AIC 58/ #96b

Technical Note

Summary A discussion meeting attended by an invited audience of some thirty people was held at the Chartered Institution of Building Services on 15 July 1981. The audience comprised researchers, consulting engineers, architects, insulation manufacturers and contractors and management personnel from both the public and private sectors of housing. The object of the discussion was to ascertain the extent of the problem of condensation in roof spaces of dwellings insulated to higher than traditional standards as evident now, to discuss the mechanisms resulting in condensation and to evaluate possible solutions. In addition, an attempt was to be made to assess the consequences in, say, ten years' time of the trends.

Loft insulation and condensation in roof spaces

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1 Introduction

Loft insulation has become accepted as the most cost effective means of energy conservation for domestic premises. Proprietary materials are easy to install and present trends suggest 100 mm as the optimum thickness.

By markedly reducing loss of heat from accommodation spaces the use of loft insulation results in the roof space being colder. However, it does not reduce the tendency for water vapour to migrate from the dwelling to the roof space. Thus, with lofts that have been thermally insulated, roof-space relative humidity levels tend to increase and the risk of condensation is, consequently, greater. Actual measurements of roof space conditions recorded by the Building Research Establishment, the Electricity Council and British Gas have shown that such conditions occur in practice. Also, condensation problems have arisen on a significant scale in housing in France where new energy saving construction standards have been applied.

These occurrences have led to concern to ensure that the stepping-up of energy conservation measures does not lead to damaging consequences for the fabric of some domestic buildings, both of new stock and existing buildings where improvements had been applied. It was therefore decided to try to ascertain the scale and extent of the problem and its likely consequences, to discuss the contributory factors and the accumulation of circumstances which could lead to condensation and to evaluate the possible solutions.

2 Operational experiences

Numerous examples of serious condensation in roof spaces were referred to, supported in many cases by photographs which illustrated vividly the extent of the problem. It was also stated that problems had been encountered in other European countries where thermal construction standards tended to be higher.

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This summary was received on 15 December 1981.

Where condensation had been identified at an early stage the remedial requirements, provided they were effected promptly, were simple and inexpensive. Where condensation had obtained for some time, generally because it had not been identified until an advanced stage had been reached, damage tended to be extensive and the necessary remedial works were considerably more costly. Such examples included advanced rot problems in roof timbers and serious under-mining of chipboard or other timber product sarkings. These were accompanied by serious corrosion of ferrous metal fixings.

In view of the extent of some of the examples referred to the fear was expressed by some members that the problem could be more widespread than had previously been thought.

3 Contributory factors

To present a better understanding of the problems one contributor to the discussion outlined the relevant factors which would play a role in the development of any roof space condensation problem.

The first factor was the presence in the dwelling or its roof space of water vapour. The source within the roof

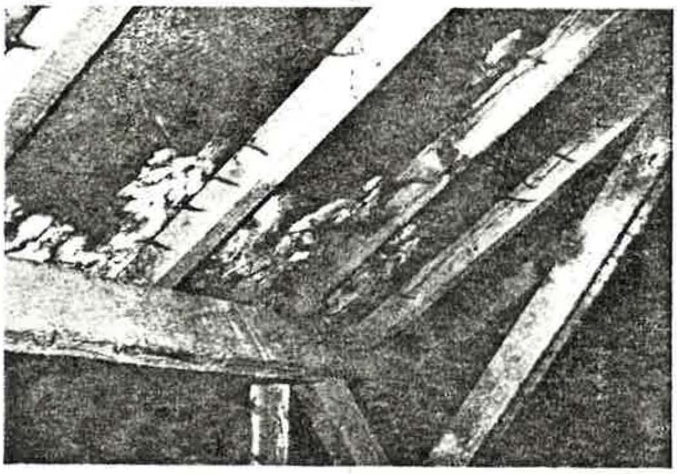

Fig. 1. Mould growth on fibreboard sarking.

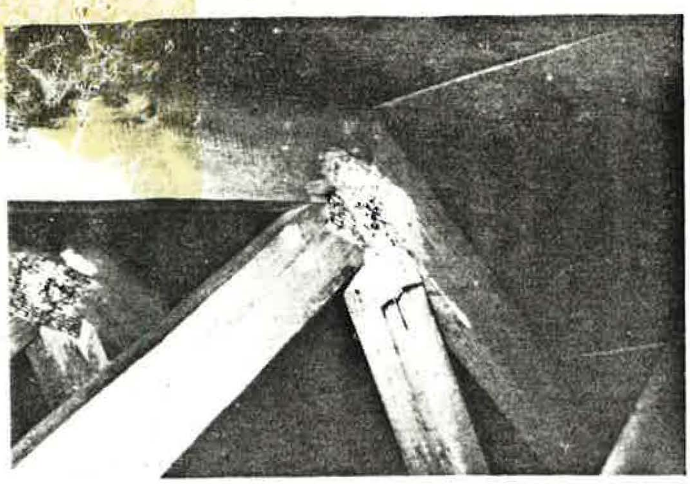

Fig. 2. Black mould on roofing timbers and rusting of gang-nail fixing.

space itself was evaporation from water tanks. Sources in the dwelling were combustion products and vapours from respiration, cooking and ablutions.

The second factor was the tendency for vapour to migrate from the dwelling to the roof space. This would occur by convection and diffusion. Without a vapour barrier at ceiling level the effects of convection and diffusion would be about 90 per cent and 10 per cent respectively. The use of a vapour barrier, however, would reduce diffusion by a factor of around 10. Bulk air movements from dwelling to roof space would vary dependent on the type of house and its construction but the proportions indicated in Table 1 were suggested.

Table 1 Air movement to roof space

Type of dwelling	*Percentage of total ventilation* *per cent*
Terrace house	20 to 30 (0.6 ac/h)
Detached house	60 to 80 (1.0 ac/h)
Flat with corridor or verandah access	50 to 70 (0.9 ac/h)

The corresponding median ventilation rate of the dwelling in air changes per hour is shown in parenthesis in Table 1.

A significant proportion of migration by convection of water vapour to the roof space was considered to be due to services provisions. The actual routes for migration were via unsealed openings provided for electrical and mechanical services, at ceiling roses for lighting and at the various pipe penetrations. Another major route was the loft access hatch which, when provided with an automatically folding access ladder, tended to be held slightly open by the counterweight thus providing a freer route for convection.

The use of ceiling vapour barriers did not seem to be common practice in UK thus providing a route for significant migration by diffusion.

The final factor was the environment of the roof space itself, the major contributory aspects being ventilation and solar heat.

Ventilation of the roof space, with the widespread use of sarking, was somewhat less than the rates associated with bare tile roofings. Typical indicative roof space ventilation rates for modern construction dwellings are shown in Table 2.

Table 2 Roof space ventilation rates

Type of dwelling	*Roof space ventilation rate*
Terrace house	4 to 6 ac/h
Detached house	10 to 15 ac/h

Solar heat gains would also play an important part in condensation control, by raising the temperature of the roof and the loft space.

4 Influence of roof pitch

In the course of the discussion it was agreed that the present trend toward lower roof pitches, would have the effect of further reducing roof space ventilation.

With low roof pitches, therefore, it was agreed that eaves need to project well beyond the building to provide a source of ventilation.

5 Control of water vapour generation

Apart from residual moisture in new construction, the presence of water vapour in a dwelling would be outside the control of the designer or builder. Lack of understanding of the process of vapour generation by occupiers and tenants of dwellings was partly to blame. However, even when tenants are urged to refrain from some practices (e.g. drying of clothes indoors) or the use of certain appliances (e.g. paraffin heaters) because of condensation risks, they show a marked reluctance to do so. This led to the view that reliance could not be placed on tenant co-operation but that owner-occupiers may be persuaded, in their own interests, to minimise detrimental effects on the fabric of their houses.

Accepting that water vapour will be created in a dwelling it was agreed that some measures can be taken to reduce the tendency for this to migrate to the roof space. Direct extract ventilation to the kitchen and bathroom were the obvious measures. However, these would affect the heating bill to some degree and, hence, may not be popular with occupiers.

This point led to a broader consideration of ventilation control in dwellings. Although it was felt that controlled mechanical ventilation for houses would become a future requirement, largely motivated by energy conservation, it was agreed that for such a concept to be effective, the house served would require to be of virtually a sealed construction.

6 Conditions in the roof space

The degree of water vapour migration to the roof space offers the potential for relative humidities in excess of 85 per cent to exist in poorly ventilated roofs. Under such conditions the long term equilibrium moisture content for timber would be between say, 15 and 23 per cent which is within the range of timber rot hazards.

For all roofs, the importance of openings at the eaves to roof ventilation was accepted, the standards set out in BS 5250, Basic data for the design of buildings; control of condensation in dwellings, representing a reasonable allowance. There may also be a need for ridge openings to ensure that the complete roof space was ventilated adequately.

Having identified the importance of eaves ventilation openings the known hazard of blocking these with thermal insulation was referred to. Conversely, however, it was pointed out that cold bridges could be created if thermal insulation was drawn-back too far from the eaves. This could have the effect of transferring the condensation problem to the bedroom ceilings and promoting mould growth.

7 Conclusions

The professional diagnosis of all the cases encountered indicated that the deficiencies involved were similar and that by bringing the arrangements into line with recognised standards the problems were alleviated. This applied even to cases where the earlier application of *ad hoc* solutions had failed to improve the situation (e.g. the provision of rainwater guttering suspended inside the roof from rafters and purlins!).

While in the fault cases studied it is not clear whether the problems had been instigated by lack of design understanding or by installation deficiencies, it was agreed generally that the correct design principles were well-known and broadly publicised. For this reason it was felt that what was required was a greater awareness and closer supervision at site level.

It was also acknowledged that houses, both in the public and the private sector, tended to be designed 'down to a price'. Local Authorities made every endeavour to ensure that the rental charged to tenants was one that they could afford but very scant attention was paid to the costs of heating the homes they provided beyond ensuring that the thermal properties of construction complied with the Building Regulations. The result was that many poorer tenants could not (or would not) meet the cost of heating their dwellings to an adequate standard. The use of kerosene or unflued Lpg heaters was still a widespread means of tenants providing single room heating without perhaps realising that condensation problems somewhere in the dwelling (possibly the roof space) would be the inevitable result. It was felt to be important to try to ensure that tenants understood fully the hazards of these practices even though it was acknowledged that they would probably still continue to use what they saw as the cheapest form of heating.

In the private field, records showed that 700,000 homes changed hands every year. An established owner could be expected to know, by experience, something about the performance of his home. A new occupier, at least initially, could use his home in a way that caused hidden condensation to develop without his realising it. During this period, damage could occur that would be very costly to remedy.

It was noted that some of the home improvement or DIY packages currently being taken-up by home owners could cumulatively lead to possible problems. Ventilation rates in the dwelling itself would tend to be reduced by the sealing-off of chimneys, by draught exclusion, by the use of balanced flue heating appliances and with the installation of double-glazing. This could lead to higher relative humidity levels and, possibly, to an increase of buoyancy ventilation to the roof space to compensate for reduced cross-ventilation. These tendencies, coupled with renewed roofing with sarking and a much higher standard of sealing could be the ingredients for condensation in the roof space.