Mold growth on ETICS as a result of “bad workmanship”?

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Mold growth on ETICS

On the external façades of a housing estate, which was completed in autumn, a noticeable biological growth appeared after a short time. As described in [1], especially in the area of the lintels an extended mold growth infestation could be seen (obvious discoloration). The lintels have not been insulated with expanded polystyrene like the rest of the walls, but with mineral wool. Also mainly circular patterns of the infestation appeared in the middle of the façades. Drill core samples were taken in these places. It turned out that the insulation slabs of expanded polystyrene had not been applied jointlessly, but that between them a continuous gap of approximately three millimetres existed. The circular patterns of mold infestation are approximately located in the area of the joint crosses where four insulation slabs meet.

It is assumed that a moistening mechanism takes effect which has already been analysed and documented in connection with the danger of frost damage (“Diffusion moistening” [2]). This diffusion moistening is immediately linked to the high vapor transmission factor of the mineral wool insulation and with the air gaps between the insulation slabs.

Hygrothermal investigations

Since closer examination of the conditions which lead to mold growth in the area of the lintels as well as the air gaps between the insulation slabs requires assessments of the moisture balance at these positions, two dimensional hygrothermal calculations were done with the program WUFI [3]. The following wall construction (from the inside towards the outside) was the basis for the calculations:

Wall construction: 150 mm of concrete
Insulation material: 160 mm of polystyrene in the middle of the façade or 160 mm of mineral wool over the lintel
Stucco: 5 mm of resin stucco

An air gap of 3 mm is assumed between the polystyrene slabs. The Test Reference Year for the location of the building provides hourly values for the exterior climate [4]. The calculations are carried out starting from 1 October. For concrete a water content of 15. vol.-% and for stucco of 10 vol.-% is used as initial condition (construction moisture).

Figure 1 shows for the first year the course of the temperature (top) and the relative humidity (middle) in the stucco near the joints (dashed line) and on the lintel (dotted line) compared to the stucco in the undisturbed area in the middle of the façade (dash-dotted line). From the middle of January the courses in the different positions diverge considerably. While the relative humidity of the stucco in the middle of the façade decreases from this point of time due to the seasonal rise in temperature of the stucco (top figure), the humidity near the joints and in the area of the lintels stays at approximately 90 % R.H. [1] up to mid-July.

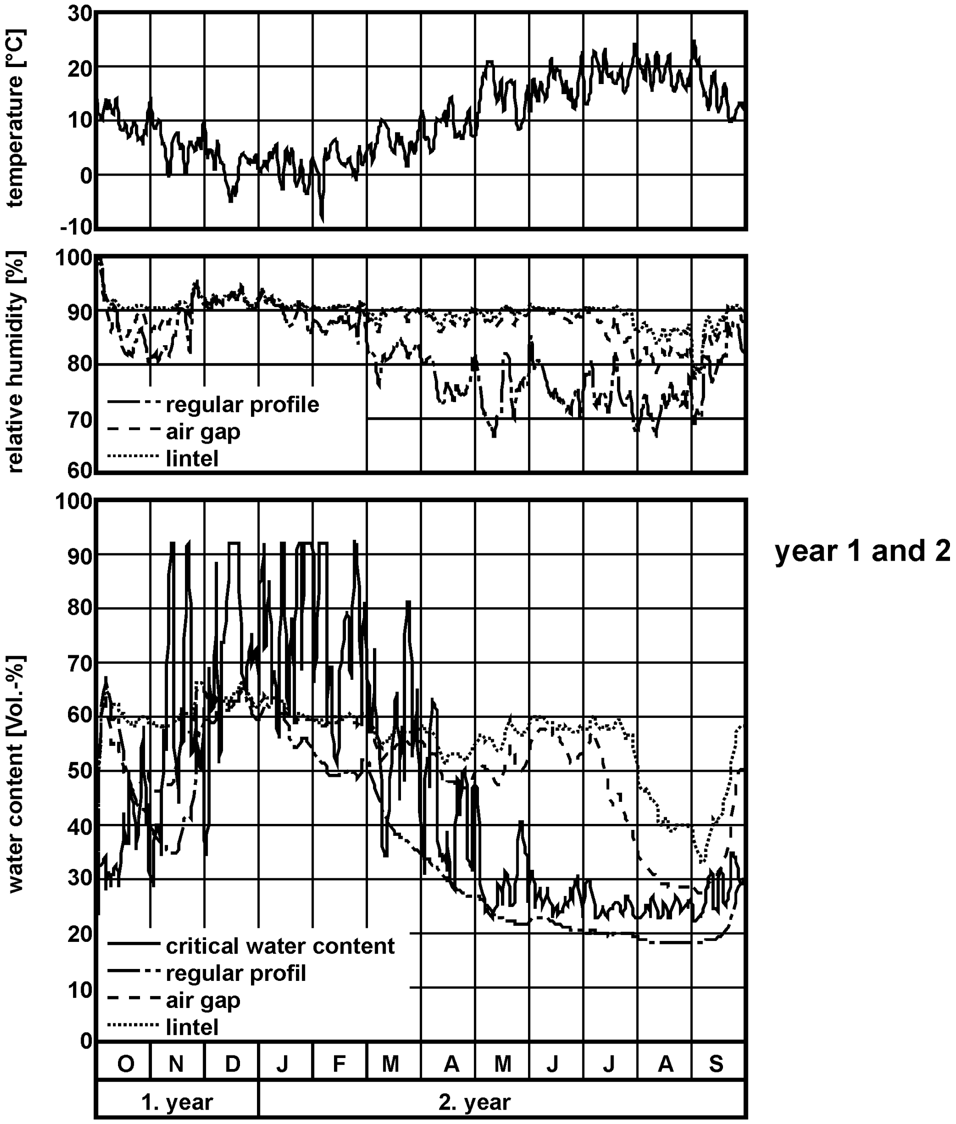

Figure 1: Courses of the temperature (top) and the relative humidity (middle) as well as the water content of the spores (bottom) at different façade positions on the exterior stucco, calculated for a wall of concrete insulated with ETICS.

Biohygrothermal examinations

In [5] a biohygrothermal procedure is developed, which allows the prediction of mold growth under transient boundary conditions. The assessment results from a comparison of the water content in a modelled mold spore determined by transient calculations, with the critical water content, above which the spore germinates and grows. This means that long-term humidity values exceeding this critical water content indicate mold growth.

For the wall construction of concrete, figure 1 (bottom) shows that the water content in model spores on the stucco in the middle of the façade is decreasing after mid-January. The strong variations in the course of the critical water content are due to the large temperature changes at the exterior façade. The water content of the spores in the middle of the façade lies, besides the initial values during the first two weeks after completion, always under the critical water content. This means that in the middle of the façade no mold growth should appear, which also agrees with the observations on the object and general experience. This is different with the stucco in the area of the lintels and at the joints. Starting in April, in the area of the lintels the critical water content is clearly exceeded. As also observed on the object, large-scale mold growth already appears in spring. At the joints of the slabs the critical water content is exceeded to a lesser extend, which leads to the smaller circular growth patterns.

Temporal extrapolation

To determine after which time the hygrothermal conditions on the ETICS cease to permit mold growth, it was investigated how the drying-out of the built-in humidity influences the microbial activity. To this end the calculations are carried out over a period of 10 years, beginning in October (building completion). The Test Reference Year is applied ten times in succession.

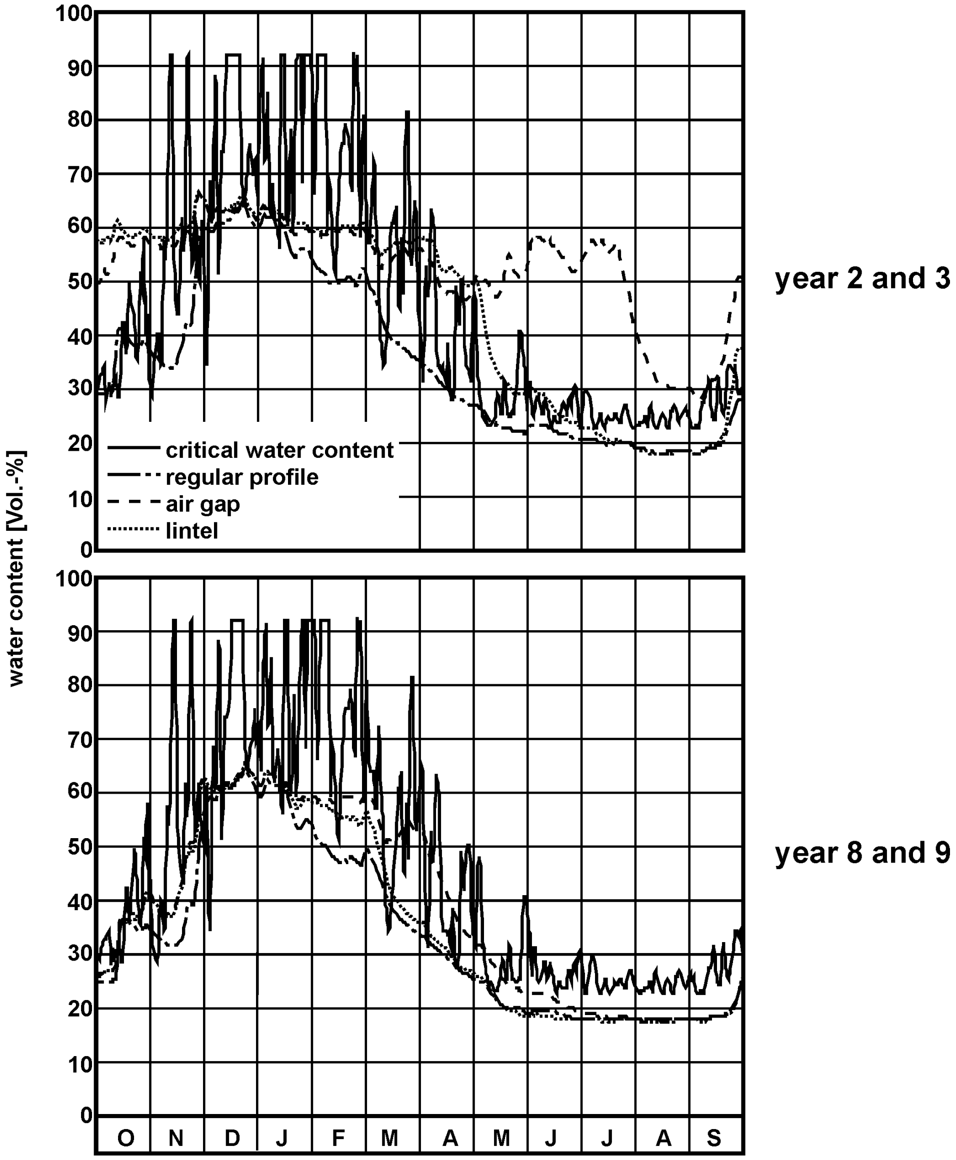

Figure 2: Courses of the water content of the spores at different places on the exterior stucco of an exterior wall in the second (top) and in the eighth year of examination (bottom), calculated for a wall of concrete insulated with ETICS.

After two years the built-in moisture in the concrete dries out in the area of the lintels around the end of the summer, so that there is no mold infestation to be expected anymore (figure 2, top). The stucco at the joints of the slabs needs approximately eight years for the same drying process (figure 2, bottom).

We can conclude from these results, that the gaps between the polystyrene insulation slabs encourage mold growth: this can be avoided for example by the use of slabs with tongue and groove joints. The period of poor performance is significantly depending on the façade material. Mineral wool slabs in the lintels (used for fire protection reasons) only lead to biohygrothermally critical conditions during the first year. This means that for example a biocide could be designed in such a way that it only has to be effective for one year. It should be noted that the influence of long wave radiation, which can also lead to cooling of ETICS surfaces below ambient air temperature at night and to microbial growth, has not been considered in this calculation.

References

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