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Ventilating cold deck flat roofs

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The current recommended minimal ventilation level for the cold deck flat roof design is evaluated using an experimental roof. The work suggests that there may be a need for ventilation to be increased above the minimal level in instances where natural draught ventilation is low or where roofs are of complex plan. Results of this work are under consideration by the British Standards Institution as part of an overall review of flat roof design recommendations. In the interim this Information Paper offers provisional guidance for designers and those involved in the maintenance and upkeep of cold deck roofs.

INTRODUCTION

With cold deck flat roofs there is a cavity beneath the deck and below that a layer of insulation. Because it is not possible to provide a fully effective vapour barrier below the insulation, some water vapour from the building interior is able to penetrate into the roof cavity. Unless this water vapour is removed by ventilation, condensation is likely to occur on the surfaces within the roof, especially in cold conditions when the temperature in the roof cavity may fall close to ambient (Figure 1). Typically, cold deck flat roofs have timber and timber-based components and if condensation causes these to become damp for long periods there is a risk of damage, including attack by wood-rotting fungi.

Present recommendations for ventilation of cold deck roofs are for a minimum aperture at the fascia of 0.4% of the roof plan area (BS 6229[1]). In this Information Paper the effectiveness of this level of ventilation is evaluated using data from a test roof. In addition various provisions for ventilation on school roofs in service are assessed.

ROOFS EXAMINED

BRE test roof: This was part of a single-storey test facility sited in a fairly sheltered position at the BRE Princes Risborough Laboratory. The roof deck was supported by softwood joists (46 mm × 246 mm)

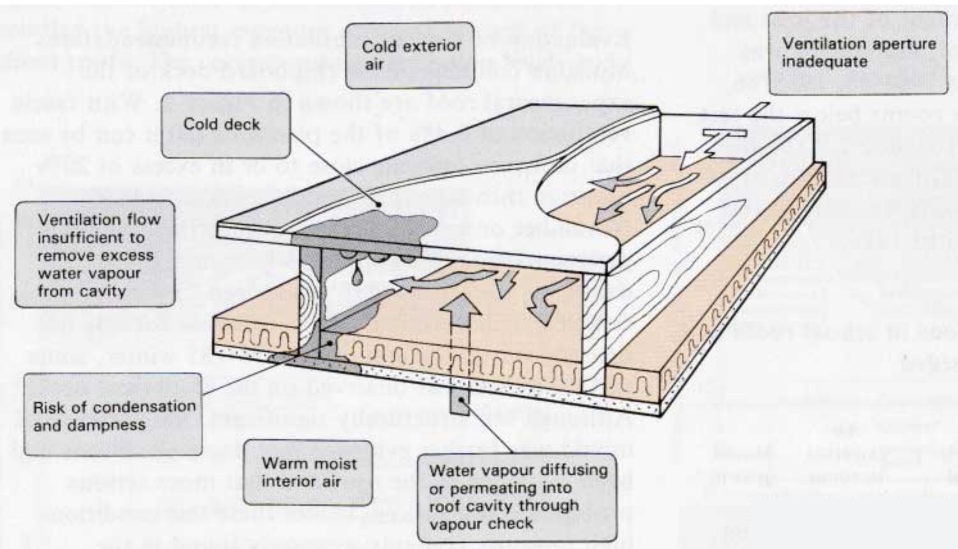

Figure 1 Inadequate ventilation has serious consequences for cold deck flat roofs

which divided the roof void into cavities, each 9 m long, 546 mm wide and 246 mm deep. The monitored part of the roof had a 19 mm chipboard deck. Insulation (100 mm glassfibre quilt) was fitted between the joists over a polythene sheet, acting as a vapour check, which was supported on a 12 mm plasterboard ceiling. The vapour check in the experimental roof is likely to be closer to ideal than in service where typically the check will have discontinuities and will be perforated for example by services.

The test roof had variable-aperture vents built into the fascia at the ends of each roof cavity. These could be opened to a maximum of 0.8% of the plan area of each cavity. In addition each cavity had two cowl-type deck ventilators which together had a total opening area of 0.062% of the plan area.

The school roofs: These were all of the same design, over one- or two-storey buildings which contained classrooms, shower rooms, a domestic science area and a kitchen. The roof decks were of plywood supported on softwood joists. Suspended ceilings, supporting a polythene vapour check and 100 mm glassfibre quilt, were supported 200 mm below the joists. This arrangement allowed air to circulate freely within each main roof cavity.

Air bricks provided ventilation along one fascia. Cowl ventilators were also present; these varied in number and position for the different roofs. For the roof over the kitchen, the air bricks on the north-facing wall were replaced with experimental variable-aperture vents which when fully opened gave a ventilation opening equivalent to 0.3% of the roof plan area. The ventilation provisions for the school roofs are shown in Table 1.

INSTRUMENTATION AND MONITORING

Cavities in the test roof and the school roofs were instrumented at various locations with thermocouples to measure air and surface temperature and with probes to measure moisture content of the joist and deck materials. For the test roof, monitoring was carried out during three winters 1984/85, 1985/86, and 1986/87. Conditions in the rooms below the test roofs were maintained at 65% rh/18 °C for the first two winters and at 75% rh/18 °C for the 1986/87 winter. Monitoring of school roofs was carried out between November 1984 and April 1986. Standard calibrations were made for moisture content values recorded for chipboard and plywood. This is reflected in the different upper maxima which can be recorded for these materials in Figures 2, 3 and 4.

Table 1 Ventilation provisions in school roofs and mould growth recorded

Roof	Fascia vent	Deck vent	Air extractor in room	Mould growth†
Above domestic science room	None	0.03%	Yes	Slight
Above classroom	less than 0.1 %	0.02%	No	Moderate to severe
Above kitchen	0.30%*	0.04%	Yes	Slight to moderate

*Ventilation was increased to this level in November 1984
†Assessed visually at the end of winter 1985/86

INTERPRETING THE MOISTURE CONTENT DATA

The moisture content data obtained in this study have been interpreted in terms of the risk of initiation and spread of wood rot.

To assist discussion, the following conservative moisture content categories are proposed, based on current knowledge.

For solid wood and plywood

- Below 20% moisture content: No risk of rot
- Between 20% and 24% moisture content: Borderline level — not considered sufficiently high to allow initiation of wood rot but could allow established rot to continue growth.
- At and above 25% moisture content: If sustained for extended periods of time this level will normally be high enough to allow initiation of wood rot.

For chipboard

- At or below 17% moisture content: Chipboard not considered to be at risk from wood rot or loss of strength
- Above 17% moisture content: Increasing risk of initiation of rot and loss of strength as moisture content increases.

MOISTURE CONTENTS IN THE TEST ROOF

Evaluation of current ventilation recommendations

Moisture contents of the chipboard deck of the experimental roof are shown in Figure 2. With fascia ventilation at 0.4% of the plan area (B) it can be seen that moisture contents close to or in excess of 20% occurred throughout the winter period from November onwards. On present understanding this pattern of moisture content, where prolonged dampness is encountered, could lead to the establishment of wood rot. In this case rot was not detected but at the end of the 1984/85 winter, some surface mould was observed on the chipboard deck. Although not structurally significant, the presence of mould was further evidence that damp conditions had been sustained in the roof and that more serious problems could follow. Under these test conditions high moisture contents were only found in the decking. Moisture content of the timber joists never rose to a level where there was any significant risk of rot, indicating how the risk of high moisture content may be distributed within the roof: the cooler surfaces of the deck probably being a more likely site for condensation under winter conditions if ventilation is inadequate.

When fascia ventilation (0.4%) was coupled with cowl ventilation (0.06%), deck moisture contents were lower but were still sustained significantly above 17% for the monitored period suggesting that the ventilation level was still inadequate (Figure 2, C and D). With only cowl vents open (A), moisture contents reached the maximum recordable value. This demonstrates the hazard associated with low levels of ventilation and supports BS 6229 which does not permit cowl vents as the sole route for ventilation.

Effect of increasing the amount of ventilation
In the following tests, fascia ventilation was provided only at one end of the roof cavity and one cowl vent was kept open. The room below the roof was maintained at 65% rh/18 °C. Under these conditions, when the fascia ventilation was set at 0.6% of the plan area, the moisture content of the deck was sustained below 17% throughout the monitored winter period, except for a short period at the beginning of February, Figure 3. Under this pattern of moisture content change, the chipboard deck would not be considered at risk from wood rot. The effectiveness of the 0.6% level of ventilation was further endorsed during the following winter when the moisture content of the deck did not rise above 18% even though room conditions below the roof were maintained at a more hazardous (75%) relative humidity.

MOISTURE CONTENTS IN THE SCHOOL ROOFS

It should be stressed that for all the school roofs the total roof ventilation openings were below the 0.4% plan area recommendations in BS 6229. Nevertheless the results of the study are instructive because they indicate the levels of moisture content which could occur if ventilation is ineffective in part of a roof or if ventilation is obstructed for any reason.

Figure 4 shows data for the monitored point which recorded the highest moisture contents in each of the school roofs. The corresponding ventilation levels and air extraction arrangements in rooms are shown in Table 1, together with mould growth assessments made at the end of the second winter 1985/86.

Very low roof ventilation without extraction facilities in the room (Classroom) resulted in high moisture contents in the deck in winter and moderate to severe mould growth. Roof ventilation was clearly insufficient in this instance and allowed moisture content to exceed 25% for long periods in successive years, indicating a significant risk of rot establishing on the plywood deck. This observation shows the need for ventilation above all occupied rooms and not just those like kitchens and shower rooms in which there are obvious major sources of water vapour.

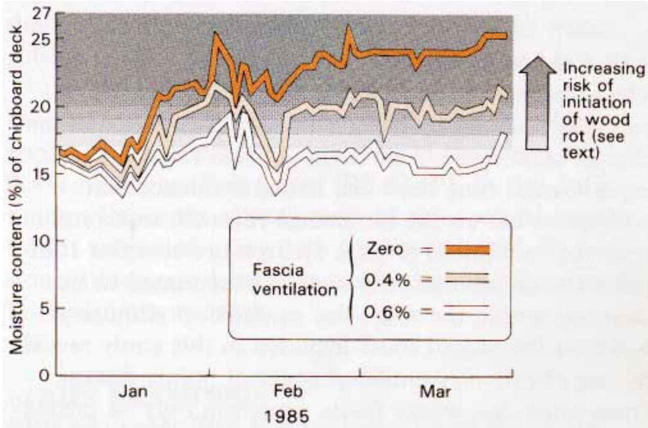

Figure 3 Test roof: moisture contents of chipboard deck with different levels of ventilation. Continuous data are presented for a single location in an equivalent position in each roof cavity.
Note: Fascia ventilation is provided only at one end of the roof cavity and one cowl vent (0.06% of plan area) is open in each case (configuration C in Figure 2)

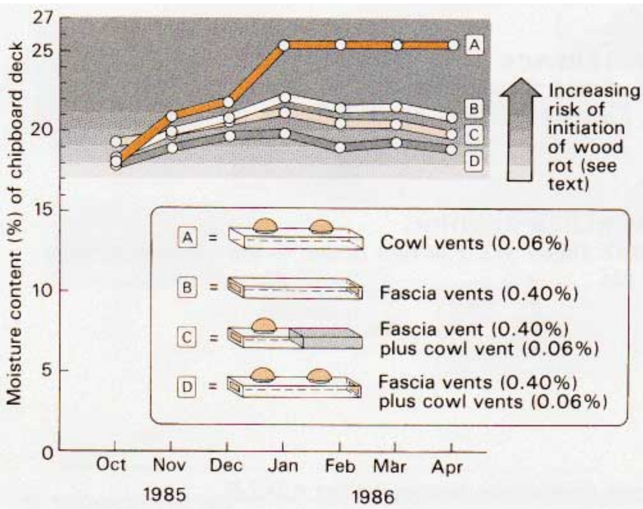

Figure 2 Test roof: evaluation of current minimum ventilation level (0.4% of plan area at fascia). Maximum moisture content values (each month) are shown for the chipboard deck

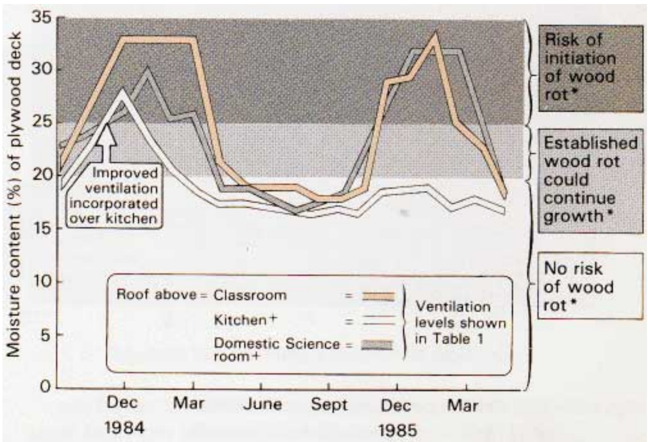

Figure 4 School roofs: cyclical pattern of moisture content of plywood decks. For each roof, continuous data are shown for the monitored position which on average recorded the highest moisture content throughout the study.
Note: These roofs had cavity ventilation provisions below the current recommendations in BS 6229.
*See text for description of these categories
+These rooms had air extractors

Importantly, where low roof ventilation was coupled with good room air extraction (kitchen), moisture contents could be sustained below 20%, a level which is not considered to indicate risk of rot in the plywood decking. These measurements suggest that the installation and correct use of remedial air-extraction facilities in rooms can counterbalance inadequate roof ventilation. The presence of mould (Table 1) in the roof above the kitchen is thought to be a result of the higher moisture contents which existed prior to the introduction of improved ventilation levels in November 1984.

In the case of the domestic science room, roof ventilation levels were very low and air extraction facilities only intermittently used. Above this room, high moisture contents (exceeding 25%) occurred in parts of the plywood deck for much of the winter period in successive years, suggesting that the deck would be vulnerable to attack by wood-rotting fungi.

AIR CHANGE RATES

The effectiveness of different ventilation provisions was also assessed by using a tracer gas to measure air change rates in the roof cavities. Data from the experimental roof show the strong influence that windspeed has on the air change rates for different levels of ventilation (Figure 5). In more complex roof plans the air change rates cannot be assumed to be constant within the roof. For example, preliminary work on the school roofs included in this study revealed less effectively ventilated zones at points distant from vents. So, where fascia vents can only be provided at one end of the roof, it is clear that the positioning of deck vents requires careful consideration.

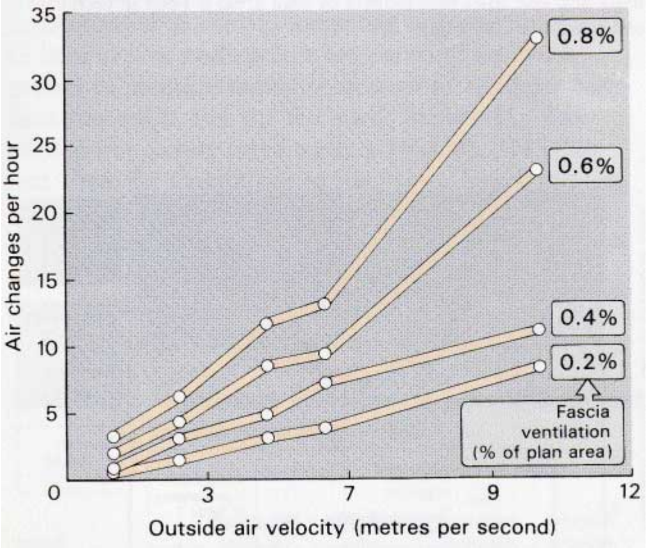

Figure 5 Test roof: air exchange rates for different ventilation levels and wind speeds (mean values for replicated tests)

CONCLUSIONS AND RECOMMENDATIONS

- The present recommended minimal level of fascia ventilation in cold deck flat roofs is 0.4% of the roof plan area, equally divided between the two ends of the roof cavity. Studies on a test roof in a sheltered location suggest that under some conditions this level of ventilation may be insufficient to ensure that moisture contents of chipboard decking are kept low enough in the colder months to eliminate risk of attack by wood-rotting fungi.

- The risk of occurrence of high moisture contents increases significantly for chipboard and plywood decking if the level of ventilation is reduced below 0.4% of the roof plan area.

- With fascia ventilation levels of 0.6% of the plan area, low and safe moisture contents were recorded in the test roof. It is therefore suggested that designers opting to use a cold deck flat roof on a low building or in a sheltered location should consider increasing the fascia ventilation from the current (0.4%) minimal level to at least 0.6% of the roof plan area. If possible the ventilation area should be equally divided between both ends of the roof cavity. A similar increase in ventilation aperture should be considered if the roof is of complex plan. **It is stressed that existing minimal ventilation requirements may be adequate for simple plan roofs if the building is sufficiently high or in an exposed location.**

- Cowl vents alone may not offer an effective ventilation pathway for cold deck roofs. However, in conjunction with fascia vents they can be effective and could be used to improve ventilation to roofs, particularly where fascia ventilation can only be provided at one side. The positioning of cowl vents must be selected with care to ensure that air exchange is possible in potentially poorly ventilated areas distant from the fascia vents.

- If properly used, air extraction facilities in rooms can reduce the risk of high moisture contents in existing poorly ventilated roofs.

REFERENCE

1 **British Standards Institution.** British Standard BS 6229. Code of Practice for flat roofs with continuously-supported coverings. London, BSI, 1982.

FURTHER READING

BRE Digest 312. Flat roof design: the technical options. 1986.

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