MOISTURE PROBLEMS CAUSED BY HYGROSCOPIC BEHAVIOUR OF MATERIALS

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ABSTRACT

A case-study on moisture and salt problems in walls is discussed. The way of correctly diagnosing the problem is given. The measurements undertaken as well as a practice experiment, showing the hygroscopic effects, are described.
On samples taken from the wall and from the plasterlayer the hygroscopic behaviour was also studied in lab. As a result of the diagnosis it became clear that the problems mainly had been caused by soluable salts that at some locations were present in the plasterlayer. Because of the hygroscopic behaviour of these salts moist spots appeared and more or less disappeared under influence of changes in the relative humidity.
Practical consequences and solutions for the present problem are given.

INTRODUCTION

In a research program that TNO-IBBC is performing on behalf of the Ministry of WVC (culture, monuments) one of the most important items is damage caused by moisture in combination with soluable salts (1).
The unwanted effects of soluable salts can show in two different forms in practice:

1. plasterlayers are loosened from their subsoil; the adhesion has gone and sometimes also the plasterlayer has been crumbled. These effects are often to be seen in combination with rising damp. The damage can be described as 'saltburst'.
2. Moist spots or zones in plasterlayers, that sometimes can appear rather suddenly; the appearance does have some relation with outdoor climate changes and rising damp could also be involved.

The research program should have as much as possible connections with practice problems in (to be) restored buildings.

The second of the already mentioned moisture/salt problems was subject of a case-study carried out in 1989 (2). As a part of the case-study the hygroscopic behaviour of plasterwork was studied in lab.

DESCRIPTION OF THE PROBLEM

In two renovated dwellings in the old center of Breda the inhabitants were, after a restoration, confronted with severe moisture problems in the newly plastered walls.

The structure of the walls was brickwork, plastered with a gypsum plasterlayer (thickness 10 to 30 mm) and finished with wallpaper. The load bearing (=founded) indoor walls were covered with visually moist areas, partly just above floor level, giving the problem at least a little bit the appearance of rising damp. On a second view the situation appeared to be more complicated: also on a higher level a pattern of moist and dry zones could be seen (fig. 1).

The inhabitants stated that the moisture seemed to come and go, related to certain periods of outdoor climate changes. In accordance with the first (perhaps to obvious) idea, a producer of acryl-amide gels diagnosed the existence of rising damp. And immediately (!) measures had been undertaken to attack the rising damp by injection of an acryl-amide gel.
Nevertheless after one year the problem still existed and the situation even seemed to have become worse. In this stage TNO was asked to judge the problem.

HYPOTHESIS AND TESTING

The research carried out was based on two different hypotheses:
1. The damage is caused by rising damp, introducing the point whether the measures taken had been effective or not.
2. The moist spots are caused by hygroscopic behaviour of the wall finishing (i.e. plasterlayer and wallpaper).

To investigate the first hypothesis, grit samples were taken from the plasterlayer and the underlying brick. In this way the moisture distribution over the height of the wall was determined. The same samples were used to determine the uptake of hygroscopic moisture at RH's of 75 and 92% respectively. The results are shown in fig. 2a and 2b. From the course of the moisture content, in relation to the hygroscopic uptake the existence of rising damp up to a height of 1.00 m in the center of the wall can be concluded. For the plasterlayer this height is only 0.50 m.

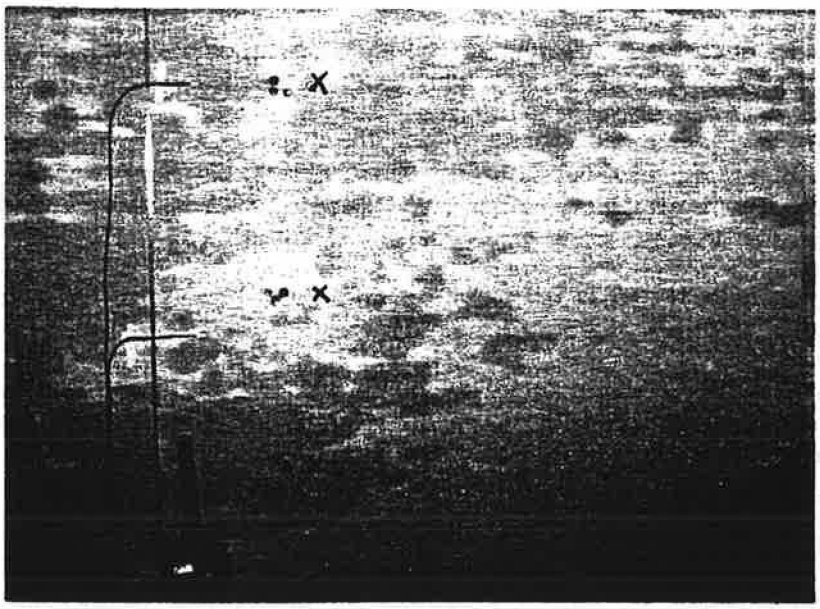

FIGURE 1. Moist areas on a plastered indoor brick wall; the spots where samples were taken are indicated by "x"

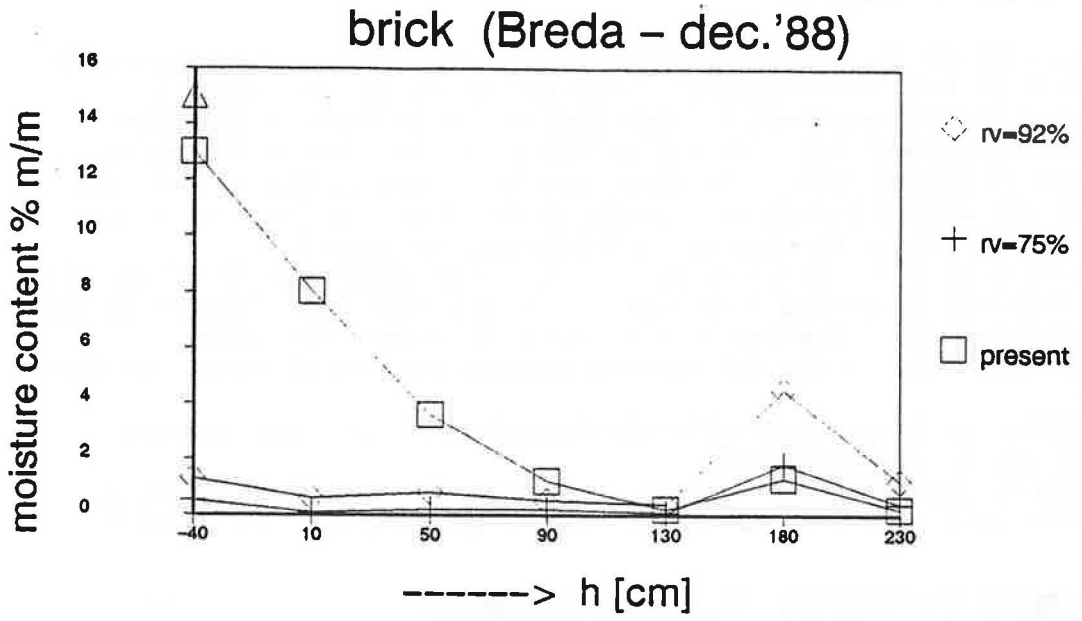

FIGURE 2a. Moisture distribution over wall height (brick) and hygroscopic moisture uptake

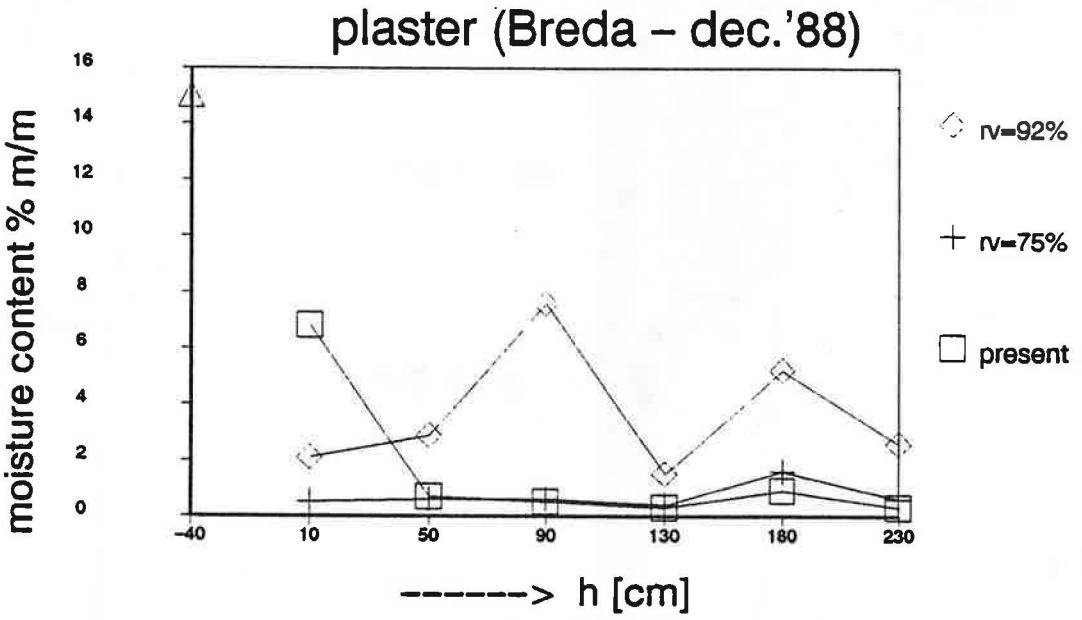

FIGURE 2b. Moisture distribution over wall height (plaster) and hygroscopic moisture uptake

Two conclusions can be drawn already:
- up to a certain height there is still rising damp involved.
- On heigher levels the moist spots cannot be attributed to rising damp.

Especially the hygroscopic behaviour of the plaster is most remarkable. The peaks in the hygroscopic curve of 92% RH do correspond to the

"moist" areas in practice !

The fenomenon of the second hypothesis, stating that moist areas might arise more or less spontaneously under influence of the relative humidity, had been supposed already earlier by us to be a possible "moisture-fenomenon" (3), but was as far as we know never thoroughly described or proved. Therefore this hypothesis was really a challenge and also the motive for an experiment on the spot. In this experiment the RH in the adjoining room was artificially increased.
The duration of the experiment was two hours in which the RH of the air in the room was increased from almost 50% to almost 80%. Figures 3a and 3b are showing the situation at the start (an almost invisible discoloration) and in the end (a very obvious pattern of moist and dry areas).
This result, in combination with the behaviour of the grit samples, confirms the second hypothesis.
There can be concluded that the main cause of the visual problems is the hygroscopic behaviour of the plaster under influence of changes in RH.

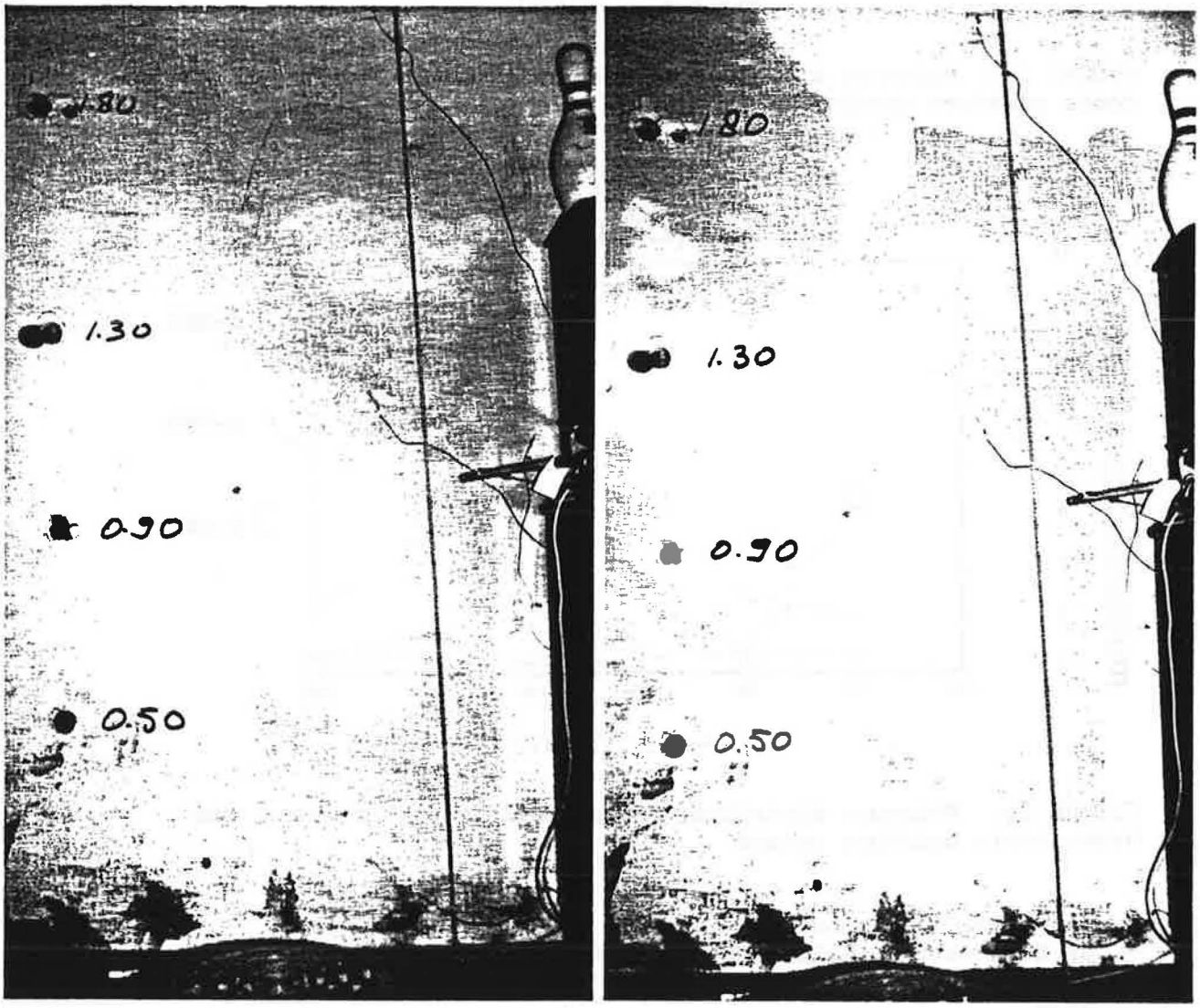

FIGURE 3a/3b. Situation at the start (3a) and at the end (3b) of the RH-experiment. During the experiment room RH increased to 80%. Height above floorlevel is indicated

FURTHER ANALYSES

Thin slices of plaster (2 mm) both from a "dry" and from a "wet" spot were taken from the affected wall. Part of the samples was used again for studying hygroscopic effects, another part was used for SEM/EDAX analysis.

Hygroscopicity

The samples were conditioned at RH's of 52%, 75% and 92% succesively, always until a constant mass was achieved. Table 1 shows the results. The difference between a "dry" and a "wet" spot is rather big. The behaviour of the "dry" sample can be considered normal for a gypsum plaster.

TABLE 1. Hygroscopic moisture uptake; thin slices of plaster

height [m]	1.30 dry spot	1.80 wet spot
present [% m/m]	0.34	0.90
RH = 52% [% m/m]	0.40	0.90
RH = 75% [% m/m]	0.55	2.00
RH = 92% [% m/m]	1.30	8.50

SEM / EDAX

The SEM/EDAX technique was used to detect type and structure of the salt crystals in some of the thin samples. Several crystals of Sodium salts were found near the surface; fig. 4 shows salts embedded in the gypsum of the material surface. It was established that no chlorides or sulphates were involved. We suppose that the salts found are nitrates. Alas SEM/EDAX is not able to detect nitrates.

PRACTICAL SOLUTIONS

It will be obvious that each solution has to start with a proper diagnosis of the problem, otherwise 'solutions' will be either not sound or insufficient.
In this case the result of the performed injection of acryl-amide is even doubtful, as there still appears to be rising damp. However being not familiar with the situation before (former moisture content and distribution) it is difficult to jugde and completely reject the method. The solution proposed was in the first place focused on combating the hygroscopic problem.

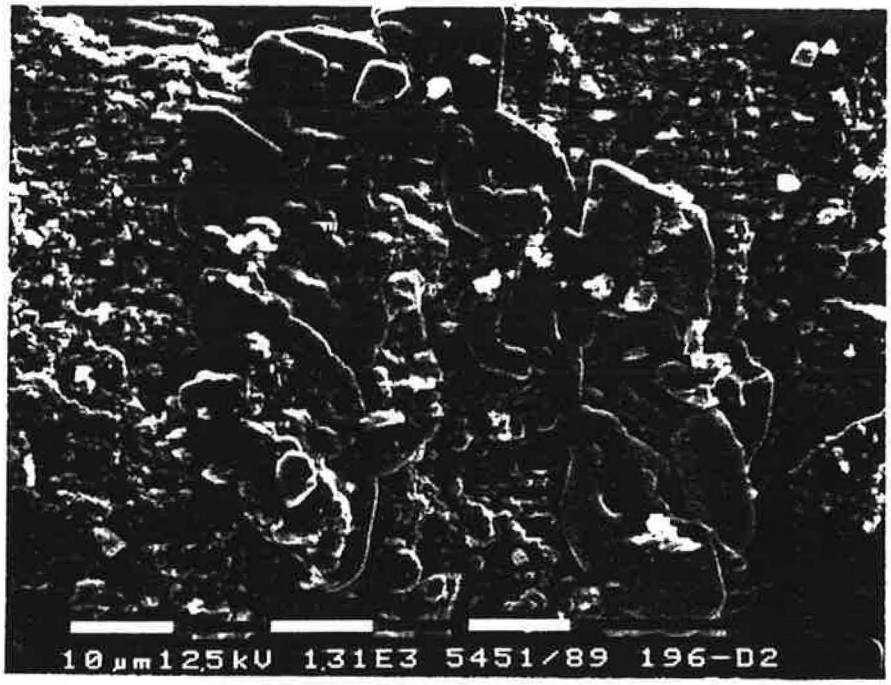

FIGURE 4. SEM/EDAX picture showing (Sodium) salt crystals on the plaster surface

Dealing with the present situation and the fact that the dwelling was inhabited, after a period of complete restoration and renovation a solution was proposed causing as little as possible trouble to the inhabitants and leaving the existing wall finishing intact.

Suggested was to cover the wall surface with a foil of high diffusion resistance, to prevent changes in room RH to effect the plaster. The new wall finishing can be a plasterlayer or gypsum board.
Apart from that and in order to reach an optimal solution it was suggested to combate the rising damp using a mechanical device to be installed underneath the floor level; see also (4). This was possible via the existing crawl space.

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