

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INTRODUCTION

As the long term performance of concrete structures is gaining increasingly more interest of clients, emphasis is shifting progressively towards a full life cycle approach for these structures and its design concept. Within the European DuraCrete project, the focus has been on the development of a performance-based durability design methodology, based upon realistic and sufficient accurate environmental and material models, capable to predict the long term behaviour of concrete structures. Most of the developed models obtain their experimental data in the first five years of the lifecycle of a concrete structure. The choices that are made in this period considering the development, choice of material(s) and execution of this models are of the greatest interest for the DuraCrete methodology to give an accurate and reliable prediction for the behaviour of a concrete structure after hundred years.
One of the main parameters in the DuraCrete methodology is the so-called chloride migration coefficient (D_{RCM}) which is determined experimentally by the Rapid Chloride Migration Method or RCM-method [1, 2].
In this paper the building and the use of the RCM-method will be explained and also the results will be presented about the experimental evaluation of the RCM-method. An overview will be provided about the experimental observations and the sensitivity of the RCM-method regarding a several variations of important materials parameters. The results will provide a better understanding of the robustness of the RCM-method, i.e. the repeatability, and the value of the method for accessing practical durability issues.

Keywords: concrete, chloride penetration, migration coefficient, RCM-method, DuraCrete

THE RCM-METHOD

The RCM-method is designed as part of the DuraCrete methodology in order to determine the chloride migration coefficient (D_{RCM}) of concrete, measured from the chloride penetration depth of cylindrical test specimens. In real life, the process of the penetration of chloride ions into a concrete will take many years but with help of an external potential that is applied axially across the a concrete test specimen, with the RCM-test method chloride ions will be forced to migrate into the concrete in a several hours or days, depending on the resistance of the concrete test specimen. That is the reason why it is called the 'Rapid' Chloride Migration Method. The method is therefore considered as very relevant for practical usage.

Building elements of a RCM-set-up

The RCM-test method is a testing method that can be build in a rather simple manner. The components necessary for this testing method are explained in this section.

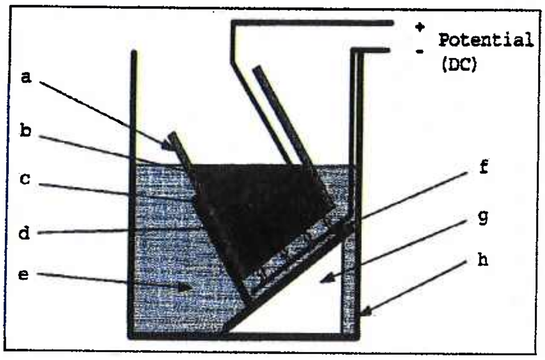

Fig. 1. Arrangement of the RCM-set-up.

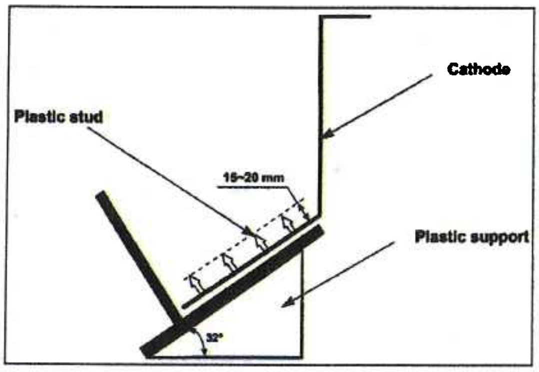

Fig. 2. Plastic support and cathode.

According to [2] the following elements are needed to build a RCM-set-up (see Fig. 1-3):

a) Silicone rubber sleeve; inner/outer diameter 100/115 [mm], about 150 [mm] long.
b) Anolyte solution.
c) Anode; stainless steel mesh or plate with holes, about 0,5 [mm] thick.
d) Concrete specimen.
e) Catholyte solution.
f) Cathode; stainless steel plate, about 0,5 [mm] thick.
g) Plastic support under an angle of 32°.

Catholyte reservoir; plastic box, 370 x 270 x 280 [mm^3] (capable of containing 1 specimen).

In order to seal off the space between the specimen and the silicone rubber sleeve and to avoid leakage in this particular area, two stainless steel clamps are needed for a specimen (see Fig. 3).
In order to build the RCM-test set-up some minor adjustments had to be made to some of the measurement components, as mentioned under points a) to h). For instance for the silicone rubber sleeve (see Fig. 6) a length of 200 [mm] was required since during the testing program as foreseen, also longer specimens then prescribed in [2] had to be tested. Furthermore the thickness of the anode (see Fig. 5) and the cathode (see Fig. 8 and 9) was not 0,5 [mm] but taken 1,0 [mm] and the dimensions of the catholyte reservoir had to be 551 x 352 x 300 [mm^3] (capable of containing 3 specimens). And finally a plastic ring was added between de stainless steel clamp and the silicone rubber sleeve to improve the tightness of the specimen set-up (see Fig. 4).

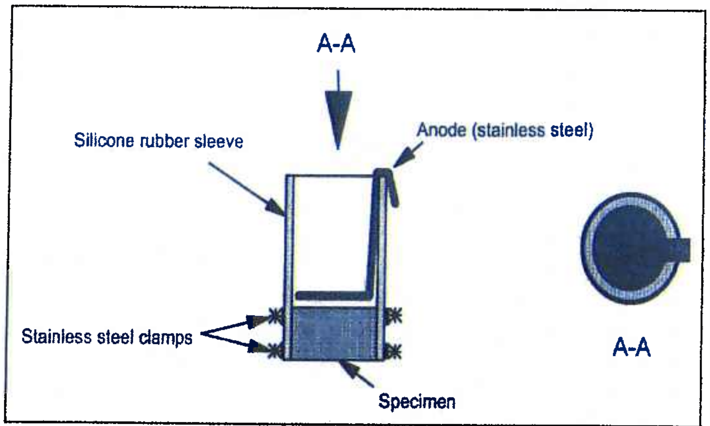

Fig. 3. Rubber sleeve assembled with the specimen, clamps and anode.

Fig. 4. Clamps + plastic rings.

Fig. 5. Anode.

Fig. 6. Rubber sleeve.

Fig. 7. Plastic stud.

Fig. 8. Plastic support with cathode.

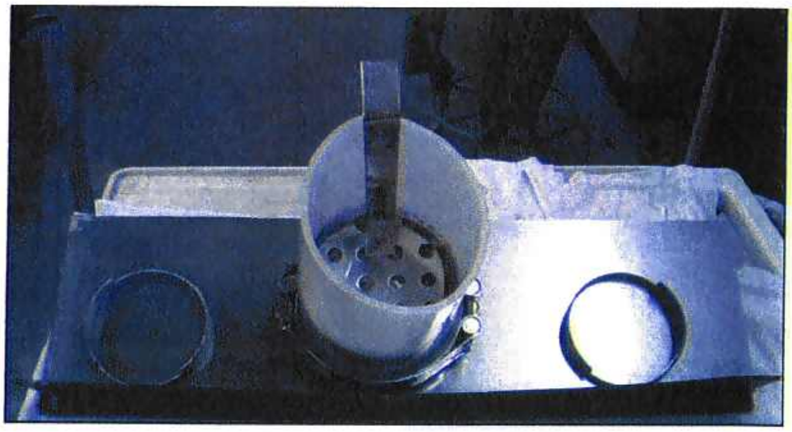

Fig. 9. Plastic support with cathode and specimen set-up.

Preparation of the concrete specimens for the RCM-test

According to [2] and [3] the preparation of the concrete specimens has to be done in a certain pre-described way. If the composition of the concrete is known several cubes (150x150x150 [mm^3]) are cast and then stored under water. After one day the mould can be removed and the concrete cubes can be put back under water. A few days before testing the cylindrical specimens, with a diameter of 100 [mm], will be drilled from the concrete cubes with a water-cooled diamond drill. After that, the outermost approximately 10 – 20 [mm] thick layer is sawed off from the specimen with a water-cooled diamond saw. Next, a slice of 50 [mm], and in this study also a slice of 100 [mm], is sawed from the cylinder representing the test specimen for the RCM tests. The surface of the specimen that was closest to the original surface of the cube is the surface that will be exposed to the chloride solution (catholyte).
The specimens that were not immediately used for testing were stored in a saturated $Ca(OH)_2$ solution (by dissolving an excess of calcium hydroxide in distilled or de-ionised water). The actual RCM tests started by placing the specimen in a vacuum container, capable of containing at least 3 specimens (this is also the minimum amount of specimens needed for one RCM-test), for vacuum treatment. The absolute pressure in the vacuum container had to be reduced to 10-50 [mbar] within a few single minutes. This vacuum pressure should maintain for three hours and then, while still under pressure, the container should be filled with the saturated $Ca(OH)_2$ solution, so that all the specimens were fully immersed in this solution. This vacuum should be maintained for another hour before allowing air to re-enter the vacuum container. Keep the specimens after the vacuum treatment in the saturated $Ca(OH)_2$ solution for 18 ± 2 hours.

Preparation and execution of the RCM-test

After the vacuum treatment (totally 22 ± 2 hours) the preparation for the RCM-test could be started. First filling the catholyte reservoir with approximately 25 litres (in the case that the catholyte reservoir has the dimensions of: 551 x 352 x 300 [mm^3]) of 10 [%] NaCl solution, this means 100 [g] NaCl in 900 [g] water. Then take the specimens (3) and fit the silicone rubber sleeves on the specimens (see Figg. 8 and 9) and