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Proposal for a Test Procedure for Injection Products against Rising Damp

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Abstract

Old masonry often suffers from aesthetical, biological and physical problems triggered by rising damp and salt transport. Compared to other methods, the creation of a physico-chemical humidity barrier through injection of chemicals, proves to be a generally efficient and fast method to stop rising damp. In Belgium, chemicals capable to change the surface tension of porous building materials are mainly used for this purpose.
Till now, the lack of a simple laboratory test procedure that is sufficiently representative of real situations has prevented a systematic comparison of the effectiveness of different injection products available on the Belgian market. Recently, such a test procedure has been elaborated by a national workgroup consisting of manufacturers, a control institution and the laboratories of KIK-IRPA and BBRI.
The set up of this test procedure is based on experience, literature-survey and research from both laboratories. The final goal is a relative simple, fast and cheap, but scientifically based, test procedure which forms the basis for a (Belgian) Technical Agreement (TA).
Within a first test campaign, 18 different products were tested, including solvent- and water based products in liquid phase and a cream formulation, at different concentrations. Most of the tested products are commercially available. This broad spectrum of products allowed to obtain a good cross-comparison of the behaviour of the different injection products. In addition, it served to relate the results of this procedure to in situ treatments of old masonry.

Keywords: restoration, rising damp, humidity, salts, injection, porous materials, monuments

1 Introduction

Old masonry was usually built without a mechanical barrier against rising damp and therefore often suffers from aesthetical, biological and physical problems (flaking, powdering) triggered by rising damp and salt transport.

Among the treatments against rising damp, the creation of a physico-chemical humidity barrier through injection of chemicals, proves to be a generally efficient and fast solution. For this purpose, chemical products, susceptible of changing the surface tension of porous building materials, are widely used in Belgium.

Till now, the lack of a simple laboratory test procedure that is sufficiently representative of in situ applications prevented a systematic comparison of the effectiveness of different products available on the Belgian market.

Recently, such a test procedure was designed by a national workgroup consisting of manufacturers, a control institution and the laboratories of KIK-IRPA and BBRI. Identification tests (among which the dry weight determination and analyses by Fourier Transformation Infra Red spectroscopy (FT-IR)) form an essential part of the procedure, since a TA label requires a continuous control of the product composition.

An artificial calcium silicate brick, i.e., sand lime brick, has been considered as the most appropriate substrate for these tests. The treatment is applied after contamination of the samples at several saturation degrees with an aqueous solution of a salt mixture. The effectiveness of the treatment is evaluated by means of capillary water absorption tests as well as by the penetration properties of the injection product.

Within a first testing campaign, 18 different products were examined, including solvent- and water-based products, both in liquid phase and in a cream formulation, at different concentrations. The active materials in these products are silicone compounds, stearates and methylsiliconates. This broad spectrum of products allowed a systematic assessment and hence cross-comparison of their behaviour and also served to relate the results to in situ treatments of old masonry.

2 Description of the test procedure

2.1 Identification of the product

For the identification as well as the conformity-control of injection products, the following methods are used :

– Determination of the density by pycnometer measurements.

- Determination of the viscosity of the formulation, using a Brookfield Synchro-electric Viscosimeter. If the product is formulated as a cream, a conus-and-plate apparatus is used.
- Determination of the mass return of the injection product. For that, 0.5 g of the injection product is conditioned in an aluminium cup at 20°C and 55% relative humidity (RH) to constant weight. This method is also used by KIK-IRPA and BBRI in their test procedure for water repellent products [9].
- Chemical identification of the product by FT-IR spectroscopy (Nicolet, KBr-method, solid transmission). The absorption spectrum is measured in the wavenumber-range between 400 and 4000 cm^{-1} [9].

2.2 Properties to be investigated

The injection products against rising damp need to have at least the following two properties to be effective

- The ability to penetrate sufficiently in a masonry loaded with moisture and salts; and,
- The ability to react chemically in a moisture and salt contaminated masonry to form a barrier against rising damp.

2.3 Substrates

Most test procedures for rising damp are performed on small scale test walls, as the one previously used at BBRI. This original procedure, being time- and money consuming, was modified into a simpler and faster method.

In most test procedures, three types of materials are usually considered: brick, natural stone and mortar tested as a single material, or combined in small test walls. In the present proposal only mortar was initially selected to reduce the costs of the test procedure. This choice was logic since mortar is the most important porous material of the masonry that needs to be water repellent as it transports most of the water. Furthermore, a successful treatment of the mortar will usually result in a successful treatment for the entire masonry.

However, mortar was replaced by an artificial calcium silicate brick in the test for the reason that mortars prepared in a mould are generally more dense than those same applied between bricks or stones. Their porosimetric properties differ due to differences in moisture transport properties during hardening. In masonry, moisture transports to the attached bricks which is not the case for a mortar prepared in a mould.

The selected calcium silicate brick is characterised by porosimetric properties very similar to many ancient mortars. It has a porosity of 28%

mostly consisting of pores with a diameter around 100 µm (Figure 1). A smaller portion of the pores have diameters ranging between 0.01 and 0.1 µm.

The shape and size of the sample are shown in Figure 2, as well as the drilled hole, having a diameter of 20 mm and a depth of 70 mm, used for the application of the salt solution and, eventually, the injection product.

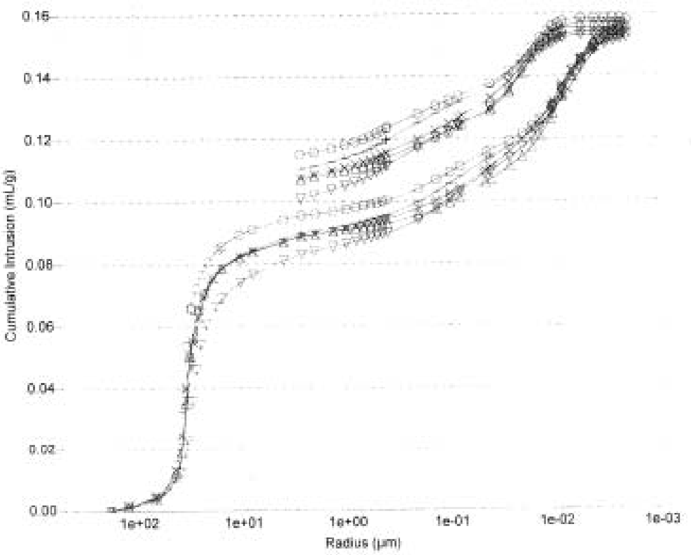

Figure 1: Pore size distribution of the calcium silicate brick. The different lines correspond to different samples, illustrating the homogeneity of this material.

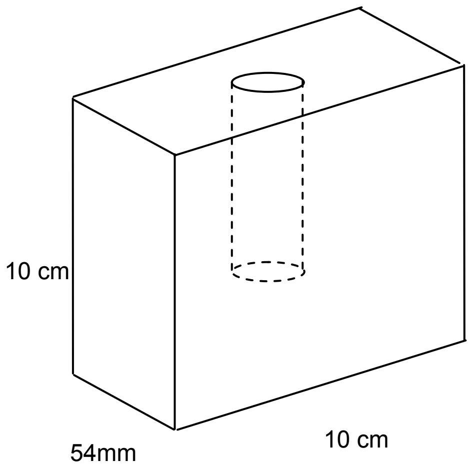

Figure 2: Shape and dimensions of the test sample.

2.4 Capillary water absorption

Every sample was submitted to a capillary water absorption test according to the test conditions in EN 1925. The largest surface (10x10 cm²) was the absorption surface. The water uptake after 2 weeks was considered as the saturation moisture content (m_{0s}).

2.5 Preparation of the samples

For the contamination of the samples, an aqueous solution was prepared containing 0.5 w% of NaCl, 0.5 w% of KNO_3 and 2.0 w% of Na_2SO_4.

The samples were prepared as follows:

- Drying at 45±5°C to constant weight.
- Pre-conditioning by pouring an amount of the aqueous salt solution into the drilled hole. The amount of solution is chosen to obtain a saturation degree of 40±5, 60±5 or 80±5 %. Initially saturation degrees of 60±5, 80±5 and around 95% were selected. The last condition was left out, because such a contamination is too severe and not representative for most real situations. So a lower contamination was selected and thus the 40 % was added to the other two, while the 95% was rejected.

- Each sample was packed individually in a watertight container and conditioned at 20±3°C for one week to enable a homogeneous distribution of the aqueous solution in the sample.
- The injection product was applied in the drilled hole. The amount of product was based on the information of the technical sheets and calculated as follows: in case that 10 litres per square meter are recommended, 16 ml of the product are poured into the drilled hole. In case other quantities are prescribed, a test-amount proportionally to the above mentioned amount is applied. This rule applies for liquid products and for products in the form of a cream. The calculated amount corresponds more or less to 1/4th of the amount one should use to treat the entire sample. By this way, an objective distinction between outstandingly and poorly performing products can be made.
- The drilled hole was closed to prevent the evaporation of volatile active components (such as silanes).
- Each sample was placed individually back in its watertight container, and conditioned for 28 days at a temperature of 20±3°C.

2.6 Effectiveness test

The sample, after drying at room temperature to constant weight was subjected to a second capillary water absorption test according to EN 1925. The drying before carrying out the effectiveness test is the weak point of the procedure, since this does not happen in real situations. The practical reason for choosing to dry the sample was that a capillary water absorption test on a wet sample takes months to reach equilibrium.

The absorption surface was again the large surface of 10 x 10 cm². The water absorption test was continued until the sample reaches constant mass.

Then following operations are carried out:

- Weighing of the sample (m)
- Drying the sample at 45±5°C to constant weight
- Conditioning of the sample at 20±3°C and 50 % RH to constant weight
- Weighing of the sample (dry weight + hygroscopic moisture content = $m_d + m_h$)
- The capillary moisture uptake (m_c) is calculated using the formula : $m_c = m - (m_d + m_h)$

The capillary moisture uptake is a measure of the effectiveness of the treatment which may be expressed as:

'effectiveness' of the product = 100% x $(1-m_c/m_{0s})$ (1)

It is to be expected that this 'quality'-parameter will depend on the initial moisture content of the samples.

2.7 Ability of the product to migrate into the porous material

For this purpose, the treated samples were cut through the middle, parallel to the largest surface of 10 x 10 cm² followed by:

- Drying of the sample at 45±5°C to constant weight.
- Placing the original outer surfaces (10 x 10 cm²) in contact with water for two hours.
- Evaluation of the water repellent zone on the sawn surface visualised by the light coloured surface.

The ability of the product to migrate into the material is expressed as the non-absorbing (dry) surface, relative to the total surface of the sample. This is again a function of the initial moisture content of the sample at the time it was treated, as illustrated in Figure 3.

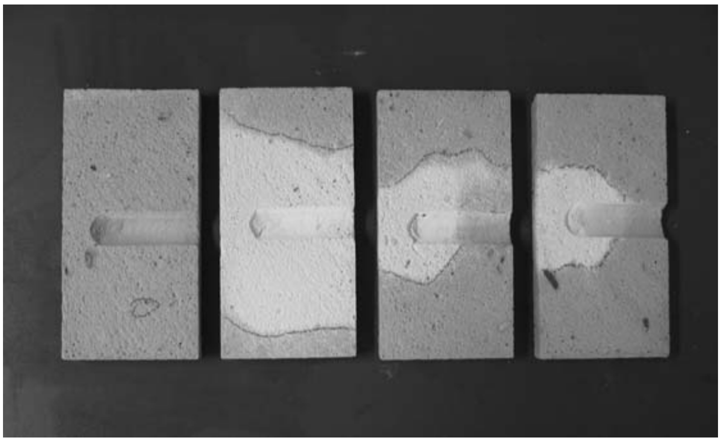

Figure 3: Example of a series of treated samples, cut in two, after placing in water for two hours. On the left is an untreated reference sample, followed by treated samples having a moisture content of 60%, 80% and 95% at the time the injection product was applied.

3 Results and interpretation

A detailed discussion of all the test results is beyond the scope of this paper. The most important results can be summarized as follows:

- The number of samples for the test procedure can be reduced to 3 per product as the homogeneity of the substrate allows this reduction without having the test lose reproducibility.
- Taking again into account that in real applications about 4 times more product is applied, an effectiveness of 25% obtained in laboratory conditions according to the decided protocol could be considered as minimum threshold value for good performing products.
- The obtained effectiveness results follow a logic order. The highest effectiveness for treatments was obtained for samples having the lowest moisture content (40%) at the time the treatment was applied. The effectiveness decreases gradually with increasing initial moisture content.
- The potassium methylsiliconate based product showed the lowest effectiveness ranging between 5% to 15%, totally insufficient for an effective treatment.
- Water based products (including cream formulations) show a rather low initial effectiveness. However, it increases significantly after repeating the capillary water absorption test. This might be attributed to the presence of emulsifying agents that might be washed out during capillary water absorption test. Therefore, two effectiveness tests are performed in the case of water based products. No further improvement was noticed when carrying out the test a third time.
- Liquid products belonging to the silicone-family as well as to the stearate-family, show an effectiveness that varies between 45% and 80%.
- The best-performing cream based products show an effectiveness ranging from 25% to 30%. Despite the lower effectiveness, creams have the advantage of showing almost no loss of injected product, contrary to liquid products that tend to disappear in cracks and voids of a masonry hence causing important product losses during treatment. Two cream based products performed very poorly. The reason for this was very simple: the recommended consumption in

the technical sheet is too low for an effective treatment. It is believed that the product type is not bad, but that larger quantities are needed to increase the effectiveness of the treatment. It was later noticed that these two products, commercialised under different names, actually have an identical composition. The similar test results obtained for these products confirm the consistency of the test procedure.

- As a test-case, a cream type product was applied on a dry sample. Contrary to liquid products, that migrate well in a dry sample, creams show low migration properties and need some pore water to diffuse into the substrate. Creams might therefore not be recommended for the "preventive" injection of walls that are dry at the time of the treatment or for walls that show season-dependant humidity properties.

4 Conclusion

The developed test procedure is meant for a comparative evaluation of the effectiveness of products to be injected into masonry against rising damp. Therefore the results obtained can not be representative of an in situ application. The main reasons are:

- The extremely homogeneous substrate is not representative for masonry characterised by cracks and voids through which an important amount of the injection product disappears. Therefore, consumption values will deviate from those obtained in laboratory conditions. This is especially the case for liquid products while cream products almost show no material loss through cracks and voids.
- The amount of product applied is much lower than in reality and never allows a 100 % effectiveness. However, by using lower product amounts, the performance of injection products can be assessed objectively thus providing a means for their categorisation.

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