

Particleboard Structural Flooring Design Manual

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Introduction to Second Printing

At the second printing of this Design Manual in January 1996 the structural basis of Stress Grades in the original, has been replaced with a direct basis on the Australian Standard. That is, flooring meeting the minimum requirements of the Standard should be used according to the Safe Load Tables in this Manual. Time has confirmed that no flooring manufacturer has identified demand for flooring meeting significantly higher structural standards.

This decision has simplified Safe Load Tables; however no significant changes to standard products or their usage have been made. This reprinting also presented the opportunity to provide advice regarding safe use of Particleboard Flooring products.

1. INTRODUCTION

Particleboard Flooring is a well established and well performed product in the Australian home building industry. This wide use and acceptance has led to an increasing number of enquiries from engineers, architects and designers about Particleboard Flooring for commercial and industrial applications.

Particleboard Flooring provides major cost savings through its economy and through lighter construction allowing reduced foundation cost. Installation times are reduced since dry trades only are involved. Particleboard floors are also more comfortable for people standing for long periods and offer better wearing characteristics than some other flooring materials for wheeled traffic (especially small wheels) because of the dense surface layer.

This Design Manual applies specifically to the structural use of Particleboard Flooring installed over a system of parallel joists. Particleboard Flooring can be installed over a concrete slab but such applications are outside the scope of this Manual. (Refer to AWPA Applications & Installations Sheet A13 - Floating Floors).

Design

Safe Load Tables in this Manual cover a range of particleboard grades, thicknesses and spans. Safe loads were calculated using a methodology developed specifically for flooring design because tests indicated that modifications to conventional design methods were required to account for special effects not usually considered.

Particleboard Flooring designed according to the information given in this Manual meets the strength and stiffness requirements of CSIRO Division of Forest Products Technological Paper No 34. Load deflection tests were used to provide reasonable allowance for the effects of specified fixings.

Certification

The design information presented in this manual is based on bending calculations with modifications for a number of effects arising from the installation specification. The information is consistent with the requirements of AS 1170 - 1989 (SAA Loading Code, Part 1 - Dead and Live Loads) and AS 1720 Part 1 -1988 (SAA Timber Structures Code).

Design procedures and Safe Load Tables have been prepared in conjunction with Consulting Engineers, J A Taylor & Associates of Melbourne who have certified to the correct application of test information and development of design methods.

A copy of this Certification is available upon request.

2. NOTICE TO PURCHASER

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Flooring design data and methods in this Manual are based on sound engineering principles applied by an experienced consultant and on appropriate Australian Standards and Building Codes. The Manual is intended to assist engineers, designers, specifiers and experienced builders in designing and constructing particleboard floors for a variety of industrial, commercial and institutional buildings.

The Manual does not cover all aspects of flooring in these types of buildings. Successful performance of particleboard floors depends on many factors outside the control of the Australian Wood Panels Association (AWPA). These include correct determination of floor loads, selection of particleboard floor systems to support these loads, details of joists or supporting framework, installation procedures, workmanship etc. AWPA accepts no responsibility for, or in conjunction with, the quality of the completed systems or their suitability for any purpose other than that which is imposed by Australian State, Federal or Territory laws, and which is not capable of exclusion.

Particleboard suitable for use as structural flooring is manufactured by members of the Australian Wood Panels Association and is identified by the AWPA stamp on each sheet.



Particleboard flooring can provide an attractive hard wearing floor in retail areas such as this timber products store in Adelaide.



and in institutional building such as the gym at Tuggeranong College in Canberra

3. DESIGN PARAMETERS

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3.1 Introduction

This section presents some information on design parameters in relation to Safe Load Tables presented in Section 4. These Tables cover joist spacings and sheet sizes most likely to apply in practice. The designer should review carefully these parameters and ensure that they apply to the particular case under consideration.

3.2 Performance Criteria

Flooring performance must satisfy the two usual criteria relating to strength and deflection. Strength is straight forward - design loads must not impose stresses in excess of allowable working stresses. The selection of appropriate deflection limits requires some judgement.

CSIRO Division of Forest Products Technological Paper No 34 provides strength and stiffness requirements for floors to guard against failure and to ensure human comfort. Particleboard floors covered by the Safe Load Tables in this Manual meet these performance criteria of Technological Paper No 34 based on extensive testing and experience of domestic use.

Safe Load Tables are provided for two deflection criteria - Span/200 and Span/300. These basic requirements lose some relevance as floor spans become shorter. Therefore an additional absolute deflection limit was imposed, and deflection criteria are as follows:

Span/200 or 3mm - whichever is greater.

Span/300 or 2mm - whichever is greater.

3.3 Calculations

Determination of safe loads was based on elastic theory, which relates stresses and deflections to applied loads, material properties and dimensions. The following considerations influenced these calculations.

- (a) Loads act on multiple spans.
- (b) Nominal end fixity of flooring sheets was determined by test.
- (c) Width over which concentrated loads are distributed was determined from plate action.
- (d) The bearing area for concentrated loads was 100 x 100mm (consistent with the SAA Loading Code).
- (e) The long term value for E was half the short term value 1 ie $j_2 = 2$.
- (f) A directional factor was applied to the value of Modulus of Elasticity.

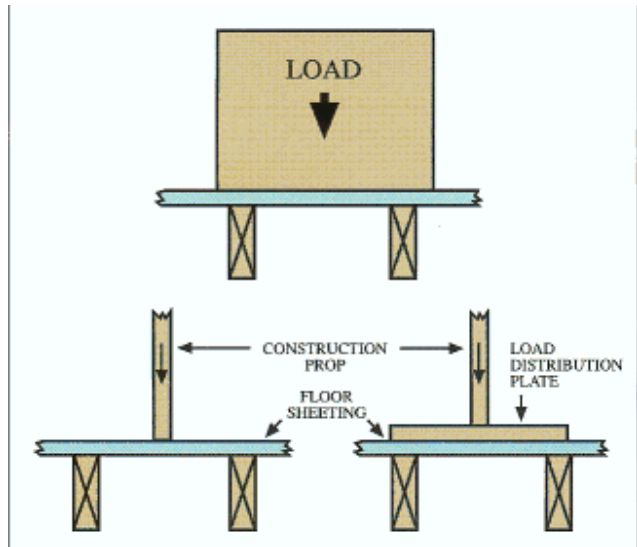
3.4 Floor Loads

Design of particleboard flooring is usually controlled by concentrated loads rather than uniformly distributed loads. Loads may be assessed by the designer or selected from the SAA Loading Code (AS 1170 Part 1). Loading Code figures are based on extreme cases and may be much higher than will apply to most floors. For example, the Loading Code nominates a concentrated load for office floors of 6.7kN. Before designing a floor for this figure, a designer should consider several points.

- (1) The SAA Loading Code figures are based on a bearing area of 100 x 100mm (unless otherwise stated).

- (2) If the 6.7kN load is caused by equipment on 4 legs, it weighs nearly 2 ¾ tonnes.
- (3) If the load is a safe or heavy cabinet the base area may be large enough to transfer the load directly to the joist system, rather than through the floor sheeting (as in Figure 1).
- (4) No normal office has equipment that imposes a concentrated load of 6.7kN on the floor sheeting.
- (5) High concentrated loads may be applied by construction or demolition equipment.

Figure 1.
Economy may be served by distributing heavy loads directly to the joist system.



3.5 Sub-Floor Design

Particleboard Flooring can be installed over timber or metal joists. This Manual does not cover the design of joists or other components of the sub-floor structure. Design of joists should be in accordance with the relevant structural design code eg. the Timber Structures Code (AS 1720 Part 1 - 1988). Correct sub-floor design and construction are essential for satisfactory floor performance.

3.6 Minimum Property Values

Flooring usage tables (Safe Load Tables-Section 4) are based on the minimum requirements of the Interim Australian Particleboard Standard (AS/NZS 1860 Part 1 2002).

Design property values used to calculate Safe Load Tables were determined from an extensive research program carried out by the Timber & Wood Products Research Centre, University of Central Queensland. This program involved sampling all members' products, extensive property testing and the derivation of design values from base data.

The above values were checked by several research projects which was a joint venture with the Forest & Wood Products Research & Development Corporation. This project was carried out by the Monash Timber Engineering Centre, which involved checking samples of a manufacturers' product, which was considered to be typical of all manufacturers' products.



Particleboard flooring can be quickly fixed to timber or steel joists with nails or screws using hand or power tools.



Sheets should be pushed firmly together by hand - mechanical cramping is unnecessary

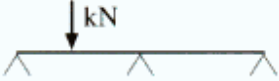
4. SAFE LOAD TABLES

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Table 1.

Allowable Concentrated Live Load - kN
 Max Deflection - Span/200 or 3mm whichever is greater

$k_1 = 1.65$ $j_2 = 1$



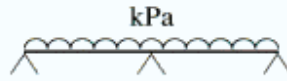
Particleboard Thickness mm	Span mm						
	300	350	400	450	500	600	700
19	3.3	2.7	2.6	2.5	2.1	1.4	1.1
22	4.8	4.1	3.5	3.3	3.2	2.1	1.8
25	6.7	5.7	5.0	4.3	4.2	3.1	2.6

Limited by Deflection

Table 2.

Allowable Long Term Uniformly Distributed Load - kPa
 Max Deflection - Span/200 or 3mm whichever is greater

$k_1 = 1$ $j_2 = 2$



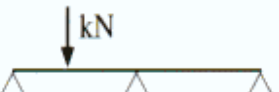
Particleboard Thickness mm	Span mm						
	300	350	400	450	500	600	700
19	18.2	13.4	10.2	8.1	6.5	4.5	3.1
22	24.4	17.9	13.7	10.8	8.8	6.1	4.5
25	31.5	23.1	17.7	14.0	11.3	7.9	5.8

Limited by Bending Strength

Table 3.

Allowable Concentrated Live Load - kN
 Max Deflection - Span/300 or 2mm whichever is greater

$k_1 = 1.65$ $j_2 = 1$



Particleboard Thickness mm	Span mm						
	300	350	400	450	500	600	700
19	3.3	2.7	2.6	2.1	1.5	0.9	0.8
22	4.8	4.1	3.5	3.2	2.6	1.5	1.2
25	6.7	5.7	5.0	4.4	4.0	2.4	1.8

$$k_1 = 1$$

$$j_2 = 2$$

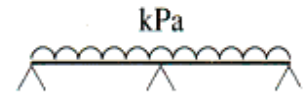


Table 4.

Allowable Long Term Uniformly Distributed Load - kPa
 Max Deflection - Span/300 or 2mm whichever is greater

Particleboard Thickness mm	Span mm						
	300	350	400	450	500	600	700
19	18.2	13.4	10.2	8.1	6.5	3.5	2.0
22	24.4	17.9	13.7	10.8	8.8	5.5	3.2
25	31.5	23.1	17.7	14.0	11.3	7.9	4.6



A string line should be set to ensure the first sheet is square with the joist.

4.1 Notes relating to Safe Load Tables

1. Linear interpolation is permitted.
2. Design data given in the Tables relates to performance under static bending. Experience shows that the dynamic effects of walking are satisfactory for 19mm particleboard over joists at 450mm spacing and 22mm flooring on 600mm joist spacing. Caution should be exercised in selecting spans above 600mm because of lack of knowledge about dynamic response.
3. Safe Loads in the Tables apply to Particleboard Flooring below 13 % moisture content. Moisture content would be expected to exceed 13 % if the floor is subjected to climate conditions in excess of 85% relative humidity for long periods of time.
4. The above requirement (3) precludes the use of particleboard flooring in commercial applications where it will be exposed to the weather. The building must be enclosed before fixing particleboard flooring.
5. If Concentrated Loads act on areas less than 100x100mm (say 25x25mm) then allowable loads will be 10-20% lower, based on bending calculations. However Punching Shear considerations (Sect 4.3) may require larger bearing areas.

4.2 Additional Requirements

The following additional requirements should be noted:

- * For Concentrated Loads higher than 3.0kN or Uniformly Distributed Loads higher than 7 KPa, Close Fixing should be used (see Sect 8.6 and Figure 3). **AND**
- * All sheet edges must be supported by joists or nogging.
- * **In Addition** if Concentrated Loads are higher than 3.5kN, fixing shall be by screws (plus adhesive) only. When all edges must be supported it may be more economical to use the larger square edge sheets (3600 x 1800mm) than the usual T & G sheets.

4.3 Punching Shear

If concentrated loads act on a small bearing area, there may be a risk of punching the load point through the particleboard sheet. This is termed Punching Shear.

Table 5 gives Safe Concentrated Loads assuming maximum spans for each board thickness. Support dimension is diameter for circular supports or the side for square supports.

If design involves small support sizes and loads higher than those given in Table 5, pads should be placed under the load point. A guide to pad size required can be obtained from Table 5.

Table 5.
Safe Concentrated Loads for Punching Shear
Maximum Load kN

Support Size – mm	Board Thickness – mm		
	19	22	25
25x25	2.5	2.8	3.0
50x50	3.2	3.8	4.0
100x100	5.5	7.5	8.0

4.4 Double Layers

Allowable Loads for double layers can be obtained by adding together the Allowable Loads for each individual layer from Tables 1-4 as appropriate. This is a conservative approach, but installation procedures to achieve composite action from the two layers are complex and difficult to verify and long-term behaviour too is uncertain.

The additional fixing and support details of Sect 4.2 are required at Concentrated Loads higher than 6kN or Uniformly Distributed Loads higher than 20kPa. In this case the bottom sheet only requires screw fixing and full support on all edges.

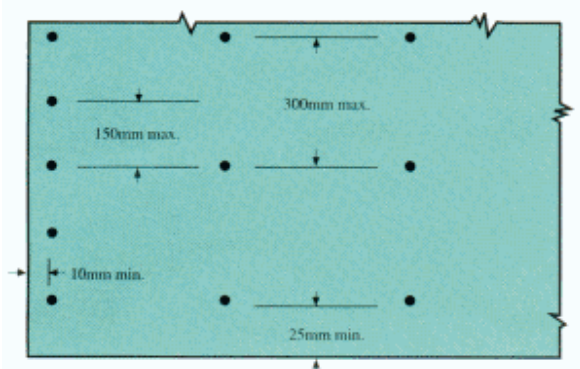


Figure 2. Standard Fixing

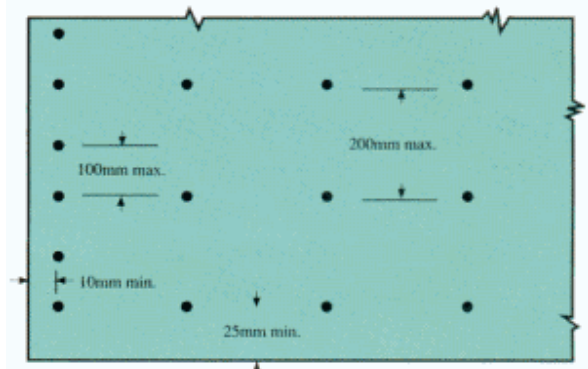


Figure 3. Close Fixing

5. PRODUCT SPECIFICATION

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Particleboard Flooring is manufactured in three thicknesses - 19, 22 and 25mm and in various sheet sizes. Sheets are factory machined to produce a groove in the two long edges and a plastic tongue or spline is inserted in one side. The plastic tongue allows easier, more accurate installation and is resistant to handling and transport damage. Square edged sheets are available as specified or on request. Particleboard Flooring is also available with fungicide and termiticide treatment. However not all companies manufacture all sizes or treated product.

AWPA Member Companies use distinctive colours of the plastic tongue to enable easier product identification. Particleboard Flooring may be factory edge sealed and again some companies use a colouring in the sealant for product identification.

Adhesive plus nails or screws is specified for the installation of all particleboard flooring.



6. DESIGN PROCEDURE

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The following procedure relates to the design of particleboard floor sheeting. Design of timber or metal sub-floor joists is not covered in this Manual. Joists must be designed to meet the specific load/deflection criteria.

Step 1. Loads and Performance

Determine the maximum Concentrated Loads (CL) and Uniformly Distributed Loads (UDL) to be carried by the Particleboard Flooring. Decide deflection limits to apply -usually span/300 for general traffic areas, span/200 for restricted areas or industrial floors.

Step 2. Preliminary Design

Consult the appropriate Safe Load Tables for Standard Particleboard Flooring and determine thickness/span options for the design CL and for the design UDL. There may be three CL thickness/ span solutions and three UDL thickness/span solutions.

Step 3. Refining the Design

If more than one thickness/span solution is possible, check total floor cost and select the most economic sheet thickness and joist span. If the solution indicates close joist spacing, review design CL. Does design CL apply generally over the floor, or does it represent a specific load? Would economy be served by designing special support for a specific load; does the whole floor need to be designed to carry it?

Step 4. Check Punching Shear

Consult Table 5 and determine if CL is below the safe maximum value for Punching Shear. If not, specify larger bearing areas.

7. DESIGN EXAMPLES

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Example 1

Design a hotel floor with maximum Uniformly Distributed Load (UDL) of 5kPa and Concentrated Load (CL) of 3.6kN.

- Step 1.** Determine loads and performance.
UDL = 5kPa CL = 3.6kN Deflection = Span/300
- Step 2.** Preliminary Design Consult Table 3 for CL = 3.6kN Possible solutions are: 19mm <300mm joist spacing 22mm 400mm joist spacing 25mm 500 - 600mm joist spacing
- Consult Table 4 for UDL = 5kPa Possible solutions are: 19mm 500 - 600mm joist spacing 22mm 600mm joist spacing 25mm 600 - 700mm joist spacing
- CL requirements are clearly more severe, so discard the UDL solutions.
- Step 3.** Refine the Design Check costs of possible solutions. Without going into detailed costs here, it is likely that close joist spacings will represent the major cost. Therefore select 25mm Particleboard Flooring at 500mm joist spacing. Note that interpolation indicates that 525mm joist spacing is allowed.
- Step 4.** Check Punching Shear CL is 3.6kN. Check Table 5 for maximum loads to resist punching failure. Concentrated Load of 3.6kN is safe for 25mm Particleboard if load point is 50mm (square or circular).

Ensure that Concentrated Loads are supported on 50mm bearing size or greater.

Installation should be in accordance with Sect 4.2.

Example 2

An office is to be constructed in an existing building. The floor is 22mm Particleboard on joists at 450mm centres. Inspection shows that all timbers are sound, but the office floor loads are assessed at UDL = 5kPa. CL = 4.5kN.

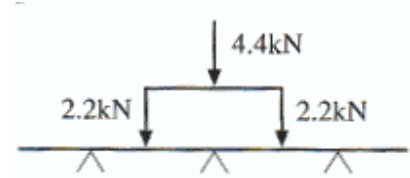
- Step 1** Loads and performance UDL = 5kPa CL = 4.5kN Deflection = Span/300
- Step 2** Preliminary Design Check capabilities of existing floor from Table 3, 22mm Particleboard at 450mm joist spacing can carry CL = 3.2kN. From Table 4, floor can carry UDL = 10.8kPa
- Thus floor can carry required UDL but not CL.
- Step 3** Consider an extra layer of 19mm flooring. Load capacity of 19mm Particleboard Flooring on joists at 450mm spacing is (From Table 3) CL = 2.1 kN.
- For one layer 22mm and one layer 19mm, add individual capabilities. Then CL = 3.2 + 2.11 = 5.3kN which is satisfactory.
- Step 4** Check Punching Shear From Table 5 Punching Shear maximum load is 2.5 + 2.8 = 5.3kN. No minimum requirements necessary for bearing areas (although size of support should never be less than 25mm).
- Step 5** Check adequacy of existing joist system. This example concentrated on the Particleboard Flooring but the joist system would also need to be checked against the new design loads.

Example 3

Single axle trolleys are being considered for use on an existing floor of 19mm particleboard on joists at 450mm centres. Trolleys carry up to 400kg load. Can the floor carry these loads?

Step 1

Loads and performance DL - unchanged *
Deflection = span/200 CL = 400kg + 40kg for
trolley = 440kg i.e. 4.4 kN Load System



Step 2

Check capabilities of existing floor. From Table 1, 19mm particleboard at 450mm joist spacing can carry 2.5 kN live load. Thus floor can carry the trolley load.

Step 3

Check Punching Shear From Table 5, maximum CL is 2.5kN. This is satisfactory providing wheels have more than the equivalent of 25 X 25mm bearing area.

Step 4

Check dynamic loads This example was intended to illustrate trolley loads. In practice dynamic loads involved with stopping and turning would need to be checked especially if the trolley is powered.

8. INSTALLATION

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8.1 Site Storage

Packs of Particleboard Flooring should be protected from the weather before installation. Particleboard Flooring is resistant to moisture and there is often a tendency to leave packs unprotected on building sites. Water absorption will cause expansion of the sheets and this will lead to gaps in the floor later when the particleboard sheets dry out.

As shown in Figure 4, packs should be clear of the ground with supports about 600mm apart. Covering should allow some air circulation during the storage period.

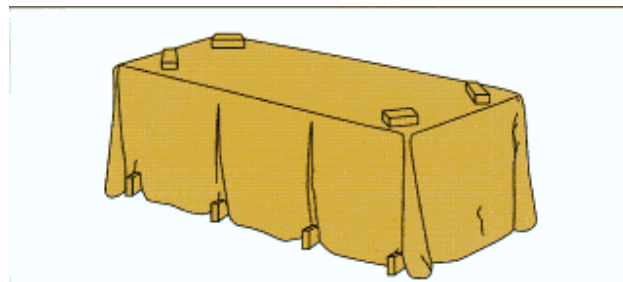


Figure 4.
Good site storage is essential

8.2 Sub - Floor

Particleboard Flooring can be installed over timber or metal joists to form a load bearing floor system. Joists must be installed such that their top surfaces are level. Timber joists must be kiln dried. Joists that are not seasoned at the time of construction may shrink unevenly as they dry out, which may lead to localised high deflection and squeaking of the finished floor. These problems can be extremely expensive to remedy some years after the project has been finished.

8.3 Sheet Layout

Particleboard Flooring sheets are laid with their long side across floor joists and ends butted over a joist. Sheet end joints should be staggered (as illustrated in Figure 5) because any slight rounding of sheet corners may present a hole in the floor if four corners come together. Select a starting point for laying and set a string line to ensure the first sheet is square with the joists. Position the first sheet with its tongued edge to the string line and note the printed information on the sheets regarding top surface.

Each sheet must be supported by at least three joists. If this is not possible (cutting in around the room perimeter) then nogging should be fixed under the edges of these smaller pieces.

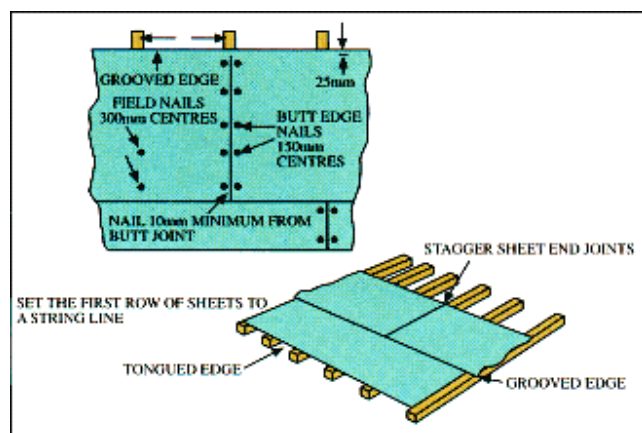


Figure 5.
Sheet layout illustrating standard fixing.

8.4 Expansion Joints

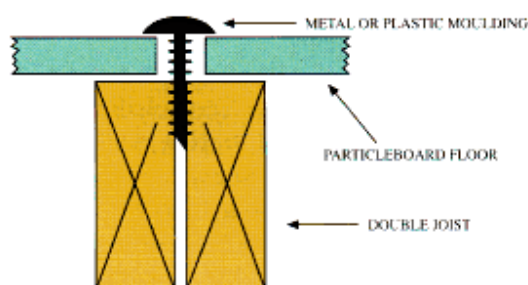
Particleboard Flooring will expand and contract as sheets respond to changes in atmospheric moisture. Allowance for this movement must be made throughout the floor area by providing gaps and special joints as appropriate to accommodate sheet expansion.

A clearance of 10-15mm must be allowed along all walls and around columns or other fixtures. These gaps may later be covered by skirting.

An expansion joint is a 20mm gap in flooring sheets located above a wide (50mm minimum) or double joist. Extra joist area is necessary so that sheet ends can be properly fixed while still allowing the 20mm gap. The joint may be covered by a metal or plastic moulding, screwed into the joist, or partitioning may be located over the joint. See Figure 6.

Figure 6.

Expansion joint.



It is difficult to provide general guidance about frequency of expansion joints. Particleboard Flooring would be supplied from the factory with a moisture content in the range of 8-11%. Long term storage in regional warehouses may raise or lower this figure but such "acclimatisation" should be of benefit in local applications.

Care must be taken to ensure that there is no likelihood of moisture build-up under the floor. Particleboard Flooring will absorb moisture (and so expand slightly) in tropical areas. Even in air-conditioned buildings, any concrete work may take a long time to dry out and cause a moist environment during this drying period. Installation procedures are based on sheets being conditioned to the building environment.

Spacing of expansion joints should be between 10 and 20m with the final decision depending upon the following assessment.

- * Is the floor elevated or on ground level
- * Is the area air conditioned
- * Is it a tropical region (coastal areas, north of 27th parallel)
- * What moisture variations are likely in the flooring.

8.5 Fixing

Particleboard Flooring should be fixed with construction grade adhesive and mechanical fasteners.

A bead of adhesive is applied from the cartridge applicator to joists before positioning particleboard sheets. The bead should be 5-6mm across and must not be laid too far ahead as it may cure quickly. The time available for laying sheets before the adhesive bead becomes too hard and dry will depend on temperature and ventilation. These conditions may restrict advance adhesive application to the amount required for one sheet only.

A bead of adhesive should also be applied along the tongue before sheets are pushed together, to ensure a squeak-free floor. Sheets should be pushed firmly together by hand ? mechanical cramping is unnecessary.

Solvent based adhesives should be used on steel joists due to the possibility of traces of petroleum based lubricants remaining on the steel.

8.6 Fastening

Fasteners (nails or screws) should be spaced according to the Standard Fixing or Close Fixing pattern as required in Section 4.2 (refer to Figures 2 and 3). Fasteners should not be placed closer than 25mm from tongued or grooved edges and 10mm from the short, butt jointed ends.

Nails may be driven by hand or by nailing gun. With gun nailing, care should be taken to adjust the air pressure for softwood or hardwood joists, so that nails do not penetrate the surface by more than 1mm.

Type	Joist Material	Flooring Thickness mm	Minimum Fastener Size mm
Hand Driven Nails	Hardwood	19, 22	50 x 2.8
		25	65 x 3.75
	Softwood	19, 22	65 x 2.8
		25	75 x 3.75
Power Driven Nails	All	19, 22	55 x 2.5
	Timber	25	75 x 3.05
	Steel	All	38 x 2.87
Screws	All	19, 22	No 10 x 50
	Timber	25	No 14 x 65
	Steel	All	No 10 x 45

Table 7.

Fasteners for Particleboard Flooring

Nails may be Bullet, Jolt, Flat or Countersunk heads for hand driving or Tee or Finishing head for power driving. Countersunk, self-drilling screws should be used for timber joists, while steel joists require countersunk, self-drilling screws with self breaking cutter nibs. Twist shank hardened nails should be used for power driving into steel joists.

Number of Fasteners per Sheet

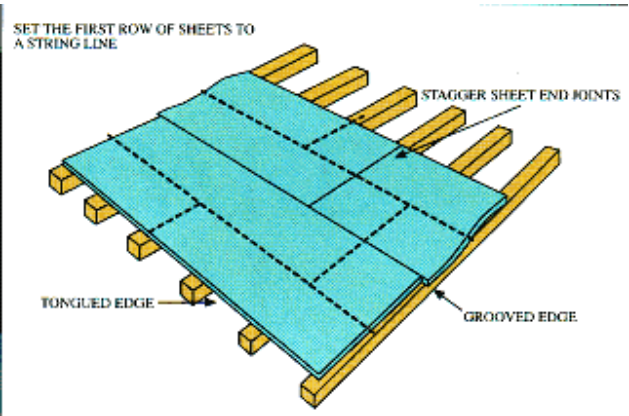
450mm joist spacing - 42 Standard Fixing
 - 62 Close Fixing
 -

600mm joist spacing - 34 Standard Fixing
 - 50 Close Fixing

8.7 Double Layers

Install the first layer as specified in this Section. The second layer should be laid so that the long joints are staggered between the two layers and end joints meet on a different floor joist (see Figure 7). Run a bead of adhesive on the first layer at joist positions and fasten through both layers into floor joists. Fastener length for the second layer should provide at least 30mm penetration into joists.

Figure 7.
Double Layer Layout



9. HEALTH AND SAFETY INFORMATION

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Wood Panel Products

Normal health and safety precautions should be taken when working with wood panel products. Machine tools should be fitted with dust extractors and work areas kept clean. If dust levels exceed the National Occupational Health and Safety Commission (NOHSC) standards, the wearing of a dust mask (AS1715 and AS1716) and safety glasses (AS1337) is recommended.

Storage and work areas should be adequately ventilated. If large quantities of Particleboard and Medium Density Fibreboard are stored in non-ventilated areas, formaldehyde emissions could accumulate to levels which may irritate some people.

For further information, please contact one of the manufacturers listed below for a copy of a Material Safety Data Sheet or download from www.woodpanels.org.au

Carter Holt Harvey Panels
Laminex Group
D&R Henderson Pty Ltd

Tel: 1300 658 828
Tel: 03 9848 4811
Tel: 02 4574 4033

www.chhwood.com.au
www.laminex.com.au

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