DO ENERGY MEASURES CAUSE MOISTURE PROBLEMS?

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ABSTRACT

This paper describes the risks associated with application of retroactive energy conservation measures. Examples illustrate the potential for condensation and mildew damage caused by thoughtless or misguided application of measures without understanding of the underlying building physics aspects that need to be considered. Damage can also be caused, of course, by fundamentally incorrect design or faulty construction or installation.

HIGHER INSULATION LEVELS

Well-insulated buildings lose less heat than poorly-insulated buildings. As well as reducing the level of energy use, this results in an improved indoor climate in the form of more uniform temperatures on interior surfaces. All this is beneficial, but in some cases increased insulation can result in a greater risk of various forms of damage. Conditions on the inside of the insulation become warmer and drier, while on the outside they become colder and damper. Two examples can illustrate this.

Example 1 - Enhanced Insulation in Roof Spaces

Temperature and moisture conditions in roof spaces depend on the amount of insulation, the permeability of the joist structure from the rooms below, the insulating performance of the outer roof cladding and the ventilation in the roof space. After installation of additional insulation, the roof space will become somewhat colder than before. With all other conditions unaltered, the risk of damage then increases for two reasons:

- lower temperatures result in earlier formation of condensation, and
- lower temperatures result in poorer drying-out for the same degree of ventilation.

Assume that a ceiling/joist structure with a U-value of 0.50 is upgraded by application of additional loose-fill insulation to a U-value of 0.20. If the outer roof covering consists of concrete tiles and there is a mean ventilation rate of 3.0 air changes per hour, the temperature in the roof space will be reduced from -2.5 °C to -4.0 °C at an outdoor temperature of -5 °C and an indoor temperature of +20 °C.

If we assume that the ceiling/joist structure is totally impermeable, relative humidity in the roof space will be determined only by the ventilation. With an outdoor relative humidity of 90% at -5 °C, relative humidity in the roof space before the application of additional insulation was 74%, rising after upgrading to 83%.

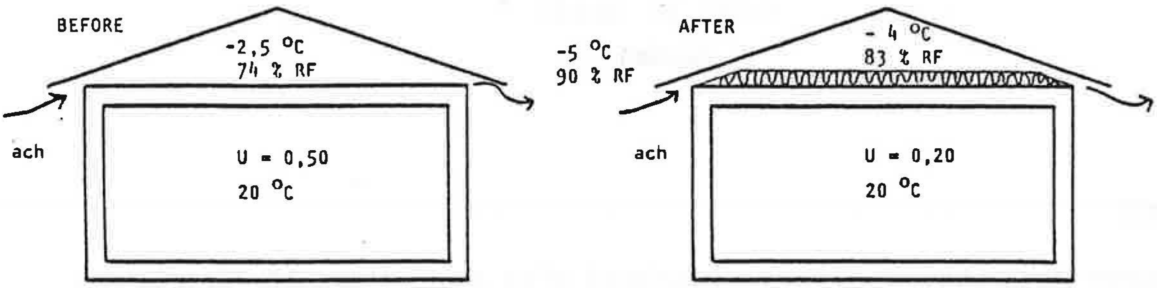

FIGURE 1. Moisture and temperature conditions in a roof space before and after application of additional insulation.

If we assume that moisture is to be removed from the roof space by ventilation, it will be necessary to double the ventilation rate if the same quantity of moisture is to be removed. However, the ventilation rate normally tends to fall after application of additional insulation, partly as a result of the lower temperature reducing the chimney effect, and partly as a result of blocking the ventilation gaps.

The conclusion to be drawn from this example is that additional insulation of roof spaces should be followed by inspection of the roof space during the next winter. If there are any signs of condensation, such as frost, damp or discoloured tiles etc., the causes should be ascertained and suitable counter-measures applied.

Example 2 - An Internally-insulated Basement Wall

If internal insulation is applied to an uninsulated basement wall, damage can be caused by the ensuing prevention of evaporation of moisture from the wall.

Moisture conditions in an uninsulated basement wall are determined by the amount of moisture input to the wall from the air outside and inside, the ground outside and the ground beneath. Inward diffusion of moisture need not cause any damage if it can evaporate off on the inside. However, insulating such a wall on the inside can result in the studding being exposed to such high moisture levels that rot and mildew can be caused. Internal insulation can be accepted only if either all inward migration of moisture from the air and the ground to the wall can be completely stopped by application of impermeable coatings, removed by ventilation or allowed to evaporate inwards through diffusion-permeable surfaces. This means that there must be no plastic film, no impermeable wallpapers and no impermeable paints on the inside of the wall. If these conditions are not fulfilled, internal insulation will involve an increased risk of moisture and mildew damage. The safest way of insulating basement walls is to apply the insulation to the outside.

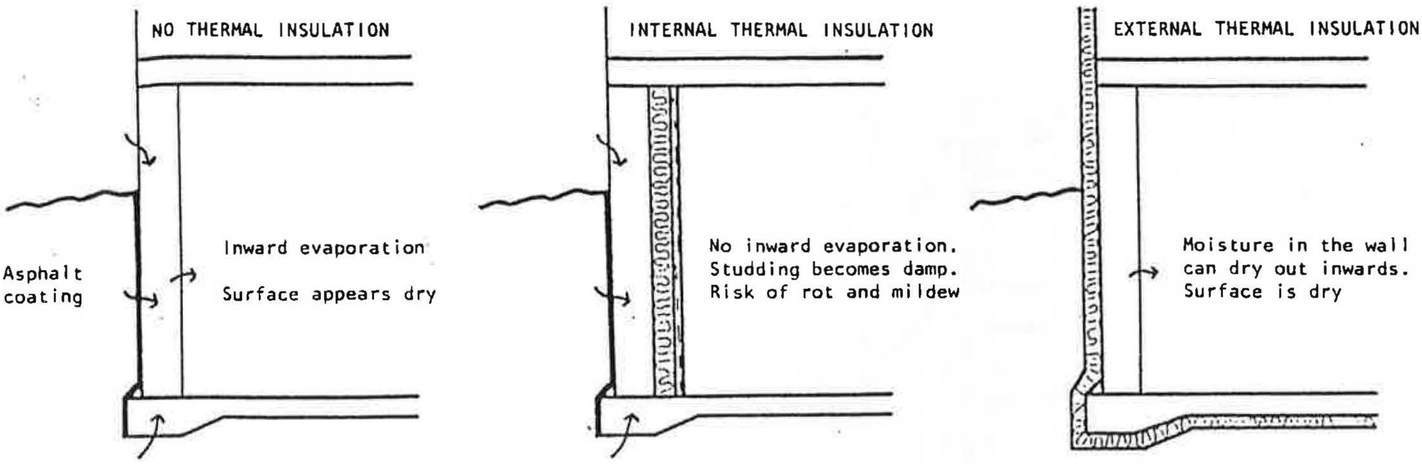

FIGURE 2. Moisture conditions in a basement wall with and without insulation

Greater Airtightness

Airtight structures reduce internal draughts and uncontrolled ventilation. Designing and building a house for high airtightness increases the scope for correct control of the ventilation. This is normally done by installation of a mechanical ventilation system, extracting air through ducts and supplying makeup air either directly from the outside through special inlet fittings or through inlet ducts. The correct balance between supply and exhaust air results in a slight negative pressure indoors, and is the necessary prerequisite for a good indoor climate and a dry house.

There is, however, also a considerable risk that an airtight house will be badly ventilated. If the ventilation system does not work correctly for any reason, the air change rate will be insufficient and problems are likely to arise. Higher indoor humidity levels, greater negative pressure indoors, changed inward air leakage paths and reverse air flows through extraction fittings are examples of problems that can arise in connection with more airtight structures and/or incorrectly operating ventilation systems.

Example 3 - Exterior Walls With and Without Internal Plastic Film

An airtight structure need not become damp. Moisture content on the inside of the sealing layer (plastic film, vapour barrier) is determined primarily by the relative humidity of the indoor air, while on the outside it is determined by the relative humidity of the outdoor air. Correctly created airtight conditions will result in the structure being dryer than if it is 'open'. (See Figure 3: next page.)

New Energy Systems and Energy-saving Building Services Systems

Certain building services systems can involve a risk of damage. A ventilation system that is working properly results in good ventilation throughout the house and a good indoor climate, while a system that is not working properly increases the risk of damage. An example of this could be a heat exchanger that allows both exhaust air and moisture to be recycled.

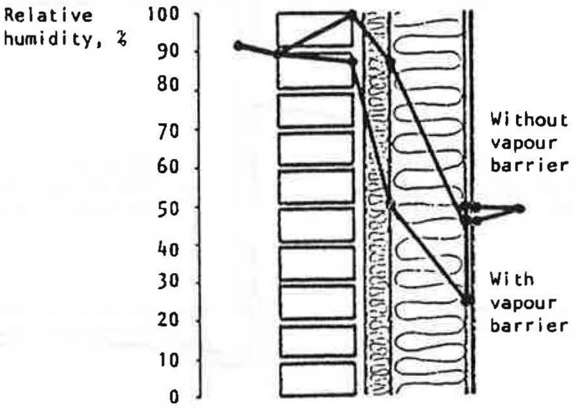

FIGURE 3. Moisture conditions (RH) in a brick-clad stud wall with and without an internal vapour barrier.

Example 4 - Rotating Heat Exchangers

In a residential area of 24 detached houses, twelve had been fitted with balanced ventilation systems (supply and exhaust fans) complemented by heat exchangers, and twelve with mechanical exhaust ventilation only. Indoor ventilation conditions in the first group were poor, with insufficient air change rates, recirculation of vitiated air by the ventilation system, high moisture inputs, frequent condensation on the insides of windows and serious condensation damage in roof spaces. Investigation found that exhaust air was leaking across to the fresh air supply in the heat exchangers, so that an estimated 60-70% of the supply air in the houses was recirculated, in systems that should have had no recirculated air at all.

The cause of the problem was partly poor sealing in the heat exchangers and partly incorrect arrangement of the fans, resulting in a high differential pressure between the supply and exhaust sides of the systems. Unfortunately, the occupants of the houses had to put up with substandard ventilation for ten years before improvements were made.

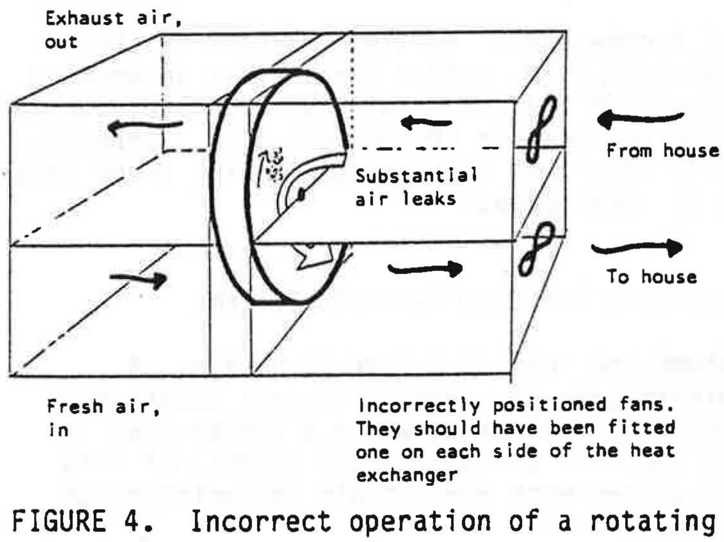

FIGURE 4. Incorrect operation of a rotating heat exchanger

Another example of a change that can cause problems can be found in the conversion from oil-fired heating to direct electric heating. The air drawn in by a boiler creates a negative pressure in the house. Changing to electric heating and eliminating the boiler reduces the negative pressure in the house, increasing the risk of condensation damage in the upper storey.

Negative pressure is high in a naturally-ventilated house in which the exhaust air ducts run in the warm chimney breast. Cooling of the chimney breast resulting from discontinuing use of the boiler when changing to electric heating reduces the air change rate and the negative pressure.

Changes in Occupants' Habits

Greater energy awareness on the part of the occupants is beneficial, but can result in a risk of damage. Substantial reductions in temperature should be avoided, as this can result in local condensation on cold surfaces. Unthinking sealing of all air leaks by weatherstripping can reduce ventilation air change rate to such an extent that the indoor relative humidity rises to levels at which condensation and mildew can form on internal surfaces. Another example of misguided energy saving is the use of drying cupboards and tumble dryers without arranging for them to discharge to the outside or to a ventilation exhaust system, so that the warm, moist air discharges instead to the inside of the house. Excessive use of the shower instead of the bath also increases the indoor moisture loading. Changes in cooking habits, too, can affect indoor moisture levels.

Reduction of indoor temperatures in parts of the house at times can also be risky. A constant indoor temperature throughout the year is a good way of avoiding damage.

SUMMARY

Energy conservation measures in buildings need not cause problems if they are applied correctly. A well-insulated, airtight house is normally an excellent house with low energy costs. However, if the measures are incorrectly applied, they can cause problems such as condensation or mildew.

The risk of moisture problems increases in cases such as the following:

- Placing thermal insulation on the wrong side of the structure. In a cold climate, thermal insulation should normally be on the outside.
- Producing an airtight envelope without mechanical ventilation.
- Placing vapour barriers on the outside of the structure.
- The use of energy-saving components, such as heat exchangers or heat pumps, in such a way as to lead to other problems.
- Applying measures with no understanding of the underlying energy-saving mechanisms or building physics principles.

It is our experience that damage caused by condensation or mildew occurs when energy-saving measures are implemented with no awareness or knowledge of either the potentials or the risks of problems. Any and every structural change in the building envelope is accompanied by a risk of problems. Energy-saving without knowledge of what can be involved should never be done.