The Role of Ventilation
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Heat Losses from Suspended Timber Floors with Insulation

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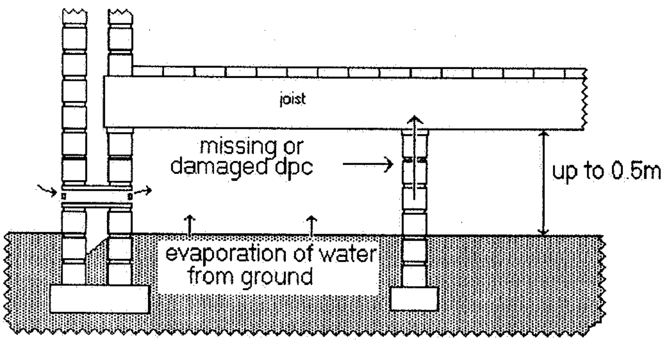
Summary

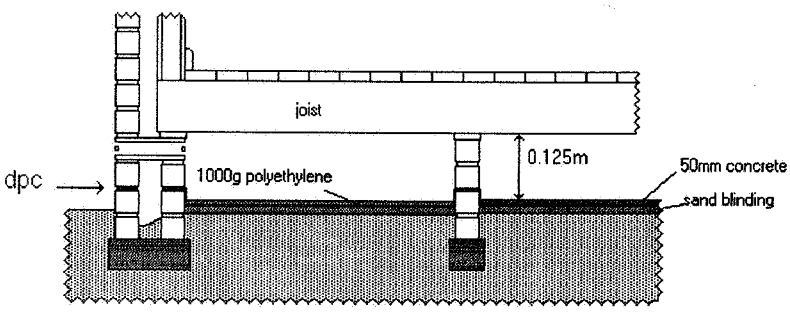
Ventilation of the void below suspended timber floors is necessary to prevent dampness, which leads to wet and dry rot. The air flow beneath such a floor has been investigated for a range of ventilator hole positions, using a full-sized test room. The variations in heat losses with ventilation rate have been measured, for floors with and without insulation. The use of radiation barriers in place of conventional thermal insulation was found to cut down the heat losses significantly at low ventilation rates, but was not so effective at higher rates.

Introduction

It was shown in a previous paper [1] how the rate of heat loss from a suspended floor without insulation increases with the rate of ventilation of the under-floor void. Here, the thermal performance of similar floors, with thermal insulation added, has been measured over the same range of conditions.



Typical floor construction of older house



Typical modern suspended floor

Figure 1. Typical suspended timber floor constructions

Suspended Floors

A number of mathematical techniques to enable the heat loss from solid floors to be predicted have been devised [2-4]. However, the usefulness of these methods in practical situations is limited because they are very sensitive to the properties of the ground beneath the floor. The thermal conductivity of earth can vary by a factor of three depending on the soil type and conditions, rendering even the most sophisticated methods prone to large errors. The analysis of the heat loss from suspended floors is further complicated by fluctuations in the rate of ventilation in the under-floor cavity, which affect the thermal resistance of the air space. Hence, no attempt has been made here to formulate a mathematical solution to the problem. For most practical purposes, the simple graphical method devised by Anderson, [5] which assumes a fixed ventilation rate, is sufficiently accurate. In this paper we are concerned with ways of minimising the heat losses while maintaining the necessary conditions beneath the floor to prevent rot.

The air in the void below a suspended floor often has a high relative humidity. In modern houses, drying out of the construction water is the main source of moisture, but in older buildings, most of it comes from the evaporation of water from damp earth (Figure 1).

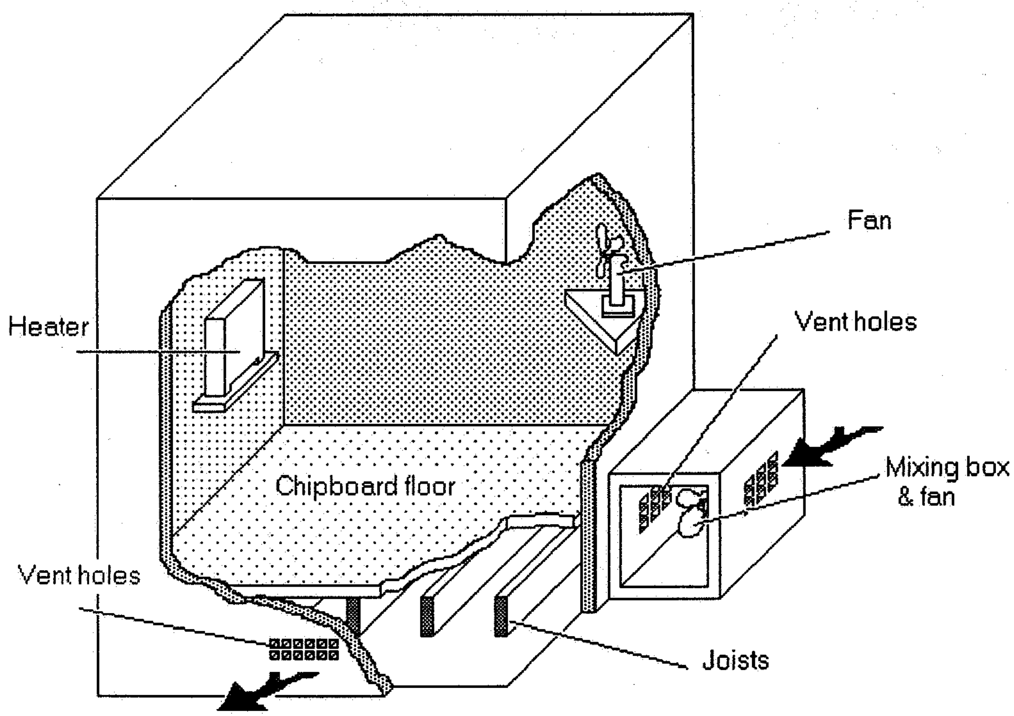
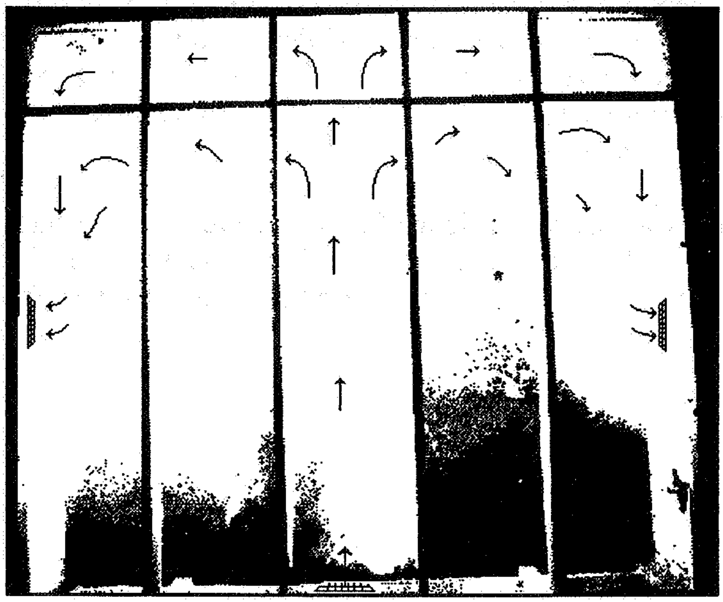


Figure 2. The test room with suspended floor.

Experimental Work - Test Room

A series of measurements were carried out on a 3m by 3m suspended floor with a 0.5m cavity beneath built into a test room situated in an environmental chamber. This has been described in detail elsewhere [1] and is shown in figure 2. Each measurement was made under steady-state conditions over a period of at least eight hours. Ventilation holes, simulating air bricks of the regulation size, were made in the opposite walls of the under-floor space, giving an orifice size equivalent to $4500mm^2$ in each wall, and a variable-speed fan was used to force air into the space, simulating the effect of a constant velocity wind perpendicular to the wall. The air movement was measured using anemometers and a smoke injection technique. The temperatures and heat fluxes were measured using platinum resistance thermometers and heat flow sensor mats



Vent where air enters

Figure 3. The air flow as shown by smoke tests using a glass floor.

Results - Ventilation patterns

In order to observe the air flow beneath the floor, the timber floor was replaced with glass panels laid upon the wooden joists, and observations were made from above. Smoke was injected into the incoming air stream so that the pattern of air movement could be observed. These were photographed using a still camera (figure 3). A range of inlet and outlet vent positions was used, and the results are shown in figures 4 to 7. They show that the overall pattern is determined principally by the position of the vent on the windward side in relation to the side wall.

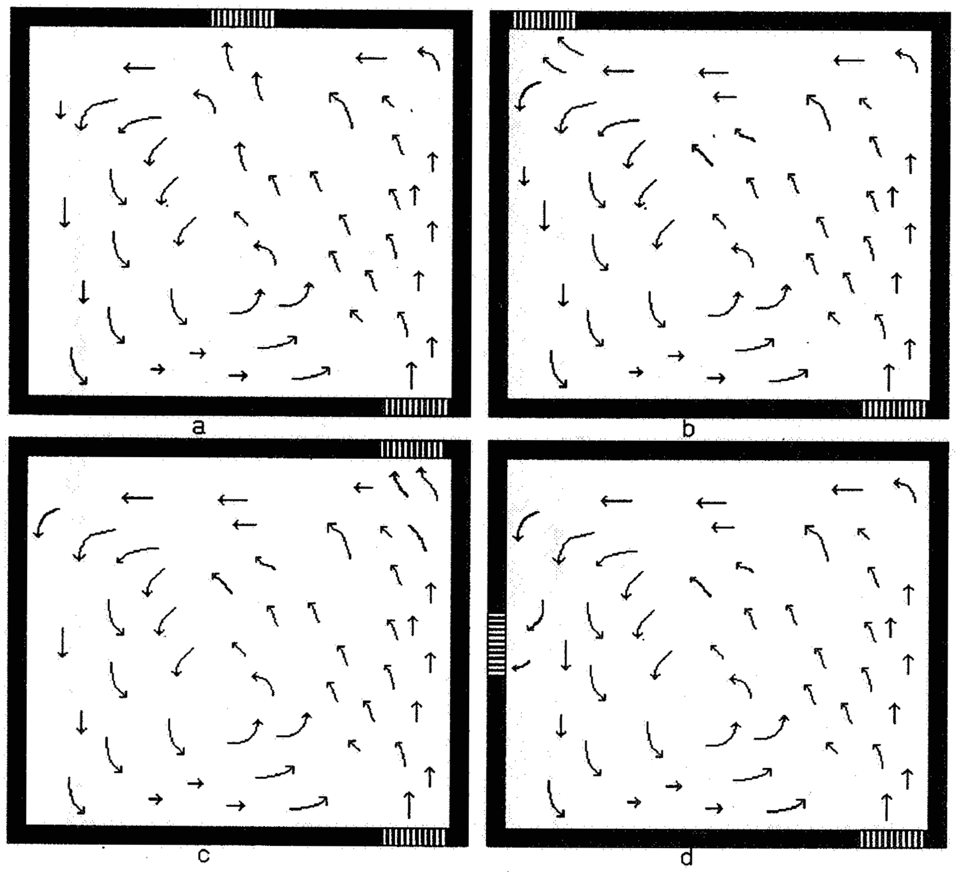


Figure 4.

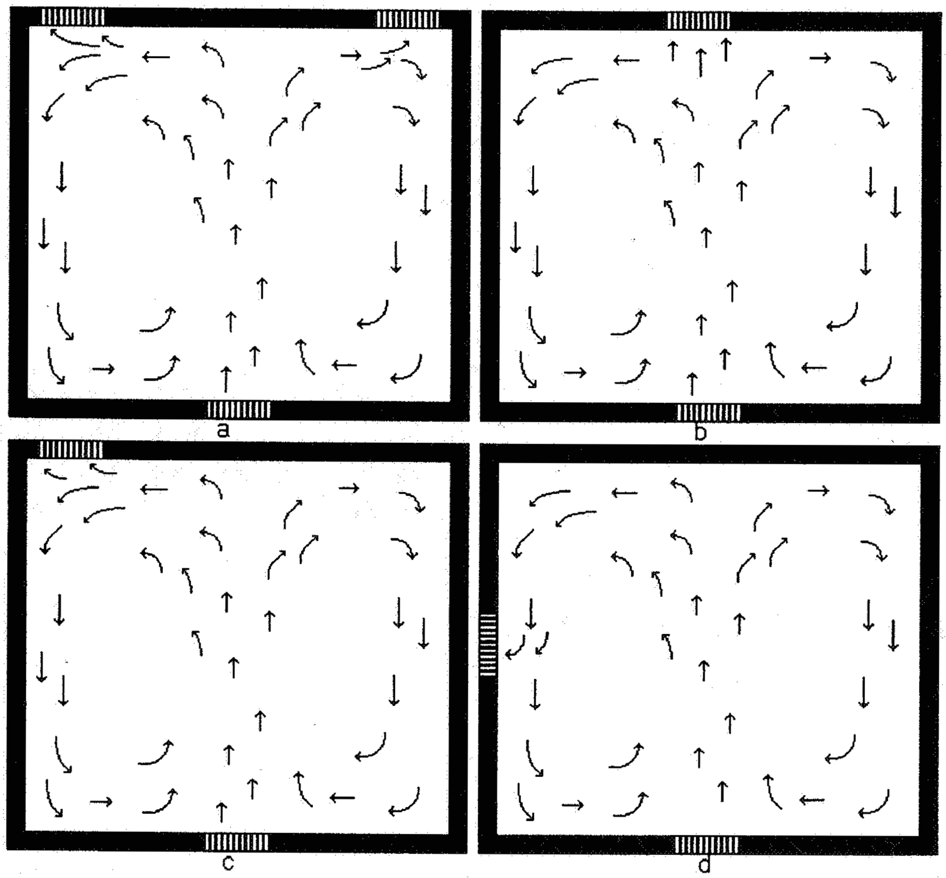


Figure 5.

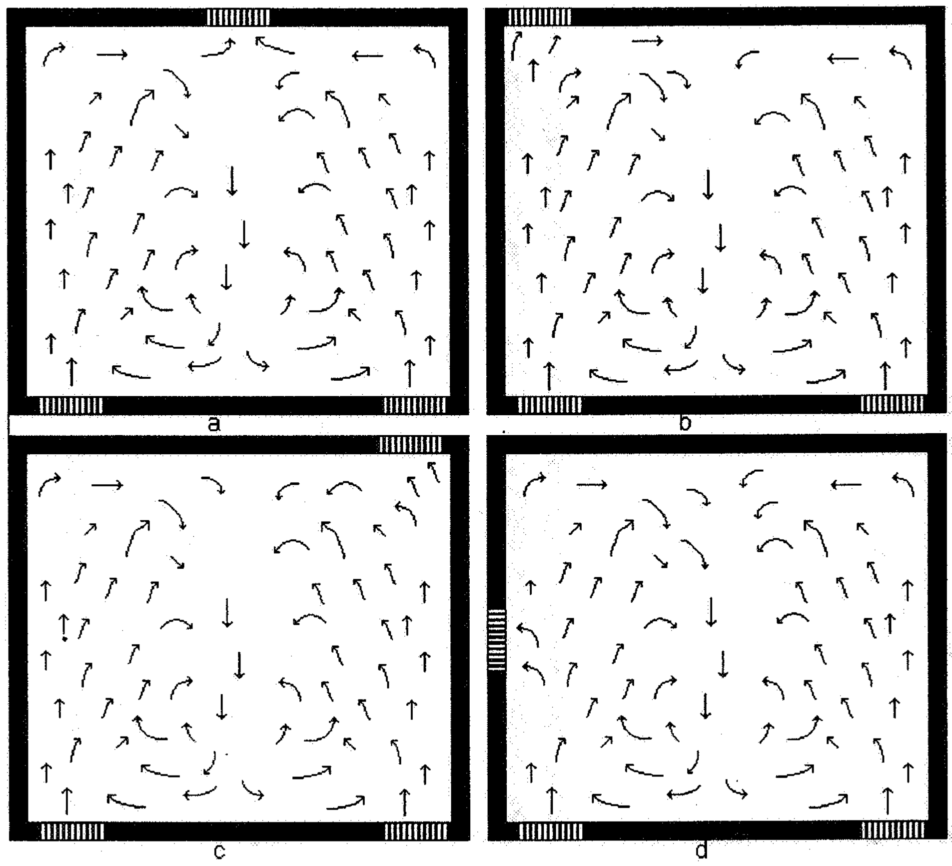


Figure 6.
Figures 4-6. Plans of the under-floor void, showing the air flow for different vent positions.

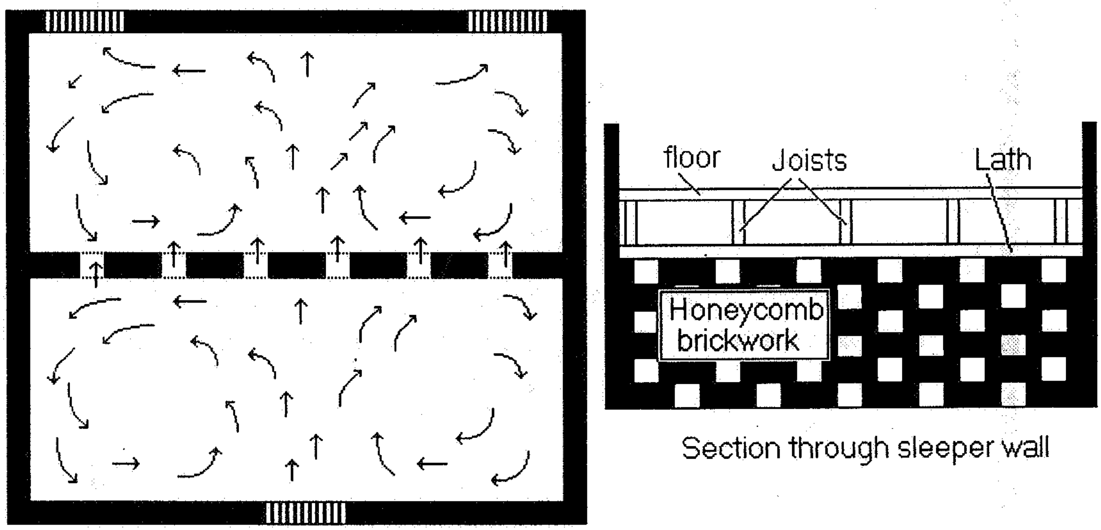


Figure 7. Airflow with sleeper wall present

The location of the vents on the leeward side has little effect upon the general air flow pattern. The addition of a sleeper wall changes the pattern and reduces the velocity of the air beyond it as shown in figure 7. Good mixing is obtained throughout the floor for all vent positions. The principal determinant of the general air flow patterns is the position of the inlet vent in relation to the corner of the building. The two main patterns, for a single vent on the windward side, are shown in figures 4 and 5. The pattern for two vents on the windward side is shown in figure 6. In reality, of course, there is no "inlet or "outlet" vent. The vents are identical, and whether air enters or leaves by a particular vent depends on the wind direction in the immediate vicinity.

Heat losses

By changing the speed of the fan, the rate of under-floor ventilation was varied from 0 - 1.5 air changes per hour. The heat flux and temperature were measured and the effective U-values calculated (figure 8). Over a range of ventilation rates from 0 - 1.5 air changes per hour (nominal airflow rate at the vent zero to 4m/s) the effective U-value of the floor without insulation increased from 0.62 to 0.87 W/m^{2}k, an increase of 40%.

The U-value of the floor was measured without insulation, and with 30mm of rigid extruded polystyrene installed as shown in figure 9.

The most effective location for the insulation should be on top of the floor (position a) since most of the heat bridges are eliminated; this proves to be the case, but the difference is small in comparison with the overall U-value. In this position, the effect at zero ventilation rate is to reduce the heat loss to 51.7% of its original value, and at 1.5 air changes per hour the heat loss is 42.2% of that for the uninsulated floor. When located beneath the joists (figure 9b) the heat loss at zero ventilation is 50% of the original, whilst at 1.5 air changes it is 57.4%, i.e. slightly less effective.

Addition of radiation barriers.

The overall heat loss is made up of a number of components - conduction, convection, radiation and ventilation. The ratio of radiation to convection heat loss is about 3:1 with no ventilation. The radiation losses can be reduced by using low-emissivity material adjacent to the air space, thus reducing the level of infra-red radiation to the nearby surfaces. The insulation was removed and thin aluminium foil (ε=0.05) was stapled to the underside of the joists to form a continuous sheet. At low air change rates it was effective, and reduced the heat loss by just over 50% (figure 10), but at 1.5 air changes the reduction in heat loss was just under 30%. This is to be expected, since at higher ventilation rates the radiation heat losses constitute a lower proportion of the total heat loss.

Conclusions

If the rate of ventilation below suspended floors is high, then greater heat losses ensue. The relationship between heat loss and ventilation rate was measured under a range of controlled conditions in a full-size test room, and the heat loss was found to increase by 40% when the ventilation rate increased from zero to 1.5 air changes per hour. When the floor was insulated, the corresponding increase was much lower, and depended on the position of the insulation. Simple radiation barriers provide a much cheaper way of reducing the heat loss, and are effective at low ventilation rates but cease to be as effective at higher rates, the U-value ranging from 0.32 at zero ventilation to 0. 62 at 1.5 air changes. The initial payback period of such foils is considerably less than for polystyrene insulation, but unless the ventilation rate is very low the overall savings over a number of years will be considerably less. When the floor is insulated the heat loss at high ventilation rates is not significantly greater than under low ventilation. Measurements on occupied houses have shown that the relative humidity below such floors is often dangerously high. If the floor is insulated, then more air vents can be added, increasing the ventilation rate and eliminating problems due to moisture in the void, but without increasing the heat loss unduly.

References

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Acknowledgements

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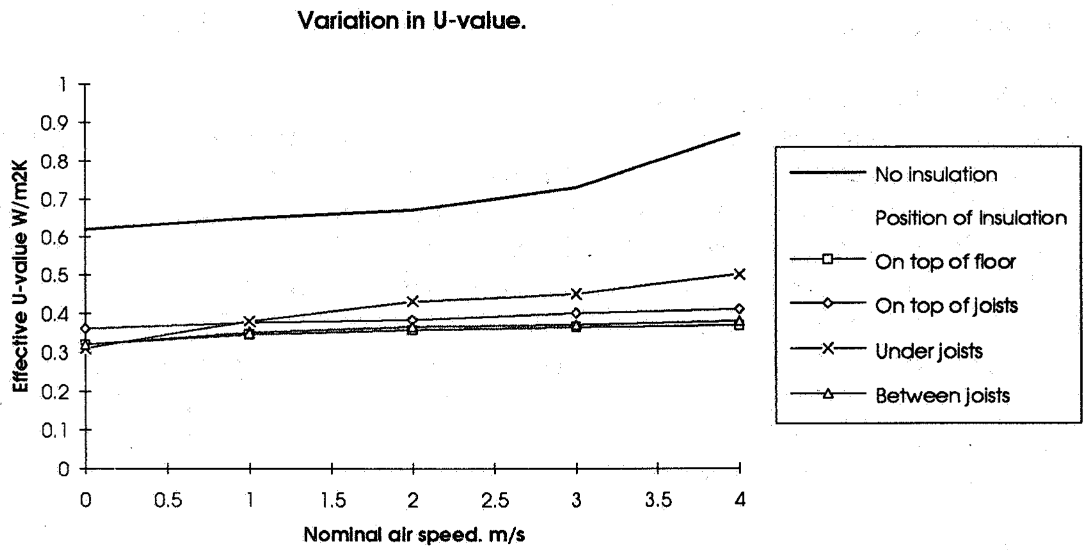

Figure 8. U-values of insulated floors.

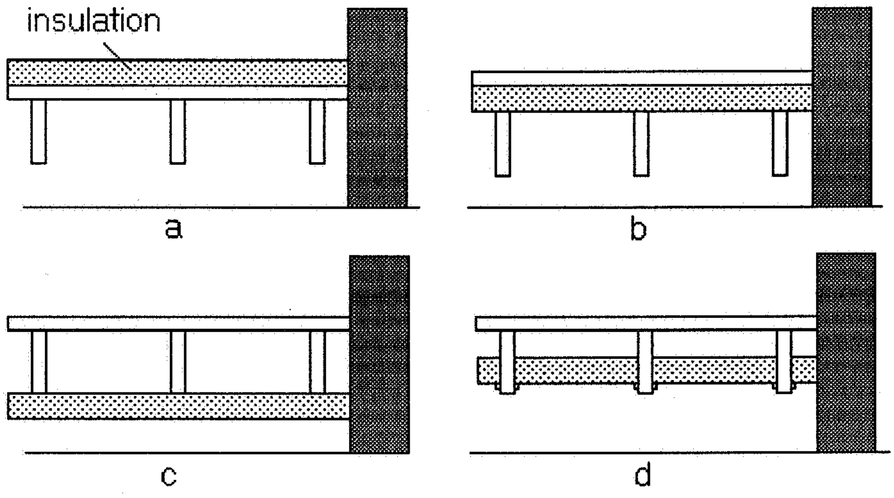

Figure 9. Positions in which the insulation was installed.

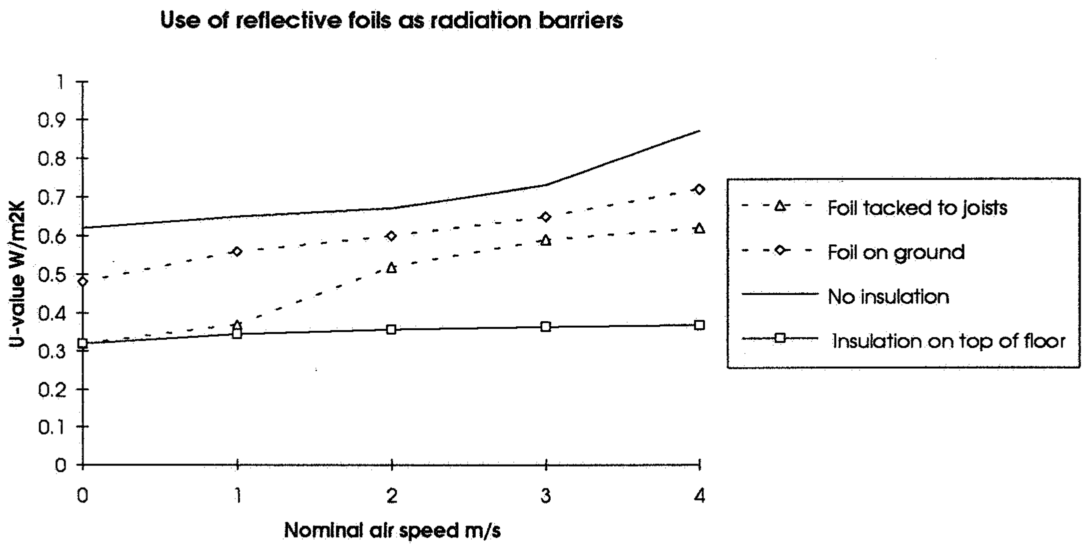

Figure 10. U-values of reflective foils.