

LONG-TERM DURABILITY OF DIFFERENT WATER REPELLENT AGENTS APPLIED AT THE PROTESTANTIC MEMORIAL CHURCH IN SPEYER DURING THE LAST 40 YEARS

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1 INTRODUCTION

The following facts are some of the main results from investigations at a 100 years old church during the past two years. I have first of all to thank the Deutsche Bundesstiftung Umwelt (German Environmental Foundation) in Osnabrück, which made it possible, with their financial support, to do this work. In addition it was the Evangelische Landeskirche der Pfalz (Palatinate Protest. Church) which gave us lot of assistance and support for our examinations.

The Protestantic Memorial Church in Speyer, planned by the Architects Flügge and Nordmann, was built from 1893 - 1904. It is entirely constructed in new - gothic style. The main building material used for the facade and the steeple is a fine- to medium grained sandstone from the eastern France, called "Bust Sandstone". It is a material with a very good water absorption capacity and a layered structure, caused by a great amount of clay minerals. Also in our days there are quarries, where this type of sandstone is worked so that we had the opportunity to study the properties of the non-weathered stone, in comparison to the stone from the church.

After World War II, which fortunately had no influence on the church, there were nevertheless the first big damages which made it necessary to start with the restoration. A lot of information and papers on these restoration works are still available and gave us a good help when we looked for information on the conservation agents that were used at this church. In different phases the church was restored from 1957 to 1977. In the last years it was obvious that the weathering of the sandstones has continued and the next restoration will start probably in 1996.

2 OBSERVATIONS FROM THE SURFACE OF THE SANDSTONE

1. Many zones with dark and light spots without any regularity
2. Strong growth of green algae following the joints in small stripes. It can be seen, that these "stripes" come from application of some liquid organic material, probably used to fix the margins of the joints.
3. Thin layers separated from the underground are found on several places, often they begin at the joints and then continue into the interior surface of the stone.
4. Many stones show fissures which follow the layered structure of the stone and caused severe deterioration .
5. Water absorption shows visible differences between different parts of the facade; this was proved by the tests on samples, it can also be seen on the facade in times when the masonry is drying after a rain period.
6. Very strong damages occur around zones with thin layers of restoration mortars.

For the examination of the stone we took about 70 samples from the building, such as drilling cores, mortar samples, efflorescences etc. During several weeks we made hundreds of measurements of water absorption following the method of the KARSTEN glass tubes.

3 CONCLUSIONS OF THE EXAMINATION RESULTS

1. In several samples with impregnations up to an age of 30 years we found very low rates of water absorption. The impregnation is still effective.
2. **ATMOSPHERIC INFLUENCE**
There is a correlation between the effectiveness of the impregnation and the exposure of the facade of which the sample is taken. In north-to east direction we find the water repellent properties much better than at the facades exposed to western and southern directions.
3. There is no difference between the two agents "Delterol" and "Monoseal". Both silicon resins, they have probably very similar composition.

4. INFLUENCE OF THE CHEMICAL PROPERTIES

Remarkable differences concerning water absorption could be found between the sandstone surfaces and the joints. The mortars show definitively a higher water absorption than the surrounding. From these results it seems sure that the impregnation had not enough resistance against alkaline materials such as mortars.

By consequence the water penetrates in the joints and has the chance to infiltrate the inner parts of the sandstones - with bad effects on the stability of the stone surface.

5. It was not possible to get any evidence on the internal mechanism of decay and alteration of the water repellent agents. Only the effects of these alterations can be seen and measured.

THESE EFFECTS SHOW TWO IMPORTANT FACTS:

- The exposure to the main wind and rain directions causes stronger deterioration of the impregnation
- The impregnations used on this church can not have been alkali-proof so that they have never been water repellent in the joints with alkaline mortar. This is the reason why they show a quite good water absorption.

The disintegration of the water repellent agents in the sandstones takes place on the very surface of the stone - in zones with influence of weather and ultraviolet light, which can destroy the Si - C - bonding in the impregnation.

So it is evident that parts of the facades, where the water repellent agents have deeper penetrated, must show stability for a longer time than in other parts.

4 INFLUENCE OF APPLICATION

It is proved that the penetration of the agents is very different. There is no possibility to find any pattern for the zones with different penetrations. There is also no correlation to the main directions of wind and rain.

The penetration varies for each of the water repellent agents from 1 to 8 mm.

As we found no other influences it must be the quality of application, which is responsible for these different penetration rates.

5 INFLUENCE OF SALTS

The steeple of the church shows in some zones remarkable concentrations of salts, such as gypsum, other sulfates and nitrates. There are mainly 3 origins of these salts:

- influence of atmospheric immissions
- Solution processes in stone and mortar
- Activities of pigeons

These salt enrichments have no regular distribution but occur as irregular spots over the whole surface, very similar to the distribution of the dark and light spots we already described. So it is very probable to look for connections between these phenomena.

As different authors found out, impregnations can not fix the salts on the stone surface. They can be dissolved by water or high humidity so that the impregnation, which has in these areas no direct contact to the surface, is removed and destroyed.

It is possible that here is a direct connection between the increasing salt concentrations and the decay of the water repellent agents. Unfortunately we had no possibility to furnish the positive proof of these connections, because this would afford a new extensive testing period.

If one recapitulates the consequences of the investigations at the Prot. Memorial Church in Speyer, there are the following points, which have been worked out:

- penetration depth of the impregnation is strongly dependent on the quality of application
- If water repellent agents are applied in a way that they have a penetration of more than 5 mm, they can keep their effectiveness for more than 30 years with a very strong reduction of the water absorptive capacity.
- The most important influence on deterioration of water repellent agents comes from atmospheric factors, especially from ultra violet light.
- It is very important to choose the adequate impregnation agents in order to get water repellent surfaces on the whole facade. Gaps in this "mantle", for example in the joints, are the source for severe damages in the surrounding.

- Fissures in the stone, defect joints etc. lead to damages which can destroy the surface of the stones in a way, that in particular the impregnated zone is detached from the intact material. At historic monuments, where the surface of the stone is the main witness of the historic work, such effects can reduce the worth in a strong way.
- In areas with high concentrations of water - soluble salts it is difficult or nearly impossible to create a water repellent surface.
- For all the following restoration techniques it is important that water soluble materials, especially mortars will have big problems to get a sufficient connection to the water repellent stone. This matters particularly for the joints
- Today we find the areas with different water absorption distributed all over the facade. It will be necessary for the future to create similar properties at the stone surface. So it is one of the consequences of the former restoration phases that the sandstone of this church must be once again treated with water repellent agents - in order to prevent similar damages in the future.