Assessing retrofitted external wall insulation techniques

Retrofitting insulation into external timber-framed walls with no underlay brings the risk of water transfer from the back of the cladding to the insulation and/or framing. BRANZ investigated this in direct-fixed weatherboard walls. Using drainage plane mesh together with underlay was found to be the best method of reducing moisture transfer. It also allows for thicker insulation than some other options.

It is estimated that over 600,000 houses in Aotearoa New Zealand lack wall insulation (based on the number of houses built before insulation became a requirement in 1978). Retrofitting wall insulation to these houses is essential to provide warmer, drier and healthier environments for the occupants, reduce energy use and help the country reach its net-zero carbon goal by 2050.

There are relatively few tested retrofit wall insulation solutions available, particularly for walls that lack underlay. While today's New Zealand Building Code Acceptable Solution E2/AS1 requires underlay with all timber weatherboard claddings, many older uninsulated houses do not have an underlay. Adding insulation to exterior walls without underlay may change the path of rainwater leaks and reduce the drying potential of the wall.

NZS 4246:2016 *Energy efficiency - Installing bulk thermal insulation in residential buildings* states (in 2.2.7): "Insulation shall not be installed in ways that allow moisture to transfer through or to accumulate in wall, roof, or floor cavities in sufficient quantities to cause condensation, fungal growth, or damage to framing, claddings, or linings."

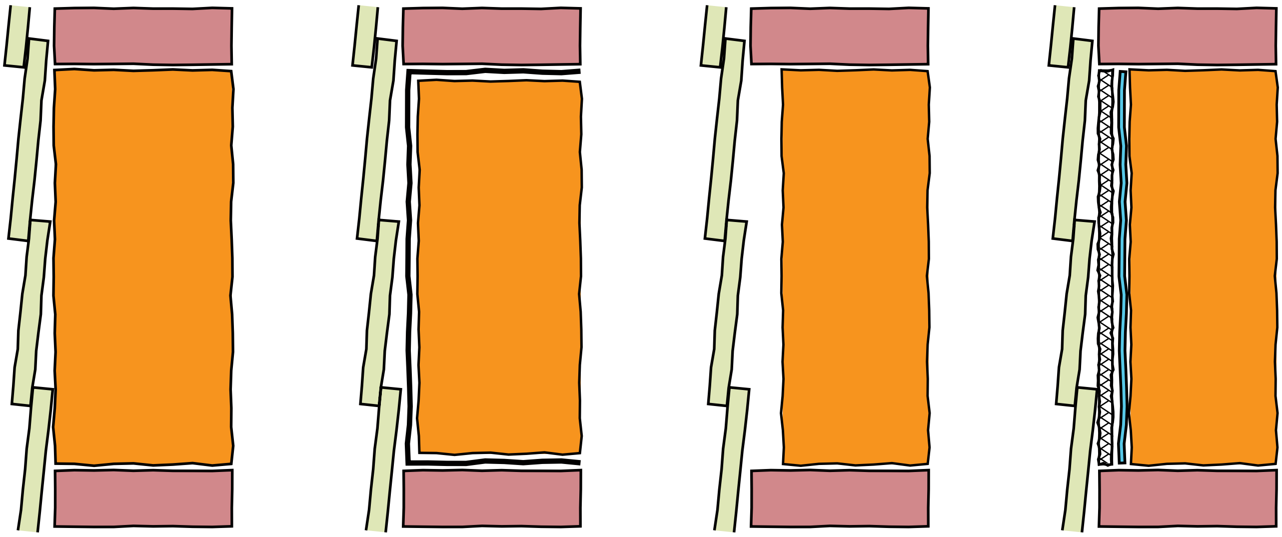
There is a need to develop retrofit options that keep both the framing and insulation dry and do not compromise the drying capability. Current options in NZS 4246:2016 are to either install a pan of underlay before adding the insulation or to provide a separation between the back of the cladding and the insulation.

Four different approaches were used to evaluate water management of retrofitted walls with direct-fixed cladding:

- Without cavity and without underlay (Figure 1a).
- Without cavity and with underlay (Figure 1b).
- With 20 mm separation between cladding and insulation and without underlay (Figure 1c).
- With drainage plane mesh and with underlay (Figure 1d).

Test procedure and analysis

To evaluate water transfer risk, BRANZ carried out lab experiments using a test methodology it had previously developed to evaluate the same risk with retrofitted blown-in wall insulation. The method is based on Building Code Verification Method E2/VM1 and that described in BRANZ Study Report SR436. In this case, it was conducted for 1 hour on 2.4 x 2.4 m framed



(a) No mitigation - BBW, insulation

(b) NZS 4246:2016 method - BBW, underlay, insulation (pan method)

(c) NZS 4246:2016 method - BBW, 20 mm separation, insulation

(d) Alternative method - BBW, drainage plane mesh, underlay, insulation

Figure 1. Investigated techniques for retrofitting insulation in exterior bevel-back weatherboard (BBW) walls without wall underlay with direct-fixed claddings.

wall specimens (Figure 2) and used a series of leak points (15 holes of 6 mm) to create a significant water load through the cladding (see BRANZ Study Report SR484 for more details).

Thermal imaging during testing and disassembly was used to characterise water management performance. Analysis of the performance was visual only - no attempt was made to quantitatively measure the amount of water transferred to the insulation or framing.

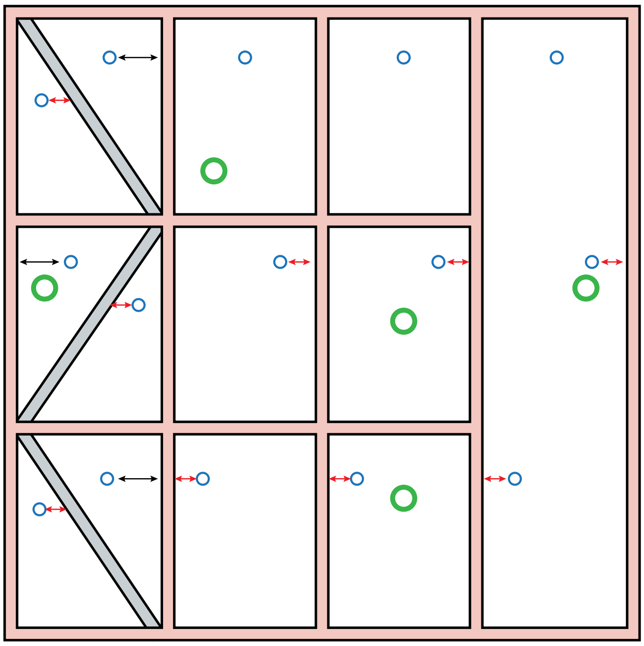


Figure 2. Wall framing layout for test specimen (not to scale). The 15 smaller circles were the water entry points for the first set of tests. The larger circles were the additional water entry points for later tests.

Results

Four types of underlay (lightweight kraft paper, heavyweight kraft paper, woven synthetic underlay and non-woven synthetic underlay), three brands of glass wool insulation and two brands of polyester insulation were tested. Overall, there was no significant difference in the outcome between the insulation materials or brand of product.

Insulation without underlay or separation (no mitigation)

Water was transferred to the framing and/or the insulation. When the insulation was in smaller pieces, there were more joins and more edges where water could track into it, highlighting the importance of installing insulation with as few joins as possible.

Insulation without separation and with retrofitted underlay (a method in NZS 4246:2016)

Some of the water was transferred onto the studs, dwangs, bottom plate or diagonal bracing. One possibility is that water was trapped between the retrofitted underlay and studs/dwangs (Figure 1b), potentially reducing the ability of the latter to dry. While insulation might have been unaffected, the outcome is still undesirable.

With diagonal bracing, water ran down the underlay to the bottom corner and onto the framing. With rectangular cavities, the underlay appeared to block the water from running down the back of the cladding and instead water was trapped along the weatherboard top edge, from where it finally reached the bottom plate.

Insulation with 20 mm separation and without underlay (a method in NZS 4246:2016)

Initial tests followed NZS 4246:2016 guidance where insulation was held in place with horizontally installed strapping. It was difficult to staple with a 90-degree corner and precise positioning, resulting in a less even separation than shown in the standard.

This technique did not prevent water transfer onto the insulation and framing.

Insulation with separation via drainage plane mesh and underlay (an alternative method)

Drainage plane mesh is a material that keeps a drainage path open and protects the installed insulation. Figure 3 shows the products used in this study. One drainage plane mesh product was supplied with an underlay already attached so there was no opportunity to add folds to the edge of the underlay (pan method). For the other two drainage plane meshes, no underlay was attached so it would have been possible to use an oversize underlay and fold the edges. The mesh is approximately 7–8 mm thick.

The drainage plane mesh supplied with the attached underlay performed satisfactorily. Water was only transferred to the bottom corner of the diagonal bracing, stud and bottom plate. No water was found at the bottom plate of the tall cavity and water was not transferred onto the sides of the studs.

Since this first test performed well, to better match the typical framing in older houses with direct-fixed cladding and no wall underlay, the wall specimen was changed to rough-sawn framing before a series of additional tests with the drainage plane mesh was started. The specimen had a large knot in one section of the bottom plate and another in a dwang.

Repeated testing using drainage planes with synthetic underlay and kraft paper resulted in only small amounts of water being transferred onto the framing at the point where the back of the weatherboard abutted the diagonal bracing or at the points around the knots in the bottom plate or dwang. This indicates that pre-existing framing defects may have an impact on water transfer.

Insulation with separation via drainage plane mesh and underlay, taping underlay to framing or tucking strip of underlay behind framing

Since the drainage plane mesh performed reasonably well, a set of five 18 mm holes was added to the 15 6 mm holes to create a much higher leak rate. This resulted in significantly more water getting to the diagonal bracing than was present for all the previous tests. Four configurations were tested under this higher leak rate:

- A separation via drainage plane mesh and synthetic underlay. A strip of synthetic underlay was tucked between the framing and back of the cladding in rectangular cavities. The drainage plane mats were able to prevent nearly all the water from getting to the framing.
- A separation via drainage plane mesh and lightweight kraft paper. A strip of kraft paper was tucked between the dwang or bottom plate and the back of the cladding. Water was transferred onto the framing and dwangs.
- A separation via drainage plane mesh and synthetic underlay with the top and bottom edges of the underlay taped to the framing. If the taping was not done very carefully, water was able to travel via capillary action to the framing under the tapes because of the rough-sawn finish. It is reasonable to assume that the tapes would also restrict the drying of the framing.
- Follow-up testing investigated which solution would be more appropriate to prevent water being transferred onto the bottom plate. In one configuration, underlay was cut to fit the cavity. In three other configurations:
  - underlay was taped to framing (Figure 4a)
  - underlay was cut approximately 5 mm longer and tucked between the framing and the back of the cladding (Figure 4b)
  - a strip of kraft paper was tucked between the framing and underlay (Figure 4c).

Strips of kraft paper tucked into the bottom plate were the most successful at preventing water being transferred onto the bottom plate and were easy to install.

(a) 8 mm, integrated underlay

(b) 7 mm, separate underlay

(c) 7 mm, separate underlay

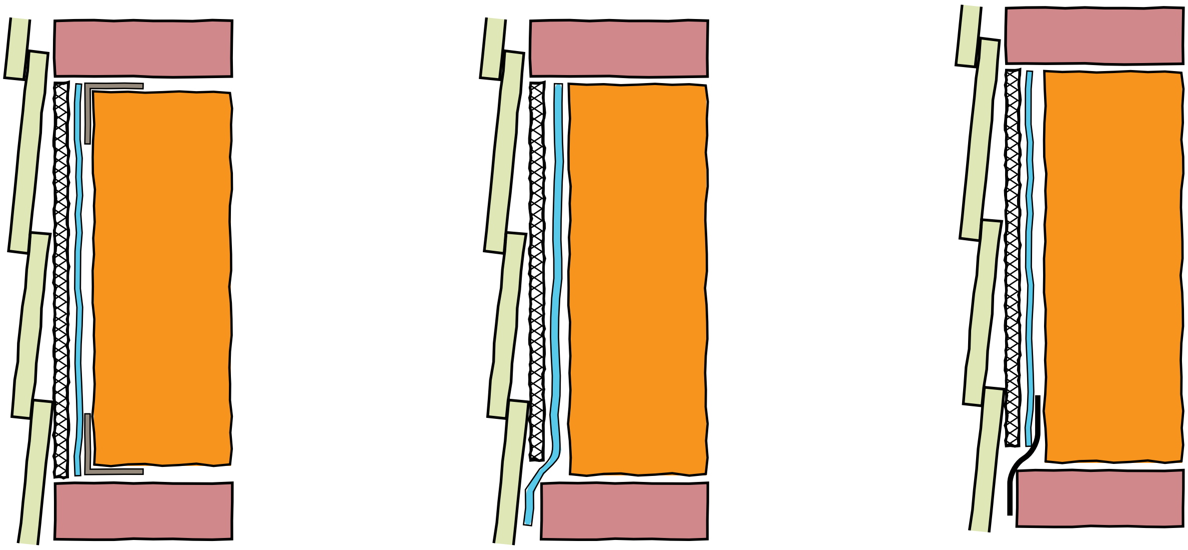
Figure 3. Drainage plane materials used in this study.

Inspecting the framing before retrofitting

After removing wall linings to retrofit insulation, the condition of the framing should be thoroughly inspected. Any defects that cause water ingress into the frame cavity instead of draining down the back of the weatherboards should be repaired. If repairs are done with care, the measures described here will only need to cope with relatively small amounts of water. If any water that gets through the cladding can drain out again without migrating into the insulation or onto the framing, the reduced drying potential resulting from the addition of insulation should not be an issue.

Conclusion

The most reliable mitigation measure was found to be drainage plane mesh combined with a synthetic underlay between the mesh and retrofitted insulation. The most effective



(a) Underlay sections taped around top and bottom edges of the framing

(b) Lower edge of underlay sections tucked into dwangs, diagonal bracing and bottom plate; no edge taping used and only lower edge tucked; other edges were a neat fit

(c) Lower edge underlay tuck replaced with an approximately 100 mm high strip of kraft paper

Figure 4. Additional tested alternative methods.

way to protect the bottom plate was a strip of kraft paper tucked into the gap between the framing and the back of the cladding (Figure 4c).

Considerations with this approach:

- The most effective way to install the mesh and the underlay was a neat fit without edge folds, making the work easy and quick.
- Fixing staples should be stainless steel.
- The 7-8 mm thick drainage mesh allows thicker, higher R-value insulation to be installed compared to using a 20 mm separation. Since standard wall insulation products are 90 mm thick to suit dressed framing, there is clearly space for the drainage mesh when used with 100 mm deep rough-sawn framing. Since some existing framing is only 95 mm depth (or occasionally 90 mm depth), the specific insulation product needs to be chosen to match the framing depth and the installation process. For example, with a 90 mm frame depth, a suitable product would need to have a thickness of 83 mm or less or be soft enough to be compressed to 83 mm to allow the lining to be correctly attached.
- Take care in the areas where diagonal bracing is hard against the back of the weatherboards. A folded strip of kraft paper was reasonably effective at directing most of the water to the back of the cladding.

Creating a separation between the back of the cladding and the insulation as recommended by NZS 4246:2016 limits the thickness of insulation that can be installed and ultimately was not able to prevent water transfer onto the framing. Using drainage plane mesh in conjunction with an underlay was the most reliable method for limiting water transfer and allows for thicker insulation to be used. Based on the results found in this study and BRANZ's previous retrofitting insulation projects, our recommendation is that these findings are considered in any update to NZS 4246:2016.

More information

SR484 *Assessing retrofitted external wall insulation techniques* (2023)
www.branz.co.nz/pubs/research-reports/sr484/

SR436 *Linings-on retrofit insulation in weatherboard walls: Ensuring effective water management* (2020)
www.branz.co.nz/pubs/research-reports/sr436-linings-retrofit-insulation-weatherboard-walls-ensuring-effective-water-management/