

3.0 INTRODUCTION

This information sheet outlines the recommended practices for laying timber strip floors over timber and engineered timber joists (it does not include steel joists), structural sub-floors such as plywood, particleboard and over concrete but does not include direct adhesive fix to slabs.

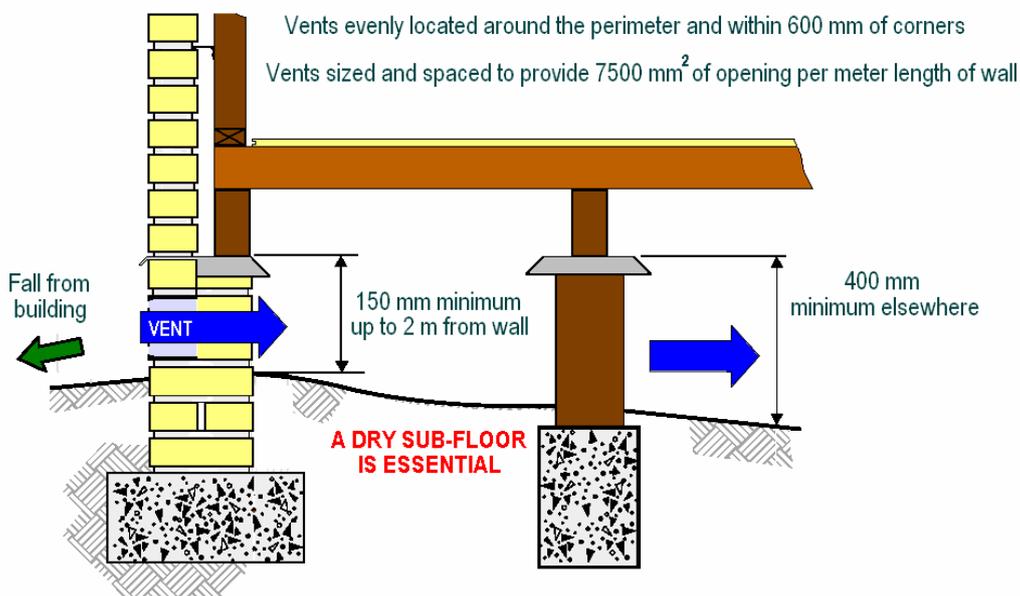
When laying a timber strip floors over joists, either directly on the joists or on sheet flooring fixed to joists, adequate sub-floor ventilation is essential for the satisfactory performance of the floor. Sub-floor ventilation recommendations are therefore included in this data sheet.

3.1 SUB-FLOOR VENTILATION

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. 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 floor boards 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 (Refer Data Sheet 2 - Pre-installation Requirements). Timber floors should not be laid over 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 humidities in the sub-floor space remain high for extended periods.

Ventilation requirements

T & G floors should be provided with sub-floor ventilation that exceeds minimum Building Code of Australia (BCA) requirements. The levels outlined in the BCA (currently limited to 6000 mm² per meter 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 7500 mm² per meter length of wall, with vents evenly spaced to ensure that cross ventilation is provided to all sub-floor areas (refer to the following figure).



In some localities, to meet constraints associated with energy efficiency, it may be decided to reduce ventilation levels to the values provided in the BCA. The BCA also outlines that a moisture barrier 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 also need to be considered with buildings in bushfire areas which limits the mesh size used in vents. Some commercially available vents of various types, their dimensions, net ventilation area and required spacing is provided below for coastal Zone 3. BCA relative humidity zones and associated BCA ventilation requirements are also provided below. It should be noted that the maximum vent spacing irrespective of net ventilation area is 2m 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.

Ventilation efficiency and site drainage

The sub-floor space must be free from all building debris and vegetation. Obstacles that prevent air-flow to and from vents will reduce the efficiency of the sub-floor ventilation system. Landscaping should not limit air-flow 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 which 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.

Where verandahs or decks are constructed outside the dwelling perimeter, care should be taken to ensure that the amount of ventilation provided around the verandah 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 cross flow is achieved.

If adequate natural ventilation cannot be provided to sub-floor spaces, a mechanical ventilation system should be installed which replaces all of the air in this space on a regular basis, and prevents 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.) again 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 taken into consideration and appropriate control measures taken prior to the installation of the floor.

The drainage system provided to the dwelling site, should 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. 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.

3.2 ASSESSING FIXING REQUIREMENTS

Due to climatic differences occurring between and throughout each state the fixing requirements of the floor need to be carefully assessed. Due to this, applicable fixing requirements differ to some degree between states and between locations within each state.

Top (face) nailing is a more robust fixing method than say 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 a 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 chosen and associated spacing of fixings or amount of adhesive used requires consideration. 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 and at times tenting of boards.

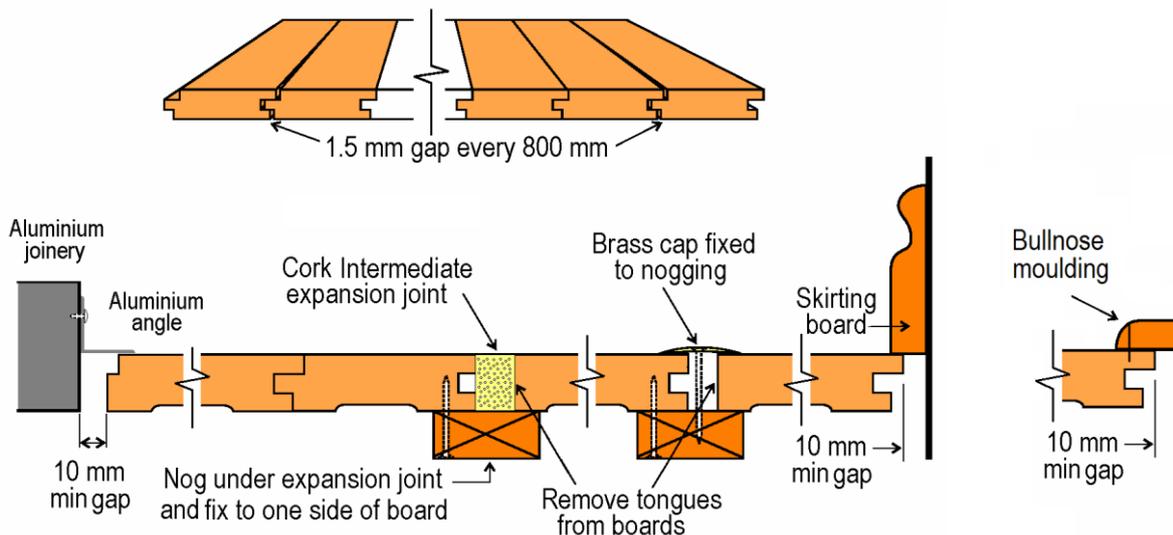
It should also be noted that the specified recommendations contained in this manual are generic in nature and although frequently used, installers with knowledge and experience in a particular locality may fix a floor in a manner that differs from that outlined here. There are also an increasing number of flooring manufacturers who are producing specific products with accompanying installation instructions and such instructions should be strictly followed. This includes wider thin overlay boards and standard profile flooring for secret fixing. Other manufacturers recommend that standard profile flooring should not be secretly fixed. 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.

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

3.3 ALLOWANCE FOR EXPANSION IN FLOORS

Fitted floors require a minimum 10 mm expansion gap between the floor boards 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. Floors up to 6 m wide (measured at right angles to the run of boards) should not require 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) cramping pressure needs to be considered along with providing an intermediate expansion joint, or a series of smaller expansion gaps every 800 mm to 1000 mm to provide equivalent spacing. If cork expansion joints are used, the cork should be 2 mm or so proud of the floor surface when installed. This will be removed during the sanding process. However, cork to the perimeter should be installed level with the timber surface. It should however be noted that cork to aluminum door joinery can cause the joinery to bow under floor expansion and an aluminum angle as shown in the diagram below overcomes this. This angle may also be inverted and adhesive fixed to the aluminum joinery or alternatively a small timber bullnose molding on flat fixed to the flooring is being used.



3.4 FLOOR LAYING PRACTICES

The moisture content, size and profile of the flooring should be checked (Data sheet 2 – Pre-installation assessment) prior to laying. If it is identified that the moisture content is not correct or the boards do not fit together properly, or are otherwise considered to not 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 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 a structural sub-floor such as plywood or particleboard it is important that the fixing is adequate. In moderately humid locations it has been found that nail and adhesive fixed sheet flooring has in some instances buckled off the joists, even when fixed in accordance with the relevant nailing requirements of Australian standards. Screw fixing to the joists as often used provides for a more robust fixing.

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 450 mm apart and that joints do not cluster together or align. For aesthetic reasons close alignment of end joints in adjacent boards should be avoided.

Installers should 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-floor. 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 through the floor.

3.5 INSTALLATION OF STRIP FLOORING DIRECT TO JOISTS

Construction Method

Where the timber floor is to be sanded and polished (i.e. feature floor) then 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 weather tight. This prevents initial degrade due to water and sunlight exposure and reduces damage from trades during construction.

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. 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.

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. If fixed into unseasoned joists, the joists need to be of a species not exhibiting high rates of shrinkage and be in single or similar species. 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.

Allowable Joist Spacing and Maximum Span of Floorboards

Species Group	Grade	Thickness (mm)	Acceptable Species, Grade and Joist Spacing			Maximum Span	
			450 mm	450 mm	600 mm	End matched	Butt joined
			End matched	Butt joined	Butt joined		
Hardwood All hardwood species listed on page 5	AS 2796 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 Select & Standard Grades	19	✓	✓	✗	410 mm	510 mm
	Other pinus species	19	✗	✓	✗	350 mm	470 mm
	Araucaria (Hoop Pine)	20	✓	✓	✗	410 mm	510 mm

Installation Direct 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.

Top (face) Nail and Secret Fixing Direct to Joists

Boards for top (face) nailing and cover widths of 65 mm or less should be 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 135mm are often top (face) nailed with two or three nails.

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 for secret fixing 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. Note that 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 the following table.

Recommended Fixing of T&G Flooring to Joists¹

TYPE OF FIXING	METHOD	JOIST TYPE	
		SOFTWOOD, LVL and I-BEAMS	HARDWOOD and CYPRESS
SECRET FIXING 19-21 mm thick boards	Machine driven	<ul style="list-style-type: none"> ▪ 50 x 15 gauge staple or 50 x 16 gauge cleat ▪ and adhesive² to joist 	<ul style="list-style-type: none"> ▪ 45 x 15 gauge staple or 45 x 16 gauge cleat ▪ and adhesive² to joist
TOP (face) FIXING 19-21 mm thick boards	Machine driven	<ul style="list-style-type: none"> ▪ 50 x 2.2mm T – head or 50 x 2.5 mm T – head ▪ and adhesive² to joist 	<ul style="list-style-type: none"> ▪ 50 x 2.2mm T – head or 50 x 2.5 mm T – head ▪ and adhesive² to joist
	Hand driven	<ul style="list-style-type: none"> ▪ 50 x 2.8 mm bullet head and adhesive² to joist 	<ul style="list-style-type: none"> ▪ 50 x 2.8 mm bullet head (adhesive² optional)

Note: 1. Fixings may vary to some degree between locations due to installers' experience of local conditions.
2. A continuous bead (6 mm to 10 mm approx.) of flooring adhesive to be applied to the joist.

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 floor boards 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.

3.6 INSTALLATION OF STRIP FLOORING OVER EXISTING TIMBER AND SHEET FLOORS ON JOISTS

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 11 mm to 14 mm thick) or structural flooring (generally 19 mm to 21 mm thick) can be laid. Floors may be fixed through the sub-floor into the joists or into the existing floor only.

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; or
- 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 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 may need rough sanding to provide an appropriate surface over which the new floor is to be fixed. Adhesives require a clean, structurally sound floor that is free from surface moisture, loose particles and contaminants. In some instances sheet sub-floors (substrates) can sag between joists and if not leveled the sagging 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 testing. Prior to laying, the new floor should be of similar moisture content (within a few per cent) to the existing floor. 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 x 45 mm or 19 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 to 600 mm centers to hold the batten in place until the adhesive is set.

Installation

The methods below are generally suitable for board widths up to 135 mm wide, both overlay and structural flooring.

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.

Note that 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 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. 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.

Installation of flooring should not proceed until other construction activities (particularly wet trades) are complete and until after the building is roofed and enclosed, with the temperature and humidity as close as possible to the expected in-service conditions. 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 floor boards. Intermediate expansion joints should also be provided in larger floors (width at right angles to boards exceeding 6 meters), to give an equivalent gap of 10 mm every 6 meters (approx. 1.5 mm every 800 mm) or alternatively the boards should be loosely cramped.

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 boards that do not allow secret fixing, top (face) nailed. When laying over an existing T&G sub-floor the new flooring may be laid either parallel with the existing boards or at 90° to or at any other angle to the existing boards, providing the sub-floor (substrate) is within the required flatness tolerances. The fixing of the floor may be undertaken relying on a combination of mechanical and adhesive fixing.

When fixing boards with a maximum width of 85 mm at close centers up to 225 mm, beads of adhesive to provide a cushion between the two floors should be used to minimise possible squeaks. This is achieved by using a continuous bead of adhesive at 90° to board length, midway between fixing points. Where flooring adhesive is used to provide more of the fixing, staples or cleats may be spaced up to 450 mm apart with beads of adhesive at the fixing points and midway between.

With wider 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 4.

For 19 mm thick flooring staples for boards up to 85 mm wide should be a minimum of 32 x 15 gauge and- cleats should be a minimum of 32 x 18 gauge. For wider boards to 135 mm x 19 mm, 38 mm x 15 gauge staples or 38 mm x 16 gauge cleats are recommended. For overlay flooring which is generally up to 15 mm thick, 25 mm long fixings are commonly used for all widths. Fixing is also required within 50 mm of board ends, however if too close splitting at ends may occur.

Recommended Fixing of T&G Flooring to Sub-floors of Plywood, Particleboard and T&G on Joists¹

TYPE OF FIXING	BOARD SIZE	SUB-FLOOR on JOISTS
		PLYWOOD, PARTICLEBOARD or T&G
SECRET FIXING	T&G boards up to 85 mm in width and 19-21 mm thick	<ul style="list-style-type: none"> ▪ 32 x 15 gauge staples or 32 x 18 gauge cleats at 225 mm centres and ▪ Adhesive beads² to be provided midway between fixing points.
	T&G boards greater than 85 mm and up to 135mm wide and 19-21 mm thick	<ul style="list-style-type: none"> ▪ 32 x 15 gauge staples or 32 x 18 gauge cleats at 450 mm centres and ▪ Adhesive beads² to be provided at the fixing points and midway between fixing points.
		<ul style="list-style-type: none"> ▪ 38 x 15 gauge staples or 38 mm x 16 gauge cleats at 300 mm centres with a full adhesive bed³. ▪ Suitability of flooring for secret fixing to be checked with manufacturer.

- Notes:
1. Fixings may vary to some degree between locations due to installers' experience of local conditions.
 2. Adhesive beads of 6 mm to 10 mm are often applied in a zigzag pattern
 3. Full bed adhesive to be applied to the adhesive manufacturer's instructions
 4. For overlay flooring up to 15 mm thick a fixing length of 25 mm is commonly used

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

When structural 19 mm flooring is used, the floor should be top (face) nailed with 65 x 2.5 mm machine nails or 65 x 2.8 mm hand driven nails through the existing floor and into the joists. For thinner overlay flooring, 50 x 2.5 mm machine nails or 50 x 2.8 mm hand driven nails should be used. In all cases, continuous beads (6 mm to 10 mm approx.) of flooring adhesive should be provided at the joists and midway between them to provide a cushioning effect between the two floors. Board ends adjacent to walls should be fixed with flooring adhesive and nailed to the sub-floor.

3.7 INSTALLATION OF STRIP FLOORING ON PLYWOOD AND BATTENS OVER CONCRETE SLABS

The methods below are generally suitable for board widths up to 135 mm wide. Structural flooring is to be used on battens and either structural or overlay flooring may be used on plywood. The secret fixing of boards requires one staple or cleat at the appropriate spacing. For top (face) nailing of boards to the batten two nails per board are required at each fixing for boards exceeding 65 mm cover width. Boards wider than 135 mm are being fixed to battens with two or three nails.

Note that 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.

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 is a more specialist field and appropriate professionals in this field should be consulted if considering this method. The following 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 two high points in a slab within a 1.5m length, a concrete topping (leveling compound), grinding or packing should be used. Slabs on ground should be constructed with a continuous under slab vapour barrier (in accordance with AS 2780). Timber floors should not be installed until the concrete slab has been assessed in accordance with Appendix A3 (generally the slab will need to have cured for a period of at least 4 months).

Installation

When floors are to be fixed over a plywood sub-floor, overlay or structural flooring may be used. When floors are to be fixed to battens at 450 mm centers, structural flooring (19 mm or thicker) is to be used. The plywood sub-floor or battens need to be at a moisture content within a few per cent of the flooring to be installed at the time of installation.

Installation of flooring should not occur until other construction activities, particularly wet trades, are complete. The building should be roofed and enclosed with the temperature and humidity as close as possible to the expected in-service conditions. For secret fixing, one staple or cleat per board at each fixing is required. For top (face) nailing to battens, boards exceeding 65 mm cover width require two nails per board at each fixing. 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 floor boards. Intermediate expansion joints should also be provided in larger floors (width at right angles to boards exceeding 6 meters), to give an equivalent gap of 10 mm every 6 meters (approx. 1.5 mm every 800 mm) or the use of loose cramping.

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

Fixing recommendations - plywood sub-floors to concrete slabs and flooring to plywood

Plywood sub-floors should be structural grade, a minimum 15 mm thick and with a type A bond. Plywood 12 mm thick is also used by floor installers but with this thickness greater consideration needs to be given to slab evenness and the possible perforation of moisture barriers 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 degrees 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.

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 as appropriate the use of a topping compound prescribed for the purpose or other measures to provide a satisfactory floor installation should be undertaken.
- Install 0.2 mm polyethylene vapour barrier.
- Fix 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 to be used per 2400 mm x 1200 mm sheet, equally spaced 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.

The fixing of the floor may be undertaken relying on a combination of mechanical and adhesive fixing.

When fixing boards with a maximum width of 85 mm at close centers up to 225 mm, beads of adhesive to provide a cushion between the two floors should be used to minimise possible squeaks. This is achieved by using a continuous bead of adhesive at 90° to board length, midway between fixing points. Where flooring adhesive is used to provide more of the fixing, staples or cleats may be spaced up to 450 mm apart with beads of adhesive at the fixing points and midway between.

With wider 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.

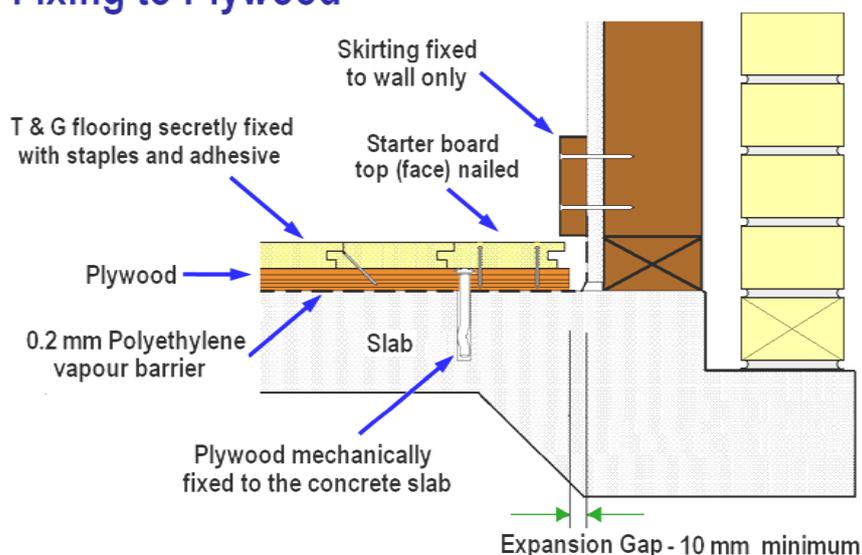
For 19 mm thick flooring staples for boards up to 85 mm wide should be a minimum of 32 x 15 gauge and- cleats should be a minimum of 32 x 18 gauge. For wider boards to 135 mm x 19 mm, 38 mm x 15 gauge staples or 38 mm x 16 gauge cleats are recommended. For overlay flooring which is generally up to 15 mm thick, 25 mm long fixings are commonly used for all widths. Fixing is also required within 50 mm of board ends, however if too close splitting at ends may occur.

Recommended Fixing of T&G Flooring to Sub-floors of 15 mm thick Plywood ¹

TYPE OF FIXING	BOARD WIDTH	SUB-FLOOR on CONCRETE SLAB
		PLYWOOD (15 mm thick)
SECRET FIXING	T&G boards up to 85 mm in width and 19-21 mm thick	<ul style="list-style-type: none"> 32 x 15 gauge staples or 32 x 18 gauge cleats at 225 mm centres and Adhesive beads² to be provided midway between fixing points.
		<ul style="list-style-type: none"> 32 x 15 gauge staples or 32 x 18 gauge cleats at 450 mm centres and Adhesive beads² to be provided at the fixing points and midway between fixing points.
	T&G boards greater than 85 mm and up to 135mm wide and 19-21 mm thick	<ul style="list-style-type: none"> 38 x 15 gauge staples or 38 x 16 gauge cleats at 300 mm centres with a full adhesive bed³. Suitability of flooring for secret fixing to be checked with the manufacturer.

- Notes: 1. Fixings may vary to some degree between locations due to installers' experience of local conditions.
 2. Adhesive beads of 6 mm to 10 mm are often applied in a zigzag pattern.
 3. Full bed adhesive to be applied to the adhesive manufacturer's instructions.
 4. For overlay flooring up to 15 mm thick the fixing length of 25 mm is commonly used.

Fixing to Plywood



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 provided above in the section on the 'Installation of Strip Flooring Over Joists'. Where higher expansion forces are expected after installation (e.g. warm humid, rural and coastal environments) batten spacing is often reduced to provide more robust fixing and floor secretly fixed. If battens are a minimum of 35 mm in thickness, the spacing between fastenings may be increased up to a maximum of 1200 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 resulting in small surface undulations in the floor and more frequent drummy sounds.

Boards for secret fixing up to 135 mm wide can be secretly fixed with one staple or cleat at each batten. Adhesive is recommended for board widths greater than 85 mm and often used with boards up to 85 mm wide. Boards for top (face) nailing and cover widths of 65 mm or less should be top (face) nailed with one or two nails at each batten. 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 batten. Boards wider than 135mm are generally top (face) nailed with two or three nails into thicker battens. Top (face) nailing is to be undertaken uniformly with respect to edge distances and alignment across the floor. Some variation due to batten layout may occur.

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, providing for expansion, board size, the species and fixing method. The following table and figure outlines the minimum batten size and recommended fixing recommendations for structural flooring to battens. The notes form part of the table outlining that some fixing options are more suitable for some locations and installation environments than others.

Recommended fixing of T&G Flooring to Battens over a Slab¹

TYPE OF FIXING	METHOD	BATTEN TYPE	
		SOFTWOOD, CYPRESS, HARDWOOD (min size 35 x 70 mm)	High density ² HARDWOOD (min size 19 x 60 mm)
SECRET FIXING 19-21 mm thick boards	Machine driven	<ul style="list-style-type: none"> 45 or 50 x 15 gauge staple^{3,4} and adhesive⁵ to batten 	<ul style="list-style-type: none"> 32 or 38 x 15 gauge staple^{3,4} and adhesive⁵ to batten for boards wider than 85 mm and up to 135 mm
TOP (face) FIXING 19-21 mm thick boards	Machine driven	<ul style="list-style-type: none"> 45 x 2.2mm T – head⁴ or 50 x 2.5mm T – head and adhesive⁵ to batten 	<ul style="list-style-type: none"> 32 x 2.2mm T – head⁶ and adhesive⁵ to batten or 38 x 2.2mm T – head and adhesive to batten optional
	Hand driven	<ul style="list-style-type: none"> 45 x 2.5mm bullet head⁴ or 50 X 2.8 mm bullet head and adhesive⁵ to batten 	

- Notes
1. Fixings may vary to some degree between locations due to installers' experience of local conditions.
 2. High density refers to species with published densities above 750kg/m³
 3. Cleats of an equivalent length (50 x 16g, 45 x16g, 38 x16g) may be used in place of the staples.
 4. In localities where the internal environment is heated during colder winters (e.g. Sydney and Melbourne) the smaller fixing size is more commonly used. In seaside locations, moist rural locations or where humid weather frequently enters the dwelling (Queensland) larger fixings, adhesive and battens at reduced centres are often used.
 5. A continuous bead (6 mm to 10 mm approx.) of adhesive to be applied to the batten.
 6. The practice of top nailing into 19 mm battens constitutes a recommended practice in Sydney and surrounding areas. In warmer more humid locations more robust fixing is needed due to greater floor expansion forces.

Fixing to Battens

