*By **Stephan Rupp**, BRANZ Building Physicist*

Cold roofs? Warm roofs?

What's the main difference between roof construction options? BRANZ explains the science to help you design better roofs.

HIGH MOISTURE LEVELS and consequential mould growth have become an issue in some newly built residential roof spaces in New Zealand. They are often caused by:

- not enough indoor ventilation in increasingly airtight new buildings (see *Build* 158 *Airflow through ceilings* (pages 82-83))
- a ceiling that is permeable to this moist air
- a relatively airtight roof cavity.

This constitutes a dire threesome.

A triple whammy

Moist air from the living quarters can easily move upwards into the attic space through openings such as old-style downlights and become trapped there. If surface temperatures then drop below the dew point temperature, condensation will occur.

Construction moisture can also be an issue. Wet timber that is closed in too early combined with an airtight roof space is a major concern. This problem often remains undetected, since visits to the roof space are rare.

The industry is aware of this phenomenon, and there are a number of strategies to reduce the risk. BRANZ has also covered this topic in science seminars on ventilation in 2017, the *Build* article mentioned above and in the Design, science, build feature in *Build* 157.

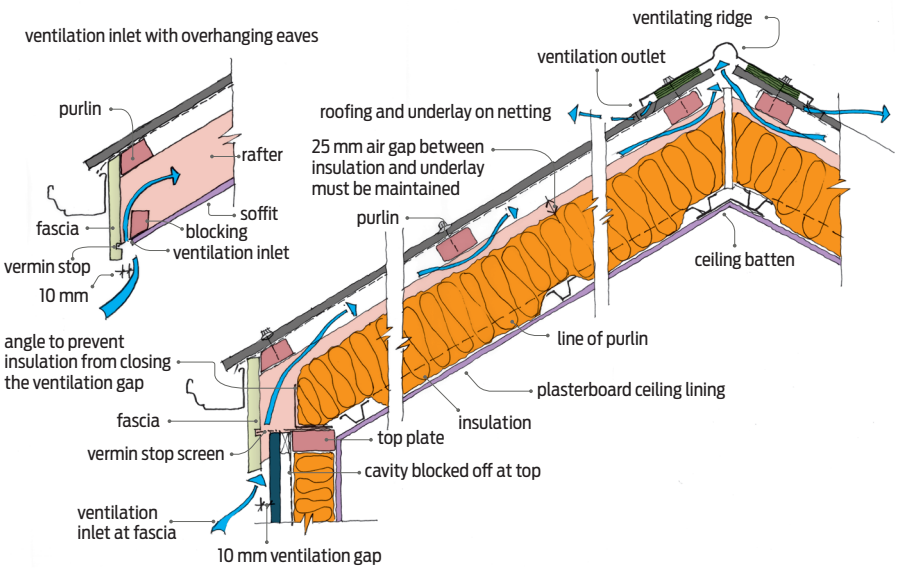

Figure 1: Construction of skillion roof to allow air movement across top of insulation.

Warm roofs and condensation

One strategy is a so-called warm roof as described in *Build* 161, *Don't be cool about warm roofs* (pages 35-36). Properly designed and well constructed, these roofs avoid condensation issues as the insulation layer is positioned outside the structure. There is no cavity below the roof cladding that is exposed to the outside climate.

However, fibreglass insulation pushed hard against the cladding does not constitute a warm roof. This practice is still found in some buildings but must be avoided at all costs. Clarifying the physics behind this should explain why.

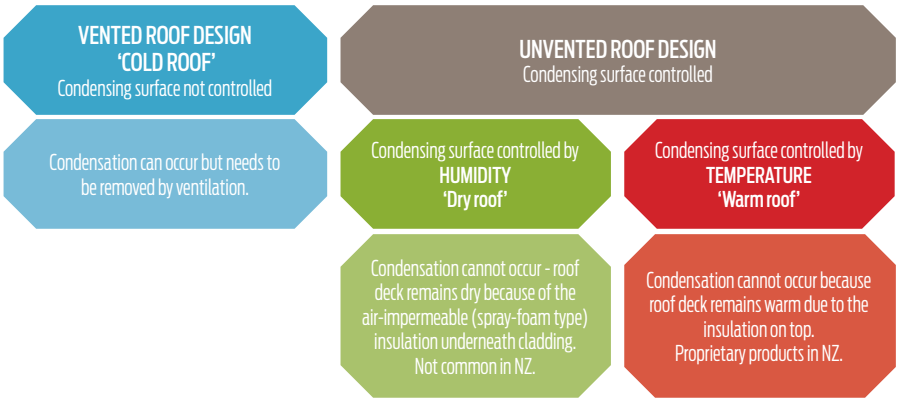

Figure 2: Comparison of vented and unvented roof designs.

Ventilated roof design

Let's start by describing a typical New Zealand metal-clad roof. The assembly of metal cladding, roof underlay and wire mesh, mounted on top of the purlins creates a space above the insulation. This space can be very large for normal truss roof spaces or a few millimetres deep in a skillion roof design (see Figure 1).

The space created in between the roof cladding and the insulation is more or less ventilated and exposed to the outside climate. Consequently, this space will get cold when the outside temperature drops, only moderated by the heat loss through the ceiling insulation layer. If the surfaces get cold enough, condensation will form.

In techspeak, we say that the condensing surface - the underside of the roof cladding - is not controlled. Any condensation that may occur will need to be removed by ventilation.

It is obvious that this cold roof space should be decoupled from the internal, conditioned building space. An airtight ceiling will prevent a flow of potentially moist air into this space, and insulation will minimise heat losses.

Unvented roofs

Warm roofs, on the other hand, should be regarded as unvented roofs. The design is such that condensation will not form on the underside of the roof cladding. We say that the condensing surface is controlled, and this can be achieved in two ways:

- An appropriate, rigid and weathertight insulation can be installed on top of the roof cladding, keeping the iron warm enough not to form condensation. The condensing surface is controlled by temperature.
- An air-impermeable, spray-foam type insulation can be installed on the underside of the roof deck and in direct contact with it, which leaves no gaps. The crucial air-impermeable aspect means that moist air can't reach the roof deck to condense on it. The condensing surface is controlled by humidity.

The second method is uncommon in New Zealand, but it is important to understand that any air-permeable insulation product is not a suitable replacement. Moist air can easily flow through the insulation layer to reach the cold roof deck to form condensation in direct contact with the insulation, spelling trouble.

Since the second approach doesn't actually entail a warm roof cladding, it is preferable to talk of an unvented roof design. We can then classify roof designs as summarised in Figure 2.

Key points when designing roof

In brief, when designing roofs, it is important to understand:

- what surfaces can get cold
- whether moist air can get to these surfaces to condense
- whether this condensation can be quickly removed without accumulating.