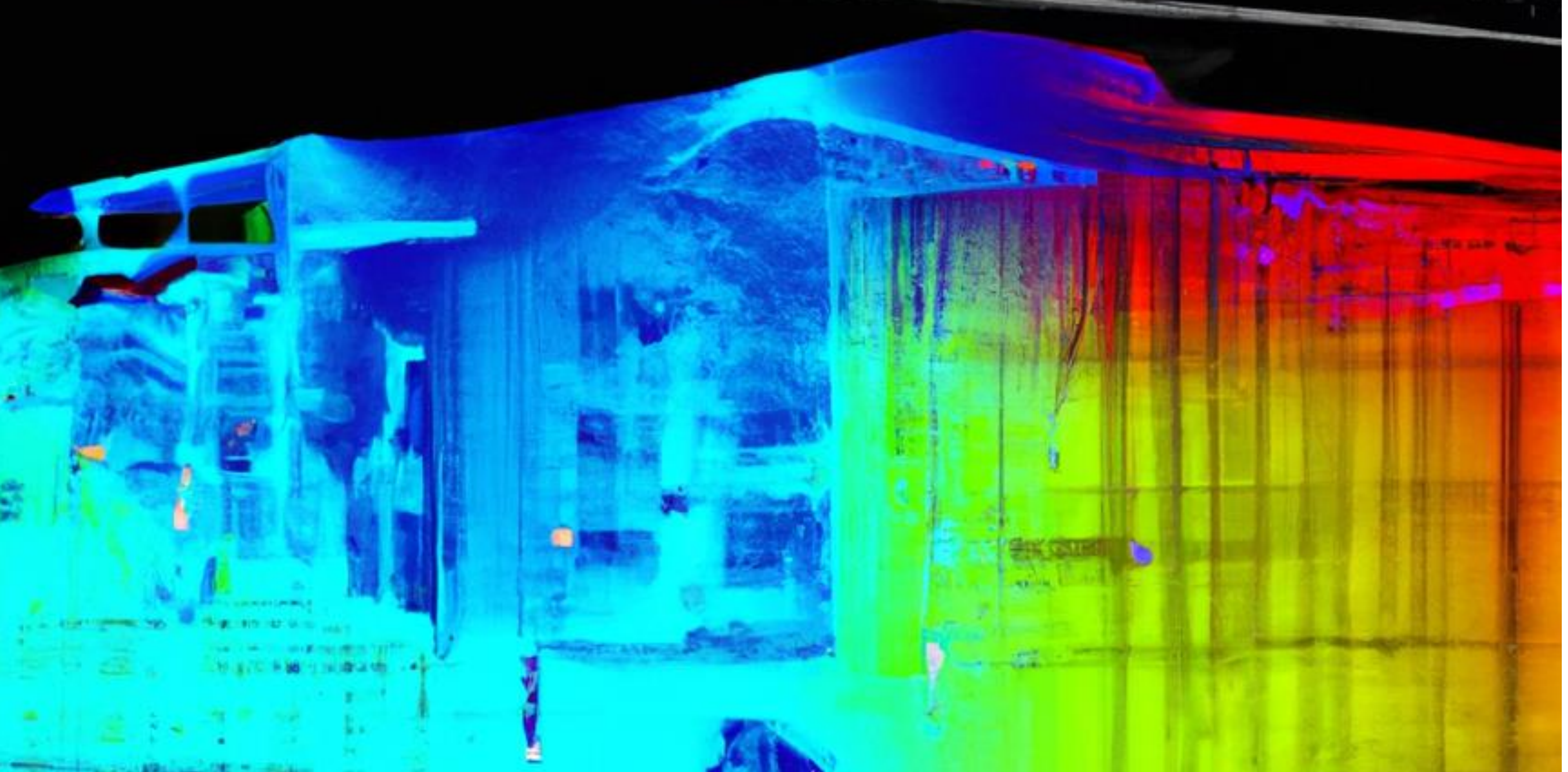
A Review of Thermal Bridging Mitigation Provisions and Thermal Break Provisions NCC 2022



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Executive Summary

LittleShrub Pty Ltd has been commissioned by the Australian Building Codes Board to conduct a comprehensive review of the National Construction Code (NCC) 2022 thermal bridging mitigation provisions. The focus of the review is on the interaction between the new provisions in clauses 13.2.5(4) and 13.2.3(3)(b) and the existing provisions of the code.

Section 1 of the review focuses on the existing thermal break provisions. It examines the necessity of thermal breaks in lightweight constructions with entirely metal frames, taking into account various ventilation conditions. The section emphasises that the new thermal bridging mitigation provisions should not replace the need for thermal breaks, but rather complement them. It presents a series of flowcharts outlining best practices for implementing thermal bridging mitigation based on the findings of the report.

Section 2 addresses the differences in wording between the thermal break requirements specified in Section J and the Housing Provisions. It concludes that despite the variations in wording, the functional requirements of both sets of clauses are essentially the same. Therefore, it suggests interpreting these provisions with a consistent understanding. Additionally, this section highlights the absence of thermal bridging mitigation options for walls and proposes potential solutions to address this gap.

Section 3 delves into the treatment of sandwich panels in walls. It establishes a compliance path for walls that incorporate sandwich panels, which aligns with the requirements for other lightweight wall constructions. However, it emphasises that the thermal bridging provisions for sandwich panels are limited to calculating the Total R-Value in accordance with AS/NZS 4859.2 and referencing Table 13.2.5q.

The review provides valuable insights and recommendations for improving the effectiveness and clarity of the thermal bridging mitigation provisions in the NCC 2022. The findings will inform future updates and refinements to ensure consistent and appropriate application of the code.

Background

LittleShrub Pty Ltd has been engaged by the Australian Building Codes Board (ABCB) to assess the degree of overlap between the existing thermal break provisions and the new provisions aimed at mitigating thermal bridging in the National Construction Code 2022 (NCC 2022). All types of constructions that require thermal breaks also require one of the thermal bridging mitigation provisions, but not all thermal bridging mitigation provisions require a thermal break. Therefore, identifying the instances of the types of constructions that require a thermal break confines the scope of this project.

Definitions

The following definitions are provided to facilitate the discussion in this report. However, "thermal bridge", "thermal break" and "thermal bridging mitigation" are not defined terms in the NCC.

Thermal bridge: is a pathway of low thermal resistance in comparison to the rest of the representative construction.

Thermal break: is a material of relatively low thermal conductivity that is strategically located in the pathway(s) of least thermal resistance to lessen the detrimental effects of a bridge.

Thermal bridging mitigation: refers to additional strategies required, specific to certain construction types, to compensate for highly bridged envelope components.

Section 1- Review of NCC 2022 to determine the extent to which thermal bridging and thermal break provisions overlap

Background

With the introduction of NCC 2022 there has been some discussion within industry with respect to the existing thermal break provisions that were present in NCC 2019 and the introduction of the new thermal bridging provisions of NCC 2022 Volume Two. The conversation is centred on whether to use the provisions in conjunction with one another, or in substitution of one another. This review will focus on the intent and objectives of each provision and provide guidance on how to navigate the provisions.

The intent of thermal bridging mitigation clauses in NCC 2022 is to ensure that overall thermal performance of a metal-framed construction element such as a wall, roof or floor is at least 90% - 95% of a timber-framed equivalent. The intention of thermal break provisions is to avoid the worst effects of localised excessive thermal conductance through a thermal bridge, as well as improving overall thermal performance.

Research Goals

- Determine the extent to which thermal breaks and thermal bridging mitigation overlap and determine if both are required
- Determine when each provision is required
- Review the effectiveness and limitations of the thermal bridging mitigation provisions
- Discuss avenues for refinements to thermal break mitigation provisions for NCC 2025

Research Scope

This research is limited to the overlap of thermal break and thermal bridging mitigation provisions. Where there are thermal bridging mitigation provisions that do not meet the definition of either 13.2.5(5) or 13.2.3(7) they will be excluded from scope.

Identifying a thermal bridge

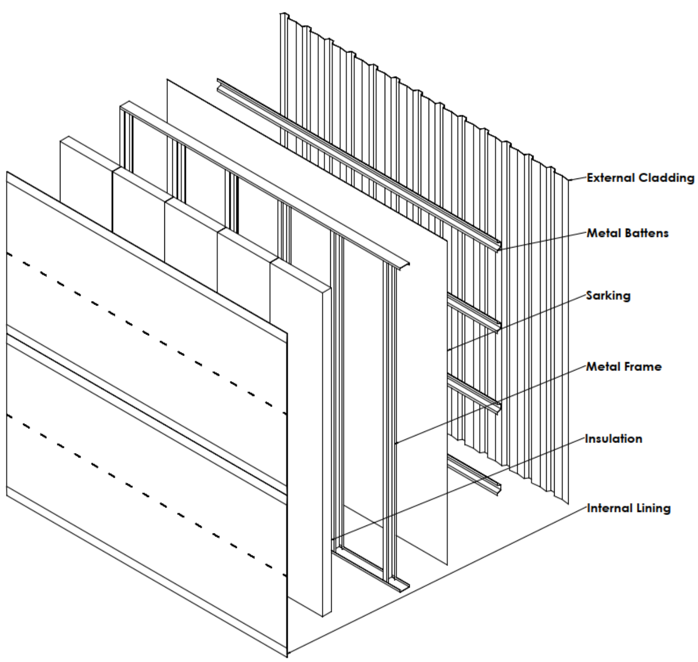
For better context, it is useful to be able to identify a thermally bridged pathway. In some envelope systems, this is easy to identify, such as in a lightweight wall where both the cladding and internal lining are fixed to the same studs (i.e., direct fix). In this instance, there are two pathways of heat flow:

1. Through the frame,
2. Through the insulation.

With the introduction of more framing elements, there are more complex thermal bridging pathways. For instance, consider a lightweight clad wall with metal battens perpendicular to the frame (Figure 1). This type of frame would have four distinct thermal pathways (Figure 2).

1. Through the air-space and insulation,
2. Through metal battens and insulation,
3. Through the air-space and metal studs,
4. Through the metal battens and metal studs.

From the descriptions above, it is possible to deduce the thermally bridged layers: those layers without insulation, or pathway 3 and 4.



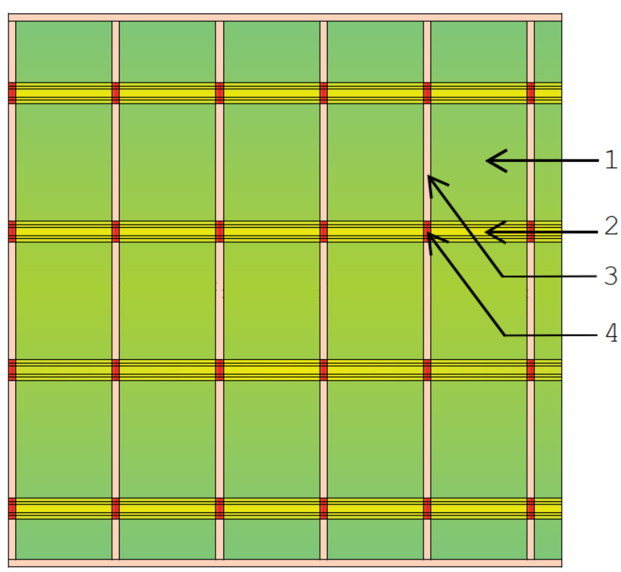


Figure 1 (Left) - Lightweight clad wall with metal frame and metal battens

Figure 2 (Right) - Thermal impression, lightweight clad wall with metal frame and metal battens. Thermal pathways numbered.

The more complex the framing system, the more challenging it may be to deduce the thermally bridged pathway(s). Therefore, relying on an analytical means of determining these thermally bridged paths might be more appropriate. AS/NZS 4859.2: 2018 (4859.2) provides a process for determining the thermal resistance of bridged areas by effectively area weighting the thermal resistance of those pathways. The method within 4859.2 uses the isothermal planes method to separate the bridged zones. In this method, the thermal resistance of the bridged zones between the homogeneous internal and external layers is determined. These values are then added to the thermal resistance of the internal and external homogeneous layers, as well as the air-film resistance, to determine the total R-Value. This process can be illustrated schematically in Figure 3.

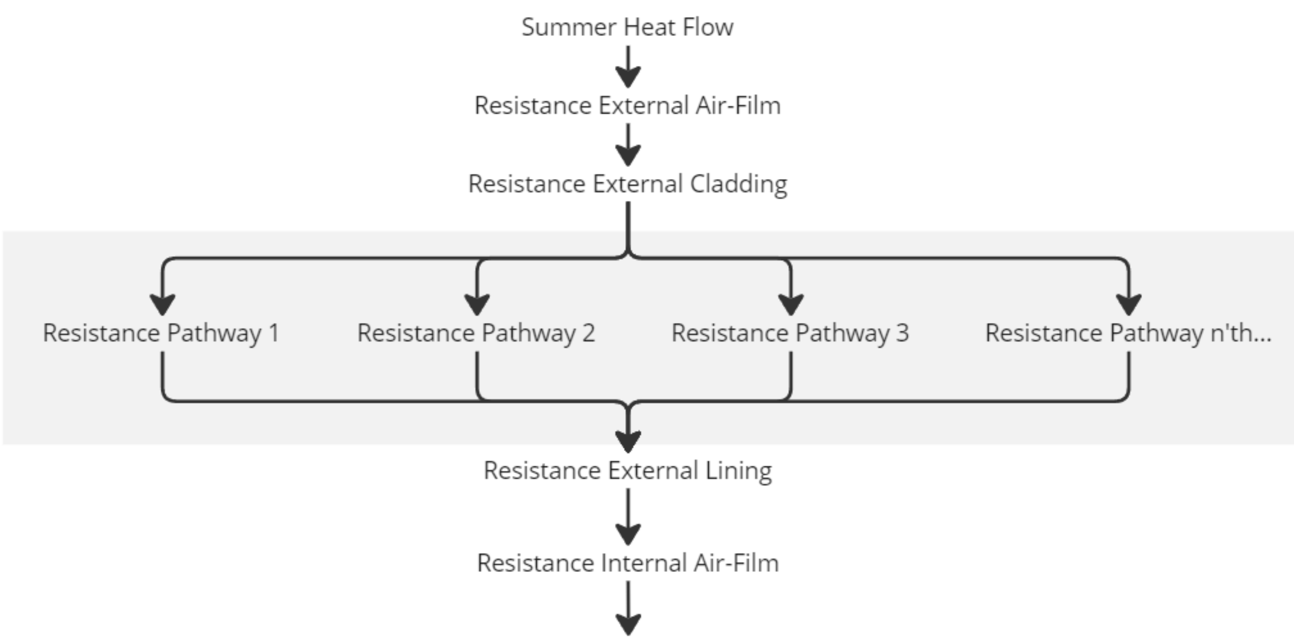


Figure 3 – Schematic diagram of heat flow using isothermal planes method

To demonstrate the analytic means of determining thermally bridged paths in more detail, consider the calculation presented in Table 1. The calculation in this table is representative of the diagram shown in Figure 1. The area of the calculation that has a background of grey corresponds to the bridged components and correlates to the grey background in Figure 3. It is demonstrated in Table 1 that pathway 3 and pathway 4 have the lowest thermal resistance. Therefore, this confirms the previous statement, and it is these pathways that are considered bridged, as they have significantly lower thermal resistance compared to pathway 1 and 2. 4859.2 is particularly useful for more complicated systems with more than four thermally bridged pathways.

In conclusion, in this scenario, wherever the metal stud frame exists, there is a thermal bridge.

Separate gradients	Winter	Summer			
Pathway 1 (80.8385%)	**R-value**	**R-value**	**mm**	**eIn**	**eOut**
Outdoor air-film (90°)	0	0	0	0	0.9
Fibre Cement (R0.024)	0	0	6	0.9	0.9
1500mm² Ventilated air-space (90°/90°)	0.04	0.04	28	0.9	0.9
Sarking e0.9/e0.9 (R0.000)	0	0	1	0.9	0.9
Unventilated air-space (90°/90°)	0	0	2	0.9	0.9
90mm Glasswool R2.0 (R2.000)	2.106	1.913	90	0.9	0.9
Plasterboard 10mm (R0.059)	0.059	0.059	10	0.9	0.9
Indoor air-film (90°)	0.12	0.12	0	0.9	0
Total	**2.325**	**2.132**	**137**		

Pathway 2 (7.3490%)	**R-value**	**R-value**	**mm**	**eIn**	**eOut**
Outdoor air-film (90°)	0	0	0	0	0.9
Fibre Cement (R0.024)	0	0	6	0.9	0.9
50mm flange x 1.15 Top Hat (R0.013)	0.013	0.013	28	0.9	0.9
Sarking e0.9/e0.9 (R0.000)	0	0	1	0.9	0.9
Unventilated air-space (90°/90°)	0	0	2	0.9	0.9
90mm Glasswool R2.0 (R2.000)	2.106	1.912	90	0.9	0.9
Plasterboard 10mm (R0.059)	0.059	0.059	10	0.9	0.9
Indoor air-film (90°)	0.12	0.12	0	0.9	0
Total	**2.298**	**2.104**	**137**		

Pathway 3 (10.8281%)	**R-value**	**R-value**	**mm**	**eIn**	**eOut**
Outdoor air-film (90°)	0	0	0	0	0.9
Fibre Cement (R0.024)	0	0	6	0.9	0.9
1500mm² Ventilated air-space (90°/90°)	0.04	0.04	28	0.9	0.9
Sarking e0.9/e0.9 (R0.000)	0	0	1	0.9	0.9
92mm x 45 x 1.15 Steel Stud (R0.076)	0.076	0.076	92	0.9	0.9
Plasterboard 10mm (R0.059)	0.059	0.059	10	0.9	0.9
Indoor air-film (90°)	0.12	0.12	0	0.9	0
Total	**0.295**	**0.295**	**137**		

Pathway 4 (0.9844%)	**R-value**	**R-value**	**mm**	**eIn**	**eOut**
Outdoor air-film (90°)	0	0	0	0	0.9
Fibre Cement (R0.024)	0	0	6	0.9	0.9
50mm flange x 1.15 Top Hat (R0.013)	0.013	0.013	28	0.9	0.9
Sarking e0.9/e0.9 (R0.000)	0	0	1	0.9	0.9
92mm x 45 x 1.15 Steel Stud (R0.076)	0.076	0.076	92	0.9	0.9
Plasterboard 10mm (R0.059)	0.059	0.059	10	0.9	0.9
Indoor air-film (90°)	0.12	0.12	0	0.9	0
Total	**0.267**	**0.267**	**137**		

Totals			
Elements	**R-value**	**R-value**	**mm**
Total	0.865	0.846	

Separate gradients	Winter	Summer			
Pathway 1 (80.8385%)	**R-value**	**R-value**	**mm**	**eIn**	**eOut**
Outdoor air-film (90°)	0	0	0	0	0.9
Fibre Cement (R0.024)	0	0	6	0.9	0.9
1500mm² Ventilated air-space (90°/90°)	0.04	0.04	28	0.9	0.9
Sarking e0.9/e0.9 (R0.000)	0	0	1	0.9	0.9
Unventilated air-space (90°/90°)	0	0	9	0.9	0.9
90mm Glasswool R2.0 (R2.000)	2.106	1.913	90	0.9	0.9
Plasterboard 10mm (R0.059)	0.059	0.059	10	0.9	0.9
Indoor air-film (90°)	0.12	0.12	0	0.9	0
Total	**2.325**	**2.132**	**144**		

Pathway 2 (7.3490%)	**R-value**	**R-value**	**mm**	**eIn**	**eOut**
Outdoor air-film (90°)	0	0	0	0	0.9
Fibre Cement (R0.024)	0	0	6	0.9	0.9
50mm flange x 1.15 Top Hat (R0.013)	0.013	0.013	28	0.9	0.9
Sarking e0.9/e0.9 (R0.000)	0	0	1	0.9	0.9
Unventilated air-space (90°/90°)	0	0	9	0.9	0.9
90mm Glasswool R2.0 (R2.000)	2.106	1.912	90	0.9	0.9
Plasterboard 10mm (R0.059)	0.059	0.059	10	0.9	0.9
Indoor air-film (90°)	0.12	0.12	0	0.9	0
Total	**2.298**	**2.104**	**144**		

Pathway 3 (10.8281%)	**R-value**	**R-value**	**mm**	**eIn**	**eOut**
Outdoor air-film (90°)	0	0	0	0	0.9
Fibre Cement (R0.024)	0	0	6	0.9	0.9
1500mm² Ventilated air-space (90°/90°)	0.04	0.04	28	0.9	0.9
Sarking e0.9/e0.9 (R0.000)	0	0	1	0.9	0.9
Thermal Break R0.2 (R0.200)	0.2	0.2	7	0.9	0.9
92mm x 45 x 1.15 Steel Stud (R0.076)	0.076	0.076	92	0.9	0.9
Plasterboard 10mm (R0.059)	0.059	0.059	10	0.9	0.9
Indoor air-film (90°)	0.12	0.12	0	0.9	0
Total	**0.495**	**0.495**	**144**		

Pathway 4 (0.9844%)	**R-value**	**R-value**	**mm**	**eIn**	**eOut**
Outdoor air-film (90°)	0	0	0	0	0.9
Fibre Cement (R0.024)	0	0	6	0.9	0.9
50mm flange x 1.15 Top Hat (R0.013)	0.013	0.013	28	0.9	0.9
Sarking e0.9/e0.9 (R0.000)	0	0	1	0.9	0.9
Thermal Break R0.2 (R0.200)	0.2	0.2	7	0.9	0.9
92mm x 45 x 1.15 Steel Stud (R0.076)	0.076	0.076	92	0.9	0.9
Plasterboard 10mm (R0.059)	0.059	0.059	10	0.9	0.9
Indoor air-film (90°)	0.12	0.12	0	0.9	0
Total	**0.467**	**0.467**	**144**		

Totals			
Elements	**R-value**	**R-value**	**mm**
Total	1.447	1.385	

Table 1 (Left) – 4859.2 Calculation of lightweight clad wall with metal battens, no thermal break and a ventilated cavity

Table 2 (Right) – 4859.2 Calculation of lightweight clad wall with metal battens, with thermal break and a ventilated cavity

Note: The calculations in these tables, the battened cavity is assumed to be ventilated. This is common practice to prevent build-up of moisture, even if not a requirement of the NCC. Accordingly, the cavity makes a minimal contribution to the Total R-Value and the materials to the outside of the cavity make no contribution to the R-Value. The significance of assumptions about ventilation is considered further in section Effects of ventilation of this report.

Walls

Provisions in review

13.2.5

(5)

(5) A metal-framed wall that forms part of the building *envelope* must have a thermal break, consisting of a material with an *R-Value* of not less than R0.2, installed at all points of contact between the external cladding and the metal frame if the wall—

(a) does not have a wall lining or has a wall lining that is fixed directly to the metal frame; and

(b) is clad with weatherboards, fibre-cement or the like, or metal sheeting fixed to the metal frame.

Note: 13.2.5(5) serves as the main intersection point of this review and confines the scope of this report. To be included in scope, a thermal bridging mitigation provision must also meet the definition of 13.2.5(5).

(4)

(4) The thermal bridging in a metal-framed wall must be addressed by—

(a) achieving the *Total R-Value* in Tables 13.2.5p, 13.2.5q and 13.2.5r, calculated in accordance with AS/NZS 4859.2; or

(b) complying with one of the options in Tables 13.2.5s, 13.2.5t and 13.2.5u.

Note: Table 13.2.5p, 13.2.5r, 13.2.5s and 13.2.5u are not caught by clause 13.2.5(5) as they related to heavyweight walls or masonry veneer walls and therefore fall out of scope of this analysis

Table 13.2.5q

Table 13.2.5q: Lightweight metal-framed walls: minimum Total R-Value to account for thermal bridging

Wall insulation *R-Value required* in accordance with 13.2.5(2)	Minimum *Total R-Value* to account for thermal bridging
1.0	1.32
1.5	1.64
2.0	1.89
2.5	2.06
2.7	2.15
≥3.0	2.27

Table Notes

(1) Where the wall insulation *R-Value* from Tables 13.2.5b, 13.2.5c, 13.2.5d, 13.2.5e, 13.2.5f, 13.2.5g, 13.2.5h, 13.2.5i, 13.2.5j, 13.2.5k, 13.2.5l, 13.2.5m, 13.2.5n and 13.2.5o falls between the values shown in this Table, the *required Total R-Value* may be interpolated.

(2) Minimum *Total R-Values* are in-situ values. They account for compression of insulation.

Table 13.2.5t

Table 13.2.5t: Lightweight metal-framed walls – thermal bridging mitigation

Wall insulation *R-Value* from Tables 13.2.5a to 13.2.5o	Thermal bridging mitigation
0 or reflective	Not required
>0 to ≤1.5	Either install *reflective insulation* outside the frame to create a minimum 20 mm reflective airspace between frame and cladding, or increase insulation between frames by R0.5.
>1.5	Either install *reflective insulation* outside the frame to create a minimum 20 mm reflective airspace between frame and cladding, or add a layer of continuous insulation with an *R-Value* of at least R0.30 on the inside or the outside of the frame.

Table Notes

(1) Minimum *R-Values* are in-situ values. They account for compression of insulation.

(2) The surface emittance of a reflective surface facing an airspace must be a maximum of 0.1.

Review of 13.2.5 – Thermal Break Provisions

Current clause wording of (5)

This section will review the current wording of 13.2.5(5) and seek to interpret the influence of the current wording in terms of its functional application. One potential area of interpretation is related to the phrase "metal-framed" in the sentence "*A metal-framed wall that forms part of the building envelope must have a thermal break...".* A key question for code users is; if a metal stud frame wall has metal battens, then are the metal battens considered part of the “metal-frame” and therefore does the thermal break requirement apply?

NCC 2022 does not provide a definition for "metal-frame". To answer this question from a grammatical perspective, it is useful to reword the clause by incorporating dictionary definitions of critical words to better define their meaning.

The most critical word in this sentence is “framed”.

- Frame is defined as: “*the rigid supporting structure of an object such as a vehicle, building, or piece of furniture”.*
- Structure is defined as *“the arrangement of and relations between the parts or elements of something complex”*

By combining these definitions, the phrase "A metal-framed wall that forms..." in 13.2.5(5) can be reworded as “A metal rigid supporting structure of parts or element of something complex that forms part of the building envelope must have a thermal break...”

To further clarify, clause 13.2.5 makes distinctions among three components:

- Metal-frame
- Lining (assuming it is present)
- Cladding

Therefore, through the process of elimination, the "metal-frame" must exclude the lining and cladding components. It is now possible to deduce that the metal-frame refers to the metal, rigid supporting structure. This definition would include the metal battens, and as a result, the thermal break requirements apply to any frame, with or without battens, that consists of an entirely metal frame. However, this analysis is purely grammatical, and further evidence of the importance of a thermal break will be explored analytically in the Effects of a thermal break section.

Analytical analysis of thermal breaks

General Assumptions

To consider the impact of thermal breaks analytically in the scenario illustrated in Figure 1, it is critical to discuss the impacts of cavity ventilation. In this review, LittleShrub analysed the values used by the ABCB, Nationwide House Energy Rating Scheme (NatHERS), and the National Association of Steel Framed Housing (NASH) for the air-space in this situation, assuming the air-space is bound by non-reflective surfaces. All three bodies seemingly used values that are attributed to unventilated air-spaces bound by non-reflective surfaces rather than ventilated air-spaces. This assumption will likely result in the overstatement of the total thermal resistance, as will be explored in the Effects of ventilation and is tightly coupled to the effectiveness of thermal breaks.

Effects of ventilation

Defining ventilation

In the case of a lightweight metal frame wall with metal battens, an important calculation assumption that needs to be determined is whether the cavity formed by the battens is considered ventilated.

In accordance with 4859.2 Clause 4.2, a well-ventilated air-space in a wall is considered to have an aggregated opening area of 1500mm² per metre. Lightweight clad walls on battens can be considered well-ventilated, unventilated, or somewhere in between. For instance, lightweight walls usually have continuous drainage cavities at the bottom side of the cladding. If the battens are vertical, then there is no compartmentalisation of the air-space for the length of the wall, and these would be considered well-ventilated.

Similarly, if the battens are horizontal but the cladding is vertically profiled, such as a corrugated metal sheet, there is also no compartmentalisation of the air-space for the length of the wall, and these would be considered well-ventilated. This is because airflow is permitted at a level greater than 1500mm² per metre through the ridges of the corrugations.

However, if a flat fibre cement sheet is used as the cladding and there are horizontal battens, then it is possible to achieve compartmentalisation of the air-space, and an unventilated air-space is formed. It is not the purpose of this advisory document to discuss all possible scenarios. When there is doubt, a well-ventilated air-space should be adopted as the conservative assumption.

Analysis of ventilation of air-spaces in a lightweight clad wall with battens

Consider the wall in Figure 4. To assess the effectiveness of ventilation, we will consider the following scenarios using AS/NZS 4859.2:

Without thermal break

- Unventilated with
  - R1.5 insulation
  - R2.0 insulation
  - R2.5 insulation
- Ventilated with
  - R1.5 insulation
  - R2.0 insulation
  - R2.5 insulation

With thermal break

- Unventilated with
  - R1.5 insulation
  - R2.0 insulation
  - R2.5 insulation
- Ventilated with
  - R1.5 insulation
  - R2.0 insulation
  - R2.5 insulation

All cases have a membrane/sarking with high emissivity (e0.9/e0.9) on both sides; thus, the air-space is considered to be bound by non-reflective surfaces. The thermal break being utilised is a strip-type thermal break that matches the width of the studs and is located between the metal studs and sarking.

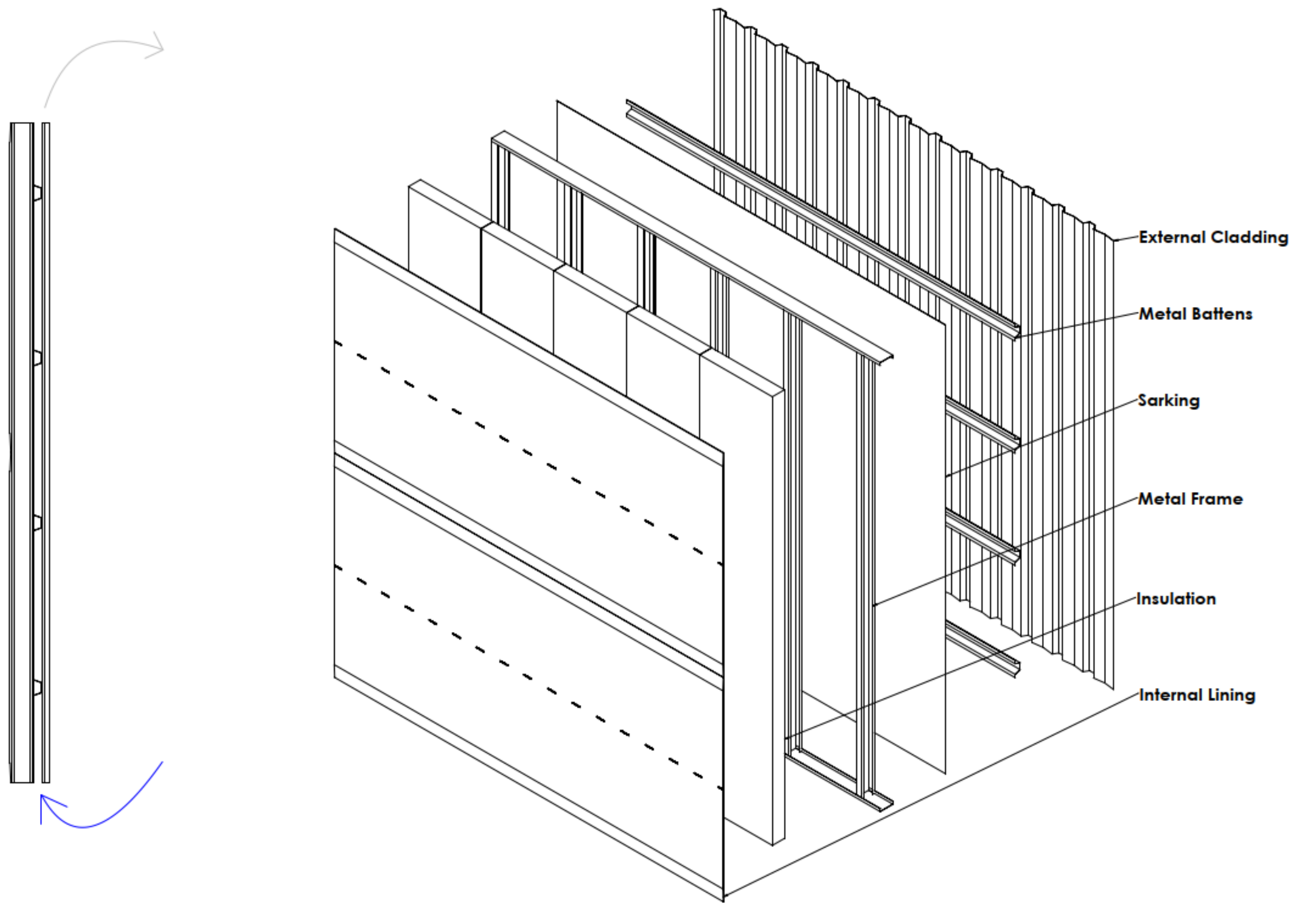


Figure 4 – Ventilated lightweight metal frame wall with metal battens

As indicated in Figure 5, if:

- the air-space does not have a thermal break, ventilating the air-space reduces the Total R-Value by approximately 30%,
- the air-space has a thermal break, ventilating the air-space reduces the Total R-Value by only approximately 15%.

This plot demonstrates the tightly coupled dynamic between thermal breaks and the ventilation of an air-space bound by non-reflective surfaces. Both unventilated and ventilated cavities experience a significant reduction in the Total R-Value without a thermal break. It can also be inferred that as the insulation R-Value increases, so does the importance of the thermal break.

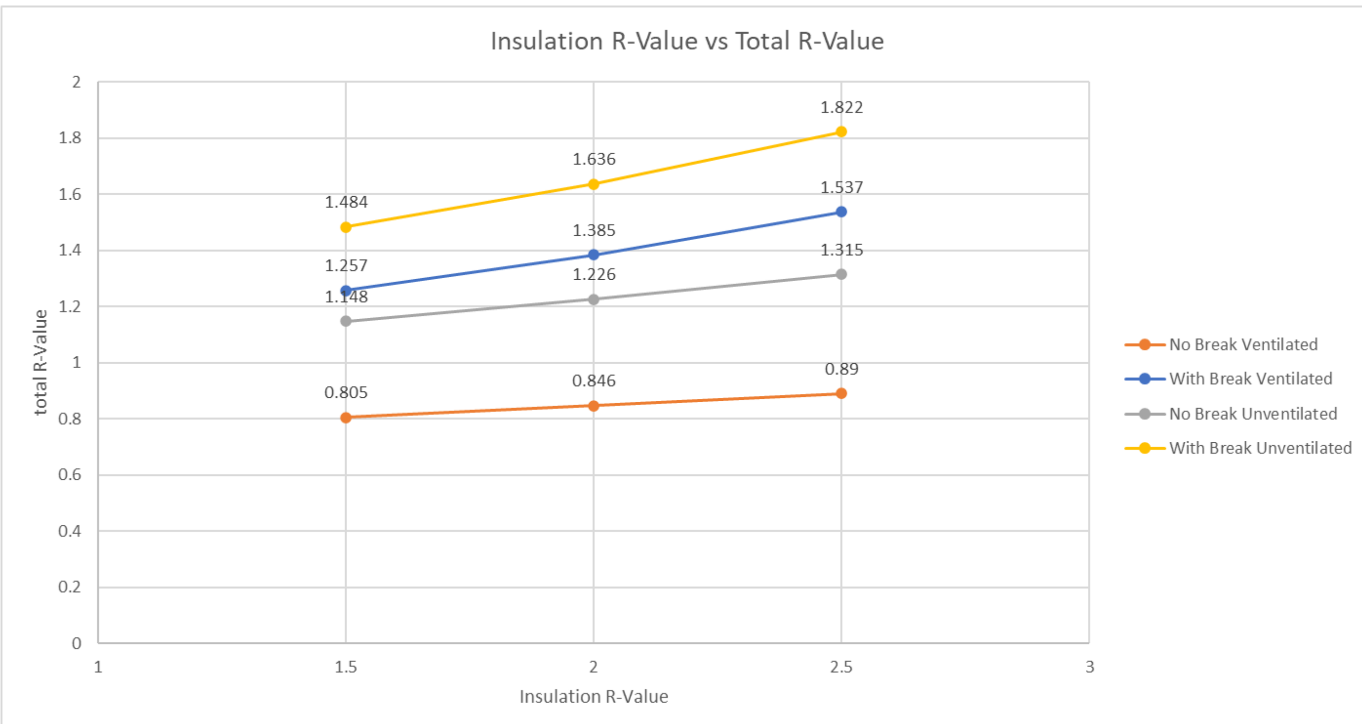


Figure 5 – Effects of ventilation and thermal breaks on the Total R-Value

Effects of a thermal break

Figure 5 allows for a comparison between the total thermal resistance of the same wall construction with and without a thermal break (Figure 6). The significance of a thermal break, whether with or without a ventilated air-space, cannot be underestimated. As demonstrated in Figure 6, the modelled scenario shows a minimum 23% reduction in the Total R-Value, highlighting the crucial role of a thermal break, even in wall systems with metal battens.

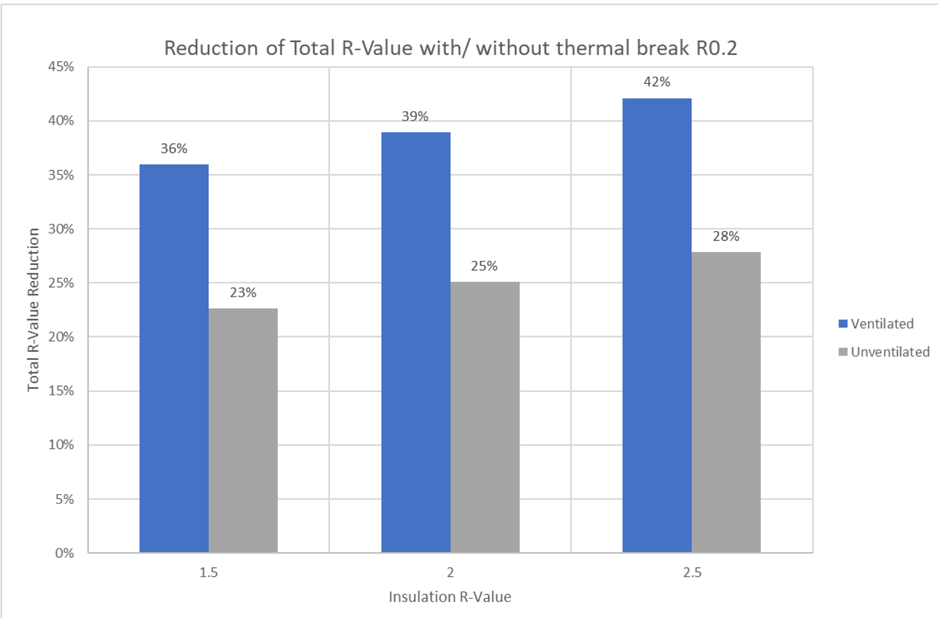


Figure 6 – Reduction of Total R-Value

Summary of thermal break provisions

This section has focused on the significance of the thermal break provision without concurrently considering the thermal bridging mitigation provisions. Analysing the thermal break provisions in isolation is relevant because thermal bridging mitigation, such as the use of a reflective airspace, becomes ineffective if the airspace is ventilated. Hence, a thermal break must be employed when utilising an entirely metal frame (including sub framing components like metal battens) structure with lightweight cladding. To provide clarity, it is recommended that NCC 2025 address this issue by introducing a definition for the term "metal-framed" or by developing guidance material.

Review of 13.2.5(4) – Thermal Bridging Mitigation Provisions

General

The thermal bridging mitigation provisions have been newly introduced to the housing provisions of NCC 2022. In the context of this Research Scope, Clause13.2.5 (5) simply directs users to utilise either Table 13.2.5q or Table 13.2.5t as appropriate.

Table 13.2.5q requires users to complete a Total R-Value calculation in accordance with 4859.2 based on the required insulation R-Value from Table 13.2.5(2). Whereas Table 13.2.5t mandates a prescribed minimum insulation R-Value along with one of three measures.

Methods

Various methods of compliance are available, and a flowchart has been developed for their utilisation. This flowchart and other flowcharts only consider the Research Scope and should not be regarded as a comprehensive list of requirements for any specific development. The foundation of this research was based on the Deemed-to-Satisfy (DtS) elemental provisions within the NCC. While the NatHERS) pathway can be used to satisfy the performance requirements of the NCC, reviewing NatHERS is beyond the scope of this project and has not been incorporated into these flowcharts or research.

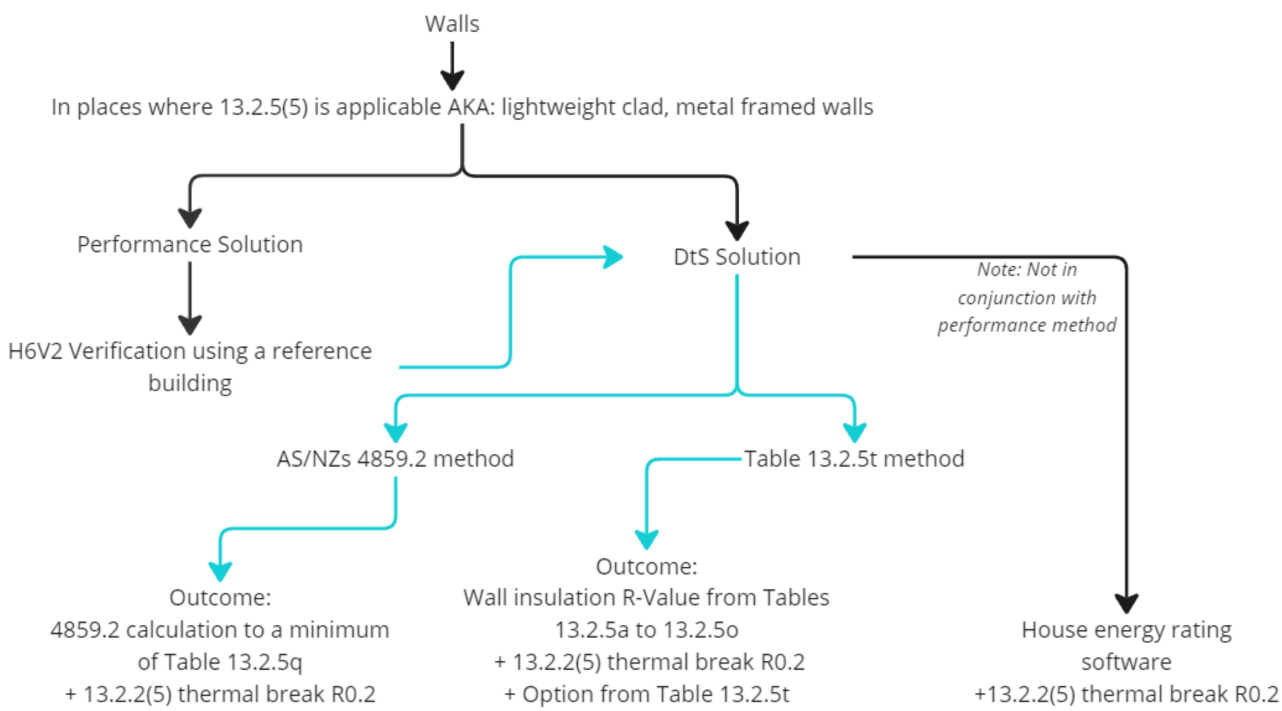


Figure 7 – Flowchart of thermal bridging mitigation provisions for walls

Review of Table 13.2.5q

General

Table 13.2.5q requires performing an AS/NZS 4859.2 calculation to determine the minimum Total R-Values, taking into account thermal bridging. It's important to note that when developing the table, a thermal break was assumed to be in place. As discussed in the No Thermal Break (NB) section of this document, there are limited cases where a thermal break can be omitted while still meeting the minimum requirements of the table. Generally, a thermal break will be a necessary strategy for designers to achieve compliance.

Summary

In NCC 2022 a thermal break is still required for compliance to Table 13.2.5q. However, in future editions of the NCC, it is recommended to exclude the thermal break provision when performing a 4859.2 calculation to provide more flexibility to designers. A thermal break would then likely be an outcome rather than a code requirement

Review of Table 13.2.5t

General

Table 13.2.5t gives three options to mitigate thermal bridging:

1. install reflective insulation outside the frame to create a minimum 20 mm reflective airspace between frame and cladding,
2. increase insulation between frames by R0.5,
3. add a layer of continuous insulation with an R-Value of at least R0.30 on the inside or the outside of the frame.

This section will review these three parts with and without the use of thermal breaks.

Effects of the thermal bridging mitigation provisions

With thermal break (WB)

This section will explore the relative Total R-Value performance of the same wall structure with the three types of thermal bridging mitigation options outlined in Table 13.2.5t. All wall types will include the addition of a thermal break as required by 13.2.5(5).

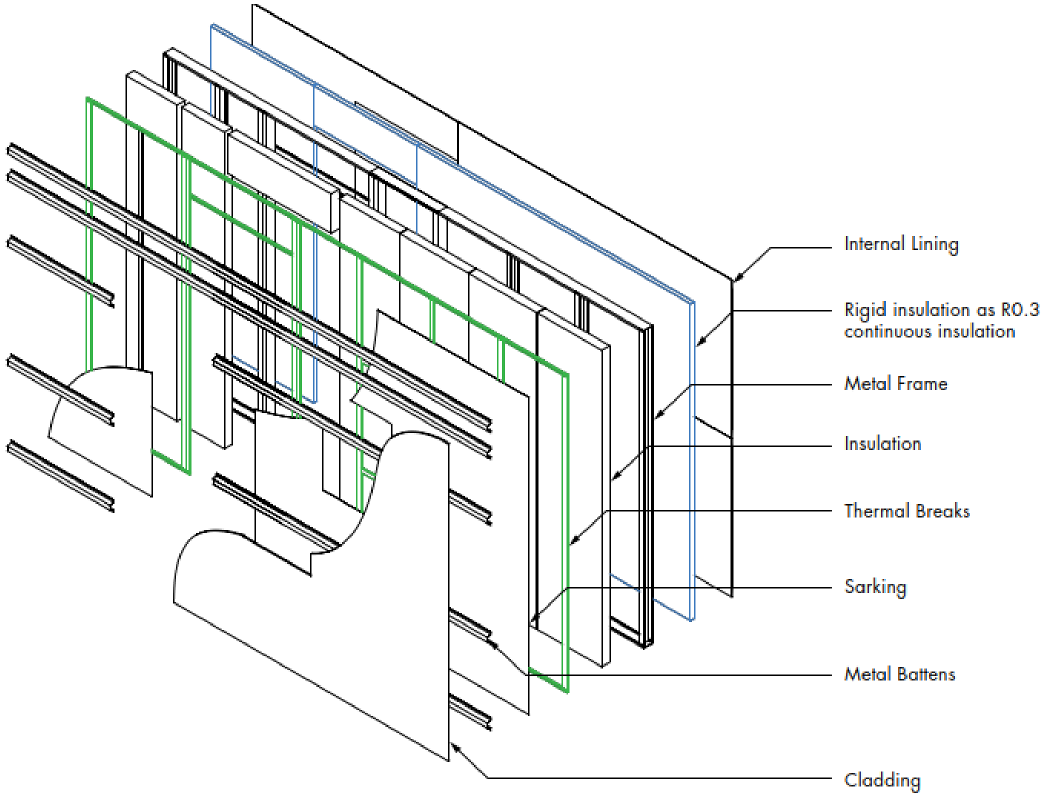


Figure 8 – Wall build up for R0.3 continuous insulation

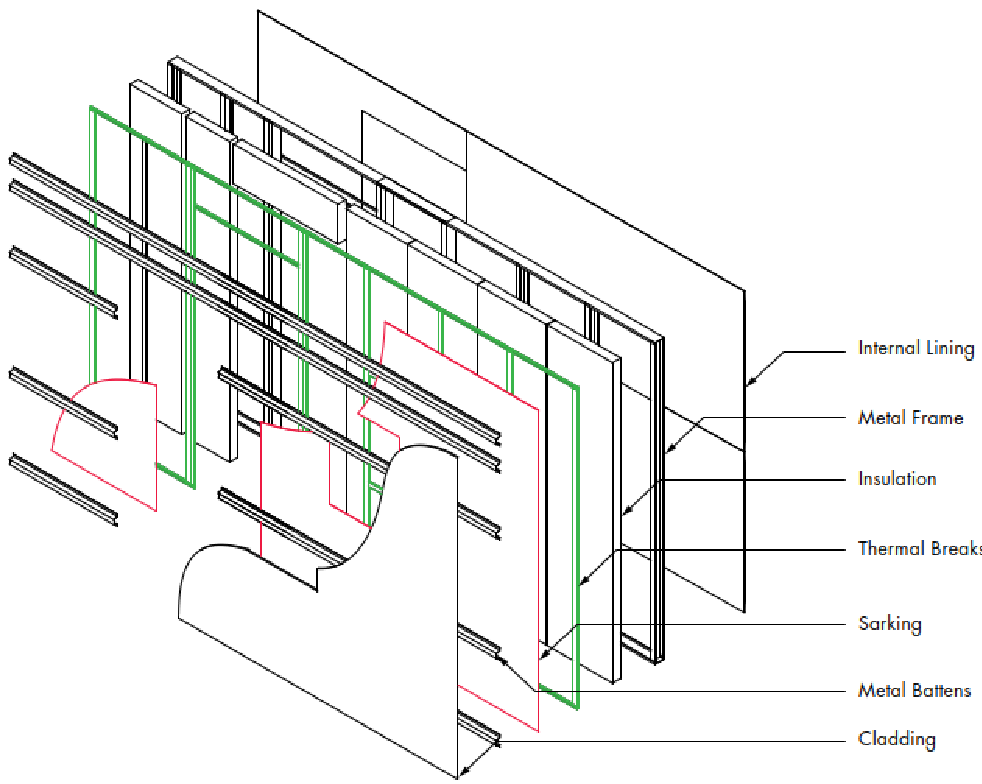


Figure 9 – Wall build up for plus R0.5 method and reflective insulation (sarking reflective or not depending on scenario)

Figure 10 demonstrates the effects of all three methods with different ventilation conditions between the cladding and membrane. To provide additional context, a direct fix wall without battens, indicated as "No Batten WB" in the key, has also been included in.

Based on the graph, the effectiveness of the three methods can be ranked as follows:

1. Continuous R0.3 insulation with an unventilated cavity
2. Reflective insulation with an unventilated cavity
3. Continuous R0.3 insulation with a ventilated cavity

---------- approximate position of Table 13.2.5q requirements-----------------------

4. Plus R0.5 insulation between stud frames with an unventilated cavity
5. Plus R0.5 insulation between stud frame with a ventilated cavity
6. Plus R0.5 insulation without battens

Note: Reflective membranes must have an unventilated air-space adjacent to the membrane to be effective.

It is important to note that reflective membranes must have an unventilated air-space adjacent to the membrane to be effective. All methods, except for Plus R0.5 insulation between stud frames with a ventilated air-space and Plus R0.5 insulation without battens, are considered approximately equivalent to Table 13.2.5q. The reflective insulation option must be used in conjunction with an unventilated air-space, as discussed in the Effects of ventilation. The Plus R0.5 insulation between stud frames method should not be used for either a ventilated cavity or a metal-framed lightweight wall without battens.

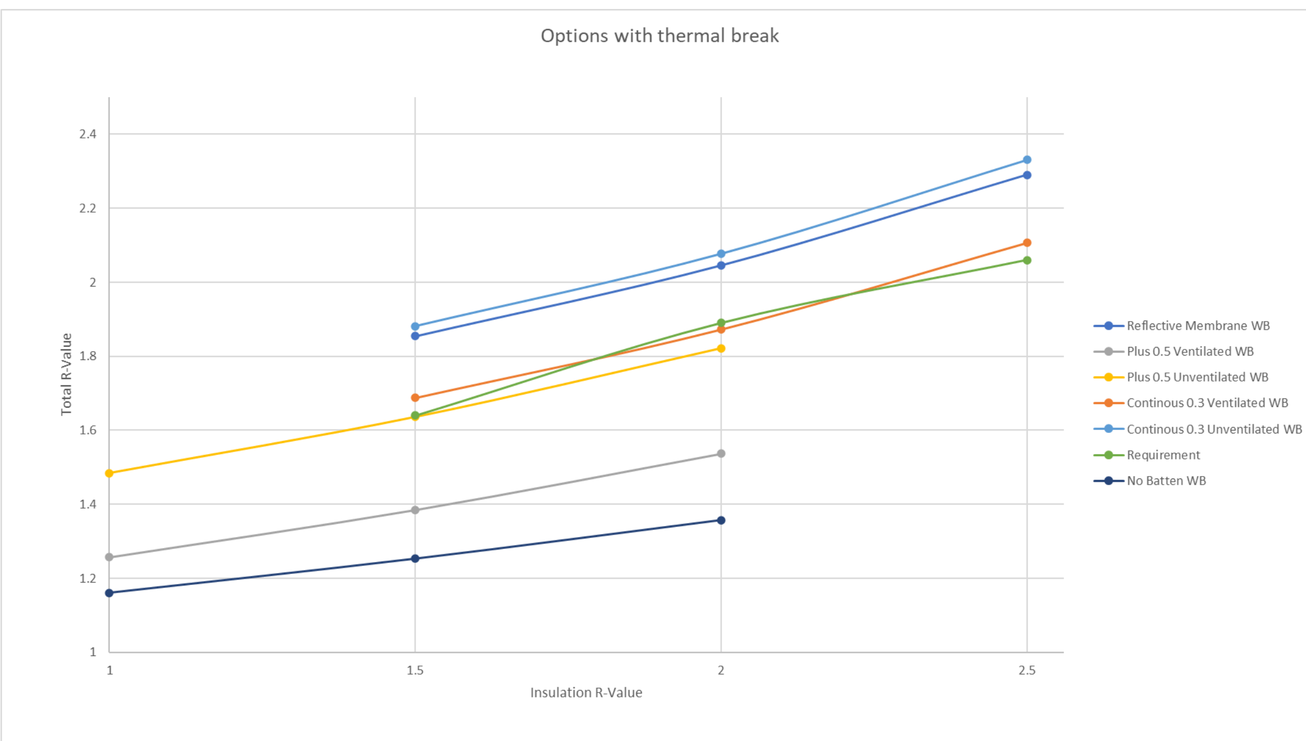


Figure 10 – Comparison of R-Value using different thermal bridging mitigation options of Table 13.2.5t with strip thermal break R0.2 consistent with 13.2.5(5)

No Thermal Break (NB)

As already indicated in this review, the requirement of a thermal break to be used in conjunction with the thermal bridging mitigation provisions was intended by NCC 2022. Figure 11 demonstrates how all methods fall short of the requirements of Table 13.2.5q, perhaps with the exception of a continuous R0.3 insulation in combination with an unventilated air-space. This supports the notion that thermal breaks must be used in conjunction with a suitable thermal bridging mitigation option of Table 13.2.5t.

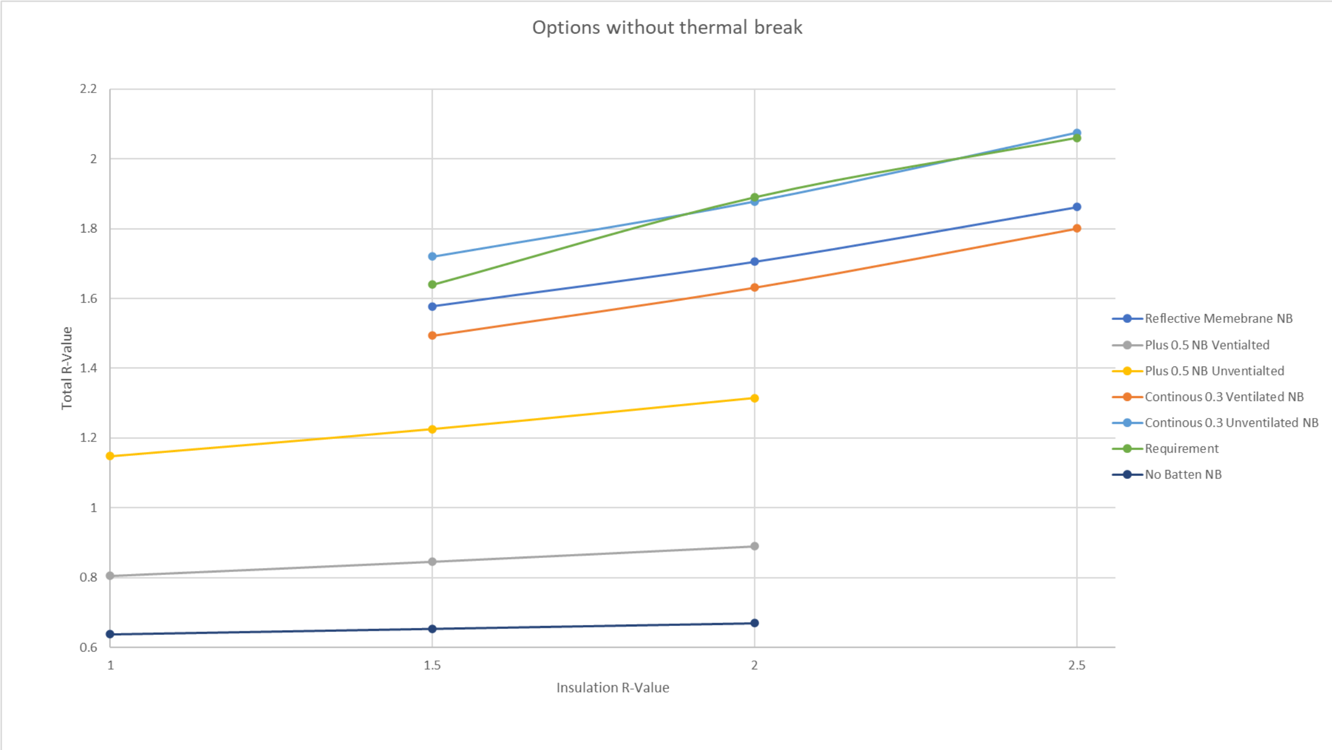


Figure 11 – Comparison of R-Value using different thermal bridging mitigation options of Table 13.2.5t with no thermal break consistent with 13.2.5(5)

Summary

It is demonstrated in this section that the thermal bridging mitigation provisions need to be used in conjunction with the thermal break provisions. This will result in an outcome approximately equivalent to the requirements of Table 13.2.5q. The ABCB should review the plus R0.5 insulation method as it is more common than not for this method to be ineffective. The only time it is effective is when it’s used in conjunction with an unventilated air-space bound by non-reflective surfaces, which is an uncommon construction type.

Note on installing reflective insulation

In Table 13.2.5t, reflective insulation has been given a new definition. AS 4200.1 describes reflective insulation with an emissivity of ≤0.05, whereas Table 13.2.5t redefines this as ≤0.1. Additionally, the term "reflective airspace" could be more accurately described as an air-space bound by reflective surfaces since air itself cannot be reflective. As discussed in the Effects of ventilation section, if the air-space is ventilated, there will be no contribution to thermal performance. To improve the clarity of this section and better describe its intent, it would be more appropriate to state: "Install reflective insulation between the outside of the studs and inside of the battens to create a minimum 20 mm unventilated air-space bound by at least one reflective surface between the frame and cladding."

Summary of the thermal break and thermal bridging mitigation provisions for walls

- A wall with a primary metal frame (metal studs) and a secondary metal frame (metal battens) must comply with the thermal break provisions of 13.2.5(5)
- A thermal break with an in-situ R-Value of 0.2 must be used in conjunction with any thermal bridging mitigation provision.
- If choosing the continuous R0.3 insulation strategy, it is possible to substitute it with R0.5 continuous insulation to satisfy both the R0.2 thermal break and the R0.3 continuous insulation thermal bridging mitigation provision.
- The plus R0.5 method should never be used on a lightweight clad wall that does not have secondary framing members such as battens, as it is ineffective.

Figure 12 can be utilised as a best practice guide based on the findings of this section. Please note that currently, the R0.3 continuous method is not permitted by Table 13.2.5t for >0 to ≤1.5. However, it is the most effective method and should be considered as an option across the full range of added R-values.

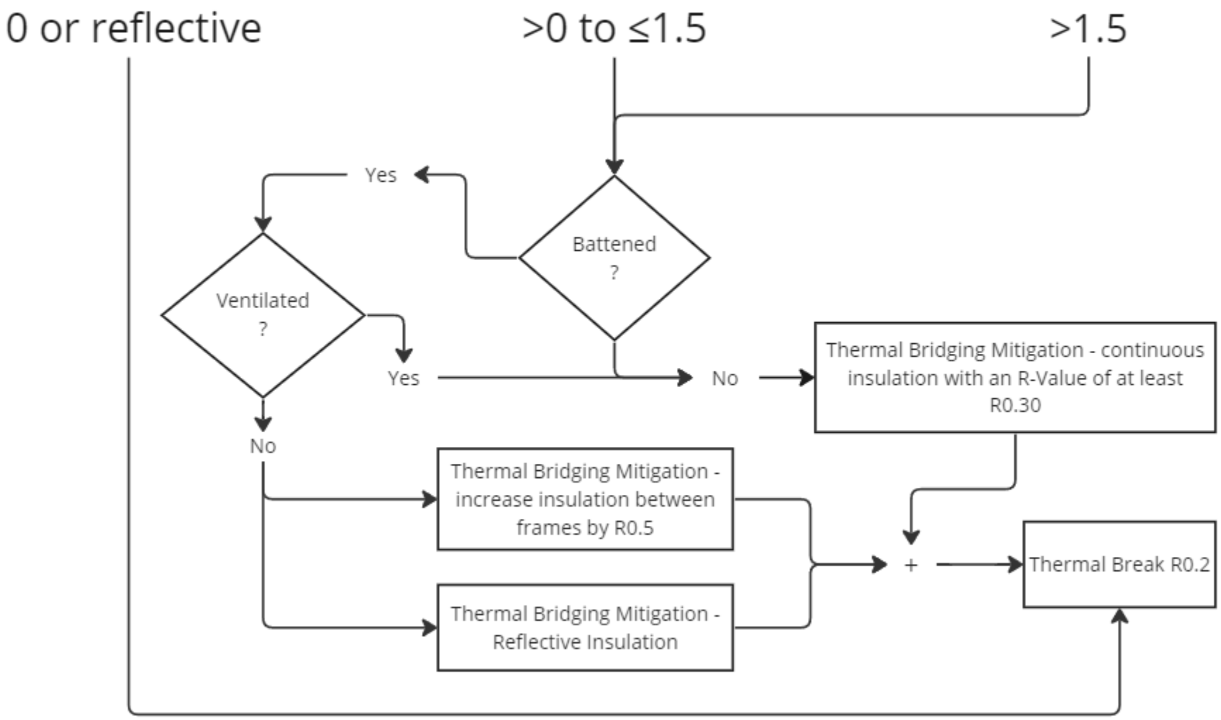


Figure 12- Best practise flow chart of Table 13.2.5t

Recommendations for NCC 2025

- The requirement of the need to use a thermal break could be removed when completing an AS/NZS 4859.2 calculation, as the calculation will determine if it is necessary or not. However, the practical likelihood of needing a thermal break to meet compliance is still high.
- The plus R0.5 insulation thermal bridging mitigation provisions should be completely removed, as they are generally ineffective or limited to use only with an unventilated air-space bound by non-reflective surfaces.
- Change the wording of the thermal bridging mitigation provision to: "Install reflective insulation between the outside of the studs and inside of the battens to create a minimum 20 mm unventilated air-space bound by at least one reflective surface between the frame and cladding."
- Include the continuous R0.3 method for any added R-Value.
- Provide a definition of "metal-framed" in the glossary section.
- The requirements of Table 13.2.5q and the performance of the thermal bridging mitigation provisions do not align when considering high percentage framing ratios or heavy gauge steel. Therefore, it is recommended to include minimum and maximum framing parameters for the thermal bridging mitigation options. For example, studs ≥450mm, BMT ≤1.15mm, etc.
- Change wording of 13.2.5(5) to “A metal-framed wall that forms part of the building envelope must have a thermal break installed on all surfaces normal to the direction of heat flow of the primary framing components (typically studs, nogs, top and bottom plate), consisting of a material with an in-situ R-Value of not less than R0.2."

Section Notes for Walls

The calculations in this section employ conservative assumptions that represent the worst combination of materials rather than typical combinations. For example, they utilise metal studs with a base metal thickness (BMT) of 1.15 mm at 450 mm centres on a 2400 mm high wall. It is important to note that walls using different parameters may perform better than indicated in this section. The purpose of these calculations is to compare walls with similar configurations, rather than aligning with the minimum requirement Total R-Value tables of the NCC. However, this does not diminish the recommendations provided in this report.

It should be noted that while some methods do not require a secondary framing member, this analysis incorporates the use of secondary framing members (metal battens) in all cases. This was done to reduce the number of permutations and allow for better comparison between methods without introducing additional variables. Additionally, all calculations presented indicate the Summer R-Value.

Roofs

Provisions in review

13.2.3

(7)

(7) A roof that—

(a) has metal sheet roofing directly fixed to metal purlins, metal rafters or metal battens; and

(b) does not have a ceiling lining or has a ceiling lining fixed directly to those metal purlins, metal rafters or metal battens,

must have a thermal break, consisting of a material with an *R-Value* of greater than or equal to 0.2, installed between the metal sheet roofing and its supporting metal purlins, metal rafters or metal battens.

(3)(b)

(b) for a flat, skillion or cathedral roof—

(i) achieving the *Total R-Value* in Table 13.2.3t, calculated using a method that accounts for the effects of thermal bridging; or

(ii) complying with Table 13.2.3u.

Table 13.2.3t

Table 13.2.3t: Metal-framed flat, skillion or cathedral roof – minimum Total R-Value to account for thermal bridging

Minimum ceiling insulation *R-Value* from Tables 13.2.3j to 13.2.3r	Minimum *Total R-Value* to account for thermal bridging – heat flow down	Minimum *Total R-Value* to account for thermal bridging – heat flow up
1.0	1.40	1.32
1.5	1.86	1.78
2.0	2.29	2.21
2.5	2.71	2.63
3.0	3.11	3.02
3.5	3.31	3.22
4.0	3.66	3.57
4.5	3.98	3.90
5.0	4.32	4.22
5.5	4.63	4.53
6.0	4.93	4.82

Table Notes

(1) Minimum *Total R-Values* are in-situ values. They account for compression of insulation.

(2) Direction of heat flow must be determined in accordance with Table 13.2.3v.

Table 13.2.3u

Table 13.2.3u: Metal-framed flat, skillion or cathedral roof – thermal bridging mitigation

Minimum ceiling insulation *R-Value* from Tables 13.2.3j to 13.2.3r	Option 1 – increase insulation between roof frame members to specified minimum *R-Value*	Option 2 – add a layer of continuous insulation with specified minimum *R-Value* above or below the roof frame members
1.0	1.5	0.13
1.5	2.5	0.30
2.0	3.5	0.30
2.5	5.0	0.40
3.0	6.0	0.60
3.5	X	0.60
4.0	X	0.60
4.5	X	0.60
5.0	X	0.60
5.5	X	0.60
6.0	X	0.60

Table Notes

(1) Minimum *R-Values* are in-situ values. They account for compression of insulation.

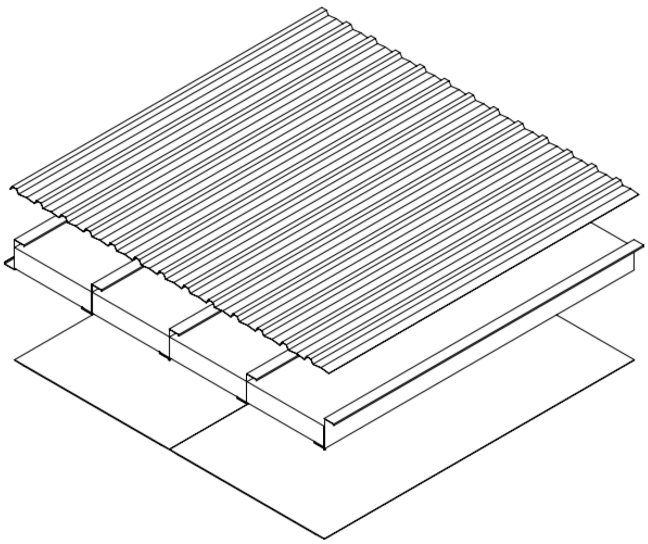
(2) X = not permitted.

Review of 13.2.3(7) - Thermal Break Provisions

Clause wording

The interpretation of roofs is slightly different from walls due to the wording in 13.2.3(7). Unlike the term “framed” in 13.2.5(5), the use of the pronoun “those” in 13.2.3(7) specifies that the metal framing referred to is the one where the ceiling lining is connected to the same members as the roof cladding. From a practical perspective, this significantly limits the number of roof types that would require thermal breaks.

For example, truss roofs generally do not require thermal breaks as the ceiling is not fixed to the same frame members as the cladding. Figure 13 illustrates a situation where thermal break provisions do apply, whereas Figure 14 depicts a scenario where they do not, as the roof lining is not directly connected to those metal purlins.



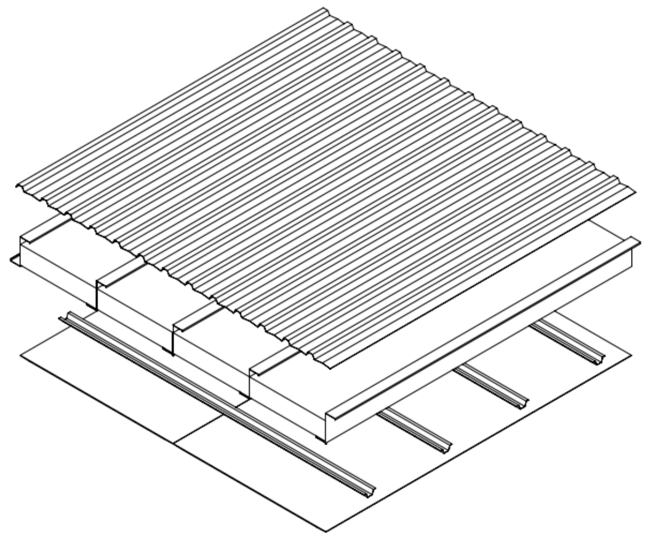


Figure 13 (Left) – Metal roof with metal purlins and a ceiling lining fixed directly to those metal purlins

Figure 14 (Right) - Metal roof with metal purlins and a ceiling lining fixed to metal battens

Practical implications

Unlike walls, the air-space between the internal lining and insulation in roofs is typically considered unventilated, while the space between the top of the insulation and the metal cladding is typically considered ventilated to meet the requirements of Housing Provisions Clause 10.8.3 (1). As a result, the analysis of air-space ventilation is not typically required, which reduces the number of permutations under consideration. However, the impact of thermal breaks in roofs is similar to that in walls. Since thermal breaks were found to be necessary for walls, they are also necessary for roofs.

Typical construction methods and thermal breaks

Typical construction practices for roofs of this nature often involve one of five methods:

1. No insulation or sarking between metal roof sheet and frame:
    a. Dedicated thermal break is required.
2. Sarking between metal roof sheet and frame:
    a. Dedicated thermal break is required.
3. Thermal break sarking in-situ R0.2 between metal roof sheet and frame:
    a. The sarking material serves as the thermal break, and an additional thermal break is not required.
4. Foil-faced glasswool:
    a. If the foil-faced glasswool has a Declared R-Value of ≥R0.4, it can be considered a thermal break when conducting a 4859.2 calculation. Crushed insulation can be used without requiring a spacer.
5. Non compressible sandwich panel:
    a. If the roof sheet is an insulation sandwich panel with an R-Value of ≥R0.2, it can be considered a thermal break, and an additional thermal break is not required.

Summary

Unlike walls, the dimensions and spacing of purlins in roofs can vary widely based on expected spans and loads, resulting in a wider range of percentage improvement when introducing a thermal break. However, thermal breaks are still a critical requirement for roof types like those indicated in Figure 13.

Considering more typical construction practices, such as using crushed foil-faced glasswool over purlins in addition to insulation between purlins, the foil-faced glasswool itself already serves as a thermal break. Therefore, a dedicated thermal break material is often not required.

Review of 13.2.3(3)b - Thermal Bridging Mitigation Provisions

General

The thermal bridging mitigation provisions have been newly introduced in NCC 2022. To mitigate thermal bridging in lightweight roofs, 13.2.3(3)(b) directs users to either refer to Table 13.2.3t or Table 13.2.3u.

Table 13.2.3t requires users to perform a Total R-Value calculation in accordance with AS/NZS 4859.2, based on the required insulation R-Value as applicable. Whereas Table 13.2.3u requires users to meet a prescribed minimum insulation R-Value along with one of two specified measures.

Methods

A flowchart in Figure 15 provides an illustrative method for complying with the requirements of thermal breaks and thermal bridging in the NCC's DtS provisions.

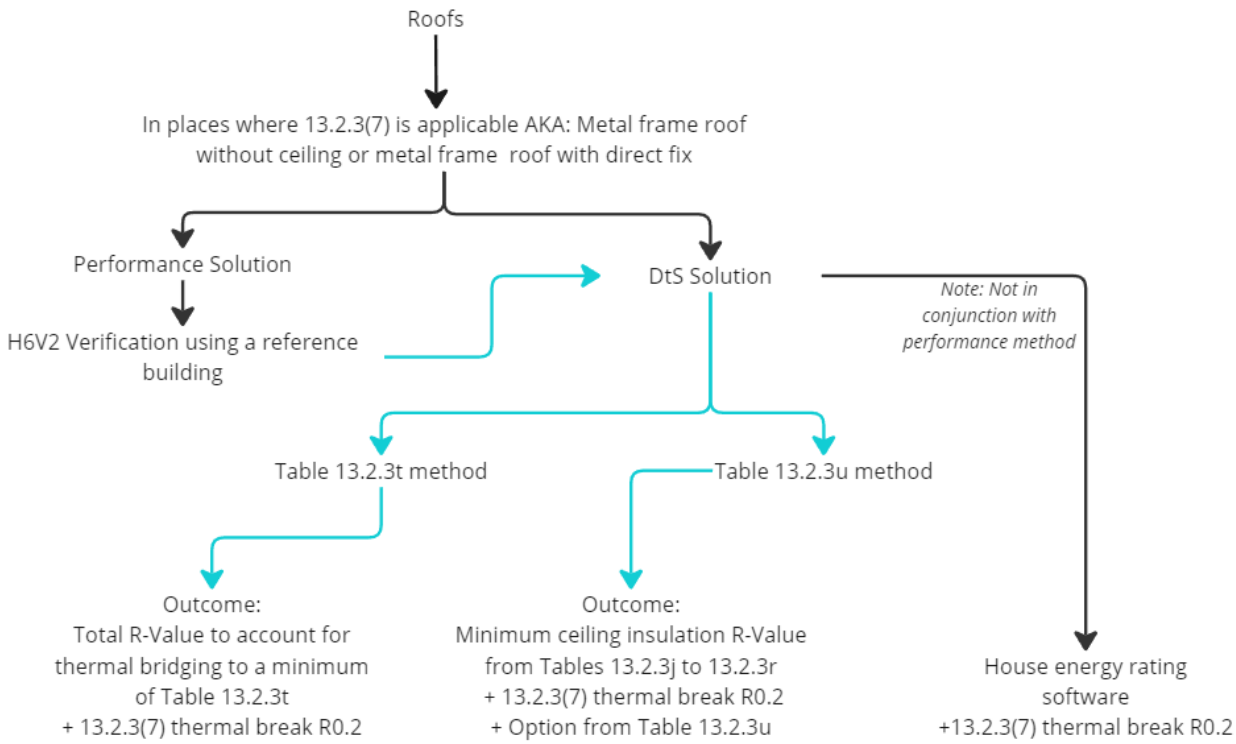


Figure 15 – Flowchart of roofs for compliance with thermal breaks and thermal bridging mitigation options

Review of Table 13.2.3t

Table 13.2.3t in the NCC specifies a minimum Total R-Value requirement that takes into account the thermal bridging of the roof structure. If a metal-framed flat, skillion, or cathedral roof also meets the definition of 13.2.3(7) as discussed in the Review of 13.2.3(7) - Thermal Break Provisions, then a thermal break must be introduced as required. Unlike walls and floors that use AS/NZS 4859.2, no method is specified for the calculation method of roofs. Convention would probably dictate to use 4859.2, but this is not mandated.

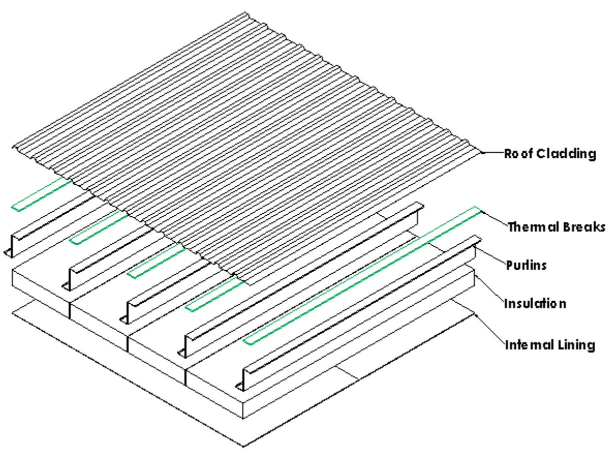
Review of Table 13.2.3u

General

The roof construction model considered in this analysis utilised C/Z Steel Purlins with dimensions of 203mm (depth) x 75mm (width) x 2.4mm BMT, spaced at 600mm and 900mm centres, and with a pitch of 15°. The variations in thermal performance were examined by adjusting the ceiling insulation and continuous insulation according to Table 13.2.3u.

The main impact of thermal performance in roofs will be from the centres of the framing materials. Option 1 and Option 2 of Table 13.2.3u can be more or less effective than each other depending on the density of the framing materials, as indicated by Figure 18. As a generalisation, as the framing density and the minimum ceiling insulation R-Value increase Option 1 becomes less effective to Option 2.

Under certain framing scenarios with larger spacing and lighter gauge steel, Option 1 or Option 2 could be approximately equivalent to the requirements specified in Table 13.2.3t.



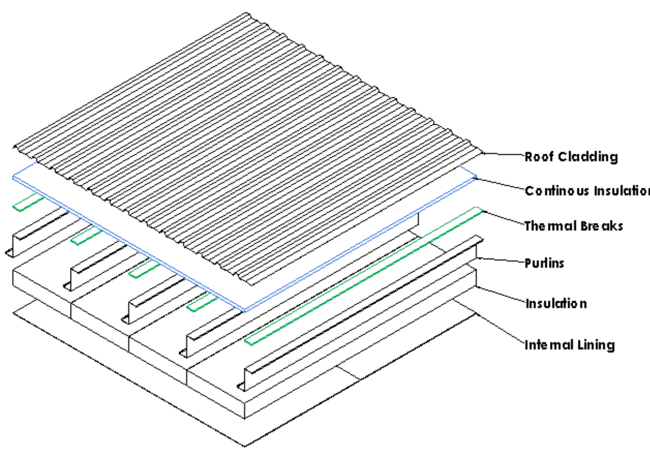


Figure 16 (Left) - Option 1 of Table 13.2.3u

Figure 17 (Right - Option 2 of Table 13.2.3u

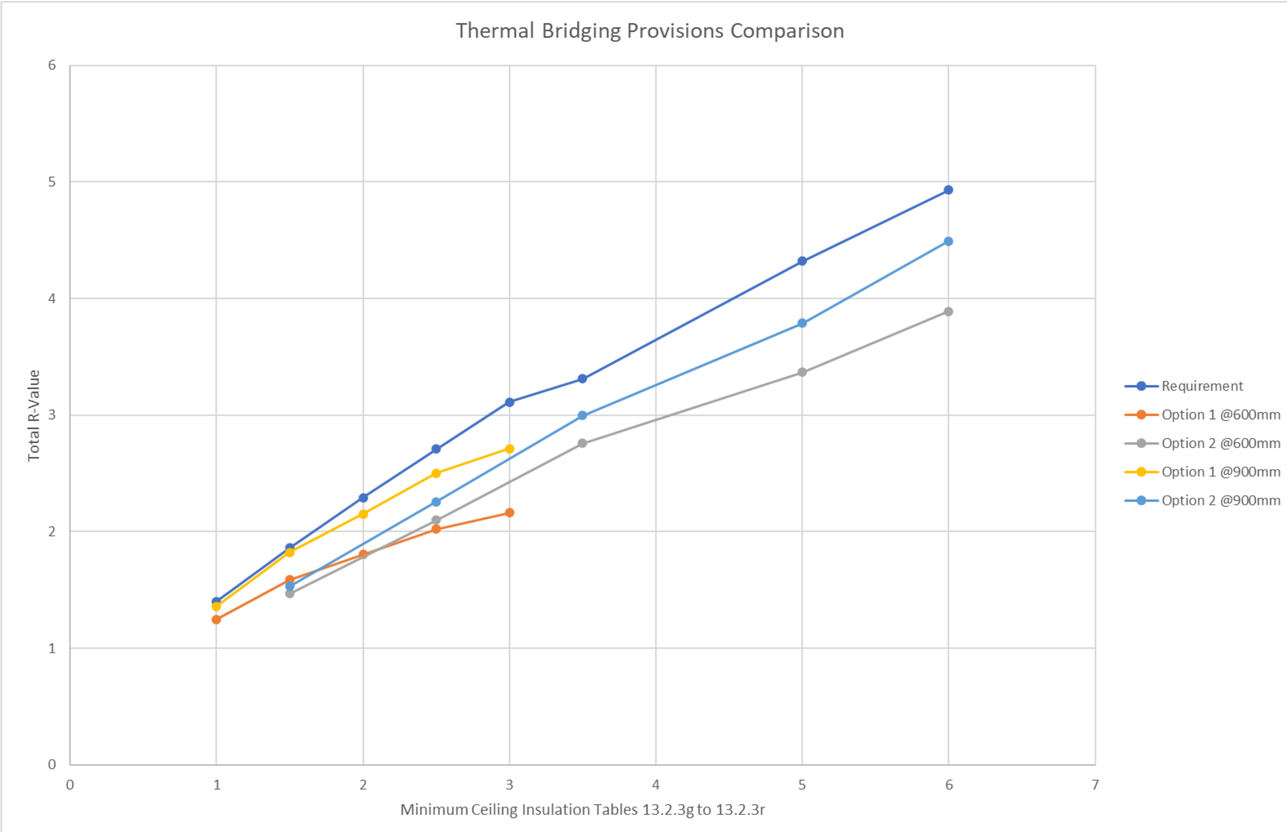


Figure 18 - Comparison of the Option 1 and 2 of Table 13.2.3u

Note: The horizontal axis uses the values from the left column of Table 13.2.3u, for instance; where Option 1 reads R3.0 on the horizontal axis, this is using a R6.0 insulation between purlins.

Limitations

Unlike walls, which typically span up to 3 meters between restraints, roofs can vary greatly in span length. The span of the roof is closely related to the material selection of the purlins and their spacing, which in turn influences the thermal performance. Additionally, roofs may need to accommodate additional imposed actions such as solar panels, air-conditioning equipment, or snow loads. These varying factors make it challenging to define a typical or conservative roof structure, including the materials and sizes of its components.

Using tables within the NCC to mitigate thermal bridging in roofs is likely to result in significant variations in performance from building to building. The effectiveness of the thermal bridging mitigation provisions may not consistently achieve their intended purpose due to the diverse nature of roof structures and the associated factors involved.

Summary of the thermal break and thermal bridging mitigation provisions for roofs

Due to the varied nature of roofs, it is recommended that for roofs with high framing ratios or high gauge steel in the primary framing components, AS/NZS 4859.2 should be used in conjunction with Table 13.2.3t to effectively mitigate thermal bridging. When opting for continuous insulation as the method of thermal bridging mitigation, common roofing insulation can be used instead of dedicated thermal break strips.

Recommended for NCC 2025

- Code users who rely on the Review of Table 13.2.3t as their compliance method should be exempted from the requirements of 13.2.3(7) to provide designers with more flexibility. AS/NZS 4859.2 should be specified as the standard for calculations.
- Reconsider the use of thermal bridging mitigation tables and instead utilise AS/NZS 4859.2 for all cases pertaining to roofs described in 13.2.3(3)(b).
    - Alternatively, limit the scope of applicability by introducing minimum framing centres and flange to BMT ratio criteria.

Section notes for Roofs

Analysing roofs from a general perspective is challenging. The sectional properties of materials used for purlins, rafters, battens, or similar components vary significantly based on the expected span and imposed loads, which are optimised by structural engineers. Therefore, any analysis presented in this section is of a general nature and may not encompass all possible construction scenarios, nor reflect conservative or common construction practices.

Section 2 - Compare and contrast Volume One Class 2 sole-occupancy units & the Housing Provisions, and identify whether the differences are appropriate.

Background

This section examines the wording of J3D5 and J3D6, as well as the Housing Provision requirements for a thermal break (13.2.5(5) and 13.2.3(7)). Some confusion has arisen from the slightly different wording of the provisions for thermal breaks found in Volume 1 compared to the Housing Provisions. The purpose of this section is to analyse the wording of each clause and determine if there is a functional difference.

Research Goals

- Identify functional differences of thermal break wording between Volume 1 and the Housing Provisions

Walls

Thermal breaks

Provisions in review

J3D6

J3D6 Wall thermal breaks of a sole-occupancy unit of a Class 2 building or a Class 4 part of a building

[2019: J0.5]

(1) A metal-framed wall that forms part of the building *envelope* must have a thermal break, consisting of a material with an *R-Value* of not less than R0.2, installed at all points of contact between the external cladding and the metal frame if the wall—

(a) does not have a wall lining or has a wall lining that is fixed directly to the same metal frame; and

(b) is clad with weatherboards, fibre-cement or the like, or metal sheeting fixed to a metal frame.

(2) The requirements of (1) do not apply to walls constructed using insulated sandwich panels.

13.2.5(5)

(5) A metal-framed wall that forms part of the building *envelope* must have a thermal break, consisting of a material with an *R-Value* of not less than R0.2, installed at all points of contact between the external cladding and the metal frame if the wall—

(a) does not have a wall lining or has a wall lining that is fixed directly to the metal frame; and

(b) is clad with weatherboards, fibre-cement or the like, or metal sheeting fixed to the metal frame.

(6) The requirements of (5) do not apply to walls constructed using insulated sandwich panels.

Differences between Section J Requirement and Housing Provisions

The texts are not identical. The differences are as follows:

In the J3D6 text:

- The condition (a) mentions "the same metal frame" for walls without a wall lining or with a wall lining fixed directly to the metal frame.
- The condition (b) mentions "metal sheeting fixed to a metal frame" as one of the cladding options.

In the Housing Provisions 13.2.5(5) text:

- The condition (a) mentions “the metal frame” for walls without a wall lining or with a wall lining fixed directly to the metal frame.
- The condition (b) mentions “metal sheeting fixed to the metal frame” as one of the cladding options.

Overall, the texts have minor differences in wording, but the main requirements and exceptions remain the same. Even though Section J introduces the words “same metal frame” and “the metal frame” making it sound more specific, as discussed in Current clause wording of (5) the meaning is still consistent with the broader interpretation of a metal frame as a structure that provides shape or strength to a building.

In the context of a wall, a possible exception to this rule is a double stud wall. Even though it is a single wall, there are two independent structures or frames that make up the wall, and therefore a metal frame double stud wall would not be subject to this clause. However, if a secondary framing member in the form of metal battens is introduced and directly attached to the primary framing member (the studs), compliance with the thermal break provisions would be required.

Appropriateness of differences of Thermal Break

While there are some wording differences, this does not change the meaning of the clauses. Therefore, these clauses, from a functional point of view, can be considered identical.

Thermal bridging mitigation

Provisions in review

13.2.5(4)

(4) The thermal bridging in a metal-framed wall must be addressed by—

(a) achieving the *Total R-Value* in Tables 13.2.5p, 13.2.5q and 13.2.5r, calculated in accordance with AS/NZS 4859.2; or

(b) complying with one of the options in Tables 13.2.5s, 13.2.5t and 13.2.5u.

J3D8

J3D8 External walls of a sole-occupancy unit of a Class 2 building or a Class 4 part of a building

[New for 2022]

(1) The *Total R-Value* of an *external wall*—

(a) in *climate zones* 1, 2, 3, 5 and 6—

(i) where the ratio of the area of opaque *external walls* to the *floor area* of the *sole-occupancy unit* is less than 20%, must be at least R1.15; and

(ii) where the ratio of the area of opaque *external walls* to the *floor area* of the *sole-occupancy unit* is greater than or equal to 20% but less than 35%, must be at least R2.04; and

(iii) where the ratio of the area of opaque *external walls* to the *floor area* of the *sole-occupancy unit* is greater than or equal to 35%, must be at least R2.24; and

(b) in *climate zones* 4, 7 and 8, must be at least R2.24.

(2) The *Total R-Value* of an *external wall* must be determined in accordance with—

(a) for a spandrel panel in a curtain wall system, in accordance with Specification 38; and

(b) for all other walls, in accordance with AS/NZS 4859.2.

(3) The solar absorptance of an *external wall* must—

(a) in *climate zones* 1 to 6, be in accordance with Table J3D8a; and

(b) in *climate zones* 7 and 8, be in accordance with Table J3D8b.

Differences between Section J Requirement and Housing Provisions

While 13.2.5(4) provides a route to use a thermal bridging mitigation option, J3D8 provides no such route. Instead, J3D8 only provides the AS/NZS 4859.2 calculation route for walls that are not spandrels. It is unclear why this route is absent, especially considering that a thermal bridging mitigation option route is included for roofs.

Furthermore, the minimum R-Value requirements in J3D8(1)(a) take into account different factors when determining the minimum value. For example, J3D8(1)(a) uses a ratio of opaque wall elements to floor area to modulate the minimum requirement, whereas the comparable Housing Provisions of Tables 13.2.5a to 13.2.5e use combination of wall type, overhang, solar absorbance and wall height to modulate the minimum requirement. The rationale for this approach is explained in Section 1.3 of Sustainable Building Specialist - technical report on DtS Elemental Provisions for NCC 2022.

Appropriateness of differences of Thermal Bridging Mitigation

The absence of thermal bridging mitigation options in J3D8 is inconsistent with both the Housing Provisions and J3D7(3). Using Table 13.2.5t as the primary reference point is unsuitable because it is based on wall insulation R-Value, while J3D8 is expressed in terms of Total R-Value. It would be beneficial to develop a new set of tables that align with the principles described in the Walls section for future use. This would ensure consistency and provide clearer guidance for compliance with thermal bridging requirements in J3D8.

Roofs

Provisions in review

J3D5

J3D5 Roof thermal breaks of a sole-occupancy unit of a Class 2 building or a Class 4 part of a building

[2019: J0.4]

(1) A roof that—

(a) has metal sheet roofing directly fixed to metal purlins, metal rafters or metal battens; and

(b) does not have a ceiling lining or has a ceiling lining fixed directly to those metal purlins, metal rafters or metal battens,

must have a thermal break, consisting of a material with an *R-Value* of greater than or equal to R0.2, installed between the metal sheet roofing and its supporting metal purlins, metal rafters or metal battens.

(2) The requirements of (1) do not apply to roofs constructed using insulated sandwich panels.

13.2.3(7)

(7) A roof that—

(a) has metal sheet roofing directly fixed to metal purlins, metal rafters or metal battens; and

(b) does not have a ceiling lining or has a ceiling lining fixed directly to those metal purlins, metal rafters or metal battens,

must have a thermal break, consisting of a material with an *R-Value* of greater than or equal to 0.2, installed between the metal sheet roofing and its supporting metal purlins, metal rafters or metal battens.

Thermal Breaks

The wording of the thermal break provision for roofs in both 13.2.3(7) and the Housing Provisions J3D5 is identical, and therefore no analysis is required.

Thermal Bridging

Provisions in review

J3D7(3)

(3) The thermal bridging in a metal-framed roof must be addressed as follows—

(a) for a pitched roof with a horizontal ceiling—

(i) achieving the *Total R-Value* in Table J3D7s, calculated using a method that accounts for the effects of thermal bridging; or

(ii) increasing the *R-Value* of the insulation between the ceiling frames by R0.5 more than the *R-Value* derived from (1); or

(iii) adding a continuous ceiling insulation layer with a minimum *R-Value* of R0.13 above or below the ceiling joists or the bottom chords of the trusses; or

(iv) achieving the *required* ceiling *R-Value* derived from (1) by stacking two layers of insulation immediately on top of each other, such that the top layer is orientated to cover the ceiling joists or bottom chord of the trusses and has an *R-Value* of at least R0.5; or

(b) for a flat, skillion or cathedral roof—

(i) achieving the *Total R-Value* in Table J3D7t, calculated using a method that accounts for the effects of thermal bridging; or

(ii) complying with Table J3D7u.

13.2.3(3)

(3) The thermal bridging in a metal-framed roof must be addressed as follows—

(a) for a pitched roof with a horizontal ceiling—

(i) achieving the *Total R-Value* in Table 13.2.3s, calculated using a method that accounts for the effects of thermal bridging; or

(ii) increasing the *R-Value* of the insulation between the ceiling frames by R0.5 more than the *R-Value* derived from (1); or

(iii) adding a continuous ceiling insulation layer with a minimum *R-Value* of R0.13 above or below the ceiling joists or the bottom chords of the trusses; or

(iv) achieving the *required* ceiling *R-Value* derived from (1) by stacking two layers of insulation immediately on top of each other, such that the top layer is orientated to cover the ceiling joists or bottom chords of the trusses and has an *R-Value* of at least R0.5; or

(b) for a flat, skillion or cathedral roof—

(i) achieving the *Total R-Value* in Table 13.2.3t, calculated using a method that accounts for the effects of thermal bridging; or

(ii) complying with Table 13.2.3u.

Differences between Section J Requirement and Housing Provisions

There are no functional differences between the thermal bridging mitigation provisions for metal-framed roofs in J3D7(3) and 13.2.3(3)

Appropriateness of differences of Thermal Bridging Provisions

No functional differences.

Summary

The differences in wording between Volume 1 and Volume 2 for both roofs and walls do not result in any functional differences in the clauses. However, there is a lack of thermal bridging mitigation options in J3D8.

Recommendations for NCC 2025

- To avoid confusion among code users, it is recommended to homogenise the wording in both Volume 1 and Volume 2 of the code so that there are no text differences between them regarding thermal break provisions.
- Develop thermal bridging mitigation provisions specifically for use in conjunction with J3D8, following the principles outlined in the Walls. These provisions should address the requirements and considerations for mitigating thermal bridging in roof constructions.

By implementing these recommendations, the code will provide clearer and more consistent guidance for code users, ensuring a harmonised approach to thermal bridging mitigation in both walls and roofs.

Section 3 - Consider sandwich panel construction, including comparing and contrasting treatment of walls and roofs.

Background

The purpose of this clause is to ensure that sandwich panels are installed in a continuous manner over the metal structure, minimising thermal bridging except for necessary point connectors such as metal screws used to fasten the metal sheets.

By conducting research on the minimum requirements and potential issues related to sandwich panel walls, it will be possible to gain a comprehensive understanding of the performance and practical considerations associated with this construction method.

Research Goals

- Identify the minimum requirements for walls when utilising a sandwich panel construction.
- Identify any potential issues or challenges associated with the use of sandwich panels in wall construction.

Provisions in review

13.2.3

(8)

(8) The requirements of (1) to (7) do not apply to roofs constructed using insulated sandwich panels.

(9)

(9) Roofs constructed using insulated sandwich panels must achieve the minimum *Total R-Value* in Table 13.2.3x.

Table 13.2.3x

Table 13.2.3x: **Total R-Value for roofs constructed with insulated sandwich panels**

Climate zone	SA ≤ 0.23	0.23 < SA ≤ 0.32	0.32 < SA ≤ 0.42	0.42 < SA ≤ 0.53	0.53 < SA ≤ 0.64	0.64 < SA ≤ 0.73	0.73 < SA ≤ 0.85	0.85 < SA ≤ 0.96
1 (single storey dwelling)	1.40	3.31	X	X	X	X	X	X
1 (two or more storey dwelling)	1.86	3.31	4.32	X	X	X	X	X
2 (heat flow down)	3.11	3.11	3.31	3.66	3.66	X	X	X
2 (heat flow up)	3.02	3.02	3.22	3.57	3.57	X	X	X
3 (heat flow down)	3.31	3.66	4.32	X	X	X	X	X
3 (heat flow up)	3.22	3.57	4.22	X	X	X	X	X
4	3.22	3.22	3.22	3.22	3.22	X	X	X
5	3.02	3.02	3.02	3.02	3.02	X	X	X
6	3.57	3.57	3.57	3.57	3.57	3.57	3.57	3.57
7	4.22	3.90	3.90	3.57	3.57	3.22	3.22	3.22
8	3.90	3.57	3.57	3.22	3.22	3.02	3.02	3.02

Table Notes

(1) SA = solar absorptance.

(2) Direction of heat flow must be determined in accordance with Table 13.2.3v.

13.2.5

(6)

(6) The requirements of (5) do not apply to walls constructed using insulated sandwich panels.

Review of 13.2.3(9)

Clause 13.2.3(8) simplifies the requirements for the use of sandwich panels in roofs. It stipulates that those intending to use sandwich panels in roofs must comply with the provisions outlined in 13.2.3(9) which directs users to refer to Table 13.2.3x. It is important to note that these calculations are based on Total R-Value, which conventionally requires the use of AS/NZS 4859.2 for calculations.

Review of 13.2.5(6)

General

Clause 13.2.5(6) eliminates the requirement for a thermal break when utilising sandwich panels in construction. However, this provision is typically irrelevant when considering sandwich panels, as they generally have an insulation value of R0.2 or higher. Therefore, in their typical application, sandwich panels can be considered a thermal break by definition.

Using Sandwich Panels in Walls

Clause 13.2.5(6) primarily focuses on what not to do when using insulated panels in walls. However, there remains a question of what measures should be taken when utilising insulated sandwich panels in wall construction. As insulated sandwich panels are still considered lightweight wall constructions, the provisions outlined in 13.2.5(2), 13.2.5(3), and 13.2.5(4) should still be followed.

(2) For lightweight wall construction, wall insulation must have a minimum *R-Value*—
- (a) in *climate zone* 1, in accordance with Table 13.2.5b; and
- (b) in *climate zone* 2, in accordance with Table 13.2.5c, with R0.3 added; and
- (c) in *climate zone* 3, in accordance with Table 13.2.5f; and
- (d) in *climate zone* 4, in accordance with Table 13.2.5g, with R0.3 added; and
- (e) in *climate zone* 5, in accordance with Table 13.2.5i, with R0.3 added; and
- (f) in *climate zone* 6, in accordance with Table 13.2.5k, with R0.3 added; and
- (g) in *climate zone* 7, in accordance with Table 13.2.5m, with R0.3 added; and
- (h) in *climate zone* 8, in accordance with Table 13.2.5o.

(3) In *climate zones* 1 to 5, the solar absorptance of the outer surface of a wall used in (1) or (2) must be not more than 0.7.

(4) The thermal bridging in a metal-framed wall must be addressed by—
- (a) achieving the *Total R-Value* in Tables 13.2.5p, 13.2.5q and 13.2.5r, calculated in accordance with AS/NZS 4859.2; or
- (b) complying with one of the options in Tables 13.2.5s, 13.2.5t and 13.2.5u.

Figure 19 – Clause 13.2.5 external walls

A code user would need to use 13.2.5(2) to determine the minimum required added R-Value for wall insulation based on factors such as climate zone, wall solar absorptance, wall height, and extent of any overhang. Once these factors are determined, utilising Table 13.2.5q becomes the appropriate method for determining the R-Value of a sandwich panel.

Table 13.2.5q: Lightweight metal-framed walls: minimum Total R-Value to account for thermal bridging

Wall insulation *R-Value required* in accordance with 13.2.5(2)	Minimum *Total R-Value* to account for thermal bridging
1.0	1.32
1.5	1.64
2.0	1.89
2.5	2.06
2.7	2.15
≥3.0	2.27

Table Notes

(1) Where the wall insulation *R-Value* from Tables 13.2.5b, 13.2.5c, 13.2.5d, 13.2.5e, 13.2.5f, 13.2.5g, 13.2.5h, 13.2.5i, 13.2.5j, 13.2.5k, 13.2.5l, 13.2.5m, 13.2.5n and 13.2.5o falls between the values shown in this Table, the *required Total R-Value* may be interpolated.

(2) Minimum *Total R-Values* are in-situ values. They account for compression of insulation.

Figure 20 – Table 13.2.5q

Summary

When using sandwich panels in walls, it is important to determine the required insulation R-Value based on the relevant factors outlined in 13.2.5(2). The solar absorbance should be limited to 0.7 for climate zones 1-5. The Total R-Value can then be calculated using AS/NZS 4859.2 and Table 13.2.5q.

Summary of changes recommended to NCC 2025

To streamline the process and eliminate the need for a 4859.2 calculation when using sandwich panels, the following changes are suggested:

- Provide diagrams illustrating typical applications that do not require a 4859.2 calculation.
- Develop separate tables for roofs and floors specifying the required R-Value of insulation panels to meet the requirements of Table – Table 13.2.5q. These tables can be based on different materials such as Mineral Wool, EPS, XPS, Polyurethane foam, and phenolic foam. Alternatively, determine the worst-case material and create a table based on that.

These changes would simplify the compliance process for using sandwich panels and provide clear guidance on the required insulation values.

Section 4 - Recommendations for NCC 2025

General

The in-scope recommendation for NCC 2025 are at the end of each section that are reviewed.

Out of scope observations

In various parts of the NCC, alternative routes to compliance are provided. While these routes are intended to be approximately equivalent, perfect alignment may not always be possible due to the varying nature of their implementation. However, it has been observed that in some areas, the alignment between routes is not close enough, resulting in significant disparities in performance based on the chosen compliance route. It should be noted that this project focused specifically on exploring these variances within the context of thermal bridging mitigation provisions, but instances of misalignment were found in other areas as well.

The housing provisions of NCC 2022 have relied on NatHERS to establish compliance thresholds for alternative methods. This means that NatHERS serves as the baseline, and other compliance methods aim to achieve an equivalent outcome to a NatHERS 7-star building. However, the current implementation of DtS (Deemed-to-Satisfy) elemental provisions in the NCC has resulted in complex and cumbersome requirements that mimic the considerations of a NatHERS simulation. As a result, following the DtS elemental provisions can be difficult and time-consuming, particularly in tropical climates where the provisions may lead to dead-end pathways.

Considering the complexity of the provisions, it is likely that NatHERS will become the preferred and practical means of compliance, as the DtS elemental provisions present challenges in terms of usability. It is important to address this issue and make the elemental provisions more user-friendly and streamlined.

It should be noted that while these observations were made during the project, they were beyond the scope of the specific research and may require further investigation and analysis.

Part 10.8.1

The vapour permeance test of ASTM E96 may not be suitable for testing insulation materials, particularly glasswool. Issues may arise with sealing the edges of the sample to achieve one-dimensional moisture transfer, as noted by AWTA Product Testing. Further investigation is needed to ensure that mandated testing is appropriate for the specified criteria.

(2)

The limitation on the vapour permeance level for continuous insulation materials located external to the primary insulation layer, as required in climate zones 4-8, requires further consideration. Closed cell rigid insulation on the external side of metal frame walls can be an effective measure for controlling condensation, which is commonly used in many parts of Europe. The intent of the NCC is to set a minimum standard, but this clause may not have established the criteria boundaries correctly. While it may address interstitial condensation in some scenarios, it also restricts other scenarios where prohibited materials could result in less interstitial condensation than permitted materials.

Table 13.2.3s

The introduction of a completely new term, "Ceiling Total R-Value," lacks a described method of completion. AS/NZS 4859.2 does not provide a documented procedure for completing this calculation. A clear procedure should be provided to achieve the values in this table.

General alignment to NatHERS

Due to time constraints, the project did not thoroughly explore the Chenath engine of NatHERS and compare its alignment with the thermal bridging considerations of 4859.2. However, limited observations suggest that there may be fundamental differences in the underlying assumptions driving the calculations. NatHERS appears to take a "typical construction" approach, whereas 4859.2 considers the specific aspects of a given envelope system.

In NatHERS, adjustments to framing ratios or framing materials are not considered and do not affect the building's performance. Instead, a "typical metal frame" is assumed. To align these approaches and provide fairness to NCC elemental provisions users, a stipulated "typical assumption" should be provided for those completing a Total R-Value calculation for comparison purposes. This typical assumption could serve as an upper bound unless the actual construction deviates and offers more favourable conditions. Alternatively, the Chenath engine could be adjusted to incorporate the same considerations as 4859.2. Other areas of misalignment, such as cavity ventilation and the effective R-Value of cavities, should also be further addressed through additional work and consideration.

Table 13.2.5r

The minimum Total R-Values specified in this section do not specify whether they refer to summer or winter conditions. It is recommended to update the table to include clear indications of the applicable conditions, such as "Minimum Total R-Value (Summer)" and "Minimum Total R-Value (Winter)," to provide clarity and avoid any confusion regarding the intended performance requirements.

Definition Total R-Value

The definition of "Total R-Value" in the glossary should be updated to include the phrase "when calculated in accordance with AS/NZS 4859.2." This clarification will ensure consistency across different sections of the code where Total R-Value is referenced.

Use of term “shading device” in tables J3D8a and J3D8b

In Tables J3D8a and J3D8b, it is recommended to replace the term "shading device" with "shading projection" to align with the terminology used in the code. While "shading device" is not a defined term in the definitions section, it is described as "shading provided by an external shading device such as a shutter, blind, vertical or horizontal building screen with blades, battens or slats." However, these examples do not typically involve an "overhang" as mentioned in the description. Using the term "shading projection" would be more consistent with the terminology used in Figure 22, which refers to external permanent projections such as verandas, balconies, fixed canopies, eaves, shading hoods, or carports.

Regarding the interpretation of solar absorbance in relation to shading projections, it can be reasonably inferred that if no shading device is added (which is not necessary), any solar absorbance would be acceptable when shading projections are less than 300mm in climate zone 2. The same principle could be applied to climate zones 4 and 5 when the wall-to-floor area is equal to or greater than 45%. However, in this scenario, it is important to provide specific guidance on what is considered allowable in these circumstances. Unlike in climate zone 2, the word "any" is not used in relation to solar absorbance in the code provisions for climate zones 4 and 5.

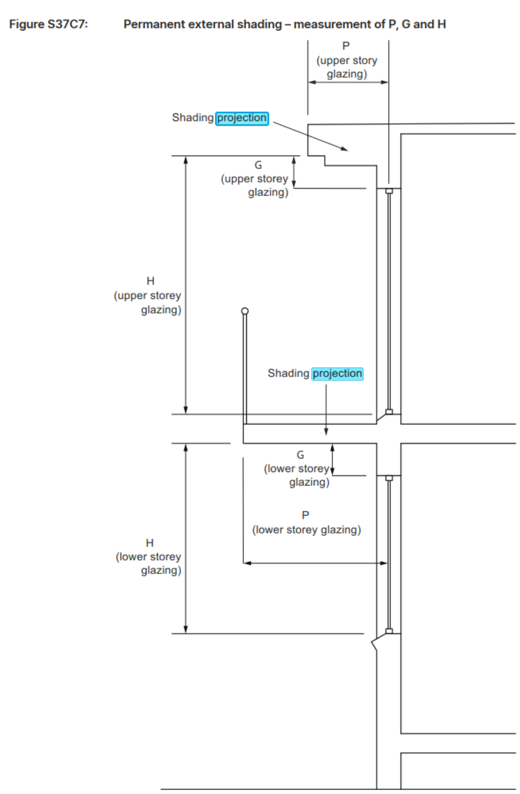


Figure 21 – Figure S37C7

Table J3D8a: **Solar absorptance – climate zones 1 to 6**

Climate zone	Opaque *external wall* to net *floor area* ratio	Permitted solar absorptance
1 and 3	< 45%	≤ 0.8
	≥ 45%	≤ 0.35
2	< 35%	Any
	≥ 35%	Any, or ≤ 0.35, if shading device overhang is < 300 mm
4 and 5	< 45%	Any
	≥ 45%	≤ 0.35, if shading device overhang is < 1500 mm
6	Any	Any

Figure 22 -Table J3D8a