BRANZ

ISSUE587 BULLETIN

DEALING WITH CONSTRUCTION MOISTURE IN NEW BUILDINGS

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- New houses can experience high internal moisture levels for up to 2 years after construction.
- This bulletin identifies sources of construction moisture and describes ways to deal with the problems arising from it.
- This bulletin updates and replaces Bulletin 447 *Preventing construction moisture problems in new buildings*.

1.0 INTRODUCTION

1.0.1 New houses can experience high internal moisture levels for up to 2 years after construction. The source of the moisture is from construction materials – some have a high moisture content when initially installed, and some may become wet during the construction period. Although the materials dry out over time, there are ways to minimise the effects of the high initial moisture levels that often occur in new houses.

1.0.2 This bulletin identifies sources of construction moisture and describes ways to deal with the high initial internal moisture level in new houses, such as:

- planning for and allowing sufficient time in the construction process for materials to dry out
- keeping materials dry once they are installed
- avoiding adding unnecessary water
- avoiding installing linings before the timber framing or other supporting structures (concrete masonry, precast concrete panels and so on) are at the correct moisture content
- avoiding applying finishes before substrates are at the correct moisture content.

1.0.3 This bulletin updates and replaces Bulletin 447 *Preventing construction moisture problems in new buildings.*

2.0 BUILDING CODE REQUIREMENTS

2.0.1 To deal with construction moisture, New Zealand Building Code (NZBC) clause E2 *External moisture* requires that, when construction is completed, excess moisture in a building must be able to dissipate without causing permanent damage to the building elements.

2.0.2 NZBC clause E3 *Internal moisture* requires that buildings must be constructed to avoid the likelihood of:

- fungal growth or an accumulation of contaminants on linings and other building elements
- damage to building elements caused by the presence of moisture.

2.0.3 Acceptable Solution E2/AS1 section 10.2 specifies maximum acceptable moisture contents:

- For timber framing at the time of installing interior linings, the maximum acceptable moisture content shall be the lesser of:
  - 20% for insulated buildings, or
  - 24% for non-insulated buildings, or
  - as specified in NZS 3602:2003 *Timber and wood-based products for use in buildings*.
- For timber weatherboards and exterior joinery, 20% at the time of painting.
- For reconstituted wood products, 18% at all times.
- For concrete floors, sufficiently dry to give a relative humidity reading of less than 75% at the time of laying fixed floor coverings.

2.0.4 E2/AS1 section 10.3 also specifies that:

- for timber, "measurement shall be by the recommended procedure in the Scion (New Zealand Forest Research Institute) publication *Measurement of moisture content of wood* using electrical resistance type moisture meters with insulated probes"
- for concrete, measurement shall be made using hygrometers.

3.0 CONSTRUCTION MOISTURE SOURCES

3.0.1 Moisture in new materials may come from:

- materials that have a high initial moisture content including concrete, concrete masonry, mortar, grout, plaster coatings, stopping compounds and paints
- materials that may have been brought to site dry but are exposed to wetting during the construction process, such as prelaid flooring, kiln-dried timber framing and concrete masonry
- wet (or green) timber.

3.0.2 Materials may also have a higher than recommended moisture content if the following are present:

- Leaks from the roof and/or wall cladding.
- Leaks from newly installed plumbing and drainage pipes.
- Ground or soil water.
- Damp or humid atmospheric conditions that may affect the moisture content of timber.

3.1 DRYING TIME

3.1.1 The length of time for construction materials to dry depends on:

- temperature – materials will have slower rates of drying in colder climates generally and during colder months of the year due to the lower temperatures
- ventilation – materials that have been closed in before they are dry enough (for example, framing where linings, particularly impervious linings, have been installed) will take longer to dry than framing left exposed in a house that has a good airflow through it
- the amount of moisture present
- atmospheric moisture levels
- exposure of the materials to rain wetting.

3.2 CONCRETE FLOOR SLABS

3.2.1 Approximately 90% of new homes in New Zealand have a concrete floor slab, and concrete is a major contributor to construction moisture in new houses. For example, concrete for a floor slab for a small 100 m^2 house requires approximately 1,700 litres of water. A small quantity of the water is required for the cement hydration process, and some water will evaporate from the surface of the slab fairly quickly, but a week after laying the concrete, the slab will still contain approximately 1,000 litres of water that must evaporate.

3.2.2 Water evaporates from a slab on ground at a rate of around 25 mm depth of concrete per month in good drying conditions (dry weather and well ventilated spaces after the walls and cladding have been erected). This means that a 100 mm thick concrete slab will take at least 4 months to dry.

3.3 TIMBER

3.3.1 Most timber framing is kiln dried, typically to 12–14% moisture content. Finishing timber may be kiln dried within an 8–14% range. Once timber is removed from its protective packaging, the moisture content will increase if it is:

- wetted during storage and frame erection
- exposed to high humidity.

3.3.2 E2/AS1 specifies that timber framing has a maximum moisture content as given in 2.0.3 above before fixing wall/roof claddings and internal linings. For linings and membrane roofing or waterproofing membrane substrates, a lower timber framing moisture content may be required. For example, major plasterboard suppliers require a maximum framing moisture content of 18% with a recommendation that, for air-conditioned or centrally heated spaces, a lower moisture content is desirable (12% or less).

3.3.3 Green or unseasoned timber, if used, may have a moisture content of 45% or higher depending on the timber species. This means that wet timber framing may contain up to 2 litres of water per stud or around 450 litres of water in the framing, which must also evaporate.

3.4 WET CONSTRUCTION PROCESSES

3.4.1 A number of other construction activities are wet or damp processes. Typical of these are:

- plasterboard stopping
- painting
- liquid internal waterproofing membrane application
- using tile adhesives
- grouting of tiles.

3.4.2 The actual amount of water that needs to be removed through drying is difficult to estimate. Removal is best dealt with through good ventilation during work operations and for a couple of weeks after the wet activities have finished.

4.0 EFFECTS OF EXCESS MOISTURE

4.0.1 Enclosing 'wet' construction materials can result in:

- a loss of performance of building materials
- moisture condensing in building cavities
- general dampness that can facilitate mould and fungal growth.

4.0.2 Moisture may be trapped if wet framing timber is enclosed before it is sufficiently dry.

4.0.3 There is a higher risk of trapped moisture causing problems in the following situations:

- Where insulation and internal linings (particularly impervious linings) are installed.
- Where waterproofing and roof membranes are applied to a damp substrate.
- Where impervious, tiled and timber finishes are laid over concrete before it is dry enough.
- When ceilings are installed too early in skillion roofs, where the potential for drying is limited, particularly with membrane roofing systems. Moisture may be emitted from 'dry' timber after installation as a result of heat build-up within an enclosed skillion roof structure. Ventilation of the space will assist with heat and moist air removal, but at present, there are no set rules for providing skillion roof ventilation.

4.1 DAMAGE AS A RESULT OF EXCESS MOISTURE

4.1.1 Construction moisture remaining in materials can result in:

- loss of durability of the materials because of rotting, degradation or corrosion
- condensation forming on cold surfaces such as the back of a roof or wall cladding
- popping of plasterboard fixings
- high internal moisture levels as the materials continue to dry
- reduced R-values of insulation
- swelling of wood and wood-based products, such as medium-density fibreboard (MDF), particleboard and wood or wood-based flooring overlays
- damage to finishes when applied to damp surfaces – for example, poor paint adhesion and durability, bubbles occurring under a roofing membrane or vinyl flooring that has been laid over a damp substrate
- moisture in wall cavities or roof spaces condensing onto colder surfaces where it may facilitate mould and fungal growth that can damage the structure – this may not be noticed until damage is well advanced
- transmission of moisture to adjacent materials that were dry when installed
- internal biocontaminants such as dust mites, fungal growth and toxic mould spores resulting in potential health problems for occupants.

4.1.2 Where work has been carried out before materials are dry enough:

- timber framing may move, causing linings to deflect and fixings to pop, resulting in poor-quality finishes
- application to damp surfaces may lead to premature deterioration of or visual defects in coatings and finishes
- materials and finishes may be affected by shrinkage and then cracking.

4.1.3 Timber that is enclosed before it has had sufficient time to dry may contribute to mould and fungal growth. Preservative treatment will discourage fungal growth on the timber but will not prevent growth on other materials such as plasterboard linings.

4.2 EQUILIBRIUM MOISTURE CONTENT

4.2.1 Timber is hygroscopic, which means it will absorb and release moisture in response to changes in the atmospheric moisture content or relative humidity. At a given relative humidity – that is, a particular temperature and humidity level – timber will reach an equilibrium state where the timber will neither gain nor lose moisture. This is referred to as equilibrium moisture content. The equilibrium moisture content differs for different timber species at the same relative humidity.

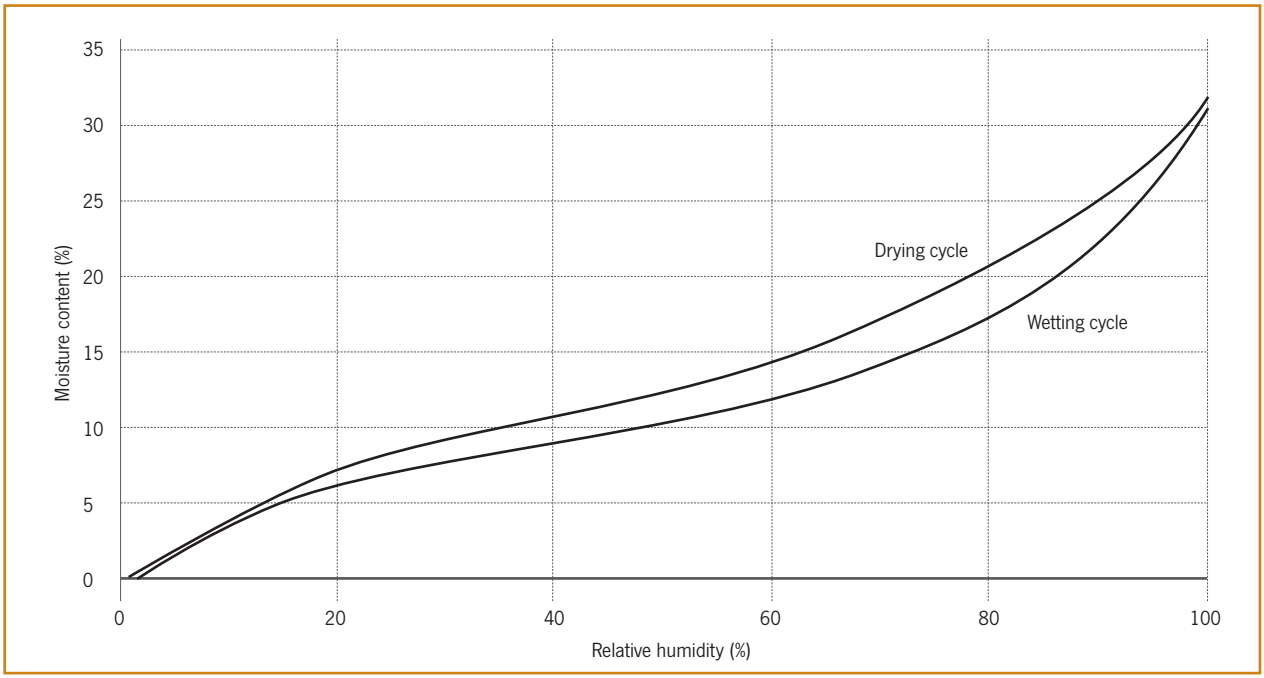

Figure 1. Relationship between moisture content of timber and the relative humidity of the surrounding environment.

4.2.2 The graph in Figure 1 shows the relationship between the relative humidity of the environment and the moisture content of a typical softwood construction timber such as *Pinus radiata*.

4.2.3 Typically, a heated or air-conditioned building is likely to have a relative humidity of approximately 30–50%, which should correspond to a moisture content of around 12%.

4.2.4 Excess moisture contained in building materials must be able to dry sufficiently before some subsequent construction activities proceed.

4.3 TIMBER SHRINKAGE

4.3.1 As the moisture content reduces, the timber also shrinks. The amount of shrinkage varies according to the timber species and the way the timber is cut. However, with kiln-dried timber, the effect of shrinkage (when compared to that occurring with wet or green framing) is lessened. It is measured as the change in dimension from the green timber to timber at 12% moisture content, expressed as a percentage. New Zealand timbers have shrinkage rates ranging from 2.2–7.1% for quarter-sawn (tangentially cut) timber and 1.3–3.5% for flat-sawn (radially cut) timber[1] (Figure 2).

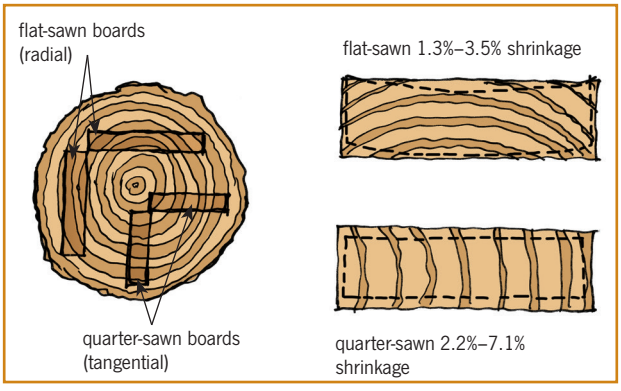

Figure 2. Timber shrinkage varies according to cutting direction.

5.0 AVOIDING PROBLEMS DUE TO CONSTRUCTION MOISTURE

5.0.1 It is impossible to avoid construction moisture, but problems arising from the initial high moisture levels can be minimised in a number of ways.

5.1 PLANNING AND DESIGN

5.1.1 Allow sufficient time in the construction process to allow materials to dry before being enclosed or having finishes applied (Tables 1 and 2).

5.1.2 Drying times will be slower:
- when air temperatures are cooler, such as in winter
- when humidity is high
- in wet weather
- once the building has been enclosed
- when the building is not ventilated during fine sunny days.

5.1.3 Once the building has been enclosed, provide good ventilation to the interior during the daytime by leaving doors and windows open as much as possible.

5.1.4 Other practices to reduce construction moisture include:
- storing materials under cover and off the ground before they are used
- protecting building materials to keep them as dry as practicable during construction – cover framing being stored and get the frames up, roof on and wall underlay installed as quickly as possible.

5.2 TIMBER FRAMING

5.2.1 Make sure that framing timber is dry before installing the linings by using kiln-dried framing, particularly in high rainfall areas and during winter.

5.2.2 Refer to BRANZ Bulletin 431 *Care of kiln-dried framing timber*, which outlines accepted construction practices when building with kiln-dried timber framing. Kiln drying is a controlled process, capable of producing timber that is stabilised and at the correct moisture content for linings and other finishes to be applied.

5.2.3 Install the roofing as soon as possible to protect the framing below from rain wetting. The wall underlay and cladding installation should follow as quickly as possible to maximise protection from rain wetting. As long as insulation and linings are not installed too quickly, moisture in the timber will dry through ventilation.

5.2.4 If using wet framing, allow enough time for the timber to dry to at least 20% moisture content (Table 1) before applying the linings or lower moisture content if specified by the lining manufacturer. Air drying is a slow process that must be done carefully to avoid differential shrinking and possible distortion of the timber. Wet framing will dry more quickly once the roofing has been installed.

TABLE 1. TYPICAL DRYING TIMES FOR GREEN TIMBER *PINUS RADIATA* (UNDER FAVOURABLE DRYING CONDITIONS)

Wood thickness (mm)[1]	Drying time (months)[2]
25	2
50	4
75	8
100	16
150	60

Notes:
1. Drying will occur more quickly in smaller dimension timber. For example, a 100 x 50 mm timber section will take approximately 4 weeks, while a site-laminated 300 x 100 mm section will take approximately 16 weeks.
2. Times will be longer under poor drying conditions.

Wet flooring and bottom plates.

5.2.5 Do not install insulation and internal linings until the building is fully weathertight – that is, wall and roof cladding, windows and doors are all installed.

5.2.6 Do not apply finishes when the ambient temperature is not within the range for application recommended by the manufacturer.

5.2.7 If the floor gets wet and remains so, moisture will 'wick' into timber bottom plates. The moisture content of bottom plates must be reduced to an acceptable level before the linings can be fixed. Timber strip flooring should only be laid after the building is enclosed.

5.3 CONCRETE

5.3.1 To keep the water content of concrete as low as possible:
- do not pour concrete where the mix is outside the specified slump value range
- do not add water to premixed concrete to aid pumping – the additional water will slow the drying process, increase the shrinkage and reduce the strength of the concrete.

5.3.2 Allow approximately 25 mm per month under favourable drying conditions for a concrete slab on ground to dry. Typical drying times are given in Table 2. Use a hygrometer or in-slab probes to check the concrete moisture content before laying floor finishes.

TABLE 2. TYPICAL CONCRETE DRYING TIMES

Concrete thickness (mm)	Drying time (months)[1,2]
75	3
100	4
150	9
200	16
300	24

Notes:
1. Times will be longer under poor drying conditions such as during the winter and in wet weather.
2. Do not use heaters to speed up drying as they will only dry the surface and give false hygrometer readings.

5.4 GENERAL CONSTRUCTION PRACTICES

5.4.1 Other general construction practices to avoid increasing the moisture content of building materials:
- Mark pipe positions within wall framing so that fixings for linings and fittings can be kept clear of the pipes. Punctured pipework is a common cause of moisture problems. Provide the building owner with a services location plan when the building is completed.
- Check that all pipes and pipe joints are free of leaks before enclosing. Leaking pipes and loose pipe joints can cause serious moisture problems.
- Do not drill bottom plates to ventilate wall cavities as this can allow moist air from the subfloor to enter the wall cavities.
- Ensure that a damp-proof membrane under the concrete slab is not damaged during placement of the concrete.
- Install interior linings once the building is fully weathertight and timber framing or other substrates are dry enough.

6.0 CONCLUSION

6.0.1 Damage from moisture in structural cavities is usually not apparent until the building has been

[1] From Table 2, Timber Design Guide (3rd ed.) 2007. New Zealand Timber Industry Federation.

occupied for some time. Remedial work is seldom simple and generally expensive and inconvenient for the occupants.

6.0.2 By following sound trade practices and allowing adequate time between different phases of construction, damage from moisture during construction can be avoided without adding extra construction costs.

7.0 DEFINITIONS

equilibrium moisture content (EMC)
The moisture content at which timber neither gains nor loses moisture from the surrounding atmosphere.

flat-sawn timber
Timber sawn so that the average slope of growth rings to the wide face of the timber is less than 45 degrees.

moisture content
The weight of moisture contained in a piece of timber expressed as a percentage of the oven dry weight.

quarter-sawn timber
Timber sawn so that the average slope of growth rings to the wide face of the timber is more than 45 degrees.

relative humidity
A ratio of the amount of water vapour contained in a sample of moist air to the maximum amount of water vapour that the sample can hold at the same temperature and pressure.

seasoned timber
Timber that has had the average moisture content reduced to below 25% before being used.

8.0 MORE INFORMATION

Ministry of Business, Innovation and Employment (MBIE)
New Zealand Building Code clauses and Acceptable Solutions
E2 *External moisture* and Acceptable Solution E2/AS1
E3 *Internal moisture* and Acceptable Solution E3/AS1
G4 *Ventilation* and Acceptable Solution G4/AS1

Standards New Zealand
NZS 3602:2003 *Timber and wood-based products for use in buildings*
NZS AS 1884:2013 *Floor coverings – Resilient sheet and tiles – Installation practices*

BRANZ
Building Basics
Internal Moisture

Bulletins
431 *Care of kiln-dried framing timber*
469 *Damp-proof membranes to concrete slabs*
585 *Measuring moisture in timber and concrete*
541 *Concrete floor slabs*

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