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Moisture in a timber-based flat roof of cold deck construction

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INTRODUCTION

In the last few years there has been an increasing number of problems with flat roofs, a significant proportion resulting from the ingress of moisture. This is particularly important in roofs containing wood-based materials which are susceptible to moisture degrade, and the most vulnerable materials — flaxboard and strawboard — cannot be recommended unless an unusually high degree of protection from moisture can be assured.

This Information Paper is not concerned with water leaks due to rain penetration although this can be a problem, but rather with moisture which penetrates the roof from inside the building in the form of vapour. The problem has increased with changes which have occurred in the life style of the occupants, resulting in the generation of greater water vapour concentrations than has been normal in the past. This wetter occupancy stems in part from the reduction of effective building ventilation as buildings are made more air tight in a bid to save energy.

ENVIRONMENTAL TEST FACILITY

A test rig has been used at PRL to examine moisture problems in a flat roof of cold deck construction[1]. The roof comprised a deck of 19 mm chipboard on softwood joists with a covering of 3-layer felt. There was a ceiling of 12 mm polyurethane foam insulation board attached to the underside of the joists which incorporated a vapour barrier of aluminium foil. The roof was fitted with instruments to measure the moisture content of the wood and the temperature and humidity of the air at a number of positions. Glazed viewpoints and air tight access hatches in the ceiling also enabled conditions inside the roof to be examined and assessed.

Chambers constructed above and below the roof enabled selected uniform climates approximating to both day and night conditions to be applied alternately. A metered supply of conditioned air from either the upper chamber, the lower chamber, or both, could be fed through each inter-joist cavity to simulate air flows caused in practice by the wind and by the stack effect due to the temperature difference between the indoor and outdoor conditions. In addition climate regimes typifying both winter and summer conditions could be simulated.

EFFECTS OF BUILDING USE ON MOISTURE CONTENT OF ROOF

The amount of water vapour in the air is commonly expressed as relative humidity. The moisture hazard to a roof from water vapour however is best expressed in terms of the water vapour pressure (VP) excess inside the building compared with that outside. The more moisture is generated by building users and their activities, and the less it is dispersed by room ventilation, the greater is the VP excess that is generated and the higher is the risk of this wet air entering the roof void.

Although timber cold roofs should, of course, be ventilated with outside air, examples exist where ventilation is ineffective or has become obstructed. Thus the effects of normal, wet and very wet building occupancy were first simulated using a winter climate and no ventilation. With wet and very wet conditions below the roof (approximating to a heavy-used kitchen and laundry respectively) heavy visible condensation appeared on the underside of the deck within a few hours, although with conditions representing those found in a kitchen it was confined to the margins of the deck, adjacent to joists. Clearly lack of ventilation combined with activities which generated moisture presented a considerable condensation risk.

Sustained winter conditions

The effect on the unventilated roof of sustained humid conditions on the underside of the roof combined with a winter climate regime was investigated. The moisture content of the decking gradually built up over several months and although it took a year or so for a steady level to be reached (27 per cent moisture), a level of 20 per cent moisture was reached after approximately four months. Comparison with measurements on a broadly similar roof in service suggests that, in terms of moisture build up, the simulated winter was akin to the relatively mild winter of 1971-72 (although the simulated conditions were of course sustained much longer). The form of the moisture build up under test showed that both the length and severity of the winter could have an important effect on the moisture content attained and that the highest level was reached when warmer spring weather could accelerate decay. As observed previously the applied test climate produced marginal condensation and this accorded with measured temperature and dew point profiles through the roof. As a result of this condensation, mould potentially hazardous to wood-based materials developed along the deck/joist junctions after a few weeks. The pattern of mould development was similar to that observed in a flat roof over actual kitchens where ventilation had been restricted.

The results of this trial confirm that, without ventilation, there is a substantial risk of moisture degrade and of condensation problems occurring in timber-based flat roofs of cold deck construction.

Effect of ventilation

The wet roof started to dry out and the condensation disappeared when ventilation air was passed through the inter-joist cavities even though the applied winter climate was still maintained. The ventilation air was principally from the upper 'outdoor' chamber but was mixed with a minor proportion (20 per cent) of humid 'indoor' air from the lower chamber. This was to simulate the effect of humid indoor air penetrating the roof void, which can occur in practice. The total ventilation rate in the void corresponded to five air changes per hour. With the ventilation applied it proved possible to add 75 mm of glass fibre insulation at ceiling level, as might be done when thermally upgrading an existing roof, without inducing a return to condensation conditions.

These trials emphasise the need to ensure adequate roof void ventilation in cold deck construction so that humid air penetrating the roof from the building interior is dispersed and its harmful effects nullified.

PROVISION OF ROOF VOID VENTILATION

Although the ventilation rate used in the tests (venting with outdoor air at a volume four times the rate at which humid indoor air penetrated the ceilings) was effective, this should be regarded as a minimal target because of the uncertainties of natural wind-induced ventilation. Preliminary tests on the air tightness of ceilings suggest that the minimal roof void ventilation needed to disperse humid indoor air should correspond approximately with a 25 mm gap along opposite roof edges as suggested in BS 5250[2], but should not be less than a total distributed clear operative opening of 0.3 per cent of the plan area. The levels of roof void ventilation now recognised as necessary are many times greater than those generally recommended a few years ago. To ventilate the roof effectively a through-flow of air is needed, and the insulation material may need to be secured against displacement by the air stream. The ventilation openings at each end of every inter-joist cavity should be protected to prevent entry of vermin or wind-driven snow. If the joist ends abut an existing building, so that inter-joist ventilation is not possible, then either the joists should be cross-battened to allow ventilation between the exposed sides or proprietary through-deck ventilators should be used at the sealed end of each inter-joist cavity. The use of cavity barriers as a fire precaution seems inconsistent with the choice of a cold deck timber-based flat roof. There have been instances where such bariers have been fitted retrospectively to roofs not designed for them and without realising the implications so that serious condensation problems have resulted. Where cavity barriers impede airflow the ventilation shortfall must be made good by other means such as the installation of through-deck ventilators[3]. The placement of insulation at the top of the roof void with a vapour barrier at ceiling level, as in some cold deck designs, is not recommended, as the ventilation needed to disperse wet air leaks could amount to a significant energy loss.

ALTERNATIVE CONSTRUCTIONS

Where the provision of effective void ventilation is difficult an 'upside down' roof (insulation above waterproof membrane) of warm deck construction might be considered, as ventilation of the void is not necessary. The effect of employing such a roof, or of converting an existing cold deck to such a construction, was investigated with the test rig subjected to humid occupancy and winter conditions. The insulation installed in the roof void was removed and 50 mm foam polystyrene roof insulation tiles were laid on top of the felt covering. The effect of this conversion was to promote a drying of the roof and a disappearance of marginal condensation. The mould growth also appeared to regress. Further tests under simulated summer conditions confirm the reputed value of the upside down construction in protecting the waterproof membrane from thermal changes that can accelerate failure — the day/night temperature range was reduced to about half. It must be remembered, however, that experience with light-weight inverted roofs is minimal and the cooling effects of sustained rainfall or melting snow percolating under the insulation have yet to be evaluated. The use of a warm deck design of sandwich construction (ie the insulation is placed between the waterproof layer and the deck) is another feasible alternative but roofs of this design also have their problems[4]: notably the difficulty of preventing the thermal movement of insulation from rupturing the waterproof membrane, and problems of moisture build up, especially in the moisture sensitive insulant, due to the difficulty of providing an effective vapour barrier.

CONCLUSIONS

Changes in the conditions of building use emphasise the importance of incorporating sufficient void ventilation in flat roofs of cold deck design. Where it is difficult to provide sufficient ventilation in a flat roof then the use of a warm deck design should be considered.

REFERENCES

1 **McIntyre I S.** Moisture and the cold deck flat roof — results of simulative studies. Building Trade Journal. In press.

2 **British Standards Institution.** Code of basic data for the design of buildings: the control of condensation in dwellings. British Standard 5250:1975, BSI, London, 1975.

3 **Building Research Establishment.** Cavity barriers and ventilation in flat and low pitched roofs. BRE Digest 218, HMSO, London, 1978.

4 **Building Research Establishment.** Flat roof design — the technical options. BRE Digest 221, HMSO, London, 1979.

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