BRANZ

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BULLETIN

SPECIFYING ROOFS UNDER H1

October 2022

- From 3 November 2022, the 5th edition amendment 1 of Acceptable Solution H1/AS1 and Verification Method H1/VM1 replace the old 4th edition.
- H1/AS1 5th edition amendment 1 introduces a schedule method minimum requirement of R6.6 for roofs nationwide for housing, and buildings up to 300 m².
- This bulletin guides architects and designers in specifying roof thermal performance that complies with H1/AS1 and H1/VM1 5th edition amendment 1.

1 INTRODUCTION

1.0.1 From 3 November 2022, the 5th edition amendment 1 of Acceptable Solution H1/AS1 and Verification Method H1/VM1 replace the old 4th edition documents for demonstrating compliance with Building Code clause H1 *Energy efficiency*.

1.0.2 However, in building consent applications for housing submitted before 1 May 2023, roof, wall and floor construction R-values can be equivalent to the 4th edition requirements.

1.0.3 The revised H1/AS1 and H1/VM1 apply to all housing (including medium-density housing, apartment buildings and other multi-unit housing), and buildings other than housing up to 300 m². For non-residential buildings over 300 m², a new H1/AS2 and H1/VM2 apply. This bulletin only covers the changes that apply to housing, and buildings other than housing up to 300 m². Where this bulletin refers to H1/AS1 and H1/VM1, it is referring to the 5th edition amendment 1.

1.0.4 The 5th edition retains three established methods of demonstrating compliance – the schedule and calculation methods are found in H1/AS1 and the modelling method in H1/VM1. (Alternative methods not involving H1/AS1 or H1/VM1 can also be used to demonstrate compliance.)

1.0.5 The 5th editions of H1/AS1 and H1/VM1 have six climate zones, replacing the previous three climate zones. However, the minimum schedule method requirement for roofs under H1/AS1 in every climate zone is now R6.6.

1.0.6 The required thermal performance of building elements in H1/AS1 and H1/VM1 is generally expressed in terms of construction R-value. This is the total thermal resistance of all the physical elements that make up or impact on a building element. For example, with roofs, it includes the ceiling, roof insulation, underlay and roof cladding (and roof framing where applicable). The construction R-value can be higher or lower than the R-value of the insulation material used in the roof.

1.0.7 BRANZ is producing material to help in compliance with the new H1 requirements. This includes a 6th edition of the BRANZ *House insulation guide* and tools for using the calculation method (see section 10). The 5th and earlier editions of the BRANZ *House insulation guide* should not be used for calculating construction R-values under H1/AS1 and H1/VM1 5th edition amendment 1 because some methods for assessing R-values have changed.

1.0.8 The BRANZ resources are not put together just to help designers comply with the minimum requirements in the Building Code. The focus is very much on supporting good design – going beyond the minimums to construct buildings, and houses especially, that are warm, dry, comfortable and healthy to live in. Some publications, such as BRANZ External Research Report ER70 PHINZ *High-performance construction details handbook*, offer designers new approaches to make significant improvements in the thermal performance of buildings. The resources also address issues around reducing carbon and preparing the industry for coming changes as the Building Code is amended to encourage more-efficient, resilient and adaptable buildings.

1.0.9 For full details of the new requirements in H1/AS1 and H1/VM1, refer to MBIE's Building Performance website www.building.govt.nz/building-code-compliance/h-energy-efficiency.

2 THERMAL PERFORMANCE REQUIREMENTS

2.0.1 The new minimum construction R-value for roofs using the schedule method is R6.6 in all climate zones. With the calculation and modelling methods, the roof R-value can be reduced by increasing thermal performance in other elements of the building – for example, by reducing the glazed area of the building.

2.0.2 Where building consent applications for housing are submitted before 1 May 2023, roof, wall and floor minimum construction R-values can be equivalent to the previous (4th edition) requirements.

2.0.3 The new H1/AS1 and H1/VM1 make allowance for the fact that the insulation materials may be too thick to extend right to the edge under a sloping roof. In roof spaces where insulation is installed over a horizontal ceiling and under a sloping roof, the R-value of the roof may be reduced to R3.3 for up to 500 mm from the outer edge of the ceiling perimeter where there is not enough space for the thicker insulation required to achieve R6.6 (Figure 1). (The problem may also be addressed by using a different insulation product.)

2.0.4 With the schedule method, the R-value of R6.6 does not need to be corrected for this situation provided the reduced R-value is at least R3.3 in a perimeter width of no more than 500 mm. If the calculation or modelling methods are used, the impact of reduced insulation at the perimeter will need to be accounted for.

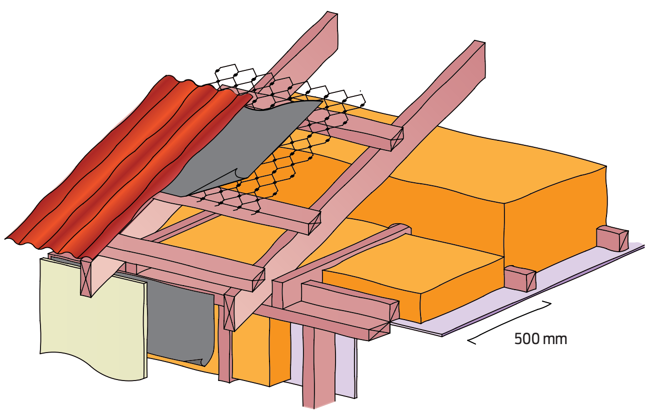

Figure 1. The construction R-value of the roof may be reduced to R3.3 for up to 500 mm from the perimeter edge where there is not enough space under a sloping roof for the thicker insulation required to achieve R6.6.

2.0.5 For compliance with the calculation method, H1/AS1 (section 2.1.3.7) allows for a roof or other building component with two or more distinctly different areas or zones to be included in the calculation as separate zones. As an Alternative Solution, the method shown in the panel on the right is based on that process but only requires knowledge of the area-perimeter (A/P) ratio. BRANZ *House insulation guide* (6th edition) includes the ability to account for any reduction in the R-value of the insulation around the perimeter of a roof using that alternative method.

2.0.6 With the calculation method, the R-value of any ceiling part, including along the edges, cannot be reduced below R3.3 (H1/AS1 section 2.1.3.8). This limitation does not exist with the modelling method.

2.0.7 With sloping roofs and horizontal ceilings, the schedule method minimum construction R-value of R6.6 in the main central portion of the roof and R3.3 for 500 mm around the perimeter will obviously give an overall construction R-value that is below R6.6. If designers wish, they can specify a higher construction R-value for the central portion of the roof to compensate for the lower R3.3 around the perimeter to lift the overall construction R-value to R6.6. Table 1 shows what is required for ceilings with different A/P ratios. Note that this procedure is not a requirement in H1/AS1.

2.0.8 A common approach that allows thicker insulation to extend further by providing more clearance to the roof deck is a raised heel truss (Figure 2). The connections of this option require specific engineering design (SED).

2.1 DETERMINING THE R-VALUES OF ROOFS

2.1.1 The R-values of roofs can be determined using NZS 4214:2006 *Methods of determining the total thermal resistance of parts of buildings*.

2.1.2 The BRANZ *House insulation guide* (6th edition) may also be used to determine the R-value of roof constructions with various insulation options. The roof R-values presented have been determined using finite-element modelling (FEM).

Making adjustment for the impact of reduced insulation at the roof perimeter for use with the calculation or modelling methods

A good approximation for the fraction of the ceiling area that has reduced R-value is:

$$\textit{edge area fraction}\ f_e = \frac{w}{A/P} - 4.\frac{w^2}{A}$$

where:
w = width of reduced ceiling R-value ($R_{reduced}$)
A = total interior ceiling area
A/P = ceiling area to ceiling perimeter length ratio.

This will slightly overestimate the edge fraction if the shape of the ceiling is not rectangular but has the advantage of only requiring the ceiling A/P ratio. The second half of the equation is important only when A/P is less than 2.5.

This assumes all the ceiling perimeter has reduced R-value (R3.3 for example). For example, if 25% of the perimeter doesn't have reduced R-value, multiply the edge area fraction by 0.75.

Once the edge area fraction is known, the R-value of the ceiling is calculated by area weighting the U-values (U-value = 1/R-value).

$$1/R_{ceiling} = f_e/R_{reduced} + (1-f_e)/R_{unreduced}$$

Alternatively, this last equation can be rearranged to determine the minimum unreduced R-value that would give the desired ceiling R-value (R6.6 for example).

Setting $R_{reduced}$ to R3.3, $R_{unreduced}$ to R6.6 and w = 0.5 m, the impact of the reduced R-value can be calculated.

Table 1. Determining the construction R-value in the main central portion of the roof to lift the construction R-value of the overall roof to R6.6, assuming the roof perimeter construction R-value is R3.3.

A/P ratio	Effective overall construction R-value with R6.6 in the central portion of the roof and R3.3 around the perimeter	Construction R-value required in the central portion of the roof to give a whole-roof construction R-value of R6.6
1.6	5.1	11.1
1.8	5.2	10.1
2	5.3	9.5
2.2	5.4	9.1
2.4	5.5	8.8
2.6	5.6	8.5
2.8	5.6	8.3
3	5.7	8.1

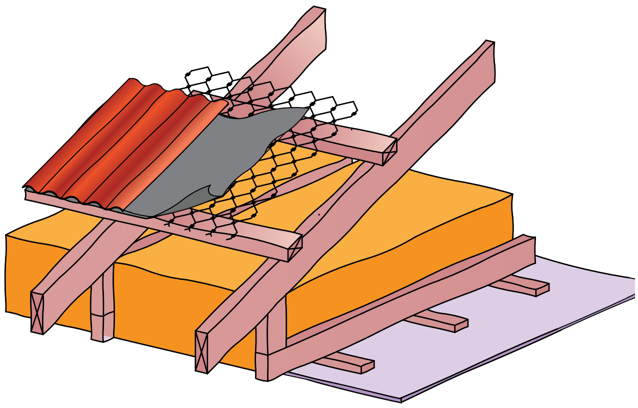

Figure 2. A raised heel truss allows thicker insulation closer to the roof edge.

3 SCHEDULE, CALCULATION AND MODELLING METHODS

3.1 SCHEDULE METHOD

3.1.1 Under the schedule method in H1/AS1, the roof must meet (or preferably exceed) a construction R-value of R6.6. The schedule method can only be used to demonstrate compliance with H1 where:
- the glazing area is 30% or less of the total wall area
- the combined glazing area on east, south and west-facing walls is 30% or less of the total wall area of these walls
- the skylight area is no more than 1.5 m² or 1.5% of the total roof area (whichever is greater)
- the opaque door area is no more than 6 m² or 6% of the total wall area (whichever is greater).

3.1.2 Using the schedule method in H1/AS1 5th edition amendment 1 may require changes to the framing typically specified using the 4th edition – see section 4 for more on this. Designers can alternatively make use of the calculation and modelling methods, increasing the thermal performance of another building element or reducing the area of glazing to allow the performance of the roof to be reduced below R6.6.

3.1.3 In coming years, it is likely the schedule method will be retired from H1 documents and modelling will be required for all new building work (as it already is in some other countries). Modelling gives a better picture of as-built performance and therefore the cost to keep the building warm, healthy and dry.

3.2 CALCULATION METHOD

3.2.1 The calculation method in H1/AS1 compares the thermal performance of the proposed building with that of a reference building that is insulated in accordance with tables outlined in the schedule method. The proposed building overall must perform at least as well as the reference building, but the thermal performance of each element – roof, wall, floor, windows and door and skylights – can differ from those in the reference building. (The requirements for each building element in the reference building are the same as those in the schedule method except for skylights, which are assigned the R6.6 roof R-value in the reference building equations – in other words, it is assumed the reference building has no skylights.) The calculation method allows a lower thermal performance in the roof if this is offset with greater thermal performance in another element and therefore allows designers greater flexibility.

3.2.2 There are limits to use of the calculation method. For example:
- the calculation method can only be used where glazing is 40% or less of the total wall area (this is a change from H1/AS1 4th edition where the limit was 50%)
- the construction R-value for roofs, walls and floors in the proposed building must be at least 50% of the construction R-value of the corresponding building element in the reference building, this includes any area with a reduced R-value along ceiling edges
- the calculation method cannot be used to reduce the performance of building elements that have embedded heating systems
- Acceptable Solution E3/AS1 also specifies minimum R-values for walls, roofs and ceilings – the calculation method cannot be used to provide lower values than these.

3.2.3 The calculation method is set out in H1/AS1 section 2.1.3, and the reference building heat loss equations are set out in Table 2.1.3.4A.

3.2.4 The BRANZ online Calculation Method Tool does the required calculations automatically. Users input the design information for the different building elements and the tool will calculate whether this complies with the requirements of H1/AS1. The results contain the information building consent authorities need to ensure that H1 has been complied with and can be submitted as part of the consent documentation.

3.2.5 The New Zealand Green Building Council also has an interactive calculation method tool and other useful resources on its website www.nzgbc.org.nz.

3.3 MODELLING METHOD

3.3.1 The modelling method in H1/VM1 gives designers the greatest flexibility. Modelling software is used to demonstrate that the sum of the annual space heating and cooling loads of the proposed building does not exceed that of a reference building with the same geometry and orientation in the same climate zone. The computer modelling method for determining this is set out in H1/VM1 Appendix D.

3.3.2 Again, there are limits to the use of this method:
- Where a proposed building includes a heated ceiling, wall or floor, minimum construction R-values apply for that particular element.
- Acceptable Solution E3/AS1 also specifies minimum R-values for walls, roofs and ceilings – the modelling method cannot be used to provide lower values than these.

3.3.3 The modelling software used must be capable of passing the ANSI/ASHRAE Standard 140 test or be tested to and pass the BESTEST (see section 10).

3.3.4 Under H1/VM1 5th edition amendment 1, the modelling method allows use of single-zone modelling tools such as the Passive House Institute's PHPP or the NZGBC's ECCHO tool in Homestar (see section 10), except for multi-unit dwellings where each household unit is required to be represented by at least one thermal zone.

4 SKILLION ROOFS

4.0.1 The new H1 requirements will have an impact on skillion roofs in particular. Many skillion roof structures that complied with the 4th edition of H1/AS1 or H1/VM1 will not comply with the 5th edition amendment 1. New approaches required may include deeper rafters, higher-density insulation or a secondary insulation layer. The secondary insulation layer can be either on the interior or exterior (hybrid warm roof) if the primary framing is also insulated.

4.0.2 A secondary insulation layer (Figure 3) can have the benefit of reducing thermal bridging if the framing for this is fixed at right angles to the rafters or if it is a homogeneous insulation layer without framing. You can find more details about secondary insulation layers in the ER70 PHINZ *High-performance construction details handbook*.

5 INSULATION MATERIALS

5.0.1 The significantly increased construction R-values required of roofs means that a wider range of insulation products and materials is likely to be used in future. For example, there are some products that are very dense and have a higher level of thermal performance than other materials of the same thickness. There are also a newer generation of insulation materials that can have lower thermal conductivity than the ones typically available (or considered cost-effective) in the past.

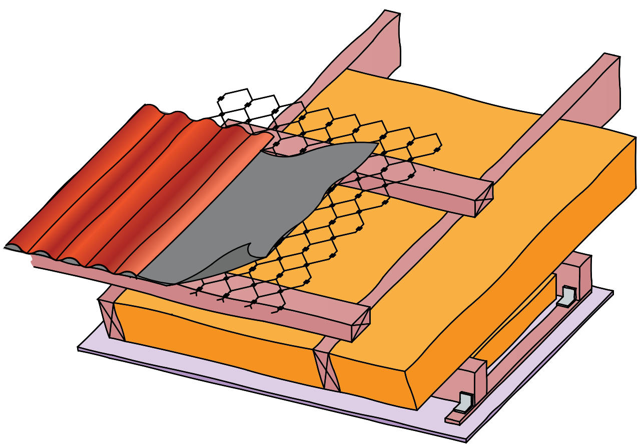

Figure 3. Skillion roof with secondary insulation layer.

5.0.2 Always specify materials that are designed for roof spaces. Materials currently on the market for roof insulation include:

- glass wool segments or rolls
- polyester segments or rolls
- blends of polyester and sheep's wool segments or rolls
- polystyrene panels – typically EPS (expanded polystyrene) but XPS (extruded polystyrene) roof insulation products also exist
- loose fill – glass wool, mineral wool, sheep's wool or treated macerated paper
- rigid insulation – many different types exist, including materials such as rock wool, polyurethane, polyisocyanurate and phenolic
- proprietary composite panels that incorporate both insulation and roof cladding.

5.0.3 Rigid products used with framed construction should be used in a continuous manner. It is too difficult to cut accurately and not create a pathway for moisture – air leaks around the perimeter – but very little drying capacity going back the other way. (For an example of potential problems, see MBIE Determination 2021/012.)

5.0.4 H1/AS1 and H1/VM1 do not include the use of foil insulation.

5.0.5 Some manufacturers and suppliers allow for the installation of insulation in two layers, one sitting directly on the other. This typically produces a total R-value that is less than double the R-value of a single layer because of the compression in the materials. If you plan to use this approach, obtain information from the manufacturer/supplier about how to calculate the R-value. Check also for installation guidance from the manufacturer – for example, with blanket-type products, the top blanket layer is typically laid at right angles to the bottom layer.

5.0.6 BRANZ and insulation manufacturers do not recommend that different types of insulation or products from different manufacturers are placed one on top of the other in an attempt to increase the R-value. The actual R-value achieved by this will be very difficult to calculate, and there may be a risk of condensation problems between the two products. Obtaining building consent may also be difficult with this approach.

5.0.7 Consider the greenhouse gas emissions produced in the manufacture of insulation materials – their embodied carbon footprints. The BRANZ online carbon tool CO_2NSTRUCT is one place to find data about this. BRANZ recommends taking a whole-of-life approach in considering where a material sits in terms of carbon. Two examples to consider:

- Where was the insulation manufactured and what energy sources were used? Some overseas countries rely much more on energy from non-renewable resources than New Zealand.
- There can be big differences between materials at the end-of-life stage. Some can be almost completely recycled into new materials, which is ideal, while others can, at the moment, only be taken to landfill.

6 INSTALLING INSULATION

6.0.1 Just specifying insulation materials with a sufficient R-value for the construction is not enough to comply with the Building Code using H1/AS1 and H1/VM1. Insulation must be installed in a way that achieves its intended thermal performance. NZS 4246:2016 *Energy efficiency – Installing bulk thermal insulation in residential buildings* sections 5, 6, 7 and 10 are directly referenced as providing acceptable methods for installing bulk thermal insulation in light timber-framed and steel-framed residential buildings. Section 6 in the standard is the one referring to ceilings and roofs.

6.0.2 As before, there is a requirement for a minimum 25 mm clearance between insulation and roofing or flexible roof underlay to prevent moisture being wicked to the insulation. (This requirement is in NZS 4246:2016 section 6.2.10.)

6.0.3 Difficulty achieving this clearance can occur around the perimeter of the roof where the ceiling and roof planes converge. A possible method for ensuring this clearance is to use what is commonly referred to as an insulation baffle. These are typically plywood (or similar) sheets fixed to the upper edge of the rafter or top chord of the roof truss. BRANZ is aware of the use of these in the New Zealand context and overseas as well. With respect to the roof insulation requirements of H1 5th edition, careful consideration needs to be given to durability in certain situations as the heatflows that have traditionally aided in drying are reduced. Further guidance is the subject of ongoing research.

7 IMPORTANCE OF THE AIR BARRIER

7.0.1 It is important for designers to pay close attention to the quality of the ceiling air barrier. Any gaps where air (and moisture carried with the air) can move from living spaces through to the roof space can lead to problems with condensation and potentially mould or corrosion/decay in the colder roof space. BRANZ is seeing failures in relatively new construction from internal moisture-laden air reaching the roof space. Raising thermal performance (as the 5th edition of the H1 documents does) is likely to raise the risk of condensation forming in the roof space as there is less heatflow to the roof space, leading to colder roof decks as well as reduced drying capacity.

7.0.2 Sources of air leakage into the roof space include:

- recessed downlights – while older models were very air-leaky, there are some models of recessed downlight available today that are much more airtight
- access hatches – poorly constructed, they can have gaps that allow air movement, but there are proprietary access hatches on the market with good air seals and insulation that are one potential solution
- poorly installed ventilation systems – bathroom, kitchen and laundry extracts must be ducted to the outside of the building
- light and electrical fittings other than recessed downlights or ventilation
- poorly installed plumbing services such as a hot water pipe that goes through the ceiling of a hot water cupboard into the roof space
- poorly fitted scotias.

7.0.3 The recommended approach is to minimise the penetrations in the ceiling, and where the ceiling is penetrated for lighting or ventilation or another type of appliance, the appliance specified must have good air seals. Square-stopped wall/ceiling junctions also help reduce moisture movement.

7.0.4 The issue is set out in H1/AS1 in a comment under 2.2.1.1: "Measures should be taken to limit the amount of moisture that can migrate from occupied spaces into the roof or roof space. This includes limiting the air permeability of ceilings, including through ceiling linings and penetrations such as recessed luminaires, electrical and plumbing services, and ceiling access hatches."

7.0.5 Another approach to tackling this problem is to design a warm roof. With a warm roof, the insulation is part of the building envelope – the insulation is directly attached to the roofing product. The roofing material could be a membrane product or an insulated panel product, which usually sees the insulation product sandwiched between metal sheets. This means that the roof structure and roof space are at a similar temperature to the building interior, reducing the potential for condensation. Other benefits of warm roofs include reducing the thermal losses in the roof space ducting of heat recovery ventilation systems.

8 VENTILATION

8.0.1 Poorly ventilated houses with a large amount of excess moisture raise the risk of accumulation of moisture in the roof cavity.

8.0.2 Building Code clause G4 *Ventilation* requires that spaces within buildings have adequate ventilation for their intended use and occupancy, have adequate fresh air and have means to remove moisture, products of combustion and other airborne contaminants. Acceptable Solution G4/AS1 states: "Within this acceptable solution, natural ventilation … on its own is not adequate to remove moisture generated from cooktops, showers and baths." G4/AS1 section 1.3.3 requires that kitchens and bathrooms in housing must have mechanical extract fans installed to remove moisture, and the fans must exhaust air to the outside.

9 SKYLIGHTS

9.0.1 Under H1/AS1 and H1/VM1, all skylights in housing are required to achieve a minimum R0.37 from 3 November 2022. From 1 May 2023, the minimum rises to R0.46 in climate zones 1 and 2, R0.54 in climate zones 3 and 4 and R0.62 in climate zones 5 and 6. (The construction R-values of R0.46/0.54/0.62 apply to buildings up to 300 m^2 other than housing from 3 November 2022.)

9.0.2 The way the thermal resistance and construction R-value of skylights is calculated has been updated to better reflect their thermal performance.

9.0.3 Guidance for calculating the construction R-value of skylights is given in Appendix E in H1/AS1 and H1/VM1. There is no table showing construction R-values of generic skylights. H1/AS1 and H1/VM1 require skylight R-value calculations to consider the effects of horizontal or angled glazing on the heat transfer. The performance reduction for inclined IGUs means that the values in H1/AS1 Table E.1.1.1 for vertical windows are not representative of performance values for skylight frame and glazing combinations. Designers should check that the supplier's claimed skylight R-values have indeed been determined in accordance with H1/AS1 or H1/VM1 (it is the same method in both documents).

9.0.4 Ideally, any skylights installed will sit flush within the roof plane, which is likely to give the best thermal performance. Skylights where part of the framing sits proud of the roof obviously have the potential for greater heat losses.

9.0.5 While skylights can increase natural daylighting in a house, they have two major drawbacks – over a full year, they very often lose more energy than they gain, yet in summer months, they can contribute to a house overheating. Consider carefully the balance of benefits and drawbacks of skylights and what other lighting options are possible.

10 RESOURCES

BRANZ

BRANZ *House insulation guide* (6th edition)

ER70 PHINZ *High-performance construction details handbook* (2022)

H1 calculation method tool

MBIE

Building Code clause H1 *Energy efficiency*

NZS 4214:2006 *Methods of determining the total thermal resistance of parts of buildings*

NZS 4246:2016 *Energy efficiency – Installing bulk thermal insulation in residential buildings*

NZGBC

Calculation method tool

ECCHO (Homestar tool)

PHINZ

Passive House Institute NZ PHPP

ANSI/ASHRAE

Standard 140

BESTEST

Building Energy Simulation Test (BESTEST) and Diagnostic Method (1995)

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