

SURFACE CONDENSATION AND MOULD

Remedies and their effectiveness



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Surface condensation and mould affect about 15 percent of the UK housing stock. This paper reports BRE studies in occupied dwellings on the effectiveness in various situations of a range of remedial measures, which included improvements to thermal insulation and heating, and the provision of extractor fans and dehumidifiers. The flats and 2-storey houses involved were all of traditional construction with brick walls and pitched roofs. The results are incorporated in a recently published BRE package of practical guidance; this article outlines significant factors revealed by the field studies.

La condensation superficielle et les moisissures affectent 15 pourcent environ du parc immobilier anglais. Cet article est consacré à des études menées par le BRE dans des logements occupés sur l'efficacité dans diverses situations d'une gamme de mesures pour y remédier, dont améliorations apportées à l'isolation thermique et au chauffage, pose d'extracteurs et de déshumidificateurs. Les immeubles et les maisons de 2 étages traitées étaient tous de construction traditionnelle avec des murs de briques et des toitures en pente. Les résultats ont été intégrés dans un guide pratique publié récemment par le BRE; cet article souligne les facteurs significatifs révélés par ces études *in situ*.

Dampness is a major problem in UK housing. Best estimates put the number of dwellings affected by severe dampness at 2 million, with a further 2.5 million affected to a lesser extent. The major cause is condensation which often leads to mould growth. The figures indicate that about 1.5 million dwellings suffer from minimal mould growth (fig. 1a), another 1.25 million have more severe problems (fig. 1b) and a further 0.25 million have extensive mould growth, often causing acute anxiety to the householders and giving rise to serious complaints (fig. 1c). These problems are widespread in all housing sectors but are most serious in tenanted accommodation, both private and public.

Having diagnosed the dampness or mould problem as due to condensation, information is then required to determine the most cost-effective treatment for the particular case in hand. There are treatments for mould growth, such as fungicides or anti-condensation paints, which can be useful for mild attacks or as short-term measures. In the long term, however, cures must concentrate on the elimination of condensation.

In order to provide better advice on the effectiveness and cost of remedial measures likely to be adopted in traditional dwellings, BRE have been carrying out trials of different remedies in occupied dwellings in Scotland and England. All the estates had a history of complaints of dampness. Results of the trials are still being analysed, but they have given some useful pointers to the effectiveness of different measures in varying situations. The remedies which have been tried out, either on their own or in combination, are insulation of external walls by cavity-fill or by externally applied insulation, new partial or full central heating systems, extract fans in kitchens and bathrooms controlled either by the householder or by humidistat, and dehumidifiers.

Field studies: flats in Scotland

In Scotland one set of field studies was carried out on an estate of 4-storey, 2- and 3-bedroom flats in Stirling (fig. 2). The construction is traditional with brick-cavity-brick walls and pitched roofs. All top floor flats had 75 mm of insulation in the roof space. The concrete floor to the living room

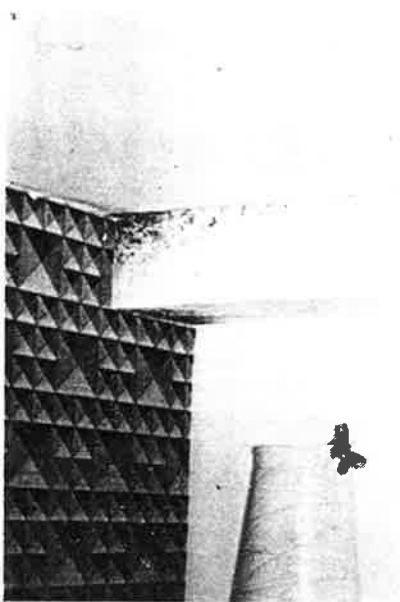


Fig. 1a. Mould severity - slight

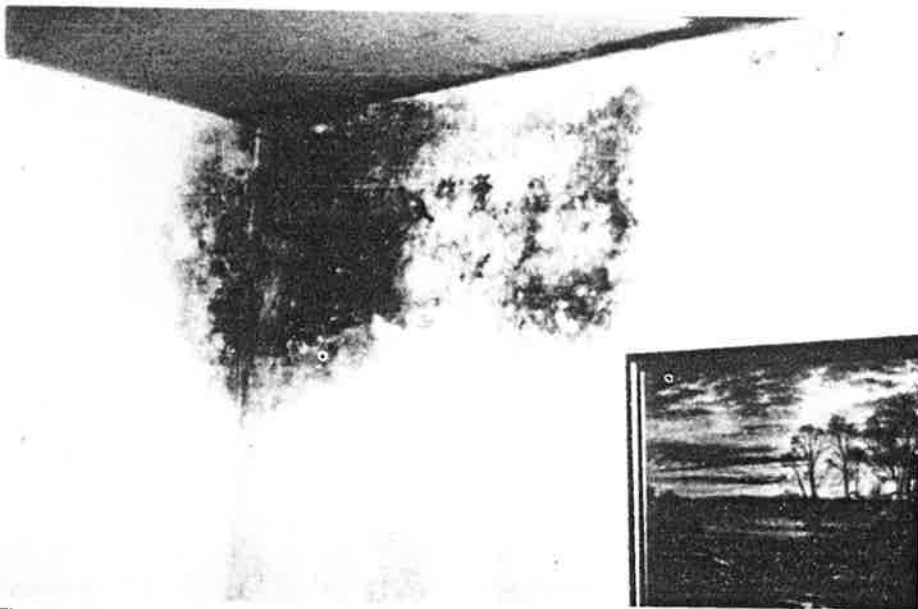


Fig. 1b. Mould severity - moderate

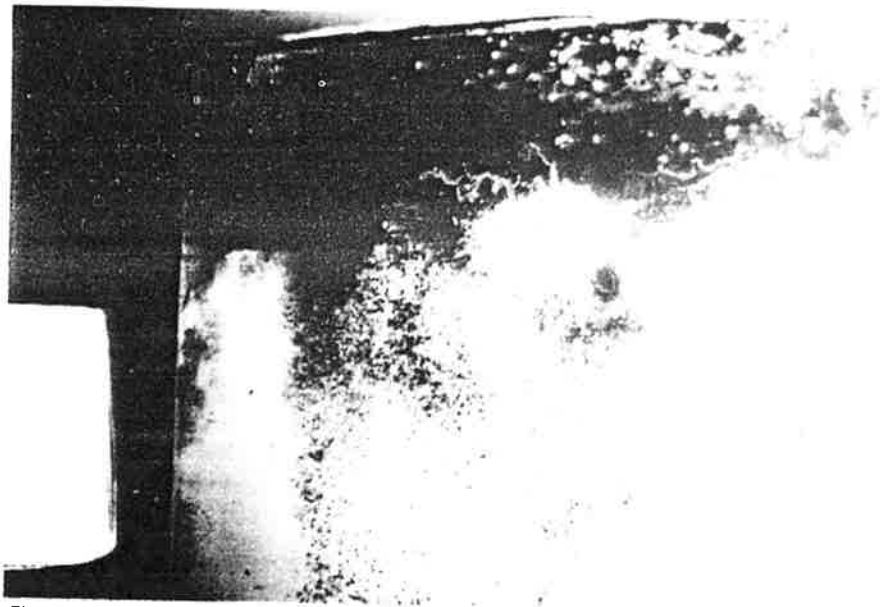


Fig. 1c. Mould severity - severe

extended to form a balcony (and possibly a thermal bridge), but this was not as important a condensation problem as the single leaf brick wall

between the bedrooms and the open stairs. Originally, underfloor heating had been installed in the living room and hall only, but this was very rarely used

either due to failure of the system or because the householders found it expensive to run: a large number of the householders had resorted to using paraffin or bottled gas. About three-quarters of the householders had complained of condensation or mould.

Eighty flats were involved in the trials, divided into five groups of 16. One group was left as control, the remainder were modified with:

- improved insulation - external cavity walls were filled with polystyrene beads;
- improved ventilation - with extractor fans fitted in kitchens and bathrooms and controlled by the householder;
- improved ventilation - with extractor fans controlled by humidistat which switched on when the relative humidity rose above 70 percent;
- improved heating, insulation and ventilation - a gas group-heating system served radiators in all rooms, and thermostatic radiator valves were set at 12°C. Cavity walls were insulated as before, and bedroom walls adjacent to the stairs were dry-lined. Extractor fans either under householder or humidistat control were also fitted.

Field studies: houses in England

In England the field studies were undertaken at Harrow, Middlesex, in an estate of traditional 1920s 2-storey, semi-detached and terraced houses (fig. 3). The construction is 225 mm solid brick walls, timber floors and tiled pitched roofs.

Twenty houses were monitored both before and after remedial measures were undertaken. The remedial packages that were investigated involved:

- fifteen houses with external wall insulation added, gas-fired partial central heating installed and extractor fans fitted in kitchens and bathrooms;
- five houses with a full gas central heating system installed throughout the house; no insulation was added to the walls.

Additionally field studies were undertaken in 30 flats at Inverclyde, Strathclyde (fig. 4), and in four 2-storey houses at Harrow to investigate the performance of some free-standing dehumidifiers.

Monitoring in all cases involved determining the temperature and relative humidities in kitchens, living rooms and one bedroom of each dwelling, together



Fig. 2. The flats at Stirling

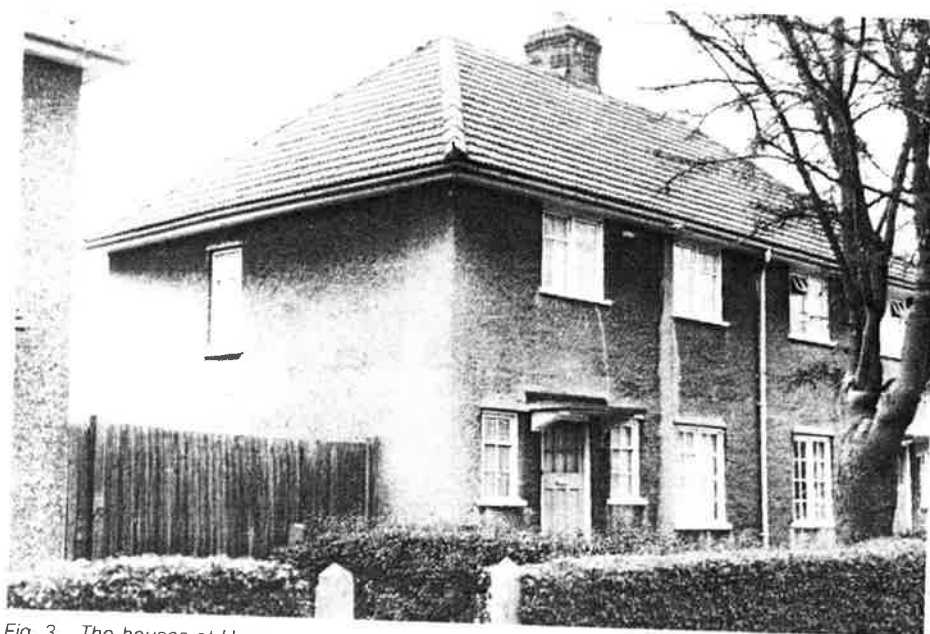


Fig. 3. The houses at Harrow



Fig. 4. The flats at Inverclyde

with external conditions. Of particular concern are the periods when relative humidity exceeds 70 percent. Above this value, conditions are favourable for mould germination which, once germinated, can easily be sustained. Energy consumptions and the length of time extractor fans and dehumidifiers ran were recorded. The amount of water collected by the dehumidifiers was noted by the householders.

Although the data from the field studies are still being analysed some useful pointers have been given of the effectiveness of the different remedial measures in varying situations.

Pointers to performance

Extractor fans

Table 1 gives the average run times of the extractor fans at Stirling. Fans under tenant control were rarely used and results confirm that they had little or no impact on conditions in the flats. In those flats where the installation of humidistat controlled fans was the only modification, they ran for almost a third of the week.

The percentage of time that the relative humidity exceeded 70 percent in each room in the different groups is shown in table 2. It can be seen that, except in the living room, which adjoined the kitchen, the effect of the fans is small. The limited effect of the fans at Stirling is thought to be caused by the fan being too small. The fans controlled by humidistats also ran very little in the group-heated flats, because the relative humidity rarely rose above 70 percent.

In the Harrow trials fans were fitted to all the houses as part of the modernisation package. They were not greatly used but the indications are that they helped improve conditions.

Thermal insulation

Mean temperatures and humidities for each room averaged over all the flats and over the whole monitoring period were calculated for each group of flats at Stirling. Figure 5 shows a comparison of the control group with the flats with cavity wall insulation.

As expected, kitchens and living rooms which are heated are warmer when insulated. However, the bedrooms are very little different. Not unusually, in these flats the bedrooms are located above each other with few heat gains from living rooms and kitchens that occur in 2-storey houses. Thus, if the bedrooms are not heated, the insulation will confer little benefit.

The results from these flats indicate that vapour pressures (air moisture contents) are higher in the insulated kitchens, one of the main sources of

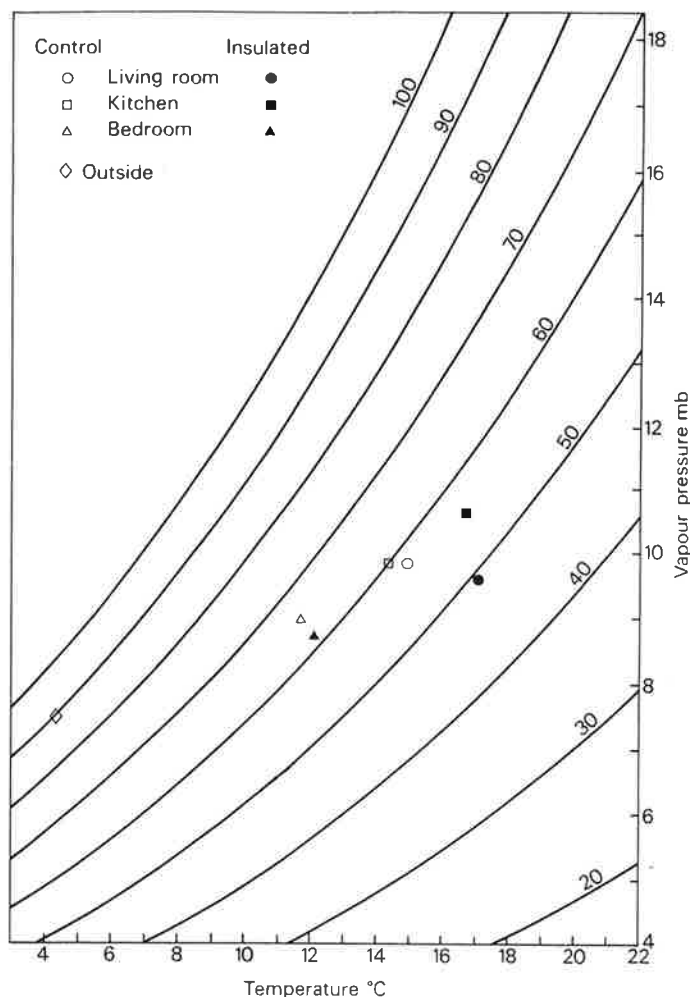


Fig. 5. Comparison of control and insulated flats

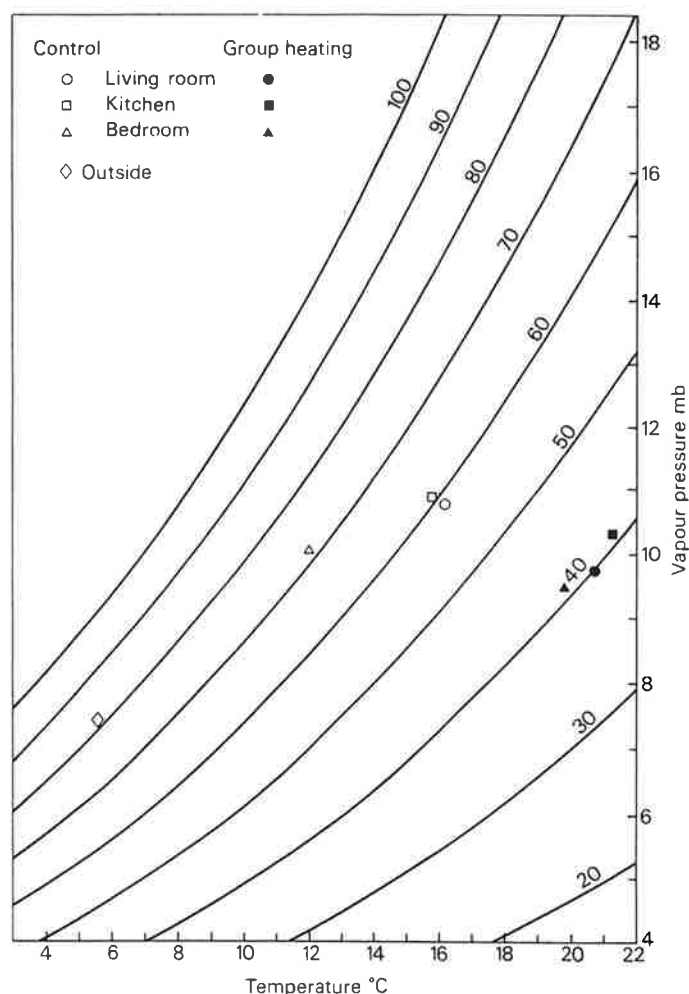


Fig. 6. Comparison of control and group heated flats

Table 1. Extract fans - running times (hours per week)

	Humidistat controlled	Tenant controlled
Fans in flats with group heating and insulation	3.8	1.4
Fans in 'control' flats	49.4	2.6

Table 2. Percentage of time relative humidity greater than 70 percent

	Control	Fans (humidistat)	Insulation	Heating and insulation
Living room	16	1	0	0
Kitchen	20	14	8	0
Bedroom	62	43	35	0

water vapour in the flats. A possible cause is a reduction in adventitious ventilation by the sealing of cracks when the cavities were filled. There is little difference in the moisture contents in living rooms and bedrooms.

Table 2 shows that insulation (at a cost of £200 per flat) has reduced the risk of mould growth in heated rooms but made little difference to unheated bedrooms.

In the 2-storey houses at Harrow, which were modernised with external insulation, partial central heating and extractor fans, the whole house temperature rose by 4.2°C. The risk of condensation was virtually eliminated even in the nominally unheated bedrooms and the great majority of the householders were satisfied with the modifications.

Results indicate that insulating the

building fabric is likely to have a significant effect on temperatures in unheated bedrooms of 2-storey houses or maisonettes, but will have only a minimal effect on the bedrooms in flats or bungalows. In these latter cases heating must also be provided.

Heating and insulation

As expected, all the rooms are much warmer in the insulated flats with full central heating. The effect is most striking in the bedrooms, which are completely removed from any risk of condensation or mould growth (fig. 6). Table 2 indicates that the relative humidity in these flats virtually never rose above 70 percent.

The results indicate a fall in the moisture content of the air in the living rooms. This may be due to increased ventilation caused by the householders' preference to open windows. Even so, the average weekly winter fuel costs of gas for space and water heating, and electricity for cooking and power, was £9: this compares with the £10.50 the householders paid in the all-electric unmodified flats.

Although the cost of the external insulation at Harrow was £1400 per house, against this must be set the

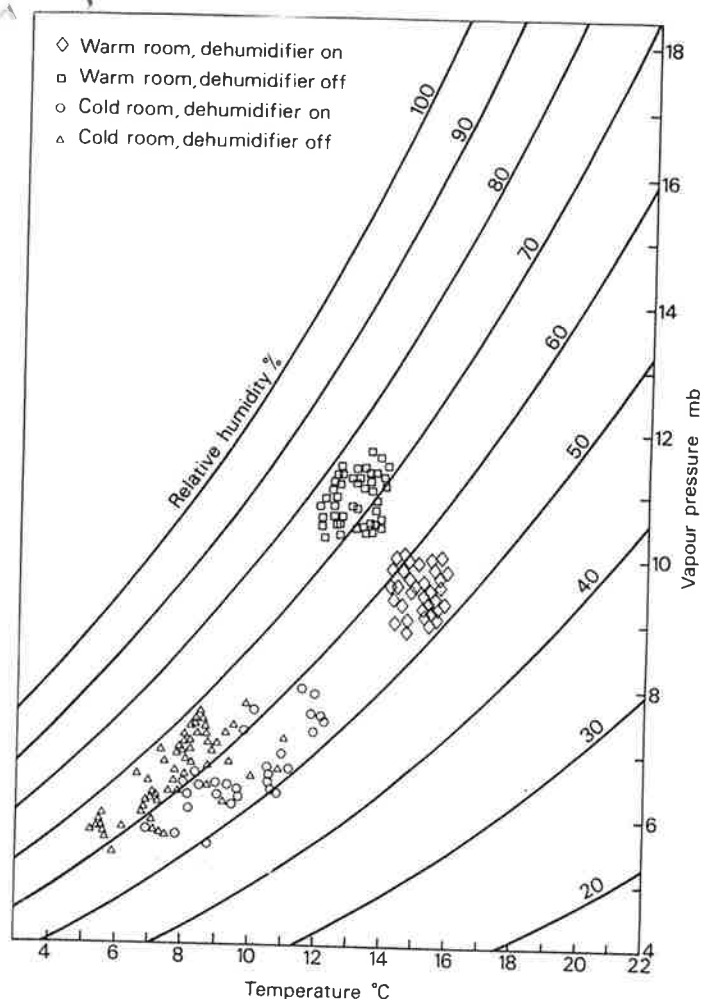


Fig. 7. Effect of a dehumidifier running in warm and cold bedrooms

saving on the cost of the central heating system which only served radiators in the downstairs rooms. Additionally, the cost included rendering which would have been undertaken as part of rehabilitation in any case. Under these circumstances, external insulation becomes economically much more attractive.

Results for these studies indicate that heating and thermal insulation should be considered as a package since this can result in a lower capital cost as well as a reduction in running cost.

Dehumidifiers

The field studies undertaken on dehumidifiers at Inverclyde and Harrow have emphasised that dehumidifiers are essentially different from the other remedial measures because to succeed they need the active participation of the householder. The machines tested needed regular emptying of the water collected and were noisy and bulky.

Results from the trials indicate that the performance of dehumidifiers is critically dependent on the ambient conditions in which they operate. They perform well at high temperatures and high moisture contents. For example, in a well heated bedroom of a flat where the problems were due to high moisture generation, the dehumidifier reduced

the relative humidity by reducing the moisture content of the air (fig. 7). In a poorly heated bedroom the dehumidifier had little effect on the moisture content, but lowered the relative humidity by raising the temperature; in effect it acted as a small (300W) and expensive (£300) heater.

At Inverclyde dehumidifiers were used in the bedrooms of the flat as there was no room for them elsewhere. Machines extracting 4 litres of water per day reduced the risk of condensation in all rooms, while those extracting only 1 litre per day made little difference to relative humidity, though the householders stated that they helped to dry damp carpets and bed clothes.

At Harrow the dehumidifiers were located downstairs in the kitchen or hall. The noise and location of the machines may explain why the average running cost at Inverclyde was just over £1 per week, whereas at Harrow it was just over £2.

Although the machines tested did not look very promising, new low-powered machines are now being developed which are more efficient and quieter.

Energy and capital costs

In order to put the results of the flats at Stirling into context, they have been

plotted in figure 8 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 some 1500 local authority dwellings in Scotland.

The results show, not surprisingly, that fuel usage for average and higher users falls with decreasing fabric transmittance (e.g. with improved insulation). However, in the case of the lowest 25 percent of users, fuel consumption is independent of the heat loss through the building fabric. This implies that the benefits of insulation are likely to be taken as increased temperatures and thus reduce the 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, although temperatures increased. In the flats with both improved heating and insulation the average fuel consumption has moved from about the lowest 25 percent of fuel users to about average. The risk of condensation has been eliminated in these flats and the householders on average now pay about £1.50 less per week for energy.

Any remedial measures must be effective at a cost which is affordable by the householders. Figure 9 indicates the costs of remedial measures in a typical flat at Stirling with a heat input of 2 kW, moisture generation of 7 litres per day and a ventilation rate of 1 air change per hour. In this typical flat the relative humidity would be about 80 percent and the flat would be at risk to condensation and mould growth. To remove the risk of mould growth the relative humidity can be reduced to 70 percent by either filling the cavities of the flats (at a cost of, say, £200-300) or by the householder spending more on fuel (about £60-150 per annum depending on fuel and tariff).

Figure 10 illustrates the likely costs of remedies in a similarly heated flat but where the moisture generation rate is now assumed to be 14 litres per day and the ventilation rate 2 air changes per hour. In this circumstance the problem can be solved by the householder spending about £80-220 a year extra on fuel. Cavity fill insulation could again be installed, but this would not solve the problem; either the householder could pay an extra £30-80 per year on fuel, or internal or external insulation could be added to the already cavity-filled walls.

Some conclusions

Results discussed in this paper are preliminary and analysis of the data is continuing. However, conclusions so far

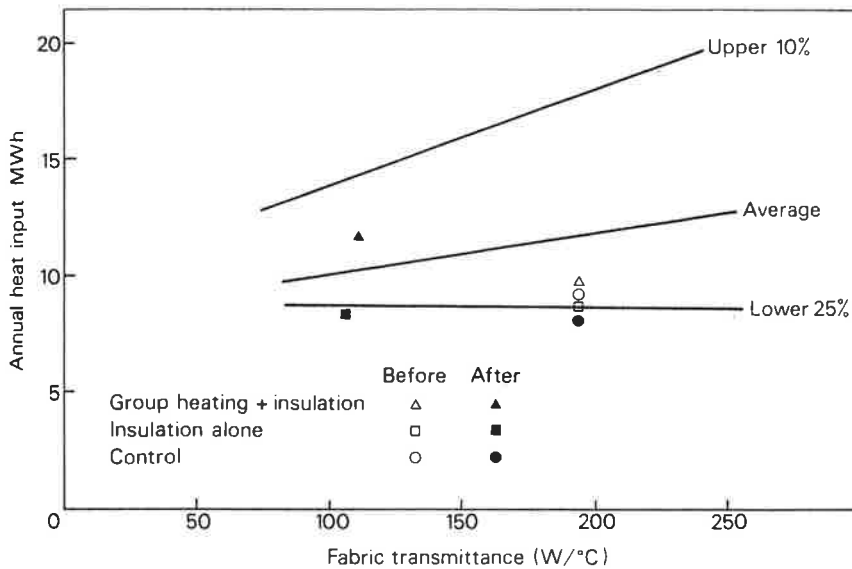


Fig. 8. Annual heat input and fabric transmittance, flats at Stirling

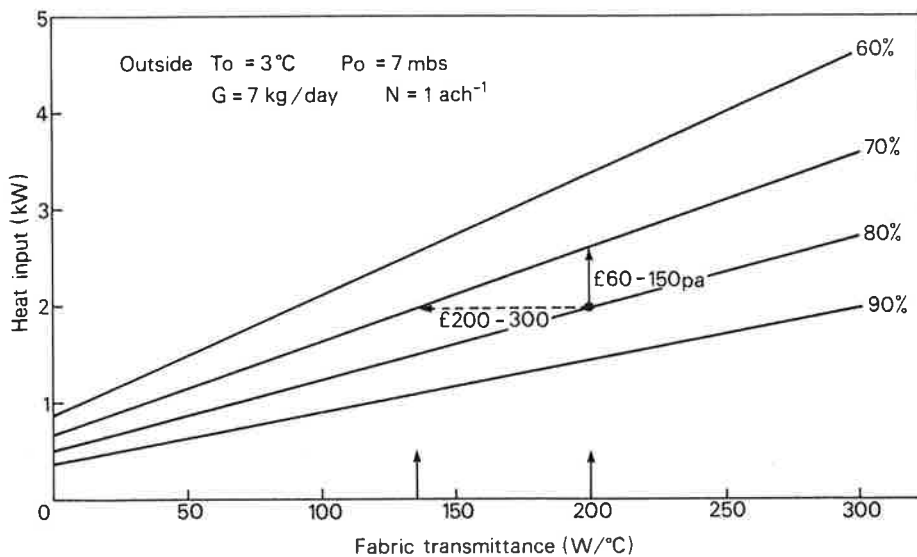


Fig. 9. The cost of remedial measures in a typical flat at Stirling

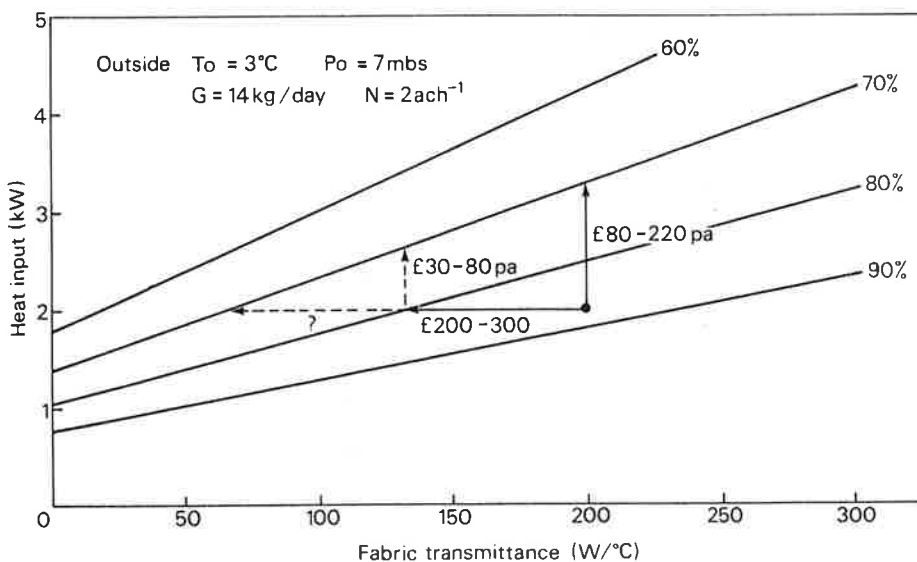


Fig. 10. The cost of remedial measures in a flat at Stirling with high moisture generation

would indicate that:

- Extractor fans in bathrooms and kitchens are effective when controlled by humidistat; those under control of tenants are rarely used.
- Improved insulation reduces the risk of mould in heated rooms. In 2-storey houses or maisonettes insulation of the building fabric results in increases in bedroom temperatures. Conditions in unheated bedrooms of flats or bungalows are likely to be very little affected by insulation alone, and heating is required.
- The provision of insulation and 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 thermal insulation should be considered as a package.
- The performance of free-standing dehumidifiers very much depends upon the conditions in which they operate. They are likely to work very well in well heated dwellings where the problems are caused by high moisture generation rates or inadequate ventilation: they are less likely to be effective in other situations. Additionally, they require the active co-operation of the householder. Newer machines are being developed which may overcome some of these problems.

Acknowledgement

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