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Housing—renovation

New method of renovating wall sills damaged by mould

RELIABLE AND FOOLPROOF RENOVATION OF SILLS SATISFIES TENANTS AND COMBATS 'SICKHOUSES'

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Exposure to mould can lead to health risks according to Professor Höglund and A. Hyppel of the Department of Building at the Royal Institute of Technology, Stockholm, who describe the work they have carried out on the smell of mould which came from partition wall sills in single family houses. The damage and the renovation measures which were deemed necessary are presented; a simple, promising and alternative method for changing sills is given.

L'exposition à la moisissure peut amener au risque pour la santé selon le Professeur Höglund et A. Hyppel du Département du Bâtiment, à l'Institute Royal de Technologie, Stockholm. Ils décrivent leur travail sur l'odeur de la moisissure qui provenait des rebords des cloisons dans les habitations individuelles. Les dégâts matériels et les mesures pour la rénovation jugés nécessaires sont présentées: une méthode simple, prometteuse et alternative de remplacer les rebords est proposée.

The smell of mould was attributable to faults and deficiencies in the join between the partition wall and the concrete slab (the floor placed directly on the ground with thermal insulation underneath). The concrete slab under this partition wall is reinforced but lacks thermal insulation, which would also give protection from vapour transference from the ground. Moreover the concrete slab does not have a moisture barrier under the partition wall. The wall sill, with strips of fibreboard under it, is therefore in direct contact with the concrete slab (Fig. 1). A critical level of moisture had been reached in the sills. This moisture was transferred from below both in the form of vapour and by capillary action. Both the sills and the fibreboard strips had been infected with the smell of mould. Visible mould was found mainly on the fibreboard strips. The high moisture ratio in the sills encourages the growth of mould fungi. In this case mainly *Aspergillus* but also *Penicillium* species were found. The intensity of the smell of mould varied from moderate to strong.

Measurements of the moisture content by means of a resistance meter was carried out parallel with readings from fixed sensors. Mycological samples were taken the whole time by means of contact strips which give 'finger-prints' of the selected tests areas. The culture was malt extract–agar and incubation was at room temperature.

Smell was determined by a panel of two to three impartial persons; the aim was to establish qualitatively whether or not there was a smell of mould. In addition the tenants were interviewed about the smell every time a test was carried out.

Results of the investigations before renovation

In tests carried out between February and June 1986 the moisture ratio in sills and the intensity of the smell of mould were determined in 12 buildings on each test occasion. The tests were restricted to sills under oak thresholds (entrance to kitchens) and lower wall sills. The results are shown in Fig. 2.

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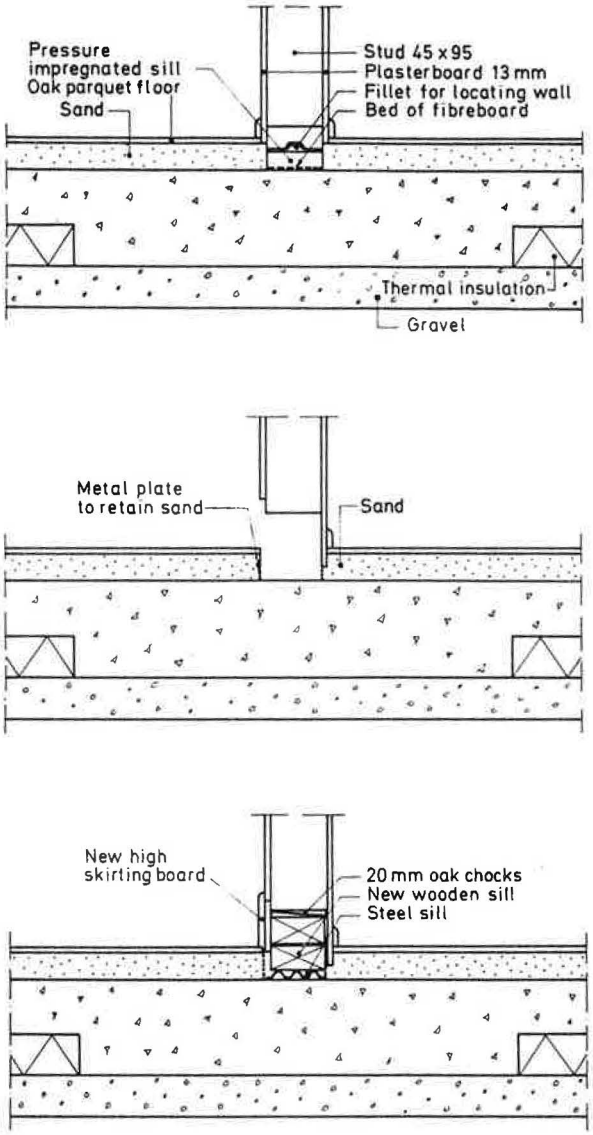

Fig. 1. The existing partition-wall construction is shown in the upper drawing. There is no thermal insulation under the reinforced part of the concrete slab, nor a moisture barrier under the sill and the strips of fibreboard. The principle of the operation on the partition wall is shown in the middle drawing above. The wall is opened up on one side. The mouldy sill has been removed. A metal plate prevents the sand from running out. The lower drawing shows how a steel sill has been placed next to the concrete slab. Above this there is a new wooden sill, a supporting sill and oak chocks glued to the wall joists in the bearing wall. The skirting board is somewhat higher than on the original wall – the only visible sign of the operation

The renovation methods studied

On the basis of the results obtained the following two main courses of action were studied as a research and development project by the Department of Building Technology at the Royal Institute of Technology, Stockholm and JM Byggnads och Fastighets AB (ref. 1):

1. Platcon Byggteknik AB steel sill with a new oversill of untreated wood.
2. Chemical treatment of the existing sill and ozon treatment to remove the smell.

The steel method has previously been studied in th Sigtuna Project (ref. 2), when it was used for the firs time in new constructions. The results are good. Thi system allows rapid drying-out of wooden sills (Fig. 3) In this case the plan was both to break the direct contac between the wooden sill and the concrete slab and t give adequate 'micro-ventilation' of the wooden sill t protect it from water vapour from below.

Five buildings were treated: the existing pressure-impregnated sills were removed and replaced by Platcon steel sills under new wooden joists in three of the buildings. In two buildings perforated steel sills were used. After the method had been developed in the first building, the sills in the remaining three buildings were removed by cutting with high precision from one side of the partition wall without bracing the ceilings and without breaking up any floors (Fig. 4). Existing low skirting boards were replaced by higher ones. This was the only visible sign of renovation work using the two methods.

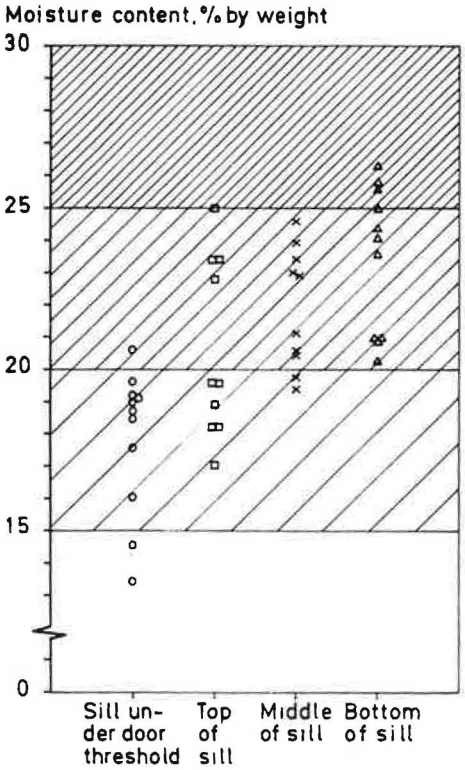

Fig. 2. Moisture content (%) in the sills. The slanting lines represent the risk of microfungoid attacks (also in Figs 3, 5 and 6).

Standard values can be taken to be as follows:

μ < 15% no risk of attack,
μ > 15–20% some risk of attack, primarily by mould fungi,
μ > 25–35% large risk of attack by both mould fungi and rot.

As can be seen there was a risk of attack by mould fungi

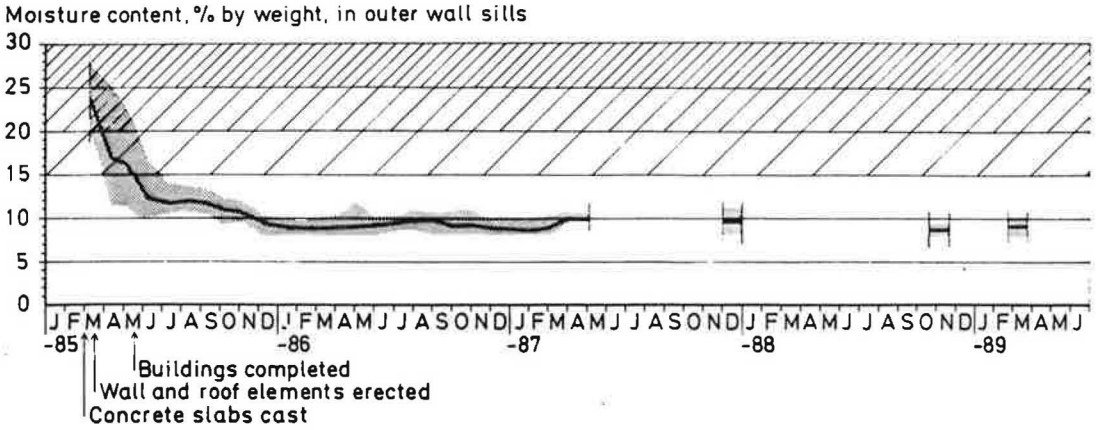

Fig. 3. The first building in which the new steel sill system was used in a new construction was an experimental building in Sigtuna, where new building components and other factors were studied (ref. 2).

Moisture content determined for outer wall sills (mean values and standard deviation for six measuring points) in this project are shown in this figure. The speed at which the buildings dried out is high and after only 2 to 3 months the moisture contents were below critical values. The mean value (with very little spread) is constant at under 10% by weight, in other words at a reassuringly low level

The second method includes both chemical treatment of the sill and adjoining material with a fungicide (mitrol 50) and removal of the smell of mould, which was done by exposing the surfaces of the material to ozone gas for 24 hours. This type of treatment was used in seven buildings and studied closely in three buildings.

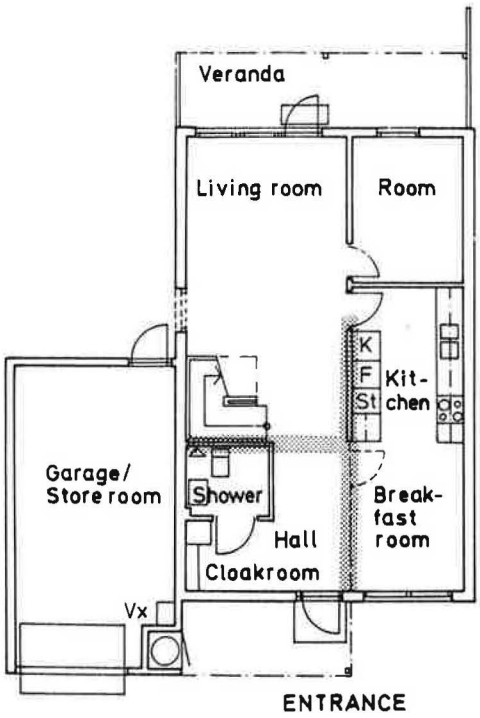

Fig. 4. Examples of one type of house plan. The reinforcements under the inner walls have been shaded in. As can be seen, adjacent to the partition walls are, for example, the living room and the bathroom and kitchen with a parquet floor and plastic floor covering respectively. It is expensive – using traditional methods – to break up these floors to get at the mouldy sills

Building physics – mycology

Checks were made on the state of moisture and fungi on a number of occasions for a period of two years after renovation. In all the buildings (see first method) fixed sensors were installed to measure moisture and temperature. The values were read as described above. Discreetly placed observation holes for mycological sampling were installed in the same buildings.

Results of the mycological analysis

The results of the mycological analysis were that the frequencies were low.

A range of mould fungi were found in the sample taken from sills and wall surfaces. Most of them were of the *Penicillium* species, some of them odoriferous. In addition the *Cladosporium* and *Aspergillus* families were represented in the fungus flora. None of the species identified is among the thermo-tolerant species which may cause over-sensitivity in the tenants.

The frequencies found were low or very low and considerably lower than those found in so-called 'mould houses'. The more or less strong smell of mould that was detected under the kitchen door thresholds before renovation had completely disappeared or occurred only weakly when the observation holes were opened for sampling later.

In no cases could the smell of mould be detected in the rooms, nor were any complaints registered in the 'smell interviews' which were carried out among the tenants.

When comparing the steel-sill and the fungicide-ozone alternative methods, 'some smell of mould' is more commonly reported in the steel-sill treated buildings. A few tenants have reported a smell of fungicide.

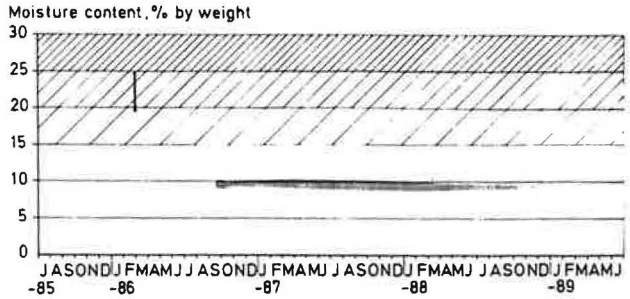

Fig. 5. Results of moisture content measurements in five buildings in which sills attacked by mould were replaced by steel sills and new wooden sills. The moisture content remained constant at a reassuringly low level. No mould attacks are possible (Fig. 7); there is no detectable difference between perforated and unperforated steel sills. The condition before renovation (indicated by first method) is also given in the figure for comparison

Results of the moisture ratio measurements

The new wooden sills dried out quickly on the steel sill system. The moisture content decreased from about 20% to < 10% (Fig. 5). The moisture content also showed very little spread for the five buildings. There was no difference between perforated and unperforated steel sills. The moisture content has since stabilized at this low level. Where the alternative method using fungicide/ozone treatment was employed, the wood dried out when the wall was opened up. The moisture content then rose again to the original level, i.e. the moisture content lay close together at about 15–16% in the buildings that were studied (Fig. 6).

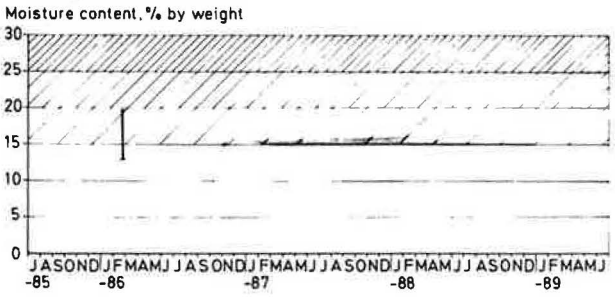

Fig. 6. Results of moisture content measurements in three buildings where renovation consisted of chemical treatment of the existing sills and the removal of smell by ozone treatment. When the wall was first opened up, the sills dried out; but after a while the moisture content rose to about the same level as before renovation. This is quite natural, since the moisture transfer from below has not been interrupted. The fungicide treatment, however, does prevent the growth of mould. The question is: for how long? Unfortunately the inhibiting effect of the fungicide has a tendency to weaken over the years

The measures adopted led to a radical change in the moisture content of the sills, which rapidly dried out and whose moisture content has remained constant at just below 10%.

A high moisture content/relative humidity (RH) is necessary for mould fungi to develop, together with a certain degree of warmth and organic growth substrata and the absence of toxic substances. The very low moisture content, < 10%, measured in the steel sill examples completely exclude the germination or growth of micro-fungi (mould, blue stain or soft rot), which means that the prognosis for this renovation technique is very good.

The alternative method using mitrol and ozone treatment also gave satisfactory results; the highest moisture content measured, 16.5%, is not sufficient for the development of the commonest types of mould fungi. Spraying the sills with mitrol also provides extra protection against attacks from airborne mould spores which may reach the wood surfaces through small gaps. It was, however, possible to detect a slight smell of mitrol about $2\frac{1}{2}$ years after treatment, when the observation holes were opened.

In the present project it can therefore be established that from a building physical/biological point of view both renovation methods can be considered satisfactory as a means of preventing the growth of mould fungi, although the steel sill method should be the more reliable (Fig. 7). Even inserting steel sills without ozone treatment led to the removal of smell to an acceptable level.

Comparative costs

It was pointed out in the beginning that it is expensive to deal with mould damage in a concrete slab on the ground and that there is therefore a great need to develop renovation methods that are not only safe and reliable but also more economical.

The following figures are for prices without VAT in 1988/89 in the Greater Stockholm area:

1. The 'traditional method' (break up floors etc.) cost about SEK 4800–5000 per m (US$ 800 per m).
2. Replacing mouldy sills with steel sills/new wooden sills in the first building, where the techniques were developed, naturally enough cost most, about SEK 2300 per m (US$ 375). The remaining four buildings using the new renovation and work methods cost considerably less, about SEK 1400 per m (US$ 225 per m).
3. The fungicide/ozone treatment cost about SEK 1,100 per m (US$ 175 per m).

No costs for evacuating the tenants are included in Method 1, which would raise the costs for this traditional method, which is by far the most expensive one. The other two methods are considerably less expensive and more or less comparable in cost, though the fungicide and ozone treatment method is somewhat cheaper per metre.

Conclusions and recommendations

One great advantage of the steel sill method is that it involves only pure building work. With fully trained operators it should be possible to carry out the work for

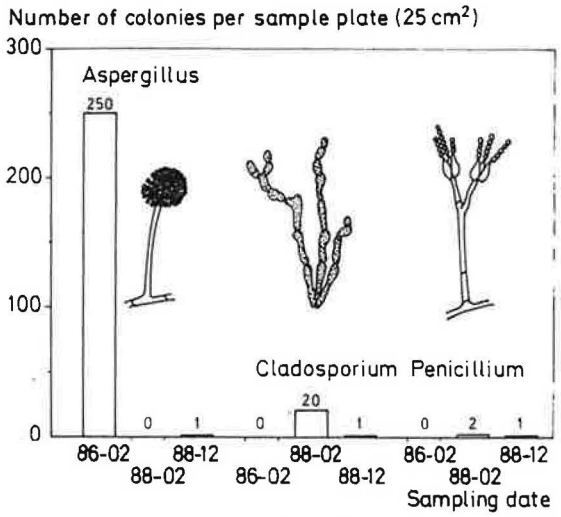

Fig. 7. Examples of results from one of the buildings where the original wooden sills were replaced by a steel sill to the right, and a new wooden sill.

The original wooden sill had been badly attacked by* Aspergillus. *After the steel sill had been laid, the conditions favourable to the development of fungi were completely eliminated.

The temporary growth of* Cladosporium *(20 colonies) in February 1988 has decreased in the sample taken in December 1988 by 19 colonies; i.e. the risk of any further growth of* Cladosporium *can be considered non-existent.

The presence of* Penicillium *was low both before and after laying the steel sill. Only occasional colonies were found in the samples.

Thus it is quite evident that by laying the steel sills the conditions favourable to the development of the commonest types of mould fungi were eliminated) i.e. the moisture content in the overlying wooden sill is far below the critical level of moisture, (fig. 5). The safety factor is high. It is therefore possible to guarantee high-quality building standards

about SEK 1000 per m (US$ 165 per m). In buildings with no sand on the slab, costs ough to lie below SEK 1000 per m. Narrower steel sills than those we used can now be supplied, which should make the work easier. The method can and has been used for renovating outer wall sills as well.

The prognosis for the steel sill/unimpregnated wooden sill method is favourable regarding physical-building and mycological factors. The method is judged to be reliable and fool-proof. Thus it can help to guarantee a high standard and quality assurance in new constructions as well. Since it is far less expensive than traditional methods, it is recommended not only for renovating partition walls but also for outer walls. The tenants are very pleased. 'Sick houses' have become 'healthy houses'.

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