SURFACE TREATMENT WITH WATER REPELLENT AGENTS

Present research in Sweden

Dr Kenneth Sandin
Division of Building Materials
University of Lund
P.O. Box 118
S-221 00 LUND
Sweden

INTRODUCTION

Much damage to external walls depends on a high moisture content, which in turn depends on high water absorption during driving rain. One example of such damage is mould and rot in joists and sills. Another example is damage due to direct water penetration in homogeneous walls. Other negative effects of a high moisture content are impaired heat insulation and accelerated degradation.

Hydrophobic impregnations have great advantages and are to an increasing extent being used in Sweden. However, there is widespread scepticism to water repellent agents. This scepticism is based on a conservative attitude where a few failures are used as a general argument against water repellents. (When asking these sceptics for a concrete example of a damage depending on water repellents they are unable to give an answer!) The usual argument against water repellents is that the treatment degrades in a few years. This may be true if you use the wrong compound. There are, however, compounds which are effective after 20-25 years. Another argument against water repellents is that you cannot renew an impregnation if needed. This argument is completely absurd. If the impregnation is degraded, it isn't there, and thus it cannot be an obstacle to a new impregnation!

In order to promote a debate on water repellents, an information and research project was started in Sweden some years ago. The project consists of three parts:

1. Compiling available facts in an easily comprehensible booklet.
2. Laboratory investigations.
3. Case studies.

This paper is a summary of the three parts of the project. Up to now all publications are written in Swedish. Our intention is to translate the publications into English as soon as possible.

2 A COMPREHENSIBLE BOOKLET

The purpose of the booklet is to give the reader a basic knowledge on the subject of "water repellent treatments". Great attention is paid to definitions and nomenclature. The description is mainly confined to different types of silicones, as they are predominant.

To start with the purpose of the treatment is described, which is to make use of all the advantages of the dry materials. The most important advantages are:

- stopping direct water leakage
- improving heat insulation
- preventing frost damage
- preventing salt efflorescence
- reducing chemical degradation
- reducing biological attack

All these advantages are illustrated in the booklet and where appropriate the disadvantages and risks are also mentioned. In this paper only one of the subjects will be discussed, namely improved heat insulation. Increasing moisture content in a material always means that the thermal conductivity increases. In aerated lightweight concrete (ALC) this effect is of vital importance for the intended function of the material. The thermal conductivity increases about 50 % when the moisture content increases from 4 to 17 percent by weight. The latter moisture content is in no way unusual. Even moisture content about 30 percent by weight occurs in practice. In this case the heat flow through the wall is doubled, compared to the dry wall.

Beside the increasing heat conductivity in a wet wall, also large amounts of energy are consumpted to dry out the water which is absorbed during driving rain. In TABLE 1 the result from a calculation of the heat flow through a 250 mm ALC wall in southern Sweden is shown. As you can see, the influence of the moisture is considerable.

TABLE 1
Calculated heat flow through a 250 mm ALC-wall in southern Sweden.

Moisture content (percent by weight)	**Cloudy autumn night** (W/m2)	**Cloudy autumn day** (W/m2)
4 (no evaporation)	7.8	3.9
10 (evaporation)	9.5	6.9
20 (evaporation)	11.5	8.3
30 (evaporation)	13.4	9.7

After this introduction the physical principles of the impregnation and the chemistry of silicones are described.

The conception and structure of silicones are discussed in detail. Common terms, such as radical, alkyl, alkoxy, organo, silane, siloxane, silicone resin and siliconate, are defined and examples of combinations are given.

Different silicone types and their properties are described, as well as different radicals and their properties.

This chapter ends with a table showing the properties of the combinations of different silicone types and different radicals.

After the description of different silicones the demands on the water repellent treatment are discussed. Examples of these demands are:

- good water repellent effect
- high vapour permeability
- good penetration into the underlayer
- good resistance against alkali
- chemical bond to the underlayer
- rapid hydrophobic effect
- tack-free and dirt-repellent surface
- invisible
- pearl effect
- applicability to wet underlayer

Some of these demands must always be fulfilled, while others can be characterized as special demands in certain situations or general wishes.

Finally there is a discussion on the area of use of the different products on the market and practical considerations in practice. Advantages and disadvantages of siliconates, silanes, siloxanes, silane-siloxane compounds, silicone resins and microemulsions are discribed. A number of factors that must be analysed before an impregnation actually takes place are mentioned, for example:

- judgement of the underlayer
- choice of water repellent agent
- preparatory work
- application

The booklet is published in Swedish. An English edition will be published as soon as possible.

3 LABORATORY INVESTIGATIONS

In the international literature on the subject no investigation of this type has been found. Most papers deal with a specific question, for example resistance against alkali or penetration depth. There is no investigation that at the same time has tested many properties of many agents on different underlayers.

The purpose of the laboratory investigations was to make a survey of the properties of water repellent agents on the Swedish market. The intention was not to classify individual products, but rather to get an opinion about the situation in general.

The demands on accuracy and scientific test methods have not been very high. Instead we have used many different simple test methods and a great number (about 30 different products from the Swedish market) of water repellent agents. The investigations can be regarded as a base for future more detailed scientific investigations.

The purpose can be summerized as follows:

- develop test methods
- give trends
- be a base for futher investigations

Examples of tests that have been carried out are:

- penetration depth
- water repellent effect
- resistance against alkali
- influence on vapour permeability
- influence on drying out
- effect when the underlayer is cracked
- aesthetic effects

There was a very great difference between the various agents. In general silane and siloxane agents had better properties than siliconates and silicone resins.

Some of the silane agents can be applied to rather wet underlayers. Silicone resins cannot be applied to a wet underlayer.

The vapour permeability is not affected to any great extent by the treatment. However, the reverse is true where the drying out of a wet underlayer is concerned. Compared to other surface treatments, for example lime rendering, the drying out of a facade treated with water repellents is normally more rapid.

To illustrate the laboratory investigations some examples of results will be given below.

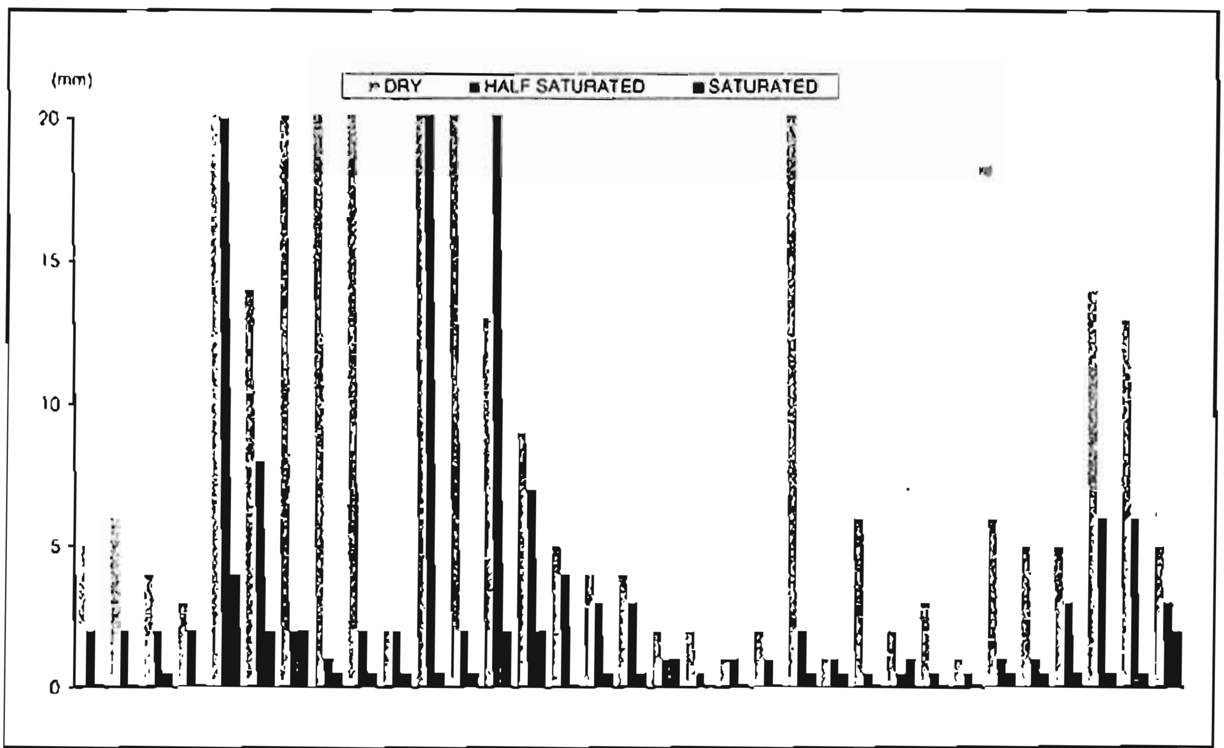
PENETRATION DEPTH

The penetration depth depends on a great number of factors. In our investigations we have tested:

- type of water repellent agent
- underlayer
- moisture content in the underlayer
- amount of applied agent
  concentration of the agent
- type of solvent

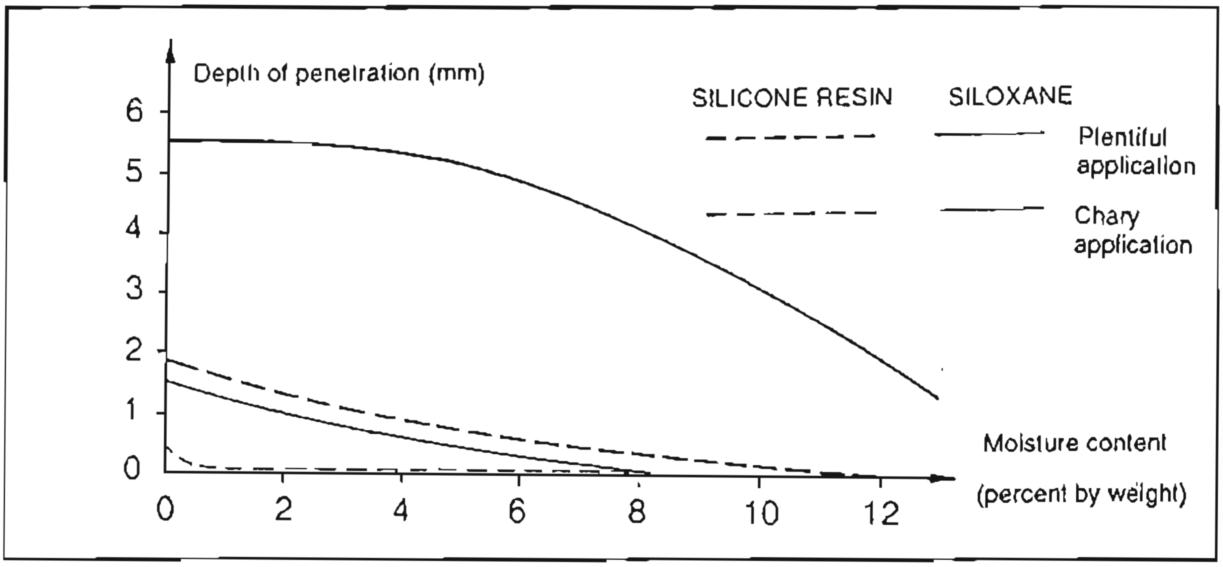
In FIGURE 1 the penetration depth in one type of clay brick in different moisture conditions is shown for all tested agents. The water repellent agents in this case were applied according to the instructions from the deliverer.

FIGURE 1
Penetration depth in clay brick at different moisture content.



In FIGURE 2 the penetration depth of a siloxane and a silicone resin into a clay brick with different moisture content is shown. The figure also shows the influence of the amount of the applied agent. As can be seen, the silicone resin has a very poor penetration depth when the underlayer is wet. On the other hand the siloxane has a good penetration depth even if the underlayer is wet.

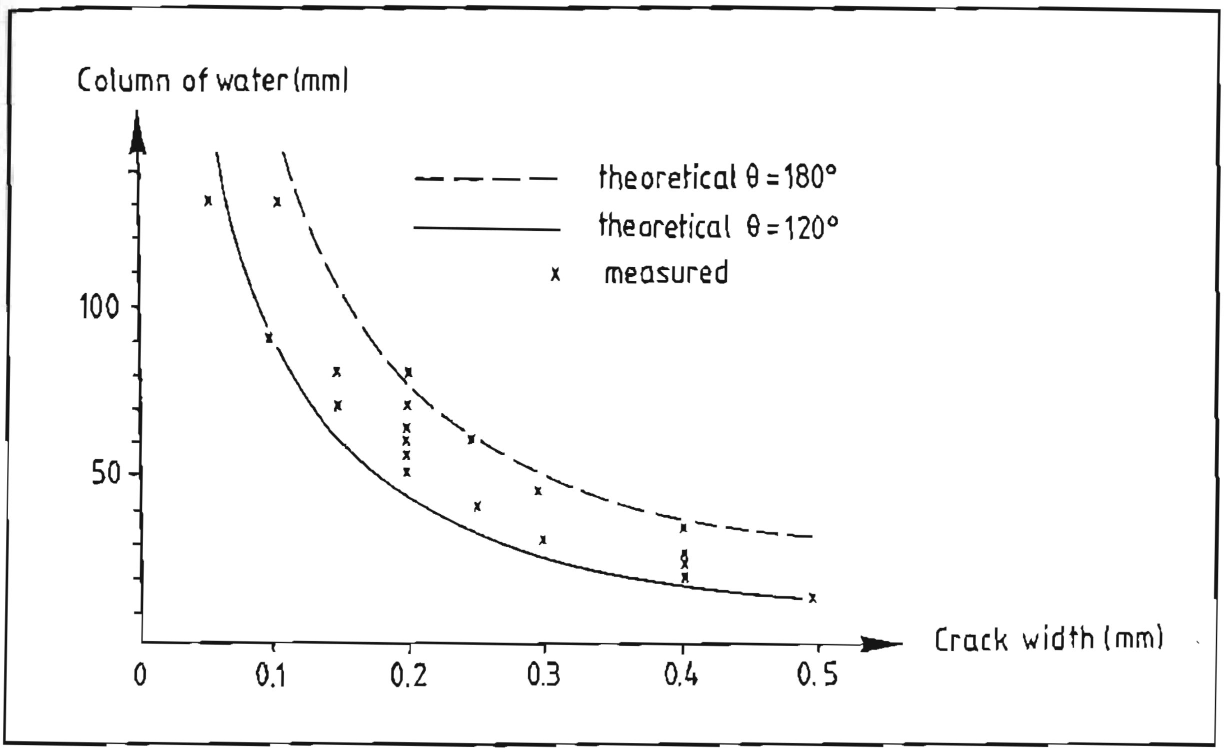
FIGURE 2
Penetration depth at different moisture content in the underlayer.



WATER ABSORPTION THROUGH CRACKS

One problem is that the underlayer in practice is often cracked, for example between joint and brick. In order to study the influence of cracks, a great number of tests have been carried out. One example is shown in FIGURE 3. Bricks which were impregnated with different agents were devided into two parts and then put together again. In this way the specimen got a crack of a width between 0.05 and 0.5 mm. In FIGURE 3 the height of a column of water over the crack, versus the crack width when the water enters the crack is shown. According to the figure, there is a great difference between various agents. The primary reason for this is different contact angles. In the figure the theoretical relationship with different contact angles is also shown.

FIGURE 3
Height of a column of water when the water enters the crack.

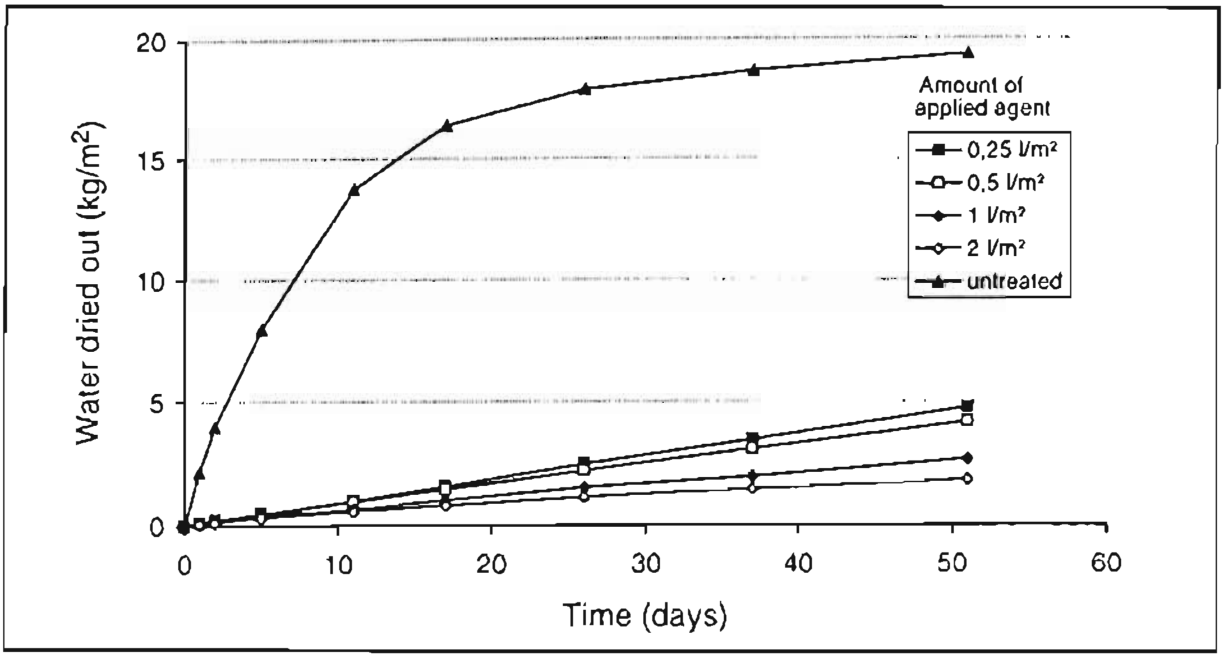


INFLUENCE ON VAPOUR PERMEABILITY AND DRYING OUT

The vapour permeability was measured with the cup-method. In one type of clay brick the vapour permeability changed from $1.0 \cdot 10^{-6}$ to $0.9 \cdot 10^{-6}$ m^2/s after impregnation.

The drying out of the same clay brick with different impregnation depths is shown in FIGURE 4. As you can see the drying out is reduced very much after the impregnation. This doesn't depend on any "tightening effect" but on the fact that the moisture transport changes from water transport to vapour transport. The same conditions are obtained when any other coating is applied, for example a lime rendering.

FIGURE 4
Drying out from water saturation of clay brick with different impregnation-depths.



FURTHER INVESTIGATIONS

The laboratory investigations are continuing. Now we are using fewer types of water repellent agents but more underlayers. The investigations are mainly directed towards:

- penetration depth at different moisture content
- influence of cracks
- resistance against alkali

CASE STUDIES

A great number of facades have been treated with water repellent agents. The reasons for the impregnations are different. Leakage and frost attack are most common. Until now all impregnations have been very successful.
One case study consists of about 30 houses, which had extensive frost damage in the clay bricks. All the clay bricks that were damaged were changed to new bricks. After this about 15 of the houses were impregnated with siloxane. Two years after the impregation the houses were inspected. On the untreated houses there were several hundred bricks with new frost damage. On the impregnated houses there were only a couple of bricks with frost damage. This damage was probably old damage, which had not been detected when the facades were repaired before the impregnation. The result of this case study is very promising and further similar objects will be treated in the same way.

4 LITERATURE

Sandin, K, 1994, Vattenavvisande fasadimpregnering. (Water repellent impregnation.) Svensk Byggtjänst. Solna. (In Swedish.)

Sandin, K, 1995, Vattenavvisande fasadimpregnering - Laboratorie-undersökningar 1992-94. (Water repellent impregnation - Laboratory investigations 1992-94.) University of Lund, Building Materials. Report TVBM-3065. Lund. (In Swedish.)

Sandin, K, 1993, Vattenavvisande fasadimpregnering - Fullskaleförsök i Lerberget. (Water repellent impregnation - Case study in Lerberget.) University of Lund, Building Materials. Report TVBM-7053. Lund. (In Swedish.)

Sandin, K, 1993, Vattenavvisande fasadimpregnering - Fullskaleförsök i Harphult. (Water repellent impregnation - Case study in Harphult.) University of Lund, Building Materials. Report TVBM-7052. Lund. (In Swedish.)