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Introduction

1.1 Scope

This publication provides a reference guide for the installation of solid timber strip flooring over bearers and joists, timber-based sheet flooring products and concrete slabs. Floors of this type fit together with a tongue and groove joint and, unless they are a prefinished product, they are sanded and finished after the flooring is in place. Also included is parquetry flooring, which is made up of short timber pieces adhered to an appropriate sub-floor. When installing solid timber flooring, many aspects must be considered, including the house design, the environment in which the floor is to be laid and the desired appearance of the finished floor. Such aspects influence the choice of species, the cover width of strip flooring, and the fixings and finish to be applied to uncoated flooring. Information relating to product selection, assessing the installation environment, floor installation and sanding and finishing are provided in this Guide together with additional information that is of importance to the floor installer, sander and finisher.

1.2 The Flooring Process

Strip timber flooring is available in a range of species and colours, including harder and softer timbers and a variety of profiles and cover widths. However, prior to the finished floor being handed over, there are a number of processes that must be correctly undertaken to achieve a floor with the performance and appearance of a professional standard. Each stage generally involves different sectors of the industry, each having specific skills. However, each stage is of equal importance with defined responsibilities and a lack of attention at any particular stage can adversely affect the finished floor. The stages are as follows.

- Manufacture – This is usually carried out by a sawmiller; however, dried rough sawn boards may be machined into finished floorboards during a separate operation. Parquetry is often manufactured as a by-product of strip flooring or is imported and prefinished. Solid flooring is also imported.
- Distribution – Flooring is often sold to timber merchants who on-sell to the installer.
- Specification – Architects, designers and owners usually specify the product to be installed.
- Sub-floor – Builders provide the joists and bearers or slab over which a floor is laid.
- Installation – Specialist floor installers and carpenters install floors over the sub-floor.
- Sanding and Finishing – Unless it is a prefinished product, this is generally undertaken by professional floor sanders and finishers.

Figure 1.1: Selective logging from sustainably managed forests often starts the process.

1.3 The Owner's Choice

Aspects relating to what customers desire are of paramount importance and should not be taken lightly. Customers are relying on the expertise of the professionals involved in the six stages outlined above, and each area can influence the owner's satisfaction with their floor. Each floor is unique and is often seen by the owner as a focal point of the interior design. Those selecting a timber floor will often choose on colour, with board width influencing how the natural colours are blended. Timber hardness, or matching to an existing floor, can also be of prime importance and other significant aspects can include the origin of the flooring in terms of country or forest type, and whether the timber is recycled.

Owners are more aware and have more access to information than ever before; however, they are unlikely to have the same depth of knowledge as those dealing with timber flooring on a day-to-day basis. It is important to accommodate customer preferences; however, this should not be to the detriment of the performance of the floor or its final appearance. Where customer preferences cannot be accommodated, this needs to be brought to their attention. Where their choices can be accommodated but may affect the appearance of the floor, then this too should be brought to their attention and followed up in writing. Colour variation between showroom samples and the product provided, provision of expansion joints, high levels of sun exposure on an area of the floor are all areas that affect appearance and may need specific discussion with the owner.

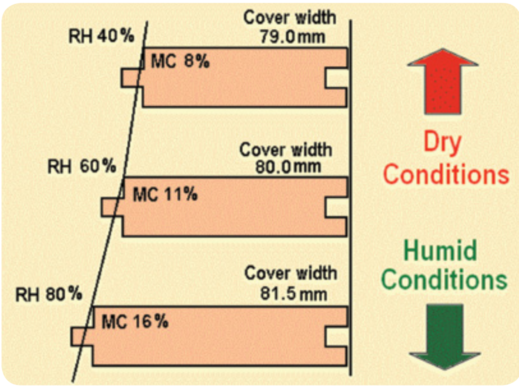
Left: Figure 1.2: Client wishes need accommodating but not at the expense of floor performance.

Right: Figure 1.3: Showrooms provide an excellent environment where clients can see many types of floors and finishes and valuable information about floor systems, performance and care of timber floors can be provided.

2 Timber Flooring and Floor Finishes

2.1 Movement in Timber Floors

Prior to discussing timber flooring products, it is important to understand the relationship between timber, humidity in the air surrounding it and the dimensional changes that occur from changes in humidity. During weather conditions of consistently high humidity, timber will absorb moisture from the surrounding air, causing it to swell or increase in size. Conversely, during drier times when humidity is low, timber will shrink, reducing in size. Unless tongue and groove (T&G) flooring is placed in a permanently controlled environment, it will always move in response to changing environmental conditions. Gaps between individual T&G boards will occur as the floor shrinks in dry weather. Similarly, during either persistent wet weather or times of naturally high humidity, strip floors will tend to be tighter and show fewer and smaller gaps.



Left: Figure 2.1: Cover width variation with changing relative humidity.
Right: Figure 2.2: Small gaps at board edges may occur, particularly during dry weather.

Therefore, a ‘continuous mirror finish’ cannot be expected from site-applied floor finishes. Prefinished strip flooring is generally manufactured with arrised edges, so board edges are defined and a higher quality of surface finish is generally obtained.

Localised shrinkage may also occur when areas of flooring are exposed to heat sources, such as fireplaces or sunlight through large doors or windows. The overall movement and rate of movement of timber varies depending on the timber species and cutting pattern of individual boards. Small moisture content variations in boards at the time of installation and differing conditions within the house (e.g. from sun exposure or fireplaces) will also cause variation in board movement. In general, parquetry flooring is less susceptible to movement due to the patterns used in laying and the piece size being smaller.

Consequently, gapping across a strip floor can be expected and may be relatively even, depending on individual circumstances, but actual gap size between individual boards will vary. Wider boards will move more than narrower boards for the same changes in moisture content. Therefore, gaps in wide-board floors are generally wider and more noticeable. An uneven distribution of gaps can detract from the appearance of the floor and may occur if a number of boards are bonded together by the finish penetrating into the joints. Floor finishes will not prevent timber movement, but may reduce the rate of response to climatic changes. Applying a finish to the underside of a floor may help reduce the impact of sudden changes in the weather.

2.2 Timber Species and Characteristics

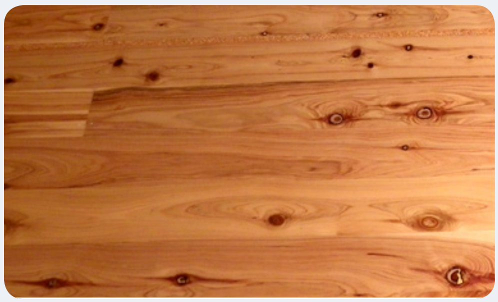
2.2.1 Species, Colour, Grade and Hardness

The species or species mix will generally determine the overall colour of the floor. Mixes may contain different species from one producer to another and may therefore appear different. Even when a single species is chosen, there can be a wide variation in colour and a limited number of boards of a different species may be present due to similarity in appearance. As a guide, the following tables indicate the range of colours that may be expected. The sapwood of many hardwoods can be much lighter than adjacent heartwood and some boards may contain both light and dark colours. Large colour variations can occur, even within a single species and individual trees. The age of the tree can have a significant influence on the colour, with younger timber often being lighter than more mature timber. The product supplied may differ in colour to showroom samples, and this should be discussed with flooring suppliers and owners. Due to these factors, it is preferable that flooring is supplied from one manufacturing source and that the packs are of a similar age.

In Australia, lyctid-susceptible sapwood of some hardwood species (e.g. Spotted Gum), is required to be preservative treated under AS 2796.1 Timber – Hardwood – Sawn and milled products. Some treatments may impart a brown tinge to sapwood, while boron preservative is non-colouring. Light organic solvent preservative (LOSP) treatment is also used. In this instance, H3 treatment may be used in lieu of H2 treatment to avoid the coloured dyes often used with H2 LOSP treatments. Some imported hardwood such as American and European Oak are also lyctus susceptible, and it can be unclear as to whether these have been adequately treated. In line with the intent of AS 2796, it is considered to be the importer's responsibility to provide flooring that is not lyctid susceptible.

The character of the floor is influenced by the species' characteristics and therefore the grade. Grading is a process that sorts boards according to the number and size of features present (e.g. gum veins and knots). The following tables indicate the grades contained in relevant Australian Standards, but it should be noted that manufacturers often have their own grades. Flooring that contains more features is often more moderately priced yet, irrespective of the features present, there is no difference between the grades in terms of machining tolerances, permitted machining imperfections and moisture content. Imported flooring may or may not comply with Australian grading rules; however, it is considered that applicable grade descriptions should be available with those products. Structural requirements for boards are covered by Australian Standards (AS 2796 for hardwoods) and, for any grade not complying with these Standards, it is the importer's responsibility to provide a structurally adequate product when used in that application. Use of an Australian Standard grade name automatically means compliance to all aspects of that Standard.

Tasmanian Oak – Medium Feature Grade.



Cypress – Grade 1.

Jarrah – Select Grade.

Blackbutt – Select Grade.

Figure 2.3: Grade, colour and board width dictate the floor's appearance.

It is important to realise that the overall colour or blend of colour in a floor is dependent on the species or species mix chosen and that the character of the floor – in terms of the features present (such as gum veins) – is determined by the grade. If choosing an alternative species from the one originally considered, not only will the overall colour differ, but the dominant type of feature may also change. It is important that suppliers, installers and clients work closely together to ensure that the desired look of the flooring is clearly understood by all.

Hardness indicates a species resistance to indentation. Damage to timber floors may occur due to continual movement of furniture, heavy foot traffic and – in particular – stiletto heel type loading. The selection of a hard timber species ensures improved resistance to indentation. Soft timber species, if used in feature floors, can be expected to indent. Floor finishes will not significantly improve the hardness of timber flooring. In some species, the hardness of the younger-growth material can be much lower than the mature timber, but this varies from species to species.

Figure 2.4: Even hard timbers will indent from stiletto heels.

Table 2.1: Australian Hardwoods – to AS 2796 – Timber – hardwood – sawn and milled products.

Species	Origin	Colour	Hardness	Common cover widths (mm)	Thickness (mm)
Hardwood flooring species grown in Queensland and Northern New South Wales (may also be supplied as a mix of similar colour) Select Grade, Medium Feature/Standard Grade and in some species High Feature Grade					
Blackbutt *(Eucalyptus pilularis)*	Qld, NSW	golden yellow to pale brown	very hard	60, 80, 85, 130, 180	19,12,13,14
Bloodwood *(Corymbia gummifera)*	NSW	medium to deep red brown	hard	60, 80, 130	19
Brushbox *(Lophostemon confertus)*	Qld, NSW	mid red-brown even colour	hard	60, 80, 85, 130	19,12,14
Forest Red Gum *(Eucalyptus tereticornis)*	Qld	dark brown, dark red brown	very hard	60, 80, 85, 130	19,12,14
Grey Box *(Eucalyptus microcarpa)*	NSW	mid brown with paler tones	very hard	60, 80, 85, 130	19,12,13,14
Grey Gum *(Eucalyptus propinqua)*	NSW	red brown paler sapwood	very hard	60, 80, 85, 130	19,12,13,14
Grey Ironbark *(Eucalyptus siderophloia)* *(Eucalyptus paniculata)*	NSW Qld	dark brown or dark red brown, light sapwood	very hard	60, 80, 85, 130, 180	19,12,13,14
Gympie Messmate *(Eucalyptus cloeziana)*	Qld	yellow brown	very hard	60, 80, 130	19
Manna Gum *(Eucalyptus viminalis)*	NSW	pale straw pinks	mod. hard	60, 80, 130	19,12
New England Blackbutt *(E.andrewsii)*	NSW	straw to pale brown	very hard	60, 80, 85, 130	19,12,13,14
Red Gum *(Eucalyptus tereticornis)*	NSW	deep red with paler sapwood	very hard	60, 80, 85, 130	19,12,13,14
Red Ironbark *(Eucalyptus crebra & fibrosa)* *(Eucalyptus sideroxylon)*	Qld NSW	dark brown, dark red brown	very hard	60, 80, 130	19,12,14
Red Mahogany *(Eucalyptus pellita)*	Qld, NSW	dark red with paler sapwood	very hard	60, 80, 85, 130	19,12,13,14
Rose Gum *(Eucalyptus grandis)*	Qld, NSW	straw pink to light red-brown	hard	60, 80, 85,130	19,12,13,14
Spotted Gum *(Corymbia citriodora)* *(Corymbia maculata)*	Qld NSW	brown, dark brown, light sapwood	very hard	60, 80, 85,130,180	19,12,13,14
Stringybark (Silver top - *Eucalyptus laevopinea,* White - *Eucalyptus eugenioides*)	NSW Qld, NSW	pale brown, some pinks pale brown with pink tinge	hard	60, 80, 85,130	19,12,13,14
Sydney Blue Gum *(Eucalyptus saligna)*	NSW	straw pink to light red-brown	hard	60, 80,85,130,180	19,12,13,14
Tallowwood *(Eucalyptus microcories)*	Qld, NSW	greyish yellow, olive green	hard	60,80,85,130	19,12,13
Turpentine *(Syncarpia glomulifera)*	Qld, NSW	pale reddish brown	very hard	60,80,85,130	19,12
White Mahogany *(E. acmenioides)*	Qld, NSW	pale yellow brown	very hard	60,80,130	19,12
Hardwood flooring species grown in Victoria, Southern New South Wales and Tasmania					
Alpine Ash *(Eucalyptus delegatensis)*	Vic, Tas	pale straw to light brown	mod. hard	60, 63, 68, 80, 85, 108, 112, 133	12,13,14,19
Blackwood *(Acacia melanoxylon)*	Tas	light golden to deep brown	mod. hard	60, 65, 85, 108, 112, 113	13,19
Brown Barrel *(Eucalyptus fastigata)*	Vic	pale brown, lighter sapwood	mod. hard	63, 80, 85, 108, 133	12,19
Manna Gum *(Eucalyptus viminalis)*	Vic	pale straw pinks	mod. hard	63, 80, 85,108, 133	12,19
Messmate *(Eucalyptus oblique)*	Tas	pale straw to light brown	mod. hard	60, 68, 85,108, 112 ,113	10,12,13, 14 19
Mountain Ash *(Eucalyptus regnans)*	Vic, Tas	pale straw to light brown	mod. hard	60, 63, 68, 80, 85, 108,112,133	12,13,14,19
Myrtle *(Nothofagus cunninghamii)*	Tas	straw & light pink, light sapwood	mod. hard	60, 65, 85,108,112 133	13,19
River Red Gum *(Eucalyptus camaldulenis)*	Vic	rich deep reds	hard	63, 80, 85,108,133	12,19
Shining Gum *(Eucalyptus nitens)*	Vic	pale brown some pinks	mod. hard	63, 80, 85,108,133	12,19
Silvertop Ash *(Eucalyptus sieberi)*	Vic	pale brown some pinks	hard	63, 80, 85,108,133	12,19
Southern Blue Gum *(Eucalyptus globulus)*	Vic, Tas	pale brown with some pink	very hard	60, 63, 80, 85,108, 112, 133	12,13,19
Tasmanian Oak *(Eucalyptus regnans, E. oblique, E.delegatensis)*	Tas	pale straw to light brown	mod. hard	60, 65, 85,108,133 160, 180, 85,112	10,12, 13, 14 19, 20, 21
Victorian Ash (Eucalyptus regnans, E.delegatensis)	Vic	pale pink to yellow brown	mod. hard	63, 68, 80, 85, 108, 133, 160, 180	12,14,19, 20, 21
Yellow Stringybark (E. muelleriana)	Vic	even, yellow brown	hard	63, 80, 85, 108, 133	12,19

Table 2.1: Australian Hardwoods – to AS 2796 – Timber – hardwood – sawn and milled products (continued).

Species	Origin	Colour	Hardness	Common cover widths (mm)	Thickness (mm)
Hardwood flooring species grown in Western Australia					
Jarrah *(Eucalyptus marignata)*	WA	rich reddish-browns to soft salmon pinks	hard	80,85,105,125, 130	12,13,19
Karri *(Eucalyptus diversicolor)*	WA	rich reddish-browns to pale pinks	hard	80,85,125,130	12,13,19
Marri *(Eucalyptus calophylla)*	WA	pale brown lighter sapwood	hard	80,85,125,130	12,13,19
WA Blackbutt *(Eucalyptus patens)*	WA	pale yellow brown	hard	80,85,125,130	12,13,19
Cypress – to AS 1810 – Timber – seasoned Cypress – milled products Grades No.1 and No. 2					
Cypress (White) (Callitrus glaucophylla)	Qld, NSW	pale straw sapwood, dark brown heartwood	mod.hard	62,85	20
Australian Softwoods – to AS 4785 – Timber – softwood – sawn and milled products except Araucaria (hoop pine) for which industry grades apply Standard Grade for AS 4785					
Araucaria *(Hoop) (Araucaria cunninghamii)*	Qld, NSW	light straw	soft	87,89,102,133, 152	19, 20, 21
Radiata *(Pinus radiata)*	Vic, NSW WA, SA	straw	soft	104	19, 21
New Zealand Species Grades - Industry grades					
Kauri *(Agathis Australis)*	NZ	pale sapwood, heartwood pale to reddish brown	soft	65, 85, 110, 135	12, 13, 18, 19, 21
Matai *(Podocarpus spicatus)*	NZ	white sapwood, straw brown to orange heartwood	soft	65, 85, 110, 135	12, 13, 18, 19, 21
Red Beech *(Nothofagus fusca)*	NZ	light brown sapwood, light to medium red brown heartwood	soft	65, 85, 110, 135	12, 13, 18, 19, 21
Rimu *(Dacrydium cupressinum)*	NZ	pale brown sapwood, red to yellow brown heartwood	soft	65, 85, 110, 135	12, 13, 18, 19, 21
Tawa *(Beilschmiedia tawa)*	NZ	white sapwood, pale to very dark brown heartwood	mod. hard	65, 85, 110, 135	12, 13, 18, 19, 21
Imported Hardwoods – to AS 2796 – Timber – hardwood – sawn and milled products Select Grade, Medium Feature / Standard Grade and in some species High Feature Grade					
Kempas *(Koompassia malaccensis et al)*	S.E. Asia	red brown, yellow streaks	hard	80,130	19
Kwila / Merbau *(Instsia bijuga)*	S.E. Asia	dark brown	hard	80,130	19
Maple *(Rock or Sugar) (Acer saccharum)*	North. America	light straw	mod. hard	50, 57, 83	19
Northern Box *(Tristania obovata)*	S.E. Asia	mid brown even colour	hard	80,130	19
Oak *(Quercus spp)*	Europe, North America	pale yellow brown	mod. hard	narrow to wide	19

Note: Not all species, width and thickness combinations are available. Check with suppliers before specifying.

2.2.2 Cover Widths, Profiles, Spans and End-matching

Typical cover widths and thicknesses for T&G strip flooring are as shown in the Table 2.1. Actual cover widths may vary from those shown and should be checked with individual suppliers. Typical T&G profiles are shown in Figure 2.5. Some profiles are produced with grooves or rebates on the underside. Where the underside of a floor forms a ceiling, the board edges may be arrised to form a 'V' joint profile. Both profiles are used for top (face) nailing and secret fixing. The standard profile is more commonly found on wider boards and some manufacturers indicate that such boards should be top (face) nailed. Some wider board flooring has the secret nail profile that allows temporary secret fixing prior to top (face) nailing. With some installations wider boards may also be fully adhesive fixed.

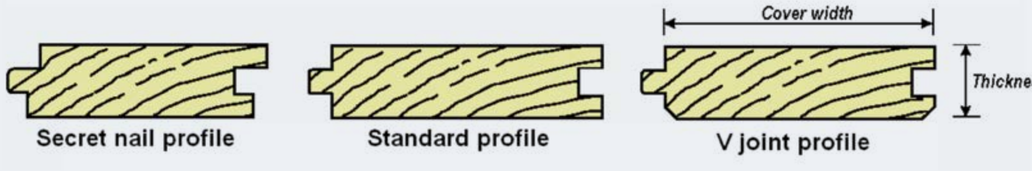


Figure 2.5: Typical T&G profiles.

If the species or species mix contain a significant variation in colours, the appearance of the floor will differ depending on the cover width. Narrower boards tend to blend the colour variations together. Gapping between individual boards during drier times is also less with narrower boards than it is with wide boards. A board width of 100 mm or less will limit potential gap size and other movement effects such as cupping (where the edges of the board are higher or lower than the centre). If wider flooring is used then wider gapping can be expected and, under certain conditions, some cupping becomes more likely.

End-matching is a process where a T&G joint is provided at the ends of boards. The majority of flooring is now end-matched. For floors laid direct to joists or battens this allows joints to be placed between the joist or batten, resulting in less wastage than plain-end flooring, which must have its ends fixed over the joist or batten.

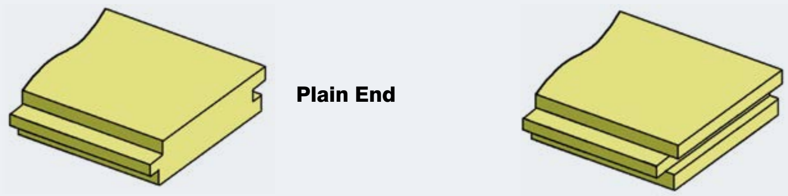


Figure 2.6: Plain end and end-matched flooring.

2.2.3 Floor Lengths

Strip flooring to be sanded and coated is generally supplied in random length packs of up to 4.8 m in length.

The average length is often between 1.8 m and 2.1 m. Packs of shorter overall length are also available from some suppliers to facilitate floors in high-rise buildings that require product to be taken to the appropriate floor by a lift. The minimum length for timber being fixed to joists is 900 mm, based on a 450 mm joist spacing. In some instances, if it is known that the floor will be laid over a structural sub-floor, lengths shorter than 900 mm may be provided. Prefinished strip flooring is usually provided in set length packs and not in longer lengths. For information about parquetry flooring, refer to Section 6.

2.2.4 Ordering Flooring

When ordering timber flooring, the following details should be provided to the timber supplier:

- species (or species mix)
- grade
- profile and end-joint type
- cover width
- thickness
- quantity (in linear metres)

Flooring is generally supplied within the moisture content range from 9% to 14%. For larger jobs in specific environments a different range may be specified.

To calculate the linear metres of flooring required, the following method is recommended:

$$\text{Total length of flooring required} = \frac{\text{Area of floor (m}^2\text{) x 1000}}{\text{Cover width (mm)}} + \text{Wastage}$$

Allowance for waste should be approximately 10%, but may vary by about 5% above or below this, depending on the installation.

For parquetry flooring, the floor area needs to be determined but the pattern and product used will dictate what needs to be ordered.

Figure 2.7: Due to the patterns, ordering parquetry can require greater considerations.

2.3 Floors over Different Sub-floors

Depending on the sub-floor supporting system (e.g. joists, plywood on slab, etc), timber floors will both feel and sound differently when walked on. Generally, strip timber floors laid over joists or battens will have more spring underfoot and there is likely to be some vertical movement at board edges and end-matched joints when walked on. Some squeaks can therefore be expected from most timber floors of this type. Squeaks can occur from movement of one board edge against another or from boards moving on nails. Squeaks are often more prevalent during drier weather due to loosening at the joints. Floors that are laid over plywood on a slab will have a firmer feel underfoot and some areas may sound ‘drummy’. Similarly, when floors are glued directly to concrete, the feel is firmer, and again some boards may sound drummy when walked on.

In cooler climates, slab heating may be present and, due to the direct heating effect on the timber and intermittent use of this type of heating system throughout the year, substantial seasonal movement can occur. Although strip flooring can be used, if care is taken with appropriate product selection and installation practices (refer to Appendix E – Underfloor heating), it may be preferable to use engineered timber flooring products where less dimensional changes would be expected. Even with these products, care is still necessary.

2.4 Floor Finishes – Types and Characteristics

The coating system that is ultimately chosen for a site sanded and coated floor will depend on a variety of considerations. In some instances, the coating system will be specified and this is generally the case for commercial projects. However, with domestic floors, it is often the client who either requests a specific coating type or is expecting the contractor to provide information from which they can make an informed decision. If a coating is specified, it is still necessary that the contractor considers the consequences of using that coating and informs client about any reservations they may have.

Aspects relating to coatings that may need to be considered and conveyed to the client include issues such as potential health hazards, including the potential of the coating to taint any food that may be in the dwelling when the coating is being applied. Floor maintenance is another important issue, as it is recognised that some coating types require more frequent maintenance than others and the owner must be prepared to undertake this. Other aspects to consider are the yellowing of the coating with age and the fact that both the timber and the coating can result in tone variation over time. With domestic floors on stairs, there is also a National Construction Code (formerly BCA) requirement for step treads to be slip resistant. This can be achieved with the correct coating, but requires the use of those with low sheen levels.

Timber floor finishes (coatings) can be grouped into five main categories:

1. Penetrating oils and waxes. This includes sub-categories of:
   - penetrating oils, including air curing and burnish curing
   - penetrating waxes, including oil/wax blends
   - film-forming hard wax oil technology with or without external cross-linker
2. Curing oils (air curing and chemical cross-linked) and alkyds
3. Urethane-modified oils
4. Acid-catalysed coatings
5. Polyurethanes including:
   - solvent-based moisture cure one-pack
   - two component solvent-based
   - waterborne one-pack
   - waterborne two-pack
   - acrylic urethane blends or copolymers.

Below is a description of each of these categories with information about their properties, benefits and disadvantages.

2.4.1 Penetrating Oils and Waxes

Products in this category can have the lowest Volatile Organic Compound (VOC) levels, although some individual products can also have a high VOC. These materials are based on sustainable natural oils and have extensive use, mainly in Europe. Routine maintenance may be higher than other categories, but the ease of repairing worn areas is an advantage. With periodic application of a rejuvenation coating, the floor may never have to be re-sanded back to bare timber in its lifetime. Hard wax oils are film forming and can have good durability. They may be one component or two component with an isocyanate cross-linker. Ease of application and timber colour enhancement are key properties. They can be 'asthma friendly' due to being low VOC and the particular types of VOC components used.

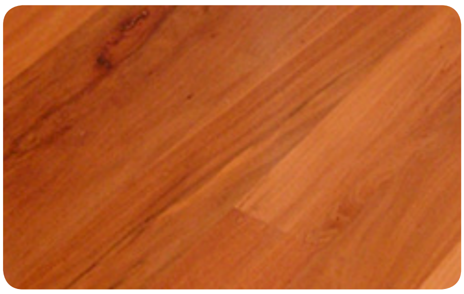


Figure 2.8: Penetrating oil.

2.4.2 Curing Oils and Alkyds

Curing oils are natural vegetable oil blends that harden (cure) by reacting with oxygen in the air. Curing is enhanced by the incorporation of metal 'dryers' such as cobalt and zinc that speed the slow hardening reaction with oxygen in the air. Contractors must take care as contaminated rags and sanding dust can spontaneously catch fire (these should be moved outside the building and damped down). These oils are film forming and are one of the earliest types of floor coatings. Good colour enhancement of the timber is a feature, but some types may be very slow when curing in cold weather. Buff burnishing of the oil into the surface can allow floors to be used soon after they have been coated. On-going maintenance is higher for curing oils than for other types of coatings.

Alkyds are based on the reaction of vegetable curing oils to a synthetic resin. This creates products with improved film build and gloss properties. As with the curing oils, they can be slow when curing in colder weather. Colour enhancement of timber is a key property as is ease of application. Alkyds are generally spirit or turpentine based with intermediate VOC levels.

2.4.3 Urethane-modified Oils

Urethane-modified oils are also commonly referred to as oil modified urethanes (OMUs). They are formed from the reaction of an oil with a urethane to form a copolymer, which is then dissolved in solvents. Properties vary depending on the ratio of oil to urethane. A higher oil ratio provides more flexibility but lower durability or wear resistance. Conversely, higher urethane content leads to a harder film and greater wear resistance. Use of these products has increased as they are more resistant to edge bonding than the moisture cure urethanes. They optimise timber colour enhancement. Wear resistance performance and maintenance and refurbishment requirements of these coatings are considered to be in-between those of the curing oils and polyurethanes. VOC levels are on the higher side; however, some water-based urethane modified oils are also available with low VOC levels. The water-based products provide reduced timber colour enhancement and may not have the durability of the solvent-based products.

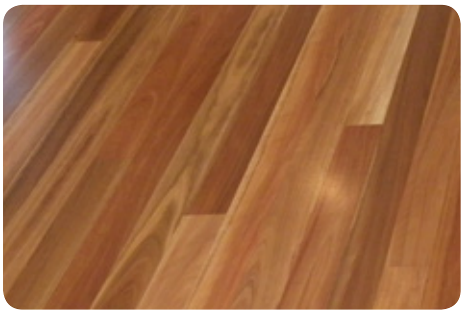


Figure 2.9: Oil-modified urethane.

2.4.4 Acid-catalysed Coatings

The principal use of this class of coatings is in furniture coating, although some use occurs with timber floors. The advantages are that they are fast drying and quick to reach initial cure, so multiple coats can be applied in the one day, but full curing takes some days. They produce a richer, darker colour in the coated timber and their rejection resistance is good. The main disadvantage is their very strong odour. Their high VOCs are mainly ethanol (ethyl alcohol).

Figure 2.10: Acid catalysed coating.

2.4.5 Polyurethane – Solvent-based

This class may be a one-pack moisture cure (MC) polyurethane where cure is achieved by a reaction of isocyanate with moisture in the air, or a two-pack product that uses a polyol component and a polyisocyanate component that react together when the two are mixed.

The solvent-based polyurethanes are the toughest and most hard wearing and have the highest gloss levels of all the classes of timber floor coatings. Their disadvantages can be an increased risk of edge bonding, high VOC and the need for particular care when using them, due to the fact that the isocyanate components of both types (and many water-borne cross linkers) are respiratory sensitisers.

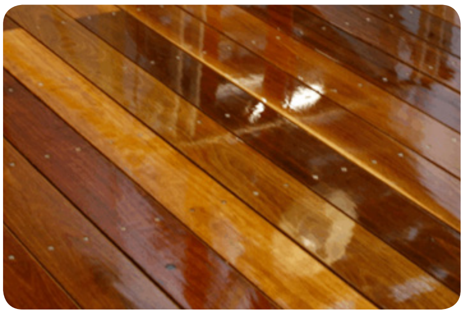


Figure 2.11: One pack solvent-based.

2.4.6 Polyurethane – Water-based

Water-based polyurethanes have the most diverse range of sub-categories.
The polymer bases used include:

- oil-modified urethane
- acrylic/polyurethane blends
- co-polymer acrylic-urethane
- 100% polyurethane.

Additionally, each group may be available in a one-pack or a two-pack. A few one-packs still feature a polyazeridine crosslinker, which is a class two carcinogen and care when using it is advised. Most two-packs use a polyisocyanate hardener, which also requires care in use.

On-floor performance (wear resistance or durability) can vary markedly within this class so care is required when selecting a particular finish. Two-pack types are generally superior to one-pack types in this regard. The Taber (wear resistance) test is a meaningful comparison test for wear resistance within this class. Key advantages are low solvent fumes (low VOCs) when they are being applied and the use of water to clean up tools. This leads to them being promoted as being less hazardous and less toxic. One-pack types are less hazardous to use than two-packs, as they do not use a hardener. They also have good edge bonding resistance. Disadvantages may include an increased tendency for application marks, and some products can develop 'tram lining' (a white stretch effect) at board edges as the floorboards expand and contract.

Figure 2.12: Water-based polyurethane.

2.4.7 Fast Dry Sealers

These high-solvent content sealers are usually based on a vinyl-type polymer combined with fast-drying solvents. Their intent is to seal the surface and the gaps between boards to reduce the tendency for following coatings to soak into the timber surface. They are generally used with solvent-based film forming coatings; some types can also be used under water-based coatings.

Advantages of using fast dry sealers include the ability to complete all the needed final coatings within the one day. Disadvantages can be a lower final coating film thickness than if all coats had been made with the final coating system, lighter-coated timber shades and a higher solvent fume hazard during use, due to their very high VOC content.

2.4.8 Quick Reference Guide

The following table is presented as a guide only. Performance of different coatings within the same class can vary markedly. Consult your coatings supplier for objective data on the product you may intend to use. Claims provided in writing by the supplier are always preferable.

Table 2.2: Timber floor coatings selection guide.

Technology and Property	Penetrating oil	Hard wax oil 1 and 2 component	Oil alkyd (e.g. Tung Oil)	Oil modified urethane	Acid catalysed coating	Solventborne moisture cured 1 pack polyurethane	Solventborne 2 pack polyurethane	Waterborne 1 pack polyurethane	Waterborne 2 pack polyurethane
Technical Properties									
Durability	Low - Med	Med	Low	Med	Med - High	High	High	Med	Med - High
Typical expected years to requiring a refurbishment coat in a more severe wear situation	1 - 2	1 - 6	3	4	4 - 5	6	6	4 - 6	5 - 6
Maintenance requirement - Care daily, weekly, monthly	Low - High	Low - High	Med	Medium	Low	Low	Low	Low	Low
Repairability of localised damage	Good	Good	Difficult	Difficult	Difficult	Very difficult	Very difficult	Difficult	Difficult
Earliest 'with care' use time @ 25°C	5 days	2 days	3 days	3 days	3 days	2 days	1 day	1 day	1 day
Earliest re-occupancy time @ 25°C	7 days	7 days	5 days	5 days	5 days	3 days	2 days	4 days	3 days
Ability to cure in cold and dry weather (non-burnished)	Low	Low	Medium	Medium	Good	Good	Good	Fair	Medium
Ability to cure in cold and damp weather (non-burnished)	Low	Low	Low	Low - Medium	Low - Medium	Medium	Good	Low	Medium
Rejection resistance (From surface tension)	Good	Good	V. Good	Good	V. Good	Fair	Fair	V. Good	V. Good
Edge Bonding resistance	V. Good	V. Good	V. Good	V. Good	Good	Poor	Poor	V. Good	Good
Timber colour impact	Darkens	Yellow / honey	Darkens	Darkens	Darkens	Yellow / honey	Yellow / honey	Natural / pale honey	Natural / pale honey
Tram lining	Nil	Nil	Nil	Low	Nil	Low	Low	High	Medium
Application marks resistance	High	Medium	High	Medium	High	High	High	Poor to Medium	Medium
U.V. yellowing resistance	Poor	Fair	Poor	Poor	Poor	Poor	Poor	Fair to Good	Good
Surface scuff resistance	Poor	Good	Poor	Poor	Good	Very Good	Very Good	Poor to Good	Good to v. good
Dust pimples from electrostatic attraction of dust to the coating	Low	Low	Low	Low	Low	Medium	High	Low	Low
Quilting resistance	V. Good	V. Good	V. Good	V. Good	V. Good	Poor	Medium	V. Good	V. Good
Grain raise effect on apply	Low	Low	Low	Low	Nil	Low	Low	Medium	Medium
External use	No	No	No	No	No	No	No	No	No
Safety, Health and Welfare (consulting the manufacturer's MSDS / SDS is essential)									
Odour – short term	Noticeable	Low	Medium	Medium	V. High	V. High	V. High	Low	Low - Medium
V.O.C. – solvent content – grams per litre	0 – 800	0 - 480	600 - 700	600 – 700	440 - 450	300 - 600	500 –550	35 – 190	85 - 190
Breathing equipment needed in use per MSDS	Cartridge type	Cartridge type	Cartridge type	Cartridge type	Cartridge type with daily change	Cartridge type with daily change	Cartridge type with daily change	No	Cartridge type
May contain a listed or suspect carcinogen	No	Suspect white spirits in some	Suspect white spirits	Suspect white spirits	Yes - Ethanol Class 2	Yes – TDI Class 2	Yes – TDI Class 2	No	Maybe if Part B is Polyazeridine - Class 2
Asthma and respiratory warning	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Flammability	Low - High	Low - High	Low	Low	High	V. High	V. High	Nil	Nil

3 Pre-installation Requirements

3.1 Storage and Handling Procedures

Site sanded and coated strip flooring should be delivered by the supplier with plastic wrapping (to top, sides and ends) in good condition to maintain the flooring at the appropriate moisture content. It is the floor installer's responsibility to check that the timber is at the appropriate moisture content at the time of installation, so flooring products must be protected from weather exposure and other sources of dampness.

Ideally, delivery during rain should be avoided and flooring should not be delivered to the site until it can be immediately stored under permanent cover. If this is not achievable, other precautions that are equally effective to prevent moisture uptake and excessive sun exposure will be needed.

Plastic wrapping is easily damaged and should not be relied upon to keep the flooring dry. If moisture penetrates the plastic or timber is stored over a moist surface, subsequent moisture uptake can result in significant swelling of some boards. Flooring should not be laid in this condition, as wide gaps at board edges may result as boards re-dry. Wrapped packs should also be protected from excessive sun exposure due to possible detrimental effects.

Prefinished strip flooring is often supplied in plastic-wrapped boxes and parquetry in cardboard boxes. These products should be stored inside the weather-tight dwelling in an area away from external walls and direct sun exposure. It is also important not to place these products directly on new concrete slabs.

Figure 3.1: Inappropriate site storage can void manufacturer warranties.

3.2 Timber Flooring Standards and Specifications

When timber flooring is received on site it should generally meet the following requirements:

- Grade – strip flooring and parquet (also refer to Section 6) are to be supplied to the specified grade, which may be a manufacturer's grade. Note that if a manufacturer has given a specific name to a grade, the product may be similar to one of the grades contained within an Australian Standard but is likely to differ in some respects. This may or may not be important to customers and should be resolved prior to supply. With imported product, grading applicable to the country of origin may apply and differ to that within the Australian Standard.
- Moisture content – should be in the range of 9% to 14% (10% to 15% for Cypress) with the average moisture content for all pieces approximately 10% to 12.5%. The moisture content range for parquet is 8% to 13%. For prefinished solid flooring, which is generally imported, the moisture content range should also be to this specification (refer to Section 7 for further information).
- Timber moisture contents should be checked and recorded. (Resistance moisture meter readings must be corrected for species and temperature, and may be affected by other factors. Corrected readings are estimates only. If in doubt confirm results by oven-dry tests.) Water marks or a significant variation in cover width within a board may be indicative that the timber has been moisture affected.

- Cover width of strip flooring should be checked and recorded – for strip flooring, solid and prefinished, not more than 1 mm difference between one board and another. Cover widths should generally be within ± 0.5 mm of the nominal cover width. (If in excess of this it can reflect changes to board dimensions that can occur after milling and prior to installation and therefore outside of manufacturing limits). Refer to Section 6 for parquetry.
- Boards should not be visibly cupped – the cupping allowance in Australian manufacturing standards for site sanded flooring prior to installation is 1 mm per 100 mm of board width and is to cater for drying stress effects. This allowance does not apply after sanding and nor does it apply to prefinished flooring.
- Tongue and groove tolerance in strip flooring – should not to be less than 0.3 mm nor greater than 0.6 mm. Boards should slot together to form a ‘snug’ fit. The fit should not be loose and sloppy or overly tight. A tighter tolerance may be applicable with prefinished flooring, particularly if edges are not bevelled.
- Undercut or relief in site sanded and coated floors – this is the difference between the upper and lower cover width of the boards. Generally, an undercut of about 0.5 mm is appropriate for an 80-mm-wide board and a little more as board width increases. If the undercut is large and there is significant expansion pressure after installation, ‘peaking’ (pressure-related cupping) can occur. The smaller the undercut, the less the effect. Note that imported product (both site sanded and coated and prefinished) has been supplied with undercut significantly wider than outlined here and, should peaking occur with such products, the manufacture of the product is often considered a contributing factor.

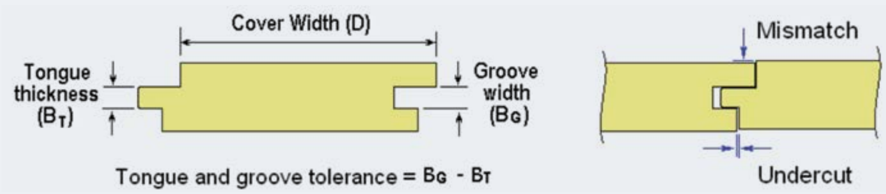


Figure 3.2: Tongue and groove tolerance.

Grading rules for Australian manufactured solid T&G strip flooring and parquetry are contained in the following Australian Standards:

- AS 2796 – Timber – Hardwood – Sawn and milled products
- AS 1810 – Timber – Seasoned Cypress pine – Milled products
- AS 4785 – Timber Softwood – Sawn and milled products

Any concerns relating to the above should be addressed prior to laying the floor. Although installers have a responsibility to check product prior to laying, suppliers have a responsibility to ensure product is adequately cared for, particularly during transport and storage, and manufacturers have a responsibility to supply product meeting the relevant manufacturing standard.

3.3 Borer Activity in Flooring

All flooring meeting the requirements of the Australian hardwood manufacturing Standard AS 2796 requires that any sapwood of lyctid-susceptible species is treated. Although lyctid attack is not common in Australian species due to treatment processes, some imported species including American and European Oak are lyctid susceptible and not all flooring is treated. Should lyctid attack occur in untreated flooring, the responsibility to address the problem lies with the importer or supplier.

Where T&G site sanded and coated Araucaria floors and floor framing are not fully enclosed, it is necessary to seal the framing members and lower surface of the floorboards to prevent attack from the Queensland pine beetle. Attack is specific to the Araucaria species (including Bunya) and is generally restricted to the area from Bundaberg to Murwillumbah and east of the Great Dividing Range. In this region, exposed framing and floors (including ventilated sub-floor spaces) require sealing to meet building requirements. The provided sealer needs to have a film-forming finish and this may also reduce the effects from rapid weather changes.

3.4 Evaluating Site Conditions and the Installation Environment

3.4.1 Why the Installation Environment Needs to be Considered

Solid timber flooring is manufactured to an average moisture content that is suited to the majority of building environments in the major capital cities throughout Australia. Due to this, the majority of floors perform with flooring laid as supplied by the manufacturer. However, a large number of timber floors are not laid under these average conditions, due to their location within Australia or conditions that differ from a 'normal' environment within a locality. It is therefore the installer's responsibility to assess the installation environment, as this will affect decisions as to whether the flooring needs acclimatisation prior to installation and the degree of expansion allowance that may be needed within the floor. Due to this, the nature of manufacture and the variations in moisture content that can occur through transport and storage, the floor installer needs to check both flooring moisture content and board widths upon accepting the flooring for laying.

3.4.2 Effect of Relative Humidity and Temperature on Floor Movement

Changes in the temperature and relative humidity within a building influence the seasonal movement (shrinkage and swelling) of timber floors. Relative humidity is a measure of the moisture vapour in the air at a particular temperature and will largely govern the seasonal moisture content range of the floor and therefore the seasonal movement. During more humid times of the year, floors absorb moisture from the air and swell, while during drier times with lower relative humidity some shrinkage can be expected. Consequently, as the moisture content changes so does the board width. Temperature is also important because in warmer climates the air holds more water vapour at a particular relative humidity, thereby making the flooring much quicker to respond. Therefore, floors in high temperature conditions will absorb moisture from the air or release moisture to the air much faster than those in low temperature conditions. The internal dwelling climate is also modified through the use of heating and cooling systems, and this too is an important aspect that influences the seasonal movement in a floor. The degree of heating and cooling is largely influenced by the locality. It also needs to be considered that different heating and cooling systems will affect floors differently. In addition, there are also significant differences that occur within a locality or region, such as conditions on the coast being quite different to those a few kilometres inland.

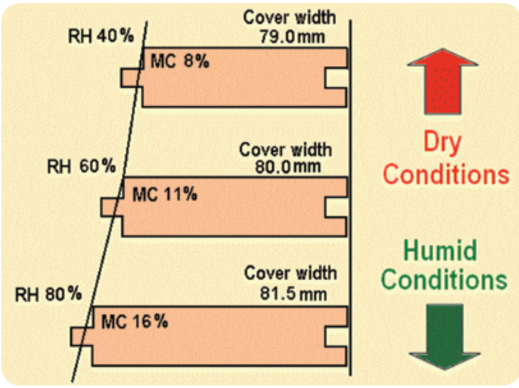


Figure 3.3: Indicative relationship between relative humidity, timber moisture content and board width.

It is therefore necessary that every site and the expected in-service environment is assessed for the floor to be able to perform to its optimum. Due to differing conditions throughout the country, installation practices have developed over many years in each state, and even within each state, to accommodate the specific climatic effects in that location. If the moisture content of the timber flooring is close to the average in-service moisture content, subsequent changes in temperature and humidity will only result in small changes in moisture content and therefore small changes in board dimensions.

It is important to know the climate in the area where a floor is being laid and then consider how the dwelling environment will be modified by heating and cooling systems. Additionally, as outlined above, it is important to note the conditions at installation, as the flooring will be more prone to movement (shrinkage or swelling) under higher temperatures. The external climate can be assessed from weather data taken at both 9 am and 3 pm.

Relative humidity data is available for Australia from the Australian Bureau of Meteorology (BOM) website at www.bom.gov.au/climate/data. Another useful international website is weatherspark.com, which provides relative humidity and other data. The relative humidity data on this site provides annual graphs of both daily maximum and minimum and includes Australia, New Zealand and worldwide locations, but it does not cover the same number of Australian weather stations as the BOM website.

Based on the humidity and temperature, the Equilibrium Moisture Content (EMC) can be determined. This can be thought of as the moisture content that timber will approach under set conditions of humidity and temperature. Seasonal changes in temperature and humidity influence the seasonal movement (shrinkage and swelling) of timber floors and therefore it is appropriate to consider a seasonal EMC range, being the seasonal in-service moisture content variation that the floor will experience. The following table provides EMC at a range of relative humidities and temperatures.

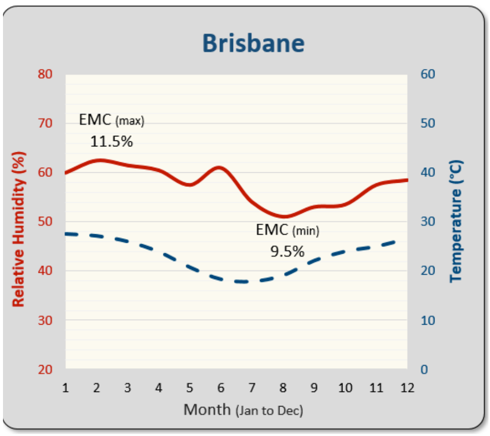
Table 3.1: EMC at various relative humidities and temperatures.

Equilibrim Moisture Content at various relative humidities and temperatures																				
Relative Humidity		5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
Temperature	0 °C	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.4	13.5	14.9	16.5	18.5	21.0	24.3
	10°C	1.4	2.6	3.6	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.3	11.2	12.3	13.4	14.8	16.4	18.4	20.9	24.3
	20°C	1.3	2.5	3.6	4.5	5.4	6.2	7.0	7.7	8.5	9.3	10.1	11.0	12.0	13.1	14.5	16.0	18.0	20.5	23.9
	30°C	1.2	2.4	3.4	4.3	5.2	6.0	6.7	7.5	8.2	9.0	9.8	10.6	11.6	12.7	14.0	15.5	17.5	20.0	23.4
	40°C	1.1	2.2	3.2	4.1	5.0	5.7	6.4	7.1	7.9	8.6	9.4	10.2	11.1	12.2	13.4	15.0	16.8	19.3	22.7

Relative humidity and temperature graphs for the major capitals throughout Australia are provided in the following figures along with EMC values and comments regarding specific seasonal conditions. Relative humidity and temperature fluctuate significantly on a daily basis. With regard to timber floors, houses are more likely to be open during daylight hours and the internal environment will be more influenced by external conditions during these times. In view of this, these graphs have been generated by averaging the 9 am and 3 pm BOM data for each city. However, as will be discussed later, closing up a dwelling and using either heating or cooling systems will significantly influence internal conditions and often moderate them. It is evident that the climate profile is similar between certain cities and these have been grouped accordingly.

Brisbane and Sydney

The temperate climates of Brisbane and Sydney are summarised in the graphs below and in both locations the EMC is at a maximum in summer during the first six months of the year. Summer rainfall generally results in floor expansion during the first few months from January. During summer, with the warmer temperatures and higher humidities, dwellings are also often open and floors are more responsive to swelling. Drier westerly winds usually occur in mid-winter from August to October and, with rising temperatures and low afternoon relative humidity, the onset of seasonal shrinkage is initiated. This is particularly so in Brisbane, where temperatures are a little higher. Minimal winter heating is needed in Brisbane, but some is required in Sydney. Average in-service EMC is often 10% to 12% in both cities, with Sydney considered as being the more stable of the two climates.



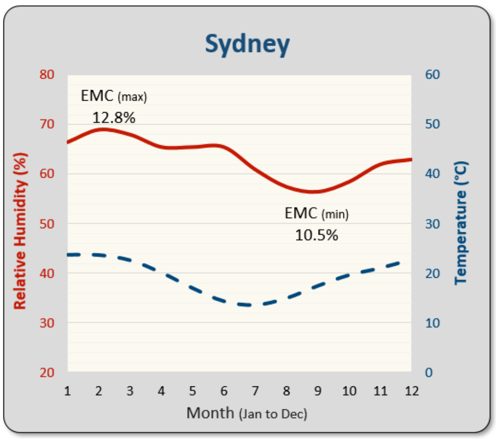


Figure 3.4: Brisbane and Sydney climate summaries.

Canberra, Melbourne and Hobart

The climate profiles of these three cities are similar, as summarised in the graphs below for Canberra and Melbourne, and they are considered as the colder southern climates. In these cities, the EMC is a maximum in the wetter winter months when temperatures are also a minimum, with Canberra experiencing temperatures a little lower than Melbourne. Due to cold winter temperatures, these cities use high levels of winter heating, which results in dry internal environments during the winter period even though external humidity is high. During summer, higher afternoon temperatures and very dry conditions can be experienced in Melbourne and Canberra, resulting in bushfire conditions. Due to winter heating, the average internal in-service EMC is often 9% to 12%.

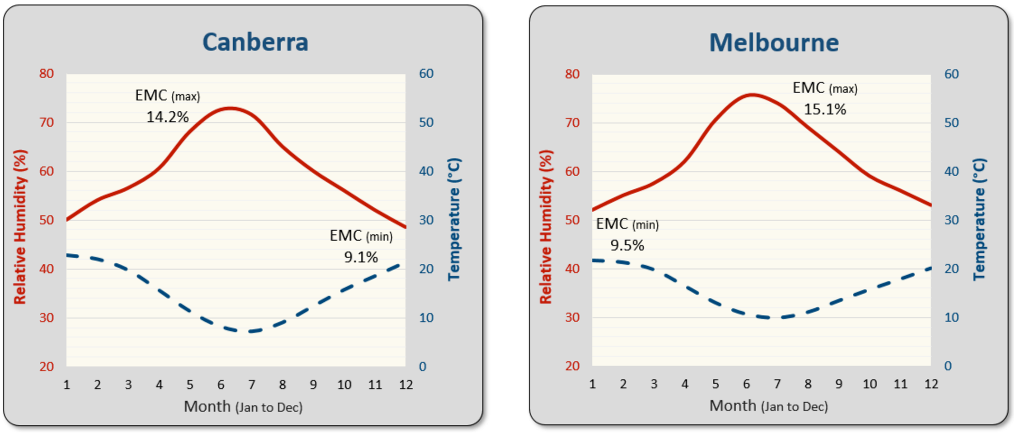


Figure 3.5: Canberra and Melbourne climate summaries.

Adelaide and Perth

Although there is considerable distance between these two cities, their climates have similarities. The climate profiles are similar in shape to that of Melbourne, but the average temperatures are higher and humidity is lower, as shown in the graphs below. In these cities, the EMC is similarly a maximum in the wetter winter when temperatures are a minimum. As such, some winter heating is used in these cities, but not to the degree used in Melbourne and Canberra. In summer, both cities can experience very hot dry conditions and low humidity conditions. During these times, bushfire conditions can be experienced. The internal in-service EMC is often 9% to 11% in Adelaide and 10% to 12% in Perth. The coastal winds and more moderate winter temperatures in Perth result in the EMC range being a little higher.

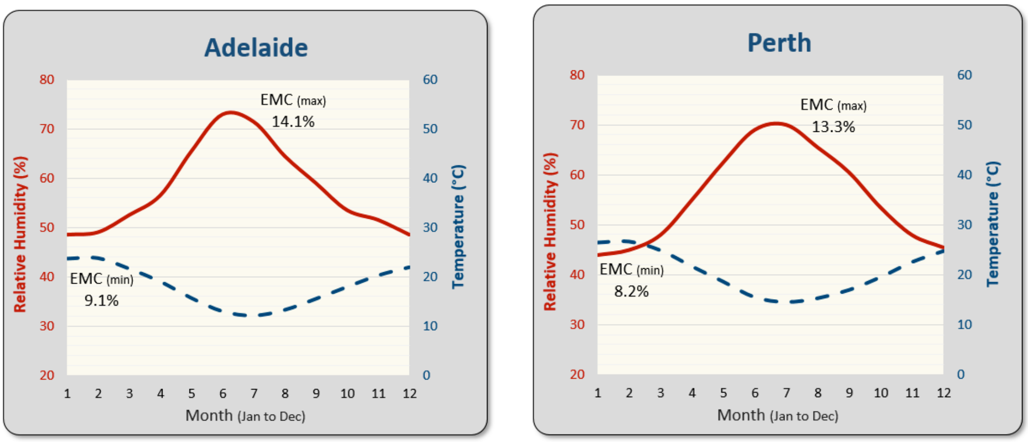
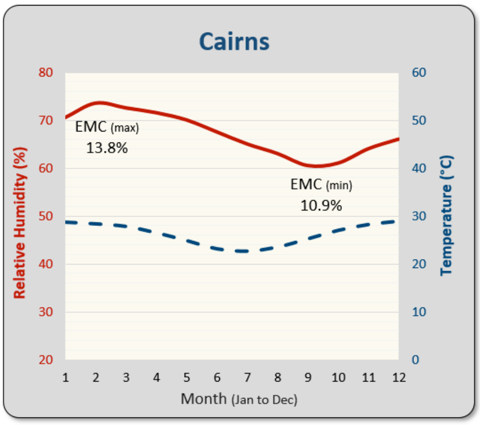


Figure 3.6: Adelaide and Perth climate summaries.

Although external conditions influence seasonal floor movement, the conditions within a dwelling are also moderated with heating and cooling used to achieve a comfortable living space and, as indicated above, internal EMC is generally between about 9% and 12% in the main city centres, which is indicative of relative humidity within dwellings of about 45% to 65%. However, within this range, floors are generally more prone to shrinkage in cities with drier internal environments (e.g. Adelaide and Canberra) and more prone to some swelling in warmer more humid cities (e.g. Brisbane).

Other Australian climates

Tropical and inland locations differ significantly to the main populated cities to the south of Brisbane. Provided below are the graphs for Cairns and Darwin. In both localities, temperatures remain significantly higher throughout the year compared to the main capital cities. In Cairns, humidity remains at higher levels for the first half of the year and, due to building practices in this area (floors often over open sub-floor spaces), the average in-service EMC is between 13% and 14%. In Darwin, there are few solid timber floors, reflecting the difficulty for timber floors in that climate. Again, temperatures remain high throughout the year causing timber flooring to be very responsive to moisture content change. The seasonal variation in humidity is much more severe in Darwin than Cairns and the resulting high levels of seasonal movement are difficult to satisfactorily accommodate. Both locations have distinct wet and dry seasons with large amounts of rainfall during the wet season over summer.



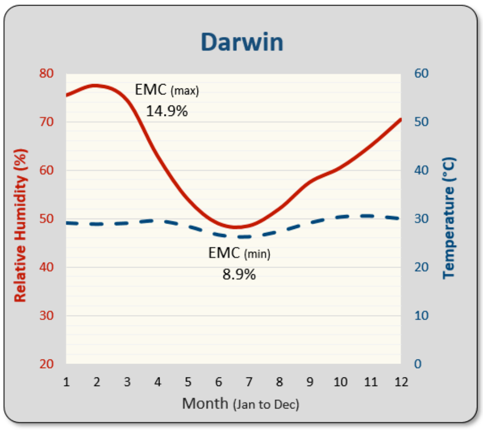


Figure 3.7: Cairns and Darwin climate summaries.

In contrast to this are the dry inland regions, and the graph provided for Mt Isa illustrates the seasonal EMC range varying from low to very low in the latter part of the year. Associated with this are moderate to high temperatures year round and characteristically very little rainfall.

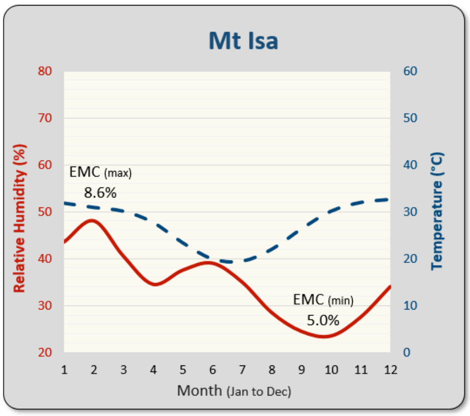


Figure 3.8: Mt Isa climate summary.

These examples of tropical regions and an inland locality serve to emphasise the extremes that occur in Australia. Again, there a limited number of timber floors in locations such as Mount Isa, but there are many timber floors from Brisbane and further north to Cairns.

It is important that, when laying timber floors in Australia, due consideration is given to the variances that occur. This should particularly include dwellings that tend to be naturally ventilated and require less heating or cooling, or floors that are exposed beneath – as external conditions can have a greater effect on seasonal floor movement.

It is evident from these graphs that both the humidity and temperature of the locality will affect the degree of heating and cooling, and that this in turn has a significant effect on moderating the internal environment and resulting in floors that perform well.

It is also evident from these graphs that the climate may result in moisture content that can be either higher or lower than the average moisture content of the flooring that has been supplied. Many manufacturers in Australia target a moisture content of between 10% and 11% to suit the in-service EMC of the capital cities. Some manufacturers selling to the tropical areas may target a moisture content that is a little higher, up to about 12.5%. It is due to these significant differences in the in-service EMC, occurring throughout Australia, that acclimatisation (covered in a latter section) or additional expansion allowance may be necessary for floors to perform.

New Zealand

In New Zealand, climate data is available from the website www.weatherspark.com, which provides both mean maximum and mean minimum relative humidity and temperature information. The data differs to that available for Australia, but through interpolating the data similar graphs can be generated to those above and can be used for general comparative purposes. Graphs have been provided for Auckland, Wellington and Christchurch. These indicate the New Zealand climate experiences cold winters and cool summers with winter heating the norm for longer periods. Relative humidity generally remains relatively high throughout the year when compared to the cooler winter climate of Australia cities that experience dry hot summers. New Zealand's main populated areas do not experience the hotter tropical weather or the extremes of dry inland climates within Australia. Therefore, buildings have moderate heating and cooling and floor moisture contents are often in the range from 9% to 12%.

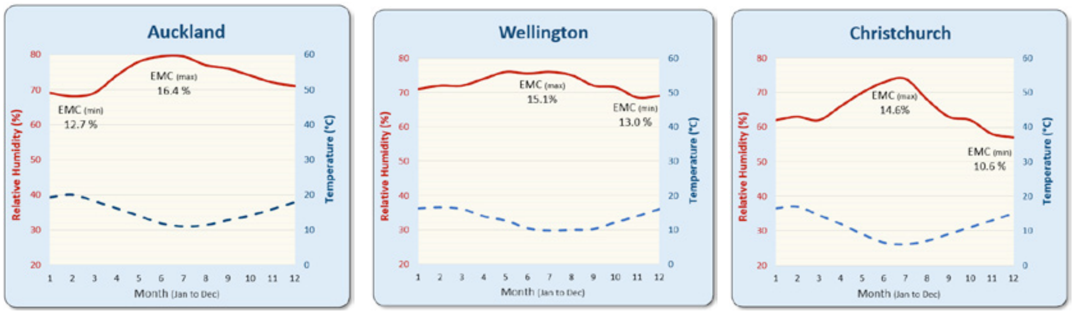


Figure 3.9: Auckland, Wellington and Christchurch climate summaries.

3.4.4 Climatic Variations within a Locality

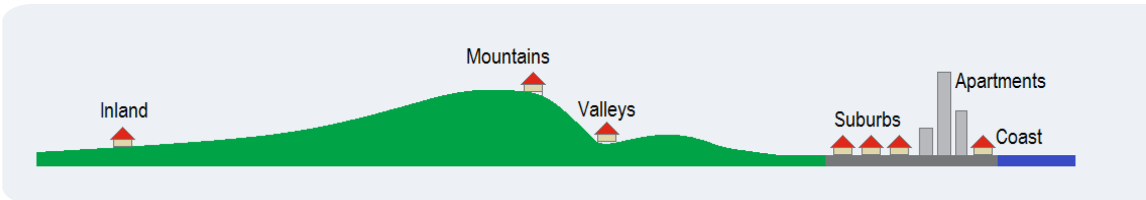


Figure 3.10: Dwellings in different geographic regions.

It is also important to understand that within a locality there are going to be geographic differences between one dwelling and another. This is best explained with reference to the figure above showing dwellings that are on the coast, in suburban environments, and also in valley, mountain and inland areas. This is indicative of the types of geographic differences that can occur. Similar principles can be applied to specific locations within the country.

This example illustrates how the foreshore has cool sea breezes that often prevail, causing lower afternoon temperatures and higher afternoon humidity. In such locations, internal EMC may range from 12% to 13% with natural ventilation more likely. Apartments along the coastal fringe may be similar, if naturally ventilated, although many have controlled cooling systems and therefore internal EMCs may be 9% to 11%. In the suburbs, there are many roads and closely spaced houses. Roads heat up and rainwater is quickly drained away from roofs and roads. As such, internal conditions are usually drier than on the coastal fringe and may be 10% to 11%. The valley environment often has more open land and trees that hold moisture and there is greater shading of the dwelling. This may result in internal EMCs of 12% to 16%. Houses elevated on the likes of escarpments can be prone to periods of lower temperatures due to the height and higher humidity, and more rain and mist, yet at other times of the year they are subject to dry winds. Houses may also be open beneath. Consequently, quite variable seasonal conditions can occur and internal EMCs could vary from 11% to 16%. Further inland, the effects of dry winds and moderate rain may see internal EMCs range from 9% to 12%.

3.4.5 The Effects of Heating and Cooling Systems

Heating systems vary considerably and include wood fires, heat pumps and convection and radiant heating. In addition, some dwellings have underfloor heating (refer to Appendix E). As a result, the intensity from the different heat sources will also vary. Heating systems are generally used when external conditions are cold and external humidity is naturally high.

The effect of heating the air within a dwelling reduces the relative humidity in the room significantly. For example, if the air temperature outside is 8°C with an external EMC of 18%, then heating raises the internal temperature to 18°C and will cause the internal EMC to be reduced to about 8%. There are many factors in this, such as hot air rising and heating only being used for part of the day, but it is also the reason why heating in cold climates results in dry internal environments at that time of the year.

Therefore, heating to maintain comfortable living conditions within the dwelling generally serves to moderate internal conditions to be within the acceptable range for timber floors. Excessive heating and high localised heat sources from, for example, wood heaters can cause significant localised shrinkage and when this occurs it is often the result of the choice of heating system and how it is operated by the owner. The flooring simply reflects the conditions it is exposed to.

Figure 3.11: Intense heating sources can cause localised shrinkage.

The two common types of air conditioning used in domestic housing are refrigerative (often referred to as reverse cycle, ducted or split system) and evaporative. Air conditioning is primarily used to lower the temperature in the building to more comfortable levels but it also has an effect on air humidity. The diagram illustrates how each can influence the relative humidity inside a dwelling. The refrigerative air conditioner extracts moisture from the air and this lowers the humidity. On the other hand, evaporative air conditioning puts cool moist air into the dwelling and increases the humidity.

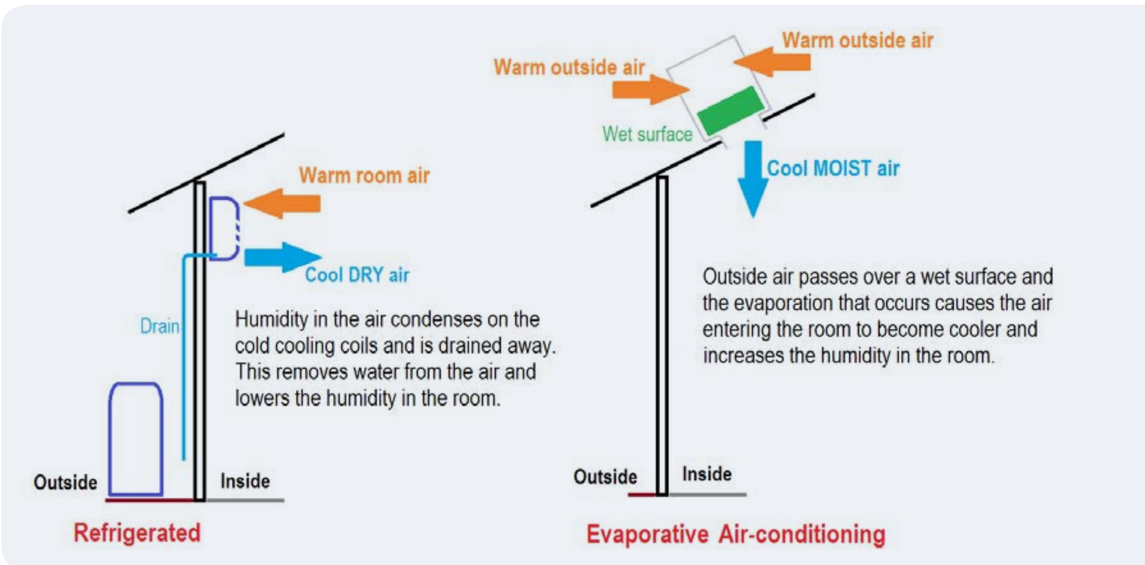


Figure 3.12: Influence of air conditioning on relative humidity inside a dwelling.

It needs to be recognised that air-conditioning is often partly countering more extreme conditions occurring outside the dwelling. Refrigerative air conditioners work well in warmer humid conditions; therefore humidity is often higher outside when lower humidity inside the dwelling can be beneficial. Evaporative air conditioning works well in hot dry conditions and some moisture added to a dry internal environment can also be of benefit. With evaporative air conditioning, it is necessary to leave some windows partly open so that the fresh air entering the dwelling can expel the warmer air present. The key is really to maintain a balance between both of these systems to provide a comfortable internal living environment. That is, cooling when necessary and relying on natural ventilation at other times of the day.

Therefore, in domestic applications air conditioning is not generally used throughout the whole year but is used to moderate the internal environment from more extreme conditions occurring outside at the time. When used in this manner, no concerns from air conditioning use generally arise with timber floors. When the occasional concern does occur, it often relates to more extreme and prolonged use of air-conditioning systems causing overly dry or overly moist conditions in the dwelling, depending on the air-conditioning system used. However, with intermittent use of air conditioning, the effects are generally relatively small and floors perform well, but solid timber floors may gap at board edges a little or tighten up a little, again depending on the air-conditioning system used.

Where excessive use of air conditioning has caused concerns with a floor, it is considered that the owner has contributed to their concerns. This, however, differs from flooring that may have been installed at too high a moisture content and where refrigerative air conditioning has promoted more rapid shrinkage. A check on the moisture content of the boards and width measurements of the floor and boards can be used to provide guidance on the cause.

Even if a dwelling may be air conditioned or is going to be air conditioned, it is the average in-service moisture content throughout the year that must be considered, and that use of the cooling equipment often moderates internal conditions from the more extreme conditions outside the dwelling. In buildings that generally use refrigerative air conditioning throughout much of the day for five or seven days a week, it can be necessary to acclimatise the flooring prior to installation to minimise shrinkage effects (see Section 3.7).

Figure 3.13: In warm climates these units are referred to as reverse cycle split system refrigerative air conditioners. In cold climates such as New Zealand they are referred to as heat pumps.

3.4.6 Other Building Considerations that Affect Floor Movement and Performance

In addition to the many different location factors and heating and cooling options, the dwelling design can also influence seasonal movement (shrinkage and swelling) of the floor. Dwellings or buildings with large glassed windows can be subject to high degrees of sunlight. The resulting higher temperatures and lower internal humidity can result in localised shrinkage in the floor, particularly where it is sun exposed. Window tinting or low emissivity glass should be used to minimise the effects from direct sunlight on the floor.

Figure 3.14: Window tinting or low emissivity glass should be considered with floor to ceiling windows to reduce shrinkage effects from direct sun.

In two-storey houses, the upper level can be hotter in summer and cooler in winter than the lower level. Consequently, seasonal movement can differ between levels, with the upper level more prone to seasonal shrinkage gaps. Some studies have shown that the EMC on the upper level of a two-storey house was about 2% lower, therefore the floorboards on the upper level would be under less pressure and narrower than the lower-level floorboards and may show some gapping, whereas on the lower level board joints may be tight.

Although now less common, with T&G site sanded and coated timber floors that are laid directly onto joists and where the house is open underneath it needs to be considered that the underside of the floor is directly exposed to external conditions. In some locations, and particularly on sloping land and escarpments, this can cause the underside of the floor to be exposed to very dry winds or wind-blown rain or fog. This can result in either extreme shrinkage or extreme swelling. In the latter case, the floor may lift off the joists and structural damage to the building may occur. Also, where there is little restriction to the prevailing wind, floors can react more rapidly to dry winds. The species used in the floor and board cover width affect the rate of movement and shrinkage that occurs. Depending on the severity of the exposure, options to protect the floor include providing an oil-based sealer to the underside of the floor, which may provide short duration protection to changes in weather, and installing a vapour resistant lining to the underside of the joists or building-in the underfloor space.

3.5 Sub-floor Ventilation

Many dwellings are 'bricked' in or enclosed around their perimeter and a lack of sufficient ventilation can result in high humidity in the sub-floor space. Inadequate ventilation and a ground surface that does not remain dry can also result in severe expansion and cupping of floorboards.

Quoted figures for sub-floor ventilation are based on sub-floor spaces that are not subjected to seepage or where ventilation through the sub-floor space is inhibited. Where humidity remains constantly high beneath a floor, coatings to the underside of the boards will not reduce the moisture uptake into the flooring. The sub-floor being dry and well-ventilated is generally a builder's or home owner's responsibility and, if necessary, needs to be corrected prior to floor installation. Failure to attend to this has resulted in a significant number of poor-performing or failing floors.

Therefore, when the lower surface of timber floors or structural sub-floors (over which a timber floor is laid) are exposed to the ground and the space is enclosed (by brickwork, etc) the sub-floor space must be adequately ventilated with permanent vents installed in the masonry during construction. In existing dwellings where a floor may be replaced, these requirements are also necessary and therefore some additional work may be required by the owner.

Figure 3.15: A dry sub-floor space and adequate ventilation is essential for floor performance.

The humidity in an enclosed sub-floor space can have a profound effect on the performance of a floor. If conditions are very moist, the lower surface of the boards may take up moisture, causing substantial swelling. Differential movement between the upper and lower surfaces of floorboards may also cause boards to cup. Similarly, caution needs to be exercised with timber floors laid in areas where the microclimate is often moist. In such locations, the floor may reach higher moisture contents than in other nearby areas and additional allowance for expansion of the floor may be required. Timber floors are not to be laid over enclosed moist sub-floor spaces, and structural sub-floors (e.g. plywood) cannot be relied upon to prevent moisture uptake in the T&G flooring if humidity in the sub-floor space remain high for extended periods. The floor installer has a responsibility to check that the sub-floor space is dry and adequately ventilated for both new floors and replacement floors to existing dwellings. When these aspects are not adequate, the builder or home owner is generally responsible for remedial works and the floor should not be laid until attended to.

3.5.1 Ventilation Requirements in Australia

Site sanded and coated solid floors in Australia should be provided with sub-floor ventilation that exceeds minimum National Construction Code (NCC) requirements. The levels outlined in the NCC (currently limited to 6,000 mm^2 per metre length of wall for higher humidity areas) are primarily to limit the moisture content of sub-floor framing timbers, which can generally tolerate greater fluctuations in moisture content than timber floors. The recommended minimum ventilation for T&G timber floors is 7,500 mm^2 per metre length of wall, with vents evenly spaced to ensure that cross ventilation is provided to all sub-floor areas (see Figure 3.16).

In some localities, it may be decided to reduce ventilation levels to the values provided in the NCC to meet constraints associated with energy efficiency. The NCC also outlines that a moisture membrane over the soil beneath the building reduces ventilation requirements and this approach is equally applicable to timber floors. If ventilation below the recommended level is used, due consideration should be given to alternative measures as outlined above and particular attention should be paid to ensuring that the sub-floor space remains dry throughout all seasons. The type of vent may need to be considered with buildings in bushfire areas, which limits the mesh size used in vents. Some commercially available vents of various types and their dimensions, net ventilation area and required spacing are illustrated in Table 3.2, for coastal Zone 3. NCC relative humidity zones and associated NCC ventilation requirements are also provided below. It should be noted that the maximum vent spacing irrespective of net ventilation area is 2 m and that any screens that may be necessary in bushfire areas or for vermin proofing may restrict airflow, and this may need to be compensated for.

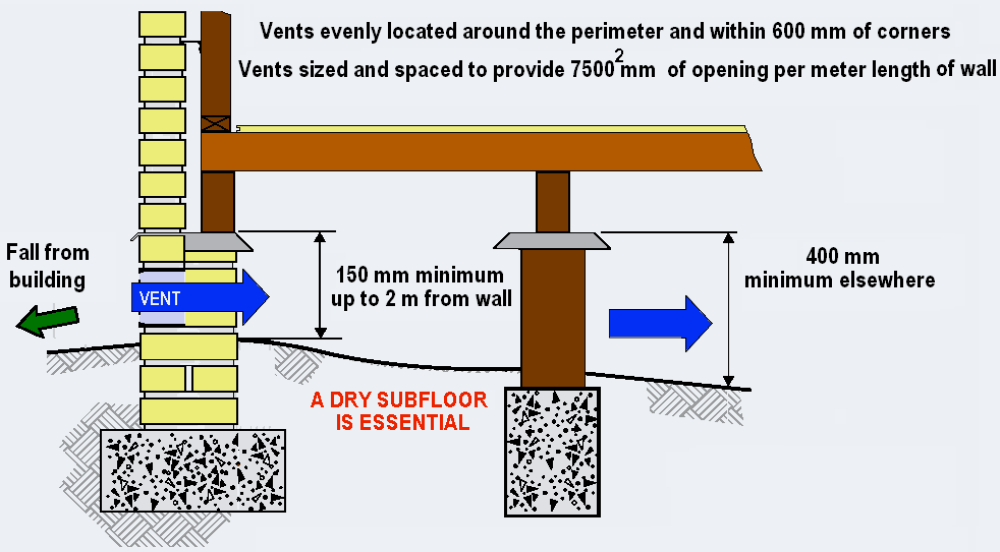


Figure 3.16: Cross ventilation must be provided to sub-floor areas.

Table 3.2: Some available vent types and specifications for coastal Zone 3.

Vent Type and Specifications				Nett Ventilation Area Provided per Vent (mm²)	Maximum Vent Spacing (mm)	
Material	Diagram	Vent size	Vent Pattern		ZONE 3 NCC Requirements (6000mm²/m) No-membrane	T&G Flooring Requirements (7500mm²/m)
Clay		160 x 230	8 slots each 75 mm x 8 mm	4800	800	640
Clay		160 x 230	15 holes each 16 mm x 16 mm	3840	640	512
Metal		200 x 400	8 slots 10 slots each 100 mm x 8 mm	5900 7400	983 1233	787 987
Metal		200 x 400	8 slots 10 slots each 175 mm x 8 mm	10700 13360	1783 2000	1427 1781
Block		200 x 400	1 slot each 310 mm x 110 mm	34000	2000	2000
Gradwell Cast Aluminium Air Vent		9" x 6" (230 x 160)	4 slots each 195 mm x 10 mm	7800	1300	1040
Pryda Vent Pryda Vent		230 x 75 230 x 165	52 holes 117 holes each 11 mm x 11 mm	6292 14157	1049 2360	839 1888
Pryda Slim Vent (GVS90) Pryda Slim Vent (GVS90H)		250 x 90 130 x 90	12 slots 6 slots each 110 mm x 8 mm	10560 5280	1760 880	1408 704

3.5.2 Ventilation Efficiency and Site Drainage in Australia

The sub-floor space must be free from all building debris and vegetation. Obstacles that prevent airflow to and from vents will reduce the efficiency of the sub-floor ventilation system. Landscaping should not limit airflow around the external perimeter of the sub-floor space, and structural elements should not limit air-flow. Vents should be installed in the masonry course below floor bearers, and should not be obscured by engaged piers or piers/stumps/columns that support the floor structure, or by any services present. Where external structures (fences, etc) or landscape may reduce airflow, consideration should be given to the use of more than the minimum number of vents. Figure 3.17 shows the NCC requirements.

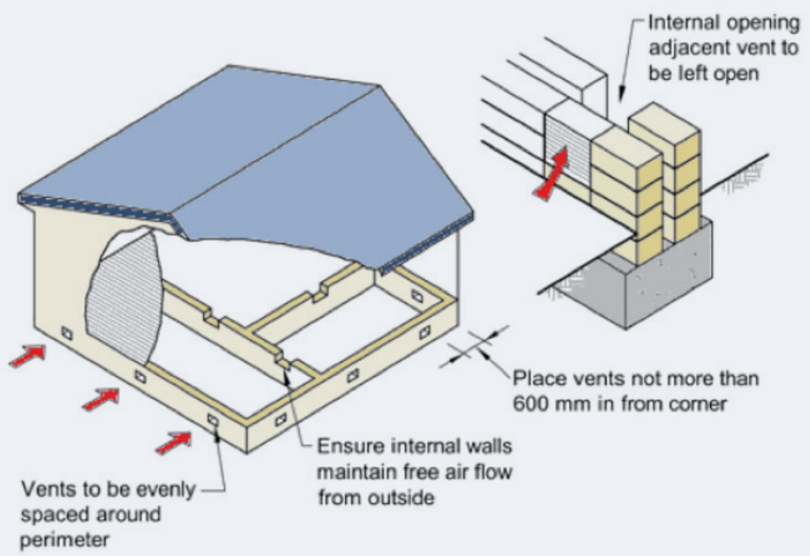


Figure 3.17: NCC requirements. Source: NCC 2015 Vol 2

Where verandas or decks are constructed outside the dwelling perimeter, care should be taken to ensure that the amount of ventilation provided around the veranda or deck perimeter is equivalent to or greater than the amount required for the adjacent external wall. Where ventilation is obstructed by patios, etc, additional ventilation should be provided to ensure that the overall level of ventilation is maintained and crossflow is achieved.

If adequate natural ventilation cannot be provided to sub-floor spaces, a mechanical ventilation system should be installed that replaces all of the air in this space on a regular basis, preventing the formation of 'dead-air' pockets.

If there are doubts over the sub-floor humidity (areas of high water table, reduced airflow due to minimum clearances between the sub-floor framing and ground, external structures, etc) a polyethylene membrane laid over the soil should be considered (taped at joints and fixed to stumps and walls). As discussed above, this can significantly reduce moisture uptake by the sub-floor air. Increased levels of ventilation should also be considered in such instances. With dwellings on sloping blocks that have enclosed sub-floor spaces, the possibility of seepage should be considered and appropriate control measures taken prior to the installation of the floor. The drainage system provided to the dwelling site is also to ensure that run-off water will drain away from the building perimeter (not towards it) and that run-off water is prevented from entering the sub-floor space.

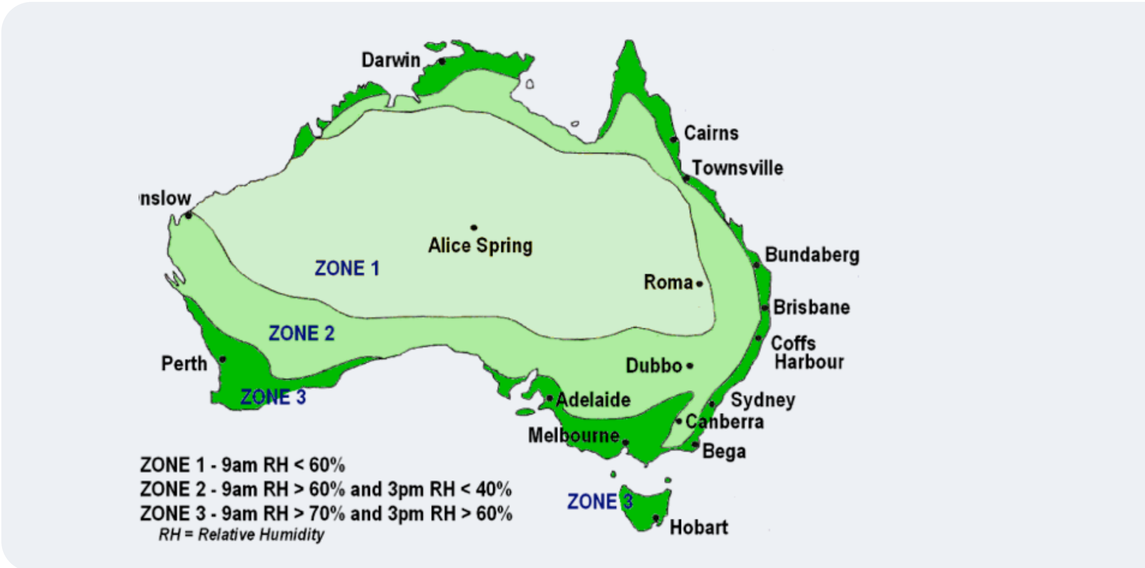


Figure 3.18: Climatic zones based on relative humidity. Source: NCC 2015 Vol 2

NCC Sub-floor Ventilation Requirements CLIMATE ZONE, CONDITIONS & SELECTED LOCATIONS		Min. Sub-Floor Ventilation mm²/m of wall	
		No membrane	Ground sealed with impervious membrane
1	Average 9am RH< 60%	2000	1000
2	Average 9am RH> 60% and 3pm RH < 40%	4000	2000
3	Average 9am RH> 70% and 3pm RH < 60%	6000	3000

Figure 3.19: NCC sub-floor ventilations requirements.

Figure 3.20: For frequently damp soil conditions, the sub-floor ground level can be raised with crusher dust and a polyethylene membrane laid over it.

The ground beneath a suspended floor should also be graded so that no ponding is possible. Where springs or aquifers are present (e.g. exposed by earthworks on sloping sites) and cause water to enter the sub-floor space, a closed drainage system should be installed under the dwelling to remove this water. The ventilation system will not cope with this level of moisture in the sub-floor space.

3.5.3 Ventilation Requirements in New Zealand

Site sanded and coated solid floors in New Zealand should be provided with sub-floor ventilation that meets the New Zealand Building Code. With sub-floor ventilation a balance with insulation requirements also needs to be considered, as too much ventilation can lead to unwanted heat loss. Vents to enclosed sub-floor spaces should be within 750 mm of corners, evenly spaced between and up to 1.8 m apart. The ventilation requirement is 3,500 mm^2 for each square metre of floor area.

Therefore, a building with 120 m^2 floor area would require 120 x 3,500 = 420,000 mm^2 of open vent area. If the building is 10 m x 12 m then install vents no more than 750 mm from corners and spacing up to 1.8 m, each 10 m long walls would require six vents and the 12 m walls require seven vents. The total number of vents is 26 and each vent would need a clear opening of 16,150 mm^2, which is a little over 160 x 100 mm for each vent.

Soil vapour barriers may also be used to reduce soil moisture evaporation into the sub-floor space.

3.6 Considering the Likely Movement After Installation

As outlined above, timber is a natural product that responds to changes in weather conditions with seasonal humidity and temperature changes in the air, causing boards to shrink and swell at different times throughout the year. Similarly, both heating and cooling systems have a significant effect on floor movement and often moderate the more severe conditions outside.

The overall movement occurring in individual boards and the rate of movement will depend on the timber species and growth ring orientation. Small differences in moisture content between boards at the time of manufacture (noting that a 5% range is normally allowed by applicable standards) and variable conditions within the house (e.g. westerly facing room compared to southerly facing) will also cause further variation in board width. Consequently, it can be expected that small gaps will occur at the edges of most boards, particularly during the drier months, and that the actual gap sizes may differ across a floor. In cases where shrinkage occurs after installation, wider boards (e.g. 130 mm) will result in larger gap sizes at board edges than if narrower boards are used.

Some movement usually occurs in timber floors after laying as the floor adjusts to the internal climate and, although floor finishes may retard moisture content changes, they will not prevent this movement. With prefinished flooring, the coating to the upper board surface (multiple coats of UV-cured urethane) is often less permeable than the single coating provided to the lower board surface. Moisture uptake is not even through top and bottom face and care is needed as moisture differential can induce cupping. In applications where greater movement is expected (e.g. from seasonal changes, use of wide boards, more prolonged air-conditioning use), particular care is necessary after finishing site coated floors to ensure that the finish does not act as an adhesive and bond a number of adjacent boards together. This is known as edge bonding and, with subsequent shrinkage, wide gaps between groups of two to eight or so boards may occur or boards may split.

Figure 3.21: Edge bonding can result in wide irregularly spaced gaps at board edges and split boards within the floor.

The way different timber species respond in a floor depends on their moisture content and also on the rate at which they take up and lose moisture, the associated movement and their density. High-density species are extremely strong and those that take up or lose moisture more quickly (such as Blackbutt) will also follow seasonal moisture changes more closely than slower responding species (such as Spotted Gum). Particular care is necessary to be able to accommodate expansion of the higher density species, particularly in warm humid localities. This may necessitate providing small expansion gaps every 6 to 10 boards during installation, in addition to normal expansion allowances, to accommodate this movement. Lower density hardwoods (e.g. Tasmanian Oak, Victorian Ash) and softwoods will, to a large extent, compress at their edges when a floor expands. With these timbers, normal expansion allowance is generally able to accommodate the expansion in more humid climates.

3.7 Installation Moisture Content and Acclimatisation of Strip Flooring

The moisture content of timber is the percentage weight of water present in the timber compared to the weight of timber with all water removed. As previously discussed, moisture content varies with changes in the humidity and temperature in the surrounding air. To minimise the movement of a floor, swelling on moisture uptake and shrinkage on moisture loss due to changes in moisture content, it is important to lay and fix timber floors close to the average in-service moisture content. This can at times be difficult to estimate. Timber flooring is usually supplied at an average moisture content between 10% and 12.5% and most boards can be expected to be within a few per cent of the average. Where the average supplied moisture content of the flooring is near the expected average in-service moisture content, acclimatisation is not necessary.

In areas where higher average moisture conditions persist and where floors are expected to have higher moisture contents, additional allowance should be made for subsequent expansion. Such areas include tropical North Queensland and northern New South Wales, areas of dense bush land, shaded gullies and forested locations, particularly at higher elevations and mountain areas.

Figure 3.22: Acclimatisation can be effective if product MCs and in-service conditions are known.

Installation methods need to be considered to accommodate the difference between the average moisture content on delivery and the average expected in-service moisture content. These can include either providing additional intermediate expansion joints or acclimatising the flooring.

Acclimatisation is simply a process of getting the moisture content of the flooring closer to its expected in-service moisture content, so that shrinkage or swelling of the floorboards will be less after installation. Increasing the average moisture content of the flooring supplied will only be effective if the humidity in the air is sufficient to cause moisture uptake. Care must also be exercised as the rate of moisture uptake differs from species to species. Some higher density species are very slow to take up moisture from the air (e.g. Spotted Gum) while others react more quickly (e.g. Blackbutt and Brush Box). If flooring is to be laid in a dry environment such as western New South Wales or a consistently air-conditioned building, acclimatisation can be effective in reducing the average moisture content of the flooring prior to laying and thereby reducing gap sizes at board edges from board shrinkage. In such climates, future expansion of the floor must be allowed for to accommodate periods of wet weather.

Acclimatisation relies on each board being exposed to the in-service atmosphere, so packs must be opened up and restacked to allow airflow between each board. Acclimatisation can only be effective in an air-conditioned building if the air conditioning is operating at the time or in dry localities during drier periods. The species and period for which it is acclimatised will also influence effectiveness. For some higher density species that are slow to lose or take up moisture, acclimatising may have little effect. Acclimatisation in dry climates does not negate the need to provide for floor expansion during periods of wet weather.

A simple guide to pre-installation considerations is provided in Figure 3.23, which should be referred to in conjunction with the preceding text. Note that, with prefinished strip flooring, some manufactures may have further advice regarding acclimatisation due to coating permeability and tolerance considerations. Also, manufacturers of thinner site sanded and coated overlay flooring often recommend not to acclimatise this thinner floor but to allow it to adjust to the internal conditions for a period after laying and prior to sanding and coating.

Figure 3.23: A guide to pre-installation considerations.

To acclimatise flooring, it is necessary to have the equipment to monitor both the moisture content of the flooring as well as the measuring equipment to assess the change in board width. Some will place 10 short boards together during the acclimatisation period. The average moisture content over the 10 boards (from 10 individual readings) is determined along with the total dimension over the 10 boards. This enables the movement resulting from moisture uptake or loss during the acclimatisation period to be more easily assessed. Moisture uptake is applicable if laying in a humid environment and desiring to increase the average board width prior to laying, and moisture loss is applicable if desiring to pre-shrink the flooring in a dry environment prior to laying. Note that an 80-mm-wide board will shrink or swell by about 0.25 mm for each 1% change in moisture content (proportionately increased for wider boards). Therefore, if the measurement over 10 boards increased during the acclimatisation period from 800 mm to 807 mm then this would reflect about a 3% increase in moisture content that should also be reflected by an increase in the average of the moisture content readings over the 10 boards.

With reference to Figure 3.24, the flooring may have been supplied at an average moisture content of 10% and the desired installation moisture content may be 15%. After a few weeks of acclimatisation, the average moisture content may have increased to 13%. This would be considered sufficiently close to the desired installation moisture content to lay the floor, as the average moisture content is just 2% away from the desired moisture content and not 5% as initially supplied. Also, on average each board would have increased in cover width by 0.7 mm prior to laying. But again it is important to note that acclimatisation does not negate the need to install appropriate expansion allowance. If the moisture content range of the flooring to be acclimatised is too wide (including from poor drying) then the acclimatisation process will result in widely variable board widths. Similarly, with wide boards the variation in board width at the conclusion of acclimatisation can be greater and also with wide boards there will be a greater tendency for board ends to be wider with moisture content increase (or narrower with moisture content decrease) than the centre of the board. Due to this, the provision of additional expansion allowance at installation may be preferred.

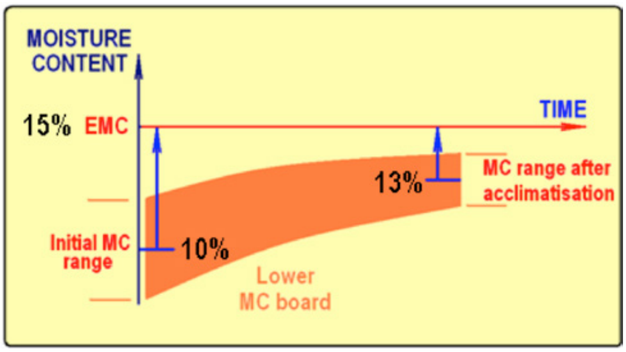


Figure 3.24: Acclimatisation example.

4

Site Sanded T&G Floor Installation: Timber and Sheet Sub-floors

4.1 Installation Practice and Products

This section outlines the recommended practices for laying site sanded and coated timber strip floors over timber and engineered timber joists (it does not include steel joists), structural sub-floors such as plywood and particleboard and over concrete, but does not include direct adhesive fix to slabs, which is provided for in Section 5. The fixing of parquetry is covered in Section 6 and prefinished timber strip floors is covered in Section 7. Note that New Zealand practices may vary to a degree with regard to thickness of sub-floor sheeting and fixings etc.

The process of laying a timber floor is a three-step process that requires: 1) assessment of the product being laid; 2) an assessment of the expected in-service environment; and 3) the laying of the floor by an appropriate method, based on what was determined in the first two steps. Aspects needing to be considered with steps one and two are provided for in Section 3. When laying a timber strip floors over joists, either directly on the joists or on sheet flooring fixed to joists, adequate sub-floor ventilation is essential for the satisfactory performance of the floor. Sub-floor ventilation recommendations as outlined in Section 3 need to be adhered to.

The specified recommendations contained in this Guide are generic in nature and, although they are frequently used, installers with knowledge and experience in a particular locality, or other constraints, may fix a floor in a manner that differs from that outlined here. However, it needs to be recognised that such systems are non-standard and the installation becomes the floor installer's system, rather than an industry recognised system. It is expected that all floor installations will be provided with a robust fixing method and guidance on this can be obtained from the recognised methods outlined in this Guide. When site sanded and coated floors are installed with due provision for movement (expansion allowance and acclimatisation as applicable) it is expected that a floor will be provided that is adequately fixed and without severe board shrinkage or severe expansion related concerns. Consequently, a final appearance complying with the provisions of Section 9, which discusses site sanded and coated floor appearance expectations, should be achievable and expected.

There are also an increasing number of flooring manufacturers who are producing specific products with accompanying installation instructions, and such instructions take precedence over the generic methods outlined in this Guide and should be strictly followed. Such instructions often relate to wider thin overlay boards and standard profile flooring for secret fixing. Other manufacturers recommend that standard profile flooring should not be secretly fixed. If flooring is fixed contrary to the manufacturer's intention for the product, it may also affect possible warranty claims. It should be recognised that specific manufacturing methods may apply to certain products and other similar-looking products of different manufacture may not perform equivalently, even with the same fixing method.

4.2 Consideration of Installation Methods

Due to climatic differences occurring between and throughout each state of Australia and in New Zealand, the fixing requirements of the floor need to be carefully assessed and will differ depending on locality. Applicable fixing requirements differ to some degree across these regions and between locations within each region or within a state in Australia.

Top (face) nailing is a more robust fixing method than floors secretly fixed with beads of adhesive. Top (face) nailed floors can therefore accommodate greater movement and expansion pressure without buckling. Increasing the amount of adhesive used will also provide more robust fixing and some installers elect to bond the floor with a full bed of adhesive. Where greater floor expansion is expected after installation, the method of fixing and associated spacing of fixings or amount of adhesive used requires consideration. With higher density timbers, a full bed of adhesive in humid localities will limit floor expansion but can also contribute to higher pressure at board edges making the floor more prone to peaking, resulting in a cupped appearance (refer to Appendix G – Troubleshooting guide for an explanation of terms).

The installation methods covered by this Guide are used extensively by many installers throughout Australia and form the basis for the industry's recommendations.

4.3 Allowance for Expansion

Site sanded and coated floors require a minimum 10 mm expansion gap between the floorboards and any internal or external wall structures. However, where board ends abut doorways, the gap may be reduced to a neat fit but with a small gap (approximately 1 mm) to prevent rubbing. Where skirtings may only be 10 mm wide, the wall board can be undercut or skirting may need to be replaced.

For floors on joists, battens and over sheet sub-floors where beads of adhesive have been used as part of the fixing method, floors up to 6 m wide (measured at right angles to the run of boards) are not required to have intermediate expansion joints, provided that it is a normal in-service environment. For floor widths over 6 m or where extra allowance for expansion is required (e.g. moist locations) an intermediate expansion joint, or a series of smaller expansion gaps usually every 800 mm to 1000 mm to provide equivalent spacing, or a combination of both is required. If 12-mm-wide cork expansion joints are used, the cork should be 2 mm or so proud of the floor surface when installed. This excess will be removed during the sanding process. However, cork to the perimeter should be installed level with the timber surface. It should be noted that cork to aluminium door joinery can cause the joinery to bow under floor expansion and an aluminium angle as shown in the diagram below overcomes this. This angle may also be inverted and adhesive fixed to the aluminium joinery or, alternatively, a small timber bullnose moulding on flat that may be fixed to the flooring.

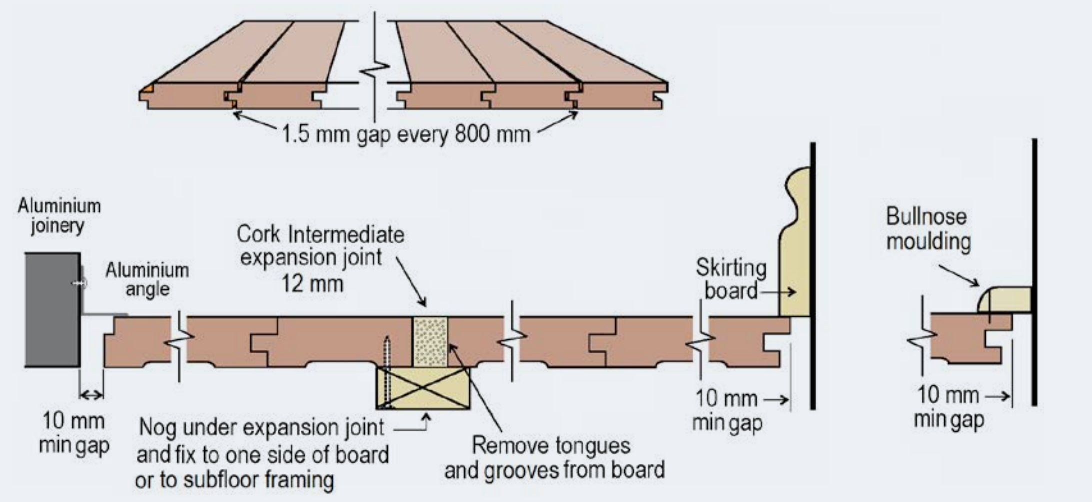


Figure 4.1: Allowance for expansion.

Figure 4.2: Small regular gaps can be used to provide the additional expansion allowance needed, particularly for wide floors or in moist climates. These often close during humid periods.

Figure 4.3: Cork intermediate expansion joints blend in well with timber floors.

When installing floors using a full bed of adhesive, it needs to be considered that the adhesive fixing substantially reduces the degree of expansion in the floor and expansion forces have to be resisted by the sub-floor. Full bed adhesive-fixed floors should be provided with a minimum 10 mm expansion gap between the floorboards and any internal or external wall structures. Similarly, where board ends abut doorways, the gap may be reduced to a neat fit but with a small gap (approximately 1 mm) to prevent rubbing. The need for intermediate expansion allowance in wider floors will vary depending on the density of the timber species being laid. With medium density hardwoods (e.g. Tasmanian Oak) and floor widths over 6 m or where extra allowance for expansion is required (e.g. moist locations) a 12-mm-wide cork intermediate expansion joint or a series of smaller expansion gaps often to provide equivalent spacing, or a combination of both is required. With higher density flooring (e.g. Blackbutt), board edges do not crush on floor expansion to the degree that occurs with medium-density hardwoods. Due to this and the restraining effect of the adhesive, a single cork joint may not provide sufficient movement allowance. In such installations, it becomes increasingly important to have the flooring laid close to the expected average in-service moisture content, and regular small gaps often provide a better solution.

In addition, when laying over a structural sub-floor such as plywood or particleboard and the flooring is of higher density, it is important that the sub-floor fixing is adequate. In moderately humid locations, it has been found that nail and adhesive-fixed sheet flooring has buckled off the joists in some instances, even when fixed in accordance with the relevant nailing requirements of Australian Standards. Screw fixing to the joists provides for a more robust fixing.

Figure 4.4: Buckling of the plywood sub-floor off the joists.

4.4 General Floor Laying Practice

The moisture content, cover width and profile (undercut and T&G tolerance) of the flooring should be checked and preferably recorded (see Section 3) prior to laying. If it is identified that the moisture content is not correct or the boards are outside of expected requirements, or are otherwise not considered to meet the specified grade, the installer should contact the supplier to resolve these issues before commencing laying. Similarly, any board found during laying that is considered outside the grade specification should not be laid.

Top (face) nailing, where used, is to be undertaken uniformly with respect to edge distances and alignment across the floor. Some variation due to batten and joist layout may occur.

When laying over sheet flooring or an existing floor, boards should be staggered to provide the look of a floor similar to that laid over joists. It is good practice to ensure that end joints are at least 300 mm to 450 mm apart and that joints do not cluster together or align. For aesthetic reasons, close alignment of end joints in adjacent boards should generally be avoided.

Installers also need to consider how the boards will be distributed in the floor in terms of length, grade, feature and colour, irrespective of whether this is on joists or other sub-floors. As such, it may be necessary to lay from more than one pack at a time so that the colour range and grade features can be blended throughout the floor. It is also necessary to take care with single boards of highly contrasting appearance and it is best that they are not installed in highly visible locations because, although not necessarily requiring remedial work, it is not seen as good practice.

With some installations, it can be beneficial to reverse the laying direction and this can be achieve by installing a row of boards ‘back to back’ with a slip (or false) tongue.

When only moderate expansion pressure is expected in the floor or the flooring is not of high-density species, the slip tongue is glued (with PVA adhesive) into the groove of the fixed board (that is fully adhesive fixed to the sub-floor), thereby creating a board with a tongue along both edges. The board with the false tongue can then be secretly fixed through the false tongue – noting that the tongue needs to be supported while fixing (usually with an offcut) so that the tongue does not drop. The adjoining board should also be fully adhesive fixed to the sub-floor and with timber and sheet sub-floors also top-nailed into them. In instances where greater expansion pressure is expected or a secretly fixed installation is required, some installers will trim the top shoulders of the adjoining boards to be in line with the bottom shoulders. Again, both boards need to be fully adhesive fixed, with the slip tongue glued into the groove of the fixed board and secretly fixed through the false tongue. With this second option, board widths will be a little narrower. Note that a slip tongue is more appropriate to flooring at least 19 mm thick, and with overlay flooring a double tongue board is sometimes used.

If a slip tongue is not used and boards are not fixed in this manner, the floor may tent with floor expansion at this location. Figure 4.5 shows the slip tongue methods described and the photo illustrates the consequence of not using a slip tongue.

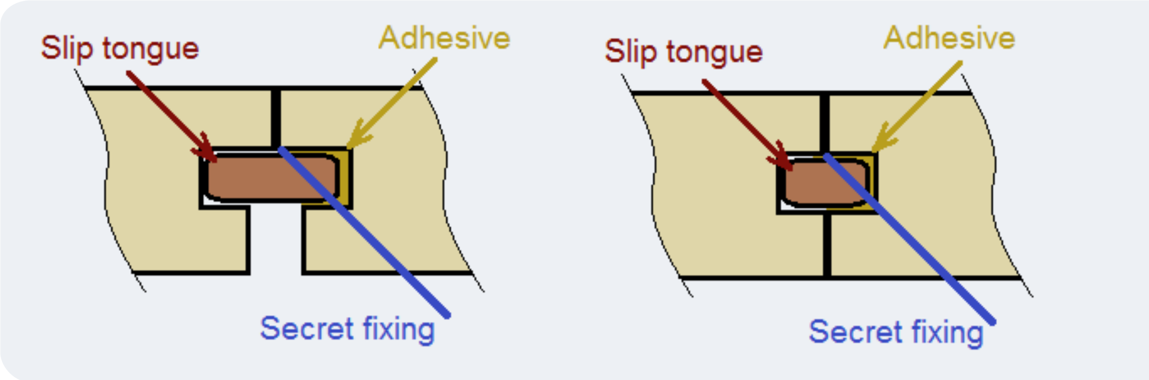


Figure 4.5: The slip tongue methods described.

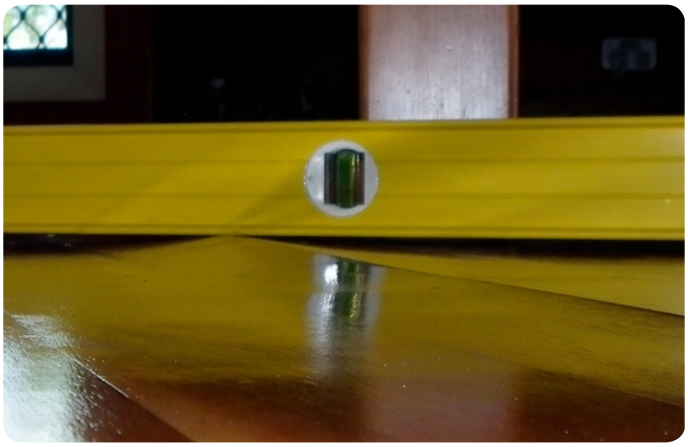


Figure 4.6: Possible consequences of not using a slip tongue and not fixing these boards correctly.

4.5 Installation Direct to Joists

4.5.1 Construction Method

Where the timber floor is to be sanded and polished (i.e. a feature floor), fitted floor construction needs to be used. With this method, the timber flooring is installed after the roof cladding and external wall cladding are in place and the house is weathertight. This prevents initial degradation due to water and sunlight exposure and reduces damage from trades during construction.

4.5.2 Sub-floor Framing – Bearer Size, Floor Joist Size and Flooring Spans

The size of timber members used to support the flooring boards can be determined from AS 1684 – Residential timber-framed construction, and in New Zealand NZS 3604 – Timber-framed buildings. This Standard should also be referred to with regard to board spans, etc, and fixing requirements for flooring installed in New Zealand.

In Australia, for end-matched flooring profiles, joists with a minimum thickness of 35 mm may be used. Where plain end flooring is butt-joined at floor joists, 45 mm or 50 mm thick joists are recommended to reduce splitting problems at butt ends.

Figure 4.7: Timber floors are successfully laid over a range of solid timber and engineered joist systems.

If installing a secretly nailed floor over joists, the joists need to be seasoned timber or Cypress, as secret nailing cannot be re-punched. If the joists shrink away from the floor, movement of boards on the fixings is likely to cause excessive squeaking.

Top (face) nailed floors may be fixed into either seasoned or unseasoned joists. Unseasoned joists are now less common and the joists need to be of a species not exhibiting high rates of shrinkage and to be of a single species or species with similar shrinkage. Species exhibiting high tangential shrinkage rates or prone to collapse or distortion should not be used unless seasoned. The potential effects of floor frame shrinkage require assessment prior to specifying or ordering unseasoned floor framing, and due allowance made in the building design and detailing. Similarly, after installation, the effects of both shrinkage and possible nail popping need consideration.

The joists must be sufficiently flat to accept the timber floor and to provide a finished floor appearance that also appears flat. The allowable span of timber flooring is dependent on the timber species, density, grade, thickness and whether or not the flooring is end-matched. The following table gives the acceptable joist spacing and maximum spans for various flooring products when fixed to timber joists. Maximum board span (the distance between where the timber is supported) needs to be considered in installations where flooring is at an angle to the joists, as this increases the board spans.

Table 4.1: Allowable joist spacing and maximum span of floorboards for Australia.

Species Group	Grade	Thickness (mm)	Acceptable Species, Grade and Joist Spacing			Maximum Span	
			450 mm End-matched	450 mm Butt-joined	600 mm Butt-joined	End-matched	Butt-joined
Hardwood	AS 2796						
All hardwood species listed on page 5	Select Grade	19	✓	✓	✓	500 mm	630 mm
	Medium Feature (Standard) & High Feature Grade	19	✓	✓	✗	450 mm	570 mm
Cypress	AS 1810						
	No. 1	19	✓	✓	✗	410 mm	510 mm
	No. 2	20	✓	✓	✗	410 mm	510 mm
Softwood	AS 4785						
Slash Pine	Select & Standard Grades	19	✓	✓	✗	410 mm	510 mm
Other pinus species	Select & Standard Grades	19	✗	✓	✗	350 mm	470 mm
Araucaria (Hoop Pine)	Manufacturers Grades	20	✓	✓	✗	410 mm	510 mm

4.5.3 Installation Directly to Joists

In most instances, when laying over joists, boards are to be supported on at least three joists. However, there will be instances where some boards may not be (i.e. floor edges or the occasional shorter board within the floor), but this should be kept to a minimum. Flooring should be laid in straight and parallel lines. Butt-joined boards must be cut to join over floor joists and joints in adjacent boards should be staggered. End-matched joints in adjacent boards should not occur within the same span between joists. It is essential that boards are in contact with the joists at the time of nailing, particularly when machine nailing is used, as this type of nailing cannot be relied on to pull the board down to the joist.

It is generally recommended that not more than 800 mm of flooring is cramped at any one time, however, this may be varied by the installer, depending on the flooring used and conditions in which the floor is laid. The pressure used to cramp the boards together will differ from one floor to another, depending on the moisture content of the flooring at installation, the air humidity and the average moisture content conditions for the location. As a general rule, cramping should be sufficient to just bring the edges of adjoining boards together while maintaining a straight line.

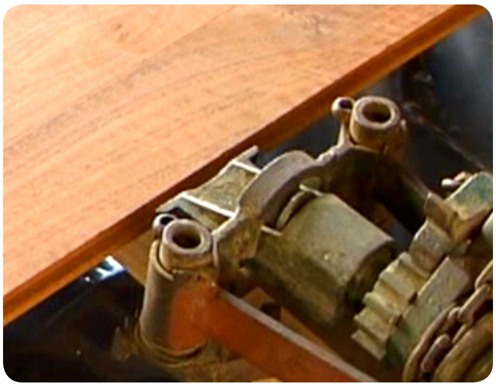


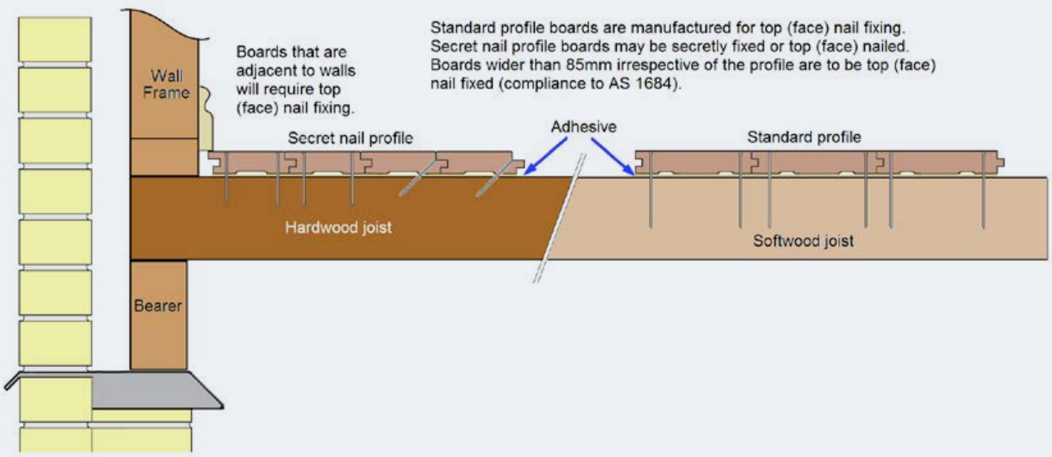
Figure 4.8: Cramping should be sufficient to just bring the edges of adjoining boards together.

4.5.4 Top (Face) Nail and Secret Fixing Directly to Joists

Boards for top (face) nailing and cover widths up to 65 mm are top (face) nailed with one or two nails at each joist. Boards for top (face) nailing and a cover width over 65 mm and up to 135 mm wide should be top (face) nailed with two nails at each joist. Boards wider than 135 mm are often top (face) nailed with two or three nails.

Figure 4.9: Buckling of 80-mm-wide Spotted Gum boards secretly fixed to pine joists in a humid locality.

Top (face) nailing is to be undertaken uniformly with respect to edge distances and alignment across the floor. Some variation due to joist layout may occur. Boards up to 85 mm wide can be secretly fixed with a staple or cleat at each joist and require a good coverage of flooring adhesive to the joist. In humid and moist localities, additional care is required to cater for possible greater expansion. Consideration should be given to board moisture contents, providing for expansion, the species, joist material and fixing method. In some locations, top (face) nailing will be the preferred option. Fixing sizes commonly used for 19 mm to 21 mm thick boards are provided in Figure 4.10.



Fixing specifications

For all installations in conjunction with mechanical fixing, apply 6 mm to 10 mm beads of flooring adhesive to the battens in a tight zigzag pattern.

Top (face) nailing into hardwood, Cypress, softwood, LVL and I-Beams

For all board widths 50 x 2.2 or 50 x 2.5 T-head machine-driven nail or 50 x 2.8 bullet head hand-driven nail

Secret fixing into hardwood and Cypress joists

For all board widths 45 x 15 gauge staple or 45 x 16 gauge cleat

Secret fixing into softwood, LVL and I-Beams

For all board widths 50 x 15 gauge staple or 50 x 16 gauge cleat.

Figure 4.10: Secret and top (Face) nail fixing structural 19 mm thick flooring directly to joists.

The recommended minimum edge distance for nailing at butt joints or board ends is 12 mm. All nails, including machine nails, should be punched a minimum of 3 mm below the top surface. During fixing, the joint between floorboards and the top surface of floor joists should be checked to ensure that gaps are not present. If gaps are present, nails should be punched to draw boards tightly onto the joists.

Figure 4.11: It should be checked that boards are tight on the joists.

Figure 4.12: Secret fixing is recommended for boards up to 85 mm in cover width.

4.6 Installation over Existing Timber and Sheet Floors on Joists

4.6.1 Assessing the Existing Floor

Timber T&G flooring may be laid over an existing T&G floor or sheet floor (plywood or particleboard). Where the existing floor is structurally sound, either overlay flooring (generally up to 14 mm thick) or structural flooring (generally 19 mm to 21 mm thick) can be laid. Wider 19mm thick boards (130 mm or wider) and thicker boards (to 21 mm) are generally top (face) nailed fixed through the sub-floor into the joists. Narrower 19mm thick boards (85 mm or less) and overlay flooring is usually secretly fixed into the sub-floor. With 19mm or thicker boards, either beads or a full bed of flooring adhesive is used in conjunction with the mechanical fixing and, with overlay flooring, a full bed of adhesive provides for a more stable floor and is recommended.

In instances where there is doubt over the structural adequacy of the existing floor, either:

a) remove the existing floor and use structural flooring laid at 90° to the joists, and fix into the joists

b) replace the defective boards or sheets to make the existing floor structurally sound (structural or overlay flooring may then be used); or

c) if the existing floor is not made structurally sound, use structural flooring at 90° to the joists and fix through the existing floor and into the joists.

The new boards may be fixed at an angle (other than 90°) to the joists in options a) or b) above, provided that the thickness of the new boards is appropriate to the increased span between the joists (as a consequence of the angle). Top (face) nails in existing flooring should be re-punched where necessary. The existing floor should be rough sanded to provide an appropriate surface over which the new floor is to be fixed. Adhesives require a clean, structurally sound floor free from surface moisture, loose particles and contaminants. This includes removal by sanding of the waxed surface layer of particle board floors. In some instances, sheet sub-floors (substrates) can sag between joists and require levelling as the sagging, if not attended to, will show through to the new floor.

It is necessary to check that the existing floor moisture content is appropriate to accept the new floor. The cause of any excess moisture (wetting during construction, leaks, inadequate sub-floor ventilation, etc) needs to be addressed prior to installation of the new floor. Moisture meters are unpredictable in sheet flooring and this may necessitate oven dry moisture content testing. Prior to laying, the new floor should be of similar moisture content (within about 2%) to the existing floor.

Figure 4.13: Before laying over existing floors, the moisture content and structural integrity needs to be assessed.

Squeaking present in an existing T&G floor may be reduced by providing a bead of flooring adhesive to fill any gaps between the underside of flooring and tops of joists (caused by cupping, shrinkage, etc). Further reductions may be achieved by fixing a seasoned batten (approximate dimensions 35 mm x 45 mm or 19 mm x 60 mm) to the underside of flooring (mid-span between joists) and parallel to the joists, fixed with a full length bead of flooring adhesive and screwed at approximately 450 mm to 600 mm centres to hold the batten in place until the adhesive is set. This, however, requires that there is access to the underside of the floor. Squeaks can also occur from sheet sub-floor fixings and at times the joist fixings, particularly if they are in line with the bearers. Checking for sub-floor squeaks prior to laying the T&G floor can prevent concerns arising later on.

4.6.2 General Installation Recommendations

The secret fixing of boards requires one staple or cleat at the appropriate spacing. For (top) face nailing of boards through the sub-floor and into the joists two nails per board are required at each fixing for boards exceeding 65 mm cover width.

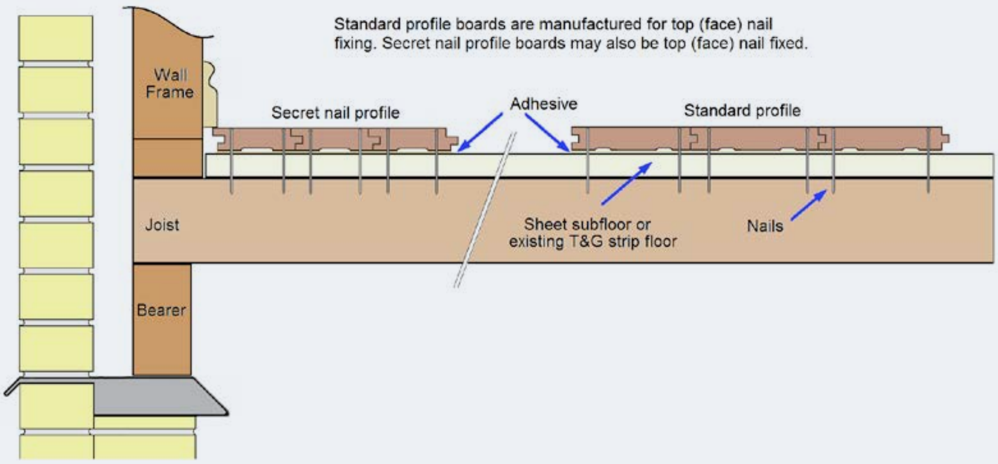
In humid and moist localities, additional care is required to cater for possible greater expansion. Consideration should be given to board moisture contents, providing for expansion, board size, and the species and fixing method. In some locations top (face) nailing with 19 mm or thicker boards may be the preferred option or a full bed of adhesive used. Overlay flooring can be more reactive to changes in environmental conditions that may be induced not only by conditions beneath the floor but also by sun exposure through large windows above the floor. For these reasons a full bed of adhesive is recommended. Some manufacturers do not recommend that their 130 mm x 19 mm or wider boards be secretly fixed and other manufacturers have specific fixing recommendations providing for the secret fixing of wider flooring that should be strictly adhered to.

Installation of flooring should not proceed until other construction activities (particularly wet trades) are complete and until after the building is roofed and enclosed. It is also preferable that the temperature and humidity are as close as possible to the expected in-service conditions although this is often not achievable as heating or cooling systems are generally not operating at the time of floor installation. Additional care or even delays to the installation should be considered if weather conditions are extreme for the locality (hot and humid, or hot and dry). As detailed above, expansion gaps of 10 mm minimum should be provided at all walls and other fixed obstructions, which are parallel to the run of floorboards.

For floors over 6m in width or where extra allowance for expansion is required (e.g. moist locations), an intermediate expansion joint, a series of smaller expansion gaps often every 800 mm to 1000 mm to provide equivalent spacing, or a combination of both is required. This is particularly so with full bed adhesive fixed floors or floors of higher density species in more humid locations.

4.6.3 Top (Face) Nailing into Joists through the Sub-floor (Substrate)

When structural 19 mm to 21 mm flooring is used, the flooring can be top (face) nailed through the existing floor or sheet floor and into the joists. Nailing is to be undertaken uniformly with respect to edge distances and alignment across the floor. Some variation due to joist layout may occur.



Fixing specifications - Top (face) nailing

- Bullet head 65 x 2.8 mm hand-driven or 65 x 2.5mm T-head machine-driven nails
- Boards to 65 mm wide, 1 or 2 nails per board at each joist crossing
- Boards 65 to 135mm wide, 2 nails per board at each joist crossing
- Boards wider than 135 mm, 3 nails per board

A 6 to 10 mm bead of flooring adhesive is applied in a zigzag pattern at the fixing points and midway between.

Board ends adjacent to walls should be adhesive fixed and nailed to the sub-floor.

Figure 4.14: Top (Face) nail nailing 19 mm thick flooring through timber and sheet sub-floors into the joists.

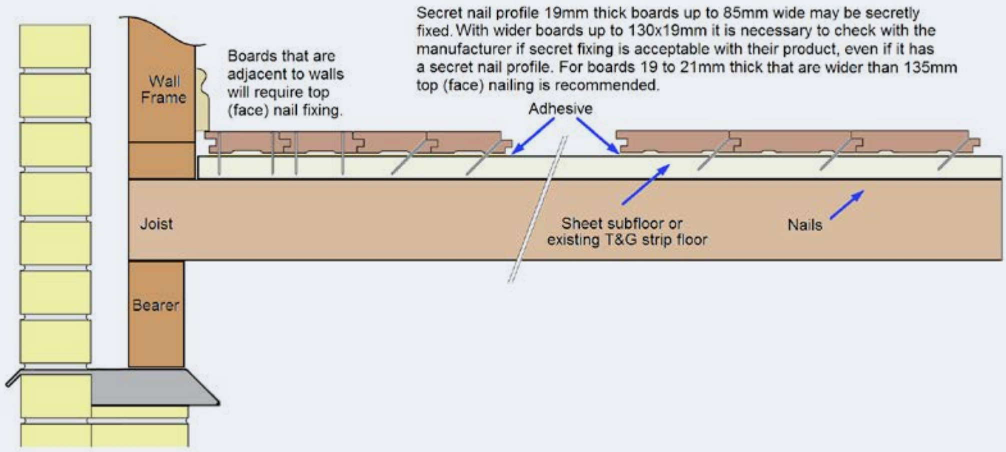
4.6.4 Secret Fixing into Sub-floor (Substrate) Only

When relying on the sub-floor or substrate for fixing, boards should be secretly fixed with the first and last few rows of boards that do not allow secret fixing being, top (face) nailed. When laying over an existing T&G sub-floor, the new flooring may be laid either parallel or at 90° to the existing boards, or at any other angle to the existing boards, providing the sub-floor (substrate) is within the required flatness tolerances and clean for adhesive fixing as outlined above. If there are potential concerns with seasonal movement of a T&G sub-floor affecting the appearance of the overlay floor, an underlay may be used. After the sub-floor is prepared, this can consist of approximately 6 mm thick plywood, adhesive and staple fixed to the T&G sub-floor. This may be achieved by adhesive beads at 100 mm intervals and staples around the perimeter of the sheet, 12 mm in from edges and spaced at 75 mm intervals. Through the main body of the sheets, staple spacing should be at 100 mm. The sheets should be laid in a brick bond pattern with the length of the sheets running at right angle to board length. In New Zealand, underlays are used when fixing over existing T&G sub-floors. Plywood squares approximately 400 mm x 400 mm are often used, which are full-bed adhesive fixed and temporarily screwed until the adhesive cures. With screws removed, a key sand and checking of floor flatness is undertaken. The fixing of the floor may be undertaken relying on a combination of mechanical and adhesive fixing. Some systems rely on mechanical fixing with beads of adhesive, while other systems rely on a full trowel spread bed of adhesive for the fixing. With full-bed adhesive systems, mechanical fixing is still used to ensure close contact between board and adhesive to result in a strong adhesive bond. In addition to fixings at recommended spacings, fixing is also required within 50 mm of board ends, however, if it is too close, splitting at ends may occur and should be avoided by fixing a little further from the ends.

When fixing 19 mm to 21mm thick boards up to 85 mm wide at close centres of approximately 225 mm, beads of adhesive to provide a cushion between the two floors helps to minimise possible squeaks. This is achieved by using a continuous bead of adhesive at 90° to board length midway between fixing points or a pattern ensuring there is adhesive to board edges. Where staples or cleats are spaced up to 450 mm apart, beads of adhesive are used at the fixing points and midway between.

With wider 19 mm thick flooring up to 135 mm, a full bed of adhesive with fixings up to 300 mm apart is applicable. Due to the reliance on the adhesive to provide much of the fixing in this instance, it is important that the adhesive manufacturer's recommendations for using the adhesive are followed. Surface cleanliness, flatness provisions and spread rate are all important. Further information on adhesives is provided in Section 5. Note that 130 x 19 mm and wider structural flooring is often required by manufacturers to be top nail fixed and therefore not recommended by them for secret fixing. Top (face) nailing through the sub-floor to the joist therefore needs to be considered or an alternate product permitting secret fixing of that board width used. With overlay flooring, board widths may be up to 180 mm and thickness generally between 12 and 14 mm. Overlay flooring is adhesive fixed with a full bed of adhesive.

The recommended fixing of the flooring is provided in Figures 4.15 and 4.16 in conjunction with the fixing specifications.



Fixing specifications - Top (face) nailing

Mechanical fixing with beads of adhesive

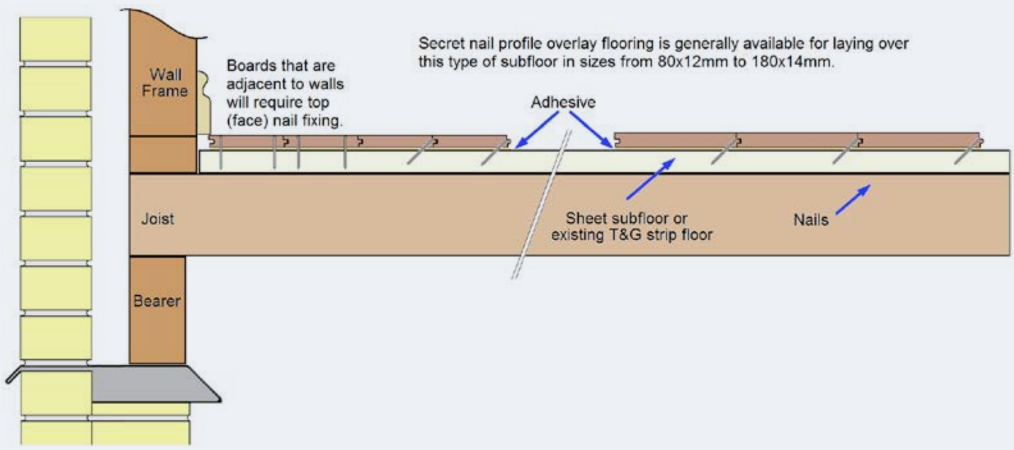
Limited to board widths up to 85 mm wide – 32 x 15 gauge staples or 32 x 18 gauge cleats:

- Either at approximately 225 mm centres and a bead of flooring adhesive (6 to 10 mm) applied in a zigzag pattern midway between the fixing points.
- Or at approximately 450 mm centres and a bead of flooring adhesive (6 to 10 mm) applied in a zigzag pattern at the fixing points and midway between.

Full trowel adhesive bed fixing

For all board widths up to 135 mm – 32 x 15 gauge staples or 32 x 16 gauge cleats at approximately 300 mm centres and with a full trowel bed of adhesive to the adhesive manufacturer's instructions. Note: suitability for secret fixing boards wider than 85 mm is to be checked with the flooring manufacturer.

Figure 4.15: Secret fixing 19 mm thick flooring to timber and sheet sub-floors on joists.



Fixing specifications - Top (face) nailing

Full trowel adhesive bed fixing

For all board widths – 25 x 15 gauge staples or 25 x 16 gauge cleats at approximately 300 mm centres and with a full trowel bed of adhesive to the adhesive manufacturer's instructions.

Figure 4.16: Secret fixing overlay flooring to timber and sheet sub-floors on joists.

4.7 Installation over Plywood or Battens on Concrete Slabs

The methods below are generally suitable for structural 19 mm thick flooring with board widths up to 180 mm wide and overlay flooring from 80 x12 mm to 180 x14 mm. Use structural flooring on battens and either structural or overlay flooring on plywood. The secret fixing of boards requires one staple or cleat at the required spacing.

In humid and moist localities, additional care is required to cater for possible greater expansion. Consideration should be given to board moisture contents, providing for expansion, board size, the species and fixing method. In some locations, top (face) nailing to the battens may be the preferred option or a full bed of adhesive used on plywood sub-floors. Overlay flooring can be more reactive to changes in environmental conditions that may be induced not only by conditions beneath the floor, but also by sun exposure through large windows above the floor. Some manufacturers do not recommend that their 130 x 19 mm or wider boards be secretly fixed and other manufacturers have specific fixing recommendations providing for the secret fixing of wider flooring that should be strictly adhered to.

4.7.1 Assessing the Concrete Slab

Timber floors may be laid on battens or plywood over a concrete slab, or by direct fix. Direct fix to the slab (as outlined in Section 5) is a more specialist field and, if considering this method, appropriate flooring contractors specialising in this field should be consulted and used. The following information covers installation of T&G flooring on plywood over concrete or on battens over concrete. Prior to installation, it is necessary to ensure that the concrete is sufficiently level to accept the system. Where there is a deviation of more than 3 mm below a 1.5 m straight edge (or, in New Zealand, 3 mm below a 3 m straight edge), a concrete topping (levelling compound), grinding or packing should be used. Slabs on ground should be constructed with a continuous under-slab vapour membrane to applicable AS or NZS standards. Timber floors should not be installed until the concrete slab has been assessed in accordance with Appendix C3. Generally, the slab will need to have cured for a period of at least three months after the roof and walls are in place and the building is enclosed. However, if due to moisture assessments or age of a slab it is considered to be near ready to accept a floor, applied moisture vapour retarding barriers can provide the necessary protection from slab moisture. These would need to be input from the particular company supplying the product.

Figure 4.17: Methods to lay timber floors over concrete slabs include battens, direct adhesive fix and over plywood. Direct adhesive fix should be undertaken by professional floor installers.

4.7.2 Installation

With floors fixed over a plywood sub-floor, overlay or structural flooring may be used but, structural flooring (19 mm or thicker) is required with battens. The plywood sub-floor or battens need to be at a moisture content within about 2% of the flooring to be installed at the time of installation.

Installation of flooring should not proceed until other construction activities (particularly wet trades) are complete and the building is roofed and enclosed. It is also preferable that the temperature and humidity are as close as possible to the expected in-service conditions, although this is often not achievable, as heating or cooling systems are generally not operating at the time of floor installation. Additional care or even delays to the installation should be considered if weather conditions are extreme for the locality (hot and humid, or hot and dry).

Figure 4.18: Secret fixing to a plywood sub-floor. A polyethylene moisture barrier has been placed over the slab and both the plywood and flooring are clear of the wall.

For secret fixing to plywood or battens, staples or cleats are used at the required spacing. For top (face) nailing of boards to battens, at each batten crossing, one or two nails are required for boards up to 65 mm wide; two nails per board are required for boards exceeding 65 mm in width and up to 135 mm; and three nails are required for boards wider than 135 mm fixed to battens. Nailing is to be undertaken uniformly with respect to edge distances and alignment across the floor.

As detailed above, expansion gaps of 10 mm at a minimum should be provided at all walls and other fixed obstructions, which are parallel to the run of floorboards. For floor widths over 6 m or where extra allowance for expansion is required (e.g. humid locations), an intermediate expansion joint, or a series of smaller expansion gaps (often every 800 mm to 1000 mm to provide equivalent spacing), or a combination of both is required. This is particularly so with full-bed adhesive fixed floors of higher density species in warm and humid locations.

As an added protection against moisture vapour from the slab (from slab edge effects, beam thickening etc.) or minor building leaks, a 0.2 mm thick polyethylene membrane is recommended. The polyethylene should be lapped by 200 mm, taped at the joints and brought up the walls (or fixed columns etc.) to or above the intended top surface of the flooring. The polyethylene is then covered by the skirting. Fixings of plywood sub-floors or battens through the polyethylene are not considered to reduce the overall effectiveness of the moisture vapour retarding barrier. An applied moisture vapour retarding barrier over the slab may also be used to protect against possible slab moisture (refer to Appendix C – Slab Moisture Assessment).

4.7.3 Fixing Recommendations – Plywood Sub-floors to Concrete Slabs and Fooring to Plywood

In Australia, plywood sub-floors that are non-structural CD grade, 15 mm thick and with a type A bond may be used, when hand-driven 'spike' fixed to the concrete slab. Plywood 12 mm thick is also used by floor installers but, with this thickness, greater consideration needs to be given to slab flatness and the possible perforation by fixings of moisture vapour retarding barrier beneath the plywood. Sheets may be installed in a 'brick' pattern or at 45° to the direction of the strip flooring with a minimum 6 mm gap between sheets and a minimum 10 mm gap to internal and external walls. In most cases, the plywood is fixed to the concrete. In those cases where for technical or acoustic reasons the plywood cannot be fixed to the concrete, the plywood sheets are laid at 45° to the direction of the floorboards and the end joints of the plywood sheets are staggered.

Various methods of fixing the plywood sheets to the concrete are used, including adhesives and mechanical fixing. In New Zealand, marine-grade structural plywood is generally used and may be mechanically or adhesive fixed to the slab over an applied moisture vapour retarding barrier. Use of polyethylene sheet as a moisture vapour retarding barrier beneath plywood is not practised in New Zealand.

Figure 4.19: Fixing of the plywood sub-floor through the polyethylene membrane and into the slab.

The option detailed below is for hand-driven spikes, which has proven to provide solid fixing to the slab:

- Slabs should be flat, in that there should not be more than 3 mm below a straight edge spanning between two high points in 1.5 m. If not, the effect needs to be assessed and the use of a topping compound prescribed for the purpose or other appropriate measures to provide a satisfactory floor installation should be undertaken.
- Install 0.2 mm polyethylene vapour barrier.
- Fix 15 mm thick plywood sheets through the membrane to the slab with hand-driven 50 mm long by 6.5 mm spikes (‘Powers SPIKE’ or equivalent). A minimum of 20 spikes should be used per 2,400 mm x 1,200 mm sheet, equally spaced (4 rows of 5 spikes down the length of the sheet) and with the outer spikes 75 mm to 100 mm from the sheet edge. If a brick pattern is used, it is preferable that sheets be staggered by 900 mm so that fixings do not line up from sheet to sheet. If 12 mm thick plywood is used, 28 fixings similarly spaced (4 rows of 7 spikes down the length of the sheet) should be used.

Figure 4.20: Adhesive spread prior to fixing.

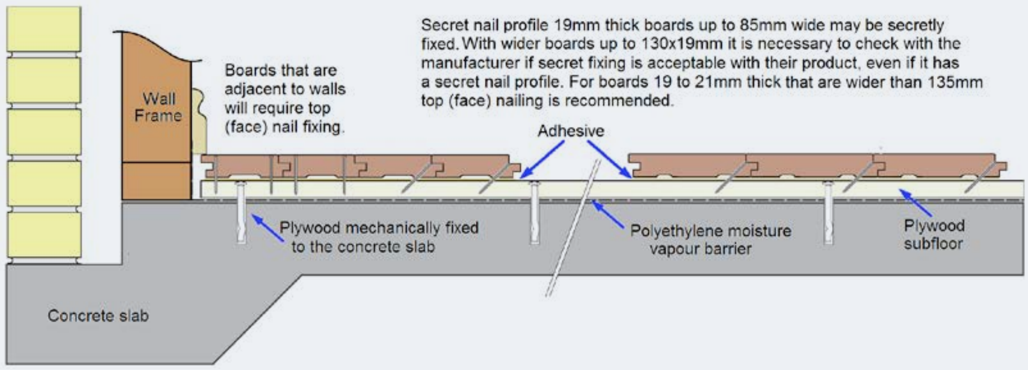
With regard to floor fixing, some systems rely on mechanical fixing with beads of adhesive while other systems rely on a full trowel-spread bed of adhesive for the fixing. With full-bed adhesive systems, mechanical fixing is still used to ensure close contact between board and adhesive to result in a strong adhesive bond. In addition to fixings at recommended spacings, fixing is also required within 50 mm of board ends; however, if too close, splitting at ends may occur and should be avoided by fixing a little further from the ends. When laying over the plywood, boards should be secretly fixed with the first and last few rows of boards that do not allow secret fixing, being top (face) nailed.

When secret fixing 19 to 21 mm thick boards up to 85 mm wide at close centres of approximately 225 mm, using beads of adhesive to provide a cushion between the two floors helps to minimise possible squeaks. This is achieved by using a continuous bead of adhesive at 90° to board length midway between fixing points, or a pattern, ensuring there is adhesive to board edges. Where staples or cleats are spaced up to 450 mm apart, beads of adhesive are used at the fixing points and midway between.

When laying with wider 19 mm thick flooring up to 135 mm, a full bed of adhesive with fixings up to 300 mm apart is applicable. Due to the reliance on the adhesive to provide much of the fixing in this instance, it is important that the adhesive manufacturer's recommendations for using the adhesive are followed. Surface cleanliness, flatness provisions and spread rate are all important. Further information on adhesives is provided in Section 5.

Note that 130 x 19 mm and wider structural flooring is often required by manufacturers to be top nail fixed and is therefore not recommended by them for secret fixing to plywood sub-floors over slabs. Top (face) nailing to battens therefore needs to be considered, or an alternate product permitting secret fixing of that board width used. With overlay flooring, board widths may be up to 180 mm and thickness generally between 12 mm and 14mm. Overlay flooring is generally adhesive fixed with a full bed of adhesive.

The recommended fixing of the flooring is provided in the diagrams below in conjunction with the fixing specifications.



Fixing specifications

Mechanical fixing with beads of adhesive

Limited to board widths up to 85 mm wide – 32 x 15 gauge staples or 32 x 18 gauge cleats:

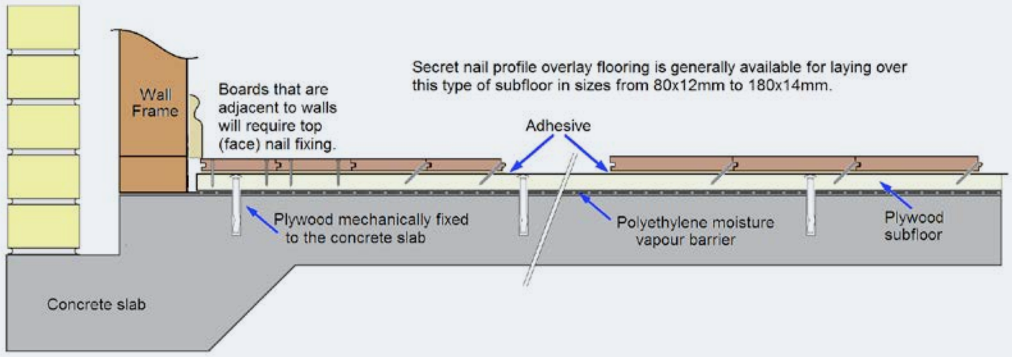
Either at approximately 225 mm centres and a bead of flooring adhesive (6 to 10 mm) applied in a zigzag pattern midway between the fixing points.

Or at approximately 450 mm centres and a bead of flooring adhesive (6 to 10 mm) applied in a zigzag pattern at the fixing points and midway between.

Full trowel adhesive bed fixing

For all board widths up to 135 mm – 32 x15 gauge staples or 32 x 16 gauge cleats at approximately 300 mm centres and with a full trowel bed of adhesive to the adhesive manufacturer's instructions. Note: suitability for secret fixing boards wider than 85 mm is to be checked with the flooring manufacturer.

Figure 4.21: Secret fixing 19 mm thick flooring to plywood sub-floor over a concrete slab.



Fixing specifications

Full trowel adhesive bed fixing

For all board widths – 25 x 15 gauge staples or 25 x 16 gauge cleats at approximately 300 mm centres and with a full trowel bed of adhesive to the adhesive manufacturer's instructions.

Figure 4.22: Secret fixing overlay flooring to plywood sub-floor over a concrete slab.

4.7.4 Fixing Recommendations – Battens to Concrete Slabs and Flooring to Battens

Battens are to be seasoned and may be either hardwood or softwood. Battens may be fixed to the slab using 75 x 6.5 mm gun nails at 600 mm maximum spacing. 'Powers Spike Fasteners' with a minimum embedment of 32 mm or equivalent fastener at 900 maximum spacing or M6 masonry anchors at 900 mm maximum spacing. Batten spacing is dependent on the species and grade of timber flooring used and the spacing shall be up to that for flooring being supported by joists (as provided in Section 4.5 – Installation direct to joists). Where higher expansion forces are expected after installation (e.g. warm humid, rural and coastal environments), batten spacing may be reduced to provide more robust fixing and floors that are secretly fixed. If battens are a minimum of 35 mm in thickness, the spacing between fastenings may be increased up to a maximum of 1,200 mm, provided minimal floor expansion force is expected after installation. Again, where higher expansion forces are expected after installation, a maximum fixing spacing of 600 mm is more frequently used with fixing in each adjacent row offset by 300 mm. This is to reduce the risk of the battens lifting off the slab surface under floor expansion and resulting in small surface undulations in the floor and more frequent hollow sounds or impact noise.

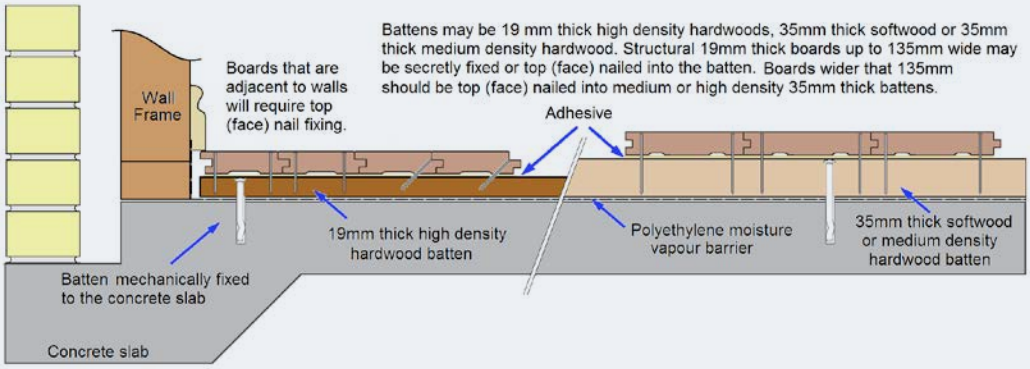
Structural flooring at least 19 mm thick needs to be used. Boards for secret fixing up to 135 mm wide can be secretly fixed with one staple or cleat at each batten crossing. Note that 130 x 19 mm and wider flooring is often required by manufacturers to be top nail fixed and is therefore not recommended by them for secret fixing to battens. Adhesive to the batten with a 6 to 10 mm bead in a tight zigzag pattern is recommended to reduce the risk of squeaking, assist with the fixing strength and ensure boards remain tight on the batten across their full width.

For secret fixing to battens, staples or cleats are used at each batten crossing. For top (face) nailing of boards to battens, at each batten crossing, one or two nails are required for boards up to 65 mm wide; two nails per board are required for boards exceeding 65 mm in width and up to 135 mm; and three nails are required for boards wider than 135 mm fixed to battens. Top (face) nailing is to be undertaken uniformly with respect to edge distances and alignment across the floor.

When fixing into battens, the batten needs to be sufficiently thick. The properties of the batten material used and the board size will govern the size of batten used. If battens are of lower density (including softwood, Cypress and hardwoods less than 750 kg/m^3 in density, e.g. Tasmanian Oak) then battens should be a minimum of 35 x 70 mm. Where high-density hardwood battens are used, the minimum size is 19 x 60 mm. Boards up to 135 mm wide may be secretly fixed or top (face nailed) into either the lower-density 35 mm thick batten or the higher-density 19 mm thick batten. Boards wider than 135 mm should be top-nailed into minimum 35 x 70 mm medium or high-density hardwood battens (such as Tasmanian Oak or Spotted Gum). Secret fixing of boards up to 135 mm wide is permitted with battens over a slab, but not when laid on joists. This is because the floor is not part of the building structure and conditions beneath the floor are more stable than a floor laid on joists that is open or has a closed-in sub-floor space beneath.

In warmer humid or moist localities, additional care is required to cater for possible greater expansion. Therefore, particular consideration should be given to board moisture contents to provide for expansion, board size, the species used and the fixing method.

The recommended fixing of the flooring is provided in the diagrams below in conjunction with the fixing specifications.



Fixing specifications

For all installations in conjunction with mechanical fixing, apply 6 to 10 mm beads of flooring adhesive to the battens in a tight zigzag pattern.

Secret fixing

- Board widths up to 85 mm wide into 19 mm thick battens – 32 x 15 gauge staples or 38 x 16 gauge cleats. For greater fixing strength (e.g. humid locations) or board widths up to 135 mm wide – 38 x 15 gauge staples or 38 x 16 gauge cleats.
- Board widths up to 85 mm wide into 35 mm thick battens – 45 x 15 gauge staples or 45 x 16 gauge cleats. For greater fixing strength (e.g. humid locations) or board widths up to 135 mm wide 50 x 15 gauge staples or 50 x 16 gauge cleats.

Top (face) fixing

- For board widths up to 135 mm wide into 19 mm thick battens – Machine-driven 32 x 2.2mm T-head nails.
- With 35 mm thick battens – Machine driven 45 x 2.2 mm T-head or 45 x 2.5 hand-driven bullet head nails. For greater fixing strength (e.g. warmer humid locations). Machine driven 50 x 2.2mm T-head or 50 x 2.8 hand-driven bullet head nails.

Figure 4.23: Secret and top (Face) nail fixing structural 19 mm thick flooring to battens over a concrete slab.

5

Site Sanded T&G Floor Installation: Adhesive Fixed to Concrete Sub-floors

5.1 Installation Practices

This section outlines the recommended practices for laying timber strip floors by direct adhesive fix to concrete slabs. This is one of three methods of laying a timber floor over a concrete slab and practices within this category differ between Australia and New Zealand and between states within Australia. Timber floors are also regularly laid on plywood or battens over a concrete slab and procedures for these other two methods are covered in Section 4.

When laying a floor by this method, which may include additional pinning (either temporary or permanent), there are aspects to consider in addition to those when laying over plywood or battens. Greater knowledge and understanding of concrete properties, levelling compounds, applied moisture vapour retarding barrier and adhesive performance are all necessary, and such installation should not be attempted without this knowledge and sound experience of general timber floor installation practices. In addition, greater care is necessary with higher density timbers, as expansion pressure in some localities can result in performance concerns (peaking, tenting and buckling). These can occur after adverse wet weather some years after installation. For this reason, floor installers may not recommend this method of installation or may advise it should only be used with thinner overlay products up to a specific board width.

Figure 5.1: Spotted Gum direct stick overlay floor.

One of the advantages of direct adhesive fix is that it can overcome possible height restrictions. The method is also used with parquetry (as covered in Section 6), which is commonly adhesive fixed to concrete slabs. It should be noted that it is not uncommon for direct adhesive fixed floors to have some 'drummy' areas and, where occurring, this should fall within industry guidelines.

Concerning practices around Australia, in Western Australia and particularly Perth – with its sandy soils and predominance of slab-on-ground double brick house construction – a particular method of installation has been developed. The majority of all timber floors in that state are laid by direct adhesive fix with supplementary top-nailing into the slab. Adelaide, which has winter heating and dry hot summers, uses direct adhesive fixing methods to slabs, similar to Perth. Some companies also have specific instructions on installing their overlay flooring direct to slabs and those instructions should be followed. Methods differ in other states, and there is a much greater mix of floors being laid by direct stick, over battens and over plywood. It is not uncommon for some individual installers in the eastern states to lay floors over slabs by each of these three methods depending on client preferences, timber species, site conditions and site constraints. Floors will have a different feel and sound when walked on, depending on what they are laid over. In the cooler climate of New Zealand, having significant periods of winter heating, direct adhesive fix systems to slabs are often used with techniques more in line with the practices used in Western Australia.

5.2 Assessing and Preparing the Slab

Slab assessment requirements are defined by most moisture vapour retarding barrier and adhesive manufacturers, and these do differ between product manufacturers –in both content and specific details. Practices used in slab assessment should meet the requirements of the product manufacturer and the assessment may need to go beyond what they require.

Aspects that commonly need to be assessed and what is required to prepare a slab are outlined below:

- Slab Moisture – Details regarding the moisture assessment of slabs are provided in Appendix C and this needs to be referred to. It is imperative that slabs are sufficiently dry to accept a timber floor to avoid cupping, inadequate adhesion and expansion-related issues that may arise from the redistribution of moisture in a slab after the floor is laid. Moisture vapour retarding barriers are often used as an added precaution.
- Surface Contaminants – It is expected that the surface will be clean, dry and free of paint, oil, grease, concrete curing sealers, previous adhesives and loose material, etc. There have been a number of instances where incompatible slab curing coatings that are not visible at the time of floor installation have prevented adhesion. Water droplets on a slab should freely soak into the surface; if not, the presence of a sealer or similar should be suspected. Mechanical removal is considered the most effective means of contaminant removal (grinding and shot blasting, etc).
- Slab Construction and Soundness – It is generally accepted that the new slabs will have been constructed to meet the applicable Australian and New Zealand standards for residential slabs and footings with a steel-trowelled finish, and will be free of floating ridges. Adhesive-fixed timber floors can fail if the slab is not suitably strong and the possibility of weak surface layers or previous patches of lower strength needs to be determined. Where suspected, the surface should be tested for weakness and hollow sounds. Any weak material needs to be removed and repaired.
- Flatness and levelling – Flatness provisions differ between adhesive manufacturers with many indicating a required flatness of 3 mm in 3 m. That is, any deviation is to be not more than 3 mm when the straight edge is placed on the slab, as shown in Figure 5.2. Self-levelling compounds with high tensile strength and rapid drying times may be required to level the slab and high spots may be ground off. When a moisture vapour retarding barrier is applied, it is usually applied beneath the levelling compound and subsequently primed prior to the levelling compound being applied. The primer enhances bond strength but may not be compatible with the adhesive and in such instances care is needed to ensure that all primer is covered.

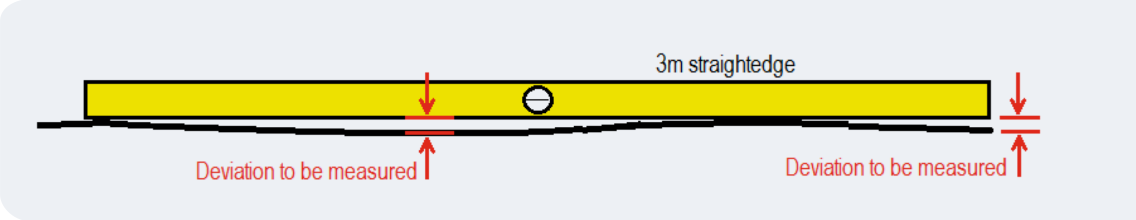


Figure 5.2: Measuring deviation.

- Slab construction joints – It is necessary to attend to slab construction joints before laying the floor. Floors have become moisture affected above joints that have not been sealed, resulting in boards cupping and expanding above the joint. Moisture ingress can be from either moisture vapour or capillary action. An applied moisture vapour retarding barrier to the slab is not going to prevent damage from this source.
- In some situations, and particularly when there is some uncertainty over slab integrity, it has been beneficial to undertake bond testing. This is where half the length of 300 mm long pieces of flooring are glued to the slab and, after 24 hours, are levered up to ensure sufficient strength and appropriate failure. The flooring should not be easy to lift and failure through the adhesive and the timber would be expected with minimal failure from the slab.

Figure 5.3: A slab being ground flat, which also removes contaminants.

5.3 Moisture Vapour Retarding Barrier

Many of the adhesive companies manufacture a compatible moisture vapour retarding barrier or will state what barrier is recommended with their product. Moisture vapour retarding barriers are not mandatory, but may be required by adhesive manufacturers as part of their warranted system. Many installers assess slab moisture and will determine the need to apply one or not. The purpose of the moisture vapour retarding barrier is to reduce any residual moisture migration from the slab to a sufficiently low level so that the timber flooring above is not affected. A moisture vapour retarding barrier is not a waterproof membrane. Requirements differ between products and usually the application of one or two coats is required with application by brush or roller. As with all coating systems, temperature and humidity constraints apply as well as recoating intervals. A curing period applies prior to the application of adhesives or levelling compound and there is often a time window for application of the adhesive, outside of which further preparation is necessary. Aspects relating to surface preparation as applicable, such as soundness and surface contaminants, are outlined above.

In timber flooring applications, it is often necessary to temporarily or permanently pin the floor to the slab. Following clarification on the effect of this from a number of moisture vapour retarding barrier manufacturers and after testing undertaken by these companies, a limited number of nail penetrations was considered by them as being acceptable with their products.

When a fixing is put into a slab and the moisture vapour retarding barrier is perforated, you would expect that there would be some leakage of moisture vapour around the fixing and, if the fixing was removed, there would be even greater moisture vapour transmission. The adjacent diagram illustrates the effects of moisture vapour transmission through a moisture vapour retarding barrier that has perforations from fixings. As indicated, the effects are small.

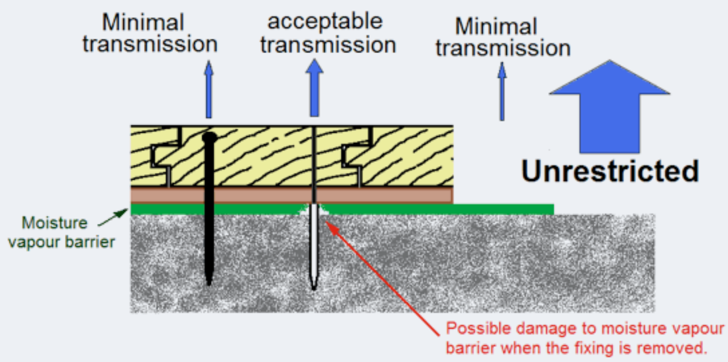


Figure 5.4: Effect of fixings through moisture vapour retarding barrier.

When a fixing is removed, there will generally be some damage to the moisture vapour retarding barrier and consideration must be given to this. Damage can expose a much larger area than the hole size of the fixing. For this reason it is best to leave fixings in place. If temporary fixing is used with clamps or similar for cramping the floor, this may mean grinding off the fixing flush with the sub-floor surface. It is necessary that nails are vertical and hand driven into predrilled holes. Angle fixing, as would occur with secret fixing, invariably chips the concrete surface and comprises the moisture vapour retarding barrier.

Companies that have undertaken testing consider that up to 10 fixings per square metre of a diameter of 3 to 4 mm would not significantly affect the performance of the moisture vapour retarding barrier or the timber flooring above. As such, provided the manufacturers' recommendations are complied with in all respects, this number of penetrations should not affect the manufacturers' warranties. To ensure that warranties are maintained, confirmation should be sought from the specific moisture vapour retarding barrier supplier that this applies to the product being used.

Slabs that are drier naturally present less risk from moisture vapour transmission and it is recommended that all slabs be at or near the recommended levels for timber floors over concrete slabs, prior to the use of moisture vapour retarding barriers (refer to slab moisture assessment in Appendix C).

5.4 Adhesives

Most of the adhesives on the market for direct adhesive fixed flooring are 1-part moisture curing polyurethane products or polymer adhesives. As indicated above, recommendations for the use of these products differ between manufacturers, both in content and specific details. It should also not be assumed that each product is the same in its properties. Some differences such as cured flexibility and foaming characteristics are easily observed; however, other characteristics such as initial hold, curing rate and final strength are not easy to discern. In addition, the polymer adhesives often have moisture vapour retarding and acoustic absorption properties.

All major manufacturers have data sheets for the use of their products and these need to be adhered to, specifically noting that the requirements in particular aspects of use may differ between products.

Aspects to be aware of include:

- Polyurethane adhesives are not designed to be moisture vapour retarding barriers and will not perform this task. Applicable polymer-based adhesives with moisture vapour retarding properties need to meet the conditions and application requirements of the product.
- The adhesive may not be compatible with primers used with levelling compounds.
- The curing rate for moisture curing adhesives will be slower in very dry conditions and can differ markedly between products.
- The working time will differ between products and needs to be adhered to.
- The time required for full curing can range up to about 7 days.
- Cleanup is easier with some products than others.
- Trowel size and the angle at which the trowel is held are both important to obtain the correct spread rate.
- It is necessary that some means of holding boards in place is employed (weighting or pinning) while the adhesive cures.
- Floor sanding is often not recommended to be undertaken for about 3 days.
-

Figure 5.5: Direct adhesive fixed 80 x19 mm Standard Grade Blackbutt.

Adhesives provide significant restraint to board movement (shrinkage and swelling); however, it must be recognised that many of Australia's hardwoods are very dense and the swelling forces generated can exceed the strength of the adhesives. Irrespective of how flexible an adhesive is, a similar amount of movement often occurs with higher density species. In locations where atmospheric moisture uptake causes significant expansion pressure, 'peaking' can also occur. This is a pressure-induced cupped appearance across a floor. Some flooring profiles are more prone to this than others. Profiles with higher levels of undercut or relief (difference between upper and lower cover widths) are generally more prone to peaking. To reduce in-service expansion pressure it is also necessary that the average moisture content of the flooring at the time of installation is aligned as closely as possible to that which the installed floor will attain in-service during humid periods of the year.

5.5 Direct Adhesive Fix Installation

5.5.1 Practices in the Eastern States of Australia

Installers may use a variety of practices to lay floors by this method and the following outlines those more commonly used.

General cleanliness is important and the floor area must be kept clean and free from debris such as stones that could prevent adequate contact between the board and the slab. Similarly, it must be ensured that partially cured adhesive on the trowel does not lessen the required spread rate or height of the adhesive. Adhesive height is particularly important to ensure bonding with variations in slab flatness. The adhesive to be used may be in either sausage form or a pail. If in a pail, any skin formed should be carefully removed to the point where the adhesive is soft below. The adhesive can then be squeezed from the sausage or distributed from the pail onto the slab surface. With pails, the lid should be loosely placed on the pail between applications to reduce the risk of curing in the pail. Care is also necessary to keep edges of the lid and pail clean if overnight storage of a part-used pail is necessary. In such instances, the pail with lid firmly attached is placed upside down.

Generally, for visual and expansion reasons, boards are laid parallel to the longest wall in the room or where boards will run lengthwise down hallways.

From the wall where the floor is being started, a chalk line parallel to the wall is 'flicked' on the floor approximately 800 mm out from the wall. The distance needs to take into consideration the actual board width and an allowance of at least 10 mm for expansion beneath the skirting.

Temporarily fix the 'starting board' with adhesive and concrete nails, often called 'mickey pins', to this line with the tongue facing the 'starting wall'. Ensure that the 'starter board' remains in firm contact with the adhesive until the adhesive has cured. The temporary pins may be removed after the adhesive has sufficiently cured, which is generally at least 24 hours.

At both ends of the floor, the required minimum 10 mm expansion allowance is also to be provided. A piece of timber of the required expansion width, placed along the wall and later removed, can be used to assist in providing an even gap.

Only use sufficient adhesive for the area that will be covered in about 20 minutes, which may be only 3 to 4 boards at a time. Adhesive manufacturers recommend that the adhesive should generally be spread at right angles to the edge of the board. The recommended notched trowel should be used to spread the adhesive, taking care to ensure the appropriate spread rate and height of adhesive is maintained.

Working from the area between the 'starter wall' and 'starter board' (now fixed in place), begin installing the floor left to right from the end wall, maintaining the required expansion gap, and lay the first row of boards away from the 'starter wall' by slotting the tongue of each board into the groove of a 'starter board' and then pressing the board firmly down into the adhesive.

When laying the boards, it is necessary to position the tongue and groove together and press the board into the adhesive as significant sliding action will spread the adhesive more thinly, lowering its height, and this in turn can then result in poor bonding between the board and slab.

In the first row, each board is laid until the wall is reached where the final board will need to be cut to fit, ensuring the required expansion gap is also provided at this wall. A board should be chosen so that the off-cut is long enough to be used at the start of the next row. With each new row, the boards should be gently tapped together, using an appropriate block so as not to damage board edges and to ensure a tight fit.

Continue to lay the floor from left to right. For any direct adhesive-fixed floor to perform, it is necessary that the boards are held down with the adhesive contacting both board and slab while the adhesive cures. Systems generally use the temporary concrete nails (as above) or weights (filled bags, filled pails or railway irons, etc). During the installation, temporary pinning will be required every 800 mm or so or the floor will need to be weighted to ensure a relatively even weight distribution.

It is good practice to ensure that end joints are at least 300 mm to 450 mm apart and that joints do not cluster together or align. This practice provides a floor that is generally considered to be more visually appealing. However, if there are many short board lengths in the flooring this may not be easy or possible to achieve.

When the wall opposite the 'starting wall' is reached the final board should be scribed and cut, again ensuring that the required expansion allowance is provided along the full length of the wall. Note that the walls in the room may not be parallel.

Once the main floor area has been laid, the area near the starting wall can be completed. At an appropriate time all temporary fixings or spacers can be removed.

A number of adhesive manufacturers indicate that floors should not be sanded for at least three days and, with some flooring products, longer periods of 7 to 14 days are considered beneficial.

5.5.2 Practices in Western Australia

In Western Australia, concrete nails approximately 3 mm in diameter provide mechanical fixing through the top surface of the boards, in addition to a full bed of adhesive beneath the floor. The nailing is done randomly throughout the floor, particularly in areas where drummy spots were observed during installation. Careful colour matching of the filler results in the nail penetrations blending in with the floor. The following section outlines performance-based considerations for acceptable practice by West Australian installers. Individual practices will vary to some degree between installers.

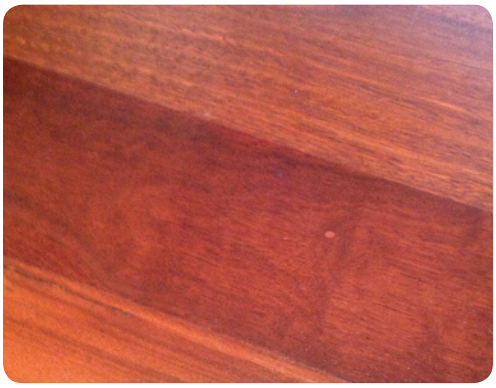


Figure 5.6: The nail penetration is to the bottom left of the photo.

Sub-floors and underlay

Surfaces must be clean and free from substances that may compromise the adhesive bond. The surface is to be in a sound condition and suitable for the purpose, that is, cohesive in structure and able to withstand the forces resulting from possible floor expansion above.

Cementitious screeds or concrete screeding may be required to patch or level sub-floors that are outside the flatness tolerances or to rectify surfaces unsuitable for glue-fixed installations. A sub-floor is generally considered sufficiently flat when no part of the sub-floor is more than 5 mm below a 3 m long straight edge placed at any location on the sub-floor. Screed application should be in accordance with manufacturers' instructions, and primers or bonding additives are recommended to enhance the bond strength of the screed. It is essential that all contaminations such as paint, plaster, old adhesive or PVA sealers be completely removed prior to screeding.

Underlay may be used as a base for glue-fixed timber flooring and common products are wood fibreboard, cement fibreboard and plywood. Underlays should be glue-fixed and nailed to achieve a sound base. Underlay thickness can vary and the installed product must be well bonded and solid.

Removal of old floor coverings such as carpet, vinyls, etc, is often required prior to the placement of glue-fixed timber flooring and the slab may need further work to provide a suitable substrate. If there is doubt about the suitability of a sub-floor for glue-fixed timber flooring, a trial lamination should be carried out to confirm the integrity of the proposed bonding base.

Moisture testing

Moisture testing is required prior to the installation of glue-fixed timber flooring. The moisture testing survey should include the proposed timber flooring and the slab. Where practical, the average relative humidity associated with the installation site should be established, which will assist in confirming the suitability of materials and site conditions. The results of the survey need to indicate that the flooring and concrete slab are suitable to proceed.

Slab moisture vapour retarding barriers

Slab moisture vapour retarding barriers are used to protect timber flooring from contamination via slab moisture that may be present at the time of installation, and as insurance against moisture that may enter the slab during the in-service life of the flooring. Moisture vapour retarding barriers need to be compatible with the proposed adhesive system and installed in accordance with the manufacturers' recommendations.

Adhesives

Adhesive, generally polyurethane or polymer-based, should be applied using a notched trowel as recommended by the manufacturer and the timber flooring should be well adhered to the sub-floor or underlay/sub-floor system, achieving a solid bond with no underfoot movement detectable after adhesive curing. When a board is placed into a bed of adhesive applied to recommended practices, the transfer of adhesive to the underside of the board with contact being maintained between the surfaces should achieve a minimum of 75% coverage. Some drummy boards can be expected in line with industry-accepted limits.

Clamping

Clamping/cramping of glue-fixed T&G timber flooring is carried out to reduce the gaps between boards. The degree of clamping/cramping required will vary with each product and consideration should be given to site conditions and the installer's evaluation of the product. Not all installations are gap free and some gaps are considered normal and acceptable in glue-fixed timber flooring. The filling of gaps is an acceptable practice.

Supplementary fixing

Supplementary fixing is carried out primarily to hold the timber boards or timber sections in place while the adhesive sets. These fixings can be permanent or temporary and can be applied mechanically or manually.

The amount of fixings can vary significantly and are often randomly applied across the floor depending on the flatness of the sub-floor. The amount and type of fixings are determined by the installer and based on site and material conditions. All holes or puncture marks resulting from supplementary fixing require filling.

Expansion allowance

Provision for expansion at walls and around fixed objects is an industry requirement and is normally set between 10 and 12 mm, depending on product and site conditions. Consideration for expansion provision is also recommended in installations which span 6 m or wider. This requirement can vary between products and installation systems and the implementation of expansion voids is often decided in consultation with the home owner or project manager.

5.5.3 Practices in New Zealand

In New Zealand, many floors are laid directly onto concrete slabs and outlined below are general procedures often used. Practices are similar to those used in Western Australia.

Sub-floors requirements and moisture assessment

The sub-floor requirements as outlined above in terms of the concrete slab needing to be dry, sound, clean and level apply. A sub-floor flatness of 3 mm in 3 m generally applies, and concrete slab sub-floors are made sufficiently flat through diamond grinding and use of levelling compounds. Slab moisture assessment is usually undertaken with above-slab relative humidity measurement, although in-slab relative humidity is also used. Above-slab humidity assesses moisture vapour transmission from the slab where checks may be done after a moisture vapour retarding barrier has been applied. Most levelling compound manufacturers require a primer to be applied over the moisture vapour retarding barrier to ensure the necessary adhesion of the levelling compound.

Flooring installation and finishing

The moisture content of the timber flooring is checked to see that it is close to the expected in-service moisture content and laid with a full trowel bed of adhesive. Semi-rigid polyurethane flooring adhesives are often used and need to be applied to the adhesive manufacturer's instructions. Some cramping may be undertaken and masonry nails and weights used to ensure a good adhesive bond. Expansion allowance is generally to the flooring supplier's specification, and may vary depending on wood density and how close the flooring moisture content is to the expected in-service moisture content. Following installation, the flooring is generally left for about two weeks prior to sanding and coating. This enables the flooring to acclimatise to the in-service conditions and undergo possible small shape changes prior to sanding, which will increase the likelihood of a flat floor.

6 Parquet and its Installation

6.1 Acceptable Appearance

The product is referred to as parquet prior to laying (refer AS 2796), and a parquetry floor after installation. This section provides information on block parquet, which is the main parquet flooring manufactured in Australia, as well as the now less common mosaic finger parquet. Block parquet consists of square edge blocks (as opposed to some imported parquet that has tongue and groove edges and ends) and is often of larger piece sizes. This section includes specific installation instructions, as well as information on manufacturing requirements, pre-installation considerations and pattern design names.

The specified recommendations contained in this Guide are generic in nature and although they are frequently used, installers with knowledge and experience in a particular locality, or other constraints, may fix a floor in a manner that differs from that outlined here. However, it needs to be recognised that such systems are non-standard and the installation becomes the floor installer's system rather than an industry recognised system. It is expected that all floor installations will be provided with a robust fixing method, and guidance on this can be obtained from the recognised methods outlined in this Guide.

When parquetry floors are installed with due provision for movement (applicable expansion), it is expected that the floor will be adequately fixed and without severe block shrinkage or severe expansion-related concerns, and will have a surface without obvious cupping.

6.2 Block Parquet Manufacture and Standards

The manufacture of parquet in Australia is governed by AS 2796 Timber – Hardwood – Sawn and milled products. It covers the manufacture of both block and finger parquet in Australia.

The Standard indicates that block parquet is to be manufactured 'square' dressed with a rebate, chamfer or groove machined to the underside to accommodate surplus adhesive. The Standard also indicates that 10 mm is the minimum thickness, even though a thickness of 14 mm to 19 mm is more commonly produced. The minimum wear thickness is half the block thickness.

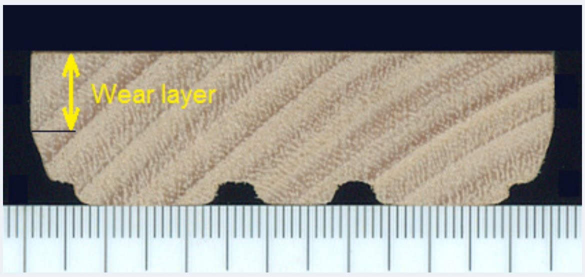


Figure 6.1: Typical 65 x 19mm block parquet profile.

The Standard indicates that the block length is to be a whole number multiple of the width and that the width-to-length tolerance does not exceed ± 0.5 mm, although manufacturers generally ensure that the multiple of block widths do not exceed block length. This small but important allowance ensures that block widths fit just inside the block length for the likes of a 'square on square' pattern.

Figure 6.2: Standard grade parquet.

In terms of moisture content, the range stated in the Standard is from 8% to 13%; however, as parquet is often manufactured from T&G flooring offcuts, the manufacturing range is more likely 9% to 13%. This variance makes no significant difference in practical terms. The Standard provides for the three grades for T&G timber flooring: Select Grade, Medium Feature Standard Grade and High Feature Grade. However, due to the small block size, a parquet floor with many blocks to Select Grade can appear higher in feature than a Select Grade T&G floor. A parquet Clear Grade (still with some feature) was included in the Standard to compensate for this. The Standard dates back many years, however, and we are not aware of any parquet Clear Grade currently being produced. Parquet in line with the other grades in the Standard is produced, but may fall under manufacturer grade names.

A common size of parquetry block is 260 mm x 65 mm, providing a 4:1 ratio. However, other block sizes may be 300 mm x 60 mm; or 400 mm x 80 mm (both providing a 5:1 ratio).

With mosaic finger parquet, the fingers are pre-adhered to a backing sheet and it is required that the sheet is sufficiently open to permit 75% adhesive contact when laid. The minimum finger thickness is 6 mm, with 8 mm and 9 mm being the more common thicknesses. Most mosaic finger parquet is a 'square on square' pattern with a 5:1 ratio and 120 mm finger length and a sheet size that can vary between manufacturers from single to groups of square panels. Ratios such as 6:1 with a 133 mm finger length and a 7:1 ratio with 145 mm finger length are also used.

The available Australian species are likely to be the northern and central coast New South Wales hardwoods, the southern Ash species and Jarrah.

6.3 Block Parquet Patterns

Figure 6.3: With parquet, a variety of patterns can be produced.

One of the attractions of a parquetry floor is the variety of patterns that can be achieved. Many of these patterns have standard names and are used extensively. However, patterns can be generated that are less standard or a distinct appearance can be achieved by using a combination of species, or creating borders to the room. More intricate patterns are used in residential work as well as commercial work.

Some of the patterns that can be achieved are illustrated in the diagram below. It shows the simpler patterns that are used more often, as well as more complex patterns that can be created. Some of the complex patterns are inspired by floors that can be found in European palaces.

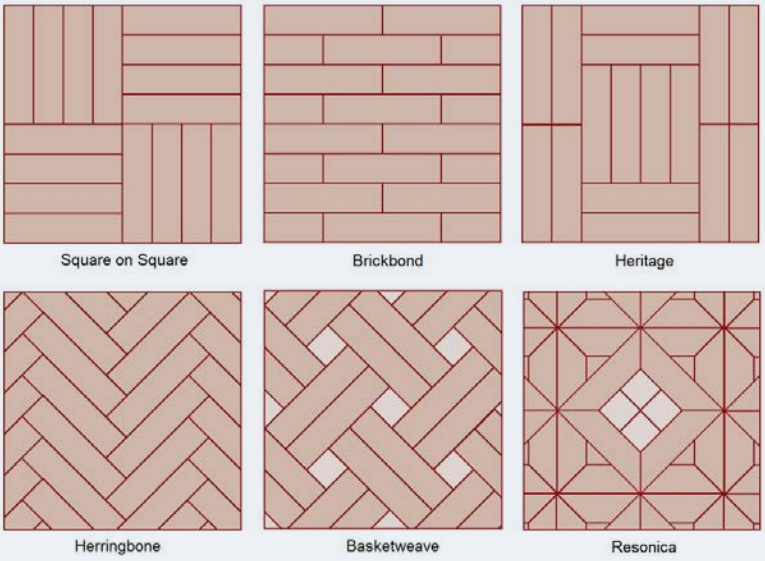


Figure 6.4: Parquet patterns.

Figure 6.5: Parquet at the Palace of Versailles, Paris.

6.4 Product Assessment

The products are usually packed into cardboard boxes after manufacture for ease of handling and, although often not provided with installation instructions, they are traditional products and subject to relatively few marketplace concerns.

When parquet boxes are received on-site, they should be checked for water or other damage. The product should be stored in a weathertight dwelling in an area away from external walls and direct sun exposure. If stored over a concrete slab, the boxes should be supported on gluts clear of the slab surface.

Before laying the flooring, it should be checked and should generally meet the following:

- Grade – Block parquet is to be supplied to the specified grade, which may be a manufacturer's grade. If a manufacturer has given a specific name to a grade, the product may be similar to one of the grades contained within an Australian Standard, but it is likely to differ in some respects. This may or may not be important to customers and should be resolved prior to supply. With imported product, grading applicable to the country of origin may apply and it may differ to that within the Australian manufacturing standard.
- Moisture content –The moisture content range for parquet is 8% to 13%, however, as block parquet is often manufactured as a by-product from strip flooring production, a range between 9% and 13% is more common.
- Block or finger moisture contents should be checked and recorded. Resistance moisture meter readings must be corrected for species and temperature, and may be affected by other factors. Corrected readings are estimates only. If in doubt, confirm results by oven-dry tests. Water marks or a significant increase in block width may be indicative of the blocks having been moisture affected.
- Block width should be checked and it should be noted that the check has been made. This is a simple test to ensure that, depending on the ratio, the number of blocks on edge do not exceed the length.
- Mosaic finger parquet should be checked and it should be noted that the check has been made. Again, this is a simple test, with the Standard indicating that the sheet is to be within ± 0.5 mm of the ordered size in both directions.

Any concerns relating to the above should be addressed prior to laying the floor. Although installers have a responsibility to check product before laying, suppliers have a responsibility to ensure product is adequately cared for, usually during transport and storage, and manufacturers have a responsibility to supply product meeting the relevant manufacturing Standard.

Figure 6.6: Imported product from a location where grading rules permit light-coloured sapwood. As this is infrequent, it is prudent to check that this meets client expectations.

6.5 Parquet Installation

6.5.1 Pre-installation

Aspects relating to pre-installation as outlined in Section 3.4 to 3.7 need to be considered for parquet flooring, although it is recognised that parquet provides a more stable floor than a T&G strip floor in the same location. These sections indicate that the site and installation environments need to be assessed and the sub-floor conditions need to be appropriate. Ensuring the sub-floor and sub-floor conditions are correct is particularly important. Acclimatisation is generally not appropriate because of the small piece size and also because it is important to maintain that the number of blocks on edge do not exceed the length. This is particularly necessary for many of the patterns used with block parquet. With moisture uptake, the block and finger width will expand but the block and finger length will not, therefore acclimatisation processes could be problematic.

With mosaic finger and many block patterns, pieces are laid at right angles to each other and – although this introduces expansion in both the width and length of the floor – it also halves the expansion that would be experienced from a solid timber strip floor. Attempts to acclimatise will also bring about variation in block width due to differences in block moisture contents and cutting pattern. This effect becomes more apparent with wider blocks. Parquet is also full-bed adhesive fixed, and this too limits the degree of expansion that occurs. Experience has shown that problems seldom occur due to expansion in parquetry floors, unless the floor has been moisture affected.

6.5.2 Allowance for Expansion

Parquetry floors require a minimum 10 mm expansion gap between the floorboards and any internal or external wall structures. Where skirtings may only be 10 mm wide, the wall board can be undercut or skirting may need to be replaced.

In many instances other than when the laying pattern is edge on edge, such as the brick bond pattern, parquetry in domestic floors does not generally require intermediate expansion allowance. If the pattern is edge on edge, then expansion allowance as for solid strip floors should be provided for block parquet (see Section 4.3). However, at times it will be necessary to separate one floor area from another, and this is more often in, for example, a doorway separating two larger floor areas. In such instances, cork expansion joints have been used with block parquet. Around doorways and architraves, the blocks can be trimmed to a neat but not tight fit. A cork expansion joint is generally used with other hard floor surfaces.

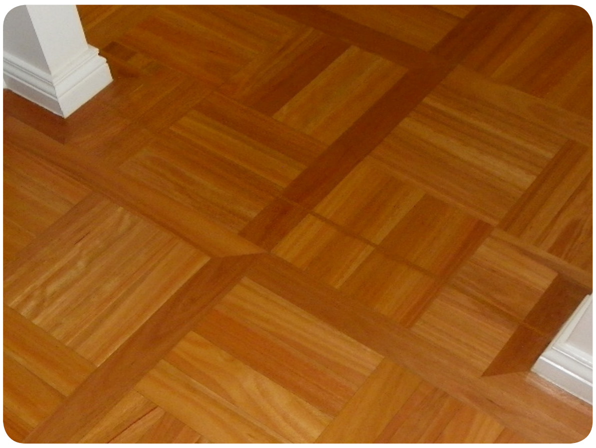


Figure 6.7: Cork expansion joint separating larger floor areas between two rooms.

6.5.3 Installation Procedures for Block Parquet

Parquet blocks are adhesive fixed to the sub-floor, which includes concrete, sheet flooring (particleboard and plywood) and existing timber floors. As such, the sub-floor assessment and preparation is the same as for site sanded and coated timber floors. For the assessment of concrete slabs, see Section 5 and Appendix C. For the assessment and preparation of sheet and timber floors, see Section 4. Note that in New Zealand a flatness tolerance of 1.5 mm beneath a 3 m straight edge is adhered to. When parquetry is laid over an existing timber floor, it may be necessary to provide a plywood underlay over the existing floor to prevent seasonal movement of a T&G sub-floor affecting the appearance of the parquetry floor. In New Zealand, it is standard practice to install a plywood underlay. The installation of underlays over T&G sub-floors is covered in Section 4.6.4. Masonite is sometimes also used. All timber and sheet sub-floors should be level sanded to remove any surface irregularities and to provide a clean surface.

Provided below are the general aspects involved in the set-out and installation of parquet floors, including consideration for borders. However, due to the wide range of patterns available, specifics will be determined by the flooring contractor who will also need to consider the layout of the dwelling.

Setting out

Within the room to be laid, it is usual for two chalk lines at right angles to each other to be made from the centre of the room, that are also near as possible to being parallel with the walls. A right angle can be determined by using the 3-4-5 rule and measurements of 900 mm, 1200 mm and 1500 mm. When one chalk line is made, the intersection of two arcs – one 1200 mm long from the room centre and the other 1500 mm long from the point 900 mm from the room centre – will provide the point where the line at right angles can be made. This is shown in Figure 6.8.

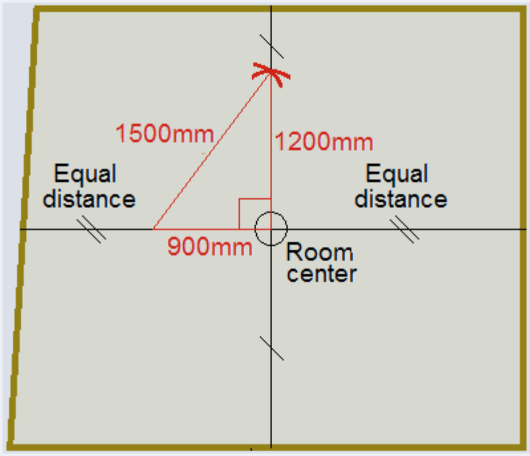


Figure 6.8: Setting out a parquet floor.

When a border is included, chalk lines are made parallel to and in from the walls, by the width of the border and the perimeter expansion allowance. When laying the blocks, adhesive is only applied up to these lines.

From the centre of the room, the block pattern is laid to the right and then to the left and this is then repeated throughout the body of the floor, with the perimeter of the floor being completed at the end. This process helps to maintain a consistent and square pattern throughout the installation. The process is shown in Figure 6.9.

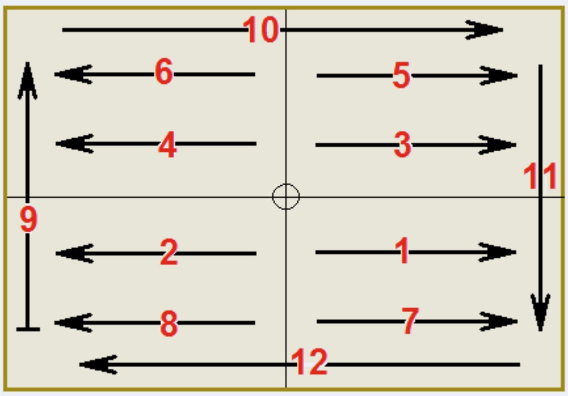


Figure 6.9: Including a border.

If a border is involved, the blocks from laying the body of the floor will overlap the border lines but, in the area of the border, they will not be bonded. After the adhesive has cured sufficiently (about 24 hours) the border lines can be remarked and, with the saw set to the correct depth, the excess can be cut off and removed to leave the main body of the floor up to the border edge. The border can then be completed.

Fixing practices

Water-based adhesives have been largely replaced with polyurethane adhesives, and some polymer adhesives are also entering the market. As some of the polyurethane adhesives foam on curing, some installers prefer to not use this type.

A full trowel bed of adhesive is applied to the slab, working from the centre and spreading about 1 m2 at a time before laying the blocks into the spread adhesive. Care is needed with the trowel to ensure the full height of adhesive is maintained as required by the adhesive manufacturer. To provide a more even distribution of colour and grade features, blocks should be laid from several boxes at one time (with a mix of manufacturing dates) and the blocks are then laid into the adhesive. During laying, it is important to keep to the string lines and also to ensure the pattern remains tight and even. Some variation in block sizes will occur due to timber properties, and such variations must be accommodated at the time of laying. If any creep occurs it cannot be corrected so, for this reason, centre and reference lines as well as the sequence of laying is important. For more intricate patterns, floors laid on the diagonal and the likes of herringbone patterns, additional reference lines are needed. A rubber mallet and timber block may be used to tap the blocks into the adhesive and reduce any mismatch at block edges. The floor is laid in a sequence as indicated in the diagram. During laying, stand or kneel on the sub-floor to ensure the blocks do not shift or slip after laying. When the perimeter of the floor is laid, blocks will need cutting – remembering that perimeter expansion allowance must be catered for. As outlined above, if a border is being installed then the blocks are cut back to the border line before working on the border. Expansion allowance at the floor perimeter is to be covered by the skirtings which need to be of sufficient thickness. The adhesive is then allowed to cure before sanding and coating as outlined in Section 8.

Parquet may also be laid on acoustic underlays and it is important that the correct underlay is used. More flexible underlays can result in blocks depressing under foot pressure once the floor is laid. To avoid this, underlays more specific to parquet are used, which are often cork and rubber composites.

Figure 6.10: Tallowwood 5:1 herringbone parquetry floor.

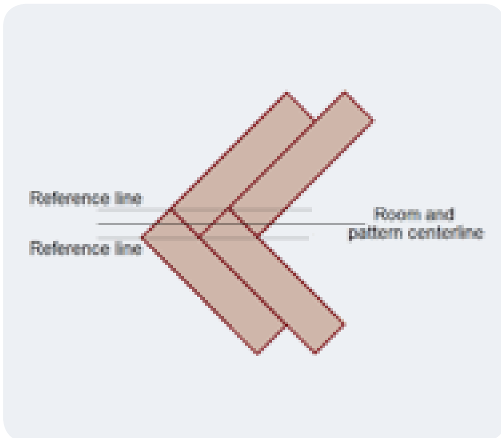


Figure 6.11: Centre and reference lines with herringbone pattern.

6.5.4 Installation Procedures for Mosaic Finger Parquet

The mosaic finger sheets are adhesive fixed to the sub-floor which includes concrete, sheet flooring (particleboard and plywood) and existing timber floors. As such the sub-floor assessment and preparation is the same as for site sanded and coated timber floors. For the assessment of concrete slabs refer to Section 5 and Appendix C. For the assessment and preparation of sheet and timber floors refer to Section 4. When parquetry is laid over an existing timber floor, it may be necessary to provide a plywood underlay over the existing floor to prevent seasonal movement of a T&G sub-floor affecting the appearance of the parquetry floor. This is covered in Section 4.6.4. Masonite is sometimes also used. All timber and sheet sub-floors should be level sanded to remove any surface irregularities and to provide a clean surface.

The sheet can be laid with a similar set out and procedure to block parquet (as above) with a full trowel bed of timber flooring adhesive being used. Some may also choose to lay the sheets at 45° to the walls, which can significantly change the look of the floor.

7

Prefinished T&G and its Installation

7.1 Installation Practice and Products

This product type is currently imported into Australia and New Zealand and is available in both Australian and exotic species. As a prefinished product, it should not be seen as being manufactured to the same specification as site sanded and coated solid Australian T&G flooring. Some product entering the country will be manufactured to the requirements of markets in perhaps Europe or the USA, while other products – often in Australian species – will be manufactured more suited to the Australian installation environment. As the product is imported, there is no Australian Standard that covers the manufacture of the product, so care is needed and checks on the product are required prior to installation. Flooring that is a minimum of 18 mm thick and at least meeting the grading requirements applicable to raw solid timber flooring (noting that flooring free of feature would comply with Select Grade) can be regarded as a structural floor.

Product is manufactured in a range of board widths up to about 130 mm wide and can include edge-laminated two strip boards. For transport and packaging in boxes, lengths up to about 1.8 m to 2.4 m are available to suit the box length. 'Nested' lengths with two or three pieces making up the box length can be expected and boards are end-matched. The maximum and minimum length will vary between manufacturers. Flooring is generally 18 mm thick and with a UV multilayer coating system to the exposed face. Boards are generally bevel edged and this will range from a micro bevel to bevels that are more pronounced. Although most flooring can be produced to be very straight, some boards will be more prone to some warping (bow, spring and twist) after manufacture. These effects become more apparent in longer length boards.

Figure 7.1: Pyinkado 127x 18 mm prefinished floor.

As this product type is more highly manufactured than site sanded and coated flooring, it should be expected that the products will be provided with accompanying installation instructions. These instructions should be strictly followed, as they take precedence over the generic methods outlined in this standard. If flooring is fixed contrary to the manufacturer's intention for the product it may affect possible warranty claims.

Laying a timber floor is a three-step process that requires: assessment of the product being laid; assessment of the expected in-service environment; and laying the floor by an appropriate method. This includes assessing that the sub-floor is also suitable to be laid over.

The specified recommendations contained in this Guide are generic in nature and although they are frequently used, installers with knowledge and experience in a particular locality, or other constraints, may fix a floor in a manner that differs from that outlined here. However, it needs to be recognised that such systems are non-standard and the installation becomes the floor installer's system rather than an industry recognised system. It is expected that all floor installations will be provided with a robust fixing method and guidance on this can be obtained from the recognised methods outlined in this Guide.

When prefinished solid floors are installed with due provision for movement (applicable expansion allowance and acclimatisation as applicable), it is expected that a floor will be provided that is adequately fixed and without severe board shrinkage or severe expansion-related concerns, and which has a surface without obvious cupping.

Provided below is further information about the products and their characteristics, including how they differ from raw solid timber boards, along with aspects that should be checked prior to laying and an outline industry-accepted installation practice.

7.2 Product Characteristics

As prefinished timber flooring is manufactured, it is important to realise that the coating to the upper face is UV-cured, multi-layered and often has aluminium oxide in one of the coats to increase wear resistance. The boards are also coated to edges and underside, often with a single coat of polyurethane.

As this flooring does not require site sanding and coating, it must also be considered that, as opposed to site sanded and coated boards, any slight cupped appearance or other movement effects cannot be sanded out.

In addition, the permeability of the coating on the upper exposed surface is generally lower than that through the coating to the underside of the board. This affects the rate of moisture transfer through the boards and any acclimatisation processes used may not be balanced, with preferential moisture uptake into the lower board surface and the potential to induce some cupping. However, once laid and over a dry sub-floor, moisture uptake through exposed UV-coated finish will generally be less than a site sanded and coated floor. As such, this reduces seasonal movement and provides for greater product stability. It is also important that the flooring is protected from possible moisture from beneath the floor as the products are usually more prone to cupping from moisture from beneath. The flooring should preferably be manufactured close to the expected average in-service moisture content, which for most of floors in major Australian cities is about 9 to 11%.

Therefore, the manufacture of the product is particularly important, and as there is no Australian Standard covering the manufacturing, it is also important that the product is assessed prior to laying. Although board profiles will vary from one manufacturer to another, is a typical board profile with associated features identified is provided below.

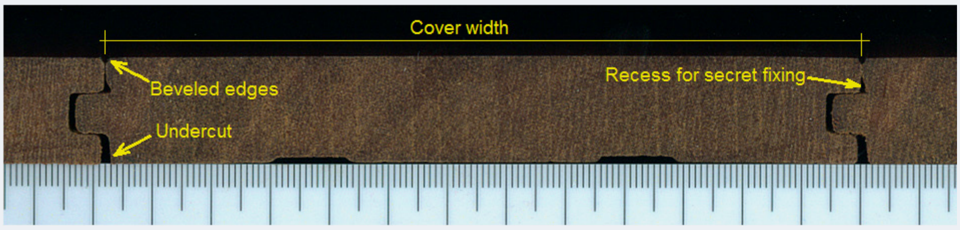


Figure 7.2: Typical board profile.

Most products have bevelled edges and ends which define the boards' outline in the floor. Any mismatch causing one board to be a little higher than an adjoining board will not result in sharp edges when boards are bevelled. Sharp edge boards can also be prone to splintering at their edges. The size of the bevel will vary between manufacturers and it ranges from a micro bevel, resulting in the boards being less defined in the floor, to a more distinct bevel.

Some products have a high level of undercut and care is necessary if higher density boards are laid in humid environments, resulting in higher expansion forces after laying. This can lead to the floor peaking, which results in a pressure-related cupped appearance.

The following aspects need to be checked and considered at the time of laying.

Figure 7.3: Peaking due to expansion pressure.

7.3 Product Assessment

When timber flooring is received on-site, it will usually be in plastic-wrapped cardboard boxes and it is necessary to ensure that the boxes have not been water or otherwise damaged. Product should be provided with installation instructions; however, this will not always be the case. The product should be stored in the weathertight dwelling in an area away from external walls and direct sun exposure. If stored over a concrete slab, the boxes should be supported on gluts clear of the slab surface.

Prior to laying, the flooring it should be checked and should generally meet the following:

- Grade – Product from exotic species is generally free of feature. With Australian species, it may be free of feature or may be to one of the Australian grades used for site sanded and coated timber floors. It should be established that the boxes are marked with the appropriate grade that was ordered.
- Moisture content – This should be in the range of 9% to 14% with the average moisture content for all pieces approximately 10 to 12%. There have been concerns resulting from product containing a significant number of boards at moisture contents below the lower limit of this range, and this has resulted in expansion-related problems after installation. Also, some product may have boards high in moisture content resulting shrinkage after installation. It is therefore important that a broad sample of boards are moisture content tested prior to laying. With some imported species, moisture meter correction may not be easily attainable. The flooring supplier has a responsibility to provide this information if not provided in AS 1080.1 Timber – Methods of Test – Method 1 – Moisture content. Moisture contents should be checked and recorded. Resistance moisture meter readings are to be corrected for species and temperature. Corrected readings are estimates only; if they are either high or low the supplier should be contacted and it may be necessary to confirm moisture contents by the oven-dry test method.
- Cover width of strip flooring – This should be checked and recorded. For prefinished strip flooring, there should not be more than 1 mm difference between one board and another. Cover widths should generally be within 0.5 mm of the nominal cover width. (If in excess of this, it can reflect changes to board dimensions that can occur after milling and prior to installation, and therefore be outside of manufacturing limits).
- Bevelled edges and mismatch – Most prefinished solid flooring is manufactured with the upper board edges bevelled (that is, the sharp edge at adjoining board face and edge removed). This to compensate for any mismatch in the machining and variance in board machining tolerance. When boards with bevelled edges are laid the mismatch is not to exceed 0.5 mm.
- Warping – Boards should not be visibly cupped prior to laying and any warping (bow, spring and twist) should be minimal so as not to prevent boards from being able to be flat when fixed and without gaps or lipping greater than 0.5 mm due to warping.
- Tongue and groove tolerance in strip flooring – Generally, this should not be less than 0.3 mm or greater than 0.6 mm. Boards should slot together to form a ‘snug’ fit. The fit should not be loose and sloppy or overly tight. A tighter tolerance may apply to some prefinished flooring, particularly if edges are not bevelled.

- Undercut in prefinished flooring – this is the difference between the upper and lower cover width of the boards. In Australia, it is appropriate for the undercut to be about 0.5 mm for an 80-mm-wide board, and a little more as board width increases. If the undercut is large and there is significant expansion pressure after installation, significant 'peaking' (pressure-related cupped appearance) can occur. The smaller the undercut, the less the effect. If imported prefinished flooring has been supplied with undercut significantly wider than that recommended here, should peaking occur, the manufacture of the product is often considered a contributing factor.

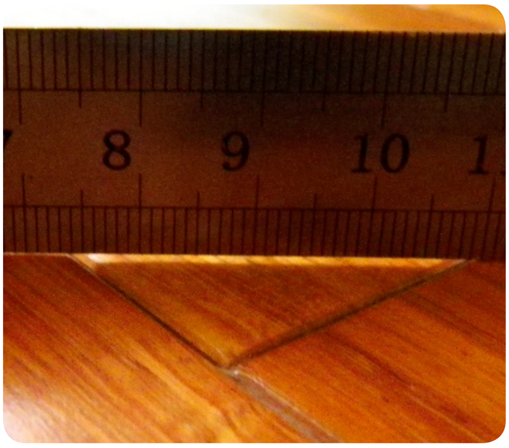


Figure 7.4: The effect of bevelled edges minimising mismatch effects.

Any concerns relating to the above should be addressed before the floor is laid. Although installers have a responsibility to check product prior to laying, suppliers have a responsibility to ensure product is adequately cared for, usually during transport and storage and manufacturers have a responsibility to supply product meeting the above points and that is fit for laying. Installation instructions should also be provided with the product or be available through the supplier of the product.

7.4 Prefinished Solid Installation in Australia

7.4.1 Pre-installation

Aspects relating to pre-installation as outlined in Section 3.4 to 3.7 are applicable to prefinished solid timber flooring. These sections indicate that the site and installation environments need to be assessed and that the sub-floor conditions need to be appropriate. As indicated above, proper acclimatisation may be more difficult to achieve with this product type and there is a need for the average manufactured moisture content to be close to the expected average in-service moisture content.

7.4.2 Allowance for Expansion

Prefinished solid floors require a minimum 10 mm expansion gap between the floorboards and any internal or external wall structures. However, where board ends abut doorways, the gap may be reduced to a neat fit but with a small gap (approximately 1 mm) to prevent rubbing. Where skirtings may only be 10 mm wide, the wall board can be undercut or skirting may need to be replaced.

Due to the flooring being prefinished, it is not appropriate to use cork expansion joints for intermediate expansion allowance. However, intermediate expansion allowance through a series of small regularly spaced gaps (2 mm gaps every 1 m to 1.5 m) can be used. The use and spacing of these gaps will depend on the initial moisture content of the floor and humidity levels within the installation environment. This allowance should be considered for all floors, but also recognising that many floors will be assessed as not needing intermediate allowance. When floors are provided with intermediate expansion allowance the gaps provided will often close at the time of the year when higher humidity conditions prevail. In some instances, a caulked joint will be used in doorways to segment one floor area or room from another. While such joints provide for some movement, it is on the proviso that the flooring will be near its average installation moisture content when laid.

Figure 7.5: Caulked joint used to relieve potential expansion pressure through a narrower doorway linking two larger floor areas.

7.4.3 Installation Procedures for Prefinished Solid Flooring

Prefinished flooring is generally manufactured up to a board width of 130 mm and, for product up to this width, secret fixing over a plywood or particleboard sub-floor is the preferred method of installation. It is necessary that the sub-floor is flat with deviations of not more than 3 mm below a 1.5 m straight edge. The surface also needs to be clean and free from any debris or protrusions from the sub-floor, as this can show through to the floor surface.

Prior to laying, as with other prefinished flooring products, boards should be checked for any faults to the surface or coating and any possible higher levels of warping. With some floors, there may also be grade considerations. Any boards that would be considered to visually depreciate the appearance of the floor from a standing position should not be laid.

As discussed above, the product is more susceptible to moisture from beneath. For this reason, if the flooring is laid on plywood over a concrete slab, a plastic sheet is to be laid under the plywood or a moisture vapour retarding barrier is to be applied to the slab, for all installations. Black polyethylene 0.2 mm thick should be lapped by 200 mm, taped at the joints and brought up the walls (or fixed columns, etc) to or above the intended top surface of the flooring. The polyethylene is then covered by the skirting. Note that fixings of plywood sub-floors through the polyethylene are not considered to reduce the overall effectiveness of the moisture vapour retarding barrier. An applied moisture vapour retarding barrier over the slab may also be used to protect against possible slab moisture (refer to Appendix C – Slab Moisture Assessment).

Prefinished floors may at times be laid on sheet or existing timber sub-floors to joists that are over an open or enclosed sub-floor space. In such instances, the prefinished flooring will be more susceptible to variable conditions that can occur beneath the floor and, prior to lifting, carpets may have trapped higher levels of moisture in the sub-floor. Before laying the prefinished flooring, it is necessary to ensure that the sub-floor space is dry and well ventilated and meeting the requirements set out in Section 3.5. However, as an added precaution, it is often necessary to lay black 0.2 mm thick polyethylene over the sheet or timber sub-floor to prevent possible moisture in the sub-floor from transferring to the prefinished flooring after it is laid. Joints in the polyethylene are similarly lapped by 200 mm and taped. Note that the sub-floor sheet can still breathe through the lower surface.

The preferred method of installation is closely spaced 32 x 15 gauge staple fixing at 250 mm centres, attached directly to the sheet sub-floor to provide a secretly fixed floor. The fixing may be through the polyethylene sheet over the sheet sub-floor. If fixing is direct to the sheet sub-floor, then beads of adhesive midway between fixing points should be used to minimise possible squeaking between the floor and sub-floor. With the closely spaced staples, this should be regarded as a mechanically fixed floor. Note that attempts to direct adhesive fix to slabs without mechanical fixing, and with higher density timbers in warm humid localities, has resulted in expansion-related failures.

Close to walls where the nailing gun cannot reach, the flooring may be top-nailed and an appropriate filler colour used to fill nail holes. Nails are to be punched 3 mm below the surface. The nailing gun with some clamping action minimises any gapping at board edges due to spring in the boards (lengthwise curvature) and assists to remove minor twist (one corner is raised when the board rests on the floor). If boards longer than 1200 mm have noticeable spring or twist then they may be cut back to this length to minimise any gapping of unevenness that may show once the board is fixed in place.

An alternate method is to adhesive fix the flooring to the sheet sub-floor with a full trowel bed of flooring adhesive. As the sheet sub-floor is without a moisture vapour retarding barrier, this method is not suited to installation on sheet or timber sub-floors on joists with either open or enclosed sub-floor spaces. The surface of the sheet sub-floor needs to be within the required flatness tolerances for an adhesive fixed system, and to be sound, dry and providing a clean surface for adhesive fixing as further detailed in Section 4.6. For adhesive fixing, the flatness tolerance as provided by the adhesive manufacturer is tighter than for mechanical fixing. If this method is used, it needs to be recognised that both spring and twist cannot be removed during laying and that, with no mechanical fixing, sub-floor flatness becomes increasingly important. As such, the flooring needs to be free from any warp that may result in concerns with the floor's appearance (e.g. wider gapping at some board edges, lipping at board ends due to twist) and the floor needs to be weighted until the adhesive has cured. Taking this into consideration, fixing by this method is more suited to shorter length boards under about 1200 mm in length. Consequently, the preferred method of installation is by mechanical fixing, as that method negates some of these potential concerns.

Laying practice also need to be considered as, in many instances, owners will be expecting a floor that has the appearance in terms of board layout that is similar to a site sanded and coated floor. Regular patterns of board ends and very short boards in the main body of the floor should be avoided. Board ends in adjacent runs should not be within two board widths and regular patterns such as a 'step' or 'H' pattern should be avoided. Also ensure that if boards of, say, three lengths are provided, that these also do not form a regular pattern. If this occurs, it does not necessarily mean that remedial work is necessary to correct it, but it is not considered to be good practice.

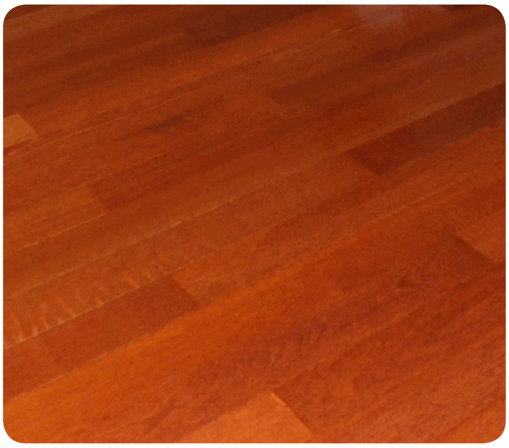


Figure 7.6: A regular pattern where every second board end lines up should be avoided.

On completion, the appearance of the floor should be checked and any minor chipping or damage that may occur at some board ends or edges may be filled with coloured hard wax. As a natural solid timber flooring product, it will be subject to small differences in movement (expansion and shrinkage) between boards. Minor gaping at some board edges may therefore be present after installation and could benefit from a colour-matched filler applied to the base of the bevel. Infrequent minor splits or checks in the coating particularly at features can occur, and are generally not detrimental.

8 Sanding and Finishing

8.1 Sanding and Finishing Practice

The sanding and finishing process is particularly important to the overall performance and appearance of the timber floor and offers a wide array of methodologies and coating systems. The practices outlined are those employed broadly throughout the industry; however, variations on sandpaper grades and procedures are common. The aim in all cases is to provide a smooth surface with the desired surface coating suitably applied to give an even level of sheen across the body of the floor. It is important that when the floor is being sanded and finished the floor is not walked on by anyone, unless under the supervision of the sander and finisher. Simple things such as fly spray, silicone sealer, boots and bare feet can detrimentally affect the floor finish. Generally, floors are out of bounds to everyone until the finisher indicates that they can be walked on.

This section aligns with *AS 4786.2 Timber Flooring – Part 2: Sanding and finishing* but has some aspects updated.

8.2 Assessing the Floor Prior to Sanding

Prior to sanding the condition of the floor should be assessed to ensure that it is suitable for sanding. This may include assessing vertical movement at board or end-matched joints, an appraisal of the overall condition and appearance of the floor (e.g. degree of cupping in boards, gapping at board edges, signs of moisture). If there are signs of abnormal moisture content, it should also include taking and recording moisture contents and moisture gradient of the installed floor. This ensures a complete history of the floor, should issues arise in the future. Any issues should be provided in writing to the applicable person (e.g. principal contractor, owner) and an appropriate course of action taken. In the case of newly installed floors, it is good practice to let the floor 'settle' for a period, which may be 3 to 14 days before the sanding process takes place, ideally in conditions that are the same as, or close to, the in-service conditions that will exist after completion. This period assists in allowing the installed floor to adjust to the internal environment where boards may undergo small shape changes prior to being sanded, and may also be necessary for curing of adhesives. This assists in obtaining a floor that exhibits minimal shape change after sanding.

Figure 8.1: Prior to sanding, the floor should be assessed to ensure that it is in a condition suitable for sanding.

8.3 Preparation for Sanding

8.3.1 Punching Nails and Filling Nail Holes

Before the sanding process can begin, ensure that all nails are punched a minimum of 3 mm below the surface of the boards. Any nail that is not suitably punched will potentially damage the sanding equipment and affect the sanding process. It is important to note that secret nailed floors may have been top (face) nailed adjacent to a wall or other areas where access is limited.

The punched nail holes can then be filled with a filler that is compatible to the surface coating (a non-oil based filler). Oil-based fillers may bleed oil into the timber and affect the colour of the wood surrounding the nail hole. In addition, they may not be compatible with various coating products and their use with these coatings is not recommended. The colour of the filler should generally be selected to minimise the visual impact of the filler on the completed floor. Many of these products are sold in colours pre-matched to specific species. In mixed species floors, or where significant colour variations are present, it is usual to mix or select a colour that is slightly darker than mid-range between the extremes of colour. Generally, all fillers are slightly darker and this allows for the boards to deepen in colour following finishing and UV exposure.

Filling can be done at this stage or after the first coat of finish is applied. By filling after the first coat of finish any potential for the filler to impact on the surrounding timber through bleed or moisture is minimised. Filling after the first coat of finish is however not suitable with all coatings and if in doubt refer back to the coating manufacturer. In all cases the filler must completely fill the hole so as not to impact on the finish quality.

Figure 8.2: Nails are to be punched and holes filled.

8.3.2 Cleaning

The floor requires thorough cleaning to make it free from dirt, grit and debris. These particles, if not removed, can cause deep, uneven scratching in the timber surface requiring substantial additional sanding to remove. The floor should be swept and then vacuumed, with particular attention given to areas not effectively cleaned by sweeping, such as gaps underneath the skirting, corners, window sills, etc. The vacuum should have sufficient capacity in terms of both suction and filtration to satisfactorily clean the floor. When sanding existing floors, care needs to be exercised where gapping at board edges is present as accumulated debris can be trapped in the gaps and loosen during the sanding process, causing unacceptable scratching of the floor. The potential problem needs to be recognised at all stages of the sanding process including the cut-back of the finish between coats.

It is important to remove any materials that may affect either the sanding or coating process. Additional care should be taken with silicone-based sealants that may have been dropped onto the floor. These products can be widely spread through the sanding process, affecting the bond between the coating and the timber.

8.3.3 Protection

During the sanding and finishing process, access to the area of the work must be restricted or denied completely. Any trades working in or around the area can potentially generate dust, wet the floor, introduce silicone-based mastics and sealants, walk over the area and generally contaminate it. Clear instructions should also be given to the owner or occupants regarding access, opening windows (which may blow dust over the area) and the time required for coating systems to adequately cure.

8.4 Sanding

The sanding operation will vary based on the condition of the floor and the hardness of the flooring species. Where the floor is being sanded for the first time, the sanding process is made up of a number of separate sanding stages, which generally start with a coarse paper and progress to a relatively fine grade of paper. It should be noted that the sanding process is effectively scratching off the surface of the boards, and the reduction in grades of paper means that you start with a severe scratching action and finish with a more subtle scratching action.

8.4.1 Level or Basic Sanding

The purpose of the level or basic sand is to cut the boards flat, removing any board-to-board inconsistencies. Prior to the removal of any cupping from the floor, it is important to assess the cause of the cupping. If it is related to moisture gradient, the floor should not be sanded as crowning may result at a later date. Sanding typically comprises three passes with the drum or belt sanding machine (often referred to as the big machine). The aim of level or basic sanding is to provide a flat, completely sanded floor, and each of the sanding procedures that follow this step is designed to remove the sanding scratches generated by this initial step and maintain the flatness of the floor. It should be noted that the term 'flat' is relative.

Pass 1 (or the first cut) is generally one from a small angle of about 10° up to a 45° angle to the direction of the grain (diagonally). This angle is dependent upon the layout and size of the area to be sanded and the condition of the floor. The paper grit (or grade) selected and the number of passes will vary from one project to another, and each project should be assessed to determine the grit of the starting paper to be used, the angle the floor is to be sanded and the number of passes required. A coarser grit of paper is used depending upon the species and the condition of the boards. That is, the coarser grade of paper may be used to enhance the effectiveness of the sanding process in a floor surface that is very uneven or with hard species such as Turpentine or Ironbark.

The big machine is designed to sand in a particular direction (generally left to right). It is important to understand this principle and use the machine as the manufacturer designed it to be used. An appropriate procedure for sanding a room is as follows; however , as all floors are different, procedures will vary. After the angle of the first cut is determined (appropriate to project specifics), sanding commences near a wall with the path of travel at the chosen angle to the run of the boards. The machine is started, ensuring that the drum is not touching the boards and with the operator walking slowly forward, the drum is slowly lowered onto the boards. A slow walking pace and consistent pressure is maintained. At the end of the pass, the drum is raised smoothly off the floor and then, with the operator walking backwards and pulling the machine, it is eased back onto the floor for the return pass. The machine should travel so that it is sanding the same section of the floor as was sanded in the forward pass. The power lead, controlled by the operator, must be kept well clear of the drum at all times.

When the original starting point is reached, the drum is again gradually raised off the floor. The machine is then moved (most often) to the right hand side of the first path ensuring an overlap to the first cut path. Sanding continues in that direction maintaining a similar overlap in each forward pass. When the limit of accessibility has been reached in the corner of the room, the machine is turned 180° and the other half of the room is sanded in the same fashion, ensuring that there is an overlap of around 200 mm between the two sides of the floor. Any area that isn't sanded with this first pass (that is accessible to the big machine) can be sanded now, or else will be sanded during the second pass. The second pass is carried out on the opposite diagonal to the first pass, using a similar grade of paper.

Figure 8.3: First and second pass of sanding at 45° to board direction.

The third pass cuts the floor in the direction of the boards using a similar grade paper to remove the sanding lines from the action of pass one and two. Typically, the operator should start at a point that enables the sanding to be done in the direction and method a described above.

Figure 8.4: Third pass of sanding in the board direction.

Once a forward and reverse path is sanded, the machine is moved to ensure an overlap to the previous cut and sanding recommences in the same manner. This process is carried out across the room. When the full width of the room is sanded, the operator should turn 180° and sand the un-sanded band of floor.

The sanding drum should never have contact with the floor unless it is moving forward or backward. Doing so will cut a groove into the floor (drum mark), which may not be recoverable. Specialist equipment should be used and manufacturers' recommendations and user instructions should be followed.

At the completion of the level or basic sanding, the boards should be generally smooth and free from cupping and mismatching of surface levels between adjacent boards. If this has not been achieved the floor will require additional passes to achieve this state.

8.4.2 Edging

The big machine will not be able to sand the boards along the edges of the room, in corners or areas of reduced access such as wardrobes, etc. In these areas, the boards need to be sanded flat and generally blended into the body of the floor. For these areas an edge sander is used, and the most commonly used machine for the edging process is the disc sander, which is designed to be easy to manoeuvre. Care is necessary to ensure the operation does not dig grooves into the boards and that the finished edge is level with the body of the boards.

Figure 8.5: Edge sanding requires a smooth action to blend into the floor.

The operator should move the machine in a smooth, even pattern at board ends and across the grain. The pattern of sanding should overlap and blend into the body of the sanded floor. It is important that the machine is held level, as the boards are easily grooved with any uneven pressure. On each movement, the machine should sand a section of un-sanded floor of about 50 mm. The edge sanding machine should be moved smoothly along walls parallel with the boards, going back and forth in the direction of the grain and overlapping some 100 mm into the body of the sanded floor. 'Clocking' the edger is a technique of orientating the edger to the wall being sanded up to. This technique is now often used, as it minimises the visual impact of the scratches left by this part of the sanding process. Finer grit papers are usually sufficient for the purpose of edging on new floors and on old floors that are in good clean condition.

In areas of very limited access or at the corners of the room, hand scraping the floor is necessary. The scraping action should always be in the direction of the grain with the surface being both hand-sanded and machine-sanded with a smaller machine – the orbital sander. With orbital sanders, too much pressure or use of an overly aggressive grade of paper can result in deep swirl marks, which will show up in the finish. Once again, care needs to be taken to blend in these hand-scraped areas with the body of the floor.

This process is repeated following the second sanding process of the body of the floor.

8.4.3 Finish Sanding

This is the process of taking a floor that has been level sanded and bringing it further along the path to the coating stage. The purpose of this stage of the sanding process is to smooth off the coarser sanding marks left by the level or basic sand with finer grade or grades of sand paper. Typically an F60–100 grade paper is used and the floor is sanded in the direction of the grain (board run). The aim is to reduce the depth of scratching and ready the floor for the next stage of the process. Some contractors undertake a second pass with the edger at the completion of this stage of the sanding process with the big machine.

Figure 8.6: The finish sand.

8.4.4 Final Sanding or Hard Plating

After the completion of the finish sanding with the big machine and edger, final sanding or 'hard plating' is undertaken. Some contractors undertake the final sanding process using a finer grade of paper or screenback (100–150 grades) attached to a soft pad using a rotary machine. Others will use a process called hard plating, which enables them to consistently achieve a very flat floor surface. Hard plating is the process of utilising a rotary machine with the sand paper on an inflexible base plate, which not only enables a flat floor surface to be achieved but – if undertaken effectively – will help eliminate minor sanding imperfections left from using the drum or belt machine and edger. With both processes, the sanding should be carried out in the direction of the grain ensuring a smooth action, and applying a balanced control of the machine.

After hard plating, or rotary sanding if hard plating is not used, the perimeter of the floor would normally be sanded with a random orbital sander. The importance of both hard plating and random orbital sanding to obtain a flat floor surface with minimal variations in the appearance of the finished floor, when the perimeter of the floor is compared to the body of the floor, cannot be overstated. Some will also buff with a fine paper after hard plating and orbital sanding to further remove any differences.

The floor must once again be fully cleaned of dust, grit and debris. Any matter left on the floor will invariably affect the quality of the finish.

Figure 8.7: Hard plating with the correct attachment.

8.4.5 Buffing

The final stage is the 'buffing' of the floor. This is often carried out with the same rotary machine used for the hard plating, but with the sand paper attached to a more flexible pad on the base of the machine. This is the final process prior to coating the floor, and it is designed to produce a uniform scratch pattern across the entire floor and is also used as the last process to check the floor, prior to the application of the coating.

The floor is then vacuumed thoroughly and – if required – cleaned with tack rag (cloth designed to remove dust). Special attention should be paid to any potential dust traps in the floor (for example, dig out any dirt or dust and vacuum away). These can contaminate the floor coating system if not cleaned adequately, as the applicator will most certainly pull the dirt onto the body of the floor. It should also be understood that heavy sanding equipment may have the potential to create wheel marks on low-density floorboards. Additional care should be taken in these applications. Each stage of the sanding process is designed to achieve a specific outcome, with the end result being a floor that is flat with a minimum amount of very fine sanding marks and little visible difference between any areas of the floor.

It should be emphasised that the floor should be vacuumed after each sanding to remove loose grit and debris before the next stage of the process is commenced. This simple step will help in the reduction of 'rogue' scratches in the finished floor.

Figure 8.8: Buffing the floor.

8.5 Coating System Application

The following information is a typical application methodology, which might be utilised for the various finish types with minor product-specific variations.

8.5.1 Cleaning

The floor finish will be easily contaminated with any dirt, dust or other extraneous matter left on the floor. It is essential that the area be thoroughly cleaned and vacuumed, paying particular attention to any areas which may have caught dust during the sanding process such as window sills, picture rails, skirtings, power and light switches, light fittings, handrails, etc. The floor needs to be well lit with adequate ventilation. It is important to not have draughts blowing across the floor during the process, as they can introduce contaminates from outside of the working area.

8.5.2 Mixing the Coating

The coating material should be thoroughly mixed so that all the solids are blended through the body of the liquid. Do not to stir too quickly or roughly, as this may introduce air bubbles to the material and affect the coating quality. If there are any additives to be used, ensure they are mixed thoroughly into the coating liquid. Follow the manufacturers' instructions in all cases.

8.5.3 Cutting In

Use a clean, good-quality brush to cut in the finish around the perimeter walls and any other obstructions or areas that may not be accessible to the main applicator. The cutting in should extend out about 150 mm into the body of the floor so that the applicator is not required to venture too close to the skirtings and other limited access areas. If any bristles fall from the brush into the finish, remove them immediately.

Figure 8.9: Cutting in the finish around perimeter walls.

8.5.4 Applying Coating

The initial coat applied to the raw sanded timber may be either a recognised sealer coat as prescribed by the coating manufacturer or the same material to be used as a finish, except when outside the manufacturers' recommendations. Sealers are available in both water-based and solvent-based products. The use of a sealer can enhance the development of colour in the timber floor and can reduce the risk of 'edge bonding'. Penetrating and low rupture sealers are available. In all cases, it is imperative to follow manufacturers' instructions closely.

There are many approaches and methods used in the application of floor finishes and coating systems. The following approach is one such application method, which has generally been accepted by the industry.

The applicator, as specified by the coating system manufacturer (often a 6 mm mohair roller or equivalent), is immersed in the coating contained in a large painter's tray or applicator bucket. These allow the applicator to be lightly squeezed on the shallow portion of the tray to avoid drips. The product should be applied to the boards in a smooth action, starting at one end of the boards and working the product in line with the grain of the timber boards. The finish should be feathered off at the outer edge to minimise any build-up of coating at that point. This process should leave a 'wet edge' so that each successive section of application blends into the previous section without any ridging, which can occur if the material skins or dries off before the next application strip. The application process should continue in the same manner, working from one end of the area to completion. An even, wet look should result without any dry patches.

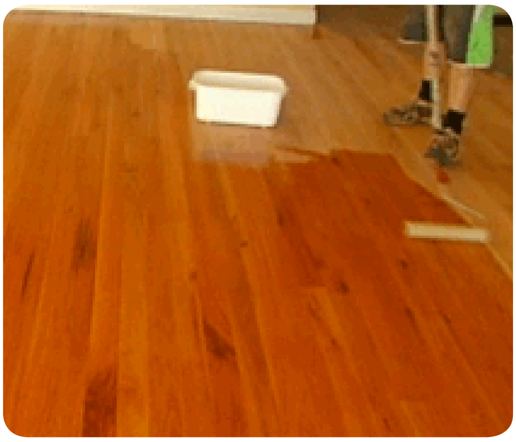


Figure 8.10: Application of the initial coat.

8.5.5 Filling/Stopping

When coating parquetry floors, it is recommended that filler be trowel applied following the first coat. This aids in reducing the phenomena known as 'quilting', where the finish does not flow across joints at board or parquetry edges. Filling of parquetry floors may be carried out prior to or following the application of the initial sealer or first coat, and is at the discretion of the floor sander. It is not a recommended practice to fill tongue and groove timber floors.

When the coating system is dry, any nail holes not previously filled and any cracks or other open faults should now be filled with a suitable filling compound that is compatible with the finish type. Generally, a non-oil based filler is best, which is colour matched to the timber.

The filler should be installed with a clean bladed applicator. Ensure the filler slightly overfills the hole and has been fully pushed into the void. If the material does not completely fill the void, it could come loose in service. Clean off any filler that is spread over the floor around the hole. Any excess will be sanded away in the light sanding between coats.

8.5.6 Sanding between Coats

The floor will typically have a slightly rough feel to it after the first coat of finish, depending on the system used and the degree of grain raise of the timber created. It is normal for more open-grain timbers to exhibit a higher degree of initial grain raise than denser close-grain species. The floor requires a light sand after the first coat to remove this roughness and also to key the surface for the next coat of finish. A 150 or finer grit paper or screenback is used at this stage with a rotary sander or similar. The sanding must not expose the timber, as this will create further raised grain. The sanding process is required to smooth off the roughness in the coating, not the timber. Edges must be hand or orbital sanded to a similar smoothness. It is important to follow the coating manufacturer's instructions as to the type and amount of sanding required, as different products often require slightly different techniques.

8.5.7 Cleaning between Coats

All dust should again be thoroughly removed from the floor along with any potential dust traps as previously described. Ensure that there are no draughts blowing through the area that could contaminate the final coat(s). In addition it may be prudent to use a tack rag over the floor to remove any dust missed by the vacuum. This will ensure that the floor is as clean as possible for the final coat(s).

8.5.8 Second Coat

The floor should again be edged with a clean brush coming out some 150 mm or more into the body of the floor. The application process is as per the first coat, with the applicator being worked along the full lengths of the boards and lightly feathered at the outer edge of each strip of application.

Figure 8.11: Application of the second coat.

8.5.9 Additional Coats

Any additional coats should follow the same process of a light sand of the previous coat, thorough cleaning and then application of the subsequent coating. Typically, a three-coat system is utilised, however, all manufacturers' recommendations should be followed with regard to number of coats and sand paper grades, in addition to any requirements of the specifier. Various water-based and oil-based coating systems require a finer grit of paper between coats, compared to the solvent-based products.

8.5.10 Providing the Floor to the Customer

When the floor is completed appropriate information should be provided to the client in terms of using the floor and maintaining it. This should include when the floor can be walked on, when furniture, etc, can be moved in, the care that must be taken with heavy items of furniture and the need for felt or similar protection for furniture legs to prevent scratching. Therefore, aspects relating to the curing time of the coating should be conveyed. Further information with regard to ongoing care with the floor is provided in Section 10.

9 Site Sanded and Coated Floor Appearance Expectations

9.1 Acceptability Considerations

There are no Standards that outline what an acceptable appearance of a timber floor should be. There are Standards that relate to the manufacture of timber flooring and, when recommended sanding and finishing practices are undertaken, there is a general level of acceptance of the finished product in the marketplace. Floors of the same species can differ markedly in their appearance depending on timber source, age of the tree, board cover width, the finish system used and the lighting in which the floor is viewed. Timber is a natural product that will shrink and swell in response to changes in atmospheric humidity. In addition, no one building environment is the same as another, the sanding and finishing is not undertaken in a dust-free factory environment and finishes may darken with time. However, even with these variables, a high standard in the finished floor is achievable.

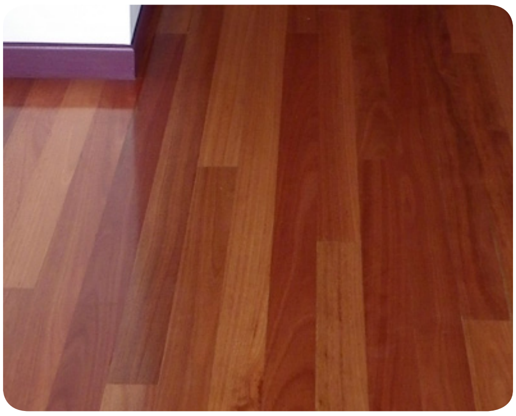


Figure 9.1: A high standard of appearance is achievable.

9.2 Acceptable Appearance Criteria

The following information is a typical application methodology that might be used for the various finish types with minor product-specific variations.

9.2.1 Colour, Species and Grade

The overall colour or blend of colour in a floor is dependent on the species or species mix chosen and the character of the floor. The features present in a floor, such as gum veins, are determined by those features permitted by the grade. Even when a single species is chosen, there can be a wide variation in colour, and it is also possible that a limited number of boards of a different species may be present due to similarity in appearance. It is also important to realise that grading rules do not cover either colour or colour variation. Grade names that do not align with the Australian or New Zealand Standards are likely to be similar to those in the Standards, but clarification should be sought regarding differences.

The grading process is rapid and relies on quick visual assessment where graders must assess the size and extent of a feature without relying on measurement. Due to this, some inaccuracy in grading can occur that may result in a limited number of boards that are outside grade limits. The sanding of a floor can also increase the size of some features or cause features to appear that were not present prior to sanding. Consequently, some boards in a finished floor may not meet the specified grade description. The presence and development of such features needs to be acknowledged by those purchasing timber floors. When viewing a floor, there is generally a clear difference between a floor that is of the incorrect grade and a floor where grade limits have been exceeded in some boards.

Where the number of boards in a floor with features that exceed grade limits, in terms of size and number, are relatively few (less than 5%) and the overall appearance of the floor is in line with the chosen grade, no remedial work is considered necessary.

Figure 9.2: A select grade Blackbutt floor where the backsawn gum vein toward the top right exceeds grade limits but is acceptable within the floor.

Grading also does not account for the distribution of features in boards, between boards within a pack of flooring or within a finished floor. It is a reasonable expectation that the installer, when laying the floor, will provide a relatively even distribution of colour and feature throughout the floor. With regard to colour, however, it must also be recognised that coating a floor highlights colour differences and the extent of the change is at times not easy to discern. Similarly, it can be expected that board lengths will be relatively evenly distributed in the floor and that groups of short boards or board ends will not be frequently clustered together.

9.2.2 Even Timber Surface

The following section outlines some problems that affect the surface of the boards and these should not generally occur in timber floors. However, specific heat sources from appliances or sun exposure through large uncovered windows may induce some cupping of boards in the affected area. Similarly, wide boards or thinner overlay boards may also show some slight cupping or peaking in certain house environments. It should also be recognised that the actions or inaction of owners can contribute to or even cause these to occur.

- Cupping – boards with their edges either higher or lower that the centre of the board. Heat in a specific location or a very dry environment above the floor may result in cupping. Moist sub-floor spaces can also cause boards to cup. Cupping is more likely to be observed in overlay flooring and standard thickness boards that are wider than 100 mm. To some degree, a small amount of observable cupping may occur in some locations within a dwelling (e.g. sun-exposed floor) where these types of flooring are used.
- Peaking – this has the appearance of cupping but is the result of expansion pressure in the floor.
- Tenting – two adjacent boards, where the adjoining edge has lifted above the level of the adjacent flooring. This is often associated with high moisture beneath the floor and can be from many causes.
- Buckling – a section of flooring containing a number of boards that is raised above an adjacent section.
- Crowning – floorboards that are flat on their lower surfaces but where the upper surface has edges lower than the centre of the board. This may occur if a floor is cupped (board edges up) at the time of sanding (see Figure 9.5). Crowning does not become apparent until some months after finishing.

Note: Floors exposed to heat sources after occupancy (e.g. from lack of curtains, fireplaces, vents from appliances, houses closed up for extended periods) may cause boards to cup. Cupping and shrinkage from such sources may be the owner’s responsibility.

Figure 9.3: Boards ends should be spaced out and preferably 450 mm or more apart.

Figure 9.4: Cupping – Board edges higher than the centre of the board, but which is barely visible in the floor.

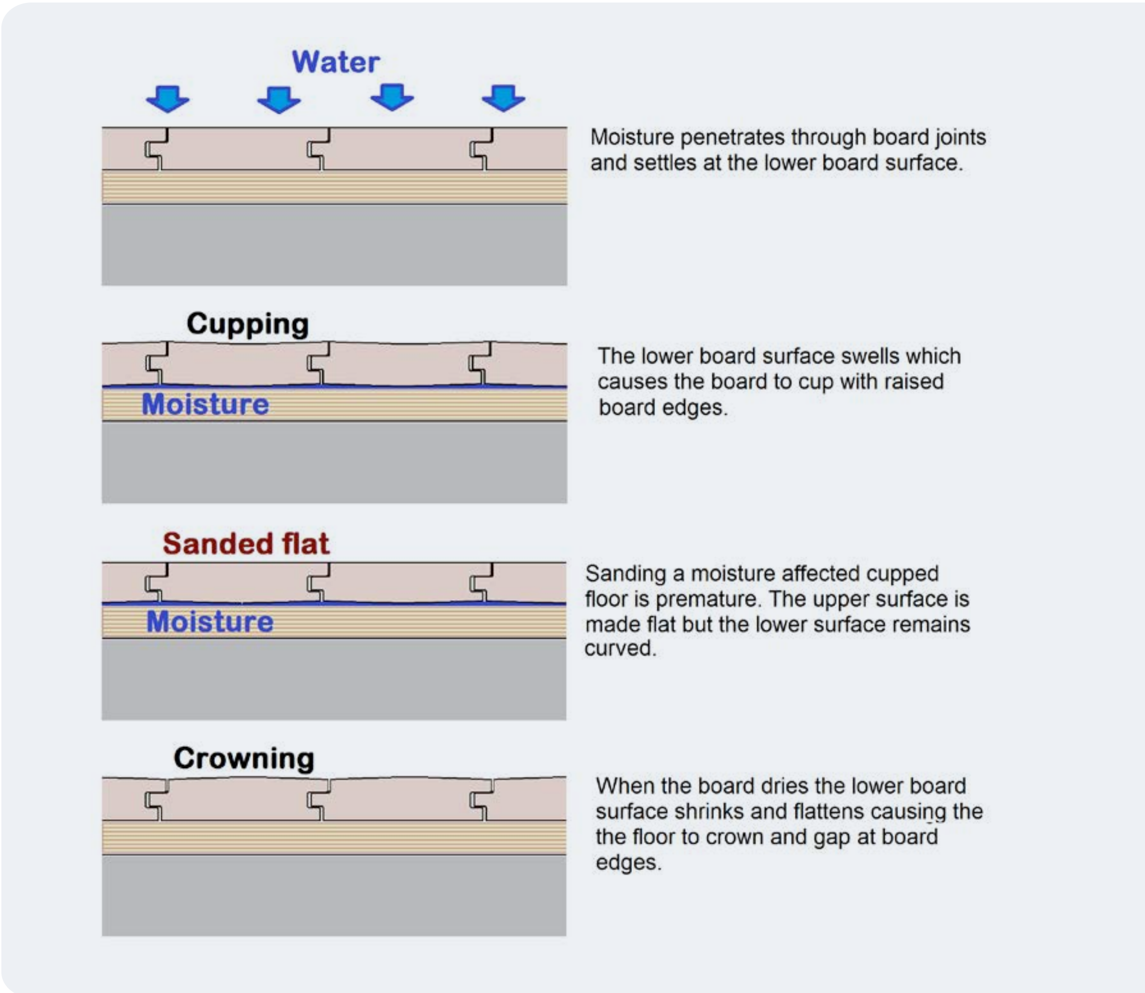


Figure 9.5: Crowning in timber floors.

9.2.3 Relatively Even Gapping Between Boards in Areas Not Exposed to Specific Heat Sources

With solid timber strip flooring, shrinkage gaps over 10 boards can average 0.75 mm for an 80-mm-wide board floor under drier internal conditions. For wider boards, proportionally wider average gapping can be expected. The appearance should indicate gapping between most boards and be free from irregularly spaced wide gaps associated with edge bonding. The provision of expansion gaps as part of the installation process and evident throughout the life of the floor is acceptable.

Figure 9.6 shows gapping near the upper limit, where the average gap size was 0.75 mm, which is considered acceptable. Figure 9.7 shows gapping that is not considered acceptable, where the average gap size was 1.8 mm. Note that this is the average gap size over 10 boards, so some gaps are greater than the average and others are less than the average.

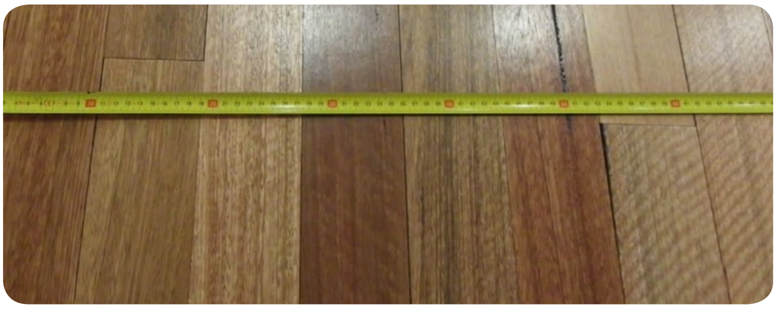


Figure 9.6: Gapping that is considered acceptable.

Figure 9.7: Gapping that is not considered acceptable.

9.2.4 Limited Vertical Movement at T&G Joints

Flooring is manufactured with the board tongue narrower than the groove. This is necessary so that boards will fit together during installation. When floorboards are laid over joists, in particular, some differential vertical movement may occur between adjacent boards, when a load is applied to an individual board. This is due to the clearance between the tongue and the groove. The clearance should not exceed 0.6 mm.

9.2.5 Minimal Squeaking

A small amount of noise can be expected from most timber floors, when walked on. Noises can occur from movement of one board edge against another or from boards moving on nails. A floor is often more noisy during drier weather, due to loosening at the joints. If squeaking is present in main trafficable areas then remedial repairs should be considered.

9.2.6 Indentations

Timber strip floors can be expected to show some indentations depending on the hardness of the species used, volume of traffic and footwear worn.

9.2.7 A Finish with Minimal Contamination and Sanding Marks

A finish similar to that of fine furniture should not be expected. Sanded and polished timber strip floors are not finished in a factory environment and different pieces of flooring will sand differently. The home environment is also not dust free. However, the finished floor can be expected to have an even appearance free from heavy sanding marks, blooming or frequent air bubbles in the surface. A minimal level of contaminants, minor sanding marks and small depressions of the finish at board edges and in nail holes, etc, may be visible. The perimeter and other hard to get at places are more likely to contain these irregularities. Due to this, a mirror finish is an unachievable expectation. Some finishes will also yellow with time and, if rugs are moved, a contrast in the depth of colour can be expected.

When floors are inspected for imperfections, the inspection is to be carried out during daylight hours with lighting on. The overall assessment of the floor is from a standing position with the floor viewed from positions that are usually occupied by people. Internal and external reflections in areas not usually covered by furniture should be assessed. Acceptability relies on judgment that takes into consideration the effect of lighting on noticeable surface imperfections as well as the initial wear of the floor, which can cause some imperfections to significantly lessen or disappear. A floor is subject to much heavier wear than furniture and, although a good-quality finish can be expected, an equivalent finish quality to furniture should not be expected.

Some imperfections that could be expected to some degree in a floor but that should also be assessed include: sanding quality; gloss variation; dust, insects and debris; bubbles and gel particles; and coat levelling.

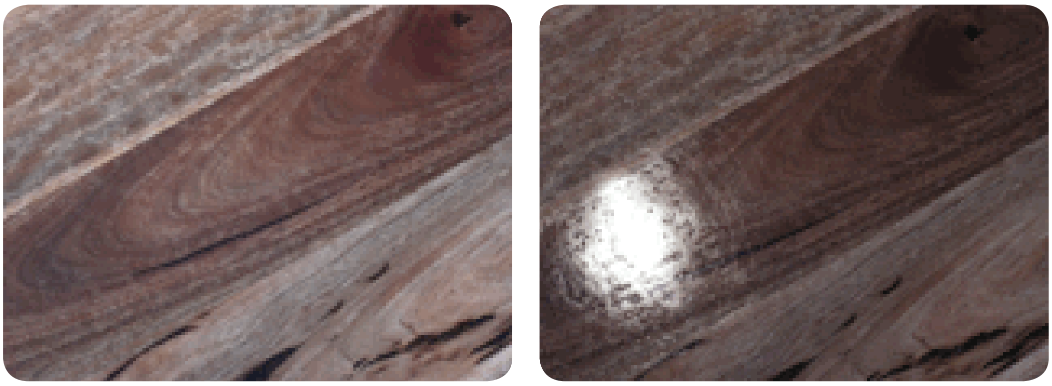


Figure 9.8: The same area of flooring, but with downlights on in the second photo. Downlights highlight sanding imperfections and dust, some of which can be considered acceptable.

10

Care and Maintenance

10.1 General Considerations

Timber floors vary in ease of maintenance depending on the type of coating used and the severity of use. They always greatly benefit from regular care. In doing so, the life of the floor finish and floor are greatly enhanced. However, at some stage the floor will need to be rejuvenated, and this usually requires buffing back and re-coating. Some of the softer floor finishes can also benefit from application of metallised polish, which provides an additional wear surface. It is important that maintenance aspects are passed on to home owners to assist in ensuring ongoing customer satisfaction.

10.2 A Newly Finished Floor

Although a floor may be walked on after initial curing or hardening of the coating, some precautions are necessary with a newly finished floor until the coating system has fully hardened. This may take up to two weeks. Use of the floor before the full cure has been realised can result in increased tendency for scuffing and scratching. It is recommended that rugs are not laid until after the floor finish has fully hardened. Additionally, rugs with rubber backings should never be used, as these may stain or otherwise affect the applied coatings. While light furniture can be replaced and used during this period, it should be ensured that furniture protection felt pads are attached to the feet of tables and chairs, etc, and furniture such as chairs should be lifted and not slid across the floor. Similarly, it should also be ensured that heavy items such as fridges are moved carefully into position – at no time should they be dragged over either newly finished or fully cured floors. Consideration should also be given to chairs with castors, as they can indent softer timbers and also cause premature wear of the coatings they are in contact with. Barrel type castors are less likely to damage a floor than ball castors. Again, these should not be used until the finish has hardened. Avoid walking on wood floors with cleats, sports shoes and stiletto heels, which can easily indent floors.

Figure 10.1: Timber floors are easy to maintain and greatly benefit from regular care.

10.3 Ongoing Care and Maintenance

10.3.1 Ingress of Grit and Direct Sunlight

There are some things that are enemies to timber floor finishes, and one of these is sand or grit that can be brought into the house with footwear. These small particles act like sandpaper, resulting in scratches in the floor. Mats placed both outside and inside external doors provide a simple and effective means of significantly reducing grit from entering the house. Similarly, in high-wear areas, carpet runners and rugs can be effective and can also add to the décor of the house. The kitchen floor generally experiences high wear and therefore a floor rug in this area can be particularly beneficial.

Another aspect that should be considered is the amount of direct sunlight that is reaching the floors. Direct intense sunlight can contribute to gapping and possible cupping of boards. It will also cause the colour of both boards and finish to change with time. Some floor finishes are more prone to darken with age and direct sunlight accelerates this process. Filtered sunlight through sheer curtains or blinds provides an effective means of slowing the colour-change processes and is also effective in controlling gap width at board edges and possible cupping of floorboards. In some instances, it may be decided that window coverings will not be used and, if sunlight has not been controlled by patio roofs or awnings, floors rugs can be used.

10.3.2 Maintenance Plan

Establishing a regular cleaning program will help keep floors in pristine condition. There are many aspects that affect how often the floor requires cleaning and these include the degree of grit present (particularly from children and pets), type of exterior and interior matting used, the level of foot traffic, the types of footwear and the general condition of the area outside the house. Spills should be mopped up when they occur and any leaks must be attended to immediately. Failure to attend to leaking pipe work can result in severe damage to timber flooring, particularly when laid over sheet flooring or directly adhered to a concrete slab. Scuff marks or stubborn stains may be removed with light rubbing using a timber floor cleaner. As some cleaners can attack certain types of coating, where possible, use the cleaning regime specified by the floor coating manufacturer. Alternatively, always test rub an isolated area of floor to verify compatibility of the cleaner used with the coating.

For regular cleaning of domestic floors, an antistatic mop provides an effective means to collect dust and grit. Continual walking on a dirty floor will quickly damage the finish. If a vacuum cleaner is used, the condition of the brushes should be regularly checked. If they have worn thin, contact of the metal head with the floor surface can result in scratching. Hard head vacuum cleaners should not be used as they will invariably cause fine scratches on the floor.

Steam mops are not recommended on polished floors as they can cause damage to certain types of coatings. Most timber flooring and coating manufacturers do not recognise this as an acceptable method, even when it is advertised by the steam mop manufacturer as being suitable. Coatings can become cloudy or opaque, or can peel after steam mop use.

On a fortnightly to monthly basis, floors can benefit from damp mopping. Providing the mop is only damp and the finish is in good condition, mopping carried out correctly will not affect either the finish or the timber. Damp mopping provides an effective deep clean and should be undertaken with a neutral pH wood floor cleaner or product recommended by the finish manufacturer. Harsh detergents or abrasive cleaners are to be avoided, as is the use of methylated spirits and vinegar, as they can chemically attack some types of coatings, e.g. waterborne coatings and penetrating oils. After wetting the mop, it should be wrung out until it is moist before mopping. Using clean water, a final mopping with a mop wrung out until it is 'dry' may be used to further remove excess moisture on the boards. Periodically, the protective pads on furniture legs should also be checked to ensure they are clean of grit and to see if they need replacement.

10.3.3 Re-coating

Timber floors are subject to different wear patterns and it is in areas of higher wear that there will initially be signs that the floor requires re-coating. It is important to ensure that excessive wear has not occurred if a total re-sand and re-finish is to be avoided. The finish should be inspected in the high-wear areas. If a few drops of water bead on the surface, the finish is still intact and may require cleaning rather than re-coating. If, however, after a few minutes the water begins to soak in and the timber colour darkens, then the finish is partially worn and re-coating should be undertaken. It is important that the details of the original coating system can be made available to the sander and finisher to ensure compatibility between coats.

A

Appendix A – Moisture Content and Timber Movement

A1 Water in Wood

In all common applications, timber contains moisture. Even timber that has been in service for 100 years will contain similar amounts of moisture to seasoned timber that has just been put into service. The reason for this is that the moisture in the air (humidity) maintains a certain level of moisture in the wood. The moisture present in freshly sawn (i.e. green) timber, straight from the log, is much higher and as a consequence of this, the air absorbs moisture from green timber until a balance is achieved.

A2 Moisture Content

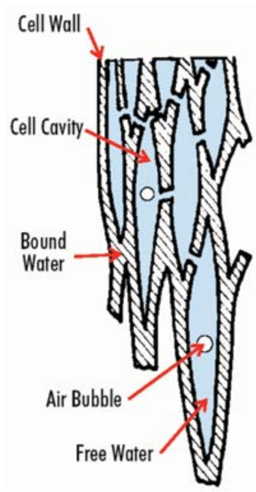
For timber products such as flooring, the amount of moisture present or its moisture content is defined as the mass of water present in the timber divided by the mass of the timber with all water removed, expressed as a percentage. The mass (measured in grams or kilograms) of water present can be determined from the difference in the mass of the timber with water (initial mass) to the mass of timber with the water removed (oven dry mass). The following equation is used to determine the moisture content of timber:

$$\%\ mc = \frac{\text{"mass of water present"}}{\text{"oven dry mass"}} \times 100\%$$

$$= \frac{\text{"initial mass"} - \text{"oven dry mass"}}{\text{"oven dry mass"}} \times 100\%$$

The structure of the cells in timber can be likened to a number of drinking straws glued together. If the straws were full of water, it could be expected that the mass of water contained in the straws would be greater than the mass of the drinking straws alone. In such a case, the moisture content as calculated above would exceed 100%. In a tree, the moisture content may be as low as 40% but can be as high as 180%. Green off-saw timber could therefore have moisture contents of 180%, which means the timber contains 1.8 kg of water for every 1.0 kg of dry timber that was present. In softwoods such as radiata pine and Araucaria, the average moisture contents of 180% or more often occur. In many of our common hardwoods, the moisture content may be no greater than 70%. Cypress, a softwood that grows in drier areas, may only have average moisture contents of 45%. There can also be sizeable variations in moisture content between the outer sapwood of a tree to the inner heartwood.

Figure A1: Timber cell structure.



A3 Drying of Timber for Flooring

Seasoning or drying is the process by which moisture is removed from timber and green timber (i.e. freshly cut boards) may be either air dried or kiln dried or a combination of both. The drying process for flooring often includes more than one stage. Timber is initially stacked to allow air movement between each layer of timber and in this state it can be either air dried by leaving it out in the open for some months, or placed in a low temperature pre-dryer to gently reduce its moisture content under controlled conditions, prior to drying being completed at higher temperatures in a kiln. Some hardwoods are kiln dried from green but many operations use initial air drying or a pre-dryer followed by kiln drying. Softwoods are generally air dried or kiln dried from green.

When we refer to seasoned timber, we are usually referring to timber that has moisture contents within the range of 9% to 14%. This range has been chosen because timber in coastal Australia will usually remain within this moisture content range when used internally. Whether timber is dried by the air or in a kiln, there is always a small variation in the moisture contents of individual boards (usually about 5%). Due to these variations, some boards will take up moisture from the air after being put into service, while others may lose moisture. When timber takes up moisture it expands and when it loses moisture it shrinks. The small moisture variations present at the time of flooring manufacture therefore translate into small differences in board widths as board moisture contents adjust to be in balance with the humidity in the air.

A4 Movement in Timber with a Change in Moisture Content

The cell structure of wood has been likened to a number of drinking straws that are glued together. With regard to this, water in wood resides both within the 'straws' (called free water) and in the walls of the straws (bound water). As indicated above, the moisture content in living trees will vary greatly depending on the species, age of the tree and location in which it is grown. However, no matter what the initial moisture content is of the wood in the trees, shrinkage in timber is minimal until the moisture content reaches approximately 25%. At this level, much of the free water has been removed and it is from this point (called the fibre saturation point) that there becomes a significant reduction in the bound water tied up in the cell walls. Associated with this, the cell walls begin to shrink and we observe shrinkage in timber. This relationship is shown diagrammatically in the graph in Figure A2.

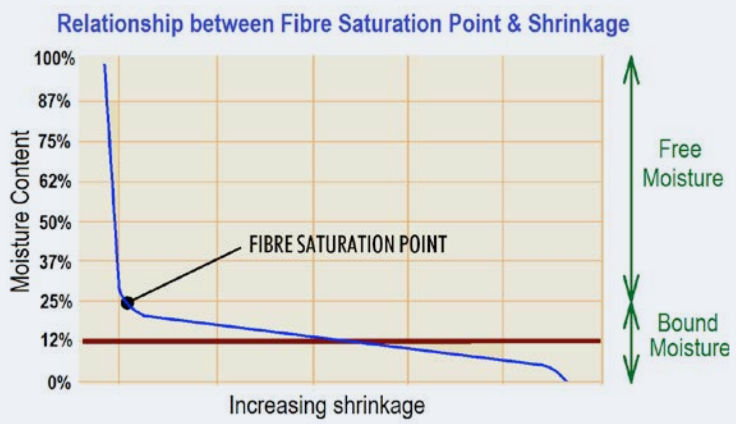


Figure A2: Relationship between fibre saturation point and shrinkage.

Within the sawmilling industry, boards are referred to as being either backsawn or quartersawn and the movement characteristics of each are quite different. In a backsawn board, the angle of the growth rings on the end section to the widest face is less than 45°. In quartersawn boards, this angle is greater than 45°. Backsawn boards are often valued for the 'figure' that appears on the surface of the timber flooring and, with backsawing, the amount of usable timber recovered from the tree is also usually greater. However, backsawn boards can be expected to shrink in width more than a quartersawn board and, due to the angle of the growth rings, backsawn boards will have an inherent tendency to cup when they dry.

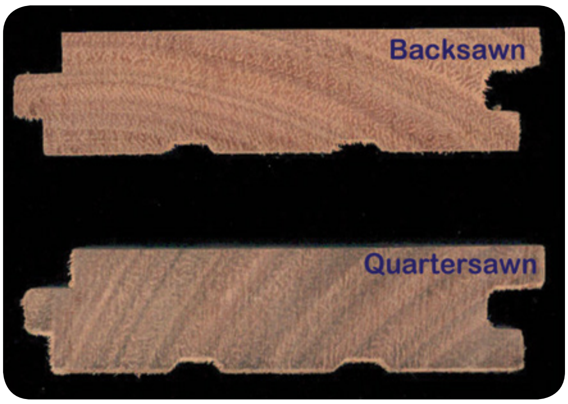


Figure A3: Backsawn and quartersawn floorboards.

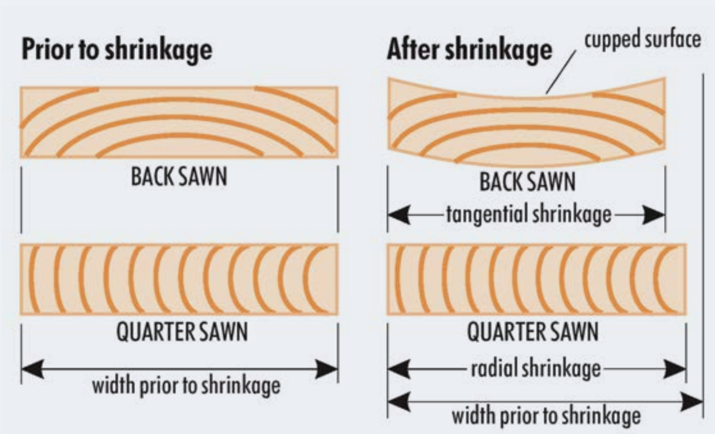


Figure A4: Shrinkage in backsawn and quartersawn floorboards.

The amount of shrinkage that occurs radially (i.e. in a direction that radiates out from the centre of the log) differs from that occurring tangentially (at right angles to the radial direction). Therefore, in a backsawn floorboard the cover width will vary as a result of tangential movement and in a quartersawn floorboard the cover width will vary from radial movement. Flooring manufactured from species grown in Tasmania and Victoria is often quartersawn, whereas species from Queensland, New South Wales and Western Australia are predominantly backsawn.

A useful measure of movement is what is termed the unit tangential movement (UTM). This is the percentage dimensional change for each 1% change in moisture content between 3% and the fibre saturation point for the particular species. For example, Brush Box has a UTM. of 0.38. Therefore a 3% increase in moisture content could on average be expected to cause an 80-mm-wide backsawn floorboard to increase in size by:

$$0.38 \times 3\% \times 80/100 = 0.9 \text{ mm}$$

When dealing with seasoned timber, the UTM can be used to estimate anticipated movement, however, actual movement is often less than the estimate. This is due to the presence of quartersawn material as well as some compression of the timber, which often occurs with regard to applications such as flooring. Therefore care is necessary when applying these figures. Tables of UTM are available from state timber organisations.

A4.1 Flooring Response to Changes in Humidity

A relationship exists between the air temperature, relative humidity of the air and the moisture content that timber will try to attain. This relationship is shown in Figure A5 and it can be seen from this that humidity has the predominant influence over moisture content. As an example, if timber is in a room at 25°C and the relative humidity is 65%, then the timber will in time try to reach approximately 12% moisture content.

Obviously, humidity and temperature will change on a daily basis as well as on a seasonal basis. Because of the relatively slow response rate of timber, we are usually more concerned with seasonal changes. The effects of seasonal changes may be observed in a polished timber floor by the opening and closing of gaps between adjoining boards at different times of the year.

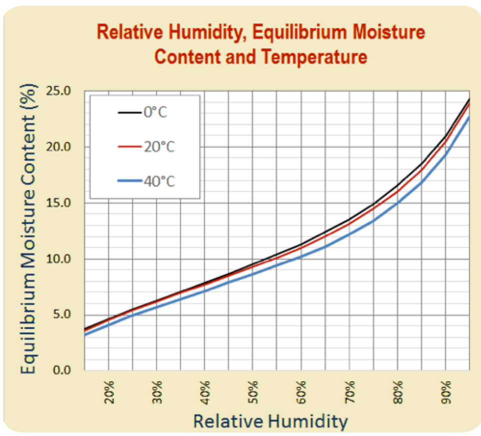


Figure A5: Temperature, RH and EMC.

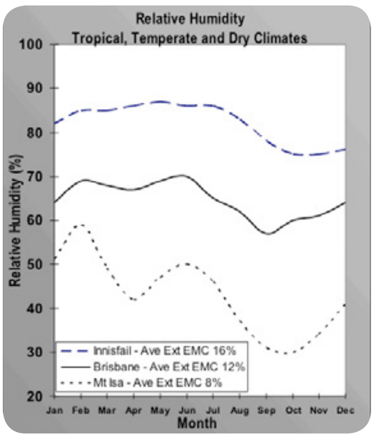


Figure A6: Climatic effects on timber floors.

Weather data provides information on the changes in relative humidity that can be expected in a particular locality, and this is particularly important if installing a floor in a location that differs from the one that you are used to. There can be significant changes over short distances,for example, between a coastal city and hilly rural environment, a half hour's drive away. Examples of different climates, seasonal humidity fluctuations and average moisture contents are given in Figures A5 and A6.

Although these graphs link timber moisture content to surrounding environmental conditions, they do not show the response rate of different species to these changing conditions. The response rate of softwoods such as Hoop Pine or Radiata Pine is more rapid than that of the denser hardwoods such as Spotted Gum. However, even within the hardwood or softwood groups, response rates can also vary quite markedly. Indicative response curves from one trial for Spotted Gum when placed in a very humid environment (18% EMC) followed by a dry environment (8% EMC) are shown in Figure A7. The first graph shows moisture content changes and the second graph the change in cover width. Clearly this illustrates the variability that can be present. Blackbutt, although a dense hardwood, takes up and loses moisture quite rapidly.

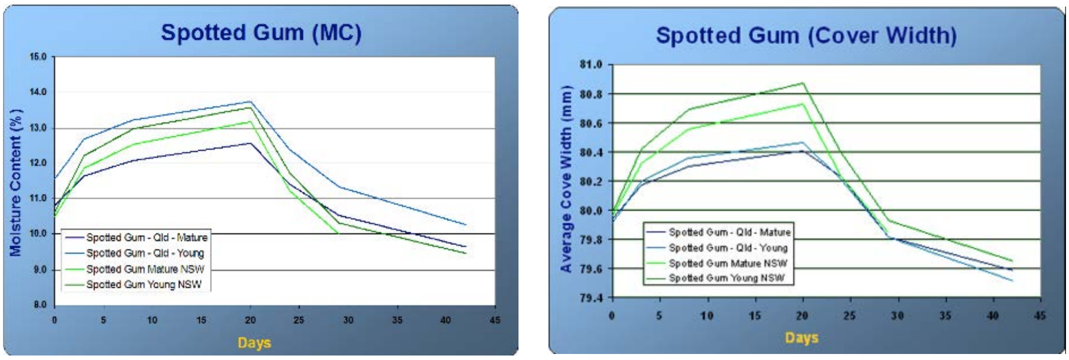


Figure A7: Results from the FWPRDC Research on Timber Flooring undertaken by Timber Queensland Ltd. The graphs show averages of 10 pieces of Spotted Gum flooring from different sources placed in a conditioning chamber at 18% EMC for 21 days followed by 8% EMC for 21 days.

The species that more quickly take up or loose moisture will generally follow seasonal changes more closely. The graphs also indicate that the rate of moisture uptake, which may result from a relatively quick and sustained change in weather conditions, can initially be quite rapid, but the rate of increase then slows over time. This aspect is also reflected in timber floors. Floor installers sometimes comment that a floor may have shrunk a lot in the first week or so after laying, but that it hadn't moved much since then.

As a guide, provided below is a table that outlines the density of the species, whether the flooring is predominantly backsawn or quartersawn and an indicative measure of the species response rate to moisture uptake and loss. In locations where floors are likely to expand after installation, particular care is necessary to adequately accommodate the expansion that will occur (i.e. intermediate expansion joints, loose lay and acclimatisation). This is particularly so with higher density timbers and particularly those higher density timbers that respond quickly to seasonal humidity changes.

Table A1: Characteristics of different species.

Species classification	Density classification	Cutting pattern	Movement in response to humidity changes
Radiata Pine	Low	Backsawn	Low
Tasmanian Oak	Medium	Quartersawn	Medium to high
Victorian Ash	Medium	Quartersawn	Medium to high
White Cypress	Medium	Backsawn	Low
Jarrah	Medium to high	Backsawn	Medium to high
Rosegum	Medium to high	Backsawn	Medium
Blackbutt	High	Backsawn	High
Spotted Gum	Very High	Backsawn	Low to medium
Grey Ironbark	Very high	Backsawn	Medium

B

Appendix B – Measuring Moisture Content of Timber and Sheet Products

Checking the moisture content of timber flooring prior to installation is important to provide a check on the product supplied, evaluate the need for additional expansion allowance and to ensure that subsequent movement (shrinkage and swelling) remains within accepted bounds. This appendix outlines the various methods used to test the moisture content of timber. Also included in the appendix is a method to evaluate the moisture content compliance of packs of flooring.

B1 Moisture Content Measurement

Figure B1: Moisture content measurement.

Initial mass 32.63 gm

Oven dry mass 29.49 gm

$$MC = \frac{32.63 - 29.49}{29.49} \times 100\% = 10.65\%$$

B1.1 Moisture Content

Moisture content is simply the mass of moisture present in wood divided by the mass of the wood with no moisture in it, expressed as a percentage. What is important about the moisture content in timber is that the board width will increase with increasing moisture content and will decrease with decreasing moisture content. At the time of machining, cover width variations are usually minimal and subsequent variations that occur in board widths are usually due to changes in moisture content. It is often the current and future variations in board width that are of primary importance, and one important purpose of moisture content testing is to indicate what future movement can be expected.

By simply looking at the end of a pack of flooring that may be a month or so old, it is often possible to obtain information about the moisture content of the timber within the pack, even without using a moisture meter.

For example in a three-month-old pack of flooring, some moisture changes are likely to have occurred. If the nominal cover width of was 80 mm and:

- board widths measure between say 79.6 mm and 80.4 mm, then the material is likely to have been dried to within narrow moisture content bounds and should perform well in service.
- board widths range from say 78 mm to 81 mm and some boards are cupped, then the material is likely to have been dried to quite wide moisture content bounds and the floor is likely to show some wide gaps at board edges along the length of the board and near end matched joints.
- board widths range from say 80 mm to 84 mm, then some of the material may have become wet after manufacture.

It is therefore important when considering moisture content to also take the board widths into consideration. Australian Standards that cover the moisture content of flooring vary in their limits as this depends on the species. Table B1 provides some information on species types, the number of the applicable Standard and the moisture content ranges applicable to flooring.

Table B1: Moisture content bounds.

Species Group	Moisture Content Bounds (moisture content anywhere within a board)	Number of the applicable standard
Hardwood	9% to 14%	AS 2796
Softwood	9% to 14%	AS 4785
Cypress	10% to 15%	AS 1810

B2 Methods of Measuring the Moisture Content of Timber

B2.1 How Moisture Content is Measured

Moisture content is determined by the oven dry test method and can be estimated using moisture meters. The two common types of meters in use are the resistance meter and the capacitance meter. Meters use changes in electrical properties caused by the wood and water within it to provide an estimate of the moisture content. Oven dry testing requires a set of scales and an oven from which the moisture content is determined from the change of mass as the sample dries.

Left: Figure B2: Capacitance moisture meter - Measures average moisture – Need to set species density.

Right: Figure B3: Resistance moisture meter - Measures moisture between the pins – Need to correct reading for temperature and species.

B2.2 Measurements by Different Methods

In any piece of flooring, the moisture content is likely to vary to some extent down the length of the piece and from the outer surfaces (case) to the centre (core). With regard to case-to-core differences, some methods of measurement are able to measure this while others can only measure the average moisture content of the board. This can be an important consideration when choosing a measuring method as case-to-core variations or the difference between upper and lower case may need to be determined. At other times, it may be important to gain many measurements quickly to gain an appreciation of the average estimated moisture content. In cases of dispute, accuracy may be of prime importance.

Resistance meters measure the highest moisture across the exposed ends of the pins, whereas capacitance meters measure an average through the piece. Oven dry testing measures the average moisture content of the sample placed in the oven but by cutting the sample up into applicable smaller pieces, case and core moisture contents can also be determined.

The three common methods of measurement, including their application, benefits, limitations and accuracy are outlined below.

When is it used

- Oven dry testing is often carried out where variations in moisture content in the final product can have a significant effect on the performance of the product.
- It is used where accurate results are required or meter readings are known to be inaccurate, which can include some timber species but also particleboard and plywood sub-floors.
- In case of disputes, Australian Standards generally refer to this method as it provides measurements that are more accurate and reliable.
- Manufacturers of board products often undertake oven dry testing in the manufacture of their products.
- Some timber organisations also have the appropriate testing equipment and contract out these services.

Testing equipment and facilities

- The equipment required is an accurate balance or set of scales and a laboratory oven that is able to maintain a temperature of 103°C ± 2°C.

Sampling from a pack

- The samples need to be representative of the timber in the pack being tested and capture the variation present. This may therefore include some outside boards as well as some from within the pack.
- If cupping is present or there is variation in the cover width by more than 1 mm, samples should be provided which include two boards that are cupped, two with wider cover widths and two with narrower cover widths. (Packing pieces are not to be provided as samples.)
- If boards are not cupped and there is little variation in cover width throughout the pack, five boards should be chosen. (Packing pieces are not to be provided as samples.)
- The samples from which test pieces will be cut should be taken not less than 400 mm from the end of a board and should be approximately 300 mm long.
- If the sample is from a board on the top, bottom or edge of the pack, it should be marked as being an outside board.
- The samples should be individually wrapped in ‘Glad Wrap’ or similar to reduce moisture content changes during transport.
- The samples should be stored in a cool place and delivered to the testing facility within 24 hours.

Figure B4: Oven dry testing – Provides the most accurate moisture content test.

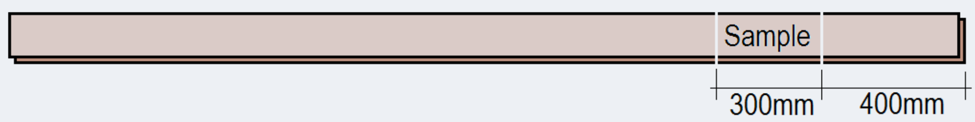


Figure B5 : Sample selection.

Testing procedure

- From the 300 mm long pack samples, test pieces are cut with a length of between 15 mm and 30mm so that the required mass is achieved to suit the accuracy of the mass measuring equipment. If the equipment measures to 0.1 g, a test sample of at least 50 g is required. The sample may be less than 50 g if the equipment measures to 0.01 g.
- The initial masses of the test pieces (and usually the cover widths) are recorded. The test pieces are placed in the oven for at least 24 hours and then reassessed at four-hour intervals until there is minimal change in mass. For longer samples in denser species, times of 48 hours or so may be required. The mass after drying in the oven (i.e. oven dry weight) is recorded.
- The moisture content is then calculated for each test piece by applying the following equation:

Moisture content (%) = ((Initial mass – oven dry mass)/ oven dry mass) x 100%

For example, if the initial mass is 57.6 g and the oven dry mass is 43.3 g then the moisture content is:

Moisture content (%) = ((57.6 g – 49.3 g)/ 49.3 g) x 100 % = 16.8%

- This method provides the average moisture content for the test pieces. Case and core measurements can be obtained by cutting the appropriate sections out of larger test pieces prior to testing.

Interpreting results

- The sampling method outlined above aims to capture the variation present in a pack of timber and from this it can be assumed that most of the timber within the pack will fall within the upper and lower moisture content measurements.
- In applications where cover width is important, both the cover width and the moisture content should be considered. Often boards of lower cover width are also those of higher moisture content and further shrinkage of this material can be expected.

Benefits and limitations

- The main advantage of this method is its accuracy.
- The method is time consuming, not portable and more expensive.
- The most common error results from insufficient drying, which underestimates the moisture content. If sample masses are small, measuring errors can significantly affect the moisture content calculation.
- Microwave ovens can produce good results and speed up testing, however, there are no formal procedures and there is the risk of evaporating volatile compounds in addition to the water, which affects accuracy.

B4 Electrical Resistance Meter to Estimate Timber Moisture Contents

Principal of operation

The electrical resistance of timber reduces as the moisture in timber increases. These meters measure the flow of electricity between two pins where the timber acts as an electrical resistor between the pins. The scale on the moisture meter is graduated to read moisture content. Wood temperature affects the readings and for this reason wood temperature above or below 20°C, requires correction to the reading. Temperature correction if not already taken care of by the meter is applied before species correction. Species correction is necessary as two different timber species at the same moisture content may not have the same electrical resistance. Meters are generally set up relative to one species, Douglas Fir (Oregon) and species corrections are then applied for other species. There comes a point where the water in timber is so low that the resistance is difficult to measure accurately or on the other hand sufficiently high that the resistance does not change greatly and is prone to greater errors. However, these meters generally provide reliable results between 6% and 25% moisture content.

Types of meters

A wide variety of meters are available. All have two pins that are used to penetrate the timber but the pins may vary in length from approximately 6 mm in length up to 50 mm. The longer pins are often insulated up to the pointed ends to prevent surface moisture effects from interfering with core measurements. Those with longer pins are also usually of the ‘sliding hammer’ type, which provides a means of driving the pins into the timber. The sophistication of the meters varies greatly in terms of features such as inbuilt temperature correction, pre-programmed species calibration and depth indication. Many of the meters now come with a calibration block.

Using resistance meters

- The calibration of the meter should be checked prior to use and this is usually done with a test block that contains electrical resistors that correspond to the moisture contents specified on the test block.
- Measurements are then taken in clear timber at least 400 mm from the ends of boards.
- Some meters require measurements to be taken with the pins running down the length of the board while with others the pins are to run across the width of the board (check with the manufacturer's manual).
- The pins are driven to the desired depth to which the moisture content reading is required. As case and core measurements can be significantly different, use of meters with short pins may require boards to be cut and the pins inserted in the end grain to provide a better estimate. In high density timbers, holes may need to be drilled for the pins.
- The pins need to be in firm contact with the timber, otherwise low readings may occur.
- Readings should be recorded to the nearest 0.5% and read shortly after penetration.
- Each reading is to be corrected for wood temperature first (provided this is not done automatically) and then for species (providing the species has not been set on the meter).
- Refer to Table B2 for temperature correction factors and species correction factors for some common commercial species. Additional temperature and species correction factors are available in AS 1080.1.

Limitations, accuracy and precautions when using resistance moisture meters

When using meters a common sense approach is necessary. Each reading should be evaluated and if not as expected, then the reasons for this should be investigated. The meters generally provide a reasonable estimate of the moisture content to 2% in the measuring range from 8% to 25% and as stated above readings should be recorded to the nearest 0.5%. There are a number of factors that are known to affect meter readings and these are:

- Measurement necessitates damaging the surface of the timber.
- The method is conducive to only taking a relatively small number of sample readings.
- Readings near the board surface can be significantly different from the core.
- Low battery can cause low readings in high moisture content material.
- Uncertainty over species that are being used in can make species corrections difficult.
- Species such as Brush Box have very high species correction factors and are prone to greater error.
- Use for extended periods in high humidity environments can raise meter readings.
- Meters only read wettest part that the exposed surfaces of the pins are in contact with.
- Surface moisture can provide artificially high readings not reflecting wood moisture content.
- Salt water or any preservative treatment salts can affect meter readings and will usually raise them.
- Electrical wiring in walls can affect the readings.
- If meter readings are not in line with what is expected, then this may necessitate oven dry testing to more accurately estimate the moisture content.

B5 Electrical Capacitance Meter to Estimate Timber Moisture Contents

Principal of operation

These meters measure an electrical property called the 'dielectric constant'. An electric field produced by the meter and the presence of the timber on which the meter is positioned, form a 'capacitor' type of arrangement. The electric field can penetrate deep into the timber but meter readings are biased toward moisture in the surface layers. Both the moisture content and the density of the timber affect this electrical property. The effective range of capacitance meters is from approximately 0% to 30% moisture content. The more sophisticated meters can be adjusted for timbers of different densities. Less expensive meters do not have density compensation and for these meters corrections to meter readings must be applied based on the density of the species being tested. Such meters are usually preset to be more suited to softwoods and lower density hardwoods, and this can cause limitations with higher density species (i.e. large correction factors are necessary).

Types of meters

Meters are imported from overseas and range from those with few features to those with a wider range. Features may include settings for timber density (or specific gravity) and timber thickness as well as the ability to store readings and apply some statistics to the results. It is necessary to ensure that the meter is going to meet your specific needs and, if it is being used with higher density hardwoods, timber density (or specific gravity) adjustment must be seriously considered.

Using capacitance meters

- The appropriate meter settings for density and board thickness, etc, should be applied and the meter checked for calibration.
- The density (specific gravity) is often calculated differently for different reasons (i.e. green density, density at 12% moisture content or basic density). Specific gravity is the density of a material divided by the density of water (approximately 1,000 kg/m3). It is necessary to obtain from the meter supplier the relevant figures applicable to the meter being used. Table B3 provides densities at 12% moisture content.
- Measurements are to be taken in clear timber away from knots, etc.
- Some meters require measurements to be taken with the meter in a particular orientation on the board (check with the manufacturer's manual).
- The plate of the meter must be in firm contact with the board before a reading is taken.
- Readings should be recorded to the nearest 0.5%. If no density (specific gravity) settings are available then these meter reading needs correcting.

Limitations, accuracy and precautions when using capacitance moisture meters

Similar to resistance meters, common sense must prevail when using these meters, with readings evaluated and investigated if not as expected. Providing the density is accurately assessed, these meters provide a reasonable estimate of the average moisture content in a board up to approximately 25% moisture content. Again there are a number of aspects that need to be considered when using these meters:

- Readings can be taken very quickly either within a single board or in a number of boards.
- The meters do not damage the surface of the timber that is being measured.
- Within species density variations can be quite high, particularly between mature and young growth material.
- Estimating the correct density adjustment can be difficult, particularly if the meter is being used on a range of different timbers.
- Density (specific gravity) information for Australian species relating to specific meters is not well documented.
- Difficulties with setting density (specific gravity) adjustment often reduce field measurement accuracy.
- If no timber thickness adjustment is provided, thicker pieces at the same moisture content are likely to read high.
- Any gap between the meter and the board (e.g. a cupped surface) will cause a lower reading.
- Framing raises meter readings where exposed timbers cross (e.g. softwood floor over hardwood joists).
- The presence of salts (either from salt water or preservation treatment) will cause readings to be higher.
- Readings are also considered to be less reliable with Brush Box.

Again, if meter readings are not in line with what is expected, this may necessitate oven dry testing to estimate the moisture content more accurately.

B6 Assessing Timber Moisture Content for Conformity

Australian Standard 1080.1 – Timber – Methods of Test – Method 1: Moisture content outlines a procedure for moisture content acceptance testing of timber using a resistance moisture meter. The Standard should be referred to for full details. Provided below is a summary of the procedure:

- Sample at least one pack out of every 10, or one pack out of every five for higher value products (e.g. flooring).
- For each pack assessed (of up to 200 boards per pack), 15 boards are randomly selected and tested.
- The pack is deemed to comply if not more than one test result (after applying temperature and species correction factors) is outside the allowable range. This is providing the result outside allowable limits is not too different from other results.
- This sampling procedure is based on at least 90% of the samples occurring within the allowable range.

B7 Measuring the Moisture Content of Plywood and Particleboard

Meters do not provide an accurate and reliable measure of moisture content in these materials. To determine the moisture content of these materials, the oven dry method should be used.

Table B2: Temperature correction factors for resistance moisture meters.
(Note: This is wood temperature not air temperature)

Meter reading %	**8 %**	**10%**	**12%**	**14%**	**16%**	**18%**	**20%**	**22%**	**24%**
Wood Temperature	Temperature correction to be added to or subtracted from meter reading before applying the species correction factor								
15 °C	Nil	Nil	+1	+1	+1	+1	+2	-	-
20 °C	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	-
25 °C	-1	-1	-1	-1	-1	-1	-1	-1	-
30 °C	-1	-1	-1	-2	-2	-2	-2	-2	-2

Table B3: Species correction factors for resistance moisture meters.

(Note that this only contains some common species – refer to AS 1080.1 and FWPRDC report PN01.1306 for a more complete list. The tabled figures are based on the Deltron Moisture Meter. Figures may differ for other meters - refer FWPRDC report PN01.1306).

Meter reading %	8 %	10%	12%	14%	16%	18%	20%	22%	24%	Density
Species	Resistance meters are generally calibrated to Oregon (Douglas Fir). Apply the following species corrections after temperature correction.									**At 12% MC**
Oregon (Douglas Fir)	0	0	0	0	0	0	0	0	0	550
Australian Hardwoods										
Yellow Stringybark (NSW)	+4	+4	+3	+3	+2	+2	+1	+1	0	900
Red Ironbark Broad Leaved & Red (NSW)	+4	+3	+3	+3	+2	+2	+2	+1	+1	1100
Grey Ironbark (Qld)	+3	+2	+2	+2	+2	+2	+2	+2	+1	1105
Forest Red Gum - Blue Gum (Qld)	+3	+2	+2	+2	+2	+1	+1	+1	0	1000
White Mahogany – Honey Mahog.(Qld)	+2	+2	+2	+2	+2	+2	+2	+2	+2	1000
River Red Gum (Vic regrowth)	+2	+2	+2	+2	+2	+2	+2	No data	No data	900
Rose Gum - Flooded Gum (Qld & NSW)	+2	+2	+2	+1	+1	0	0	0	0	750
Sydney Blue Gum (NSW)	+2	+2	+1	+1	0	0	-1	-1	-1	850
Blackbutt (Qld & NSW)	+1	+1	+1	+1	+1	+1	+1	+1	+1	900
Turpentine (Qld & NSW)	+1	+1	+1	+1	+1	+1	+1	+1	0	950
Blackbutt (NSW regrowth)	+1	+1	+1	+1	+1	0	0	0	No data	900
Grey Ironbark (NSW)	+1	+1	+1	+1	0	0	0	0	0	1100
Red Ironbark Narrow Leaved (Qld)	+1	+1	+1	0	0	0	0	0	0	1090
Blackwood (Tas)	+1	+1	0	0	0	-1	-1	-2	-2	640
Myrtle (Tas)	+1	+1	0	0	-1	-1	-2	-2	-2	700
Spotted Gum (Qld Citridora)	+1	0	-1	-1	-2	-3	-3	-4	-5	1100
Shining Gum (Vic)	+1	0	0	0	0	0	0	-1	-1	700
Jarrah (WA regrowth)	0	0	+1	+1	+1	+1	+1	+1	No data	780
Grey Gum (Qld & NSW)	0	0	0	0	0	0	0	0	0	1050
Tallowwood (Qld & NSW)	0	0	0	0	0	0	0	0	0	1000
Alpine Ash (Vic & Tas regrowth)	0	0	0	0	0	0	-1	-1	No data	650
Mountain Ash (Vic & Tas regrowth)	0	0	0	0	0	0	-1	-1	No data	650
Messmate (Vic & Tas regrowth)	0	0	0	0	-1	-1	-1	-1	-2	750
Southern Blue Gum (SA plantation)	0	0	-1	-1	-1	-2	-2	-3	-3	700
Spotted Gum (NSW Regrowth Maculata)	0	-1	-1	-2	-3	-4	-5	-5	-6	1100
Brush Box (Qld & NSW)	0	-1	-2	-3	-4	-5	-6	-8	-9	900
Manna Gum - Satin Ash (NSW)	-1	-1	-1	-1	-2	-2	-2	-2	-3	800
Imported Hardwoods										
European Beech	+3	+3	+3	No data	No data	No data	No data	No data	No data	690
Kwila / Merbau (Malaysia)	+2	+2	+2	+2	+1	+1	+1	+1	+1	850
Sugar Maple (Nth America)	-1	0	+1	+1	+1	+1	+1	+1	No data	740
New Zealand Species										
Kauri	+2	+1	0	-1	-2	-2	-3	-4	-5	560
Matai	+1	+1	0	0	0	-1	-2	-2	-2	600
Red Beech (heartwood untreated)	-	+2	+2	+2	+2	+2	+2	+1	+1	560-740
Rimu (sapwood untreated)	-	+2	+1	+1	+1	0	-1	-2	-3	560
Rimu (truewood untreated)	-	+1	0	-2	-3	-4	-5	-6	-7	560
Tawa (untreated)	-	+1	0	-1	-1	-2	-3	-3	-4	730
Softwoods										
Araucaria - Hoop Pine (Qld & NSW)	+3	+2	+2	+2	+1	+1	+1	0	0	550
Radiata Pine (Vic)	+2	+2	+2	+2	+2	+2	+2	+2	+2	550
Cypress (Qld & NSW)	+2	+1	+1	+1	+1	+1	+1	0	0	700

Note:

1. No correction factors are published for Gympie Messmate, New England Blackbutt or Northern Box. Oven dry testing is the preferred method for Brush Box.

2. Tables for Tasmanian Oak indicate a +2% species correction for meter readings up to 16% and +1% thereafter. Research, as outlined above, indicates that a +0% correction as provided in the table for this species mix of Alpine Ash, Mountain Ash and Messmate to often be applicable with younger material.

C

Appendix C – Slab Moisture Assessment

C1 Properties of Moisture in Concrete

Concrete is a porous material that is able to hold water and water vapour in small voids or pores within its structure. Similar to the cells in timber, the pores can be saturated and full of water or moisture can also exist inside the pores as a vapour.

It is therefore possible to determine the moisture content of concrete by the oven dry method, similar to timber, but with concrete it is also possible to determine the quantity of moisture vapour held within the pores by measuring relative humidity within a slab.

Another similarity to timber is that water vapour will move in and out of concrete depending on atmospheric conditions and the relative humidity within a slab will remain quite high until the water in the pores has evaporated. At this point, the moisture content of the concrete is near 2%. However, when concrete is near saturation the moisture content is only about 6%.

Referring to Figure C1, it is apparent that once both timber and concrete have lost their 'free water' from inside their cells and pores then under conditions of 75% relative humidity timber attains a moisture content of approximately 14% and concrete about 2%.

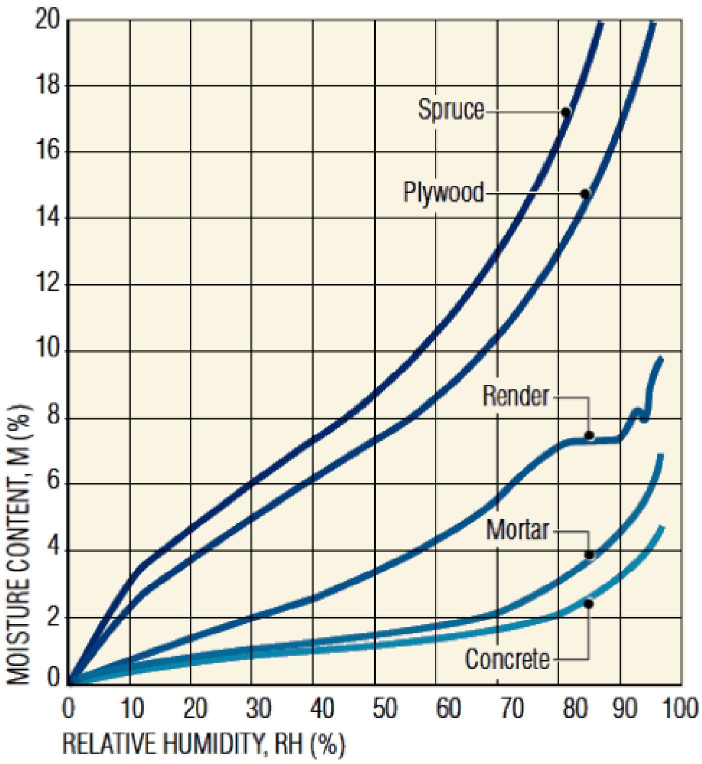


Figure C1: Sorption isotherms. *Source: CC&A datasheet – Moisture in Concrete*

When concrete cures, a hydration reaction occurs that uses up much of the added water. However, even after curing, the pores will contain a significant amount of water, similar to the water within the cells of a board that has been freshly cut from a tree. In both cases, it is from here that drying begins with the lower relative humidity air of the surroundings causing evaporation from the surfaces, and this continues until the 'equilibrium moisture content' is achieved. Similarly, with both materials, the thicker either the board or slab is – the longer it takes to dry.

With timber, we know that density affects the drying rate. With concrete, the water–cement ratio can and does vary and the lower this ratio is, the shorter the drying time. Lower water–cement ratio concrete also results in less permeable higher strength concrete. With a water–cement ratio of 0.5, drying will generally be achieved within three months. Concrete will, however, be slower drying in higher humidity or lower temperature conditions or with higher water–cement ratios.

When measuring the moisture content of an unseasoned timber post, the moisture content soon becomes much lower near the exposed surface than in the core. The same principal applies to a concrete slab. If we were to measure the relative humidity throughout the depth of a slab as it dried, it may initially be close to 100%. Over time, for example, the relative humidity may reduce to 50% near the surface, but toward the lower surface of the slab it may still be well over 90%. In either case, a surface moisture content reading is not going to provide an indication of the moisture held deeper within the post or toward the bottom of the slab. If a timber floor is laid directly over a concrete slab prior to it drying from lower down, then moisture will migrate to the slab surface and affect the timber floor. This is illustrated in Figure C2 for a 100 mm thick slab over a ground moisture membrane.

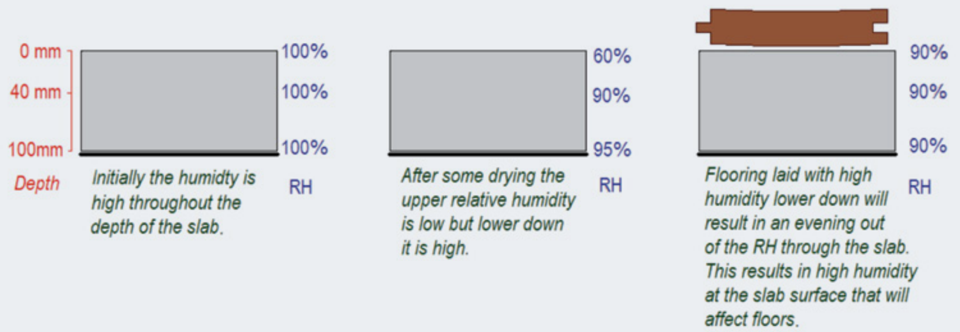


Figure C2: Relative humidity redistribution in a concrete slab as it dries.

From Figure C2, it is evident that surface moisture measurements cannot be relied on to ensure the performance of a timber floor laid above and, for this reason, in-slab relative humidity measurement is gaining in popularity around the world. You will also note in this example that with flooring laid over the slab, the relative humidity at 40 mm or 40% of the depth of the slab is the same at 90% relative humidity prior to and after the flooring was laid. It has been found in slabs that dry from one side only that measurements taken at 40% of the slab depth provide a close approximation to the relative humidity that will occur beneath the floor covering at some later date. If able to dry from both sides, measurements at 20% of the slab depth are applicable.

C2 Timber Floors and Concrete Slabs

Whenever a timber floor is laid over a concrete slab, it is important that the slab is sufficiently dry, irrespective of the method of installation of the timber floor. A polyethylene vapour barrier or slab moisture vapour retarding barrier can be used directly over the top of the slab as an added precaution. It is not recommended that such barriers be used to compensate for slabs where slab age is young and other testing indicates that slab moisture levels are high. A moisture vapour retarding barrier will still permit the transfer of some moisture and the rate is to some degree dependent on the moisture within the slab. In such instances, the flooring could still be affected. Note that not all moisture vapour retarding barriers used on concrete are recommended for use with timber floors. Appropriate measures must also be taken when there are construction joints or where a new slab is added to an existing slab.

It is also important to ensure that slabs have ground moisture membranes beneath them that comply with AS 2870. These membranes separate the concrete from possible sources of moisture that may delay or could prevent the concrete from drying adequately. Provided they are installed correctly, water vapour transmission through them is minimal. It has been shown that such membranes form close contact with the slab preventing lateral moisture movement between the two. Puncturing or gaps in the membrane can result in localised areas of higher moisture, and slab edge dampness also needs to be considered.

With a water–cement ratio up to 0.5, (although likely to be a little higher in house slabs), three to four months drying after the house is enclosed should be sufficient with a 100-mm-thick slab drying from one surface only, or six months for a 150-mm-thick slab and 12 months for a 200-mm thick-slab. If drying from both sides of the slab, then these times are halved. However, relying only on slab age is not sufficient as experiences have indicated that in some instances moisture-related problems have still occurred. At the time of floor installation, you will generally not be aware of what the actual water–cement ratio was (or if water had been added on site), how well the ground moisture membrane was installed or how well the concrete was placed. The presence of beams also needs to be considered. As indicated above, aspects such as weather, including temperature and humidity, also influence drying. Therefore, regardless of the age of the slab, its moisture levels require further assessment prior to laying a timber floor.

C3 Measuring Slab Moisture

There are various methods of measuring the moisture content of slabs and, similar to timber, these include both types of electronic moisture meters. However, there are also other means that measure the vapour emission from the slab. These tests include a simple polyethylene film test, use of a hygrometer to measure the humidity above or within a slab and use of various chemicals.

Preferences of test method vary considerably and each has its limitations. Meters or use of a hygrometer are often preferred as they are relatively quick and easy to use and results may be recorded. However, as with any electrical instrument, the accuracy of the instrument needs to be taken into consideration and periodic calibration checks are necessary. As with all testing, the results need correct interpretation.

It is evident from the above that what is important is the potential amount of moisture that can be released from the slab as well as the rate at which it is released. Test methods and equipment have been developed for each aspect, but each one has its associated advantages and disadvantages.

A qualitative test was developed where clear polyethylene film or glass is fixed over the slab and condensation or darkening of the concrete after 24 hours can indicate a high release rate of moisture from the slab. However, this simple method has been found unreliable as it is temperature dependent, and results at times have indicated that slabs were dry when they were not. In the United States, the moisture vapour emission rate (MVER) has been the standard test for many years. Calcium chloride readily absorbs moisture from the air and this method uses its increase in weight when encased above a slab to determine the moisture release from the slab. For timber floors, 15g/m2/24 hr was deemed to be the upper limit. This method takes a number of days to complete and over the years has been found deficient under certain conditions. It also does not account for moisture deep in the slab. In New Zealand and some other parts of the world, a relative humidity box above the slab has been used. In Australia, moisture meters – either resistance or capacitance – have been used. More recently, in Australia as in other parts of the world, in-slab relative humidity measurements are being taken and this method is becoming increasingly accepted as providing more useful information about slab moisture.

Test methods and considerations relating to moisture meters and in-slab relative humidity are outlined below. However, with any method it must be remembered that the test provides no indication about how slab moisture may change seasonally or that outside moisture sources can affect the flooring system. Although the flooring contractor may not be responsible for such external influences it is expected that the contractor would assess the moisture condition of the slab prior to floor installation.

With regard to this, it would be appropriate to determine quite precisely when the slab was laid and assess moisture contents or relative humidity, within or above the slab, together with the age of the slab. It should also be assessed whether an older slab may not have a moisture membrane beneath the slab. These details need to be recorded for each job and the installer needs to be satisfied with the results before proceeding.

C4 Moisture Meters

Figure C3: Concrete capacitance moisture meter.

Both resistance moisture meters and capacitance meters have been available for some years. Australian Standards such as the pre-2007 version of AS 2455 (Textile floor coverings – Installation practice) specified that moisture contents below 5.5% were acceptable for resilient flooring and it appears that this figure was taken up by the timber flooring industry. In view of the information provided on sorption isotherms in Figure C1, it would appear that this limit is consistent with a saturated slab. There have been many floors laid with readings of, for example, 4.5% where no problems were experienced. In other instances, however, readings of this level have been associated with floor moisture issues. Due to this quandary and the fact that meters and particularly capacitance meters only measure within 25 mm of the concrete surface, their use can provide guidance and be useful for comparative purposes but should only be used as part of the assessment. With one brand of capacitance meter, readings of 6% to 7% have been recorded on a slab that was a few days old and, on a five-year-old slab with no moisture concerns, readings of 1.7% to 2.0%. This is in line with the data shown in Figure C1.

The availability of resistance moisture meters has reduced and that of capacitance moisture meters has increased. The capacitance meter has the advantage of being able to perform many tests very quickly over the slab and therefore, for the purpose of doing a quick survey and comparing different areas, it has significant benefits. Finally, it should be noted that additives as used in some parts of the country may have an effect on meter readings.

C5 In-Slab Relative Humidity

In the United States, the test method is covered by ASTM F2170 'Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs using in-situ Probes'. It simply involves drilling a hole in the slab, inserting a capped sleeve, waiting a period of time and then inserting a probe to measure the relative humidity of the air in the hole in the slab. Some specifics of the testing requirements are:

- The in-service conditions of relative humidity and temperature are to be maintained for 48 hours prior to testing (21°C to 29°C and 40% to 60% RH).
- The depth of the hole is 40% of the slab thickness if drying is from one surface or 20% if drying from two surfaces.
- The hole is sealed for three days to allow the internal relative humidity of the air in the holes to become the same as that of the concrete. The probe must be given time to equilibrate before taking a reading.
- Three tests are required for approximately 100 m2 of floor area.

There has been much discussion about acceptable in-slab RH levels and no clear guidance is available at this stage. In some literature a maximum value of 75% is suggested, in other literature specific to parquetry floors a figure of 60% is quoted. However, in humid climates it may be difficult to achieve 60%. It is also not clear from the literature whether there is a difference between above-slab relative humidity limits and in-slab relative humidity limits. Similarly, companies producing measuring equipment do not provide guidance in this area.

C6 Considerations for House Slab Assessment

When considering house slabs, a check list (see example) can be used to assess the risk. Note that, as there can be differences between the readings of capacitance meters, the limits in provided in Table C1 may differ and need to be determined depending on the meter and locality.

Example check list

If the answer to any of the following questions is 'No' then risks are greater and need to be considered.

1. Is the slab height/floor >150 mm above ground level (including above external patios)?
2. With slab surface testing, was the slab found to be sound, flat and with no hollow sounds under any patches?
3. Do water droplets readily absorb into the slab?
4. Is the slab known to be of an age where an under-slab moisture membrane was a building requirement?
5. Moisture testing (refer to Table C1) – If using a capacitance meter, record at least 20 readings including all internal and external corners and where possible slab thickenings or beams may be present. Are all readings in the moderate-to-low range of the table?
6. If using an in-slab Hygrometer, readings of 75% are indicative of an older dry slab. In Sweden, in-slab relative humidity up to 80% is seen as suitable for timber flooring products to be laid over.
7. If using above-slab relative humidity (as more often used in New Zealand), a RH of not more than 70% is indicative of minimal moisture transmission from the slab or through a moisture vapour retarding barrier.

Table C1: Slab age, moisture content and risk.

SLAB AGE	MOISTURE CONTENT	RISK
< 3Months	-	Very High
3 Months	Up to 5%	High
3 to 6 Months	Up to 4%	Moderate
6 Months - 3 yrs	Below 2.75%	Low
6 Months - 3 yrs	2.75% to 3.5%	Moderate
6 Months - 3 yrs	Over 3.5%	High
> 3 years	Over 3.5%	High

D

Appendix D – Acoustic Performance

Timber floors are used in many multi-storey apartments, both in new construction and renovation work. With new projects, building regulations often apply restrictions to sound transmission between units and in renovation work the noise associated with any replacement floor can often be no greater than the original floor. With regard to sound transmission, timber flooring is similar to other hard flooring surfaces and, in particular, it will freely transfer impact sounds. For this reason, it is necessary to ensure correct detailing and installation measures to provide a floor system with the required sound performance.

D1 Noise Transmission through Timber Floors

Whenever the acoustic performance of a material is being tested, great care is taken to ensure the material is isolated so that only the sound transmission through that material is assessed. When materials are not isolated, as occurs in buildings with floors connected to walls and walls being common to upper and lower-storey units, additional non-direct sound transmission paths or 'flanking' paths are introduced. Sound from a floor above can then radiate from the wall surfaces in the unit beneath and this can contribute considerably to sound transmission between units.

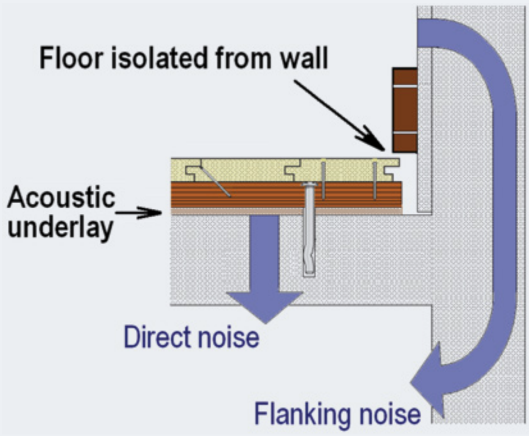


Figure D1: Acoustic underlay and floor isolation significantly reduces direct and flanking noise transmission.

When concrete cures, a hydration reaction occurs that uses up much of the added water. However, even after curing, the pores will contain a significant amount of water, similar to the water within the cells of a board that has been freshly cut from a tree. In both cases, it is from here that drying begins with the lower relative humidity air of the surroundings causing evaporation from the surfaces, and this continues until the 'equilibrium moisture content' is achieved. Similarly, with both materials, the thicker either the board or slab is – the longer it takes to dry.

This indicates that great care is necessary in building design and detailing to provide effective solutions and the system needs to consider providing isolation, absorptive materials and increased mass (i.e. slab thickness). Each of these is important to reduce sound transmission. Timber floors, as with other hard floor surfaces, are particularly affected by impact noise resulting from foot traffic.

D2 Approaches to Improve Acoustic Performance

D2.1 Timber Floors on Battens

Timber floors over concrete slabs are often fixed to battens that are, in turn, directly fixed to the concrete slab. To provide a degree of isolation between each element, resilient pads may be used between the batten and the slab. Fixing of the batten to the slab is still necessary and this will result in some sound transmission. Generally, thicker battens require less frequent fixing and thereby reduce the frequency of direct fixing. With battens at 450 mm centres, 19 mm strip flooring may be used for domestic loading. The flooring may be secretly fixed to 19-mm-thick hardwood batten or top (face) nailed. If top (face) nailing is used the hardwood battens needs to be at least 35 mm thick. For more specific details of floor fixing, refer to Section 4 of this manual.

D2.2 Timber Floors over Sheet Floors

This system uses a complete sheet of acoustic underlay over an existing timber floor or slab. A plywood sub-floor is then laid over the acoustic underlay and fixed to the slab or timber floor beneath. Again, the fixing of the sub-floor will result in some sound transmission. Both 19-mm-thick and overlay flooring may be used in this instance, as the boards are fully supported. Secret fixing with the addition of a polyurethane flooring adhesive is generally used to fix the boards. More specific floor fixing details are provided in Section 4 of this Guide.

D3 Other Important Considerations

D3.1 Selecting the Underlay and Isolation Pads

The purpose of the underlay or pads is to provide isolation of the timber floor from the building elements beneath. Many products are available and each should have test data relating to performance. The products need to fulfil the following criteria:

- Pads need to be sufficiently thick to ensure separation is maintained when the floor is being walked on.
- The product needs to be rigid to prevent compression when the floor is walked on.
- It should provide long-term performance without flattening, particularly under heavy appliances and furniture.

D3.2 Isolation at Floor Edges

It was outlined above that isolation is a key aspect to prevent flanking sound transmission. Gaps need to be maintained between the flooring and all walls, steps, window joinery, etc, and a small gap is also necessary between the skirting and the floorboards.

D3.3 Further Improvements

Improvements in sounds transmission from a floor to a unit below can also be achieved at the design stage by ensuring that the slab is of adequate thickness. An extra 25 mm in slab thickness can make a significant difference to sound transmission. In addition to this, ceiling systems can also be used, which isolate the sound source (i.e. timber floor) from the unit beneath. These systems generally consist of a grid of isolation mounts with furring channels attached. Insulation and plasterboard complete the system. With multi-residential timber framed construction (MRTFC), two layers of fire-rated plasterboard are used. Such systems are effective and are considered to be relatively economical. Finally, rugs, hall runners and mats used in conjunction with timber flooring can not only complement the timber floor but, with their sound absorbing properties, can also reduce noise levels both within and between units.

E

Appendix E – Underfloor Heating

E1 Timber Floors and Underfloor Heating

Timber floors with underfloor heating systems (UFH) are common in Europe and North America. However, they are not common in the cooler southern states of Australia, although public interest is increasing. Due to the limited number of installations, experience in Australia is limited, particularly with the medium and higher-density hardwoods that are available. Research by the Centre for Sustainable Architecture with Wood (University of Tasmania) has recently evaluated the use of overseas practices with the performance of Messmate and Blackbutt. Floors with an underfloor heating system in place in Tasmania were monitored over a period of time, through winter and summer. This Appendix provides guidance regarding the installation of timber floors over underfloor heating systems and is relevant to the southern states of Australia.

E2 The Climate Experienced with Heating Systems

Temperature and relative humidity are the two key factors that influence the internal climate or environment within a dwelling. An increase in the temperature inside the dwelling will cause a lowering of the relative humidity and, with this, the drying capacity of the air increases. Low relative humidity will result in timber flooring releasing some of its moisture to the air, thereby reducing in moisture content and shrinking. As such, the moisture content of a floor is affected by changes in the heated environment. The term equilibrium moisture content (EMC) is often used. EMC can be thought of as the moisture content that timber will attain under set conditions of relative humidity and temperature. Therefore, if the conditions inside a dwelling are maintained at 20 C and 60% RH, the flooring – depending on its current moisture content – will either take up or lose moisture to try to attain a moisture content of about 11%.

The external EMC can be calculated from weather data, and Figure E1 illustrates how this varies seasonally for the southern states. The external RH during winter is high and in summer it is much lower. When cooler external air is then heated, as in an internal environment, the RH and therefore the EMC drops significantly. The Tasmanian study calculated the effect of EMC values resulting from heating to 20°C for the period from May to September, and this is shown in the lower graph.

As can be seen from Figure E1, the effect is dramatic and suggests that the conditions associated with a heated internal environment will result in EMCs between 8% and 9% during the heating period. Both graphs are based on external relative humidity values and a less extreme variation would be expected inside a dwelling. Even so, the flooring needs to be able to cope with very dry conditions during the heating period over winter and moderate rises in moisture content over summer. While this can be catered for, there is an obvious concern if the UFH system was not to operate for a significant period over winter, as this could create expansion that was greater than would occur over the summer months.

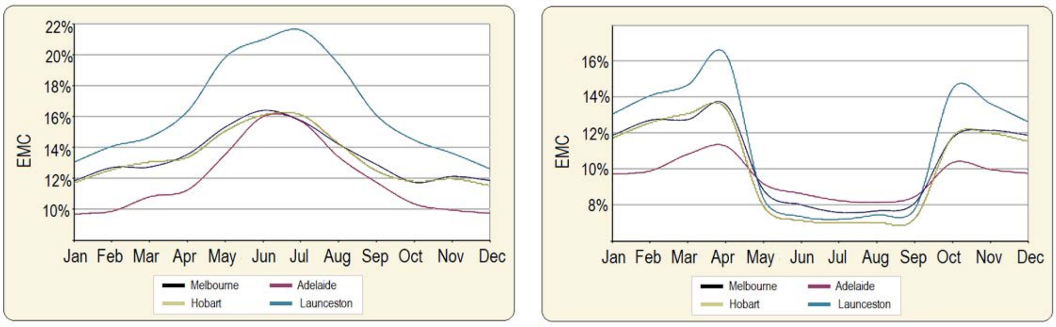


Figure E1: Seasonal variation of EMC for the southern states.
Source: FWPA Project PN07.104 – Advanced Research into Floor Performance Issues – University of Tasmania, 2008.

E3 Choice of Timber Flooring

Two species were chosen in the Tasmanian research: Messmate, a medium-density hardwood; and Blackbutt, a higher-density hardwood. Both species are known to be relatively responsive to moisture uptake and loss from the air, however, under-floor expansion the Blackbutt would tend to crush less at board edges and result in greater expansion forces. Blackbutt is also usually backsawn, whereas Messmate is usually quartersawn. For the same increase in moisture content, a backsawn board will swell more than a quartersawn board. The cover width of the 19-mm-thick flooring used in the research was 85 mm for Tasmanian Oak and 80 mm for Blackbutt.

In the United Kingdom, recommendations are to limit board width to 75 mm with underfloor heated applications. However, with American Oak, a cover width up to 130 mm has been found to give good results. It is not recommended that board widths in Australia exceed 130 mm and the preference is for 80 mm or 85 mm boards in these applications to minimise gapping and the potential for a cupped or crowned appearance.

The Tasmanian research indicated that 19-mm-thick flooring was considerably more robust to effects of cupping than 12-mm-thick overlay material. It must be considered that in times when heating is not on and floor expansion occurs, then the thinner boards will be more reactive and the risk of cupping is very high. For this reason a board thickness of 19 mm is recommended.

Figure E2: Sydney Blue Gum floor with underfloor hydronic heating.
Source: FWPRDC project PN07.104

Concerning the moisture content of the flooring, AS 2796 indicates a normal manufacturing range of 9% to 14%. However, research has indicated that 8% to 9% – which is near the middle of the expected internal seasonal range in Australia's southern states – is more appropriate. Overseas, an average of 8% is often recommended. In Australia, it is unlikely that manufacturers will produce specific batches of flooring at these low moisture contents. Much of the flooring is, however, produced to the lower end of the 9% to 14% range of AS 2796 and flooring packs with boards averaging 10% are likely to be available. To obtain this, close liaison between manufacturer or supplier and the installer would be necessary.

To determine suitability, the proposed flooring would need to be sampled and oven dry testing undertaken to determine exact moisture contents. This can be expected to add some cost but is considered important. Also, great care of the lower moisture content flooring needs to be taken to ensure minimal change in moisture content prior to laying. Irrespective, some gapping at board edges after installation can be expected as a result of the underfloor heating.

E4 Heating System Considerations

Heating systems used with solid timber floors range from hydronic heating, where warm water is piped through a concrete slab beneath the floor, to electric heating systems beneath the floor. It is necessary that the client makes available to the floor installer full installation and operating instructions of the system that is in place, and that the system or proposed system is considered by the heating system manufacturer to be compatible with solid timber floors.

Even heat distribution is vitally important, as hot spots can cause greater board movement (shrinkage or cupping) in some areas of the floor compared to others. Pipes within a slab set at different heights can be the cause of this, and the installer should make the client aware of this possibility.

Figure E3: Blackbutt flooring (130 mm wide) with electric underfloor heating in Adelaide.

The client should also recognise that with seasonal operation of the system some gapping and change in board shape (slight cupped or crowned appearance) is likely, and particularly so if the client has chosen wider boards.

The client also needs to be made aware of the constraints to the system with regard to operating temperature and the need to avoid abrupt changes when adjusting floor temperature. Small increments of 2°C per day are appropriate and underfloor temperatures should not to exceed 27°C.

E5 Typical Installation Procedures

Installation procedures in countries that more regularly lay floors over underfloor heating are relatively consistent, but can vary in certain details.

A typical procedure is provided here for guidance only, as Australian experience is limited. It involves the following steps:

1. **Site conditions**
   The site should be free from all wet trades, be in a state where the dwelling can be lived in and with the heating system fully commissioned. The sub-floor should also have been levelled if necessary to accept the timber floor.

2. **Pre-heat the sub-floor prior to laying to remove excess sub-floor moisture**
   The heating system needs to be operated for a period of two weeks prior to floor installation to lower the moisture content of the sub-floor, particularly if it is a slab, to remove further moisture. The possibility of higher levels of humidity in the room during this process should be checked for and ventilation provided as required. When conditions are sufficiently dry, the flooring should be stored in the installation location in a manner that does not interfere with the drying of the sub-floor. During and particularly toward the end of this period, the room conditions regarding temperature and humidity should be checked and the relative humidity should be in the range of 45% to 60% at a temperature of about 20°C. This equates to an EMC of 8.5% to 11%. The moisture content of the flooring to be laid should have already been thoroughly checked prior to supply to ensure that boards are generally 9% to 10% moisture content, and this should again be checked prior to laying. Similarly, the sub-floor should be checked to ensure it is suitable for accepting a timber floor. The sub-floor temperature should not exceed 27°C with in-slab heating. (With hydronic heating, water temperatures may be 45°C or so to attain an underfloor temperature up to 27°C.)

3. **Turn off the heating and follow this by a non-heating period**
   The period of time that the heating remains off is generally about two days.

4. **Lay and fix the floor**
   If the floor is laid direct to a slab, an elastomeric polyurethane adhesive is used. As this may differ from those used with normal floor installation, advice should be obtained from the adhesive supplier. For other types of sub-floor, normal fixing practices apply. Following installation, the heating is to remain off for a further two days.

5. **Gradually increase the UFH to normal expected temperature**
   The heating should be increased in stages from a low level to the desired room temperature over a period of about 10 days, incrementing by no more than 2°C each day, and should then maintained for a further two weeks.

6. **Sanding and finishing**
   Recommendation vary, with some indicating that it should be carried out about three days after the heating was turned back on, while others indicate that the heating should be turned off and the floor sanded two days after the floor has cooled.

7. **Turn the heating system on**
   The system with installed and finished floor can then be operated, but again the temperature should be raised gradually to the desired operating temperature. With an UFH system in place, the optimum relative humidity range is between 45% and 60% year-round with room temperatures of about 18°C to 24°C.

F

Appendix F - Installation Checklist

Assessing Packs of Timber Flooring

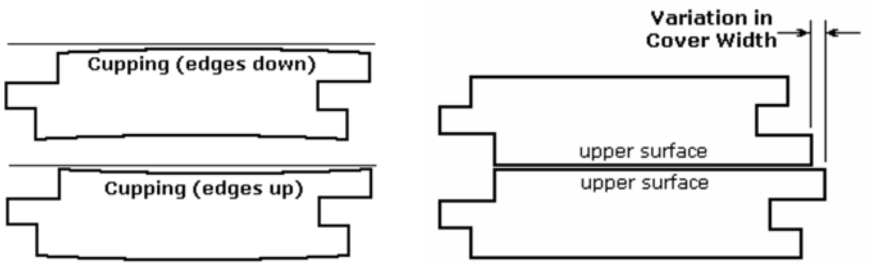
Flooring Manufacturer:

Pack Nos.

Species/Species mix: Cover width: Grade:

Wrapping is in good condition and there are no signs of the product getting wet. ☐ Yes ☐ No

Boards should be checked for:-
- **Cupping** (Use a steel rule or similar)
- **Cover width variation** (Should not vary by more than 1mm between boards)
- **Tongue and groove tolerance** (Snug fit to slightly loose)



Note: Cover width variation exceeding 1 mm, sloppy T&G fit, signs of moisture or cupping may indicate possible problems.

Records

Widest Boards	Moisture Content	Cover Width	Cupping
1			
2			
3			

Narrowest Boards	Moisture Content	Cover Width	Cupping
1			
2			
3			

Note: Ensure that the appropriate moisture meter corrections have been applied. Moisture contents should be between 9% and 14% (average between 10% and 12% is common).

Site Conditions and Installation Environment

Site location

Average 9am RH Average ext EMC

Note: If the external EMC is greater than 2% higher or 1% lower than the estimated average moisture content then additional provision for future expansion or shrinkage needs to be considered (refer Section 2).

If applicable, are sub-floor conditions dry, ground levels beneath dwelling not lower than external ground and graded to prevent ponding, ventilation to recommendations and ground sloping away from dwelling?

☐ Yes ☐ No

Note: If 'no' then these issues may need to be attended to or other measures taken prior to installing the floor.

If the floor is laid on joists ensure the joists are sufficiently level.

If the floor is over a concrete slab or sheet sub-floor, are the sub-floors adequately level, dry and in good condition?

Slab moisture contents or checks undertaken with the following results:

Slab level checked and within ± mm in 1.5 m throughout (plywood or batten system).

Note: Maximum is ± 3 mm

If sheet sub-floors have become wet prior to or during construction and may not have sufficiently dried then moisture contents need to be checked. Moisture contents are as follows:

Note: Plywood and particleboard moisture contents need to be determined with oven dry testing. Sheet sub-floors should be within 2% of the timber flooring moisture content being laid over it. Slab moisture assessed in accordance with Appendices A3.

If the floor is over a concrete slab then check it for construction joints and determine whether it has a moisture barrier beneath the slab.

Note: If construction or similar joints are present in slabs then possible moisture penetration from capillary action needs to be considered. Older slabs may not have moisture barriers beneath the slab and are more prone to seasonal moisture fluctuations that can affect timber floors.

The following slab moisture barrier as applicable has been applied to or over the slab:

Expected Movement after Installation

If wide board flooring is being used greater shrinkage can be expected during dry times.

In moist localities high levels of expansion can be expected *(Ensure adequate additional expansion allowance).*

Is the building design such that the floor will experience high levels of sunlight or has heating/air-conditioning systems? *(Drier in-service conditions can be expected at certain times of the year and shrinkage gaps will be more likely.)* Is the underside of the floor is exposed to dry winds or mist? *(Sealing or protection to the underside of the floor needs to be considered to assist in controlling both expansion and shrinkage.)* Is the floor an upper storey floor *(Drier in-service conditions can be expected – shrinkage gaps are more likely.)* or below grade in shady conditions? *(Wetter in-service conditions can be expected – ensure adequate expansion allowance – refer Section 3.)*

Installation Moisture Content and Acclimatisation

Based on the expected in-service movement the following pre-installation procedures have been undertaken:

Note: Acclimatisation (flooring stripped out or loose layed) or provision of additional expansion allowance, etc, should be recorded.

Method of Installation

This floor is being laid by the following method:

Choice of Finish System

Based on the movement expected and condition of the floor at the time of sanding and finishing some floor finishes are more appropriate than others. (Possible issues such as wear, grain raise, edge-bonding and white lines need to be considered).

The finish system used on this floor is:

(Note: The above is provided as a guide only. Additional testing may be necessary or there may be the need for other considerations.)

G

Appendix G - Troubleshooting Guide

G1 Performance of Timber Floors

In most instances, timber floors perform well in a range of localities and with a variety of installation practices, depending on the sub-floor type. There can, however, be instances where the performance or appearance of the floor can be affected and the major contributing factors are:

- The manufacture of the product does not meet Australian Standards.
- Recognised installation and finishing procedures are not followed.
- There is moisture ingress directly (e.g. leaks) or indirectly (e.g. seepage into sub-floor space).
- The owner has not paid adequate attention to some aspects of the floor.

The table below outlines some of the performance issues with timber floors, common causes and how they appear in the floor.

Table G1: Common performance issues with timber floors.

Performance Issue	Common causes	Appearance in the floor
Cupping	• Moisture from beneath the floor • Dry conditions above the floor • High moisture contents in boards at time of manufacture	• Boards cup throughout the floor and the floor is tight • Boards cup throughout but gaps are present at board joints • Some boards in the floor will cup in the floor but not others
Crowning	• Moisture uptake and the floor sanded and finished in this condition	• During dry periods the floor gaps at board edges and develops a washboard look
Peaking	• High pressure on the upper shoulder of the board often resulting from atmospheric moisture uptake • Board tolerances and MC differences between supply and in-service also contribute.	• The joints at board edges are raised. This can have the appearance of cupping
Tenting	• High expansion. • May be directly related to high humidity or other moisture issues. • May relate to inadequate expansion allowance, poor ventilation or inadequate fixing	• Adjacent boards in the floor rise at the joint above the level of the floor
Buckling	• High expansion • May be directly related to high humidity or other moisture issues • May relate to inadequate expansion allowance, poor ventilation or inadequate fixing	• A group of adjacent boards lift off the sub-floor
Wide or irregular gapping	• The finish gluing adjacent boards and the floor shrinking • High moisture contents in boards at time of manufacture • Boards inappropriately stored and have taken up moisture prior to laying • Wide boards and dry conditions	• Loud cracking noises, irregularly spaced wide gaps and splits through boards • Gaps at board edges associated with narrow cover width boards. • Frequent gapping. The measurement over sections of the floor is inconsistent. • Regular wide gaps

Figure G1: Tenting resulting from atmospheric moisture uptake.

Figure G2: Wide gaps due to high moisture contents at the time of machining.

G2 Sanding and Finishing Imperfections

A high standard of sanding and finishing can be expected when the floor has been completed; however, some sanding and finishing imperfections can be expected. The degree to which imperfections are apparent depends on many factors, including timber colour and use of downlights, both of which can highlight such things as sanding marks and dust in the finish. Consequently, it is difficult to provide objective measures of finishing imperfections. Even so, it is known that a high standard of workmanship also provides an equally high standard of customer acceptance and satisfaction. When the appearance of a floor is being assessed, the assessment should be carried out in daylight hours with lights on and curtains or blinds in their usual position. Imperfections should be viewed from a standing position a few meters away and also from various directions. If the imperfection is difficult to discern, the appearance is generally satisfactory. It should be noted that viewing any imperfection directly toward light sources – such as toward uncovered sliding external doors – will always exaggerate imperfections, and this needs to be considered when evaluating the floors appearance. In addition to this, aspects to be considered should include whether the imperfection is in excess of what would generally occur, whether it is likely to covered by furniture or floor rugs and whether the imperfection will decrease in time with foot traffic. The table below outlines some of the sanding and finishing imperfections with timber floors, common causes and how they appear in the floor.

Figure G3: Rejection and contamination in the finish.

Table G2: Common imperfections in timber floors.

Appearance Issue	Common causes	Appearance in the floor
Rejection	• Contaminants leaching out of the flooring affecting the curing of the finish	• Ranges from a change in a localised gloss level to an 'orange peel' appearance
Delamination	• Movement of the timber at board joints or at the end of the board. • Inappropriate sealers	• The finish peels at board joints or board end
Quilting	• Surface coatings flow into the joints between boards	• A lack of consistency of the coating over board joints highlighting the joints and giving a 'bed quilt' appearance
Contaminants	• Floor not clean • Windy external conditions • Dust in gapped boards or under skirting	• Small specks or insects in the finish which is often worse near poorly sealing external doors
Ghosting	• People walking on the floor at the time of sanding and finishing with certain types of boots and footwear or bare feet	• After a period of 12 months to two years the appearance of a foot or boot print appears in the floor as a lighter colour
Pimples	• Fine air bubbles occurring during coating application	• Popped bubbles in the finish
White lining	• The rapid stretching of waterborne finishes when boards gap	• White lines appearing along board joints.
Edge bonding	• Finish flowing into gaps at board edges and gluing boards together • Thinned finish used as a sealer and penetrating fine joints between boards	• Wide irregular spaced gapping at board edges • Splits in boards
Gloss variation	• Weather conditions • Surface evenness of the boards	• Shiny and dull patches in the finish
Swirl marks	• Rotary sanding particularly at the edges of floors	• Circular swirling scratch marks
Chatter marks	• Vibration in the floor • Sanding technique	• Undulations running across several boards

For further information on the floor inspection process and many of the more common problems refer to the Australasian Timber Flooring Association (AFTA) publication *Problems, Cures and Remedial Measures*.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