HOW TO AVOID SURFACE CONDENSATION

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Abstract

Surface condensation and mould growth affect a large proportion of the UK housing stock. This paper reports BRE studies in occupied local authority flats in Scotland in which a range of remedial and insulation, improved ventilation with automatic control and the use of free standing dehumidifiers. The results indicate that improved insulation is not likely to be effective in unheated bedrooms in flats where there is no adventitious heat gain from below. Automatic controls can make extract fans more acceptable to occupants. Dehumidifiers are relatively intrusive and much more successful in warm humid conditions than in dry cold rooms. A high capital cost can lead to reduced running costs with increased likelihood of use by occupants. A method of assessment of remedies is proposed and illustrated.

Introduction

Dampness with resulting mould growth is one of the major problems in UK housing today. Problems are widespread in all sectors but are worst in rented housing, both public and private. Condensation is the most important cause in public rented housing, with other causes being relatively minor. The mould that results can cause extreme distress to house-holders and be the focus of many complaints to the housing authority. Questions arise as to possible health effects, especially to individuals with allergic reactions, from the moulds, their spores and associated micro fauna.

Previous studies undertaken in the late 1970s (4) indicated that local authorities were reacting to complaints of dampness often with short term palliative measures. Advice was given to householders suggesting that they alter their lifestyle: many houses were simply redecorated, often annually. In only two percent of cases were measures carried out which were likely to alter the internal environment of the house. Little or no information was available on the likely success of individual remedies and, more importantly, the costs of successful treatments.

Consequently, trials of a range of remedial measures were set up in various estates of occupied local authority housing. In parallel, studies were made of the species of moulds occurring on surfaces and the concentration of their spores in the air in housing. As the mould studies are reported elsewhere (1), this paper concentrates on the environmental conditions achieved and the costs of the different remedies installed.

The Remedies Studied

The main field studies were carried in an estate of 4-storey 2 and 3 bedroom flats in Stirling in central Scotland. The construction is traditional with brick-cavity-brick walls and pitched roofs. All top floor flats had 75 mm of insulation on the ceiling. The main condensation risk area was the single leaf brick wall between the bedrooms and unheated common stairs. Originally, under floor heating had been installed in the living room and hall, but this was rarely used, due to high running cost or because it had failed. Use of paraffin or bottled gas heaters was widespread. About three quarters of the tenants had complained of condensation and mould.

A range of remedial measures were designed and installed in two phases by Stirling District Council in collaboration with BRE Scottish Laboratory.

First Phase

In the first phase eighty flats were involved in five groups of 16 (i.e. two stairs in each group). One group was left unmodified to act as a control, the remainder were modified with:

Improved insulation: The external cavity walls were filled with polystyrene beads; evidence of slumping was subsequently observed, leaving the top storey uninsulated.

Improved ventilation: A fan was fitted to extract air from both the kitchen and bathroom in two groups of flats. In the first group the fans were controlled by the tenants; in the second they were controlled by humidistats set at 70% relative humidity in both rooms.

Improved heating, insulation and ventilation: A gas group heating system served radiators in all rooms with thermostatic radiator valves set so the temperature could not fall below 12°C. Integrating heat meters were installed in each flat so the tenants could be charged realistically for the heat used. Cavity walls were insulated as before and the solid walls between bedrooms and stair dry-lined. Extract fans under either tenant or humidistat control were also fitted.

Second Phase

In the second phase a further group of 16 flats was modified:

Heating, insulation, and ventilation: Besides the insulation and extract fans, as in the first phase, electric storage heaters running on a cheap overnight tariff were installed in every room.

Dehumidifiers: Thirty flats and mainsonettes in Inverclyde, selected with tenants willing to cooperate, were used to investigate the performance of three different sizes of free-standing dehumidifiers. The cost of the electricity used by the dehumidifiers was reimbursed to the tenants.

Monitoring

In all the field studies, continuous recordings were made of the temperature and humidity in kitchen, living room and one bedroom of each flat, together with the outside condtions. Of particular interest are those periods when the relative humidity exceeds 70 %, which if sustained will permit mould germination. Energy consumptions and length of time that extract fans and dehumidifiers ran were recorded, together with the amounts of water collected by the dehumidifiers.

Samples of the moulds growing in the flats were taken for identification and the spore concentration in the air determined by aerial sampling (1). Tests of fungicidal paints were carried out in the laboratory and in a controlled humidity test chamber, which simulates extreme hazard conditions, at the Princes Risborough Laboratory of BRE. Site trials of fungicidal paints are in progress in a limited number of occupied houses in Glasgow and London (2).

Pointers to Performance

Table 1 shows, for each room, the percentage of time that tlhe relative humidity was over 70%, allowing moulds to germinate. The results from each group of flats are summarized below.

Improved Insulation and Heating

The mean conditions in the control, insulated and gas heated flats are plotted on figure 1, which shows, as expected, that the kitchens and living rooms which are heated are warmer in the insulated flats. However, the bedrooms are very little different from the control flats. As usual, in these flats the bedrooms are located above each other with very low heat gains from living rooms, compared with 2-storey houses. Thus, if the bedrooms are not heated, the insulation will confer very little benefit. Vapour pressures were higher in the kitchens (one of the main sources of water vapour) when insulated. Possibly adventitious ventilation was reduced by the sealing of cracks when the cavity was filled.

Table 1 shows that the insulation has reduced the risk of mould in heated rooms but made little difference in the unheated bedrooms.

In contrast, all the rooms are much warmer in the insulated flats with gas or electric full central heating. The effect is most striking in the bedrooms, which are completely removed from any risk of mould growth (Fig. 1). Table 1 shows that the relative humidity rarely rose above 70 % in either group of flats.

Table 1. Number of hour/week that relative humidity exceeds 70 %.

	GROUP A	B	C	D	E
Living room	21.8	0.3	1.8	0.0	0.0
Kitchen	34.6	17.6	21.0	0.1	1.7
Bedroom	102.8	87.4	70.0	0.1	5.0

Key to groups:
- A: Control
- B: Insulation alone
- C: Humidistat controlled fans
- D: Gas heating, insulation and fans
- E: Electric heating, insulation and fans

<u>Extract Fans</u>

Table 2 shows the average run times for the extract fans.

Table 2. Extract fans - running times (hours/week).

	Humidistat Controlled	Tenant Controlled
Fans with gas heating and insulation	3.8	1.4
Fans alone	49.4	2.6

Fans under the control of the tenants were rarely used and the results show that they had little effect. In comparison the humidistat fans ran for almost a third of the week in those flats where they were the only modification. Also tenant reaction to the humidistat controlled fans was much more positive; they could appreciate the purpose of the fans, as they operated when needed. Both types of fans ran very little in the group heated flats where the relative humidity rarely rose above 70 %.

It can be seen from Table 1 that, except in the living rooms which adjoint the kitchen, the fans had limited effect. The fans used were small and may have been undersized.

Dehumidifiers

The field studies emphasized that dehumidifiers are different from other measures because, to succeed, they need active participation from the householder. The machines tested needed regular emptying of the water collected and were noisy and bulky.

Performance is critically dependant on the conditions in which they run. They perform well, extracting large amounts of water vapour, in warm humid environments, much less well in cold conditions. This was shown in the field studies, where in a well heated bedroom with problems caused by high moisture generation, the dehumidifier reduced the relative humidity by both reducing the vapour pressure and providing some heat. In a poorly heated bedroom the machine acted as a small (300 W) heater but had little effect on the vapour presure.

In the field trials at Inverclyde the dehumidifiers were used in the bedrooms as there was no room for them elsewhere. Machines extracting 4 litres a day, under typical conditions, reduced the risk of condensation in all rooms, while those extracting only 1 litre made little difference to conditions, though householders stated that they helped to dry damp carpets and bed clothes.

Energy Use and Costs

In order to put the results from the flats in Stirling into context, they have been plotted in Fig. 2 on a graph of total annual energy consumption against fabric transmittance (i.e. the heat loss through the building fabric). The solid lines are derived from a survey of 1500 local authority dwellings in Scotland.

The results show that fuel usage for average and higher fuel users falls with decreasing fabric transmittance (e.g. with improved insulation). However, in the case of the lowest 25 % of users, heat used is independent of heat loss through the building fabric, implying that the benefits of insulation are likely to be taken as increased temperatures and reduced risk of condensation.

The results from Stirling indicate that there is very little difference in energy consumption in the flats when insulation alone was added. In the flats with both improved heating and insulation, the average fuel consumption has moved from about the lowest 25 % of users to slightly above average.

The capital costs of the remedial works (at 1982 prices) and the weekly payments by tenants for all energy used are summarized in Table 3. While the capital cost of both heating installations was high (especially the gas group heating), the weekly cost to the tenants was lower than in the unmodified control group. A single large capital payment by the authority has given the tenants greatly improved conditions at lower cost.

Table 3. Capital cost of modifications and fuel costs to tenants.

	GROUP				
	A	B	C	D	E
Capital cost L/flat	-	160	320	2,900	1,250
Fuel Bills L/week	10.50	9.86	11.40	9.10	8.90

Keys to groups: See Table 1.

The calculation procedure originally developed by London (3) is being developed to allow assessment of the different remedial strategies open to householders and housing authorities. For example, given typical values of outside conditions, moisture production and ventilation rate, the relative humidity can be calculated as a function of fabric transmittance and heat input as shown in Fig. 3. One of the unmodified flats at Stirling lies on the 80 % RH line. As shown in the figure, there are two options available to more to 70 %. The walls maya be insulated at a single capital cost of £200-300 or the householder can spend more on fuel (about £60-150 extra every year depending on fuel).

This technique is being extended to provide a generalized model to assess the likely consequences of remedial measures in housing.

Conclusions

A number of conclusions as to the performance of remedies can be drawn from the studies reported in this paper.

Extract fans in bathrooms and kitchens are likely to be much more effective when controlled by humidistats than when controlled by tenants.

Improved insulation reduces the risk of mould in heated rooms. Conditions in unheated rooms in flats are likely to be little improved by insulation without heating unlike 2-storey housing where insulation may suffice.

The provision of insulation and whole house heating eliminates the risk of mould growth. The cost of insulation can be offset by the reduced cost of the heating system; consequently heating and insulation should be considered as a package.

The performance of dehumidifiers depends on the room air conditions. They are effective in well heated dwellings with problems of high moisture generation or low ventilation: they are less effective in colder properties. They also require the active cooperation of householders.

Acknowledgements

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References

1. Bravery, A.F., Grant, C., and Sanders, C.H. Controlling mould growth in housing. Unhealthy housing: Proceedings of IEHO Conference, University of Warwick, December 1987.

2. Grant, C., Bravery, A.F., Sprindle, W.R., and Worley, W. Evaluation of fungicidal paints. International Biodeterioration Journal 1986, Vol. 22, No. 3, p179-194.

3. Loudon, A.G. The effects of ventilation and building design factors on the risk of condensation and mould growth in dwellings. BRE Current Paper 31/71, HMSO 1971.

4. Sanders, C.H., and Cornish, J.P. Dampness: one week's complaints in five local authorities in England and Wales. London: HMSO, 1982.

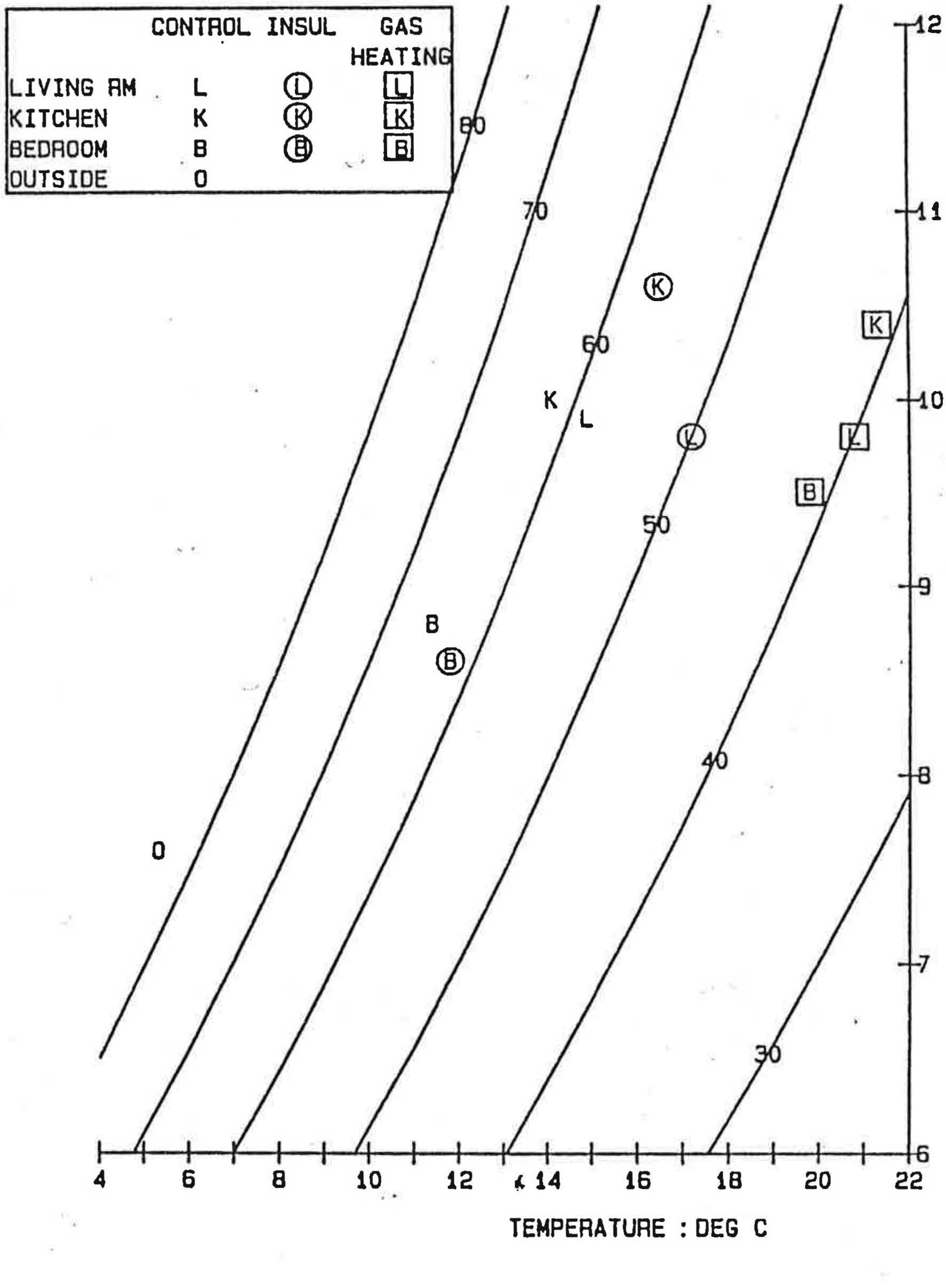

Fig. 1. Mean conditions in control, insulated and gas heated flats.

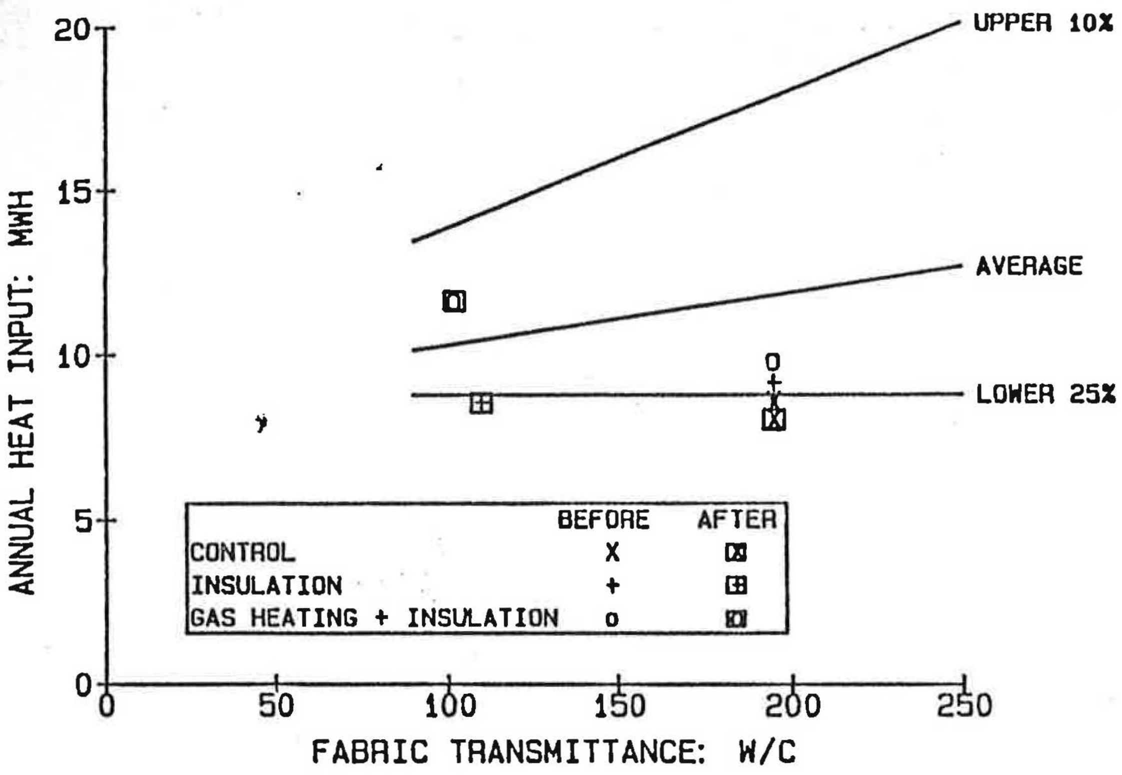

Fig. 2. Annual heat input to flats compared to large scale survey.

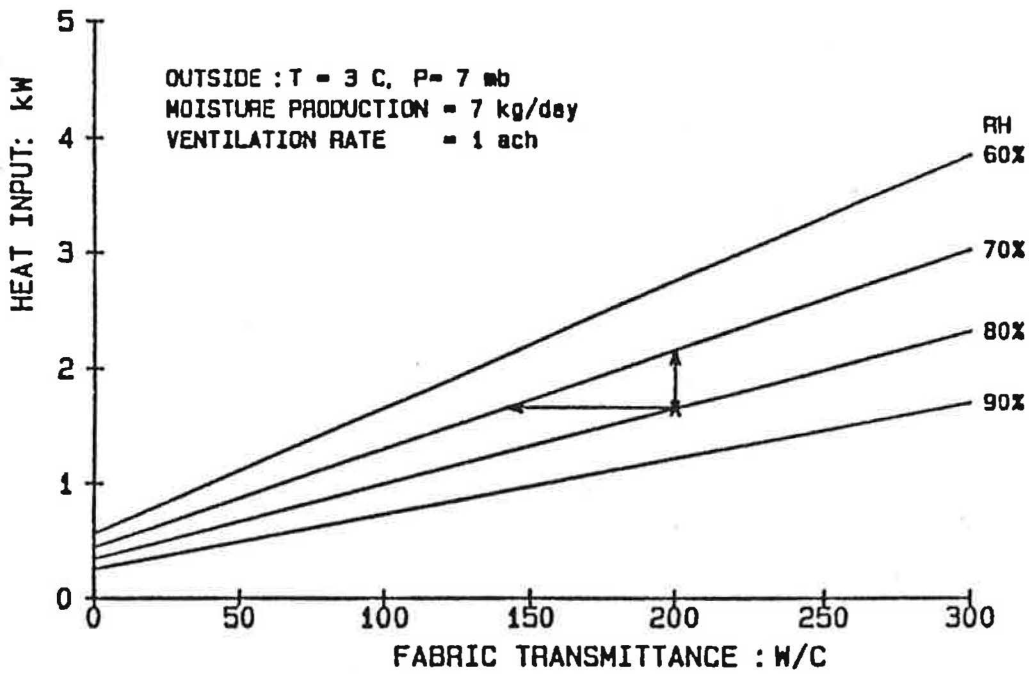

Fig. 3. Options for remedial measures in a typical flat.