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Can painted glass felt or glass fibre cloth be used as vapour barrier?

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KEYWORDS: *Acrylic paint, silicate paint, glass felt, glass fibre cloth, water vapour permeability, water vapour resistance*

SUMMARY:

In most Nordic homes the interior surfaces of walls and ceilings have some kind of surface treatment for aesthetical reasons. The treatments can for example be glass felt or glass fibre cloth which are painted afterwards.

To evaluate the hygrothermal performance of walls and ceilings it is essential to know how much influence a surface treatment has on the water vapour transport. Traditionally, there has been most focus on paints that affect the permeability as little as possible. However, sometimes water vapour resistance is desirable. Especially, this is relevant in existing buildings with a ventilated attic where the ceiling may be air tight but has no vapour barrier; post-insulation of the attic may cause the need for a vapour barrier. Placing a vapour barrier above the ceiling can be tiresome and it is difficult to ensure tightness. A simpler way is to paint a vapour barrier directly on the ceiling e.g. as an ordinary paint.

This paper presents the results of an investigation of the water vapour resistance of surface treatments which are commonly used in-door. The water vapour resistance was measured by the cup method. Aerated concrete was investigated with and without various surface treatments. The surface treatments were glass felt or glass fibre cloth with different types of paints or just paint. The paint types were acrylic paint and silicate paint. The results show that the paint type has high influence on the water vapour resistance while the underlay i.e. glass felt or glass fibre cloth has very little impact.

The measured water vapour resistance for specimens with acrylic paint was the highest, these were measured to be up to approximately $3 \cdot 10^9$ Pa·m²·s/kg which is considerably less than $50 \cdot 10^9$ Pa·m²·s/kg as recommended for a vapour barrier. Therefore, two layers of ordinary acrylic paint on glass felt or glass fibre cloth cannot be used instead of a vapour barrier.

1. Introduction

In most Nordic homes the interior walls and ceilings have some kind of surface treatment for aesthetical reasons. Surface treatment will to some extent affect the moisture transport and reduce the moisture transport by diffusion compared to untreated surfaces. How much the diffusion will be reduced depends on the water vapour resistance of the surface treatment. In some cases it is desirable to achieve a high water vapour resistance, e.g. if a vapour barrier is needed but difficult to install. Existing buildings with a ventilated attic where the ceiling may be air tight but has no vapour barrier is

an example of this; post-insulation of the attic may cause the need for a vapour barrier. However, placing a vapour barrier above the ceiling can be tiresome and it is difficult to ensure tightness. A simpler way is to paint a vapour barrier directly on the ceiling e.g. as an ordinary paint. In the present study aerated concrete was investigated with various surface treatments. The surface treatments were glass felt and glass fibre cloth which were painted with two different types of paints, acrylic paint and silicate paint, respectively. For comparison results without glass felt or glass fibre cloth are also presented.

To investigate the water vapour resistance for the surface treatments the cup method was used.

2. Theory

The vapour resistance is determined by the cup method according to EN ISO 12572 (2001).

It is known that the water vapour resistance is depending on the type of paint, as silicate paint is generally described as an open paint opposed to acrylic paint (Brandt, 2013).

The hypothesis of this paper is, that the water vapour resistance can be increased if the paint layer is supplemented with a layer of glass felt or glass fibre cloth, as these surface treatments are expected to absorb more paint than surfaces without this extra layer. In this way common surface treatments may act as vapour barriers.

3. Materials

Aerated concrete with dry density $535 \pm 15 \text{ kg/m}^3$ was used as base material as this material has a high water vapour permeability.

The materials for the surface treatments have been chosen because they are commonly used as surface treatments of walls and ceilings in Denmark, and are expected to have different water vapour permeability.

Seven test specimen series were fabricated:

1. Aerated concrete with no surface treatment (pure aerated concrete)
2. Aerated concrete with two layers of acrylic paint (three series)
 - a. Putty and acrylic paint
 - b. Putty, glass felt and acrylic paint
 - c. Putty, glass fibre cloth and acrylic paint
3. Aerated concrete with two layers of silicate paint (three series)
 - a. Putty and silicate paint
 - b. Putty, glass felt and silicate paint
 - c. Putty, glass fibre cloth silicate paint

For the series with surface treatment a thin layer of putty was applied on one side of the aerated concrete, this was used to level out and fill the coarse pores in the surface. The layer thickness is less than 0.5 mm. On the putty one layer of liquid prime was applied; the liquid prime had a viscosity as water. After this either paint or one of the two kinds of glass fibre and paint was applied. The liquid prime and paint was applied with a roller.

The two kind of glass fibre are called glass felt and glass fibre cloth, which has different structures. They are both made of the same inorganic material; small fibres of glass. However, the differences in the two are the structure; one has a glass fibre mat with a smooth surface where the other is woven glass fibre. The two different structures are shown in FIG 1.

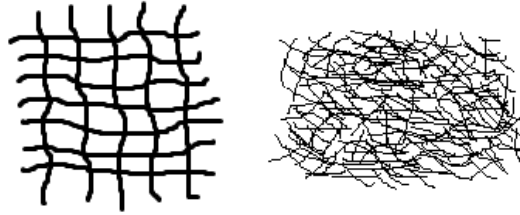


FIG 1 A sketch of the structures of the glass fibre cloth (left) and glass felt (right) which are used in the experiments. It is seen that the structure for glass fibre cloth is rougher compared to glass felt.

The two types of painting were acrylic paint and silicate paint. Acrylic paint consists of i.a. acrylic polymers and water. When the paint dries out the polymers will glue together and establish a layer of polymers.

The silicate paint is a natural mineral product, where the binding agent is silicate.

4. Methods

The experiment was divided into preparation of the specimens and measurements of the water vapour resistance of the seven series.

4.1 Preparation of the specimens with surface treatments

Aerated concrete was used as underlay for the surface treatments. Six different surface treatments were investigated. The constitutions of the specimens are listed in the paragraph of Materials.

When the surface treatments were applied to the aerated concrete slab the surface area of the slab was 600 mm x 400 mm to obtain an evenly distributed surface.

After the surface treatments the specimen were drilled out of the slab. All the specimens had a diameter of 80 mm and a thickness of 24 mm. Four specimens of each surface treatment and eight specimens without surface treatment (pure aerated concrete) were tested. The pure aerated concrete specimens were tested to be used as references.

Afterwards, all the specimens were placed in a ring of plexi glass. The height of the plexi glass ring was 25 mm and had an outer diameter of 100 mm and inner diameter of 93 mm. To achieve that the volume between the plexi glass ring and the specimen was completely sealed epoxy was used.

Furthermore, all the specimens were painted with two layers of epoxy on the vertical perimeter surface to make sure that it was only the surface treated area that would be examined. The specimens which were used for the cup experiment is shown at FIG 2.



FIG 2 Specimens to the cup tests. Left: Specimen, which has just been painted with epoxy on the vertical perimeter surface sides. Middle: Specimen placed in a plexi glass ring with epoxy between the specimen and the plexi glass ring. Right: Specimens ready for the cup test.

4.2 The cup tests

The cup test has been performed according to the European standard EN ISO 12572 (2001) Hygrothermal performance of building materials and products – Determination of water vapour transmission properties. This investigation contained only wet cup tests. The cup equipment that was used is more detailed described in West and Hansen (1988).

The principle for the cup test is that the specimen is sealed to the top of a cup containing a saturated aqueous solution of Potassium Nitrate (KNO_3). The air space between the saturated aqueous solution and the bottom side of the specimen is 6-8 mm, and has a relative humidity of 94 % RH. A net was placed upon the glass cup to avoid the salt solution reached the specimen during handling of the cup. To ensure the sealing between cup and specimen as well as specimen and lid rubber packings were used beneath and above the specimen. A section of the cup used is shown in FIG 3. The cup is placed in a test chamber where the relative humidity and the temperature of the air are controlled to 50 % RH, 23 °C. Between the chamber air and the air inside the cup a water vapour pressure gradient will give a one-dimensional stationary moisture transport through the specimen.

By weighing the cup periodically the weight decrease was determined. The weighing was continued until five successive determinations of change in mass per weighing interval for each specimen were constant within ± 5 % of the mean values for the specimen. The weight change was afterwards used for calculation of the water vapour resistance.

The standard prescribes that the water vapour resistance should be determined as an average of the water vapour resistance of five specimens of this size. However, eight specimens of aerated concrete without surface treatment were used, while four specimens were used for each of the surface treatments.

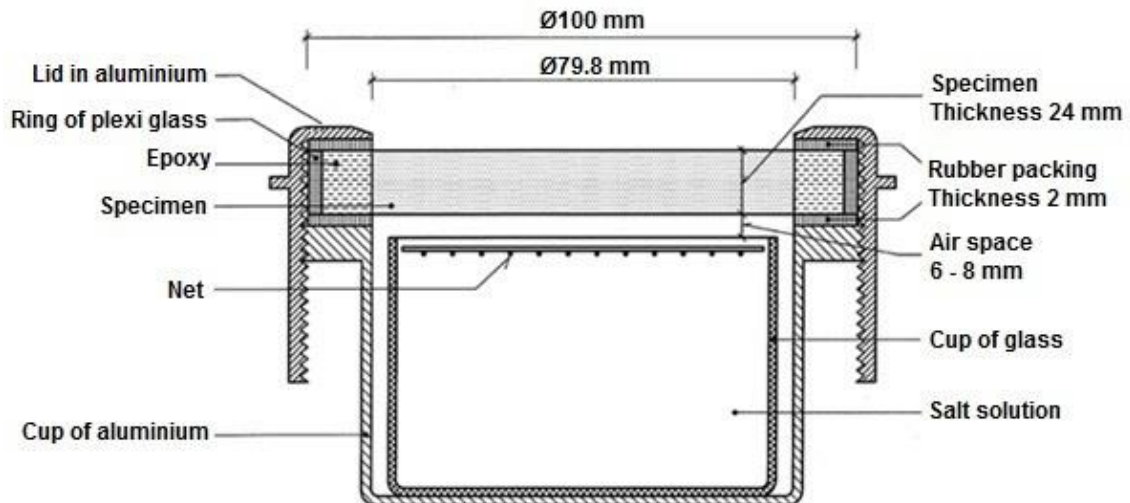


FIG 3 The aluminium cup which was used to the test specimens. Inside the aluminium cup was a glass cup placed were the salt solution (KNO_3) was located. The cup was placed in a climate chamber at 50 % RH and 23 °C.

5. Results

The water vapour permeability δ_p for pure aerated concrete was measured to be $26.6 \cdot 10^{-12}$ kg/(Pa·m·s). The measured water vapour resistance Z_p for the specimens are shown in FIG 4.

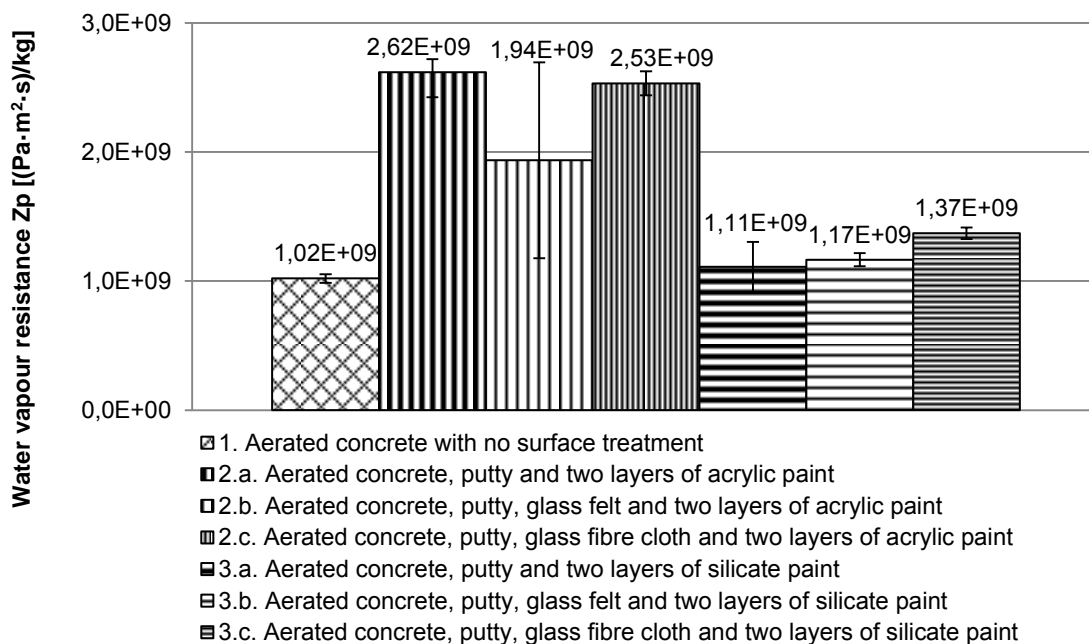


FIG 4 The water vapour resistance, Z_p , with standard deviation for the aerated concrete and the different surface treatment. The vapour resistance and its deviation are calculated from four specimens with same surface treatment and have been tested equally. However, for pure aerated concrete the vapour resistance and its deviation are calculated from eight specimens.

6. Discussion

The water vapour permeability and water vapour resistance factor for the pure aerated concrete were found to be $23.6 \cdot 10^{-12}$ kg/(Pa·m·s) and 8.30, respectively. The water vapour resistance factor is compared with values from IEA – Annex XIV (1991), Gottfredsen and Nielsen (2006) and information from the manufacturer of the aerated concrete slabs. The comparison is shown in FIG 5.

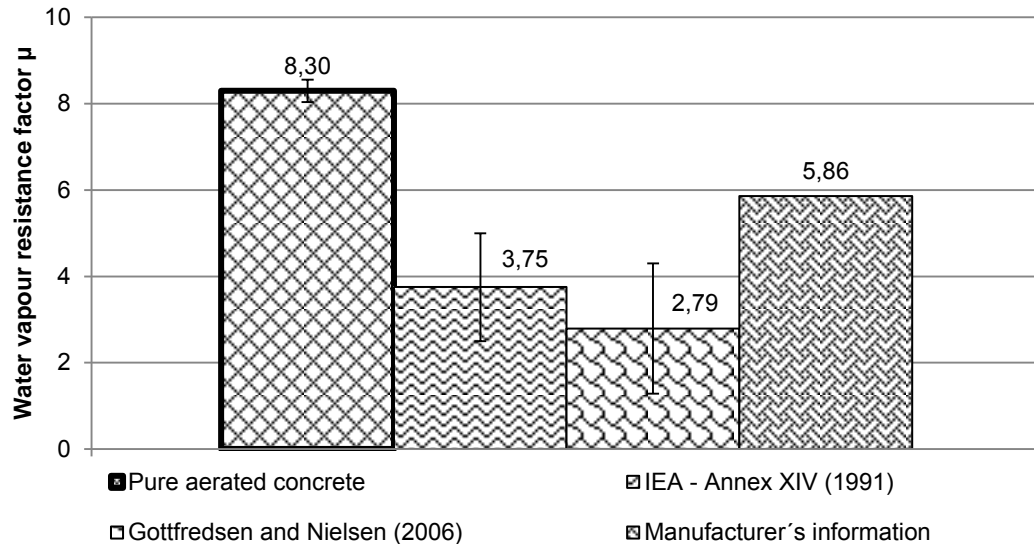


FIG 5 Pure aerated concrete. The water vapour resistance with standard deviation for the cup test compared with Gottfredsen and Nielsen, (2006), IEA – Annex XIV, (1991) and information from the manufacturer of the pure aerated concrete. The manufacturer does not state the standard deviation.

If the measured water vapour resistance factor is compared with information from the manufacturer there is a factor 1.4 in difference which is lower than compared with IEA – Annex XIV (1991) and Gottfredsen and Nielsen (2006). Here is a factor of 2.21 and 2.97 in difference. That means that the recovered water vapour resistance factor is bigger than in the literature. It is important to mention that the water vapour resistance factor is calculated from eight samples, whereas EN ISO 12572 (2001) prescribes that five samples is sufficient. Additionally, the recovered standard deviation is low.

FIG 4 show the water vapour resistance for the different aerated concrete specimens with surface treatment compared to the one without surface treatment. The water vapour resistance is calculated from four specimens that are tested concurrently. It was expected that the surface treatments would have a blocking effect. However, the water vapour resistance in the specimens with silicate paint were not significantly affected; the specimens with only silicate paint have almost the same water vapour resistance as aerated concrete without surface treatment.

It is seen that by using acrylic paint it is possible to get a higher water vapour resistance than when using silicate paint. This was expected as Brandt (2013) characterises silicate paint as more open to water vapour than acrylic paint. Additionally, FIG 4 show paint combined with glass fibre cloth or glass felt has no significant influence on the water vapour resistance, regardless of the paint type. Therefore, glass felt or glass fibre cloths are not able to absorb more paint than surfaces without this extra layer.

Two layers of acrylic paint enhances the water vapour resistance of the aerated concrete by $1-1.6 \cdot 10^9$ Pa·m²·s/kg. This should be compared to $50 \cdot 10^9$ Pa·m²·s/kg, which by Brandt (2013) is considered to be the lower limit for the water vapour resistance of a vapour barrier. Therefore, two layers of ordinary acrylic paint on glass felt or glass fibre cloth cannot be used instead of a vapour barrier.

The results show that the specimens that were surface treated with glass felt and acrylic paint have a high standard deviation. This could indicate that glass felt makes the distribution of acrylic paint more uneven. A possible explanation could be that the fibres in the glass felt makes it harder for the paint to be evenly distributed so the paint may not cover everywhere even though two layers are applied. As silicate paint has no effect on the water vapour resistance an uneven distribution of silicate paint would not be noticeable.

To test the theory of uneven distribution of paint on glass felt more specimens should have been tested. First of all five specimens should have been used for each surface treatment; this would in general have decreased the standard deviation. Additionally, tests could have been made on specimens with more than two layers of paint. If the theory of uneven distribution is true, more layers of paint would have reduced the unevenness. It would also be interesting to see if e.g. four layers of paint would have doubled the water vapour resistance compared to two layers.

As water vapour resistance of each layer can be added this should theoretically be true. However, the treated surface may not absorb as much paint as the untreated surface. In this test it could have been determined by simply weighing the samples after applying each layer of paint.

7. Conclusions

In the present study it was tested how different surface treatments change the water vapour resistance of aerated concrete. Aerated concrete without surface treatment was compared to aerated concrete with a thin layer of putty and different paint types, silicate paint and acrylic paint, respectively, with and without an underlay of glass felt or glass fibre cloth. The results were:

- The used aerated concrete has lower water vapour permeability than usually reported in the literature and by the manufacturer
- The water vapour resistance is not changed if silicate paint in two layers is used
- Acrylic paint in two layers enhances the water vapour resistance by $1-1.6 \cdot 10^9$ (Pa·s·m)/kg
- Glass fibre cloth or glass felt as an underlay tissue for the paint has no significant effect on the average water vapour resistance
- Glass felt as an underlay for acrylic paint has higher standard deviation than the other surface treatments. Maybe the glass felt makes the distribution of the paint more uneven.

As a result it must be concluded that glass fibre cloth or glass felt does not absorb more paint than putty without this layer. It might only enhance the unevenness of the distribution of the paint. As two layers of the paint with the highest water vapour resistance (acrylic paint) is about 20 times more open to water vapour than what is recommended for a vapour barrier, two layers of ordinary acrylic paint, with or without glass fibre cloth or glass felt cannot be used as a vapour barrier.

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