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NT METHOD

HYDROPHOBIC IMPREGNATIONS FOR CONCRETE – PREVENTION OF CHLORIDE INGRESS – FILTER EFFECT

Key words: Concrete, hydrophobic impregnation, chloride ingress, performance test, diffusion of chlorides

1 SCOPE

This test method describes a procedure to measure the ability of hydrophobic impregnations to prevent chloride ingress in concrete. The new method is based existing Finnish, Norwegian and Swedish test methods and intends to replace these national methods.

The method may be used as a basis for classification of hydrophobic impregnations with regard to their capability to protect concrete from chloride ingress.

2 FIELD OF APPLICATION

Chloride induced corrosion of the reinforcement is the major cause of degradation of reinforced concrete structures. Using of de-icing salts during winter, leads to severe degradation of edge beams in road bridges. Thus, in order to extend the service life and decrease maintenance costs, hydrophobic impregnations are commonly used to prevent or slow down chloride ingress into concrete.

The harmonized standard EN 1504-2 (CEN, 2004) is the basis for CE-marking and declaration of performance of hydrophobic impregnation systems, but the property "diffusion of chloride ions" is, according to the standard, "subject to national standards and national regulations".

The transport and roads administrations of Sweden, Norway and Finland had used different national methods to evaluate the performance of this type of products meaning that the same CE-marked product needs to meet different requirements.

The method is also suitable for evaluating the capability of hydrophobic impregnations to prevent chloride ingress above sea-level in marine environments.

3 REFERENCES

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4 DEFINITIONS

The terminology used is in accordance with EN 1504-2 (CEN, 2004).

5 THE TEST METHOD

5.1 Short description of the test method

Concrete specimens are prepared by sawing 100 mm cubes into two halves, three cubes per test series. The sawn surfaces are defined as exposure faces. Three halves are treated with the hydrophobic impregnation to be tested and the other three halves are kept as untreated references. The specimens are exposed submerged in 15% NaCl-solution for 56 days. After exposure, the chloride ingress is determined by profile grinding and the total amount of penetrated chlorides is calculated. The filtering effect in % of the hydrophobic impregnation is determined based on the ratio between the amount of penetrated chlorides into treated and non-treated concrete specimens.

5.2 Preparation of the specimens

The test specimens shall be prepared from cast 100 mm concrete cubes.

The concrete used shall be of the type MC (0.45) according to EN 1766. The cement used shall be of the type CEM I 42.5 or CEM I 52.5 and the maximum aggregate size shall be 10 mm.

For each hydrophobic impregnation to be tested, 3 treated specimens (half-cubes) shall be tested together with 3 corresponding reference specimens (half-cubes) from the same batch. Up to 3 hydrophobic impregnations can be tested simultaneously with the same reference series (non-treated). The standard procedures for mixing and casting shall be used. The cubes shall be demoulded after 1 day and thereafter cured in water at (20±2) °C until the age of 28 days.

At the age of 28 days, the specimens shall be prepared by sawing the cubes into two halves (Figure 1) with a water-cooled diamond saw. The sawn faces shall be carefully scrubbed with a soft brush under running tap water immediately after cutting in order to remove the cutting slurry from the as-cut surfaces. The exposure to tap water shall be as short as possible.

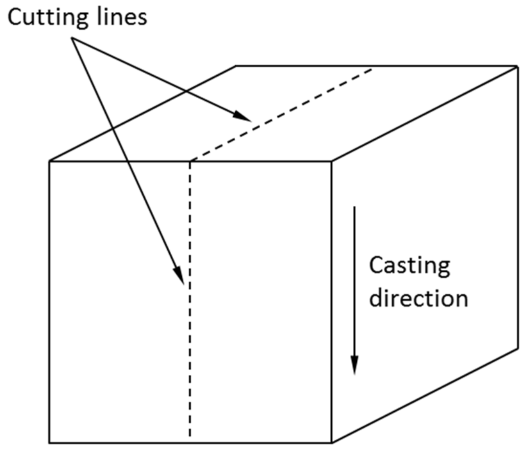

Figure 1: Illustration of cutting direction.

When still wet, each specimen shall be judged visually with respect to a homogeneous distribution of aggregate and content of encapsulated air. Specimens that are abnormally inhomogeneous and/or have abnormally many air bubbles or air voids ≥ Ø5 mm shall be rejected.

After cutting, the specimens shall be left to dry, placed with the sawn surfaces facing down on a damp tight substrate (plastic sheet), at (20±2)℃ and (65±5)% RH for 2-4 hours. After 2-4 hours drying, all surfaces, except the cut surface, shall be coated with 2 layers of epoxy resin. During coating, the surface to be impregnated shall be lifted up from the underlay/table, for instance by placing the specimens on hollow cylinders with the sawn surface facing down. The specimens are then left to harden overnight at (20±2)℃ and (65±5)% RH with the sawn surface facing down.

The specimens to be treated with the hydrophobic impregnation shall be wrapped using a band (30 mm wide) of adhesive neoprene, protruding 5-10 mm from the cut surface (Figure 2). This is to guarantee a homogeneous distribution of the hydrophobic impregnation and preventing it from running off the test surface. The inner edges shall then be sealed with moisture resistant contact glue (e.g. Casco Kontaktlim). The specimens shall be stored at (20±2)℃ and (65±5)% RH for preconditioning. Care should be taken to avoid contamination of the exposure face during sealing.

5.3 Preconditioning of the specimens

After preparation, the specimens shall be preconditioned at (20±2)℃ and (65±5)% RH for 7 days, with the exposure face upwards.

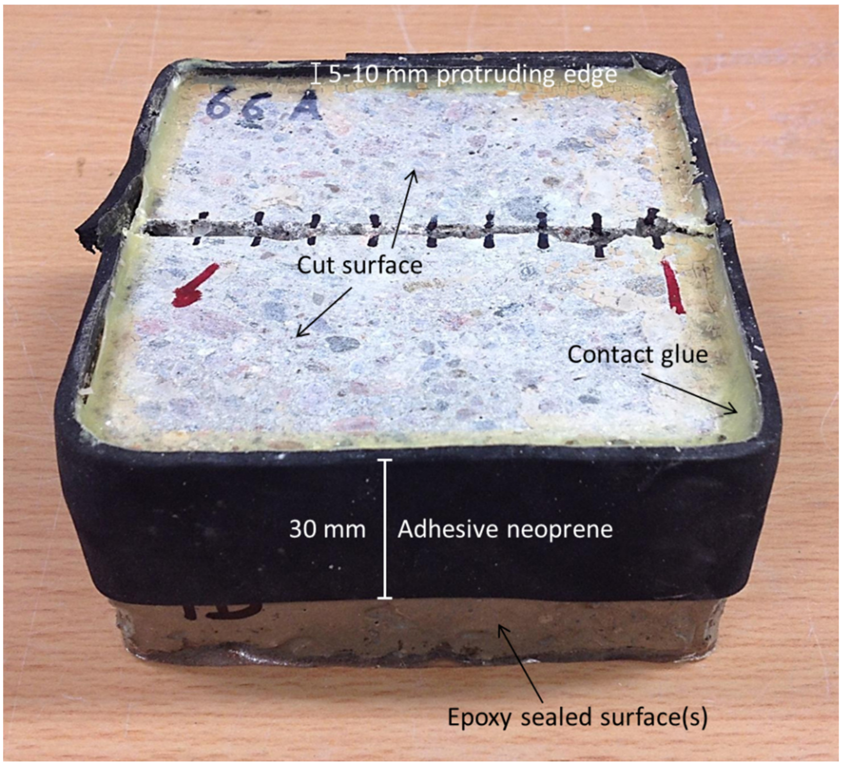

Figure 2: Illustration of test specimen.

5.4 Application of the hydrophobic impregnation

After 7 days at (20±2)℃ and (65±5)% RH, the specimens to be treated shall be placed on top of a scale, in the horizontal position with the sawn surface facing up. The scale is counterbalanced and the hydrophobic impregnation is applied to the test surface, in the amount (in grams) recommended by the supplier. The product shall be applied and homogeneously distributed using a non-absorbent soft brush. The weight of the applied product shall be recorded in grams, to the second decimal.

5.5 Curing or the hydrophobic impregnation

After application of the hydrophobic impregnation, the treated specimens shall be conditioned at (20±2)℃ and (65±5)% RH for 28 days.

5.6 Storage of reference specimens

After preconditioning at (20±2)℃ and (65±5)% RH for 7 days, the reference specimens shall be continually stored at (20±2)℃ and (65±5)% RH for further 28 days, separated from the treated specimens. Care should be taken that the reference specimens are not contaminated by airborne hydrophobic impregnations.

5.7 Exposure to chlorides

An aqueous NaCl solution is prepared to a concentration of 150±1 g NaCl per litre of solution. The NaCl concentration of the solution shall be checked before and after 14 and 28 days of exposure, and if necessary adjusted within 150±1 g NaCl per litre solution.

At the beginning of the exposure, the temperature of the solution shall be (20±2)℃. Exposure shall be carried out in a room in which the climate is controlled at (20±2)℃.

Reference and treated specimens shall be immersed in the saline solution, in separate containers. The containers should be completely filled with solution and closed with a lid. The volume of NaCl-solution should not be less than 12,5 ml/cm^2 exposed concrete surface. The exposure period shall last for 56 days and the solution in the containers shall be stirred once a week. The date and time of the start and termination of the exposure shall be recorded.

5.8 Removal from the chloride solution and storage until grinding

When the specimens are removed from the NaCl-solution, the excess solution on the surface shall be carefully wiped off with a cloth moistened in the NaCl-solution and squeezed in order to remove all excess liquid.

If it is not possible to grind the specimens directly thereafter, the specimens shall be tightly sealed in plastics and stored at 5±2 ℃.

5.9 Grinding and drying of the concrete powder

The specimens shall be ground within 7 days from the moment they are taken up from the NaCl-solution. All parallell specimens (same hydrophobic impregnation/reference) shall be ground the same day. The grinding of the treated samples and their corresponding references shall be carried out within 48 hours.

Concrete powder shall be ground in layers with an area of at least 25 cm^2 down to a depth of 25 mm. Grinding should not be performed within 10 mm from the edge of the test surface.

It is recommended to use 5 mm thick layers. The layer between 20 and 25 mm of both impregnated specimens and references can normally be used to determine the initial chloride content of the concrete.

The date and time of grinding shall be recorded.

After grinding the ground samples shall be oven-dried in 105±5 °C.

The ground samples shall, before and after oven-drying, be kept protected from humidity and CO_2 until the chloride analysis is carried out.

5.10 Chloride analysis

The acid soluble chloride content in each layer shall be determined according to EN 14629 (CEN, 2007) (or another method with the same or better precision), as percent of the oven-dry concrete mass. The chloride content shall be given with three significant numbers.

5.11 Expression of results

For each layer, the total chloride ingress shall be calculated according to the following expression:

$$Cl_i = [Cl_{t,i} - Cl_0]$$

where:

Cl_i is the total chloride ingress in layer *i* (in % or g per oven-dry concrete mass*)

$Cl_{t,i}$ is the total chloride content in layer *i* (in % or g per oven-dry concrete mass*)

Cl_0 is the chloride background level (in % or g per oven-dry concrete mass*);

The total chloride ingress over the depth considered (normally 25 mm) in one specimen is then calculated as:

$$Cl_n = \left[\sum_0^d Cl_i \cdot x_i\right] \cdot \frac{1}{d}$$

where:

Cl_n is the total chloride ingress over the analyzed depth (d) of specimen *n* (in % or g per oven-dry concrete mass*)

d is the total analysed depth (in mm)

x_i is the thickness of layer *i* (in mm)

The efficiency of the treatment, expressed in terms of filter effect based on the chloride content down to a depth of 25 mm from the surface, FE_{25}, shall then be determined using the following equation:

$$FE_{25} = Filter\ Effect\ = [1 - \frac{\sum Cl_{a,treated}}{\sum Cl_{a,reference}}]$$

where:

$Cl_{a,treated}$ is the average chloride content (Cl_n, depth =25 mm) of the three parallell specimens treated with one hydrophobic impregnation product (in % or g per oven-dry concrete mass*);

$Cl_{a,refernce}$ is the average of the chloride contents (Cl_n, depth =25 mm) of the three parallell reference specimens (in % or g per oven-dry concrete mass*);

If other total depths are used for specific purposes, the number in FE_{25} shall be changed accordingly.

$^{*)}$ *Other units may be used. The same unit shall be used throughout the calculations.*