MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HIKINA WHAKATUTUKI

Determination 2021/012

Regarding alterations to install insulation in a skillion roof at 96 Lochiel Branxholme Road, Lochiel, Winton

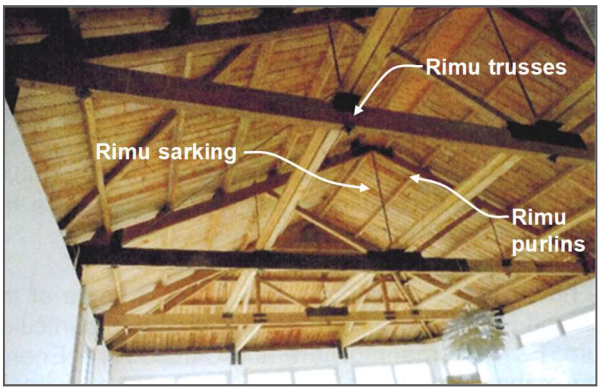


Figure 1: Original roofing timbers

Summary

This determination considers the compliance of a design to install insulation into a skillion roof and the authority's decisions to grant the building consent for that design and a code compliance certificate for the completed work. The determination considers whether the proposed building work would comply with Clause E3 Internal Moisture if the work was completed in accordance with the plans and specifications, and the performance of the building work as constructed with Clause E3.

1. The matters to be determined

1.1 This is a determination under Part 3 Subpart 1 of the Building Act 2004[1] ("the Act") made under due authorisation by me, Katie Gordon, National Manager Determinations, Ministry of Business, Innovation and Employment ("the Ministry"), for and on behalf of the Chief Executive of the Ministry.

1.2 The parties to the determination are:

- the applicant, Southland District Council ("the authority"), carrying out its duties as a territorial authority or building consent authority
- the owners of the house, C Jaegar and C Menlove ("the owners")
- the licensed building practitioner concerned with the relevant building work, J Carter[2] ("the builder"), acting via an agent ("the lawyer").

[1] The Building Act and Building Code are available at www.legislation.govt.nz. The Building Code is contained in Schedule 1 of the Building Regulations 1992. Information about the Building Act and Building Code is available at www.building.govt.nz, as well as past determinations, compliance documents and guidance issued by the Ministry.
[2] Licensed Building Practitioner for carpentry and design (BP100168)

1.3 This determination arises from the decision of the authority to issue a building consent in 2011 and a code compliance certificate in 2013 for alterations to a skillion roof to install insulation. The owner is concerned that the roof as constructed does not comply with certain clauses[3] of the Building Code in particular in regard to moisture accumulated within the concealed roof framing.

1.4 The matters to be determined under section 177 of the Act are therefore:

- whether the design of alterations to the skillion roof comply with Clause E3 of the Building Code (section 177(1)(a))
- whether the authority was correct to grant a building consent for the alterations to the skillion roof (section 177(1)(b) and (2)(a))
- whether the authority was correct to issue a code compliance certificate for the building work (section 177(1)(b) and (2)(d)).

1.5 In deciding these matters, I must consider whether the skillion roof as consented and as completed complies with Clause E3 Internal moisture of the Building Code. The skillion roof includes the components of the system (such as the ceiling linings, the framing, the insulation and the roof underlays), as well as the way the components have been installed and work together.

1.6 Matters outside this determination

1.6.1 Determinations can consider matters of Building Code compliance and decisions of an authority, but cannot decide on some of the other issues raised by the parties in their submissions, although they assist me in providing the context leading to the determination. This determination does not consider matters associated with liability or other civil disputes.

1.6.2 The authority has questioned compliance with Clause H1 Energy Efficiency, however the performance requirements of Clause H1 relate to the building and building envelope as a whole, not to an individual component or assembly. I have therefore not considered compliance with Clause H1 as part of this determination. For the benefit of the parties I note that an assessment of the building work against Clause H1 is an alteration to an existing building and section 112 of the Act is applicable (see Appendix A). This assessment considers whether the performance of the building as a whole is reduced by the work. In this case, the installation of a new insulation product where there was none before, will either improve performance or at least continue to meet the current performance of the building and building envelope as a whole with Clause H1.

1.6.3 This determination does not consider the change of use (refer paragraph 3.1), the outstanding notice to fix (refer paragraph 3.2) issued in relation to the refusal to issue a code compliance certificate for a 1999 building consent (BLD/99/0624/1), or the second stage building consent No. BLD/2011/47162/2 issued on 16 December 2011 for strengthening window and door openings.

1.6.4 This determination is limited to the skillion roof alterations approved under the building consent BLD/2011/47162/1 and the matters outlined in paragraph 1.4.

[3] In this determination, references to sections are to sections of the Act and references to clauses are to clauses of the Building Code.

1.6.5 In making my decision, I have considered:

- the authority's submission, which includes a report by a building surveyor engaged by the owners to assess the roof ("the building surveyor")
- the report of the independent building physicist commissioned by the Ministry to advise on this dispute ("the specialist")
- the submissions and evidence provided by the parties, and
- the other evidence in this matter, including relevant industry guidance.

1.6.6 Relevant provisions of the Act and the Building Code can be found in Appendix A, and relevant industry guidance on skillion roofs discussed in this determination in Appendix B.

2. The building work

2.1 The skillion roof was installed as part of alteration work to an old factory building situated on a large level rural site in a wind zone assumed to be medium[4].

Figure 2: The original cheese factory

2.2 The original factory

2.2.1 The building was originally constructed as a cheese factory in the mid-1930s as one of many co-operatives similar in plan, form and function built in New Zealand. Figure 2 indicates the condition of the factory by about the late 1990s.

2.2.2 The large open space shown in Figure 1 was the original cheese-making area (the 'making room'), which included Rimu board ceilings and exposed Rimu roof trusses at 3m centres supporting the main roof. The west wing was the original curing room and packing area and included ceiling linings installed below the trusses.

2.3 The alteration work

2.3.1 The extent of building work considered in this determination is shown in Figure 3. The original 200 mm thick concrete walls and roof framing have been retained, with a new insulated roof constructed as shown in Figures 4 and 5.

[4] Wind zones as described in New Zealand Standard NZS 3604

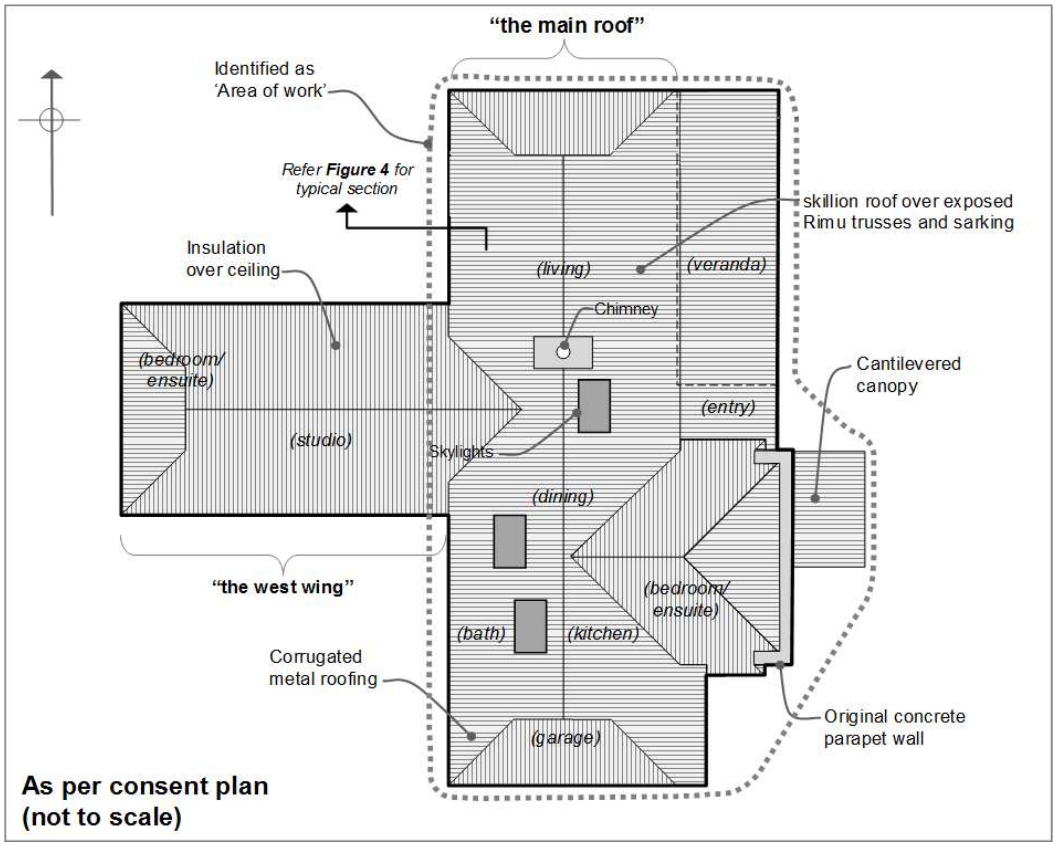


Figure 3: Approximate roof plan

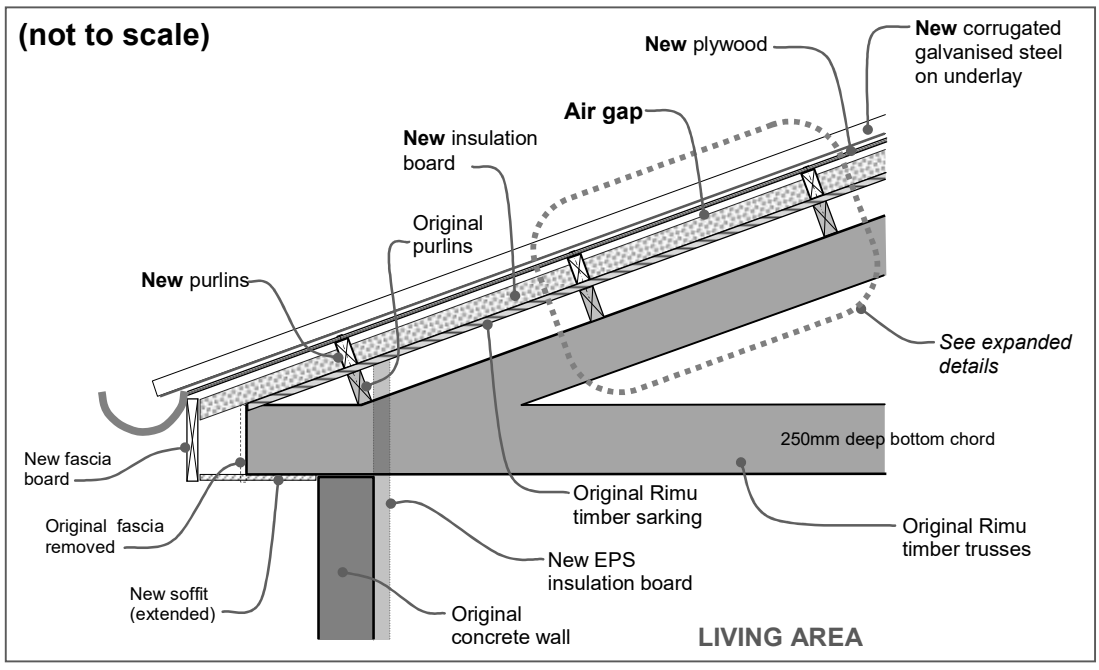


Figure 4: Typical section

2.3.2 Figure 4 shows the general construction of the new skillion roof above the original timber sarking, with the original rimu timber trusses and sarking left exposed as shown in Figure 1. Expanded details are provided in Figures 5A and 5B.

2.4 The skillion roof construction

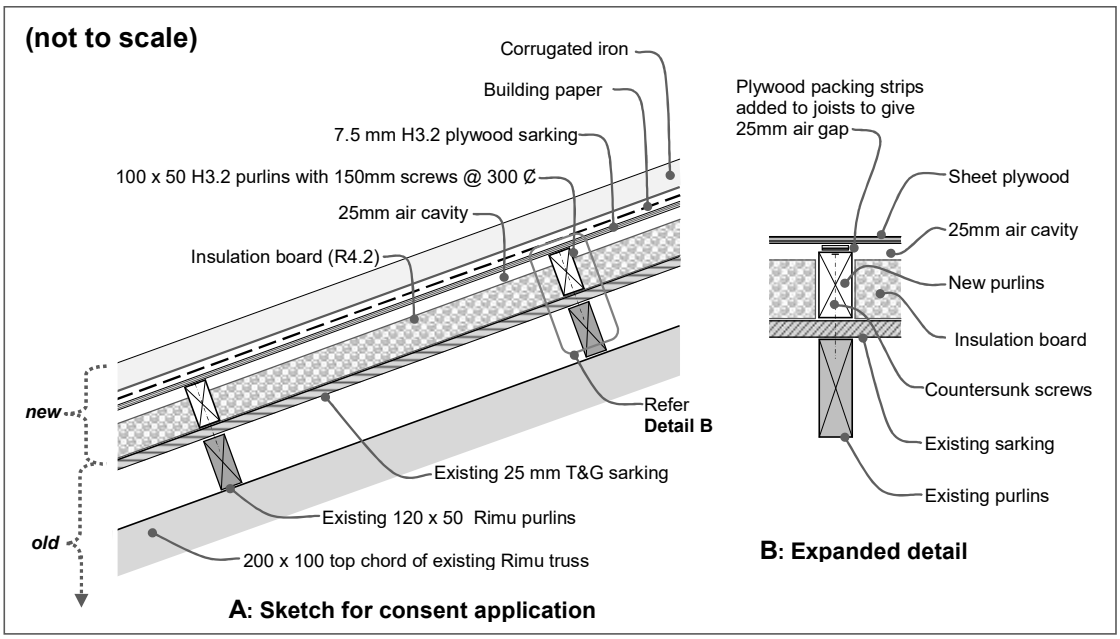


Figure 5A & 5B: Expanded details of consented roof

2.4.1 Figure 5A provides an expanded section of the builder's hand-drawn sketch submitted in the application for a building consent, and Figure 5B shows the addition of packing strips to provide the 25mm air gap requested by the authority.

2.4.2 The builder's scope of work dated 31 August 2011 for the roof stated:

1. Remove ex iron roofing and replace with [product named] corrugated.
2. On Main roof pack up purlins with 100 x 50mm H3.2 Timber Purlins over ex sarking to make room to fit insulation.
3. Purlins screwed @ 300 centres with 150mm countersunk 14 gauge galv screws through ex sarking and into ex 120mm Rimu Purlins.
4. New 300 x 50mm H3.2 Fascia boards and replace 100mm T & G timber soffits.
5. Fit 80mm [proprietary insulation] Soffit board on top of ex Rimu sarking between new 100 x 50 purlins
6. Fit 7.5mm H3.2 plywood as sarking leaving 20mm air cavity between insulation and sarking.
7. Lay [product named] black building paper over new ply.
8. Fit [coated] corrugated metal roof and all new flashings.
9. New 200mm ½ round spouting.

2.4.3 The insulation board has a rigid thermoset phenolic insulation core sandwiched between an upper tissue-based facing and a reflective aluminium foil bonded during manufacture of the product. The board is provided in a variety of thicknesses to provide different thermal resistances. The manufacturer's technical information dated October 2009 for this insulation board was provided in support of the building consent application, and stated "Exposed boards joints and cut edges should be taped with a minimum 50 mm foil tape".

3. Background

3.1 Approval to change the use of the building from industrial to residential was given in 1999, under section 46(2) of the Building Act 1991, in association with a separate building consent[5] (BLD/99/0624/1) granted to a previous owner. A code compliance certificate has not been issued for this 1999 building consent.

3.2 A notice to fix was issued[6] in 2010 outlining a number of items required to be remedied, including among other things, the requirement for the walls and ceiling to be insulated. The requirement was related to the approved change of use.

3.3 In 2011, to address the notice to fix requirement for the walls and ceiling to be insulated, an application for a building consent was made to 'insulate roof'. The authority issued building consent No. BLD/2011/47162/1 for 'alterations to the skillion roof' on 14 October 2011, which covered the building work described in this determination (see paragraph 2.3). The consent conditions included the requirement for a 'skeleton inspection' during construction of the new roof.

3.4 Inspections during construction

3.4.1 The builder commenced work, with old roofing progressively removed and new framing, insulation and ply sheet installed over the next month. The authority carried out three 'progress' inspections and took photographs of the work. I note here that in one photograph the installed insulation is visible on two sections of roof, and that there are no obvious (large) gaps visible in the photographs.

3.4.2 The first inspection on 19 October 2011 was 'to check framing being placed over the existing sarked roof' and the record noted:

> H3.2 purlins have been secured over the existing and packers placed on top to ensure a minimum 25mm air gap in place.
>
> H3.2 ply sarking going over the purlins with heavy weight [proprietary] roof underlay then [corrugated roofing] placed over.
>
> 80mm poly insulation with silver foil to the underside...

3.4.3 The next inspection record dated 27 October 2011 included the following notes:

> Roofing still being removed, 80mm polystyrene insulation being placed between new H3.2 100 x 50 horizontal purlins, batten placed on top to ensure 25mm clearance air space, 8mm tan ply sarking going over with heavy weight [proprietary] roof underlay going over that....
>
> ...2/3 of the roof is now insulated, apron flashing being placed to change of pitch junction, [proprietary] corrugated iron screw fixed.
>
> OK to proceed...

3.4.4 The authority carried out the last 'progress' inspection on 16 November 2011 noting:

> ... roof nearly all flashed, flashings installed ok, [proprietary] corrugated roofing screw fixed, stainless steel internal gutter fitted, rainhead not installed yet. Skylight flashed and also chimney framing...
>
> OK to proceed...

3.4.5 The roof was substantially completed by the end of the year and the owners occupied the house from January 2012; completing the second stage strengthening work (see paragraph 1.6.3). From 2013 to early 2015, the house was intermittently occupied as a 'holiday home' while other interior work was gradually completed.

[5] I have not seen a copy of the building consent.
[6] I have not seen a copy of the notice to fix.

3.5 The 2013 inspections

3.5.1 No further inspections were carried out until the owners applied for a code compliance certificate on 25 March 2013. The authority undertook the first final inspection on 25 July 2013, with the record noting:

> Roof now all finished, [corrugated roofing] all screwed down, flashings to ridges and skylight as approved, apron completed, laps ok, the internal gutter has no drip edge to the inside nor is the iron overhanging 50mm as it should. The parapet side is completed as per approved. Spouting all hooked up to approved outfall, the chimney penetration is capped and water tight at present, this is another stage that has not yet been applied for. Rainheads placed with over[flow] to parapets.

3.5.2 The authority re-inspected the roof on 18 September 2013 and noted:

> The internal gutter has been rectified as I discussed with the builder, a drip edge on the inside edge has been formed and bitumix type corrugated seal back up 60mm from the underside edge of the iron and on top of the return for the gutter. This will now meet performance requirement of the code. [Application for code compliance certificate] is in and now ok to issue [code compliance certificate].

3.5.3 The authority issued a code compliance certificate on 23 September 2013.

3.6 Identification of moisture problems

3.6.1 In June 2017 the owners inspected the concealed area above the dining/living area. Large gaps around the insulation panels were revealed together with wrinkling to the foil underside. Photographs provided by the owners that were taken from inside the building show gaps around the insulation, with large gaps at the ridge line and smaller gaps at the edges of some of the other insulations boards, and there is no tape visible. The photographs also show wrinkled foil facing on all of the insulation, which indicates the insulation panels had shrunk.

3.6.2 In February 2018, following discovery of the gaps around the insulation, the builder removed a section of roofing to find that the insulation board 'had shrunk back at least 25mm over 850 mm wide'. The builder advised that the product had come 'from the same batch which had failed on an installation in Dunedin'. The owners have submitted that there is no evidence this is the case or that the cause of the shrinkage has been established.

3.6.3 I make no conclusion as to whether the gaps are due solely to shrinkage or if the insulation board was not cut and installed to fit snugly, nor do I consider the cause of any shrinkage.

3.7 The building surveyor's report

3.7.1 In August 2018, the owners sought advice from the building surveyor and decided to commission an investigation of the skillion roof. The surveyor inspected the skillion roof area on 5 November and provided a report dated 28 November 2018.

3.7.2 The building surveyor noted that the instructions were to:

> ...undertake a site inspection and provide a written report on the design, workmanship and installation of the roof and associated flashings, identifying any faults, the likely cause, and proposed corrective actions...

3.7.3 The building surveyor assessed the roof, based on 'primarily a visual assessment with some isolated de-construction of the roof to the south west and the north eastern slopes only' which involved removal of:

- corrugated metal roof sheets
- roofing underlay

- plywood sheets beneath the underlay
- insulation board and exposure of the underlying original Rimu boards.

3.7.4 The surveyor identified various defects in regard to roof fixings, gutter and flashings at junctions and intersections, and during deconstruction observed (in summary):

- roofing installed directly over the underlay, which was stapled onto the plywood sarking and appeared to be satisfactorily installed
- plywood nailed through a 10mm batten installed over the roof purlins, with uPVC[7] jointers at vertical joints and horizontal butt joints
- visible black stains on the underside of the north east but not the south west plywood
- 80mm insulation board 'loosely laid' between purlins with some large gaps
- the use of expanding foam to various gaps
- wrinkling to the top paper and the foil underside of the insulation board
- moisture staining to the underside of the Rimu boards to the northern end.

3.7.5 The report concluded by commenting on the roof design and on possible cause(s) of the moisture problems; including the following comments (in summary):

- In regard to the roof design:
  - Skillion roofs have limited air spaces and little or no natural ventilation, so are inherently at higher risk of condensation being trapped within the roof structure than conventional roof structures.
  - New roofing sits over plywood, with little allowance for ventilation of the enclosed framing below, despite a 25mm air gap above the insulation.
  - The original roof construction was designed for the original industrial function of the building. The design of the new roof system is outside the scope of E2/AS1[8] and required specialist design.
  - As well as lacking ventilation, no measures are provided to minimise moisture vapour from passing through the timber sarking from below.
- In regard to the installation:
  - Insulation board was not installed to manufacturer's instructions and large gaps allow the passage of moisture into the unventilated cavity.
  - Roofing defects have resulted in ongoing leakage, with evidence of elevated moisture levels and damage within the roof structure.
  - Internal moisture is also likely to be migrating through the rimu sarking and insulation gaps, with the lack of ventilation resulting in condensation and mould growth on the plywood underside.
  - Current research indicates vapour barriers are not necessary except in colder climates, so specialist advice is needed. Additional ventilation of the roof space is needed unless a 'warm roof' system is used.

[7] Unplasticised Polyvinyl Chloride
[8] Acceptable Solution E2/AS1 External Moisture for Clause E2

3.7.6 The building surveyor concluded:

> The failures observed to the insulation appear to be systemic. It is therefore our considered opinion that the defects observed, and the inherent risks associated with condensation in skillion roofs cannot be suitably reduced without re-design. In our opinion, the only viable option is removal of the roof covering and insulation and replacement with a new robust system of insulation incorporating suitable ventilation being designed in accordance with current best practice and in accordance with the New Zealand Building Code.

3.8 The dispute

3.8.1 A dispute arose between the owners and the builder as to the liability for alleged defects, with letters exchanged between respective solicitors.

3.8.2 Failing to satisfactorily resolve the situation, the owners wrote to the authority on 28 May 2019 attaching the surveyor's report and claiming that the new skillion roof did not comply with the Building Code. The owners included comments that I have taken to be part of their submissions for this determination:

> We are aware you will say the installation meets E3 internal moisture because there is a 25mm gap between the insulation and the roofing underlay. We believe in this case it is clear the roof envelope has been affected by internal moisture and the [authority] should not have ever issued the consent.

3.9 The application for determination

3.9.1 The situation remained unresolved and the Ministry received an application from the authority on 28 June 2019 which was accepted for determination on 9 July 2019. The Ministry sought further information from the parties in a letter dated 12 July 2019. The owners responded to the Ministry's requests on 16 July; providing some additional background and several general comments that are included within their submissions.

3.9.2 The authority responded on 16 July and 1 August 2019 with information that I have included as part of its submissions in paragraph 4.1. In regard to why the skillion roof design was considered code-compliant when the building consent was issued, the authority noted (in summary):

- The proposed roof (see Figures 4 and 5) accorded with E3/AS1[9] and was therefore deemed to comply with Clause E3 of the Building Code because:
  - The roof underlay accorded with E2/AS1 and the plywood substrate was assessed as a support for the roof underlay.
  - The 25mm gap between insulation and the plywood met E3/AS1 (1.1.3 – see Appendix A3.3).
  - The BRANZ House Insulation Guide[10] provided examples of acceptable roof construction, which would have been used to verify compliance (E3/AS1 1.1.3 – see Appendix A3.3).
  - The unventilated roof cavity complied with E3/AS1 (1.1.4(b) – see Appendix A3.3).
  - The plywood is not a primary underlay; it provides support to the roof building paper underlay and encloses the framing cavity in accordance with E3/AS1 (1.1.3 and 1.1.4).

[9] Acceptable Solution E3/AS1 for Clause E3 Internal Moisture
[10] Fifth edition 2014 – see Appendix 0 Figure 8

4. The submissions

4.1 General comment on submissions

4.1.1 At times the owner and builder have disputed particular points in the others' submissions. This following section is to record in summary the opinions and information provided by each party during the determination process, not to determine which set of facts or circumstances is more or less accurate than others.

4.2 The authority's submission

4.2.1 The authority's submission accompanied the application as an email to the Ministry dated 28 June 2019, which stated that it:

> ...issued the consent as the information provided indicated the insulation complied with the building code and specifically building code clauses H1 and E3. The information provided showed there was to be a minimum gap of 25 mm between the top of the insulation and the bottom of the roofing underlay. There was a minor variation from the consent during construction but this was assessed as having no impact on the consent and was dealt with during the inspection process. [The authority] issued the CCC believing on reasonable grounds that work was carried out in accordance with the consented documents.

4.2.2 The authority also responded to the Ministry's requests for further information, and made the following comments (in summary):

- There is no record of a variation and the reference to a 'minor variation' likely relates to a separate building consent issued on 16 December 2011 for a second stage consent to strengthen window/door openings (see paragraph 1.6.3).
- The roofing building paper is a 'compliant barrier in accordance with E2/AS1', with 'the provision of the ply sarking assessed as supporting the paper'.
- The roof design as consented complied with Clause E3 of the Building Code, as required by section 49 of the Act (as explained in paragraph 3.9.2).
- The inspection records and construction photographs confirm that the roof was constructed in compliance with the building consent as required by section 94(1)(a) of the Act (see Appendix A1.2).

4.2.3 Within and following the application, the authority provided copies of:

- the consent documents
- the building consent dated 14 October 2011
- the inspection records
- the owners' letter dated 28 May 2019
- the building surveyor's report dated 28 November 2018
- other correspondence between the parties.

4.3 The owners' submissions

4.3.1 The owners' letter to the authority set out their position in regard to the matters considered in this determination; in summary:

- The authority should not have issued the building consent because there were flaws in the roof design.
- The authority should not have issued the code compliance certificate because

the 'product was not installed correctly'.

- A number of determinations[11] have confirmed that 'there are issues with condensation in colder climates', which should have alerted the authority that the 'proposed design was flawed'.
- The plywood under the roof membrane has reduced roof ventilation, causing condensation within the framing cavity.

4.3.2 The owners responded to the Ministry's requests for further information, which provided background that I have taken into account in this determination. The owners also included the following general comments (in summary):

- Moisture problems were revealed in all areas opened and are not confined to roof areas above moisture-generating areas such as bathrooms, kitchen etc.
- The building surveyor's report also identified 'poor workmanship and faulty installation of flashings' leading to external moisture penetration.

4.3.3 On 27 July 2019, the owners responded to the builder's submission dated 25 July (see paragraph □) and provided some details that I have taken into account within the determination as I consider appropriate. The response also provided additional background to the dispute and included the following comments (in summary):

- In regard to the skillion roof design:
  - the owners provided a product data sheet for insulation board that met the R-value[12] required for approval of a change of use to residential.
- In regard to the building surveyor's report:
  - the report made it clear that 'the insulation would have failed regardless due to the design faults of the roof and other multiple problems'
  - the legal advice the owners received was to try and work with the authority and the builder to find a solution to fix the roof, and that the roof is 'growing mould and continuing to deteriorate'.

4.3.4 In response to the Ministry's request for further information, the owners provided:

- copies of the floor plan and elevations of the original building
- photographs of the underside of the insulation board above the dining/living area.

4.4 The builder's submission

4.4.1 The builder made a submission on 25 July 2019, and included the following (in summary):

- In regard to the skillion roof design:
  - The drawing was reviewed by the authority prior to issuing a building consent for the work.
  - The builder installed the roof in accordance with the consented drawing.
  - Skillion roof design is not well understood in the building industry even by some building professionals.

[11] For example Determination 2015/057 issued 7 September 2015: Regarding the refusal to issue a building consent for stage one of remediation to an apartment complex

[12] The R-value, or resistance value, of insulation indicates its thermal resistance.

- In regard to the building surveyor's report:
    - The surveyor identified moisture problems due to inadequate ventilation; describing the roof, its risks and the complexity of skillion roof design.
    - The surveyor also 'expressed a variety of opinions' on installation practices, materials used and remedial possibilities.
    - The insulation board had been identified as defective.
    - Investigations of internal moisture problems in other buildings have required highly specialist engineering input and advice.
    - While there is 'clearly an inadequately ventilated skillion roof', specialist input is needed in regard to other problems and possible remedies.
    - The building surveyor's report went 'beyond his strict sphere of expertise and also the scope of his largely visual inspection'.

4.4.2 The builder made a further submission on 1 August 2019 in response to the owners' letter of 27 July 2019, which expanded on the above and included (in summary):

- In regard to the skillion roof design:
    - The owners provided product a data sheet and drawings of how the ceiling should be configured, with neither the owner nor the builder aware of any need for specialist design.
- In regard to the insulation board:
    - The insulation board was tight when it was fitted and expanding foam was used to fill any 1-3 mm gaps.
    - When it was discovered that the board had shrunk, the builder removed a section of roof and found shrinkage of at least 25 mm over 850 mm.
- In regard to the building surveyor's report:
    - The assertion of problems in the ceiling space being caused by external moisture due to poor workmanship is not correct.
    - The owners' building surveyor clearly highlights the inadequate design of the skillion roof, with little provision for ventilation.
    - The builder denies that moisture issues come from poor workmanship and there is 'simply no evidence of external moisture ingress but the inadequately designed skillion roof is plain and unequivocal.'

4.5 The first draft determination and submissions in response

4.5.1 A draft determination was issued to the parties for comment on 3 February 2020. This first draft concluded the design of the skillion roof as consented and constructed did not comply with Clause E3, and reversed the authority's decisions to grant the building consent and the code compliance certificate.

4.5.2 On 31 March 2020 and 11 August 2020 the owners responded indicating that they did not accept the draft determination's decision, and submitted (in summary):

- When the building consent was sought it was not highlighted that the design of the skillion roof contained an alternative solution and this omission contributed to the errors made when the building consent application was assessed. Also the consent did not indicate that the sarking boards have gaps in excess of 12mm.
- Gaps in the insulation were only visible when the owners inspected the

concealed area above the dining/living area in 2017 (refer paragraph 3.6.1) and would not have been visible at the time of the inspection.

- The manufacturer's specifications included in the approved building consent state that the insulation board joints and cut edges should be taped; as the insulation board joints were not taped the installation was not in accordance with the approved building consent.

4.5.3 On 31 March 2020 the authority responded that it did not accept the draft determination's decision, and submitted (in summary):

- In deciding whether to issue the building consent "it is important to only consider if the documentation provided with the application for the building consent were adequate to demonstrate compliance" with the Building Code at the time and present knowledge of skillion roof design cannot be considered.
- The documentation provided with the building consent application meets the requirements of the BRANZ House insulation guide as referenced in E3/AS1 and therefore demonstrates compliance with Clause E3.
- A continuous air barrier (foil) is shown between the insulation and the ceiling lining and it is reasonable to expect that the insulation panels will form a continuous air barrier to prevent the movement of water vapour from internal building activities into the confined roof space.
- The failure of the insulation material has caused the air barrier to be ineffective and allow excessive moisture to enter the roof cavity. If this air barrier had been maintained the moisture would have been prevented from accumulating within the roof cavity.
- Construction was in accordance with the approved documents and regular inspections had been carried out, therefore there is no reason why the code compliance certificate should not have been issued.

4.5.4 The builder did not make a submission in response to the first draft of the determination.

4.6 The second draft determination and submissions in response

4.6.1 A second draft of this determination was issued to parties on 2 November 2020. The second draft concluded the design was compliant with Clause E3 and the authority was correct to issue the building consent, but the skillion roof as constructed does not comply and the authority was incorrect to issue the code compliance certificate.

4.6.2 The authority responded on 30 November 2020 accepting the draft determination with minor corrections identified.

4.6.3 The owners responded on 30 November 2020 stating they did not accept the draft determination and submitted:

- The design was not compliant; "the roof alteration design and the insulation product were not compatible", and "it was the [authority's] statutory responsibility to check the design and products being used were compatible." They also made comment that "there needed to be a vapour barrier and not just the air barrier."
- The drawing has no information regarding taping of the insulation panel joins to create the air barrier.

- In regards the insulation, "it [the insulation board] has never proven to be defective." There are other potential causes for shrinkage in the insulation such as exposure to moisture during construction, leaking flashing, and the angle of the roof screws.

4.6.4 The builder responded on 30 November 2020 stating they did not accept the draft determination and submitted:

- They do not take issue with the conclusions drawn on how moisture is entering the roof cavity.
- They disagree with the conclusion that the design was compliant when it was "going to be very difficult if not impossible to achieve" what is shown in the design.
- The design as consented did not provide for taping joints and if tape was required the builder would have noted the design could not be practicably installed due to the installation being proposed from above with the existing sarking remaining in place.
- That they believe the design as approved was not compliant "because it lacked what the expert now says was necessary, namely a continuous air barrier."
- The builder disputed comments made by the owner on the installation and the role of the manufacturer of the insulation board.

5. The specialist's report

5.1 As mentioned in paragraph 1.6.1, I engaged an independent specialist to assist me. I requested the specialist carry out an assessment of the plans and specifications supporting the consent application and an assessment of the building work as-built. The specialist is a building physicist for the Building Research Association of New Zealand (BRANZ) and inspected the skillion roof on 22 October 2019; providing a report finalised on 3 December 2019 and forwarded to the parties on 4 December 2019.

5.2 The supplied information

5.2.1 In regard to the consent documentation the specialist noted the following (in summary):

- The documentation consisted of:
  - hand drawn sketches of the proposed roof design
  - excerpts from Clause E2 with annotations
  - a PS1 (producer statement – design) from a structural engineer to confirm the load carry capacity of the existing structure
  - information from the insulation manufacturer.
- The insulation manufacturer's information included:
  - where boards are cut, they should also have edges taped
  - the provided insulation has good thermal performance, low vapour permeability, and low air permeability.
- Rigid insulation products are intended to be installed in a continuous manner, with joints between sheets taped and sealed.

- The lack of a 25mm air cavity above the insulation was questioned by the authority and the design was modified to use an H3.2 batten on top of the purlin to provide the additional 25mm clearance.

5.2.2 In regard to the building surveyor's report, the specialist noted (in summary):

- The building surveyor observed numerous workmanship/quality issues, along with evidence of elevated moisture in several locations, including the plywood underside and there were significant patches of mould on the underside of removed sheets.
- While the report did not come to a firm conclusion as to causes of moisture accumulation, it noted some possible causal factors, in particular:
  - the lack of ventilation of the structure
  - the lack of an air barrier at the ceiling level.

5.3 Roof investigations

5.3.1 The specialist noted that adverse weather conditions with heavy rain prevented timber moisture readings from being taken during his visit, though parts of the roof cladding on the north and south facing side were temporarily removed. In addition, the corresponding roof underlay, plywood sheeting and insulation were lifted to inspect for signs of moisture and mould growth.

5.3.2 Removal confirmed the building surveyor's findings, with the specialist observing:

- east-facing: underside of plywood sarking, displaying mould growth
- west-facing: underside of plywood sarking, displaying mould growth
- a clear line of mould growth on plywood that aligns with underlying purlins.

5.4 The compliance of the design

5.4.1 In regard to moisture movement within structures generally, the specialist noted:

- Construction must be designed to be durable and safe for occupants. Key to this is how heat, air and moisture are managed throughout the construction.
- Internal moisture is typically transported by:
  - migration of vapour-laden air moving around or between materials, and/or
  - vapour diffusion through materials due to pressure differences.
- Moist air moving through gaps or cracks transfers vapour much faster than by diffusion through materials, particularly for thick materials or materials with a high vapour resistance.
- A 'vapour open' air barrier (such as thin porous underlay) limits air movement, while allowing drying via vapour diffusion during favourable conditions.
- The above processes must be managed and adequate provisions made to deal with possible moisture accumulation to avoid condensation or fungal growth, as required by Clause E3.

5.4.2 Concerning the skillion roof design generally, the specialist noted (in summary):

- Skillion roof design is inherently more risky than a roof with a ceiling space. There is little tolerance for design and/or construction defects, so care must be

taken to get details correct.

- Warm moist air from a building's interior will condense and accumulate as water when it meets the colder underside of a roofing underlay.
- An air barrier at ceiling level restricts the amount of water vapour that can migrate into the cavity and reach the underlay.
- Minimising and restricting most of the air-carried moisture transfer to vapour diffusion reduces the rate at which moisture reaches materials such as plywood sarking, which can absorb that moisture.

5.4.3 The specialist noted the following about the authority's rationale for approving the roof design (see paragraph 3.9.2):

- E3/AS1 (amendment 3) was the Acceptable Solution for Clause E3 when the building consent was issued (see Appendix A3.3), and the authority maintains that the consent complied with that by:
  - providing a gap of 25mm minimum above the insulation as per the BRANZ House Insulation Guide[13], in accordance with E3/AS1 1.1.3, and
  - allowing no ventilation to the cavity in accordance with E3/AS1 1.1.4 b).
- In regard to ventilating the framing cavity, the specialist noted (in summary):
  - The 1995 BRANZ guide had also noted that a roof space:

    > ...should only be considered ventilated if roof or gable vents are built in or building paper has not been correctly installed under the cladding.
  - BB 525[14] addresses ventilation of the roof space in section 7.4 (see Appendix B1.4) by noting that the amount of natural air leakage in most skillion roofs is sufficient to remove small amounts of vapour.
  - However, natural ventilation is limited for materials that are practically airtight when installed, so additional measures may be needed.
  - Skillion roofs with wire mesh supporting the roof underlay (see BRANZ details in Appendix B, Figures 6 and 7) should have sufficient natural air leakage.
  - However, the subject roof has continuous plywood sarking supporting the roof underlay, which has significantly reduced natural air leakage.
  - The plywood sheet enclosing the cavity (see Figure 5A) does not accord with the intent of E3/AS1 1.1.4 b), which the specialist considers is:

    > ...to ensure that direct means to excessively ventilate the insulation space were not undertaken. There is no indication that [the intent of E3/AS1 1.1.4 b)] is to make these spaces be as airtight as possible.
- The provision of an air barrier at a skillion ceiling level has been consistent in BRANZ advice since the first edition of the house insulation guide in 1996, which stated:

  > A good quality, airtight membrane is required over any ceiling construction which has unsealed gaps between the roof spaces and the rooms below.

5.4.4 The specialist considered the compliance of the subject skillion roof design with Clause E3 of the Building Code and included the following comments (in summary):

- In regard to the inclusion of air barriers in skillion roofs:

[13] First Edition 1995
[14] BRANZ Bulletin 525 Preventing moisture problems in timber-framed skillion roofs (Issued Aug 2010 superseded by BB610 in June 2017)

- An air barrier at ceiling level restricts the amount of moisture that can migrate into insulated cavities, so minimising condensation when moist interior air contacts colder underlays.
- The need for an air barrier was well established prior to the 2011 skillion roof design, as a barrier would reduce the rate that moisture can reach and be absorbed into materials such as the plywood sarking.
- The 1995 BRANZ guide referenced in E3/AS1 noted that:

  > ...a good quality, airtight membrane is required over any ceiling construction which has unsealed gaps between the roof spaces and the rooms below.

- Other BRANZ guidance current in 2011 included sketches showing 'building paper air barrier over T&G boarding' (see Figure 7 Appendix B,) or 'continuous air barrier material (spec E2/AS1 Table 23) under insulation' (see Figure 8 – Appendix 0 to B1.4).
- BRANZ Bulletin 525 (7.3.1) stated:

  > Ceiling linings such as tongue and grooved boarding, that allow free flow of air through the joints must be sealed by an air barrier.

- In regard to this 2011 skillion roof design (see Figures 4 and 5):
  - Tongue-in-groove timber ceiling linings allow moisture vapour through the joints.
  - Although the foil facing to the underside of the insulation board could be considered as an air barrier, this is negated by the gaps around the panels which have resulted in a lack of continuity.
  - The initial fit of insulation appears to have been poor and the board has subsequently shrunk and distorted at the edges, resulting in substantial gaps that do not accord with E3/AS1 1.1.4 c).
  - In addition, the 1995 BRANZ guide warned against the use of rigid and semi-rigid insulation board in skillion roofs, noting 'Do not use. Workmanship demands are too stringent to be used in practice'.
  - Although subsequent BRANZ guide did not specifically state that there should be an air barrier at the ceiling, all example sketches show plasterboard linings with no example that showed timber board linings.

5.5 The specialist's conclusions

5.5.1 Taking the building surveyor's report and the site investigation into account, the specialist noted that any external moisture penetration appeared to be isolated and able to be dealt with accordingly. However the specialist considered that the 'more pressing concern' was internal moisture accumulation, noting (in summary):

- Fundamental design issues have 'led to the failure of the roof to keep dry and avoid moisture accumulation' of interior moisture within the structure.
- Elevated moisture to the underside of the plywood sarking is due to a combination of the following compounding issues:
  - The unventilated 25mm air space, due to plywood sarking severely restricting natural air leakage that would otherwise occur.
  - The board ceiling is very air permeable, allowing moist internal air to reach cold areas of the roof structure.
  - Gaps around insulation have allowed moisture into the cavity at a greater rate than the roof could dry at – resulting in accumulation and mould.

- The high vapour resistance of the foil-faced insulation board effectively turns the sarking level of the roof into a one-way valve.
- The upwards air pressure differential supplies warm, moist air into the roof space, with the only drying pathway via vapour diffusion through the insulation largely blocked off.

5.5.2 The specialist concluded that 'if not remedied the issues noted in this roof structure will be ongoing, which may lead eventually to decay and associated problems.'

6. Discussion

6.1 Performance of the skillion roof

6.1.1 The functional requirement of Clause E3[15] of the Building Code requires buildings to be constructed to avoid the likelihood of:

> (a) fungal growth or the accumulation of *contaminants* on linings and other *building elements*; and …
> (c) damage to *building elements* caused by the presence of moisture.

And the performance criteria of Clause E3 requires:

> E3.3.1 An adequate combination of thermal resistance, ventilation, and space temperature must be provided to all habitable spaces, bathrooms, laundries, and other spaces where moisture may be generated or may accumulate.

6.1.2 In considering the primary concerns raised by the owners about the adequacy of the skillion roof installed to this house, I have assessed the available evidence in the context of the particular circumstances applying to this house; taking into account:

- the background and condition of the original factory
- the 2011 consent documentation
- the authority's 2011 inspection records during construction of the new roof
- the building surveyor's 2018 investigation of the roof
- the specialist's report
- other available relevant 2011 guidance from authoritative sources such as:
  - BRANZ
  - NZ Metal Roofing Manufacturers Association ("MRM")
  - Standards New Zealand.

6.1.3 The specialist's report provided some helpful commentary on best practices in regard to skillion roof design, and this has been the subject of a number of the parties' submissions. In response, it is important to note that the requirements of the Act, and therefore the assessment in this determination, focus on compliance with and assessment against the minimum requirements of the Building Code, rather than best practice.

6.1.4 I also note that in assessing the design the specialist has referred to the gaps around the panels, the fitting of the panels and shrinkage. These are a feature of the construction itself rather than of the design. In paragraphs 6.2.5 to 6.2.28 I have assessed the design for compliance as it was proposed in the documentation provided

[15] The relevant clauses are unchanged from when the building consent was issued in 2011.

to the authority in the application for building consent.

6.1.5 I make the following general observations about this particular skillion roof:

- The original factory had a skillion roof, with exposed timbers and a ridge vent as shown in Figures 1 and 2. The ridge vent was removed as part of the roof alterations in 2011.
- The 2011 skillion roof design included plywood sheet sarking to support the roof underlay with a 25mm gap above the rigid insulation board. The insulation board was cut to fit between purlins and sat directly on top of the original permeable ceiling linings – as shown in Figures 3 and 4.
- Photographs in the building surveyors report of the timber ceilings show water marks resulting from moisture migrating through the timber lining from the enclosed cavity above, with marks pronounced at junctions of linings with the exposed purlins, which align with the new purlins above as shown in Figures 4 and 5.
- The site investigations also revealed moisture absorption into the plywood enclosing the cavity; resulting in mould growth on the underside of the plywood, particularly above insulation/purlin junctions. Photographs also show significant gaps around the insulation board edges.

6.1.6 Moisture currently appears to be moving within and through the framing as shown in the following schematic sketch:

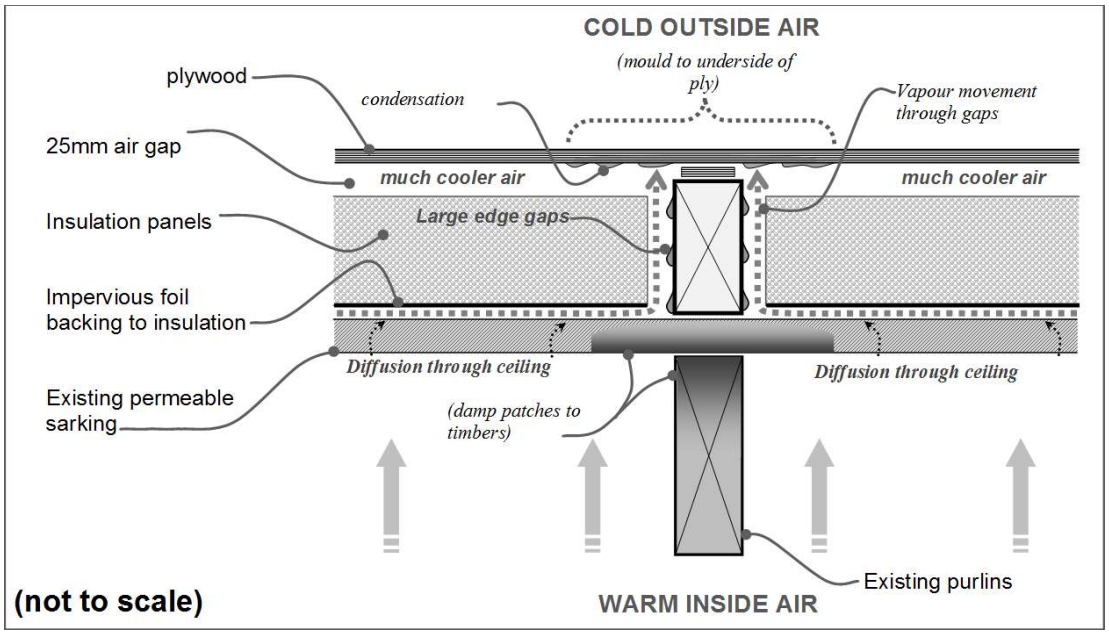


Figure 6: Moisture movement through the assembly

6.1.7 The above observations satisfy me that the skillion roof as-built does not comply with Building Code Clause E3. This is because the presence of the accumulated moisture over time would cause damage to building elements.

6.2 The 2011 decision to issue the building consent

6.2.1 I now consider whether the authority correctly exercised its powers when it granted a building consent for the building work in 2011 with regard to the requirements of Clause E3.

6.2.2 Section 49(1) of the Act requires an authority to:

> ... grant a building consent if it is satisfied on reasonable grounds that the provisions of the building code would be met if the building work were properly completed in accordance with the plans and specifications that accompanied the application[16].

6.2.3 In order for the authority to form a view as to the compliance of the proposed skillion roof, it needed to consider the evidence that was available and to seek further information as required. By doing so, the authority can then consider whether it is satisfied, on reasonable grounds, that the building work would comply with the Building Code if built in accordance with the plans and specifications submitted.

6.2.4 One way of establishing compliance with the Building Code is by means of an Acceptable Solution[17]. Section 19 of the Act (see Appendix A) states that a building consent authority must accept a design in accordance with an Acceptable Solution as complying with the Building Code.

Compliance by way of Acceptable Solution E3/AS1

6.2.5 The authority submitted the design was in compliance with the version of E3/AS1 that was in force at the time. I have summarised this view at 3.9.2.

6.2.6 Acceptable Solution E3/AS1 that was current at the time the consent was granted was E3/AS1 (2nd ed. Amendment 3). Under the heading "Thermal resistance", paragraph 1.1.1 of the Acceptable Solution detailed the R-Values to be used for parts of buildings, with an R-Value of 1.5 nominated for roof or ceilings of any construction. The following paragraph described how the R-values are determined:

> 1.1.2 *R-values* shall be determined using the methods in NZS 4214[18] or ASTM C236[19]. Laboratory test samples shall be truly representative of the wall, roof or ceiling system, including any provision for reducing thermal bridging.

6.2.7 The insulation board specification does note that R-values were calculated using the method described in NZS 4214:2006. However the specification also notes "The figures quoted are for guidance only. A detailed R-value calculation together with condensation risk analysis should be completed for each individual project". The assembly tested for the specification had the insulation board fixed directly to the soffit of a 200mm concrete deck. The assembly in this project is different from the assembly used for testing and therefore the design cannot be assessed on the R-values given in the specification. However, the 80 mm board itself has an R-value of 4.0, so if installed in accordance with the specifications would be adequate achieve thermal resistance required in E3.3.1.

6.2.8 Further, paragraph 1.1.3 of E3/AS1 cited the BRANZ House Insulation Guide as a means to satisfy paragraph 1.1.1:

> **1.1.3 Materials and installation**
>
> The BRANZ House Insulation Guide provides examples of acceptable wall, roof and ceiling constructions to satisfy the requirements of Paragraph 1.1.1.

6.2.9 The BRANZ House Insulation Guide provides a calculation method for determining the final construction R-value for various types of roof, wall and floor construction and glazing. It set out R-values for different types of insulating materials, including blown insulants, blanket and segment insulants, as well as rigid and semi-rigid

[16] Section 7 of the Act includes the following definition of plans and specifications: (a) means the drawings, specifications, and other documents according to which a building is proposed to be constructed, altered, demolished, or removed; and …

[17] Acceptable Solutions and Verification Methods are produced by the Ministry and, if followed, must be accepted by a building consent authority as establishing compliance with the Building Code.

[18] New Zealand Standard NZS 4214:2006 Methods of determining the total thermal resistance of parts of buildings

[19] ASTM C236:1989 Standard test method for steady-state thermal performance of building assemblies by means of a guarded hot box

insulants.

6.2.10 For some roof construction types the guide states rigid or semi-rigid insulants are not to be used, for other roof construction types the use of this insulant type was subject to additional requirements. These additional requirements clearly anticipated the risk of gaps around the boards that would reduce the thermal performance of the whole assembly and potentially allow moisture-laden air to be transmitted into the roof cavity.

6.2.11 The relevant roof construction detail in the BRANZ House Insulation Guide for this design is Sheet C3: Skillion roof, metal clad, ceiling battens (see Appendix A.4). Under the heading for rigid and semi-rigid insulants it states:

> **Rigid and Semi-Rigid Insulants**
> Do not use.
> Workmanship demands are too stringent to be achieved in practice.

6.2.12 The proposed insulation board in this case was a rigid insulant, which was therefore outside the scope of the Acceptable Solution. However, building work designed in accordance with the relevant Acceptable Solution for a particular Building Code clause is not the only way to demonstrate compliance with that clause.

Compliance as an alternative solution

6.2.13 Another option for establishing compliance with the Building Code is to assess the design directly against the performance criteria – this method is commonly referred to as an "alternative solution". An alternative solution may be a design that departs partially or completely from the Acceptable Solution or other compliance pathway provided for in section 19. In considering an alternative solution proposal a building consent authority will require further evidence to be satisfied that the building work meets the functional requirements and performance criteria of the clause (see paragraph 6.1.1).

6.2.14 The means to achieve compliance in the proposed design included the installation of insulation board to improve the thermal resistance of roof, the roof assembly constructed to limit movement of moisture laden air that may accumulate in the cavity, and management of any moisture that did reach the cavity so that it would not cause damage or fungal growth. This necessitated installation of an insulant with an appropriate R-value, an effective (continuous) air barrier above the permeable ceiling lining, the selection of appropriately durable materials, and the provision of an air gap between the insulation board and the underlay above to prevent moisture soaking into the insulation and provide space for drying.

Air barrier

6.2.15 The BRANZ House Insulation Guide highlights the need for an effective air barrier for certain types of roof construction:

> A good quality airtight membrane is required over any ceiling construction which has unsealed gaps between roof spaces and the rooms below.

6.2.16 The need for a continuous air barrier was reiterated again in BRANZ guidance published in 2005[20], which included an air barrier above a boarded ceiling lining in skillion roofs (see Appendix B1.2 and Figure 7), and in BRANZ guidance published in 2007[21] (see Appendix B1.3 and Figure 8).

[20] BUILD October/November 2005
[21] BUILD April/May 2007

6.2.17 The purpose of the continuous air barrier is to prevent or significantly limit the movement of moisture into the cavity from the spaces below; the two mechanisms that moisture can be carried into the cavity being air movement through gaps or by diffusion through materials.

6.2.18 The foil facing on the insulation board, if taped as required in the manufacturer's specifications, would provide a continuous air barrier above the permeable ceiling lining, preventing the movement of moisture-laden air into the roof cavity which is the most likely source of moisture moving from internal spaces.

6.2.19 Notwithstanding the subsequent shrinkage of the insulation board, which I am of the view could not be anticipated in 2011, I note there were construction challenges with this particular design that presented risks in terms of performance with Clause E3. The performance of the insulation board, as a continuous air barrier, relied on there being a snug fit between the insulation and purlins and the boards being taped at edges and joins.

6.2.20 Cutting the boards to fit snugly would have presented a challenge at angles, in particular along the ridge line. Given the age of the existing framing, the insulation board would have also been difficult to fit well in other areas where framing was not square and true. The chosen method of installation, from above with the existing sarking remaining in place meant that there was no access to tape edges and joins.

6.2.21 However, the fact that there were challenges to the method of installing the insulation board did not mean that the design itself was not compliant.

Air gap

6.2.22 The design included a 25mm air gap between the top of the insulation board and the roof underlay. This 25mm air gap prevents the insulation from becoming damp or saturated by absorbing moisture held in the underlay. If the insulation were to become wet, it would lose its effectiveness, causing an increase in condensation. I also consider it provides a space to allow for additional drying (albeit with limited air movement because of the plywood sarking).

6.2.23 As noted by the specialist, there were risks associated with the plywood sarking limiting the drying potential of the roof cavity. The selection of plywood support for the building paper, rather than netting, meant the drying potential of the underlay was reduced. However, if the continuous air barrier had been achieved the amount of moisture moving into the roof cavity from the internal spaces would be a much smaller amount via vapour diffusion.

Durability of components

6.2.24 The new plywood and purlins were both treated to H3.2. The specification for the insulation board states the board has low water absorption[22], achieves a vapour resistance of 100 MNs/g[23], and the core and facings resist attack by mould and microbial growth.

6.2.25 I am of the opinion that the durability of these components is adequate for the small amount of exposure to moisture in this design.

Conclusion

6.2.26 The design specified an insulant with an appropriate R-value, incorporated an air barrier, had a 25 mm air gap, and the ply underlay was treated to H3.2.

[22] ASTM C272 Water Absorption of Core Materials
[23] Mega- Newton seconds per gram – the measure of the material's reluctance to let water vapour pass through

6.2.27 When taking into account the small amount of natural air leakage in the roof cavity, the 25mm air gap and the H3.2 preservative treatment of the plywood sarking and purlins, I am of the opinion there would be time for moisture in the cavity from the internal spaces to be removed through drying before any damage or fungal growth would occur.

6.2.28 I conclude that the proposed roof design would comply with Clause E3 of the Building Code (that was in force at the time the authority made its decision) if the building work was properly completed in accordance with the plans and specifications. I therefore confirm the authority's decision to grant the building consent.

Other matters

6.2.29 The owner has raised an issue with the foil tape for the insulation board not being specifically noted in the consent drawings. I note it is often not possible to show all installation instructions for every building element in a set of consent drawings.

6.2.30 Section 49 of the Act (see 6.2.2) requires an authority to consider both plans and specifications when making a decision on a building consent. Therefore consent drawings must always be read in conjunction with accompanying specifications which provide more detail. A product specification had been provided in this case which stated "exposed boards joints and cut edges should be taped with a minimum 50mm foil tape". I consider in this instance the drawing and specification, when read together, describe how the building work was to be completed.

6.2.31 The owner has also queried whether there is a requirement to install a vapour barrier as well as a continuous air barrier. A vapour barrier protecting a skillion roof would generally only be required where the internal room contained significant moisture (for example rooms containing a spa pool or swimming pool) or in extremely cold environments (ski lodges and mountain huts). If a vapour barrier was to be used it would require careful design. Current industry guidance instead recommends specific design for additional ventilation[24].

6.3 The issue of the code compliance certificate

6.3.1 I now consider whether the authority was correct to issue the code compliance certificate.

6.3.2 I have already concluded that the as-built work does not comply with Clause E3. Photographs in 2018 show significant gaps around the insulation board edges. The performance of the insulation board as a continuous air barrier has been negated by the gaps around the panels, which have resulted in a lack of continuity. Moist air has been moving into the cavity and has resulted in mould growth on the underside of the plywood.

6.3.3 In regard to the gaps around the insulation panels, I make the following observations:

- The authority inspected the insulation board installation during construction, with no mention of unacceptable gaps around the edges. Inspection photographs also suggest a reasonably snug fit of the insulation in the areas visible.
- Gaps between insulation boards and between the insulation boards and purlins were filled with expanding foam, with the builder submitting this was in the

[24] BRANZ Facts Roof Ventilation#4 Moisture and Ventilation in skillion roofs. November 2018, and BRANZ Bulletin 610 Preventing moisture problems in timber-framed skillion roofs. June 2017

order of 1-3mm at that time of installation.

- The installation of the insulation from above, with existing sarking remaining in place, meant that it was not possible to tape the edges and joins of the insulation boards.

6.3.4 It is not clear how much the shrinkage of the insulation, if any, has contributed to the performance failure in this case. However, the fact that the insulation had not been taped as per the manufacturer's specifications meant that the system was vulnerable with regard to the management of internal moisture. As installed, especially without application of appropriate taping, the performance requirements of Clause E3 were unlikely to be met.

6.3.5 The evidence of moisture accumulation within the skillion roof now clearly demonstrates that the as-built roof system has not met the internal moisture and durability requirements of the Building Code. I therefore conclude the decision to issue the code compliance certificate was incorrect and should be reversed.

7. The decision

7.1 In accordance with section 188 of the Building Act 2004, I determine that in regard to the design and approval of the alterations to the skillion roof system:

- the design of the alterations to skillion roof as consented complied with Clause E3 of the Building Code and the authority was correct to grant the building consent, and accordingly I confirm the authority's decision to issue the consent,
- the skillion roof as constructed does not comply with the building consent and the authority was incorrect to issue the code compliance certificate,
- the skillion roof as constructed does not comply with Clause E3 of the Building Code, and accordingly I reverse the authority's decision to issue the code compliance certificate.

Signed for and on behalf of the Chief Executive of the Ministry of Business, Innovation and Employment on 21 June 2021.

Katie Gordon
National Manager Determinations

Appendix A: The legislation

A.1 Relevant provisions of the Building Act 2004

A1.1 Various parts of the Building Act, the Building Code and the Acceptable Solution E3/AS1 are referred to in this determination and the more significant of these are provided in the following paragraphs.

A1.2 Provisions of the Building Act 2004 relevant to this determination include:

19 How compliance with building code is established

(1) A building consent authority must accept any or all of the following as establishing compliance with the building code

(b) compliance with an acceptable solution

49 Grant of building consent

(1) A building consent authority must grant a building consent if it is satisfied on reasonable grounds that the provisions of the building code would be met if the building work were properly completed in accordance with the plans and specifications that accompanied the application.

94 Matters for consideration by building consent authority in deciding issue of code compliance certificate

(1) A building consent authority must issue a code compliance certificate if it is satisfied, on reasonable grounds,—

(a) that the building work complies with the building consent; and...

112 Alterations to existing buildings

(1) A building consent authority must not grant a building consent for the alteration of an existing building, or part of an existing building, unless the building consent authority is satisfied that, after the alteration

(a)…..

(b) the building will,

(i) If it complied with the other provisions of the immediately before the building work began, continue to comply with those provisions; or

(ii) if it did not comply with the other provisions of the building code immediately before the building work began, continue to comply at least to the same extent as it did then comply.

A.2 Relevant provisions of the Building Code

A2.1 The relevant parts of Clause E3 are:

E3—Internal moisture

Objective

E3.1 The objective of this provision is to—

(a) safeguard people against illness, injury, or loss of amenity that could result from accumulation of internal moisture; and...

Functional requirement

E3.2 Buildings must be constructed to avoid the likelihood of—

(a) fungal growth or the accumulation of contaminants on linings and other building elements; and...

(c) damage to building elements caused by the presence of moisture.

Performance

E3.3.1 An adequate combination of thermal resistance, ventilation, and space temperature must be provided to all habitable spaces, bathrooms, laundries, and other spaces where moisture may be generated or may accumulate....

Limits on application
Performance E3.3.1 does not apply to communal non-residential, commercial, industrial, outbuildings, or ancillary buildings.

A.3 Relevant parts of the Acceptable Solution E3/AS1

A3.1 The consent application was lodged prior to 10 October 2011, so E3/AS1 Second Edition (Amendment 3) would have been the relevant Acceptable Solution when the building consent was issued.

A3.2 Relevant definitions of E3/AS1 Amendment 3 included:

Building element Any structural and non-structural component or assembly incorporated into or associated with a building. Included are fixtures, services, drains, permanent mechanical installations for access, glazing, partitions, ceilings and temporary supports.

Concealed space Any part of the space within a building that cannot be seen from an occupied space.

R-value The common abbreviation for describing the values of both thermal resistance and total thermal resistance.

A3.3 Other relevant parts of E3/AS1 Amendment 3 include:

1.1 Thermal resistance

1.1.1 R-values for walls, roofs and ceilings shall be no less than:...

d) For roof or ceilings of any construction, 1.5....

1.1.3 Materials and installation

The BRANZ House Insulation Guide provides examples of acceptable wall, roof and ceiling constructions to satisfy the requirements of Paragraph 1.1.1.

COMMENT:
The BRANZ House Insulation Guide gives constructions for a range of R-values. It is essential to choose the correct R-values from these shown in the tables in order to comply with this Acceptable Solution.

1.1.4 For the construction to be acceptable:

b) Insulated cavities shall be enclosed with no ventilation.

c) There shall be no perimeter gaps between the insulating material and the framing members.

1.1.5 Insulation for energy efficiency

Insulation satisfying the energy efficiency requirements of NZBC H1 cannot automatically be assumed to meet the R-values for internal moisture requirements of Paragraph 1.1.1.

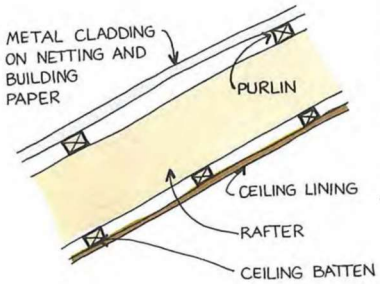
COMMENT*:*
Insulation to prevent condensation relates to thermal resistance of the building element in question (e.g. wall or roof). Insulation for energy efficiency relates to the building as a whole, and the requirement can be met in different ways. It is possible, for example, to obtain sufficient energy efficiency in a building by heavily insulating the floor and ceiling with no insulation in the walls. This would not satisfy the requirement for this acceptable solution because there would not be sufficient insulation in the walls to minimise condensation.

A.4 BRANZ House Insulation Guide

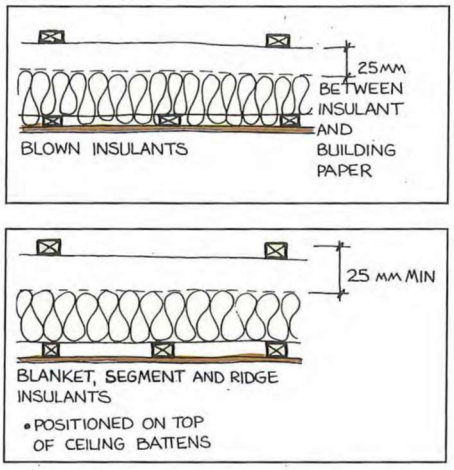
A3.4 At the time of the building consent, the BRANZ House Insulation Guide (First edition 1995) was cited in E3/AS1.

Skillion Roof, Metal Clad, Ceiling Battens

Construction detail



Insulation details



FRAMING Timber Size	Spacing	Nil	Amount of Insulation within Ceiling R-Value of Insulating Material R1.4	R1.8	R2.2	R2.6	R3.0	R3.4	R3.8
			Total Construction R-Value ($m^{20}C/W$)						
			Blown Insulants						
			Do not use						
			Blanket and Segment Insulants						
Rafter, 144x47	900								
Batten, 35x69	450	0.5	1.8	2.2	2.5	2.9	3.3	3.6	3.9
Batten, 35x69	600	0.5	1.8	2.2	2.5	2.9	3.3	3.6	3.9
Metal Batten	450	0.5	1.7	2.1	2.5	2.8	3.2	3.5	3.8
			Rigid and Semi-Rigid Insulants						
			Do not use. Workmanship demands are too stringent to be achieved in practice.						

Notes:
1. ***Deduct 0.2*** *if building paper is omitted.*
2. ***Add 0.2*** *if 12 mm sheet softboard is used.*
3. ***Deduct 0.1*** *if metal cladding is primed or painted on the underside.*
4. ***Deduct 0.1*** *if the profile of the roof cladding is flat with narrow ribs.*
5. *Some insulants may not be able to deliver the performance specified by the insulant columns R2.6 through R3.8 unless deeper joists can be used.*

Appendix B: Other BRANZ guidance

B.1 Other BRANZ guidance before the consent was issued

B1.1 Other BRANZ guidance was generally accessible before the building consent was applied for and approved in 2011. As well as published Guides, guidance on current knowledge was issued in the form of a Building Bulletin ("BB") supported by articles published in the BUILD magazine which is widely available to the building industry.

B1.2 BRANZ guidance published in 2005[25] (based on Bulletin No. 36826) described skillion roof construction and included the following diagram of a skillion roof:

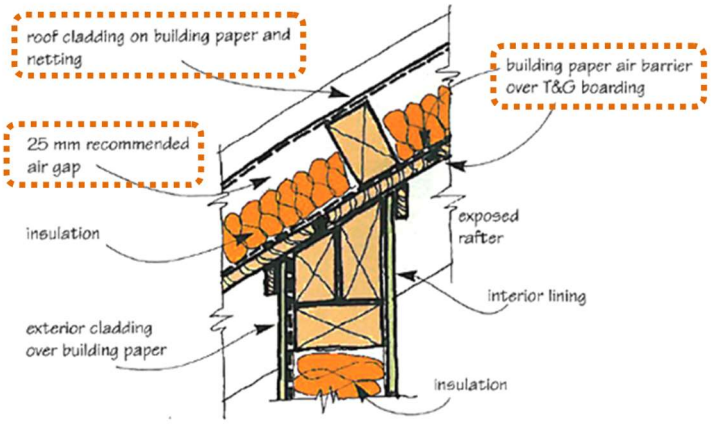


Figure 1: Air barrier over a boarded ceiling lining in a skillion roof.

Source: BUILD October/November 2005

Figure 7: BRANZ Guidance in 2005

B1.3 BRANZ guidance published in 2007[27] was also based on BB 368 and considered the functions of vapour barriers and underlays, noting that a 'wall or roof underlay is very different from a vapour barrier. One lets moisture through and out of a building and the other doesn't. Using the wrong one will trap moisture where you don't want it'. That article also included the following:

> For roofs, a roof underlay should be used, not a vapour barrier. The only buildings that may require a vapour barrier are those in very cold climates (ski lodges for example) or if there is a wet process in the room below (such as a spa pool or a wet industrial process).
>
> **Where to use vapour barriers**
>
> The designer will need to decide if a vapour barrier-like material is required as part of a total building system (i.e. floor/wall/roof) for the building consent application. The New Zealand Building Code Acceptable Solutions provide guidance....
>
> ...Neither NZS 3604: 1999 Timber framed buildings or NZS 4229:1999 Concrete masonry buildings not requiring specific engineering design define the term 'vapour barrier'. The term is mentioned only in relation to the similar industry tested specifications and details as already provided in E2/AS1.
>
> As these standards are referred to in a number of the NZBC compliance documents by Verification Methods and/or Acceptable Solutions (i.e. Clauses B1 Structure, B2 Durability and E2 External moisture). This indicates that in the

[25] BUILD October/November 2005
[26] BRANZ Bulletin 368 Preventing moisture problems in timber-framed skillion roofs (Issued March 98 withdrawn in June 2007)
[27] BUILD April/May 2007

majority of typical new houses it is not necessary to use vapour barriers as part of wall and roof systems.

Keeping moisture out of the roof space

Generally a better solution is to use an air barrier to prevent the movement of water vapour from internal building activities into confined skillion or flat roof spaces as shown in Figure 5. This meets the performance requirements of NZBC Clause E3 Internal moisture.

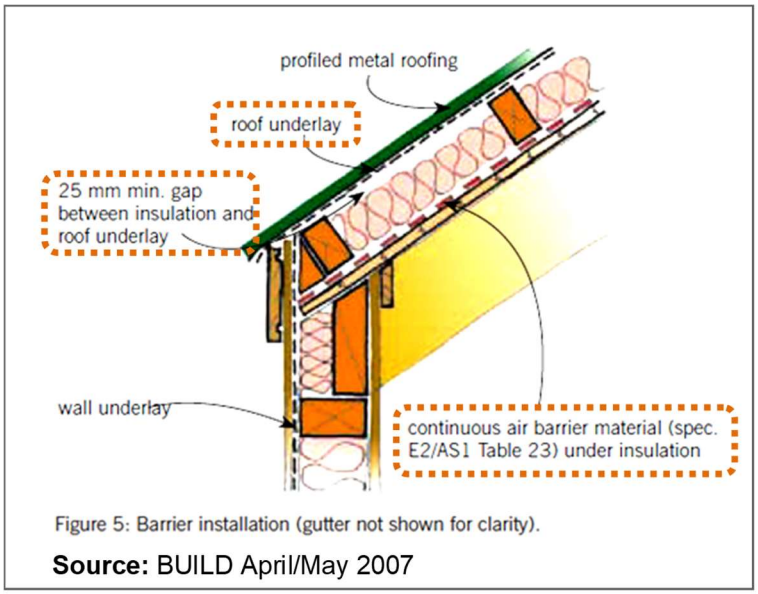


Figure 5: Barrier installation (gutter not shown for clarity).

Source: BUILD April/May 2007

Figure 8: BRANZ Guidance in 2007

Vapour barriers ≠ underlays

Vapour barriers are not the same as wall or roof underlays which are referred to frequently in E2/AS1 and defined as follows:

A roof underlay is an absorbent permeable building paper that absorbs or collects condensation or water that may penetrate the roof cladding or metal wall cladding.

A building wrap (wall underlay) is a building paper, synthetic wrap or sheathing used as part of a wall cladding system to assist the control of moisture by ensuring moisture which occasionally penetrates the wall cladding is directed back to the exterior of the building..

B1.4 Bulletin 525[28] was issued in August 2010 and this would have been the most up-to-date advice available at the time the skillion roof was designed and approved. BB 525 addressed ventilation as follows:

7.4 Ventilation of the roof space

7.4.1 Research has shown that, for most skillion roofs, including those that are not deliberately ventilated, the amount of air movement in the roof cavity, although limited, is sufficient to remove small amounts of vapour. However natural ventilation is limited for materials that are practically airtight when installed, such as:

- Long-run trough or tray section metal roofing
- Continuous membrane roofing material.

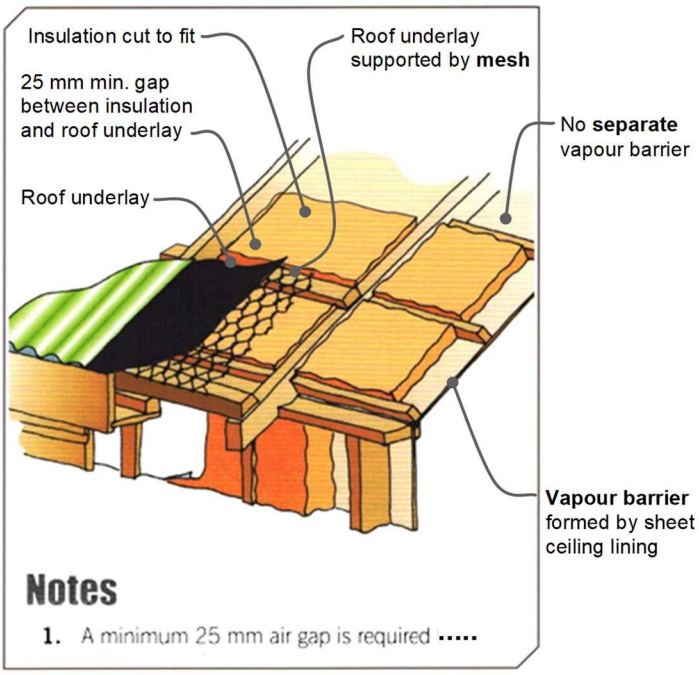
7.4.2 Manufacturers of membrane roofing recommend ventilation of the roof cavity. Obtain their specific requirements.

7.4.3 By ensuring that natural air leakage from the air cavity is possible in roofs that use a continuous membrane for weathertightness, normal levels of moisture can be satisfactorily maintained.

[28] BRANZ Bulletin 525 Preventing moisture problems in timber-framed skillion roofs (superseded by BB610 in June 2017)

B.2 Other BRANZ guidance after the consent was issued

B2.1 The BRANZ House Insulation Guide referred to by the authority is the Fifth edition of the guide, which was issued on July 2014, three years after the building consent was issue in 2011. The sketches referred to by the authority (see paragraph 3.9.2) included the following:



Source: BRANZ House Insulation Guide (July 2014)

Figure 9: BRANZ Guidance in 2014