BRANZ

ISSUE 644 **BULLETIN**

SOLID TIMBER STRIP FLOORING ON A CONCRETE SLAB

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- Solid timber flooring is a popular overlay flooring over a concrete slab.
- Problems can occur if the moisture content of the concrete is too high or if the moisture content of the timber does not match the moisture content of the internal space when the flooring is installed.
- This bulletin describes the requirements and installation practices for installing solid timber strip flooring over concrete. It replaces Bulletin 506 *Laying solid timber strip flooring on concrete slabs*.

1 INTRODUCTION

1.0.1 Solid timber strip flooring is a popular flooring for both domestic and commercial buildings. Traditionally, timber was installed over suspended timber subfloor framing but is now commonly specified as an overlay flooring over a concrete slab.

1.0.2 Poorly installed timber strip flooring can result in problems such as cupping, buckling and popping of boards. Common causes of problems include:

- the moisture content of the concrete slab being too high or insufficient moisture vapour barrier protection when the timber flooring is installed, resulting in moisture uptake and swelling of the timber
- the moisture content of the flooring timber not matching the moisture content of the internal space at the time of installation, resulting in expansion or contraction of the boards.

1.0.3 High levels of UV light on the flooring can result in fading, deterioration of the finish and more shrinkage than otherwise expected.

1.0.4 This bulletin describes the recommendations for installing timber strip flooring including:

- moisture levels required for the concrete and the timber
- methods of installing timber strip flooring
- timber finishes, protection and maintenance.

1.0.5 It deals with solid timber flooring only. It does not include engineered, laminate or hybrid flooring products.

1.0.6 It replaces Bulletin 506 *Laying solid timber strip flooring on concrete slabs*.

2 CONCRETE SLAB MOISTURE LEVELS

2.0.1 Before installing a solid timber strip floor over a concrete slab, the concrete must be sufficiently dry or moisture from the slab will be absorbed by the timber, causing floorboards to swell.

2.0.2 When a concrete slab is poured, it contains a large amount of water. Some is used in the cement hydration process, and some is used to make the concrete workable and must evaporate out of the concrete. The amount of evaporation is approximately 10–15 litres per square metre of concrete, which means an average size house must lose approximately 1,000–1,500 litres of water from the slab.

2.0.3 A damp-proof membrane under the slab means the water can only evaporate upwards. Once the building has been closed in and under good drying conditions, a general rule of thumb is to allow at least 1 month of drying for every 25 mm of slab thickness. This means that, for a slab 100 mm thick, at least 4 months' drying time is required from when the building is enclosed. Note that this is a high-risk method and is not a recognised test as no definitive result is attained.

2.0.4 Forced drying of the slab using a heater or dehumidifier is not recommended as it only dries the surface of the slab and will not evaporate the moisture from within the slab. It can also have a reverse effect – driving the moisture deeper into the concrete before migrating back to the slab surface.

2.0.5 If a new or existing slab is not sufficiently dry, treatment with an applied moisture vapour barrier may be necessary. The success of such a treatment and any subsequent flooring installation will depend on the product used. Specifiers will need to be satisfied that the performance claims made can be independently verified.

2.1 MEASURING MOISTURE IN CONCRETE

2.1.1 Acceptable Solution E2/AS1 to New Zealand Building Code clause *E2 External moisture* only recognises using a hygrometer (calibrated in accordance with ASTM E104-02 (2012) *Standard practice for maintaining constant relative humidity by means of aqueous solutions*) to measure the moisture release from a concrete slab.

2.1.2 Under E2/AS1, the maximum relative humidity above the slab permitted before laying fixed floor coverings is 75%. However, BRANZ considers it prudent to not install the timber until the concrete floor slab has a relative humidity of 70% or less due to the hygroscopic nature of timber.

2.1.3 To measure the relative humidity above the slab, the hygrometer is sealed to the concrete and left for at least 16 hours. It measures the relative humidity of the air in the sealed chamber over the slab, which in turn provides a reading of the moisture vapour released from the slab. It will not give an accurate reading if the slab surface is wet, and conditions such as forced drying or the use of a curing agent will also distort a hygrometer's reading.

2.1.4 An alternative method of measuring moisture content, not included in E2/AS1, is to assess in-slab relative humidity using relative humidity probes, which are embedded into the slab through a hole drilled into the slab after it has been poured and cured. Probes are a more effective method of measuring the moisture conditions within the concrete rather than what is being transferred from the surface. Testing is in accordance with ASTM F2170-19 *Standard test method for determining relative humidity in concrete floor slabs using in situ probes*.

2.1.5 When using probes, a maximum of 80% relative humidity is considered acceptable, although some overseas literature recommends 75% or lower for glued timber flooring systems.

2.1.6 Slab moisture content can be assessed with a concrete impedance meter. This assesses slab moisture content in the upper 25 mm of the slab and can be used to determine areas of higher slab moisture including slab edge dampness. It can also be used to assess whether a slab is drying as expected and if an old slab has a higher moisture content than would be expected for its age.

3 SOLID TIMBER STRIP FLOORING

3.0.1 The timber used for flooring should be stable and hardwearing. Many timbers are suitable but each is different – aspects such as board size, grade, timber hardness and moisture content need to be considered. Suitable species include mataī, rimu, silver beech, red

beech, hard beech, Australian hardwoods, tawa, jarrah, American oak, American white maple, kwila, merbau, cypress species and locally grown eucalyptus species.

3.0.2 Solid timber strip flooring consists of tongue and groove boards generally 12–21 mm thick. Thinner boards are typically used for direct adhesive-fixed flooring, while the typical thickness for boards fixed over framing is 19 mm.

3.0.3 Tongue and groove boards must be accurately machined as tongues and grooves that are too tight or too loose can result in a floor that squeaks and can cause coating delamination at board edges.

3.0.4 Timber expands and contracts as a result of changes in moisture content as the result of changes in relative humidity. Narrower boards allow movement to be distributed over a greater number of joints so the floor shows less seasonal movement effects.

4 MOISTURE CONTENT OF TIMBER STRIP FLOORING

4.0.1 When a timber floor is laid, the moisture content of the timber should be near the average in-service moisture content. This will help minimise the amount of board movement.

4.0.2 If the timber is too dry when it is laid, it can absorb moisture from both the air and the concrete, causing it to swell and potentially result in the edges of boards being crushed or a section of the flooring being forced upwards (buckling).

4.0.3 Conversely, if the moisture content of the timber is higher than the moisture content it will adjust to when in service, the boards will shrink as they dry out, potentially resulting in joints between boards opening up or boards cracking or splitting.

4.0.4 Air-conditioned or centrally heated buildings generally result in a drier internal environment, so at installation, timber flooring moisture levels are required to be lower than for other buildings. NZS 3602:2003 *Timber and wood-based products for use in building* Table 4 sets out allowable installation moisture content for timber flooring as:

- for air-conditioned or centrally heated buildings – 8–12%
- for intermittently heated buildings – 8–12%
- for unheated buildings – 12–16%.

4.0.5 Timber flooring can be installed over an underfloor heating system but care must be taken with the type of timber selected and the installation procedure. There are two main considerations:

- There may be a reduction in heat transmission from the heated slab into the space above.
- Floorboards may form wider gaps at board edges and may crack and warp as a result of too much heat.

4.0.6 Thicker floorboards will reduce the amount of heat transmitted through the flooring. Floorboards that are about 19 mm thick are recommended. Thinner boards have been found to be unstable and should not be used.

5 CONDITIONING OR ACCLIMATISING TIMBER FLOORING

5.0.1 When a timber floor is laid, it is beneficial that the average moisture content of the flooring is within a few percent of the expected in-service moisture content to reduce the amount of swelling or shrinkage after installation.

5.0.2 Equilibrium moisture content relates to humidity and temperature – for example, at 65% relative humidity and 20°C, timber will approach 12.0% moisture content.

5.0.3 If the flooring moisture content is significantly lower than the expected average in-service moisture content it will attain, the timber needs to be acclimatised before laying or additional expansion allowed for. If the internal environment is to remain very dry (such as in a controlled environment), acclimatisation may be used to lower board moisture content, shrinking the boards prior to laying.

5.0.4 Acclimatisation is achieved by storing the timber in the space where it is to be installed prior to installation and monitoring the moisture content and cover width of the boards. The timber flooring should be stored stacked and filleted to enable air to circulate around the timber. It may take 3–14 days for the timber flooring to adjust. Note that putting timber to acclimatise on a site that is still being built may not achieve the required in-service moisture content as the site may be too damp from construction moisture.

5.0.5 With flooring supplied at a lower moisture content than the expected in-service moisture content, monitoring should indicate an increase in moisture content and cover width of the boards. The opposite applies to flooring at a higher moisture content.

6 TIMBER FLOORING INSTALLATION

6.0.1 Timber strip flooring can be installed over a concrete slab:

- by direct adhesion
- over an intermediate layer
- over timber battens.

6.1 DIRECT ADHESION

6.1.1 Direct adhesion means that timber boards are laid directly onto the concrete and fixed using a polyurethane or polymer adhesive. It is one of the most common methods of installation of solid timber flooring over concrete.

6.1.2 For direct adhesion, the concrete slab must be sufficiently flat. Variations in the flatness of the slab should be filled with a concrete filler or ground down to create an adequately flat surface. The maximum permitted deviation in level is 3 mm in 3 m of length.

6.1.3 Before applying the adhesive, the concrete must be clean and sound (no loose or crumbly material on the surface). It should be free of any surface contamination such as a curing agent.

6.1.4 The slab must also be sufficiently dry – an applied moisture vapour barrier will often be needed.

6.1.5 If the adjacent floor finish is to have a different thickness to the timber flooring, a set-down in the slab is likely to be required so careful planning at the design stage of the building project is necessary. Alternatively, transitions may be used.

6.2 OVER AN INTERMEDIATE LAYER

6.2.1 An intermediate layer consists of a sheet material, typically plywood, which is glued to the concrete substrate. An alternative is mechanically fixing by pinning/spikes or using proprietary countersunk screw-in anchors to fix the intermediate layer to the concrete. The minimum thickness of plywood is 12 mm, which requires 28 pins per sheet, or 15 mm thick plywood, which requires 20 pins per sheet.

6.2.2 The slab must also be sufficiently dry – an applied moisture vapour barrier will often be needed.

6.2.3 The timber strip flooring can then be glued and nailed to the intermediate layer.

6.3 OVER TIMBER BATTENS

6.3.1 Timber battens can be fixed directly to the concrete floor slab to create a support system similar to timber joists. This method is particularly suitable where the slab is uneven or adhesive cannot be used. This option also allows for installation of insulation between the timber battens and the concrete. A slab set-down may be required to accommodate the thickness of the flooring to align with adjacent floor finishes.

6.3.2 Before installation, timber battens should be stored on site to allow them to condition and be of similar moisture content as the timber strip flooring.

6.3.3 The slab must also be sufficiently dry – an applied moisture vapour barrier will often be needed.

6.3.4 Timber battens may be fixed mechanically or by mechanical fixing plus gluing.

6.3.5 Irregularities in floor level can be accommodated by:
- packers under the battens at fixing points (Figure 1)
- firring or scribing the battens to the floor irregularities (there is a risk of firring splitting when the flooring is nail fixed).

6.3.6 Set out timber battens in accordance with Table 2, which gives the maximum spans and minimum thicknesses for various species of timber strip flooring.

7 INSTALLATION REQUIREMENTS

7.0.1 General requirements when installing a solid timber strip floor:
- Do not lay timber flooring until the building is completely weathertight.
- Ensure that the slab is sufficiently dry or provide protection with an applied moisture vapour barrier.
- Ensure that the concrete surface is clean, sound for the installation method and sufficiently flat.
- Ensure that the moisture content of the timber flooring is close to the expected average in-service moisture content where possible, and take steps to assess and accommodate seasonal movement.
- If installing flooring over timber battens, ensure that they are at a similar moisture content to the floorboards.
- Handle boards carefully to prevent damage to the tongues and grooves and board edges.
- Allow an 8–10 mm gap around the perimeter of the floor to accommodate movement – this will be covered by the skirting.
- Lay boards with randomly staggered end joints (Figure 2).

7.0.2 If the floor area exceeds 6 m in either direction, install movement control joints – fill joints with cork or a sealant appropriate for use with timber flooring. Alternatively, smaller joints may be incorporated at closer spacings, or a combination of larger and smaller joints can provide movement control over a large floor area.

7.0.3 Specific recommendations when installing flooring by direct adhesion:
- Use a polyurethane or polymer timber flooring adhesive for gluing timber to concrete. Apply adhesive in accordance with the manufacturer's instructions for application temperatures and open times, and ensure the adhesive meets the 15-year durability requirement of the Building Code.
- Ensure the air temperature is within the range recommended by the adhesive manufacturer.
- Apply adhesive to the concrete surface in an even bead height using a notched trowel or adhesive gun or in accordance with specific adhesive installation instructions.
- Apply the beads of adhesive in parallel lines so air is able to escape as the boards are pressed onto the adhesive.
- Contact must be made before the adhesive has begun to go off or skin over. Any adhesive that has begun to cure must be removed and replaced.
- Press the timber boards firmly onto the adhesive, making sure that the glue bond is to both the timber and the concrete.
- Tap each board into place making sure that the tongue of the board is well fitted into the groove of

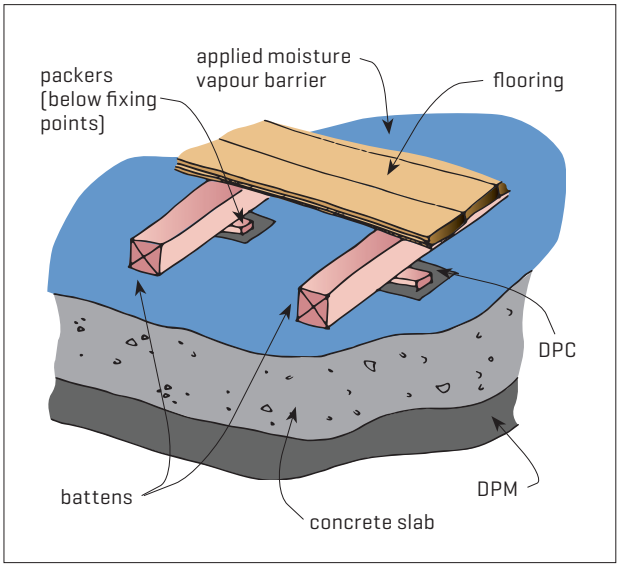

Figure 1. Packers under battens.

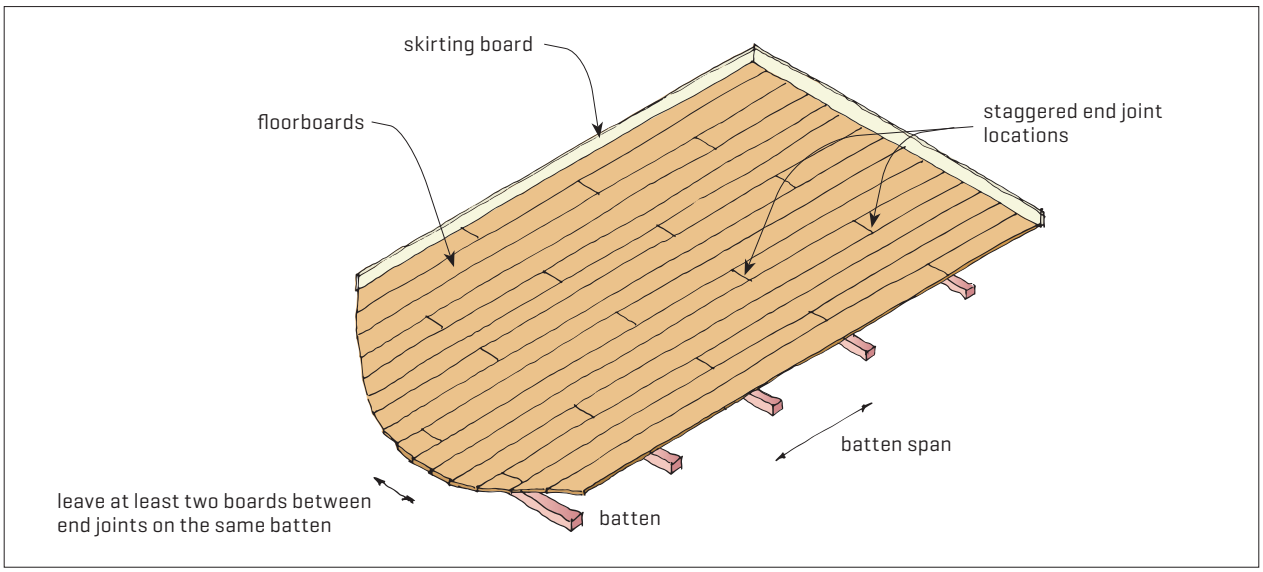

Figure 2. Randomly staggered end joints.

the adjacent board as it may be difficult to get good leverage for cramping boards. Use a packer to protect the boards – do not tap directly onto floorboards.
- Use 'parrot' or tapered concrete nails with predrilled 3 mm holes and punched below the surface to keep the boards cramped and held down in the adhesive.
- Progressively weight the flooring using sandbags or weights until the adhesive cures.
- Do not walk on the floor for at least 48 hours after laying to allow the adhesive to cure – refer to the adhesive manufacturer's instructions.

7.0.4 Specific recommendations when installing flooring over an intermediate layer:
- Structural (19 mm) or overlay (12 mm) flooring may be used on an intermediate layer such as plywood.
- Ensure the slab is sufficiently level to accept the system.
- A slab on ground should be constructed with a continuous underslab vapour membrane.
- Assess whether an applied moisture membrane is necessary to protect from slab moisture.
- A plywood intermediate layer needs to have a moisture content within 2% of the flooring to be installed at the time of installation.
- Installation should not proceed until other construction activities (especially wet trades) are complete and the building is roofed and enclosed.
- Floor fixing: some systems use mechanical fixing with beads of adhesive (for boards up to 85 mm wide), others use a full trowel spread bed of adhesive for the fixing (for all board widths up to 135 mm).
- Press the timber boards firmly onto the adhesive, making sure the glue bond is to both the timber and the plywood substrate.
- Tap each board into place making sure that the tongue of the board is well fitted into the groove of the adjacent board (it may be difficult to get good leverage for cramping boards).
- Progressively weight the floor (using sandbags or weights) until the adhesive cures.

7.0.5 Specific recommendations when installing flooring over battens:
- Install battens at no more than the maximum permitted centres required for the specified board thicknesses given in Table 1.
- Fix minimum 35 x 70 mm kiln-dried timber battens (on the flat) directly onto the concrete using packers under battens (if required and spaced to not exceed the batten spacing), or fir the battens as required to ensure framing is level (see Figure 1).
- Mechanically fix all battens to the slab with drive pins or equivalent at packers or, if direct to the slab, at no more than 900 mm between fixings with or without adhesive.

Table 1. Spans for timber board flooring from NZS 3604:2011 *Timber-framed buildings*.

Maximum batten spacing (mm)	**Minimum thickness (mm)[1]**	
	red beech, silver beech, rimu, mataī, radiata pine, Douglas fir, larch[2]	karri, blackbutt, tawa, hard beech, jarrah, tallowwood eucalyptus[2]
400	16[3]	16[3]
450	19	16[3]
600	22	19

Notes:

[1] Flooring timbers thinner than the figures given must be fully supported by plywood or the concrete itself.

[2] Timbers other than those provided in the table may be used. With timbers below a published density of 720 kg/m^3, the first column is applicable.

[3] Some timber suppliers recommend a minimum thickness of 19 mm rather than 16 mm allowed by NZS 3604:2011. Imported timbers often have a nominal thickness of 19 mm.

- Check that the boards are straight and parallel, and manually tighten boards before cramping.
- Use flooring offcuts to protect the edge of the boards from damage when tightening and cramping
- If not end matched (plain end), cut clean and square and make all end joints over battens (Figure 3).

7.0.6 To fix boards, face nail or secret nail boards to the battens in accordance with the nailing schedule in NZS 3604:2011 Table 7.5. A combination of adhesive and nailing is recommended. When secret nailing, use 50 mm long staples or cleats, or if nailing, predrill nail holes to prevent tongues from splitting.

7.0.7 Using adhesive with floors on battens:
- Use a polyurethane or polymer timber flooring adhesive.
- Apply adhesive in accordance with the manufacturer's instructions for application temperatures and open times.
- Ensure the adhesive meets the 15-year durability requirement of the Building Code.
- Apply a 6–10mm bead of adhesive to the battens.
- Press the flooring firmly into the adhesive to make the glue bond to both the timber and the batten then immediately cramp up the boards.
- Contact must be made before the adhesive has begun to go off or skin over. Any adhesive that has begun to cure must be removed and replaced.
- Nail the boards.

7.0.8 Face nailing for board widths up to 150 mm:
- Cramp a maximum of six boards at a time using floor cramps.
- Do not fix the board immediately adjacent to the cramps to enable the tongues of the next group of boards to be easily fitted.
- Keep the floor weighted while fixing to allow the boards to be nailed tightly onto the batten.
- Use one nail fixed 10–15 mm from the tongue edge of the board at each batten for boards 75 mm or narrower and two nails per board for boards wider than 75 mm (Figure 4).
- If hand fixing, use annular-grooved jolthead nails with length of 2.5 times the finished board thickness.
- Nail in straight lines.
- When the whole floor has been laid, punch nails 3 mm below the timber surface in preparation for filling and sanding.

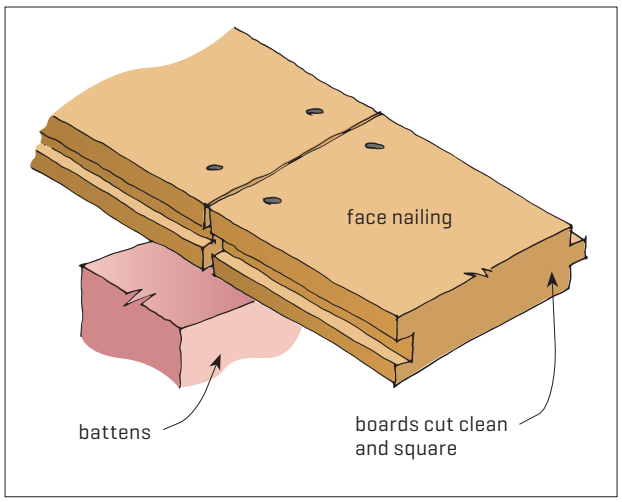

Figure 3. Fixing of plain-end flooring.

7.0.9 Secret nailing for board widths 85 mm or narrower:
- Fit each board individually.
- Fix boards with a 50 mm long staple or cleat through the top of each tongue or predrill nail holes to prevent tongues from splitting.
- Skew nail the board through the top of the tongue once it is tightly fitted (Figure 4).
- Cramp each board individually as necessary.
- Ensure boards are tight to the batten.

7.0.10 Protect the flooring (if necessary) from damage. Softboard sheets or similar may be laid over the floor to protect it from foot traffic before and after sanding and coating.

8 FINISHES AND MAINTENANCE

8.1 FLOOR FINISHES

8.1.1 Timber flooring is susceptible to moisture penetration at the end grains and joints so they must be sealed with a waterproof coating, especially when used in areas exposed to watersplash.

8.1.2 Once a face-nailed floor has been installed, fill nail holes and sand the timber, ensuring that joints are level and machine marks are removed.

8.1.3 Finishing options for timber floorboards include:
- polyurethane (solventborne or waterborne)
- an oil-modified urethane
- a penetrating oil or hard wax.

8.1.4 Polyurethanes may be moisture cure solventborne or evaporative cure waterborne. They provide a hardwearing, water-resistant and easy-to-clean finish. Solventborne polyurethanes are highly durable but are also high in volatile organic compounds (VOCs) with significant odour until cured. Timber that has been coated with polyurethane, particularly if it is solventborne, tends to darken over time when exposed to UV light. Waterborne polyurethane is less affected by light, although a bleached appearance can occur in direct sunlight. They can be less hardwearing and the coating is more permeable to moisture, requiring spills to be attended to more quickly. Solventborne polyurethane can provide a very hardwearing higher-gloss finish.

8.1.5 Oil-modified urethane consists of a mixture of oil and urethane. It may be either solventborne or waterborne. Both are high in VOCs, reasonably hardwearing and will darken with exposure to light.

8.1.6 Oils soak into the timber, and hard wax oils can be buffed to a sheen. They require a specific and regular maintenance regime that periodically adds oil back into the floor as part of the cleaning process. Some can be susceptible to spillage damage. They are much lower in VOCs than oil-modified urethane or polyurethane finishes. They are also much easier to repair than a polyurethane-coated floor.

8.2 CLEANING, MAINTENANCE AND PROTECTION

8.2.1 Timber flooring should be cleaned by soft-bristle vacuuming (ensure brushes are not worn) or using a

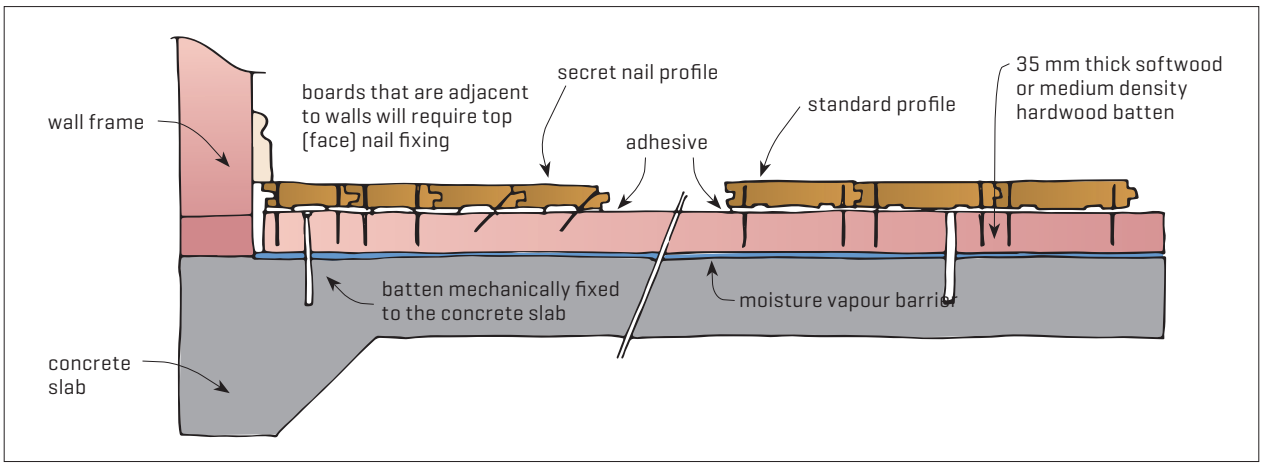

Figure 4. Face nailing and secret fixing to battens over concrete slabs.

microfibre mop. Marks and spills should be cleaned as quickly as possible as the length of time a substance is on a floor can affect the degree of possible damage.

8.2.2 Use water sparingly to clean as moisture may cause swelling and discolouration at the joints between boards.

8.2.3 Avoid using harsh cleaning products such as detergents, scouring cleaners, steam mops and waxes and polishes. Follow the coating manufacturer's recommendations. Generally, neutral pH cleaning products should be used.

8.2.4 Solar heat gain through north-facing windows or internal heat build-up can affect the in-service moisture content of a timber floor, particularly in an intermittently heated building. Areas of floor near glass doors or large windows should be protected by screening or tinted windows to reduce shrinkage effects and bleaching effects with some coatings.

8.2.5 To repair damage to a polyurethane or oil-modified urethane timber floor, most floors will require resanding to remove scratches and marks. As the floor colour will change with time, the whole floor may need to be sanded and recoated.

8.2.6 Worn coatings can be rejuvenated through cutting back and recoating but only if the coating has not worn through to bare timber. In newly coated floors, a patch repair to individual boards may be possible. Floors with hard wax oil can be repaired much more easily as the oil and wax can be buffed back in.

8.2.7 To protect timber floors:

- use door mats on both sides of exterior doors
- remove sand or other abrasive materials as soon as possible
- fit the feet of furniture with felt pads or use rubber or cork coasters or cups
- place furniture legs or castors on pads or cups to distribute the weight.

9 FURTHER READING

STANDARDS

- NZS 3602:2003 *Timber and wood-based products for use in building*
- NZS 3604:2011 *Timber-framed buildings*
- NZS 3617:1979 *Specification for profiles of weatherboards, fascia boards, and flooring*
- NZS AS/1884:2013 *Floor coverings – Resilient sheet and tiles – Installation practices*
- ASTM E104-02 (2012) *Standard practice for maintaining constant relative humidity by means of aqueous solutions*
- ASTM F2170-19 *Standard test method for determining relative humidity in concrete floor slabs using in situ probes*

BRANZ BULLETINS

- BU498 *Preparation for concrete floor slabs*
- BU513 *Timber composite overlay flooring*
- BU541 *Concrete floor slabs*
- BU585 *Measuring moisture in timber and concrete*
- BU592 *Concrete slab-on-ground floors*

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