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H1 Changes 2022

Part Two: Roofs

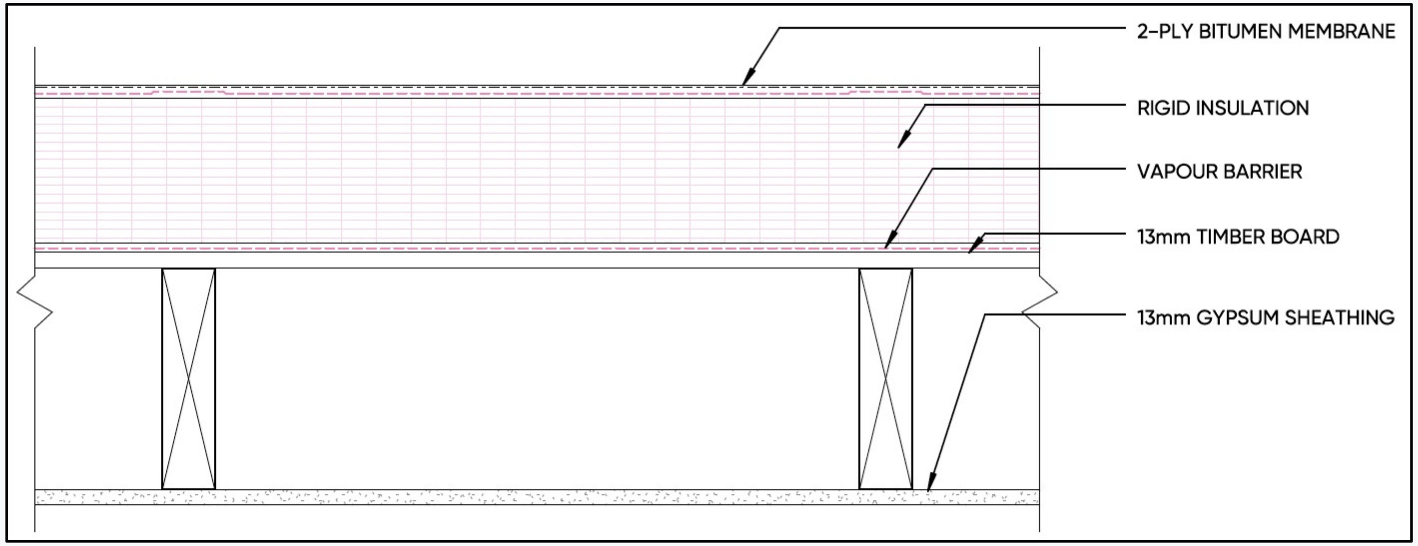
What has changed?

More insulation – that's it.

Since they've raised the R values to R6.6, as a single standard insulation product, you are looking at 120 - 240mm alone. Once you account for the thermal bridging of timber framing you are looking at a total insulation thickness of 300 – 400mm total, depending on insulation material and framing percentage. The more framing you have, the more insulation you need.

What does the new roof look like?

Because 300-400mm roofs are not an off the shelf product (yet), we have put a few options together that will get you where you need to be with a few adjustments to existing products.



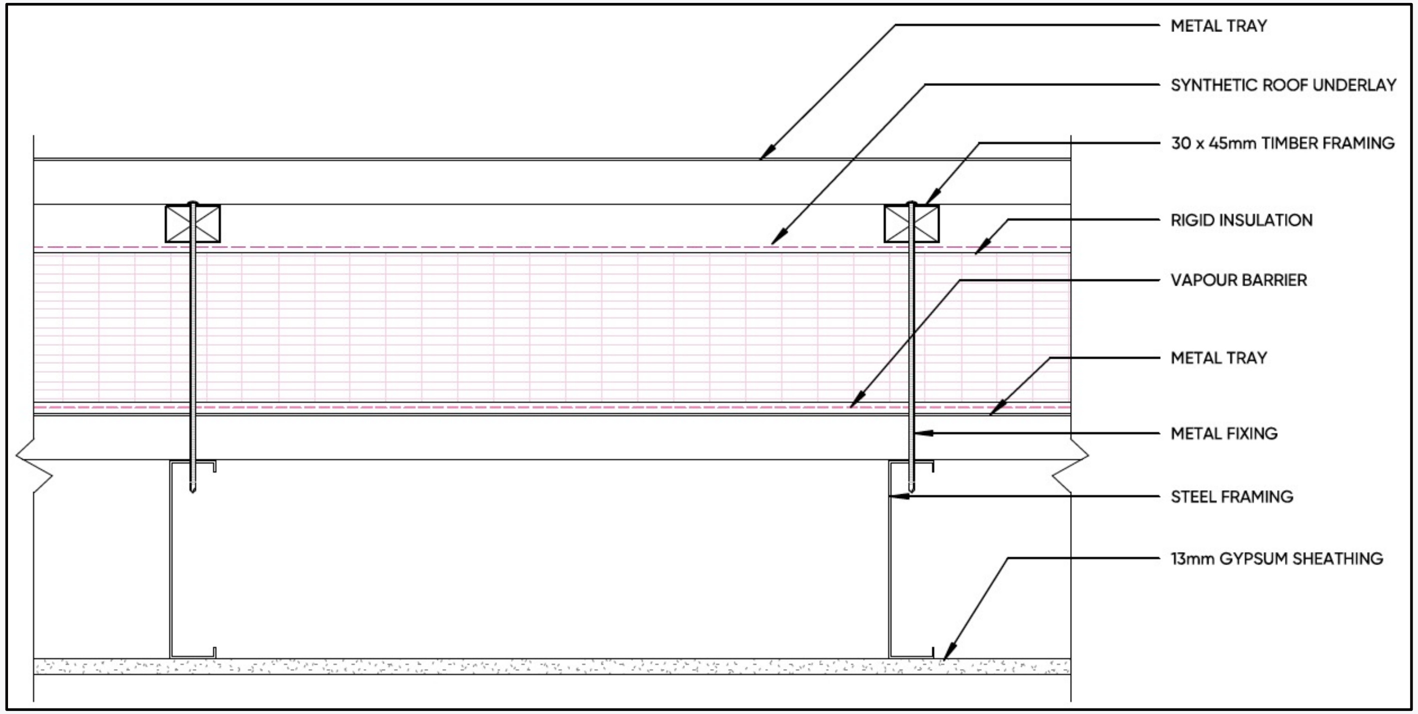
Wooden Frame – Warm Roof

For all membrane roofs that have no mechanical fasteners (fully adhered), the new way to go is 120mm-240mm (depending on your rigid board insulation product - PIR being the thinnest option and EPS the thickest).

These roofs are great for 0-10º slopes, come with a vapour barrier, are airtight and usually allow plenty of space for services between the structural framing below! The structure here can be steel framing too, without thermal bridging being a problem, because the fully-external insulation keeps the framing warm and above the dew point temp.

What does the new roof look like?

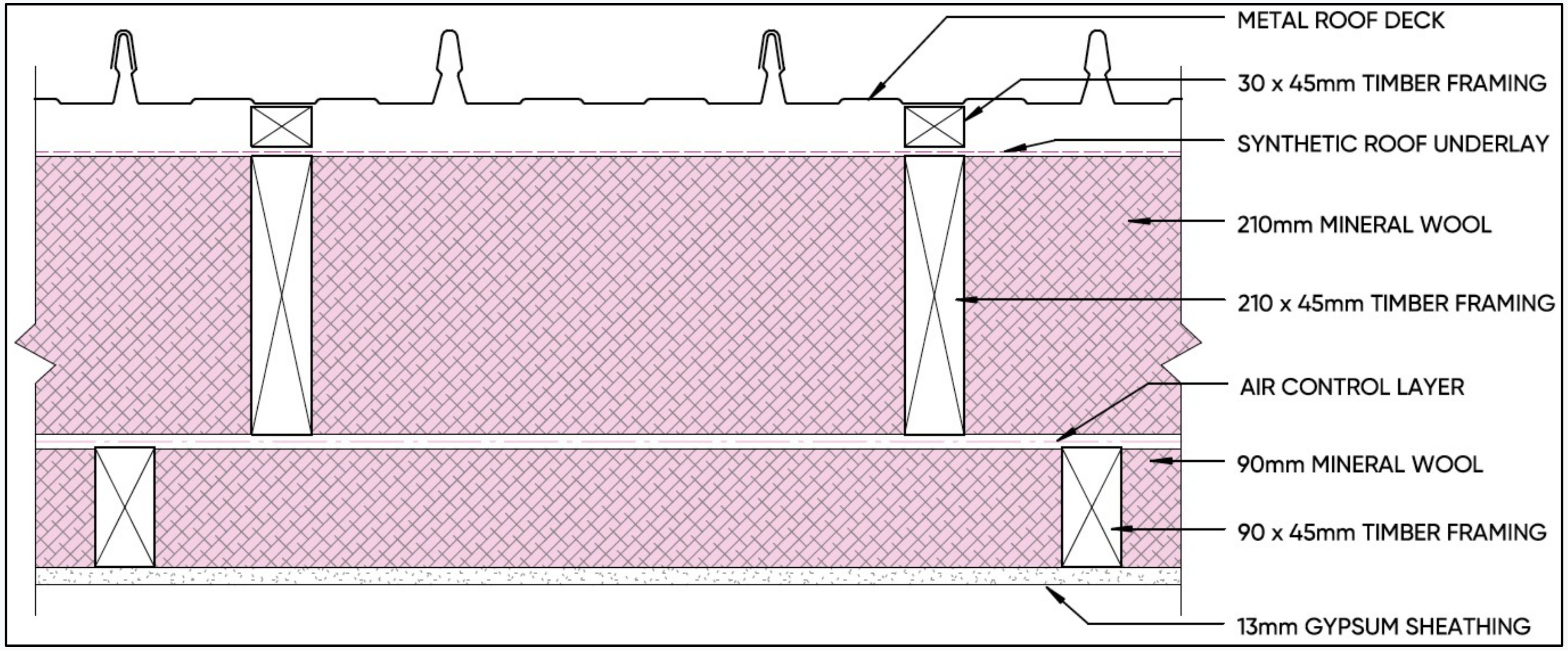
Metal tray roof systems can be trickier because they usually have metal fastener systems that connect the external roof through to the structure below. With the insulation being fixed mechanically, thermal bridging greatly reduces the total R-Value and insulation needs to increase to make up for it. This type of assembly will have condensation under the top metal tray on most cold days and nights, so drainage and adequate ventilation of that cavity is extremely important.



Metal Frame – Warm Roof

What does the new roof look like?

Standard "cold roofs" can be constructed using a split approach where the main rafter space is insulated as usual, and an internal insulation layer is added in a separate layer. This allows the insulation being uninterrupted across the main area while the internal framing provides space for internal services (great approach for walls, too). The separation of the layers also allows for the use of an air control layer which is important for moisture management. Also, good for roofs down to 3º slopes. Because of the thermal bridging of the framing, the interior air control layer is required for condensation control.



Wooden Frame – Cold Roof 210 + 90mm Framing

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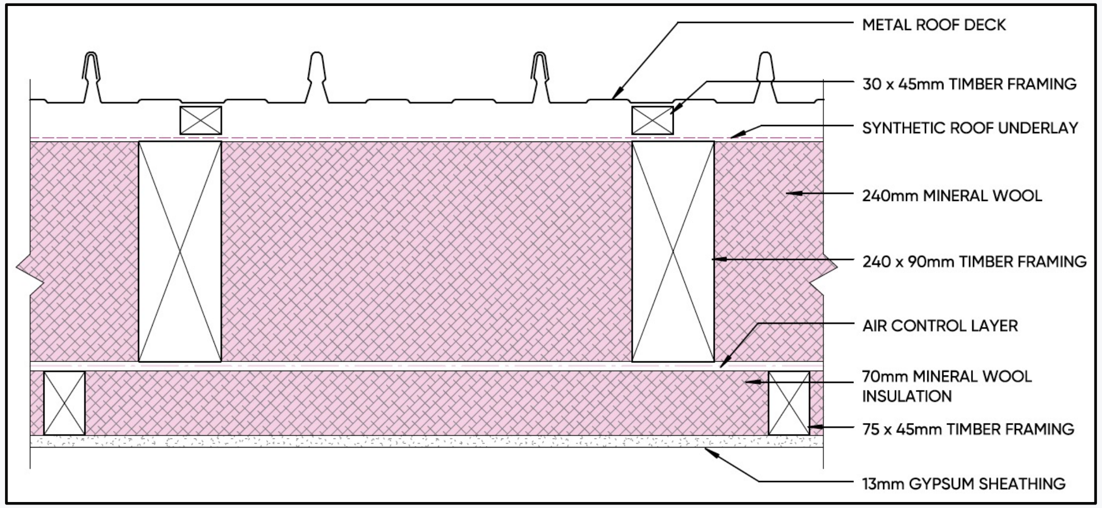
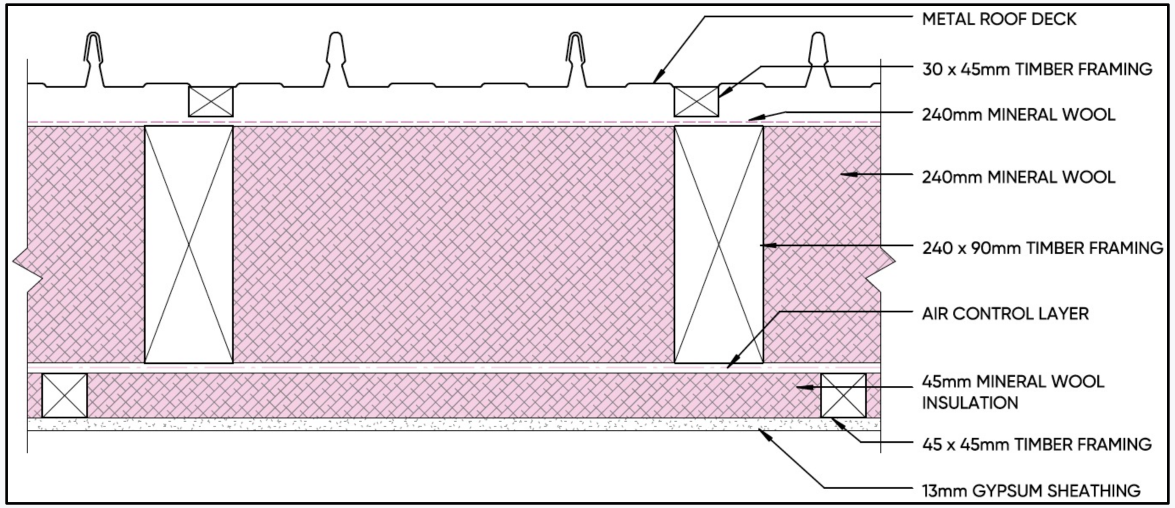
What does the new roof look like?

If you have bigger framing depth you can reduce the internal cavity size accordingly, but notice that the air control layer always remains.



Wooden Frame – Cold Roof 240 + 90mm Framing



Wooden Frame – Cold Roof 240 + 45mm Framing

What does the new roof look like?

Another trick is to use two layers of a thinner insulation product as the thermal resistance usually decreases relative to insulation thickness, e.g. 2 x R3.2 skillion give you R6.4 at 210mm, instead of 1 x R6.3 at 275mm.

PRODUCT RANGE

SPECIFICATIONS

	Material Code	R-Value (m^2K/W)	Thermal Conductivity (W/mK)	Thickness (mm)	Width (mm)	Length (mm)	Pieces per pack	Area per pack (m^2)
2x	683642	3.2 Skillion	0.033	105	430	1160	11	5.5
	683674	3.3	0.047	155	430	1160	21	10.5
	731850	3.6	0.049	175	430	1160	17	8.5
	731848	3.6	0.049	175	600	1200	17	12.2
	731846	4.1	0.048	195	430	1160	15	7.5
	683653	5.2	0.040	210	430	1160	11	5.5
1x	683654	6.3	0.044	275	430	1160	11	5.5

All dimensions are nominal.

Source: https://www.knaufinsulation.co.nz/products/earthwool-glasswool-insulation-ceiling-batt#product

Why do we need to change the roof design?

The most common type of roof built in New Zealand is also the most problematic:

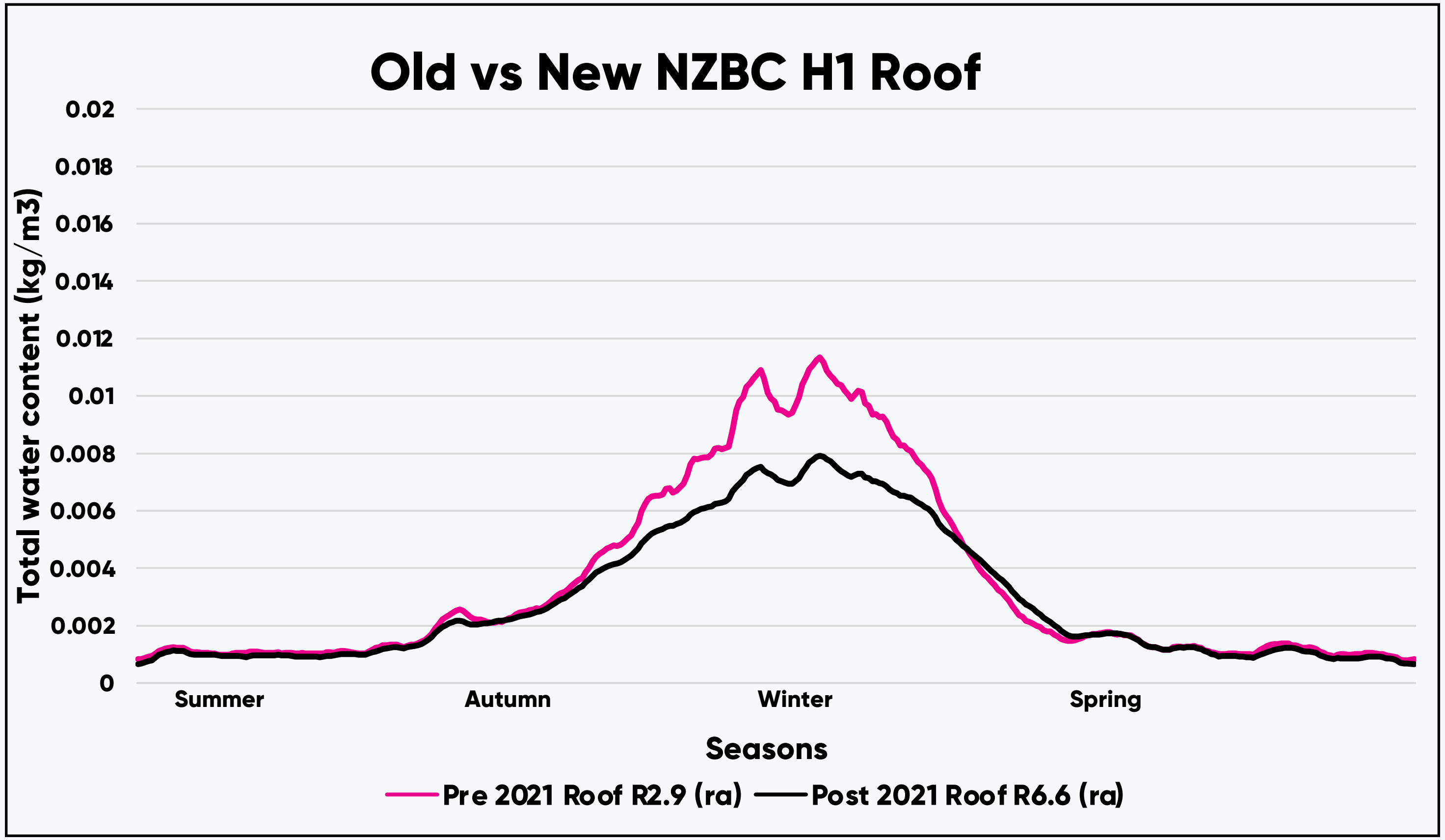
• A cold roof without an air (and vapour-) control layer

The cold roof system has “worked” in New Zealand for decades, mostly by accident. Back in the day when there was no insulation and most houses had fireplaces, heat simply left through the ceiling and into the attic space and roof. Because most roofs (entire houses) were very draughty this was not usually an issue. The uncontrolled heat and airflow made these houses less comfortable and efficient, but the heat and air in the attic kept everything dry.

From 1977, insulation was added into our homes with the purpose of keeping its resident's warm inside. This was a good thing, but by keeping the inside warmer, areas on the other side of the insulation (like the attic) become colder and therefore much more susceptible to interstitial condensation. With increasing insulation and improving methods of construction that lead to better airtightness (for comfort and efficiency) the moisture problems became more prominent, because the building code did not consider how to get excess humidity out of the house safely now that the drafts were stopped. These newest changes also highlight the need more a more holistic approach to H1. By increasing airtightness and thermal control, proper ventilation becomes extremely important.

What are the factors that influence condensation in our roofs?

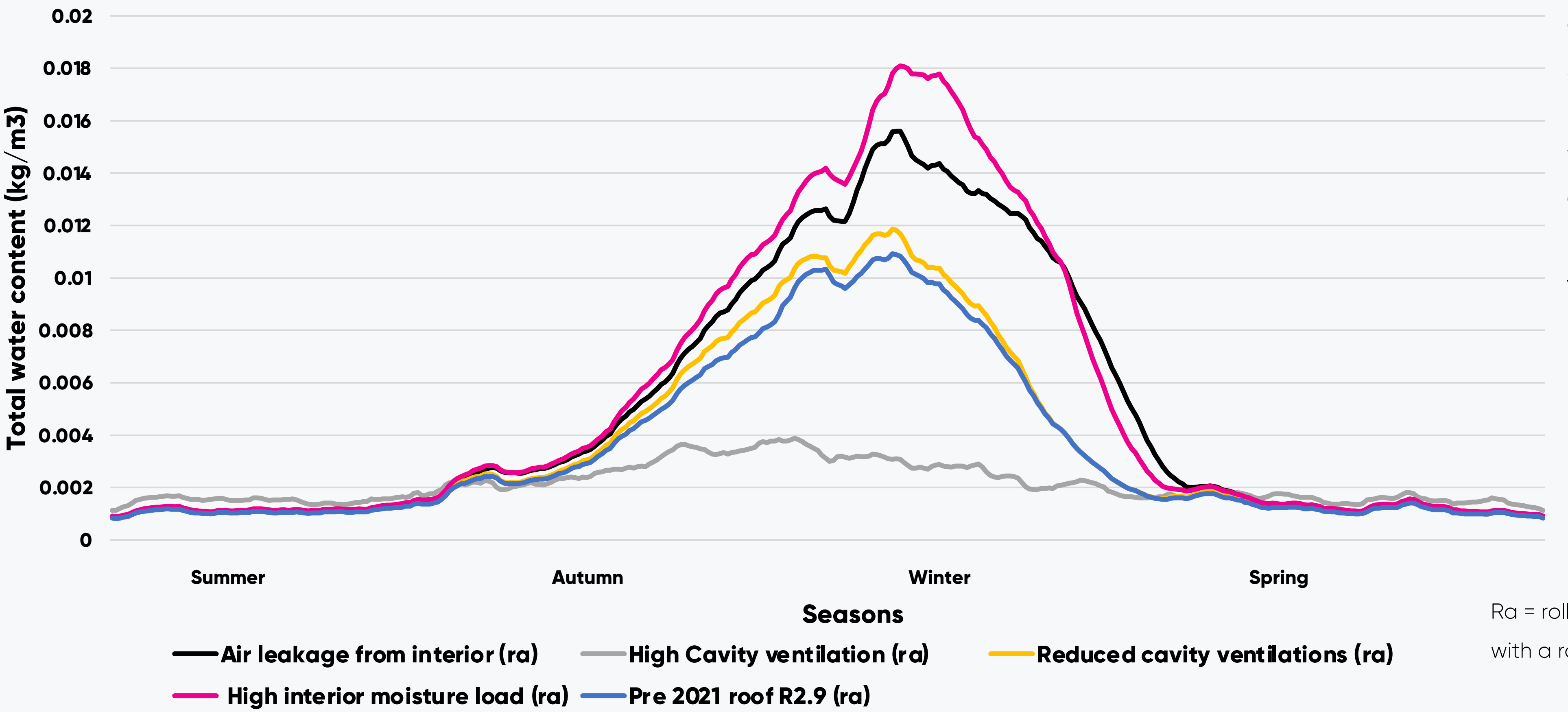
Old vs New NZBC H1 Roof – Does more insulation lead to condensation?



Using computer modelling, we compared the moisture content of the roof underlay of two roofs with the same climate, orientation, build up and boundary conditions but with different amounts of insulation, and found very similar high moisture loads, which means the insulation isn't the main cause – so what is it?

Ra = rolling average: The data is smoothed with a rolling average over 14 days

Old NZBC H1 Roof – what really causes condensation in roofs?



Once again, using modelling, we've shown the moisture content of the underlay in a traditional cold roof with R2.9 insulation (the blue line), and changed different variables (as shown below) to see which variable has the biggest effect.

Ra = rolling average: The data is smoothed with a rolling average over 14 days

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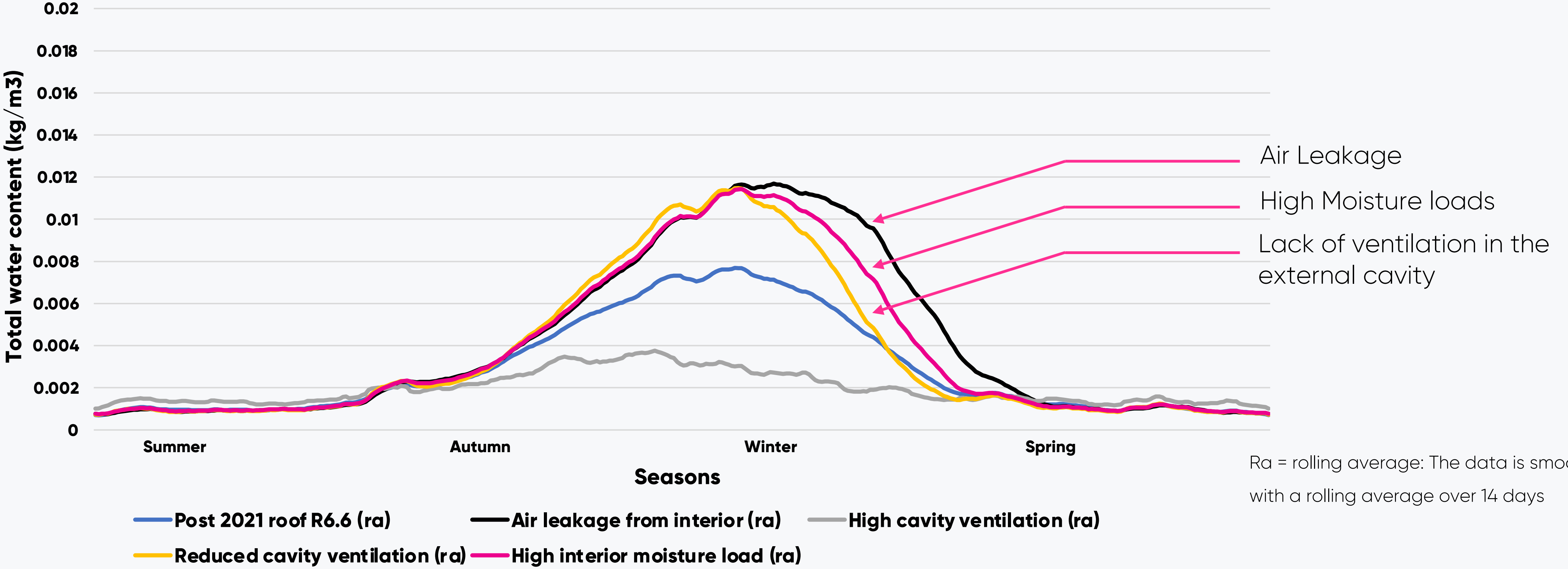
New NZBC H1 Roof – what really causes condensation in roofs?

Comparing what we learned with the last graph to this one with the same variable but more insulation, we can see that the more insulated roof has a bit less water content overall, with the other variables contributing to the moisture load in the new roof similarly to that in the old roof. What we can see is that no matter what amount of insulation, the contributing factors to condensation in a roof are:



Ra = rolling average: The data is smoothed with a rolling average over 14 days

What roof should we be designing?

Airtight – vapour controlled – and adequate cavity design to promote good ventilation

There are only two roof systems that reduce condensation in your roof:

- A warm roof
- A cold roof with a vapour control layer at the ceiling line, fully taped around every penetration and sealed to the adjacent wall assemblies (or better – also along your walls to make your airtightness complete)

The design of a house should be approached holistically including:

- Ventilation to control moisture (relative humidity ideally between 40-60%)
- Insulation to control the temperature (ideally between 20 – 25 degrees Celsius)
- Airtightness to prevent unwanted draughts and energy loss
- Window design to control natural light and temperature

You must consider all elements that separate the inside from the outside together as a full system, because they all affect one another. Since your roof protects your building from the most severe weather conditions (since it faces up) it is one of the most important components to get right.

What are the benefits of a warm roof?

The common belief that "warm roofs are too expensive" does not consider the true costs of creating a cold roof that prevents condensation occurring.

Warm roofs that are designed correctly can not only be more affordable to build than a cold roof, but the long-term benefits of thermal efficiency are greatly enhanced, this makes a warm roof by far the smarter, healthier, more durable and most cost-effective solution over the lifetime of the building.

One thing is for sure, knowledge is key. Make sure the project team fully understands the risks (moist smells, attic mould, and timber deterioration long term) to ensure the design of the roof assembly mitigates any potential for interstitial condensation.

This approach to building a roof will keep your home healthy and avoid the need for expensive repairs down the line.

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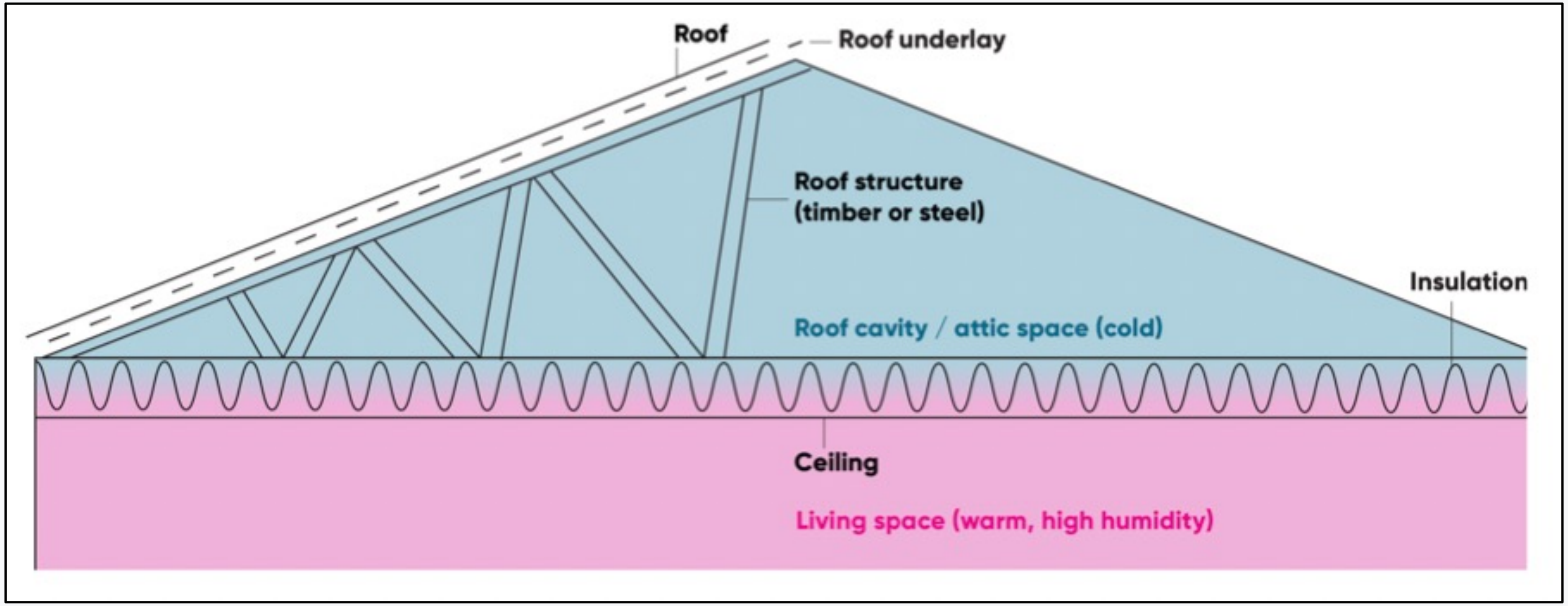
Cold Roof



Most NZ houses have a cold roof which means the insulation is installed at the ceiling line, keeping the house warm but the attic space cold.

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Cold Roof – Main Concerns

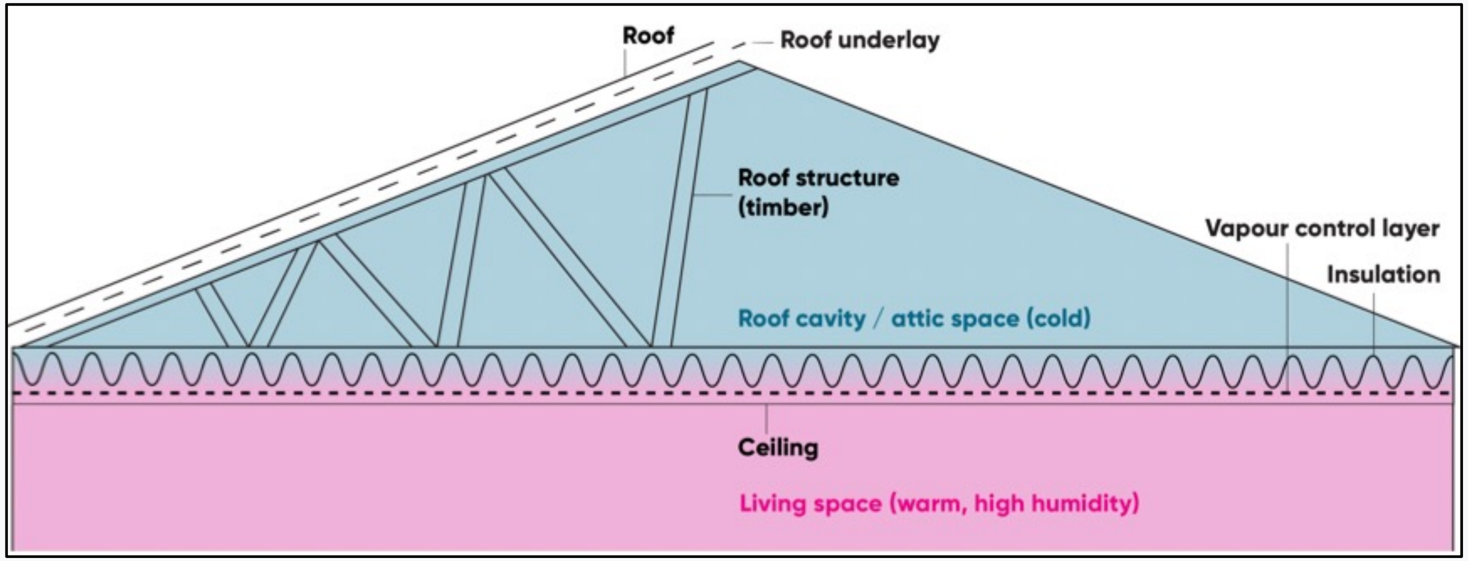
1. Water vapour is rising and condenses in the attic space

Because there is insulation at the ceiling line, the temperature inside the house is warm and the attic space is cold. Water vapour is created by people cooking, washing and breathing in the house. This means the absolute humidity inside the house is significantly higher than that of the attic. This creates a vapour pressure difference between the living space and the attic, which causes moisture to rise through the ceiling where it condenses when it touches a cold surface (like the steel roof or structure holding it). If this condensation occurs over a long period of time, it will lead to mould growth and rot in the roof framing, insulation and ceiling. The problem can be made significantly worse where downlights and other services do not form an airtight seal to the ceiling as thermal buoyancy creates a pressure forcing air through. We recommend retrofitting a vapour control layer if you already have a cold roof or decide to build a house with a cold roof.

2. Night sky radiation with steel framed roofs

On clear nights, radiative cooling causes the temperature of the roof to drop below the air temperature. This causes condensation to form on the cold surfaces below the roof and in the attic. Condensation on the exterior surface of the roof is not a problem as it runs down and into the gutter, neither is the condensation on the inside surface of the roof, as it will collect on the roof underlay and drain into the gutter. However, if the underlay is hard up against the steel, condensation forms under the underlay, and if the roof framing is steel, condensation will form on the framing inside the attic. This means it is likely to drip and run off the framing onto services, and ultimately onto the insulation and ceiling, aiding rot and mould growth! Although ventilation is always needed in a cold roof, it should be noted that ventilation is unlikely to solve the problem, due to high ambient humidity in winter. You can't dry out an attic with cold wet air.

Cold Roof with Vapour Control Underlay

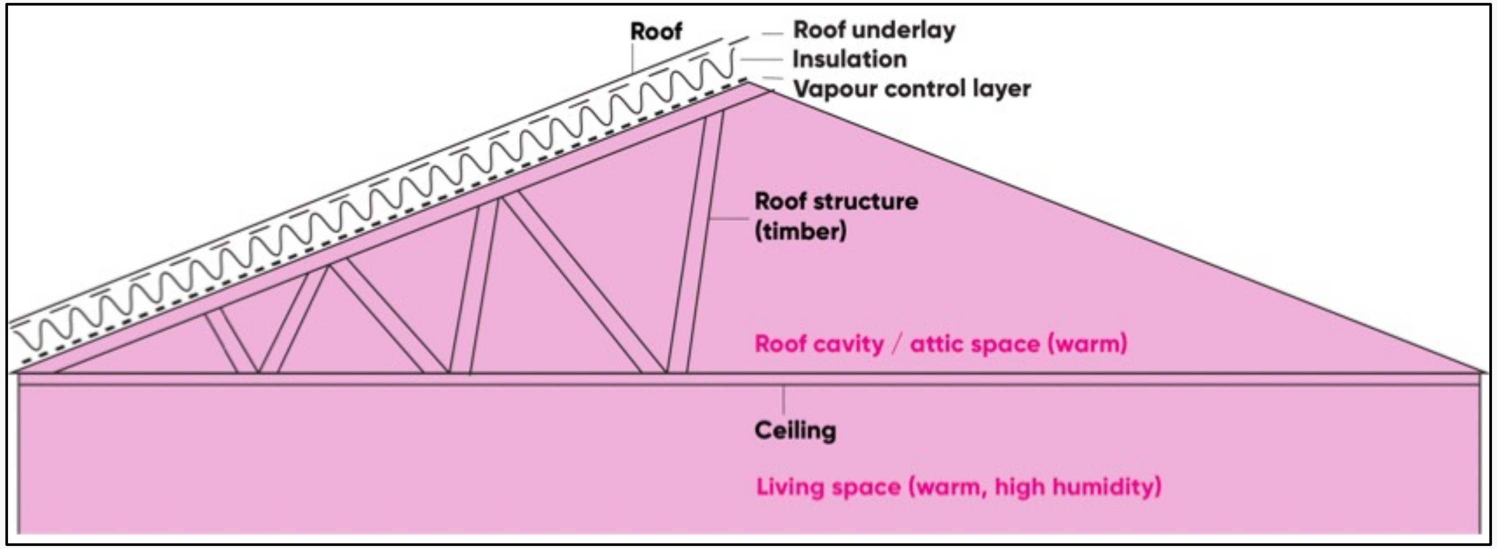


As the name indicates, a cold roof with a vapour control layer is a cold roof with a special membrane installed below the insulation at the ceiling line. A vapour control layer (V.C.L.) prevents water vapour molecules moving through it.

Typically, ceilings are made of gypsum board which lets water vapour pass through uninterrupted. (Paint may help slow the vapour down, but it is not reliable). As this membrane is being installed above the ceiling it prevents large amounts of moist air and water vapour moving into the attic space. Keep in mind that this vapour control layer needs to be fully sealed around downlights, service penetrations and inter-tenancy walls, which can be very difficult and expensive to achieve in practice, unless you just plan with the service cavity like we showed in our split insulation details earlier. Then this approach actually makes the installation of your electrical and plumbing much easier and faster - which saves money.

The larger the roof attic the better it can deal with moisture in the air, but ventilation is still recommended (just external air exchange into and out of the uninsulated attic. We can all agree that the attic is not a place to draw "fresh air for your interior". There are better ways to recover heat from your interior spaces.

Warm Roof



A warm roof has its insulation installed above the roof structure. This keeps the attic space and structure (timber or steel) warm. Therefore, the roof structure doesn't suffer through daily temperature fluctuations and subsequently prevents condensation as the surfaces remain warm.

In a warm roof design, you do not need a vapour control layer at the ceiling line because the attic within the warm roof system is an interior space. There is a vapour control layer below the insulation above the structure to prevent condensation within the insulation layer.

How can ventilation be achieved in roof cavities?

Ventilated roof coverings, for roofs ≥15º

To achieve additional ventilation and to maintain the ventilation layer above the insulation layer, a secondary ventilation pathway is created using counter battens in line with the roof fall. The rear ventilation takes place in the counter battens level*. This has several advantages:

- in the case of extreme weather, any water that does penetrate the roof can be drained and dried out directly in the counter battens level
- Condensation water under the roof covering can be drained off
- Any moisture from the interior can diffuse through to the cavity and ventilated outward
- The rear-ventilated roof covering creates a high level of security against moisture and mold damage.
- The high slope aids in drainage

**The separation between roofing iron and treated timber can be achieved using strips of roofing underlay*

How can ventilation be achieved in roof cavities?

Ventilated roof coverings, for roofs ≤15º

Effective ventilation in a low pitch roof with a separate ventilated roof covering is more difficult to achieve in real life. Air change in the roof cavity can be reduced significantly through:

- Urban environments
- Orientation
- Eave, or ridge detailing
- Obstructions within the cavity (narrowing, Windows)

The more moisture the construction is accumulating the higher the air change needs to be. There are no specific standards to rely on at the moment, but our recommendations are:

- Roof underlay to be placed between the rafters and purlins, or counter battens (to create a cavity above)
- Insulation and roof underlay at same angle as roof cladding
- Drainage channel to gutter, or drip edge
- Roof angle >3º
- Rafter lengths (ventilation path) as short as possible and without interruptions where possible
- Eve and ridge in line with prevailing wind direction, or
- Increase cavity cross section as the roof angle gets lower (DIN68800-2 recommendations, 3-5º/ 80-150mm, 5-15º / 40 – 80mm)
- Use a non-absorbent underlay to ensure proper drainage.