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Conservation of Buildings by Filling of the Pores with Paraffin

Conservation de bâtiments par remplissage des pores avec de la paraffine

Erhaltung von Gebäuden durch Porenfüllung mit Paraffin

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SUMMARY

The reason for the destruction of stones and elements of construction is the moisture, which penetrates in the pores and destabilizes, through several processes, the matrix of the construction material. Therefore it is very important to decrease the moisture content. An effective method is the filling of the pores with paraffin. If the building materials are warm enough, paraffin penetrates and fills the pores completely. Paraffin is an absolutely benign material. It can penetrate in the material over the surfaces through irrigation, flood-ing or plunging or through injection in holes. After the treatment, the water-absorbing ca-pacity, the moisture transfer and diffusion of the material is nearly null. The strength of damaged material increases.

RÉSUMÉ

L'humidité pénétrant dans les pores détruit l'équilibre d'un matériau de construction par des processus différents et entraîne la destruction des pierres et des éléments de construction. Pour cette raison, il est très important de réduire la teneur en humidité. Une méthode efficace est le remplissage des pores avec de la paraffine. Si le matériau de construction est assez chaud, la paraffine pourra pénétrer et remplir les pores complètement. La paraffine est une substance favorable à l'environnement. Elle peut pénétrer dans le matériau par irrigation, saturation et injection. Après traitement, des propriétés du matériau comme la capacité d'absorber de l'eau, le transport d'humidité et la diffusion sont infiniment petites. La résistance du matériau déjà endommagé peut être améliorée.

ZUSAMMENFASSUNG

Der Grund für die Zerstörung von Steinen und Bauteilen ist die Feuchtigkeit, die in die Poren eindringt und durch verschiedene Prozesse die Matrix eines Baumaterials destabilisiert. Deshalb ist es sehr wichtig, den Feuchtegehalt zu vermindern. Eine effektive Methode ist die Porenfüllung mit Paraffin. Ist das Baumaterial ausreichend erwärmt, kann das Paraffin penetrieren und die Poren vollständig füllen. Paraffin ist ein absolut umweltverträglicher Stoff. Es kann über die Oberfläche durch Berieseln, Tränken oder Injizieren eingebracht werden. Nach der Paraffin-Behandlung ist die Wasseraufnahme, der Feuchtetransport und die Diffusion verschwindend gering. Die Festigkeit von bereits geschädigtem Material wird erhöht.

1. INTRODUCTION

Moisture is the main reason for deterioration of stones, bricks, constructions and buildings. It penetrates into the pores and causes by several processes, such as frost-dew-alternation, chemical corrosion and material removal and transfer the deterioration of the material matrix, reduction of stability, changing of thermal and other qualities, development of heterogeneous structures among other consequences. That is why when attempting to preserve damaged and endangered buildings one tries to influence the moisture balance in a way that reduces the moisture contents in building materials. An effective method is the using of pore-sealing materials. These mediums have to fulfil the following requirements:

1. The pore must be sealed completely and with high reliability.
2. The spreading of the medium inside the building material must be determinable and controllable.
3. The medium should be compatible with the building material and should not cause any secondary effects.
4. The environmental compatibility should be very high.

Paraffin is a medium fulfilling these demands to a high degree. It is compatible with the building materials and the environment. Important for the effects of the stone-protecting and the stone-stabilising systems is the penetration of the medium (i.e. paraffin) deeply into the constructions so that the treatment takes not only place on the surface.

Treatments with paraffin and wax have been already used for centuries. But with the historical restrictions people had they could achieve a limited degree of protection.

The building material may be extensively filled with paraffin by warming it sufficiently and spraying, soaking or injecting with paraffin. Because there are no chemical or volatilisation processes while filling and locking the pores (only a sufficient temperature is required), you may practice the treatment as long as the process of sealing the pores is completely accomplished and deeply inside the building material.

2. THERMALLY STIMULATED INJECTION OF PARAFFIN TO BUILD UP SUBSEQUENT MOISTURE BARRIERS INSIDE THE WALL

Building up subsequent moisture barriers belongs to the most difficult tasks in the area of building reconstruction. The barrier has to be placed in base walls, which are decisive for the building's stability. Because this problem can't be solved with simple structural methods there exist several strategies with different modes of operation and results. Besides mechanical and electrophysical methods, above all injection methods are used. The damaging moisture transport in porous building materials takes place in the pores and capillaries where especially pores and capillaries with a radius of R=0.001mm are effective. That is the reason for injecting a pore-sealing or water repellent material. If the pores and capillaries are sealed or treated with a water repellent no moisture can be transported and the treated area operates as a moisture barrier. To realise these moisture barriers, the injection medium has to be brought into the walls in a way which assures that the whole wall cross-section is affected. This is done by boring holes with distances of 10 cm up to 12 cm into the wall. The depth of the bore holes should be compatible with the wall's strength. The injection medium is introduced into the

holes with or without pressure. With the pressure-less methods the capillary forces distribute the injection medium inside the building material. This process is accelerated with external pressure using pressure injection.

The injection methods mainly differ through the used injection medium. Silicates, water glass mixes, silicones, silanes and stearates serve as water repellent substances. By means of several methods, for example vaporisation of solvents, reaction with coal dioxide or moisture with low alkalinity, the silicon resin molecules form a chain and the water repelling silicon resin covers the pore walls. If the pores are filled with water or there is not enough moisture, if not enough solvent diffuses to the outside or not enough coal dioxide diffuses to the inside of the massive and wet wall, the water repellent effects of the mentioned methods will decrease or not appear.

As pore-sealing substances commonly cement suspensions, resins and paraffin are used. Cement suspensions and resins are generally introduced into the wall under pressure. This is necessary because after producing or mixing these substances the hardening process starts after a so called pot-time and the mediums have to first fill the pore space. Furthermore these materials can not be sufficiently transported through the capillaries because of their high viscosity. Therefore pressure is required.

Using paraffin as a pore-sealing substance, many of the above mentioned problems can be solved. Liquid paraffin is able to penetrate by means of capillary forces or pressure support. Therefore the treated wall has to be warmed up to a temperature above the melting-point of paraffin before, or while, the treatment takes place. Through this heating process the moisture vaporises and the moisture-damaged masonry becomes dry. Thus the pore space may be freed from moisture, filled and sealed with the heated paraffin. Paraffin injection is practised in the following way: heating sticks are introduced into the bore holes and after a sufficient drying and warming the paraffin is filled in. Simple technologies work with cans and storage

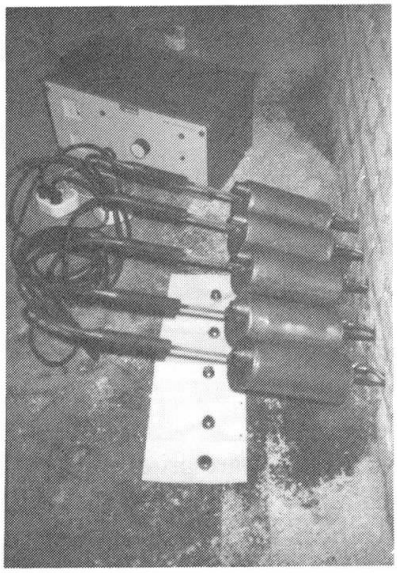

Fig. 1 Device of a paraffin infection

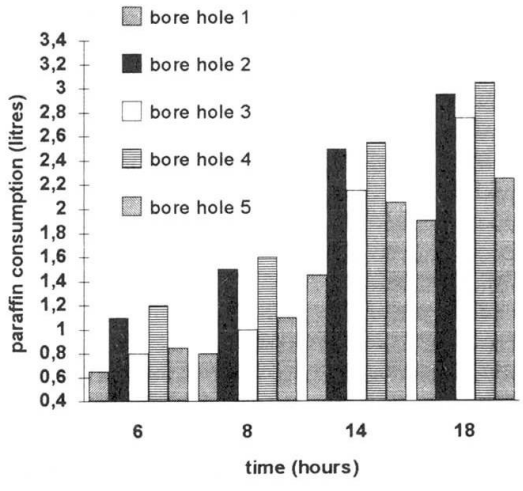

Fig. 2 Penetrating volume of paraffin during a paraffin injection

containers. The capillary forces then secure the distribution. It is also possible to accelerate the distribution of paraffin under pressure by using pressure aggregates. The sufficient warming of the masonry is important for these variants lest the paraffin stiffens during the penetration process.

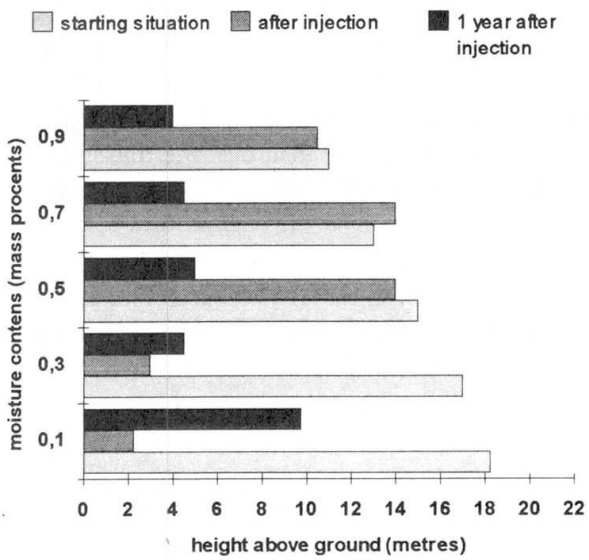

Fig. 3 Moisture distribution inside a wall before and after a paraffin injection

With another variant of paraffin penetration you heat inside the bore holes and simultaneous fill them with as much paraffin out of the storage containers as the bore hole admits. This method ensures that the maximum absorbable volume of paraffin is available. Fig. 1 formal represents the injection method. While using this device the heating stick inside the bore hole is continuously surrounded by liquid paraffin. The heat transmission is greatly enhanced through that compared with methods where the heating sticks warm the masonry before the paraffin injection starts. And it leads to an intensive warming, to an increase in efficiency and through this to performance decrease of the heating systems. The relatively big quantities which are able to penetrate by this method are comparable with the pore space to be sealed and indicate the high degree of pore filling. Fig. 2 shows the paraffin consumption by a bore hole injection with an injection into five bore holes. The paraffin injection method distinguishes itself with a certain operating mechanism because the solidifying process and the pore seal only depend on temperature and no other reaction conditions are required. Furthermore paraffin is absolutely compatible with the environment. Its use presents no negative hygienic or ecological consequences for the population and the environment.

Fig. 3 shows three moisture distributions measured before, immediately after and half a year after a paraffin treatment. Clearly recognisable is the direct drying effect through the heating and the certain barrier effect of the treated area.

3. INCREASING THE DURABILITY OF POROUS STONES BY PARAFFIN IMPREGNATION

A large number of damaging processes which affect stones and building materials are produced by water or steam entering the pore space and causing several damaging reactions. By preventing the moisture entry by a pore seal the moisture balance of the endangered building-construction improves. This leads to the slowing down or ending of the damaging processes. Present experiences with the paraffin treatment of porous stones prove that almost all pores can be sealed. Fig. 4 shows the water admission of impregnated stones before and after the paraffin treatment. The drastic water admission decrease clearly proves the pore-sealing effect of paraffin. This can be simply shown by the absorption quantities. The treatment with paraffin has to be done in a way through which the moisture is not locked in and treated areas can not

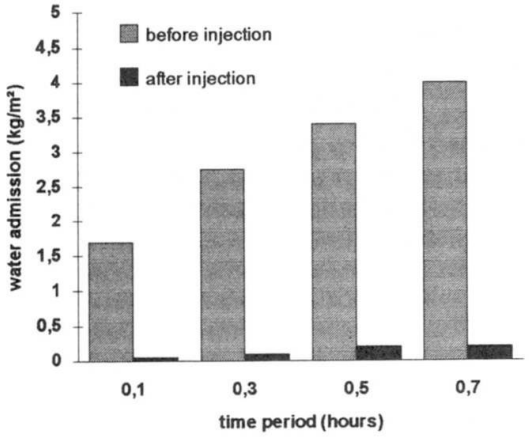

Fig. 4 Water admission of paraffin-treated and non-treated stones

be by-passed. To achieve this it is essential that sufficient depths are achieved and complete areas are treated. Impregnations with these effects can be easily done with paraffin. The prerequisite is warming up the areas to be treated to temperatures above the melting point of paraffin. As long as these temperatures exist the paraffin may spread by capillary forces and reach large areas. Whereby due to the laws of capillary material transport the process takes an extended period of time. The paraffin's ability to penetrate depends only on the temperature, therefore long treatment times are technically possible and in principle uncomplicated. Fig. 5 shows the entry of a paraffin front into sandstone. Filling the pores with paraffin does not only stop the processes of moisture exchange and moisture movement but also changes the mechanical properties of the treated building material. Fig. 6 demonstrates the increasing of pressure firmness of bricks by paraffin impregnation.

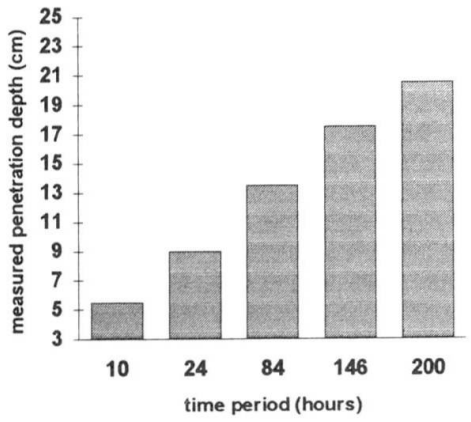

Fig. 5 Penetration depth of paraffin inside sandstone

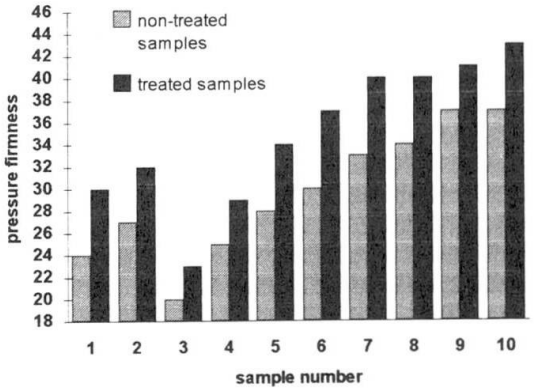

Fig. 6 Increase of pressure firmness

For these experiments old stones, which had already been damaged or weakened through frost-dew-alternation and salt crystallisation have been used. Several samples were obtained out of these stones to compare treated and non-treated stones. Increases of firmness of up to thirty percent, as shown in Fig. 6, could be achieved. Similar results were found by Franke [1] with comparable experiments.

4. SUMMARY

The treatment of stones to be protected with waxes and paraffins is an old method which can be used very effectively with today's technical possibilities. The penetrated areas are absolutely impermeable for water so that safe barrier layers can be built up. The paraffin spreading is tied to temperatures above 50°C. Through this it is possible to determine the spreading zones of paraffin penetration and adapt them to the requirements of moisture- and stone protection. Filling the pores with paraffin also changes the mechanical stone properties. Firmness increases could be proved with damaged stones and stones of limited firmness.

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