BRANZ

ISSUE 550 BULLETIN

DAMAGE FROM WEATHERTIGHTNESS FAILURE

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- Weathertightness failure of a wall cladding system can lead to health problems for occupants and significant building damage including fungal decay of timber, toxic mould growth and corrosion.
- This bulletin outlines the damage, with a focus on timber damage that can occur and the repair options available.
- This bulletin replaces Bulletin 434 *Results of weathertightness failure.*

1.0 INTRODUCTION

1.0.1 Buildings are designed to deflect water and stop it entering the building envelope, but some water gets in to most structures. Buildings must therefore be constructed to manage water entry.

1.0.2 New Zealand Building Code clause E2 *External moisture* has as its objective "to safeguard people from illness or injury which could result from external moisture entering the building".

1.0.3 This bulletin outlines the damage that can occur when water enters and remains within a building and the repair options available. It replaces Bulletin 434 *Results of weathertightness failure.*

2.0 CAUSES OF WEATHERTIGHTNESS FAILURE

2.0.1 General factors that have led to building weathertightness failure include:

- lack of technical knowledge and skills when houses are designed, detailed and built
- inappropriate specification and installation of a number of claddings available at the time
- insufficient details in the Approved (now Compliance) Documents of the time
- design and construction that did not allow for deflection, drying and drainage of water that entered and/or had insufficient durability
- lack of building maintenance
- increasing building complexity.

3.0 TYPICAL WATER ENTRY POINTS

3.0.1 Studies of leaking buildings have identified some common specific causes of water entry, which include:

- insufficient level differences between decks and the inside floor level
- omission of flashings to windows, parapets and balcony walls
- installing raked apron flashings without stop-ends
- omission of movement control joints in monolithic claddings
- cracking in stucco and texture-coated fibre-cement
- failure of membrane roofs and roof decks
- exposed structural members such as rafters and floor joists that penetrate the cladding
- leaks around windows, doors, meter boxes, service penetrations and appliance vents
- poor detailing and installation of wall and roof claddings, particularly corners and junctions with other elements
- handrails that penetrate the top of framed and clad balcony walls
- claddings without sufficient clearance to the ground or a deck
- raked or curved window heads.

4.0 MOISTURE-INDUCED DAMAGE

4.0.1 Almost all building materials deteriorate when exposed to moisture over time. Consequences of damage as a result of a building leak can include:

- fungal decay of timber (discussed in section 5.0),

Figure 1 Rot in the ends of intermediate floor joists, with deterioration also visible in the flooring.

- which, if present, is likely to compromise the safety and structural performance of the building
- loss of timber strength as it deteriorates
- toxic mould formation on plasterboard, fibre-cement, kraft building paper and timber
- corrosion of steel components – fixings in timber and steel frames
- deterioration of kraft paper underlays
- loss of strength in plasterboard, which may affect bracing, fire ratings and the material's ability to support finishes such as tiles
- mould and rotting of carpet, particleboard flooring and timber or MDF skirtings
- the need to remove existing, often sound, elements in order to carry out repairs – an example is the need to remove kitchen cabinetry that is located adjacent to a leaking external wall.

4.0.2 As a result of damage from water entry, the repair may require:

- replacement of significant amounts of wall and floor framing
- a new cladding, typically installed over a cavity – most failed buildings did not incorporate a drained and vented cavity
- internal wall and ceiling relining, which may include the removal and replacement or reinstallation of wet area linings and finishes, windows and doors, bathroom showers, vanities and baths, and kitchen joinery
- removal and replacement of insulation, pipes, wires and fittings that are within moisture-damaged framing.

4.0.3 Where moisture damage to a building is suspected, designers and builders new to such work should obtain expert assistance.

5.0 CAUSES OF STRUCTURAL DAMAGE

5.0.1 Structural damage to buildings as a result of water entry may be due to:

- fungal decay of timber
- corrosion of steel components
- deterioration of sheet bracing elements.

5.0.2 Visual identification of timber that may be affected by fungal decay can be difficult. Where timber is suspected of being affected, samples will need to be removed for testing under the direction of a suitably experienced person.

5.0.3 Moulds (described in section 5.6) don't usually lead to loss of timber strength.

5.1 FUNGAL DECAY OF TIMBER

5.1.1 The three broad classifications of fungal decay (known as rots) of timber are:

- brown rots – both dry and wet rots
- white rots – wet rots only
- soft rots.

5.1.2 Rot is caused by certain species of fungi, which are spread by airborne spores. Rots require food, moisture, oxygen and warmth. Spore germination needs the presence of free water. For rot to develop on radiata pine, for example, a moisture content above the fibre saturation point of 29% is required. Once established, some rots can remain active at moisture contents as low as 20%, although any decay will be slow at moisture content levels below 25%.

5.1.3 External timber framing that contains bulk insulation will have varying moisture contents – usually drier on the inside 'warm side' and damper on the outside 'cold side'. In addition, water leaks tend to accumulate within or on the back of claddings. This is because water vapour moves from warm to cold. Quoted or measured moisture contents may be misleading in terms of decay risk. Measurement of moisture contents in the very outside of timber framing is the practice adopted by trained and experienced building surveyors.

5.2 BROWN ROTS

5.2.1 Brown rots eventually darken the appearance of the timber, as they consume cellulose only, leaving the darker woody lignin behind. (Cellulose is a key part of plant cell walls and makes up about 40–50% of wood. Lignin binds cellulose and other substances in the cell walls.) Decayed timber may still look satisfactory but can be readily penetrated by a knife. When dried, the affected wood will darken, and cross-grain cracks appear.

5.2.2 In the very early stages, brown rot fungal growth is invisible to the naked eye. Its presence can only be determined by microscopic examination by a suitably experienced mycologist (a scientist who specialises in fungi). Once progressed into early decay, it can be detected by evidence of bleaching, staining or loss of timber fibre strength. However, not all staining or strength loss is due to decay.

5.2.3 Brown rots are considered to be more severe than other types of rots. This is because they decay timber more rapidly and, once started, tend to operate at lower moisture levels than other rots. They are commonly found in untreated framing

5.2.4 One particularly malignant brown rot is *Serpula lacrymans*, commonly known as dry rot. It derives its name and feared reputation because of its ability to transport moisture, enabling it to attack otherwise dry timber. It can grow over masonry and cement-based materials, obtaining both moisture and nutrients from these sources. It is very destructive if established. All timber infected with dry rot must be removed completely and destroyed by burning. Dry rot is less common in New Zealand than other types of rot. It grows in alkaline soils and is usually found in damp, poorly ventilated subfloors. *Serpula lacrymans* is uncommon in wall framing containing untreated radiata pine.

5.3 WHITE ROTS

5.3.1 White rots appear to bleach the timber, giving decayed timber a yellow-white fibrous appearance. The colouration is because the rots consume both the lignin and the cellulose. White rots commonly operate at mid to higher moisture levels. They are often found in decaying timber weatherboards and external timber joinery.

5.4 SOFT ROTS

5.4.1 Timber infected by soft rots often shows little outward sign of decay. The only sign is that the timber may have darkened or appear to be greyish. The decay is taking place from within the cell wall and only becomes apparent when prodded with a sharp object. In advanced stages of soft rot decay, the timber can easily be carved with a sharp knife. Sometimes, the latewood bands in the timber (the growth that comes later in each season) may darken, and if a matchstick-sized splinter is snapped off, the fracture surface will look like that of a broken carrot.

5.4.2 Soft rots are usually found on timber in contact with the ground. They tend to be more resistant to fungicides than brown rots or white rots and need elevated moisture levels to grow. In boron-treated timber, soft rot is the common form of decay where timber has been wet for a prolonged period.

5.5 CORROSION

5.5.1 Excess moisture will lead to corrosion of steel building components such as fixings, structural elements and lightweight steel framing. Constantly elevated moisture levels, as found in leaking walls, are ideal conditions for promoting corrosion.

5.5.2 Timber framing most often relies on steel fixings and brackets such as nails, screws, nail plates and various proprietary metal connectors. Corrosion byproducts such as rust can chemically attack timber, weakening the zone around the fastener (known as nail sickness) or can affect the strength of the component.

5.5.3 Steel framing, unlike timber framing, does not absorb and release moisture, but corrosion damage can occur if excess moisture is present for prolonged periods, especially at fixing points and cut ends where the galvanising layer is damaged.

5.5.4 Corrosion of steel components will be more severe where a copper-based timber treatment has been used and the timber is damp or wet. The threshold for corrosion between CCA-treated timber and galvanised steel is 20% timber moisture content. This is due to the interaction between the copper present in the timber treatment and the zinc in the galvanising.

5.6 MOULDS

5.6.1 Moulds are a type of fungi.

5.6.2 Mould occurring within damp wall cavities is quite different and unrelated to moulds on surfaces inside the building and, in some cases, is a more serious matter. A damp wall cavity can form an ideal environment for mould growth. Typical mould growths include *Penicillium, Aspergillus and Stachybotrys chartarum*.

5.6.3 The spores of moulds such as *Stachybotrys chartarum* carry chemical toxins known as mycotoxins. These may cause flu-like symptoms. They particularly affect the young, the old and those with weakened immune systems. Other moulds can cause allergic reactions and illness through infection. The highest risk to people occurs during the repair process when wall linings are removed and spores dry and become airborne.

5.6.4 Wall framing cavities may be wet due to rainwater or pipe leakage. Sometimes, there will be visual evidence such as mould growth on the back of wall-hung paintings or photographs, and MDF skirtings or furniture adjacent to the wall may swell. Often, there are few visual signs, no smell, no feeling of dampness and no apparent ill effects on the health of the occupants while the linings stay intact.

6.0 TREATMENT OF TIMBER AGAINST FUNGAL DECAY

6.0.1 Until 1988, radiata pine framing in New Zealand was traditionally treated using mixtures of sodium octaborate and boric acid to prevent borer attack. The boric treatment process has the beneficial side effect of offering a level of protection against common decay fungi.

6.0.2 Between 1988 and 2011, dry LOSP (light organic solvent preservative) treatment with permethrin to H1 levels was allowed but was not all that common until boron treatment was largely curtailed in 1998. Permethrin is an insecticide with no fungicidal benefit. Some designers and builders who ordered 'dry H1 boric' received H1 LOSP, unaware of the lack of any fungicidal content. H1 treatment can also be achieved using CCA (chromated copper arsenate), and the associated fungicidal benefit of CCA at H1 levels will be similar to that of H1 boron.

6.0.3 From 1995 until 2004, the use of kiln-dried untreated timber (commonly known as 'chem-free' timber) was also allowed by NZS 3602 for framing where it was not exposed to ground atmosphere and the in-service moisture content of the timber didn't exceed 18%. Its use became very common from 1998 through to 2003 when the Building Industry Authority (BIA) approved its use. The BIA responded to the weathertightness problem by publishing a directive recommending H1.2 treated timber (or H3.1 in some higher-risk situations) in all exterior wall framing except that in low-risk single-storey masonry veneer buildings, from April 2004.

6.0.4 In April 2011, B2/AS1 was revised (Amendment 7) to require H1.2 boric treatment for all radiata pine and Douglas fir framing that is protected from the weather but has a risk of moisture penetration conducive to decay or that is protected from the weather but exposed to ground atmosphere.

6.0.5 Amendment 7 also requires the use of H3.2-treated timber for cantilevered floor joists used to form a deck.

6.0.6 B2/AS1 does allow the use of untreated Douglas fir on a low-risk building where the cladding is installed over a drained and vented cavity, providing the 10 conditions given in clause 3.2.2.2 of the Acceptable Solution are met.

6.0.7 Identifying the preservative treatment of installed framing can be difficult. Sometimes, the required markings on the timber cannot be found or read. The presence of boron can sometimes be inferred from the types of decay encountered, but the only reliable method of determining the treatment used is to take samples for chemical analysis. Both boron and copper-based preservatives such as CCA can be identified by chemical spot tests of the timber.

Figure 2 Timber in external walls that is sound but untreated (or not treated to current B2/AS1 requirements) should be given two coats of brush-on boron glycol preservative treatment as part of any remediation work

7.0 CONSTRUCTION REMEDIAL OPTIONS

7.0.1 The aims of remediation design are to ensure a dry environment for the framing, to address the specific weathertightness shortcomings, to repair resultant damage and to improve the durability of the building.

7.0.2 All building work, including repairs, must be undertaken to meet the performance requirements of the Building Code.

7.0.3 If leakage is found, the options are:
- doing nothing – although carrying out essential maintenance is recommended
- temporary repairs
- localised repairs
- recladding and replacing damaged timber
- demolition and rebuilding.

7.1 DOING NOTHING

7.1.1 Presented with an expensive repair plan, an owner may choose not to proceed with any remediation option. Often this includes not carrying out essential maintenance.

7.1.2 The designer should inform the owner of the risks in this and advise the owner to seek expert advice. The risks of doing nothing include:
- the building condition is likely to continue to deteriorate
- the building may eventually be declared unsafe by the local territorial authority, which can then require work or demolition at the owner's cost
- potential exposure of the occupants to health effects from a damp mouldy environment
- the owner will need to advise a new buyer of the problems, which affects saleability.

7.1.3 Despite the risks, the owner may have no option if they cannot afford to carry out the repairs.

7.1.4 An owner may decide to sell the building 'as is' with disclosure of the weathertightness issues. While the owner may have to accept a lower price, selling may be a more affordable option than undertaking repairs.

7.2 MAINTENANCE

7.2.1 Failure of building owners to carry out regular maintenance, particularly of the building envelope (such as repainting) and water drainage systems (cleaning out gutters), can itself lead to weathertightness failure.

7.3 TEMPORARY REPAIRS

7.3.1 Temporary repairs may be desirable to slow or limit further damage until a decision can be made on the preferred long-term remediation option. They may also be useful to show a proactive response by an owner where a claim is being made for repair costs. (If the owner opts for temporary repairs, make sure that they are aware of the 10-year limit on lodging a claim with the Weathertight Homes Resolution Service.)

7.3.2 However, temporary repairs can be problematic. Repair work requires a building consent where the failure has occurred within the minimum durability period of the element (within 15 years for claddings). Such consented repairs will need to be undertaken by a licensed building practitioner.

7.3.3 Careful consideration should be given when carrying out temporary repairs, and it may be advisable to discuss proposed temporary repairs with the local building consent authority.

7.3.4 If a designer is assisting an owner with temporary repairs, the designer should ensure (and include in their contract) that the owner understands that temporary works do not constitute a remediation solution.

7.3.5 Unless properly targeted at the actual causes of water entry, the problem may be worsened by temporary repairs, particularly applying a membrane coating over monolithic walls, which may trap in moisture. It is advisable to seek specialist advice from a remediation expert.

7.3.6 Temporary repairs may obscure or destroy evidence that may be useful in a future claim.

7.4 LOCALISED OR ISOLATED REPAIRS

7.4.1 In some situations, repairs that only address a specific isolated defect (such as the insertion of a stop-end to an apron flashing where it was originally omitted) may deliver a weathertight solution. Another example is where timber framing is proven to have sufficient levels of treatment (H1.2 boron), the building has a low weathertightness risk and there are specific defects, leaking and damage.

7.4.2 Designers proposing these options need to be aware of (and ensure their client is also aware of) the risk that further damage may be found during repairs, necessitating a substantial redesign and a significant increase in costs. Also, any defects not identified and repaired during the remediation process will continue to cause deterioration, necessitating further remediation. With localised repairs, merging the repair (such as the replacement of a plaster finish) may in itself create difficulties. Unless the designer manages these risks carefully, the designer could find they are involved in further claims made by the owner.

7.4.3 Advice from a specialist remediation expert should be sought when considering whether a localised repair is appropriate.

7.5 CLADDING REPLACEMENT

7.5.1 Systemic failure of a cladding system (particularly where framing is untreated) is likely to require full replacement of the cladding, with replacement of damaged framing or other building materials or elements. The advantages of this option are:

- a drained and ventilated cavity can be introduced to reduce risk of future failure
- greater confidence can be given to owners
- all faults and decay are more likely to be found
- all exposed timber can be surface treated with a suitable paint-on boron-based fungicide (including injection of the solution into holes drilled into built-up members such as lintels)
- evidence can be uncovered for potential legal action
- there is the opportunity to address other building faults
- there is the opportunity to improve amenity and value, for example, by increasing the level of insulation or changing the building appearance
- there is the opportunity to remove riskier features from the building.

7.5.2 Cladding costs a lot to replace. However, it is not unknown for targeted repairs to match or exceed the cost of cladding replacement, so a careful and thoughtful evaluation before any remedial action is undertaken is essential.

7.5.3 Where damage to cladding and framing is extensive, demolition and rebuilding may be a viable or safer option.

8.0 REPLACING TIMBER

8.0.1 The recently-published booklet *Dealing with Timber in Leaky Buildings* (Department of Building and Housing) outlines the steps for removing decayed timber. Key steps are:

- identify the type of damage
- get timber samples tested to determine extent of damage
- remove 1 m of timber past the last visual sign of decay
- site-treat the remaining untreated or H1.1 treated timber
- install replacement H1.2 treated timber.

9.0 FURTHER INFORMATION

BRANZ Bulletins
437 (2003) *Dealing with mould*
526 (2010) *Specifying timber*
527 (2010) *Drained and vented cavities*
538 (2011) *Timber treatment*
545 (2012) *Key changes to* B1/AS1 and E2/AS1

OSH Bulletins
Risk to health from moulds and other fungi (November 2002) Workplace Health Bulletin 17

Figure 3 Full cladding replacement allows all faults and decay to be found and exposed timber to be treated.

Building and Housing Group, Ministry of Business, Innovation and Employment (formerly DBH)
Weathertightness: Guide to remediation design (with BRANZ)
Compliance documents E2/AS1 and B2/AS1
Dealing with Timber in Leaky Buildings
Weathertightness: Guide to the diagnosis of leaky buildings
External moisture: An introduction to weathertightness design principles
Weathertightness: A guide to timber remediation
www.dbh.govt.nz/weathertight-services - Weathertight services help for owners of leaky homes

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