WEATHER TIGHTNESS

BRANZ

FRST-FUNDED WEATHERTIGHTNESS RESEARCH AT BRANZ

This document summarises the research findings from the FRST-funded Weathertight Buildings programme (BRAX0302) and the challenges to be faced in the current WAVE (Weathertightness, Air Quality and Ventilation Engineering) programme (BRAX0901). Whereas the previous programme was very much reactive in nature, WAVE aims to take a more proactive approach and tackle issues that will face all New Zealanders in the coming years.

Weathertight Buildings – BRAX0302

At the inception of this programme, it was known that many buildings/homes were failing to manage moisture and so changes were made to the Building Code (in the form of Acceptable Solution E2/AS1) to reduce the incidence of new leaky buildings. In lieu of any rigorous scientific or engineering data, many of the details in E2/AS1 were based on existing systems or expert opinion. BRAX0302 was designed to provide a scientific understanding of moisture in walls and so allow future decisions to be made in a more robust manner.

The programme was strongly connected with overseas research teams at the Fraunhofer-Institut für Bauphysik of Germany and the National Research Council of Canada. Within New Zealand, the research team included building physicists and materials scientists from BRANZ and SCION.

The research highlights are described below, using a three-pronged framework: experimental work, simulation work and knowledge transfer.

Experimental

Figure 1 – The Weathertightness Test Hut

Much of the research activity was centred on the Weathertightness Test Hut, which was built as part of the programme. This facility has 24 openings around its exterior into which wall specimens can be placed. Each wall is connected to a data logging system (looking at temperature, humidity and framing moisture content within the wall). A weather station is also located on site. This allowed the specimens to be exposed to real climatic conditions – a huge advantage over similar laboratory-based experiments. A series of experiments were conducted whereby water was introduced into various parts of the walls and the time taken for the walls to dry was measured. This allowed us to quantify the benefits of cavity wall construction and also, importantly, to identify situations it doesn't help.

A series of ventilation measurements were also conducted – the BRANZ group was the first to really measure the air flows that occur behind wall claddings. These ventilation levels were higher than those predicted by the accepted theory and explained the performance of the open rainscreen wall (specific vents at the bottom but no specific provision for ventilation at the top of the wall).

Many of the research findings are represented in Figure 2.

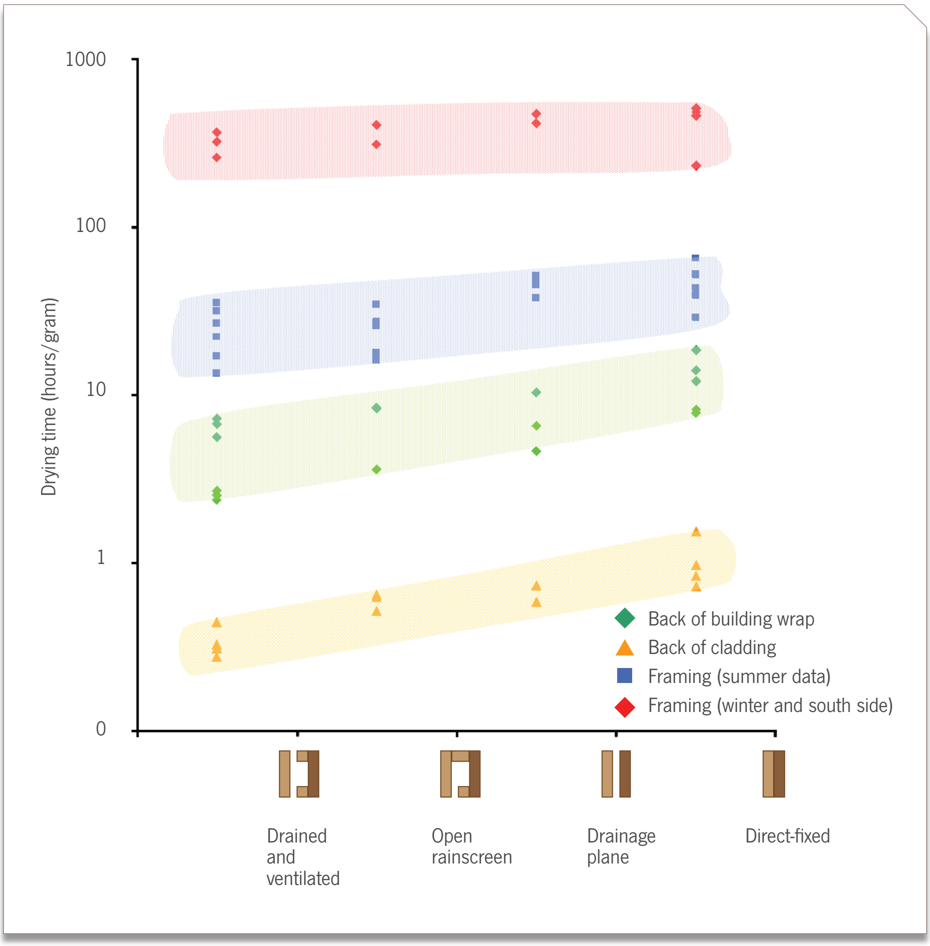


Figure 2 – Drying rates for selected walls and locations

Cavities help walls dry out – but only when water is on the back of the cladding or on the building wrap. With wet framing, the presence of a cavity had little effect on the drying time. In these cases, the drying time is limited by the moisture transport properties of the timber itself. The long drying times for wet framing highlighted the single most important reason for having a cavity; it helps prevent the framing from becoming wet in the first place.

Climate and wall orientation are important. Drying rates from the back of an absorbent cladding and from the building wrap were slowest in the winter on the south side.

Weatherboards were an exception in terms of direct-fixed claddings. When painted on the backs, they drained back out through the laps and were sufficiently well ventilated to dry retained water faster than monolithic direct-fixed walls.

Simulation

One of the difficulties with any building science experiment is that the results are technically only valid for the particular building used in the study. For example, a building in Auckland or Dunedin, say, would behave differently to the Weathertightness Test Hut because its orientation, exposure level and climate would all be different.

In parallel to the experimental work in the programme, BRANZ collaborated with a group at the Fraunhofer Institute in Germany to develop the WUFI computer program. WUFI simulates the flow of heat and moisture in building materials, but prior to the programme, it was unable to satisfactorily model the airflows present in wall cavities. The team at BRANZ added this capability and subsequently saw a marked improvement in the agreement with the measured drying rates from the Test Hut and those predicted by the computer program. This meant that the WUFI models had effectively been validated by the experimental work and could be used to generalise the results to the rest of the country.

The use of computer models also allows us to generate results that would be hard to visualise in any other way. For example, we can now 'see' the moisture content profile in a piece of timber framing and 'show' how this changes with time (see Figure 3).

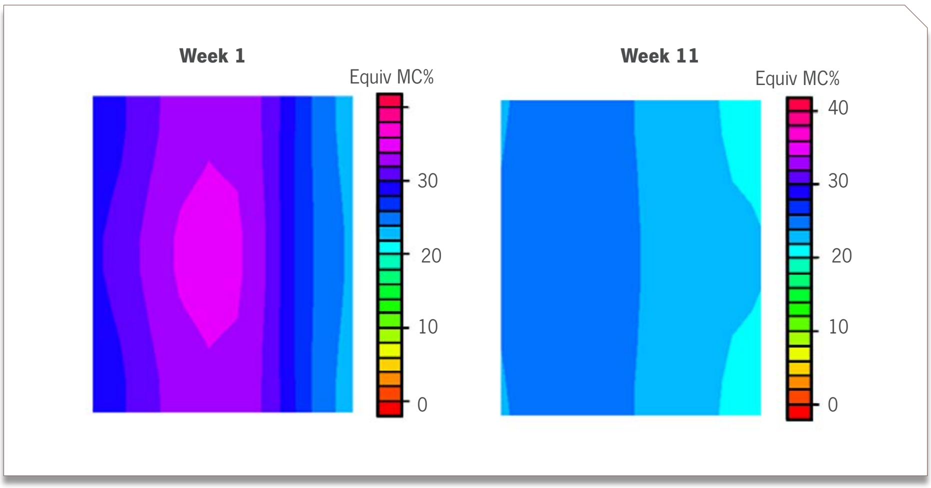


Figure 3 – Simulation allows the moisture content profile through framing members to be visualised

Knowledge transfer

Principal Scientists Mark Bassett and Malcolm Cunningham have been running the weathertightness training course for the NZIBS for several years and used the course as a vehicle for communicating the research from BRAX0302. The latest development in this area was the creation of WALL-DRY. This Excel-based program comprised the results from the entire programme, i.e. thousands of numerical simulations of a relatively simple building in a variety of New Zealand centres. It allows the user to look at the effect of changing building location, cavity type, exposure and so on quickly and easily. In this way, people can get a feel for what is important in cavity wall design.

Over the course of the programme, BRAX0302 has generated 20+ internationally peer-reviewed journal or conference papers, in addition to numerous articles in BRANZ's *Build* magazine.

WALL-DRY will continue to be developed throughout the WAVE program as results become available. There is scope to release WALL-DRY more widely, but it is currently our intent to use this as an educational tool only.

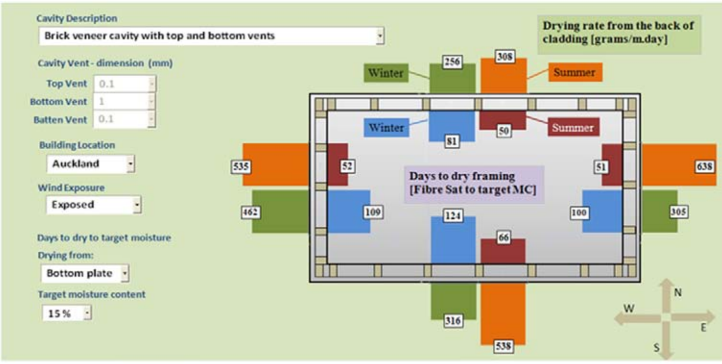


Figure 4 – A screen shot of WALL-DRY

Other research

Relative decay rates caused by brown rot in five timber species (heart and sap) and with three treatment options (untreated, LOSP and boron) were measured by researchers at SCION. After 2 years, there was severe decay in the untreated radiata pine and in the untreated sapwood of the other species. Decay was established in the untreated heartwood of Douglas fir and larch, but only isolated minor spots were present on the macrocarpa and Lawson cypress. Boron treated samples were free from decay. There were isolated decay pockets at the joints in LOSP treated Lawson cypress and macrocarpa sapwood. This comprehensive decay rate comparison has helped the industry to select treatment options for building framing in New Zealand.

Conclusions

BRAX0302 essentially found that the decisions made when E2/AS1 was modified were actually sensible. A cavity of 20 mm has a capacity to cope with moisture on the cladding that far exceeds any likely water entry rate. It has highlighted the importance of keeping the framing dry – something that is also emphasised by the failure criteria of E2/VM1.

The programme assisted with a total rethink of the Acceptable Solutions to the weathertightness requirements in the New Zealand Building Code in E2/AS1:2005 *External moisture*. More recently, it has helped prepare the ground for the next review of E2/AS1 and has also contributed to NZS 2295:2006 *Pliable, permeable building underlays*. The programme has also contributed to improving confidence in specifying a wider range of framing options than H1.2 and H3.1 treated radiata pine framing, whilst also showing durability deficiencies in some untreated options.

The techniques and expertise developed during the programme (ventilation measurement, WUFI and so on) will be of vital importance to the next generation of weathertightness research in New Zealand – the WAVE programme.

WAVE – BRAX0901

The WAVE (Weathertightness, Air Quality and Ventilation Engineering) programme represents the evolution of two previous programmes: BRAX0302 – Weathertight Buildings; and BRAX0703 – BRANZIAQ.

The WAVE programme will help develop practical solutions to the current problems that plague New Zealand homes (e.g. leaky buildings, indoor mould) and help avoid future issues resulting from changes to materials, designs and construction methods. The intermediate outcomes are to have homes that do not leak and homes that have safe indoor environments.

In short, this programme recognises that the performance of the building envelope is linked to the environment within the building and aims to form a complete model of how buildings manage contaminants (including moisture). This would allow designers and builders to assess the impact of any features they want to implement.

The programme consists of four complementary streams: weathertightness, ventilation, interstitial moisture and indoor air quality technology. The research aims to pull together these four areas into one coordinated programme with the aim of developing a unified model to better manage moisture contamination in buildings.

Using the same three-pronged framework as used above, the following shows the progression from BRAX0302 to WAVE.

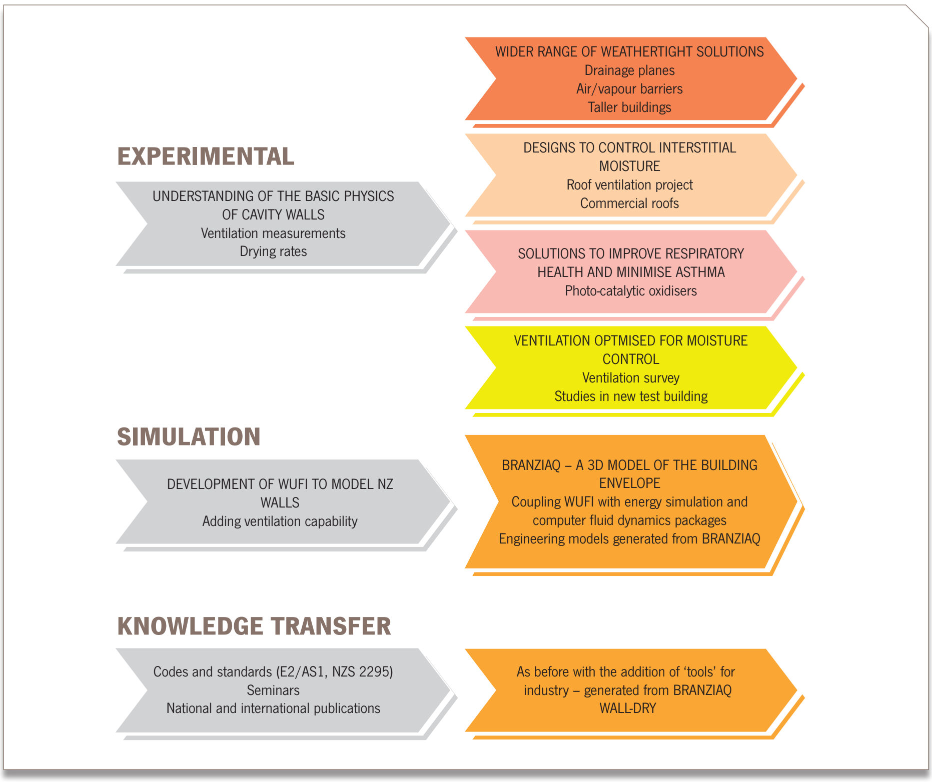


Figure 5 – From BRAX0302 to WAVE

Weathertightness and indoor air quality

The focus of the previous weathertightness programme was largely residential buildings. The new programme will begin to look at issues that affect taller buildings as well as maintaining momentum in the low-rise area.

Work on air barriers will address confusion that exists in industry relating to building wraps, rigid air barriers and sheathing. Building surveyors have reported a growing caseload of leaking apartment buildings and medium-sized commercial buildings. It appears that design details that work in low-rise buildings are being pushed too far; the air barrier components are not adequately managing the wind pressures across the cladding at the higher altitudes.

The management of this pressure is a key factor in determining the amount of rain that may enter a wall cavity. Although the work will focus largely on the impact of the choice of air barrier on water management, the study will also emphasise the practicalities of the different options.

In the low-rise area, packages of work will establish the relative drying potential of direct-fixed weatherboard and sheet claddings. This work will clarify the theory behind the performance of capillary grooves and compare water leakage rates through various types of weatherboard.

Moisture plays a large part in other aspects of the WAVE programme too. The interstitial moisture (condensation within the building structure) stream will look at moisture management in roof spaces, and the ventilation stream will investigate the moisture removal effectiveness of various ventilation strategies.

The ventilation work links closely with other work on indoor air quality (IAQ). In the IAQ stream, we will be characterising the performance of devices such as photo-catalytic oxidisers and see how they can be used effectively in real-world situations such as schools.

The IAQ stream represents the area where much of the development of the complete model, BRANZIAQ, will take place. This model will require us to combine the strengths of several powerful software packages: WUFI (heat and moisture transport in solids); Energy+ (energy simulations); and Phoenics (movement of air and other fluids and biocontaminants within the living space).

The success of the WAVE project will provide a complete performance basis for weathertight design – removing some of the guesswork from current practice and ensuring a dry and safe future for the New Zealand building stock.

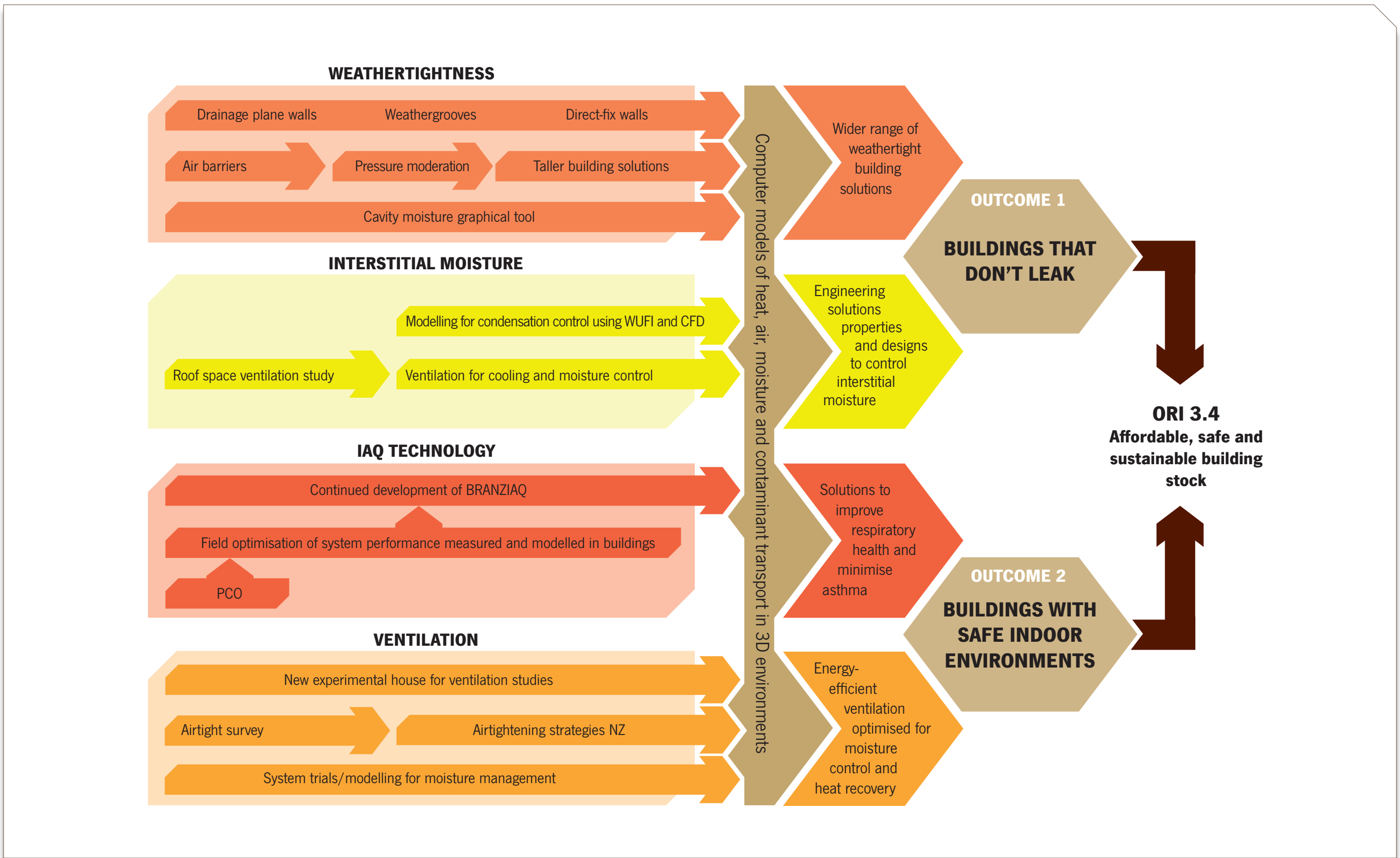


Figure 6 – The WAVE programme.

WEATHERTIGHTNESS PUBLICATIONS

PUBLISHED TO DATE

Bulletins

6–8 page detailed practical works covering a wide range of building and construction areas.

Prior to 2005, 12 bulletins relating to weathertightness were published. From 2005 onwards (i.e. the last 5 years) the following have been released:

2005

- 463 *Aluminium windows and E2/AS1*
- 465 *Domestic flashing installation*
- 466 *Timber frame parapets, balustrades and columns*
- 467 *Principles of flashing design*
- 468 *Fixing timber weatherboards*
- 470 *Wall underlays*

2006

- 472 *Waterproof decks*
- 475 *Structurally fixed cavity battens*
- 476 *Natural stone veneers*

2007

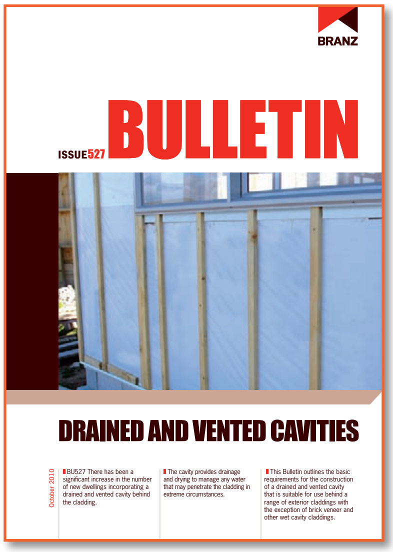
- 481 *Timber windows*

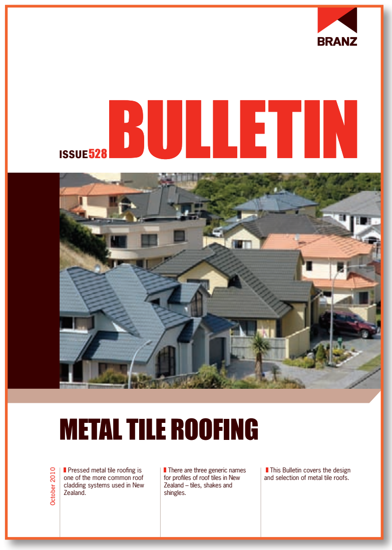
2009

- 516 *Moisture management in masonry veneer*

2010

- 527 *Drained and vented cavities*
- 528 *Metal tile roofing*

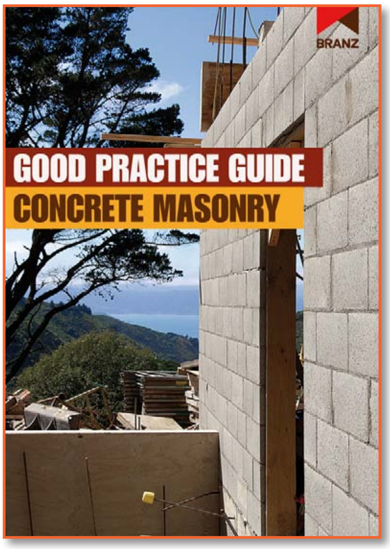




Good Practice Guides

A4, full colour, fully illustrated books aimed at architects and designers at approximately 80–140 pages in length.

- *Concrete masonry*
- *Exterior coating*
- *Masonry veneer*
- *Membrane roofing*
- *Profiled metal roofing*
- *Profiled metal wall claddings*
- *Stucco* 2nd edition
- *Texture-coated claddings*



Weathertight Solutions

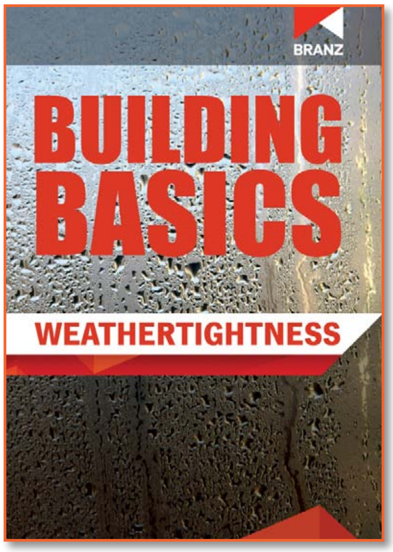
Six volumes of good construction details in hardcopy, CD format and available individually from the BRANZ website. Average individual detail purchase = 26 per week.

- Volume 1 – *Horizontal weatherboards*
- Volume 2 – *Stucco*
- Volume 3 – *Profiled metal*
- Volume 4 – *Masonry*
- Volume 5 – *Roofing*
- Volume 6 – *Membrane roofing*

Building Basics

Basic works that are comprehensive, practical and easy to read with extensive use of clear full colour 3D drawings and photographs.

- *Weathertightness* – just released in hardcopy format and soon to be available in digital. Over 12,000 copies distributed free to the industry as a result of a Board initiative.
- 2011 will see *Mould and rot* released as part of this series, along with *Condensation*.



Build magazine

Build magazine publishes bi-monthly both in hardcopy and digital formats, 88–120 pages per issue.

Audited circulation as at June 2010 is 16,898.

Readership circulation is nearly 50,000.

Downloads of articles from digital build (www.buildmagazine.org.nz) = over 3,000 per week.

Virtually every issue of *Build* has features, research, Design right and Build right articles relating to weathertightness.

In the last 10 years, over 430 technical articles on weathertightness have been published.

The August 2010 edition of *Build* was a special issue featuring weathertightness only.

Examples of articles focused on the BRANZ research and good practice advice:

- Drying in wall cavities
- Can drainage mats perform in New Zealand?
- WUFI – modelling tool for NZ conditions
- Window and door cladding penetrations
- Minimising builders' risk
- Drainage from the back of the cladding
- E2 and E2/AS1
- Homeowners' maintenance requirements

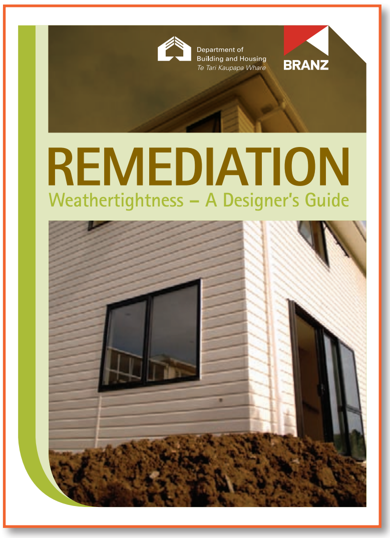
References to weathertightness in our publications

Weathertightness is referred to in various ways in a large number of the BRANZ works for the industry.

An example of these elements can be found in:

- most issues of *Guideline* (a monthly newsletter to the industry)
- *Maintaining your home* 2nd edition
- Level (a sustainability web resource and accompanying texts – in particular, *Windows*)
- numerous issues of *Builder's Mate* (a simple highly illustrated 4-page work for the trades).

Future works



- BRANZ is currently co-authoring the remediation design guide with DBH.
- A web resource weathertight.org.nz is currently in preparation. This will include good basic building advice and also information on remediation, in particular, dealing with buildings that need repair. It will also include links to other useful web resources. Scheduled for soft launch late 2010.
- Bulletins:
  - Strawbale construction
  - Review and update of:
    - 433 *Weathertightness do's and don'ts*
    - 434 *Results of weathertightness failure*
    - 435 *Weathertightness evaluation*
- Remediation construction details – digital only.
- Expansion of the Building Basics series to include *Mould and rot.*
- *Build* magazine will continue to provide essential learning from BRANZ research and good practical advice on an ongoing basis.
- Continued updating of all works to include new information where appropriate.

WEATHERTIGHTNESS EDUCATION 2004 – 2010

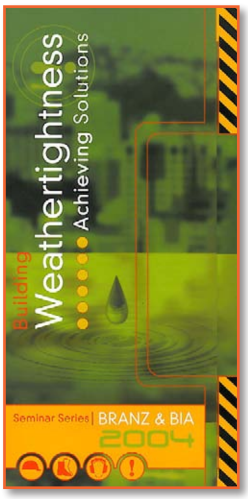
In total, BRANZ has held eight education programmes over the past 6 years that have had a weathertightness focus. There has been a total of 173 presentations with 13,408 attendees. All seminars held since 2007 are also available for viewing online via webstreaming. One further distance learning programme has recently been launched, with another seminar also planned for late 2010.

Building Weathertightness – New Solutions Seminar

Date held: June – August 2004
Attendees: 3,058 over 24 centres

Joint presentation with the Building Industry Authority on amendments to E2/AS1 and how to make buildings weathertight.

Building Weathertightness – Achieving Solutions Seminar

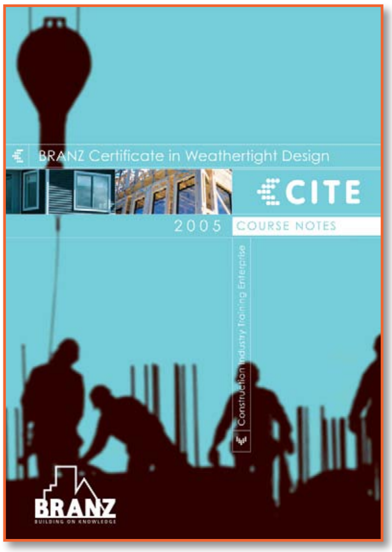


Date held: October – November 2004
Attendees: 2,506 over 24 centres

Joint presentation with the Building Industry Authority. A focus on designing weathertight solutions and methods of assessing details for effectiveness in keeping water out. These methods can be applied to all weathertight details and will assist owners, designers, builders, subcontractors, building officials and certifiers to design and evaluate Alternative Solutions.

CITE Weathertight Design Course

Date held: Nine courses held from 2005 – 2007
Attendees: 113 over 3 years



An intensive 8-day course designed to provide the skills necessary to design and/or assess Alternative Solutions for weathertightness compliance with the New Zealand Building Code performance requirements for E2 *External moisture*. It covered the theory and practice behind water entry into buildings, applied the theory to real building situations and provided an opportunity for students to tackle real problems with the object of designing or assessing weathertight and buildable details within the constraints of the aesthetic intent of a building design.

Structured to provide designers with the tools to allow them to design Alternative Solutions to NZBC E2 and equip building officials to assess submitted Alternative Solution designs to determine compliance with the performance requirements or, where appropriate, recognise where they do not comply.

Discontinued as a face-to-face course in 2007 as not Levy funded and so not financially viable.

Profiled Metal Wall Claddings Seminar

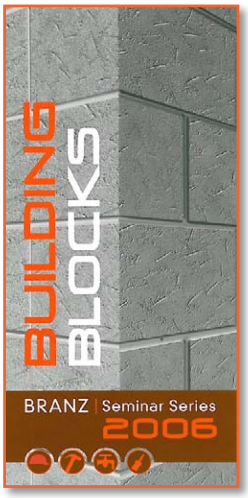
Date held: February – April 2006
Attendees: 1,753 over 25 centres

This seminar looked at best practice guidance associated with profiled metal wall claddings including the weathertightness aspects.

Building Blocks Seminar

Date held: June – August 2006
Attendees: 1,520 over 25 centres

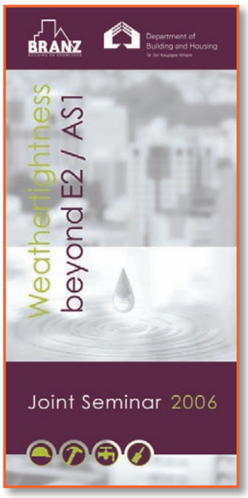
This seminar looked at best practice guidance associated with concrete masonry construction including the weathertightness aspects.



Weathertightness – Beyond E2/AS1 Seminar

Date held: November – December 2006
Attendees: 1,865 over 22 centres

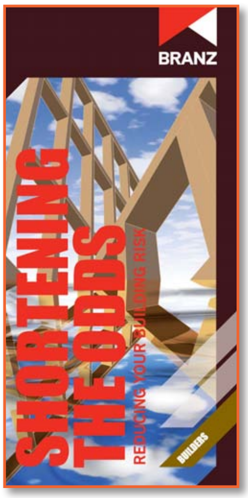
Joint presentation from the Department of Building and Housing and BRANZ. Explored how weathertight principles should be applied to Alternative Solution designs, using real-life examples.



Shortening the Odds – Reducing Your Building Risk Seminar

Date held: November 2007 – March 2008
Attendees: 912 over 22 centres

Aimed at builders, this seminar focused on practical tips and examples for achieving the critical aspects of weathertight construction.



Are We There Yet? Seminar

Date held: July – August 2010
Attendees: 1,681 over 22 centres

This seminar series aimed to see how far we have come since the current building control system was implemented in 1992 and look at where improvements could still be made.

Weathertight Design Course

Distance learning in association with the Open Polytechnic of New Zealand.

The course provides a broad overview including the various factors to take into account when designing a weathertight building. It covers:

- the most suitable materials to use
- the most likely water ingress points
- drying out a leaky building and keeping it dry and ventilated
- legislation regarding weathertight design
- the building consent and application processes and procedures
- different New Zealand building styles
- the responsibilities of the homeowner around weathertight design

Launched in October 2010.

Remediation Design Seminar

Date held: November – December 2010
Attendees: Not held yet

Joint presentation with the Department of Building and Housing focusing on the complexities of working in the remediation design area.

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