QUALITY CONTROL OF SURFACE TREATMENTS WITH WATER REPELLENT AGENTS

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ABSTRACT

A new method to determine the penetration profile of water repellent agents has been developed. It is described in detail in another contribution to this conference. The water repellent agents are quantitatively determined by means of FT-IR spectrocopy. This method can be used as reliable quality control. Some practical examples are presented.

1 INTRODUCTION

Durability of concrete is determined among other factors by its complex interactions with the environment. For instance the uptake of water or agressive chemicals (e.g. chlorides from de-icing salts) can lead to the deterioration of building materials due to chemical reactions which take place in the porous structure. Freeze-thaw cycles lead directly to the mechanical deterioration of building materials. The uptake of water or aggressive salt solutions by concrete can be drastically reduced by the application of a water repellent agent. Normally silicon-organic compounds dissolved in water or organic solvents are used. The solution is applied on the surface of concrete. After the transport of the solution into the concrete by capillary suction a chemical reaction takes place, which leads to the formation of the active substance, a water-repellent silicon resin. The silicon resin forms a thin layer on the inner surface of the capillary pores. As a result the capillary water uptake will be eliminated or reduced.

So far many reports about applications of water repellents on concrete indicate that the success of an impregnation depends on different factors such as age and quality of concrete, type of used water repellent agent or climatic conditions. Müller and Wittmann investigated the effect of 3 to 14 years old impregnations applied on different concrete structures in the Swiss highway system /1/. The results of the investigation have shown clearly the nessecity of a quality control for treatments with water repellents. The following aspects should be taken into consideration:

- Applicability of a water repellent agent
  According to German standards /2, 3/, the performance and long term behaviour of concrete treated with water repellents must be characterized by

the reduction of the water uptake and the durability of the impregnation in an alkaline media. Furthermore, the influence of the treatment on the freeze-thaw salt-durability of concrete must be determined.

- Performance of the application
  The properties of concrete such as age, pore size distribution, porosity, moisture and salt content must be estimated. The application of the product must be carried out according to the guidelines of the manufacturer or to results of application tests. The consumption of the water repellent agent must be measured. The climatic conditions before, during and after the application must be taken into account.

- Effectiveness of the treatment
  According to /2/, the criterion of a working application is the reduction of the water uptake to at least 50% of the untreated concrete. In practice this criterion is not acceptable in many cases. It is too weak. The performance of an impregnation can be determined in different ways. For instance, the measurement of the water uptake before and after the treatment with a burette according to Karsten. It has been shown that the quality of measurements can be increased significantly by using modified Karsten burettes with a higher suction area. Gatz and Grossmann developed a method to check the performance of an impregnation, based on the measurement of an electric current /4/.

The uptake of the active substance and the penetration depth are decisive for the performance of the impregnation. Actually the penetration depth is often determined visually. With the methods used so far the action of water repellents can be estimated qualitatively. But in this way the determination of the content and distribution of the active substance in concrete is not possible.
The influence of factors such as the type of the water repellent agent or the properties of the concrete on the performance of an impregnation cannot be characterized by this methods. Therefore, we developed in the Institute for Building Materials, ETH Zürich, a new method to determine the content of the active substance, the silicon resin, in the covercrete quantitatively by using FT-IR-spectroscopy. Fundamentals of this new method will be presented in another contribution to this symposium. In this contribution the results of an investigation are presented in which FT-IR-spectroscopy is used for the quality control of a treatment with water repellent agents. Two types of aqueous water repellent agents were applied on the surface of highway bridges. After the application cores were taken out from this bridges and analysed in the following way. Some specimens were used to determine the content of silicon resin in the covercrete by using FT-IR-spectroscopy. The rest of the specimens were used to determine the profiles of capillary suction by using the step-cutting method. For comparision standard specimens were impregnated under laboratory conditions and characterized by using FT-IR-spectroscopy combined with the step-cutting-method. The results were compared to the results of specimens, taken out from the bridges. It can be shown that the FT-IR-spectroscopy is a useful tool for

quality control of treatments with water repellent agents applied under practical conditions.

2 FT-IR SPECTROSCOPY

The FT-IR-spectroscopy is a well-known and powerful tool in chemistry for chemical analysis and determination of the structure of molecules. Furthermore, FT-IR-spectroscopy can be used to analyse the content of trace compounds in a complex matrix like concrete quantitatively. It has been shown that the FT-IR-spectroscopy can be applied to determine the distribution of water-repellent silicon resins in covercrete /5/. The fundamentals of FT-IR-spectroscopy and the application of this method to determine the penetration depth of water repellent agents in concrete is described in detail in another contribution to this conference.

3 EXPERIMENTS

3.1 PREPARATION OF THE SPECIMENS

3.1.1 Application of a impregnation carried out under practical conditions

Two types of aqueous water repellent agents were applied on the surface of highway bridges. The water repellent agent A is a micro-emulsion of a siloxan and the water repellent agent B is a emulsion of a silane. For testing the water repellent agents are applied with two different techniques termed I and II. For the technique I the water repellent agent is applied by spraying "wet in wet" on the surface of the concrete. That means that directly after the first treatment a second treatment is carried out. For the technique II 10 days after the first treatment the application has been repeated. For the agent Type A the technique I and II were carried out, for agent Type B only the technique I was used. The applications were carried out in rainy september. Three weeks after the application cores with a diameter of 50 mm were taken out from this bridges and send to the Institute for Building Materials, ETH Zürich. The specimens were analysed in the following way. Some specimens were used for the analysis by FT-IR-spectroscopy. The rest of the specimens were used to determine the profiles of capillary suction by using the step-cutting method.

3.1.2 Preparation of the specimens under laboratory conditions

For comparision standard specimens were impregnated under laboratory conditions with Type A respective Type B using technique I. The standard

specimens were characterized in the same way as cores taken out from the bridges.

3.2. Analysis of the impregnated specimens by FT-IR-spectroscopy

The cores taken out from the bridges and the specimens impregnated under laboratory conditions are prepared in the following way. Starting from the impregnated surface the specimens are cut in layers in the range of 0 to 6 mm by using a specially designed milling tool. The thickness of the layers is 0.5 mm. The collected very fine concrete powder is dried at 105 ¡C. For FT-IR-spectroscopy the samples are prepared by using the KBr-technique. Therefore, 1000 mg potassium bromide is mixed with 40 mg of the ground and dried concrete powder in a mortar. For making a transparent sample 250 mg of this mixture are compressed under vaccuum by 250 bar in a specially designed mould. On this standard samples FT-IR-spectra with 20-100 scans in the range of 2800 cm^{-1} to 3100 cm^{-1} are taken. The FT-IR-spectra are evaluated by the baseline-method, which is installed in the FT-IR-spectrometer software.

3.3 Profiles of capillary suction

In order to determine the profiles of capillary suction the step-cutting method is applied. First, the specimens are coated on the side with a epoxy resin. After the immersion of the specimen in water, the capillary water uptake through the impregnated layer is measured for 48 hours. Then the first 1 mm thick layer which had been in contact with water, is cut off. For re-conditioning the specimens are dried at 50 ¡C for 24 hours and subsequently, stored at 20 ¡C and 60 % R.H. for 5 days. Afterwards the samples are immersed into water again. The procedure as described above is repeated several times until the water uptake are corresponds to the value of an untreated concrete.

4 RESULTS AND DISCUSSION

4.1 EVALUATION OF THE FT-IR-SPECTRA

The evaluation of the FT-IR-spectra for the impregnated and untreated concrete show that the silicon resin can be detected by the absorption peak of the CH_2-group at 2925 cm^{-1}. For the determination of the content of silicon resin in covercrete this peak can be used because the intensity of the peak is sufficient and no influence of organic contamination in the investigated concrete can be detected. The details of this former investgation is described in another contribution to this conference.

4.2 CHARACTERISATION OF AN IMPREGATION CARRIED OUT UNDER PRACTICAL CONDITIONS

Two types of aqueous water repellent agents were applied with the different techniques I and II on the surface of highway bridges. After the application drilling cores were taken out from the bridges and analysed. For comparision standard specimens were impregnated under laboratory conditions with Type A and Type B using technique I.

In Fig. 1 the measured profiles are shown. It can be seen that two spraying applications "wet in wet" on site do not result in a sufficient penetration of agent Type A. If after a period of 10 days the agent is applied a second time a reasonable profile can be observed for both agents A and B. It must be stated that careful application of agent Type B according to the "wet in wet" procedure leads to the best of all measured profiles.

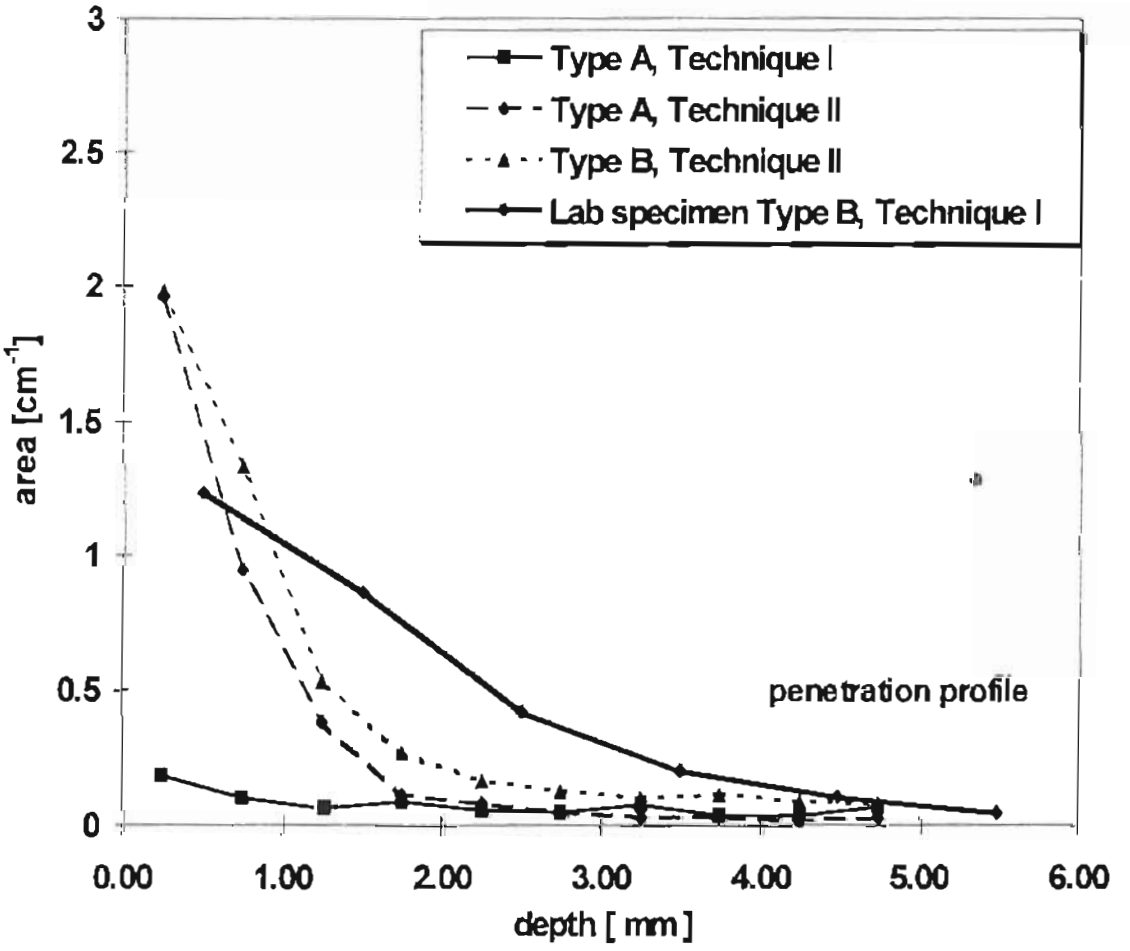

FIG. 1
Penetration profiles of the water repellents Type A and B

In Fig. 2 the corresponding suction profiles are shown. It is understandable that type A applied according to "wet in wet" procedure has only little effect. A small quantity of the water repellent agent must be directly on the surface. If agents A and B were twice applied with a interval of 10 days sligthly better results have been obtained. The best result is obtained with a careful application under laboratory conditions.

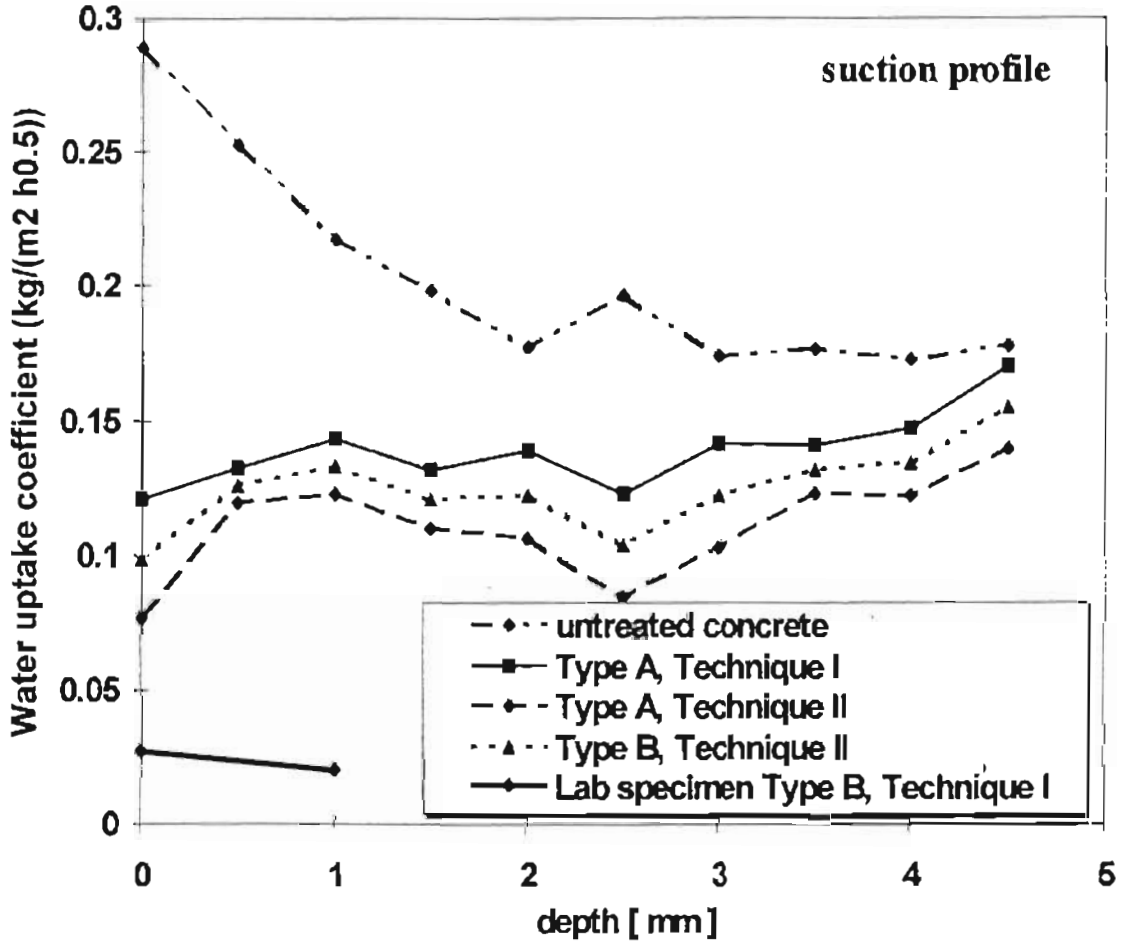

FIG. 2
Suction profiles of the specimens treated with water repellent Type A and B

5 CONCLUSIONS

The penetration profile of water repellent agents can be determied by means of FT-IR-spectroscopy.

- The penetration profile can be used to characterize the quality of the surface treatment.
- In practical applications the climatic conditions have an extreme influence on the result of a surface impregnation
- It is most important to determine the appropriate application procedure in order to obtain an optimium penetration profile.

6 REFERENCES

/1/ F.H. Wittmann und T. Müller, Beständigkeit einer Hydrophobierung - Ergebnisse einer Bestandaufnahme, Forschungsauftrag Nr. 85/92, Hrsg. Bundesamt für Strassenbau, Bern, (in press)

/2/ Deutscher Ausschuss für Stahlbeton, Richtlinie für Schutz und Instandsetzung von Betonbauteilen - Teile 1 bis 3, , Beuth-Verlag, Berlin, (1990)

/3/ Bundesminister für Verkehr, ZTV-SIB 90, TL/TP OS: Technische Lieferbedingungen/Technische Prüfvorschriften für Oberflächenschutzsysteme, Verkehrsblatt-Verlag, Dortmund, (1990)

/4/ H.P. Gatz und F. Grossmann, Verfahren zur Beurteilung der Qualität von Hydrophobierungen bei Beton, Bundesanstalt für Strassenwesen, Bergisch-Gladbach, (1989)

/5/ A. Gerdes und F.H. Wittmann, Bestimmung der Eindringtiefe eines Hydrophobierungsmitteln mit Hilfe der FT-IR- Spektroskopie, Int. Zeitschrift für Bauinstandsetzen, 1, 135-152, (1995)