BRANZ

ISSUE 699 BULLETIN

WARM ROOFS IN DOMESTIC CONSTRUCTION

March 2025

- Warm roofs can provide better thermal performance and energy efficiency and fewer risks of condensation and mould problems than cold roofs.
- They can enhance the performance of services that have ducts in the roof space such as balanced heat recovery ventilation systems or ducted heating systems.
- While warm roofs have most often been used in commercial construction, a growing number of homes are now being built with a warm roof.

1 INTRODUCTION

1.0.1 A warm roof has its thermal insulation installed on the outside of the roof structure (Figures 1 and 2). This means that the roof framing and any ceiling cavity are within the thermal envelope of the building at a similar temperature to the building interior. Cold roofs – the most common type of domestic roof until now – typically install the thermal insulation just above the ceiling, placing the roof structure above it and any roof space outside the thermal envelope.

1.0.2 A skillion roof is not a warm roof. The impacts of thermal bridging on performance and condensation risk remain.

1.0.3 Cold roofs can suffer from big swings in temperature. Daytime solar radiation can heat the roofing and roof space to well above the outdoor temperature, while night-time radiative cooling can result in roof deck and roof space temperatures being below the external air temperature. There are frequently large areas of thermal bridging such as where timber framing breaks up the insulation.

1.0.4 Cold roofs face some challenges:

- A risk of condensation, mould and other problems in the roof space. This has been observed by BRANZ scientists in multiple parts of the country over a range of typologies – even in new construction. Risk factors for condensation include:
  - where living areas are poorly ventilated
  - where moist air moves up from the living spaces, for example, through ceiling penetrations cut for downlights or poorly sealed attic hatches
  - in locations with limited daytime solar radiation on the roof.
- Potentially reduced durability of building materials and elements in the roof space if condensation and mould develop.
- Reduced thermal performance of the building.
- Reduced performance of ducted heating, air conditioning and/or ventilation systems such as balanced heat recovery ventilation, with a risk of condensation forming.

1.0.5 Warm roofs have a number of potential advantages:

- The risk of condensation and mould in the roof space is significantly reduced (if not eliminated) because the roof structure is kept at or close to the conditions indoors, assuming that occupants are heating the home in colder weather.
- It is often easier to design and construct new warm roofs that comply with H1/AS1 5th edition than it is using some conventional cold roof designs.
- Linear thermal bridges through rafters, purlins and battens are largely eliminated (and thermal performance enhanced) as the insulation has greater continuity over the roof structure. (Point thermal bridges exist, but their impact is minimal.)
- A warm roof construction is ideal for mechanical air conditioning/ventilation systems that have ducting in the roof space as it improves system performance as a result of the warmer roof space. It reduces the need for insulation on the ducting and the risk of condensation in the ducts. BRANZ research has found that a balanced heat recovery system can see its performance reduced to half or less in a cold roof, but a warm roof can deliver closer to the specified core performance. (Stephen McNeil presentation)
- The substrate under the insulation adds rigidity to the roof structure and can enhance acoustic performance such as transmitting less rain noise.
- When a warm roof is used to replace an old roof or roof cladding, it can allow the designer to achieve significantly greater construction R-values. In some cases, the existing roof can be retained as a substrate.

1.0.6 Warm roofs have potential disadvantages:

- Initial costs may be higher than a cold roof design but this may be offset over the longer term by better thermal performance, energy efficiency and comfort. Reduced moisture and durability risks also reduce liability concerns for industry.
- Warm roof systems with polymer-based foam insulation have higher embodied carbon than some other roof systems.
- Building practitioners typically have less familiarity with warm roof design and construction than with cold roofs.
- Warm roof design is not currently included in NZS 3604:2011 Timber-framed buildings or covered by New Zealand Building Code Acceptable Solutions. Other means of demonstrating Code compliance must be used. Appropriate supporting documents will need to be provided with the building consent application. Some structural insulated panel systems have CodeMark certification and/or a BRANZ Appraisal.

1.0.7 While warm roofs have most often been used in commercial construction and restricted to proprietary systems, more homes are now being built following these principles. Calls to the BRANZ helpline on the topic suggest that growing interest has been sparked partly by the minimum thermal performance required of roofs – R6.6 nationwide – in the Acceptable Solution H1/AS1 5th edition.

1.0.8 BRANZ has constructed a warm roof using conventional building materials that most designers and builders could design and build (see 2.3). Testing has shown this roof has good performance in terms of both moderating temperature fluctuations and reducing moisture risks, benefiting the roof space and the indoor environment.

1.0.9 Where a warm roof system is providing structural stability to the building – for example, using structural insulated panels – the structure must have a minimum durability of 50 years under Building Code clause B2 Durability. A 50-year durability is also required if failure to comply with the Building Code would go undetected during both normal use and maintenance of the building or where the building elements are difficult to access or replace.

1.0.10 As a point of interest, warm roofs are a requirement for the Ministry of Education's new school buildings (which have high occupancy rates per m²) in colder climatic zones to provide a more effective thermal envelope, help eliminate thermal bridging and reduce rain noise. The Ministry does not require warm roofs in the two warmest climatic zones.

2 WARM ROOF CONSTRUCTION

2.0.1 There are a number of different options for designing a warm roof, including:

- systems where rigid thermal insulation sits on a structural deck and a waterproof membrane is installed above the insulation
- systems that use structural insulated panels with metal skins
- a warm roof using conventional materials such as profiled metal roofing.

2.0.2 Design considerations should include whether the roof is required to be trafficable, roof pitch and the number of roof penetrations required for items such as solar panels or rooftop mechanical plant. Penetrations should ideally be minimised.

2.1 WARM ROOF USING A WATERPROOF MEMBRANE

2.1.1 This system (Figure 1) is widely used in commercial construction of flat roofs with limited access but can also be used in domestic buildings. It involves:

- a concrete, plywood or steel structural deck – in colder climate zones, this must have a vapour barrier installed over it
- a rigid thermal insulation layer such as polyisocyanurate (PIR)
- a waterproof membrane installed above the insulation – typically a thermoplastic polyolefin (TPO) or a torch-applied modified bitumen membrane.

2.1.2 Where a plywood substrate is used, it must be CCA-treated to a minimum of H3. LOSP treatment cannot be used. The plywood must be at least CD grade structural and have the sanded C face upwards. In practice, 20 mm or 21 mm CCA-treated H3.2 tongue and groove plywood is often used. Acceptable Solution E2/AS1 (8.5.5.1) requires plywood to be fixed with staggered joints, face grains to be at right angles to main supports, supports to be at 400 mm maximum centres and all edges fully supported. Fixings must be 10 g x 50 mm stainless steel countersunk head screws at 150 mm centres on edges and at 200 mm centres within the body of the sheets.

2.1.3 There is a functional difference between this option with a waterproof membrane and a warm roof with battens and a profiled metal cladding (see 2.3). The battens/metal cladding option is designed to have engineered drainage paths should the cladding be damaged. The membrane warm roof should lap the vapour barrier correctly and be turned out over the fascia to achieve the same redundancy. The vapour barrier is also a critical component in many cases as the membrane is prone to a number of possible failure modes as it is not permeable enough to dry moisture that migrates up through the insulation.

2.1.4 There are some proprietary warm roof systems with a BRANZ Appraisal that fit into this category. Some of these require licensed and trained installers while others only require licensed building practitioners with the appropriate roofing licence.

2.2 WARM ROOF USING STRUCTURAL INSULATED PANELS

2.2.1 The structural insulated panels (SIPs) used for roofing are made up of a low-density insulating cellular core with rigid metal skins either side. They are sometimes referred to as sandwich panels.

2.2.2 SIPs have traditionally been used in cold stores and other commercial applications such as long-span roofs. There has been a large expansion of products and materials available in recent years, with the use of SIPs expanding to housing and light commercial applications such as schools and offices. As an example, Kāinga Ora used warm roof construction using SIPs in its Bader Ventura housing in Auckland.

2.2.3 Warm roof construction using SIPs has several advantages:

- Where SIPs are made into roof sections off site and craned into place on site, construction can be faster than using conventional materials and methods. This would have benefits especially for developers who are building multiple homes, with significantly reduced construction times possible and savings in labour costs.
- Metal-clad insulated panels can self-support over longer spans than some conventional roof cladding and lining materials.

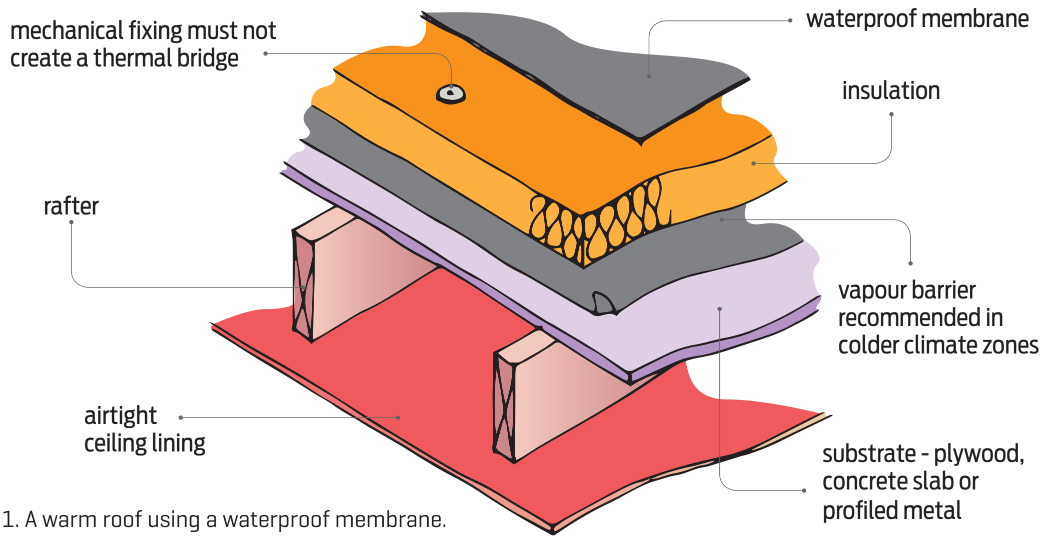

Figure 1. A warm roof using a waterproof membrane.

2.2.4 Careful detailing is required as some of these designs rely heavily on sealants and may lack a secondary rainscreen defence layer. Failure may also require the return of a crane to remove elements/panels.

2.2.5 Panels are best suited to a reasonably simple monopitch roof structure – junctions can be challenging to make weathertight. Fascia details in particular need careful consideration to ensure robustness/durability/weathertightness.

2.3 WARM ROOF USING BATTENS AND PROFILED METAL ROOF CLADDING

2.3.1 It is possible to construct a warm roof using conventional building materials and techniques (Figure 2). A solid substrate is installed over the rafters and a membrane is added as an air barrier followed by rigid insulation, roofing underlay, battens and sheet roofing such as profiled metal roofing. This option has ventilation below the roof cladding but above the underlay. The ventilation manages the condensate load under the metal deck (which is much reduced from conventional roofing). This provides a robust system with a measure of redundancy in dealing with moisture. This option works better than some other options for roofs with valleys.

2.3.2 A light timber-framed building on the BRANZ campus at Judgeford used for ventilation tests had its conventional cold roof replaced with a warm roof using this approach (Figure 3).

2.3.3 It is important to make the roof/wall junction airtight with the roof space now forming part of the thermal envelope:

- Continuous solid blocking was installed between the junctions of the top chord of the truss and the top plate of the wall (Figure 4). The blocking just overlaps the back edge of the top plate. The top edge was chamfered to the same pitch as the roof. (The principle is the same if you are using rafters instead of trusses.)
- A bead of sealant was applied up both sides of the blocking and along the bottom edge junction with the top plate.
- An additional bead of sealant was applied across the top of the blocking/trusses for the length of the building as the plywood deck was fitted.
- Additional fibrous Insulation was added outside of the blocking, covering the top plate to improve the thermal performance of the junction. This keeps the plane of greatest airtightness inside the thermal envelope.

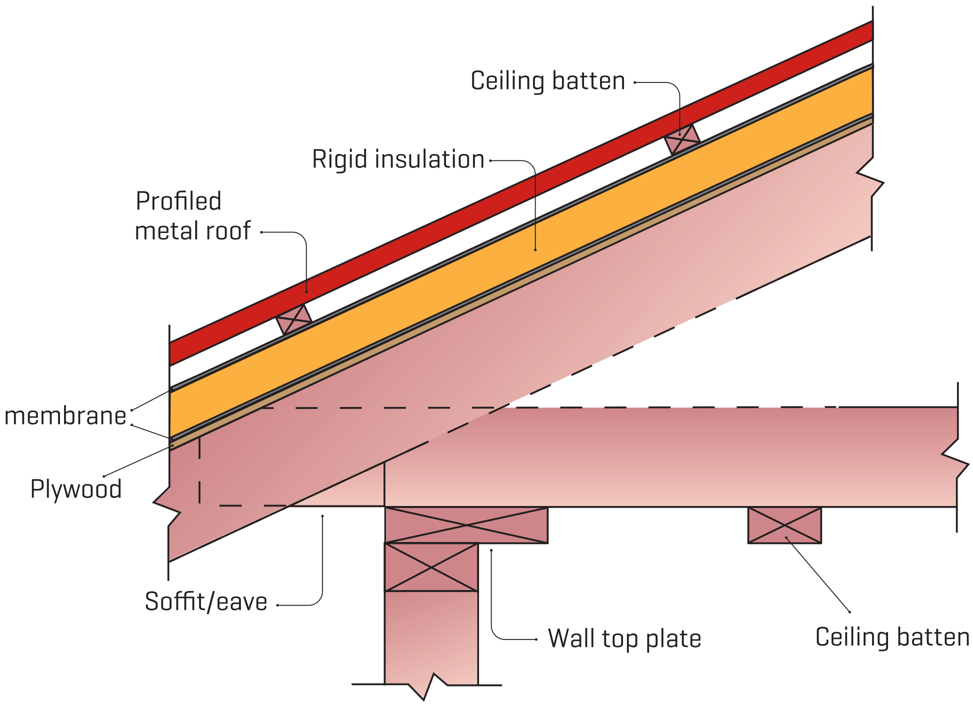

Figure 2. A warm roof can be designed and built with very commonly used construction methods and materials. This schematic drawing shows the type of warm roof retrofitted to a building on the BRANZ campus.

Figure 3. The plywood substrate being installed for the warm roof on the BRANZ ventilation test building.

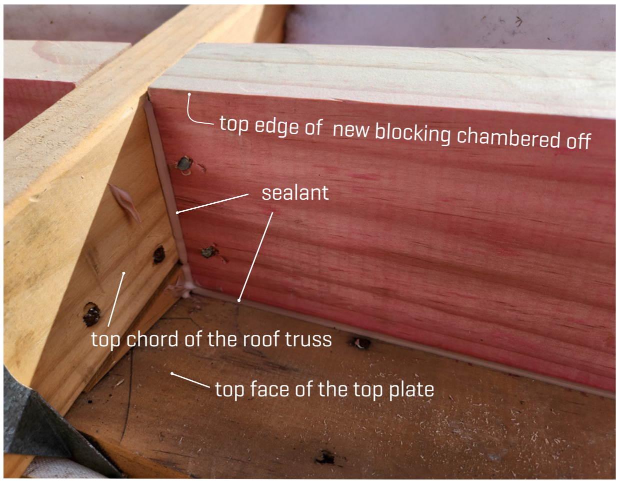

Figure 4. Continuous solid blocking and sealant was installed at the top plate/roof junction to improve airtightness.

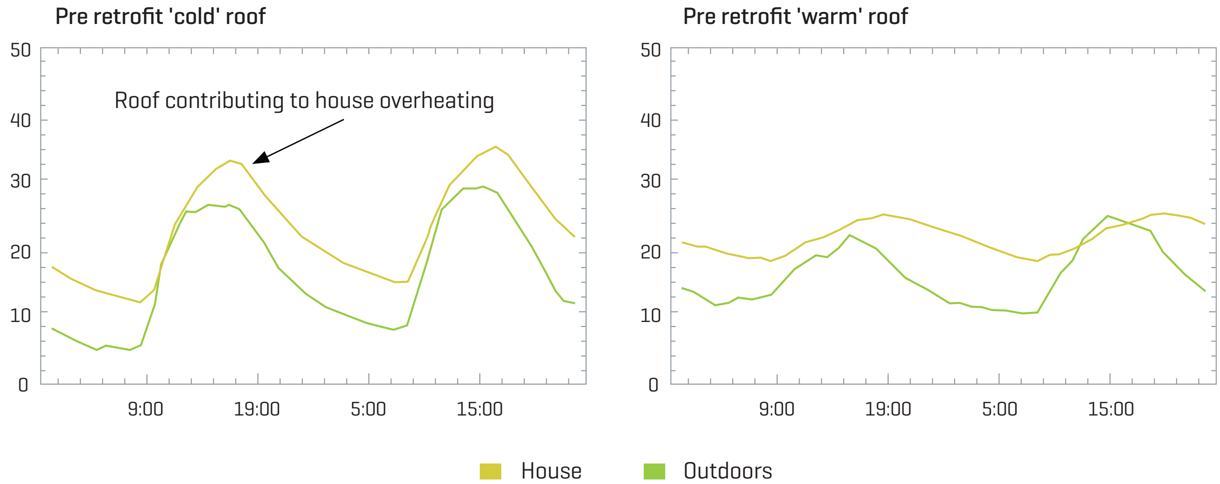

Figure 5. An illustration of roof space performance in the warmer months. A warm roof significantly reduces the roof contribution to potential overheating in a house.

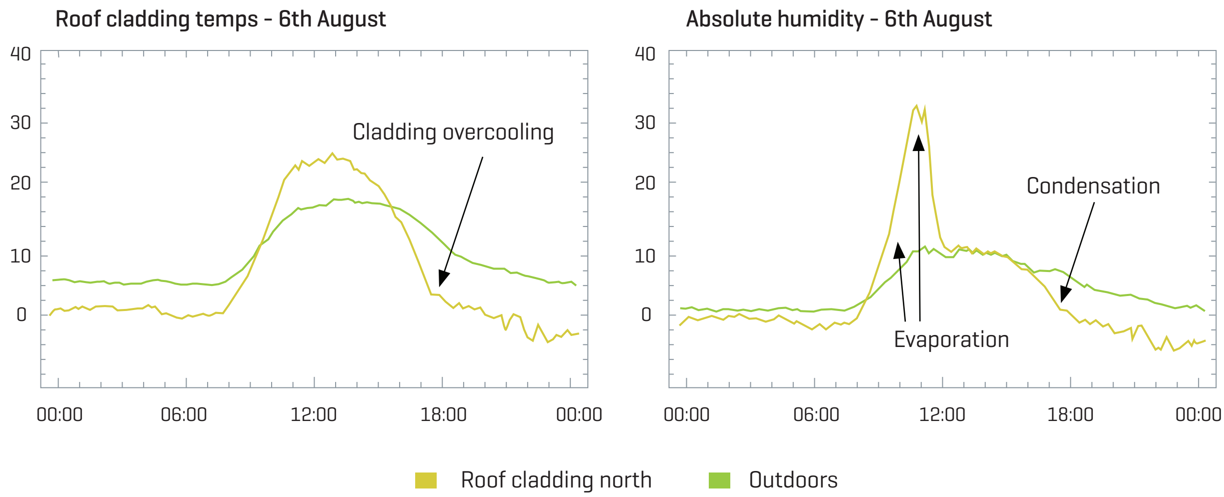

Figure 6. Cladding temperatures and absolute humidity in August (winter).

2.3.4 Sensors were placed just below the roof cladding and in the roof space to measure temperature and moisture under the cold roof and then under the warm roof. The pre-retrofit cold roof had strong temperature swings (Figure 5), with the roof contributing to house overheating during the warmer months. Even in March when the external temperatures were not particularly cold, the overcooling of the roof space below ambient conditions was evident. Data from the post-retrofit warm roof showed the roof space and house interior having very similar temperatures, as expected.

2.3.5 Sensors placed just under the profiled metal cladding of the warm roof recorded that, in August (winter), the roof cladding warmed rapidly during the day and then cooled just as rapidly in the afternoon (Figure 6). The cladding is overcooling as its temperature sinks below that of the outdoor temperature. This causes the condensation shown in the second chart in Figure 6. Measures of absolute humidity showed evaporation taking place in the morning and condensation forming in the evening. The ventilation and roofing underlay managed this.

3 REPLACING AN EXISTING COLD ROOF WITH A WARM ROOF

3.0.1 Warm roofs have an advantage in roof refurbishments such as when a low-slope roof needs replacement because they alleviate restraints any existing truss structure places on achieved R-values. Insulation does not have to be fitted within the truss webs – it is fitted as a flat area on top. As noted above, care needs to be taken with detailing, especially fascia detailing, to ensure robustness, durability and weathertightness.

3.0.2 Retrofitting a warm roof may improve the amenity of the roof space, particularly if used for storage. It may also potentially improve the performance of heating and ventilation system ducting that runs through the roof space.

3.0.3 In some cases, the existing roof can be retained as a substrate. The key factor in reusing the old roof is making it airtight. Reuse also reduces or eliminates demolition costs and means that building weathertightness is maintained.

3.0.4 With a hybrid assembly such as this, it is important to carefully consider the condition of the existing structure and whether pre-existing insulation should be retained. BRANZ generally recommends removing existing insulation unless specialist advice (backed up by modelling such as WUFI modelling) suggests it could be retained. Advice from a chartered professional engineer or registered architect should be sought regarding the additional weight that may be added to the roof. Care will need to be taken that the thermal envelope is airtight, including the roof/wall junction.

3.0.5 In many cases, a better option will be to take off the existing roofing as this will make the condition of the roof framing more visible and make it easier to address requirements around airtightness. This also allows for reducing the increase in height. BRANZ took this approach in retrofitting the ventilation test building with a warm roof.

3.0.6 Whether a building consent would be required for replacing an existing cold roof with a warm roof is a grey area. BRANZ recommends talking with the local building consent authority for their view. The additional weight is minimal. For example, with an existing concrete tile roof, the new assembly will actually be lighter if the concrete tiles are removed as part of the process.

4 FURTHER INFORMATION

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BU677 Specifying roofs under H1

BU630 Roof space ventilation

BU695 Structural insulated panels

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