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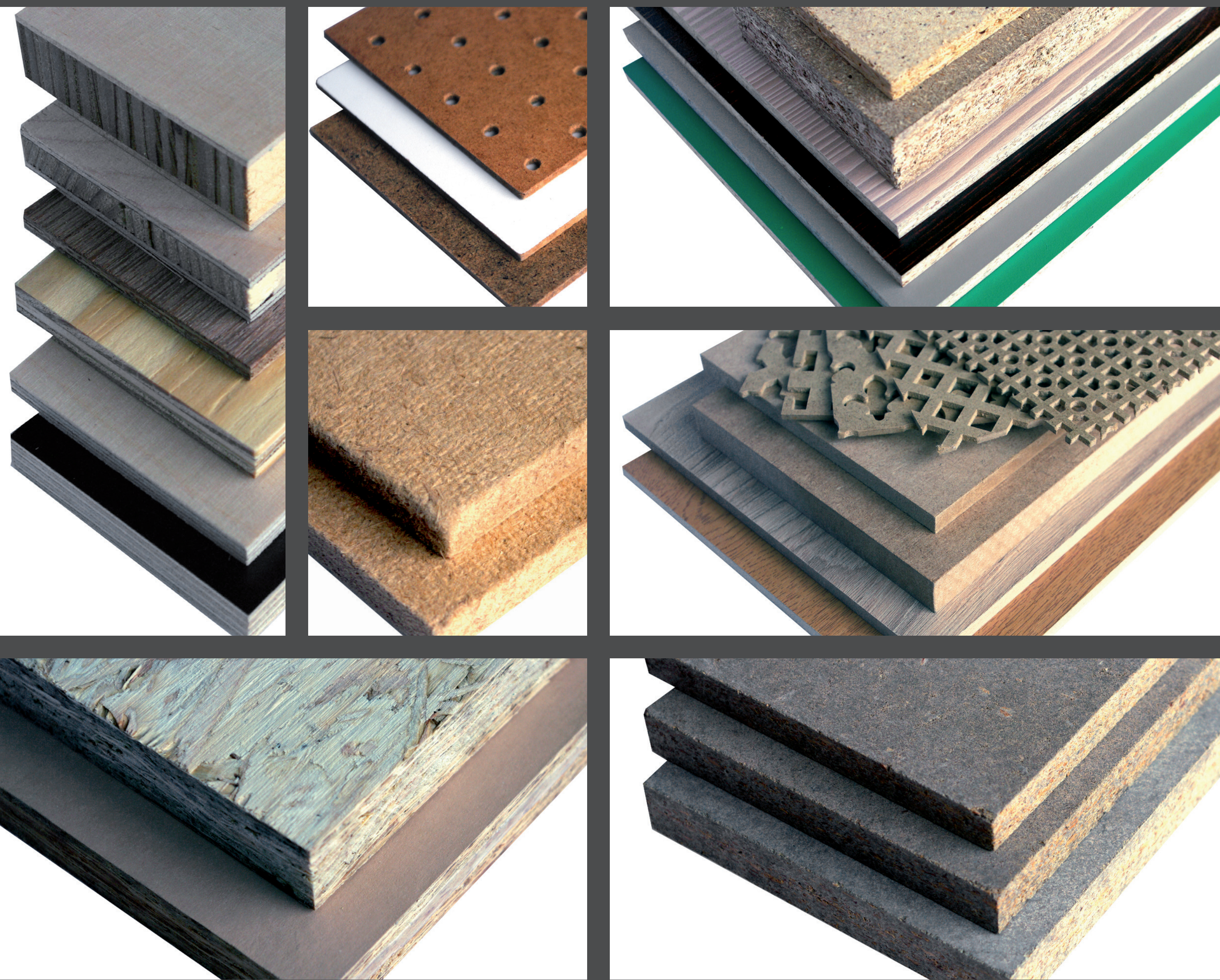
Panel Guide

Version 4.1



PanelGuide Version 4.1
ISBN 978-1-909594-21-0

Published in 2014 by the Wood Panel Industries Federation, TRADA Technology Ltd, and the National Panel Products Division (a division of the Timber Trades Federation).

Revised with amendments to Section 2 and Annex 3, 2018

Previous editions are listed in Annex 4 of the PanelGuide

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Preface

PanelGuide gives the panel user and specifier guidance and information on the use of wood-based panels in an authoritative and comprehensive manner.

It covers all the main types of wood-based panel:

- plywood (including blockboard and laminboard)
- particleboard (chipboard, flaxboard, cement-bonded particleboard)
- oriented strand board (OSB)
- fibreboard (hardboard, mediumboard, softboard)
- medium density fibreboard (MDF).

PanelGuide gives information on the properties of each of these products and guidance on their application in a range of end uses, separated into construction and non-construction, including the following:

Construction	Non-construction
• suspended floors • floating floors • raised access floors • overlays • roofs – flat, pitched • wall sheathing • formwork • cladding, fascias and soffits • architectural mouldings • internal linings, partitions • doorskins	• furniture • industrial uses • shopfitting • packaging • transport • agricultural • manufacturing

It also explains the current legislation (UK and European) affecting the use of wood-based panels in the UK construction industry and the design/decision-making process involved in selecting a panel for a specific end use.

PanelGuide is aimed at construction professionals (specifiers, designers, building engineers, architects), panel manufacturers, distributors and users. It is intended to be used as a reference source for all types of wood-based panel, giving information quickly and in a simple and concise form as and when it is required. The information can be read on screen or printed out. No part of this publication may be reproduced without prior permission and acknowledgement of the copyright holders.

This is Version 4.1 (V4) of PanelGuide, which supersedes Version 4. The main changes are to Section 2 and Annex 3.

In the UK where an EN (European Norm) replaces a BS (British Standard) the ENs are published as BS ENs. Where there is a reference to BS this refers to a standard that is a British Standard only. All standards cited are undated and readers should refer to the BSI website for the current versions: http://shop.bsigroup.com/

This guide is prepared as a collaborative project between the Wood Panel Industries Federation, National Panel Products Division (a division of the Timber Trades Federation), and BM TRADA, on behalf of the Timber Research and Development Association (TRADA). The contribution of the Building Research Establishment Limited to previous versions of PanelGuide is gratefully acknowledged.

How to navigate the PanelGuide pdf

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- Use the expanded bookmark menu on the left to navigate between sections
- Click on the links to website addresses to open external web pages in a separate window using your internet browser
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Useful tools

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Alternatively, some tools can be accessed by right clicking on the text and selecting the appropriate command from the pop-up menu.

Contents

1 Introduction

1.1 General overview

Wood-based panel products are panel materials in which wood is predominant in the form of strips, veneers, chips, strands or fibres. The categories usually recognised within this group of panel materials are:

- plywood, including blockboard and laminboard
- particleboard, including wood particleboard (chipboard), flaxboard and cement-bonded particleboard (CBPB)
- oriented strand board (OSB)
- fibreboards, including medium density fibreboard (MDF).

Wood-based panels are versatile products with a wide variety of end uses. Their use continues to expand because of:

- their good strength/weight ratio
- their good strength/cost ratio
- their ease of working/finishing/fixing
- the range of sizes and thicknesses available
- the range of types and special products available
- their good environmental credentials (made from a renewable raw material, recyclable, low life-cycle costs)
- their long, proven history of successful use.

The consumption of wood-based panels in the UK is now almost 5 million cubic metres per annum, with UK production comprising a substantial proportion of this figure concentrated in OSB, particleboard and MDF. The UK does not currently produce other types of wood-based panel.

1.2 Development of panel products

Particleboards and fibreboards were originally developed to provide utility panel materials with uniform properties. They utilise chipped or defibrated forest round wood and thinnings, sawmill products and recycled wood. There have been many developments in adhesive and manufacturing technology and, from the original utility products, the industry has developed a whole family of panel products with specific properties targeted at a wide variety of end uses. They can be found in numerous high-profile, prestige projects.

OSB was developed in the mid 1970s to utilise smaller logs that are not suitable for plywood production. Made of strands normally about 75mm long, OSB is often in three layers, with the strands in the surface layer oriented roughly in line with the length of the panel. This gives the panel higher mechanical properties in that direction. OSB was developed from the earlier waferboard or flakeboard, which had random particle orientation.

Plywood was originally developed to provide panels with dimensional stability and good strength properties both along and across the panel. Straight, well-grown timber is required for plywood manufacture.

Plywood, particleboards and fibreboards all include both general purpose or utility boards and special purpose products. Several types of panel can be engineered to meet specific property requirements.

1.3 Standards and legislation

There is a fairly complex matrix of interrelated standards and legislation. PanelGuide helps users to understand the legislation and the relationship between the various standards. Refer to PanelGuide *Section 2.1* for more detail.

1.3.1 Standards

Wood-based panel products are now manufactured to a series of European Standards (ENs), which are published and implemented as national standards by individual EU Member States. In the UK these 'British adopted European Standards' are published as British Standards (BS ENs). The BS ENs replaced the previous BS wood-based panel product specification standards in the UK in 1997. Under the BS EN system, each category of panel material has its own standard(s) that generally follow a similar pattern:

- General information – defining the panel types and the general requirements for all panel types in relation to: tolerances on sizes, thicknesses, moisture content, density etc as appropriate.
- Requirements (which in some cases are published in a series of separate parts) that define the requirements for the panel type in relation to its use in different environmental and load conditions. The environmental conditions are 'dry', 'humid' or 'exterior' defined in relation to a series of 'service classes'. The requirements are also further refined, depending on the panel type, for non-load-bearing, load-bearing and heavy-duty load-bearing boards. (Note that throughout PanelGuide, the use of the term 'structural' is used to mean 'load-bearing', and conversely the term 'non-structural' means 'non-load-bearing'.)

The main product standard usually refers to other standards for test methods and methods of demonstrating compliance.

The specification standards are not related to any given application and reference should also be made to codes of practice or other application-specific guidance where appropriate. The specification standards as listed and referred to in PanelGuide have in general been developed to cover wood-based panels for use in the construction sector; they may also be utilised for the specification and testing of panels for non-construction uses.

Always ensure you are using the most recent version of a British Standard by referring to the BSI website: http://shop.bsigroup.com/

1.3.2 Construction Products Regulation (CPR)

In order to satisfy legal requirements, as of 1 July 2013 wood-based panel products used in construction have to comply with the Construction Products Regulation (CPR)[1]. The CPR makes it a requirement for construction products that fall under the scope of a harmonised European standard (hEN) to be CE marked and provide a Declaration of Performance (DoP). The harmonised European standard for wood-based panels is published in the UK as *BS EN 13986 Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking*[2].

1.4 Product types

Information on each product type is given in the Annexes and selection and specification information in relation to end use is covered in the main text. The following sections outline the range of products available.

1.5 Veneer and core plywood

Plywood is a versatile product that can maintain a high performance under a wide variety of environmental conditions. Its construction enables comparatively high strength to weight ratios which are predominantly influenced by the species used. It is available in a range of wood species (both hardwood and softwood), some of which can have an attractive surface appearance, and a range of glue types for interior and exterior conditions. The term 'plywood' includes the true 'veneer plywood' and also 'blockboard' and 'laminboard'.

Veneer plywood is generally made from veneers that are peeled from a log. These are bonded together with an adhesive that is appropriate to the end use, with the grain of adjacent veneers generally at right angles to each other. The adhesive is cured by pressing the panel using heated platens.

Blockboard and laminboard are produced in a similar fashion to plywood except that the core of the material is made up from strips of solid wood or veneer laid on edge and this core is then faced with two or more veneers on each side.

Figure 1.1: Different types of plywood

The current British Standard for specifying both veneer and core plywood is: *BS EN 636 Plywood. Specifications*[3].

BS EN 636 refers in turn to other standards dealing with factors such as bond quality and surface appearance. The durability of plywood is a function of the bond quality, the durability of the timber species used in the veneer and the veneer quality. Suitable coatings or preservative treatments can also enhance the durability. Plywood is one of the few panel types that has an EN product standard covering its use in exterior conditions.

Plywood is an engineered wood product that can be manufactured to have specific properties, making it suitable for a wide range of applications. It is the only wood-based panel for which information on the use in structural applications under external conditions is given in *BS EN 1995-1 Eurocode 5: Design of timber structures. General. Common rules and rules for buildings*[4] or *BS 5268-2 Structural use of timber. Code of practice for permissible stress design, materials and workmanship*[5] (although now withdrawn, this latter standard will still be in use for a period).

The mechanical (structural) properties are a function of the species of timber used, the veneer quality and the lay-up. Because of the wide range of products available, mechanical properties for plywood have not been standardised. Refer to the manufacturer's DoP for details of the strength properties of their products.

Some of the typical 'types' of plywood include:

- structural plywood
- marine plywood
- utility plywood
- decorative/overlaid plywood
- blockboard/laminboard.

The two panel directions are termed the major and minor axes, with the higher mechanical properties being in the direction of the major axis. In structural applications it is important that the panels are laid in the direction specified by the manufacturer. Further information on plywood, its properties and uses can be found in PanelGuide *Annex 2D*.

1.6 Particleboard

Particleboard as defined in the British Standard *BS EN 309 Particleboards. Definition and classification*[6] is a 'panel material manufactured under pressure and heat from particles of wood (wood flakes, chips, shavings, sawdust and similar) and/or other lignocellulosic material in particle form (flax shives, hemp shives, bagasse fragments, straw and similar), with the addition of a polymeric adhesive'. In the UK, particleboard is made from wood and is traditionally known as wood chipboard.

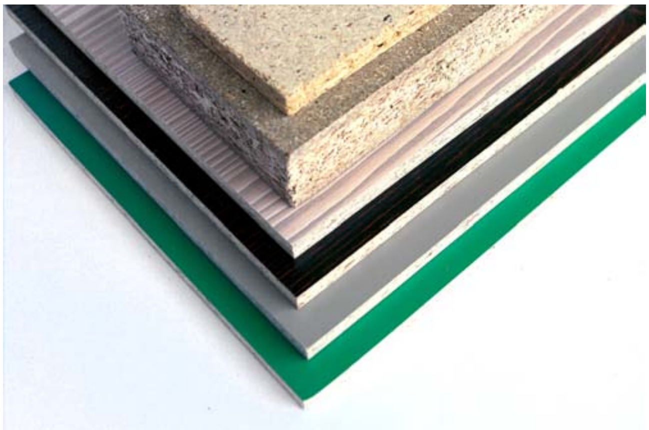


Figure 1.2: Raw and coated particleboard

Wood chips comprise the bulk of particleboard and are prepared in a mechanical chipper generally from coniferous softwoods, principally spruce (although pine and fir and hardwoods, such as birch, are sometimes used). Particleboards may also incorporate a large proportion from recycled sources. These chips are generally bound together with synthetic resin systems such as urea-formaldehyde (UF) or melamine urea-formaldehyde (MUF), though phenol-formaldehyde (PF) and polymeric methylene di-isocyanate (PMDI) are used by a few manufacturers. The chips are formed into a mat and are then pressed between heated platens to compress and cure the panel. The finished panels are then sanded and cut to size.

The current British Standard for specifying particleboard is *BS EN 312 Particleboards. Specifications*[7].

BS EN 312 specifies the requirements for particleboards to be used in dry and humid conditions; they are not normally suitable for exterior applications. The term 'moisture resistant' is sometimes used in relation to panels classified for use in humid conditions. While such panels may be resistant to periods of short-term wetting or high humidity, this term does not mean that the panel is waterproof and direct wetting should be avoided. While particleboard is not normally attacked by wood-boring insects, it can be subject to fungal decay under prolonged wetting.

The basic mechanical properties of particleboard are controlled by *BS EN 312* and design characteristic values for use of the load-bearing grades with *BS EN 1995-1-1 (Eurocode 5)* are given in *BS EN 12369-1 Wood-based panels. Characteristic values for structural design. OSB, particleboards and fibreboards*[8]. *BS 5268-2* gives conversion factors to allow these values to be used with that standard, which although withdrawn, is still in use by some designers.

The various types of panel defined in *BS EN 312* indicate the range of use conditions of particleboard, and common applications include domestic, office and mezzanine flooring, kitchen units and worktops, furniture and shopfitting. Further information on particleboard, its properties and uses can be found in PanelGuide *Annex 2A*.

1.7 Oriented strand board (OSB)

OSB is an engineered wood-based panel material in which long strands of wood are bonded together with a synthetic resin adhesive. OSB is usually composed of three layers with the strands of the outer two layers orientated in a particular direction, more often than not in the long direction of the panel. While there is an orientation, it is often hard to see because there is quite a large degree of variability in this orientation among adjacent strands in the panels from any one production line, as well as between panels from different producers.

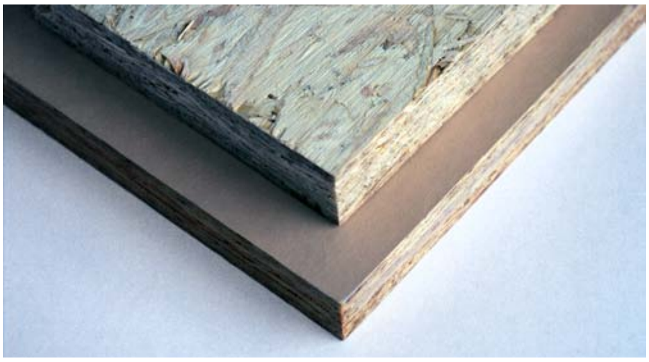


Figure 1.3: Coated and sanded OSB

The current British Standard for OSB is *BS EN 300 Oriented Strand Boards (OSB). Definitions, classification and specifications*[9].

BS EN 300 contains the requirements for the following four grades (technical classes):

- OSB/1 – General purpose boards, and boards for interior fitments (including furniture) for use in dry conditions
- OSB/2 – Load-bearing boards for use in dry conditions
- OSB/3 – Load-bearing boards for use in humid conditions
- OSB/4 – Heavy-duty load-bearing boards for use in humid conditions.

Selection of a grade of load-bearing panel is dependent upon the ambient climatic conditions together with the level of loading that is anticipated.

As with particleboards, there is no specification for an exterior quality OSB, and panels should generally be kept away from direct contact with water. Panels for use in humid conditions have a degree of resistance to short-term wetting and high humidity but are not intended for exposure to prolonged wetting.

Common applications for OSB include flooring, wall sheathing, roof sarking, packaging and furniture. Some specialist products, with a surface coating, are now available for non-structural applications, such as site hoarding, giving an extended service life.

Further information on OSB, its properties and uses can be found in PanelGuide *Annex 2B*.

1.8 Flaxboard

BS EN 15197 Wood-based panels. Flaxboards. Specifications[10] is the British Standard which specifies the requirements for flaxboard for general purposes, non-load-bearing applications and interior fitments in dry conditions, and for flaxboard for non-load-bearing applications for use in humid conditions. Flaxboard is not suitable for exterior applications.

Figure 1.4: Flaxboard

The basic mechanical properties of flaxboard are controlled by *BS EN 15197*. Panels in accordance with this standard may be referred to as FB1, FB2, FB3 or FB4 panels and indicate the range of use conditions of flaxboard. Common applications include filling purposes, further processing such as veneering, and furniture.

Further information on flaxboard, its properties and uses can be found in PanelGuide *Annex 2G*.

1.9 Cement-bonded particleboard

Cement-bonded particleboards (CBPB) are also available in which a cementitious binder, usually Ordinary Portland Cement (OPC), is used.

Cement-bonded particleboards are produced in accordance with *BS EN 634-1 Cement-bonded particleboards. Specification*[11] and *BS EN 634-2 Cement-bonded particleboards. Specifications. Requirements for OPC bonded particleboards for use in dry, humid and external conditions*[12]. They can be bonded with OPC or with magnesium-based cements. *BS EN 634-2* relates only to OPC CBPB. They have a very high durability and are suitable for use in dry, humid or exterior conditions. Their high density gives good acoustic and fire performance. They are used for flooring, modular buildings and applications where high durability is required.

Figure 1.5: Cement-bonded particleboard

Further information on cement-bonded particleboard, its properties and uses can be found in PanelGuide *Annex 2C*.

1.10 Fibreboards

Fibreboard is produced by one of two basic process methods, according to type. These are:

- wet process
- dry process.

Wet process fibreboards are made by reducing steamed wood into fibres and adding water to form a slurry. This is then formed into a mat on a moving wire mesh. During processing, much of the water is removed by pressing and the final heated pressing promotes bonding of the fibres using the adhesive properties of the natural lignin adhesive present in the wood.

Depending upon the degree of pressing involved and hence the final density of the panel, the product is termed softboard, mediumboard or hardboard. Additives are sometimes included to improve properties.

Figure 1.6: Wet process fibreboards

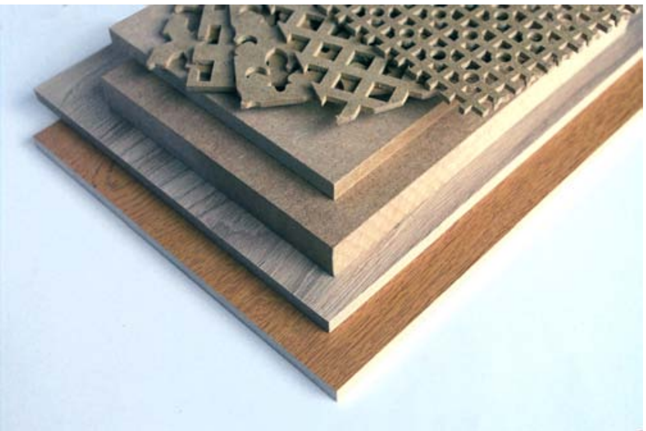


Figure 1.7: Dry process fibreboards

Figure 1.8: MDF rail and skirting

In the case of dry process fibreboards, the wet fibres are dried and an adhesive is added. This is then formed into a mat and pressed in a similar way to particleboard. The resulting product is generally termed medium density fibreboard (MDF) and should not be confused with the wet process mediumboard.

The current British Standard for fibreboards is *BS EN 622*. This is divided into five parts as follows:

- *BS EN 622-1 Fibreboards. Specifications. General requirements*[13]
- *BS EN 622-2 Fibreboards. Specifications. Requirements for hardboards*[14]
- *BS EN 622-3 Fibreboards. Specifications. Requirements for mediumboard*[15]
- *BS EN 622-4 Fibreboards. Specifications. Requirements for softboard*[16]
- *BS EN 622-5 Fibreboards. Specifications. Requirements for dry process boards (MDF)*[17]

Within parts 2 to 5 of *BS EN 622*, there is a series of grades of product defined according to:

- suitability for use in dry, humid and exterior conditions
- application – general purpose, load-bearing, heavy-duty load-bearing.

The wide range of panel types within the fibreboard family means they have a wide range of properties and end uses. While some fibreboards are available in load-bearing grades, most of the types are not intended for structural applications.

Typical end uses of fibreboards include flooring and roofing overlays, internal wall linings, roof sarking and wall sheathing. MDF is commonly used for architectural mouldings, staircases and window boards.

Further information on fibreboards, their properties and uses can be found in PanelGuide *Annex 2E* and *Annex 2F*.

1.11 References

1 Construction Products Regulation (CPR), Regulation 305/2011/EU

2 BS EN 13986. Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking, BSI

3 BS EN 636. Plywood. Specifications, BSI

4 BS EN 1995-1-1. Eurocode 5: Design of timber structures. General. Common rules and rules for buildings, BSI

5 BS 5268-2. Structural use of timber. Code of practice for permissible stress design, materials and workmanship [WITHDRAWN], BSI

6 BS EN 309. Particleboards. Definition and classification, BSI

7 BS EN 312. Particleboards. Specifications, BSI

8 BS EN 12369-1. Wood-based panels. Characteristic values for structural design. OSB, particleboards and fibreboards, BSI

9 BS EN 300. Oriented strand boards (OSB). Definitions, classification and specifications, BSI

10 BS EN 15197. Wood-based panels. Flaxboards. Specifications, BSI

11 BS EN 634-1. Cement-bonded particle boards. Specification. General requirements, BSI

12 BS EN 634-2. Cement-bonded particleboards. Specifications. Requirements for OPC bonded particleboards for use in dry, humid and external conditions, BSI

13 BS EN 622-1. Fibreboards. Specifications. General requirements, BSI

14 BS EN 622-2. Fibreboards. Specifications. Requirements for hardboards, BSI

15 BS EN 622-3. Fibreboards. Specifications. Requirements for mediumboard, BSI

16 BS EN 622-4. Fibreboards. Specifications. Requirements for softboard, BSI

17 BS EN 622-5. Fibreboards. Specifications. Requirements for dry process boards (MDF), BSI

2 Panels for use in construction

2.1 General

2.1.1 Legislation and regulations

Probably the single most important piece of European technical legislation for the construction industry in the last few years was the Construction Products Directive (CPD)[1] which was adopted by the Council of Ministers in 1988. The Directive has now been replaced by the Construction Products Regulation (CPR)[2] which came fully into force on 1 July 2013.

Construction Products Regulation 2013 is the enabling law in the UK and in the main it covers enforcement and penalties for failure to meet the requirements of the European CPR legislation.

Replacing the Directive with a Regulation means that Member States no longer have the option to interpret the Directive into national law. In the UK this means that CE marking is now mandatory, where it wasn't previously, because the UK had interpreted the CPD to mean CE marking was not compulsory. The CPR now makes it clear that construction products covered by the scope of a harmonised European standard (hEN) or a European Technical Approval (ETA) must be CE marked.

Wood-based panels used for construction purposes are covered by a hEN (*EN 13986,* implemented in the UK as *BS EN 13986 Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking*[3]) and therefore it is now mandatory to CE mark those products. Having said this, the European wood-based panel sector has always embraced CE marking and the UK industry has been CE marking its construction panel products since 2004.

2.1.2 Product supply chain

One significant difference between the previous Directive and the current legislation is that the requirements of different economic operators (manufacturer, distributor and importer) are specified in detail and it has sought to address the issue of limited information regarding the performance of products being available to those in the supply chain.

The issue of poor information has been addressed by the introduction of the Declaration of Performance (DoP) which is central to the concept of the CPR. The DoP is the legal statement from the manufacturer that their product meets the performance criteria presented in the DoP relating to that product. It is this DoP which is passed down the supply chain from manufacturer to distributor to user so that it is clear what is being claimed and, in addition, provides the name, registered trade name or registered trade mark and contact address of the manufacturer.

For products bought from outside the European Economic Area (EEA), the name, registered trade name or registered trade mark and contact address of the of the importer based in the EEA that has supplied the product in the EEA for the first time has to be given with the product (on the product, the packaging or accompanying documentation).

It is worth noting that one trading company, when considering the CPR, could be a manufacturer, an importer and a distributor for different products that they are handling rather than forming part of their core business activities. For example, a company that is essentially a distributor of panel products would be:

- the manufacturer if it sells a product under its own brand
- an importer if it bought a product directly from outside of the EEA
- a distributor if it passes on a product either bought or sold from an importer or from a manufacturer in the EEA.

As such, the company would have to abide by the rules given in the CPR for each role it plays in the supply of construction products.

2.1.3 CE marking

Much confusion has arisen in the past over the significance of the CE mark. Basically it is only a symbol of conformity with its declared performances and it gives a product a 'passport' enabling it to be legally placed on the market in the EEA. Therefore it is not a mark of quality, and it is not intended to be interpreted as such.

One very important point which must be appreciated is that EU Member States have the freedom, where different levels of performance are included in a Standard, to opt for whichever level they wish for the purposes of legislation. This means that if the higher of two levels is adopted in a particular EU Member State, boards complying with the lower level will not satisfy the legislation in that country for that particular end use, despite bearing the CE mark.

Conversely, a Member State may indicate that its law or building regulations do not require compliance with a specified level for a given property of the product. In this case, there is provision for 'no performance determined' (NPD) to be declared for that property in the market of such a Member State. Under the CPR however, there must be at least one performance declared.

Once the CE mark is affixed to a product, the burden of proof for non-compliance of the product with the hEN or the ETA passes to the national enforcement authority which, in the UK, is the Trading Standards Department.

2.1.4 UK Building Regulations

In the UK, construction is governed by Building Regulations. These Regulations have been amended to include the fact that it is mandatory for products to be CE marked if they fall within the scope of a hEN or an ETA, but as a whole CE marking has very little effect on the majority of Building Regulations, as these are concerned with the performance of the structure and not the individual products used to construct it.

Having said that, Approved Document 7 (material and workmanship) of the UK Building Regulations[4] does stress that just having a CE mark does not in itself mean that a product is fit for purpose. This can be determined by assessing the requirements of the materials to be used in the construction works with the properties declared in the DoP of the material under consideration.

One other aspect of UK building practice which should be mentioned is that for the purposes of structural design, *BS 5268-2 Structural use of timber. Code of practice for permissible stress design, materials and workmanship*[5] (permissible stress design) has now been withdrawn and replaced by the Eurocodes (limit state analysis). This in itself does not mean that *BS 5268* should not/cannot be used but over time the information it contains will become increasingly out of date as it will no longer be updated by the British Standards Institute (BSI). It will most definitely still be used by some, but it would be expected that designers will start using the Eurocodes over the next few years. This edition of PanelGuide has been updated to reflect this (see *Section 2.2*).

2.1.5 Further information

For further information regarding Building Regulations and CE marking the following websites should be consulted:

- For England, Wales: www.planningportal.gov.uk
- For Northern Ireland, 'Buildings and energy efficiency of buildings' section: www.dfpni.gov.uk
- For Scotland via the 'Technical handbook' section: www.scotland.gov.uk/Topics/Built-Environment/Building/Building-standards
- For the Republic of Ireland the Technical Guidance Documents can be found at: www.environ.ie/en/TGD
- Other information can be sought from the Regulations and Codes section of: www.trada.co.uk
- Information on the Construction Products Regulation can be found here: http://ec.europa.eu/enterprise/sectors/construction/index_en.htm

2.2 Factors in design

2.2.1 Structural application (load-bearing)

2.2.1.1 Loading conditions

Before embarking on the design of a construction or part of a construction the designer must be in possession of the following information:

- The actual load to be carried, which in turn will assign the construction to a load class as set out in *BS EN 1991-1-4 Eurocode 1. Actions on structures. General actions. Wind actions*[6] (*Eurocode 1*) in conjunction with *BS EN 1990 Eurocode. Basis of structural design*[7] (*Eurocode 0*). (If using *BS 5268* (now withdrawn) then loads should be taken from *BS 6399-2 Loading for buildings. Code of practice for wind loads* (withdrawn)[8].)
- The environmental conditions under which this load will be sustained, which will have a very significant effect on the performance of the wood-based panel. These conditions are defined in terms of Service Classes in *BS EN 1995-1-1 Eurocode 5: Design of timber structures. General. Common rules and rules for buildings*[9] (*Eurocode 5*), and were replicated in *BS 5268*.
- The duration of the principal load, which in turn will determine the long-term strength and deflection of the construction. In *Eurocode 5*, these parameters are quantified in terms of a duration of load factor (k_{mod}) and a creep factor (k_{def}).

There are three basic approaches, outlined below, to the design of structures using wood-based panels.

2.2.1.2 'Deemed to satisfy'

There are currently 'deemed to satisfy' tables for domestic floor and roof applications in *BS 8103-3 Structural design of low-rise buildings. Code of practice for timber floors and roofs for housing*[10], for particleboard, OSB and a limited range of specific types of plywood, which are based on historical practice. Other plywood types are not precluded from use but the required thickness would need to be derived by design and/or testing in accordance with *BS EN 13986*.

There is no deemed to satisfy route for non-domestic floor applications.

In the case of wall sheathing and roof sarking with a bracing role, it is also possible to employ a deemed to satisfy approach, provided load-bearing panels complying with *BS EN 13986* are used and by using *BS 5268-6 Structural use of timber. Code of practice for timber frame walls*[11], where racking resistance figures can be obtained for various grades and thicknesses.

Those manufacturers that have carried out performance tests for floors, walls and roofs as described in *Section 2.2.1.3* will have done so to provide information on the panel thicknesses required to span various joist spacings and details for different fixing systems to those included in current guidance or any situation which is not covered by *BS 8103-3* or *BS 5268-6*.

2.2.1.3 Performance (prototype) testing of floors, walls and flat roofs

The actual testing of a prototype of the design offers the most efficient use of materials. However, the design cannot be modified from that tested, without further test work. Consequently, performance or prototype testing is generally applied only where a large number of identical units will be produced from the same design or where a calculation method (*Section 2.2.1.4*) cannot be used.

The prototype is tested using one of the new European performance tests, for example in the case of flooring, *BS EN 1195 Timber structures. Test methods. Performance of structural floor decking*[12]. The test results can then be converted into characteristic load and stiffness data for design use in accordance with *Eurocode 5*, using the requirements given in *BS EN 12871 Wood-based panels. Determination of performance characteristics for load bearing panels for use in floors, roofs and walls*[13].

2.2.1.4 Design by calculation

This is the generalised case in which a design of a structure is produced without the need for any prototype testing. Consequently, the design tends to be conservative, but there are no testing costs (provided the design data exists).

The actual design work may employ either limit state design (*Eurocode 5*) or permissible stress design (*BS 5268*). The Eurocode approach is now the method referred to in Approved Document A of the Building Regulations[14].

When the design is executed using limit state design according to *Eurocode 5*, the characteristic stress and moduli values used in the design analysis are to be found in *BS EN 12369-1 Wood-based panels. Characteristic values for structural design. OSB, particleboards and fireboards*[15] and *BS EN 12369-2 Wood-based panels. Characteristic values for structural design. Plywood*[16] for all panel types except solid wood panels, and cement-bonded particleboard (CBPB).

Alternatively, characteristic values for all load-bearing panel types can be derived according to *BS EN 789 Timber structures. Test methods. Determination of mechanical properties of wood based panels*[17] and *BS EN 1058 Wood-based panels. Determination of characteristic 5-percentile values and characteristic mean values*[18] and may be obtained from the manufacturer.

The time modification factors to be incorporated in the design analysis are included in *Eurocode 5*, for all structural panel types except CBPB, or these can be derived from testing to *BS EN 1156 Wood-based panels. Determination of duration of load and creep factors*[19]. Design is carried out to *Eurocode 5* and in the UK this should be in conjunction with *PD 6693-1 Recommendations for the design of timber structures to Eurocode 5: Design of timber structures. General. Common rules and rules for buildings*[20].

When using the permissible stress design method, the working stresses and moduli used in the design calculation for plywood are provided in *BS 5268-2*. The material characteristic values should be converted into permissible stresses as described in *BS 5268*.

2.2.2 Non-structural applications

Perhaps the single most important parameter to be taken into account in non-structural (non-load-bearing) applications is moisture. Too often the ingress of moisture, either liquid or vapour, degrades the performance of wood-based panels used non-structurally in construction. Thus, window boards, skirting boards, claddings, fascias, door skins and floor overlays can and do suffer from the effects of moisture ingress. Consequently, in the tables on panel selection given in *Sections 2.4 to 2.14* of PanelGuide, different panel grades are given for:

- dry application with no risk of subsequent wetting
- wet application or where there is a high risk of the panel becoming wet.

Particular applications may necessitate consideration of more specialised properties such as sound absorption: this can be of great significance in the refurbishment and conversion of old properties into flats, especially so with the use of high density overlayment panels on the floors.

Water vapour permeability and abrasion resistance are other important factors that may need to be considered in specialised applications.

2.2.3 Fire performance

2.2.3.1 Fire classification systems

Over the last few years in the UK there have been two separate systems for quantifying and specifying the performance of materials in fire. This is due to the existence of a transitional period as the new CEN (the European Committee for Standardization) reaction to fire specifications begin to replace the previous set of British specifications (BS).

Although the two systems still co-exist, and both are referred to in UK Building Regulations, readers should appreciate that since 1 July 2013, when CE marking of wood-based panels for construction became mandatory, only the new CEN reaction to fire classifications can be used in the Declaration of Performance (DoP).

2.2.3.2 European standards (CEN)

All construction products are classified into one of seven Euroclasses (A to F) according to their reaction to fire performance in fire tests. Two of these tests will be used to classify the least combustible materials (Euroclasses A_1 and A_2). These two new tests are:

- A furnace test for non-combustibility, *BS EN ISO 1182 Reaction to fire tests for products. Non-combustibility test*[21] which is based on *ISO 1182*, but differing in small but significant detail.
- An oxygen bomb calorimeter test to measure the gross calorific potential, *BS EN ISO 1716 Reaction to fire tests for products. Determination of the gross heat of combustion (calorific value)*[22] which is based on *ISO 1716*, but with modifications to improve consistency of operation.

At the lower end of the range of Euroclasses (classes E and F), construction products of appreciable combustibility can be assessed using a simple 'ignitability' test *BS EN ISO 11925-2 Reaction to fire tests. Ignitability of products subjected to direct impingement of flame. Single-flame source test*[23]. For products where no performance has been determined or where Euroclass E cannot be achieved, the products are assigned to Euroclass F.

Products that fall into Classes A_2, B, C and D (and D contains the wood-based panels except CBPB) are tested using the 'single burning item test' (SBI) to *BS EN 13823 Reaction to fire tests for building products. Building products excluding floorings exposed to the thermal attack by a single burning item*[24] except where the products are used as floor coverings. The classification using test data from the reaction to fire tests is given in *BS EN 13501-1 Fire classification of construction products and building elements. Classification using test data from reaction to fire tests*[25].

For floor coverings such as wood-composite laminate flooring, a 'critical flux (radiant panel) test', *BS EN ISO 9239-1 Reaction to fire tests for floorings. Determination of the burning behaviour using a radiant heat source*[26] is used to determine performance in Euroclasses B to E.

When using wood-based panels in construction, the reaction to fire performance shall either be determined by test and classified according to *BS EN 13501-1* or the classes shall be taken from the appropriate table in *BS EN 13986* (Table 8 in the 2004 version). The Euroclasses given in this table refer to panels installed under specific conditions including:

- jointing
- fixing
- mounting, including any backing material or air spaces
- thickness
- density.

If the manufactured product does not satisfy any of these conditions, or the method of installation is different to that specified, then the product must be tested and classified according to *BS EN 13501-1.*

The reaction to fire tests cited above relate to the product. When that product is incorporated into a building element, the fire resistance of that element will be determined by a further series of fire resistance tests.

2.2.3.3 British Standards (BS)

The British Standard tests are still referred to in Part B of the UK Building Regulations and can therefore still be used to demonstrate compliance with the Regulations. (Only the EN test system can be used to demonstrate compliance with the Euroclass system, although attempts have been made to draw best fit parallels between the two rating systems.)

- Non-combustibility test. The first of the existing British Standard tests is the 'Non-combustibility test for materials' (*BS 476-4 Fire tests on building materials and structures. Non-combustibility test for materials*[27]) where a small sample of the wood-based panel is subjected to a temperature of 750ºC. All wood-based panels, even when treated with fire retardants, are classified as 'combustible'.
- Ignitibility test. The second test is a measure of ignitability where a small pilot flame is used to determine whether the sample will ignite easily *BS 476-12: Fire tests on building materials and structures. Method of test for ignitability of products by direct flame impingement*[28]); this Standard replaced *BS 476-5:1979 Fire tests on building materials and structures. Method of test for ignitability*[29], which rated boards and wood-based panels as 'not easily ignitable'.
- Spread of flame. Following ignition, the development of a fire is dependent on a number of factors, one of the more important being the rate of spread of flame. Using *BS 476-7 Fire tests on building materials and structures. Method of test to determine the classification of the surface spread of flame of products*[30] wood-based panels over 400 kg/m^3 are rated as Class 3 (except (CBPB)). Whereas panels with a lower density are rated as Class 4, CBPB is rated Class 1.

For many applications, when using the BS system, current regulations call for wall and ceiling linings to conform to Class 1; wood-based panels can be upgraded either by the application of intumescent paints to the surface, or by the incorporation of, or impregnation by, flame-retardant chemicals. These products can influence the method of combustion, lower the temperature of onset of decomposition and increase the thickness of the char layer.

The rate at which a combustible material contributes heat to a developing fire is a most important aspect. The fire propagation test (*BS 476-6 Fire tests on building materials and structures. Method of test for fire propagation for products*[31]) provides some measure of the rate of heat release. There are a few wood-based panel products that have a Class 1 spread of flame (*BS 476-7*) as well as having a satisfactory rating in the fire propagation test: these are then rated Class 0 under the BS system.

2.2.3.4 Guidance on fires in timber frame buildings during construction

In recent years, there have been a number of high-profile fires on timber frame construction sites. As a result, greater attention has been paid to the risk of fire during construction. Once completed, timber frame buildings comply with UK Building Regulations in relation to fire safety, but additional measures may be necessary during the construction phase. This has led to consideration of new products and changes to the specification of both timber frame and sheathing panels. Specifiers and constructors should refer to published guidance on this subject, such as:

- The Health and Safety Executive's *Fire safety in construction: Guidance for clients, designers and those managing and carrying out construction work involving significant fire risks*[32]
- *Fire Prevention on Construction Sites 8th edition Code and Checklist*[33]
- The Structural Timber Association (formerly UK Timber Frame Association) *Design guide to separating distances for timber frame buildings during construction*[34], for timber frame buildings and projects above 600m^2 total floor area.

2.3 Selection of panels for specific end use: general requirements

In the selection of panels for specific end uses, a number of criteria must be considered and satisfied (*Figure 2.1*) including:

- Is the panel to be permanently incorporated into a construction and hence subject to the Construction Products Regulation (CPR)? For products outside of the scope of CPR, for example furniture, the product must meet the specification agreed between supplier and customer and must be fit for the intended purpose, but compliance with *BS EN 13986* is not required unless this forms part of the agreed specification.
- Since July 2013, when the CPR came into force, wood-based panels for use in construction must meet the requirements of the harmonised European standard *BS EN 13986* for wood-based panels. An alternative, voluntary route to gaining a CE mark, for wood-based panels that are outside the scope of *BS EN 13986*, is through issuing a European Technical Assessment (ETA) by a suitable Technical Assessment Body (TAB). In support of the CE mark, the manufacturer must prepare a Declaration of Performance (DoP) listing the properties of the panel and must have a Factory Production Control (FPC) system in place to ensure that the properties in the DoP are maintained.
- The CE mark will make it clear whether the product is intended for structural or non-structural use and whether it is suitable for specific applications, such as flooring, roofing or wall sheathing.
- Structural panels must be capable of carrying the imposed loads as set out in *Eurocode 1* and *Eurocode 0* if design is by limit state according to *Eurocode 5*, or to meet specific loads where known. (Where design is being carried out to *BS 5268-2* the imposed loads should be taken from *BS 6399*.) Demonstration of the panel's ability to carry the loads may be calculation based on material characteristic properties or by performance testing for specific end uses.
- The panels must be appropriate for the ambient environmental conditions of the projected end use. Panels in the following tables are listed according to use in one of three service classes. The Service Class system is mainly aimed at assigning strength values and for calculating deformations under defined environmental conditions. The appropriate service class will be designated in the CE mark.
  - **Service Class 1:** is characterised by a moisture content in the materials corresponding to a temperature of 20°C and the relative humidity of the surrounding air only exceeding 65% for a few weeks per year. (Note: in Service Class 1 the average moisture content in most panels will not exceed 11%.)
  - **Service Class 2:** is characterised by a moisture content in the materials corresponding to a temperature of 20°C and the relative humidity of the surrounding air only exceeding 85% for a few weeks per year. (Note: in Service Class 2 the average moisture content in most panels will not exceed 15%.)
  - **Service Class 3:** climatic conditions leading to higher moisture contents than in Service Class 2.

Further criteria relating to other properties, for example thermal conductivity, vapour permeability, durability, dimensional stability and sound absorption, may also have to be taken into account in the selection of panels for particular applications.

Tables in the following sections set out the types and grades of panels that are available for specific end uses within construction, given a particular load level and a particular environmental condition.

It should be appreciated that:

- These tables give the minimum grade of panel that will satisfy a particular set of requirements. Panels of higher quality than the minimum may be substituted, and in certain circumstances their selection may result in a reduced thickness of panel being used.
- Although all the panels meeting the grade specifications in a particular table satisfy the particular requirements, the level of performance of different brands of these panels may vary considerably. Moreover some may be endowed with high levels of properties not included in the tables, such as thermal conductivity, or sound absorption; these properties may be listed in the DoP.
- The design of structures using any one of these panels is dependent on the availability of the relevant design stresses and their subsequent modification to account for environmental factors and duration of load. These factors in design should be included in the DoP and are discussed further in *Section 2.2*.

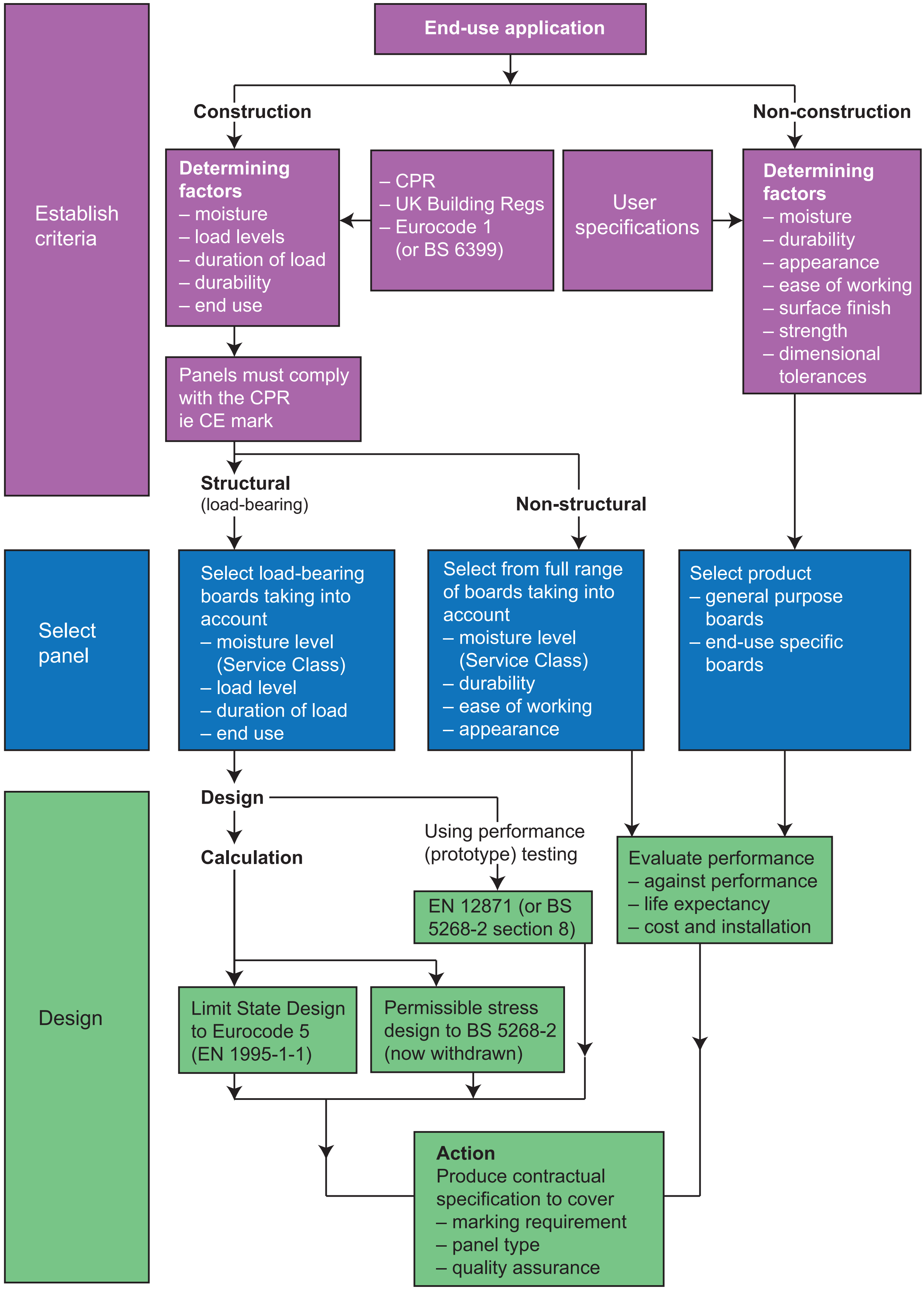


Figure 2.1: Panel selection and use

2.4 Application of panels in flooring

2.4.1 Selection of panels for flooring

The selection of wood-based panels for flooring depends on a number of factors of which the most important are:

- the type of floor
- the load that the floor has to carry
- the ambient moisture conditions.

2.4.1.1 Type of floor

It is convenient to recognise the following different types of floor:

- Suspended floors in which the floor decking is attached to a series of joists.
- Floating floors in which the floor decking rests either on insulation above a structural sub-floor, or on a series of battens which has insulation between them. Note that in both situations the panel is load-bearing as, in event of failure, the underlying insulation is unlikely to be able to sustain the imposed loads.
- Raised access floors in which the floor segments are supported on short pillars to permit access to cables below the floor.
- Industrial platform floors which embrace both mezzanine and raised storage floors.

The selection of wood-based panels for the different floor types is set out in *Table 2.1* and *Table 2.2*.

2.4.1.2 Loading

The second criterion is the load that the floor has to carry. Load classes for use with limit state design to *Eurocode 5*, are given in *Eurocode 1*.

In *Eurocode 1* (Actions on structures) there are four basic 'categories of use' of which there are also sub categories for most uses. Each European Member State will have its own National Annex detailing the imposed loads for each category of use, the UK is no exception. The categories of use are as follows:

- Category A – Domestic, this includes houses, bedrooms and wards in hospitals and rooms in hotels
- Category B – Offices
- Category C – Public areas where people might congregate, this category is split into five sub categories. Some examples might be cafes, restaurants in schools, churches, theatres or cinemas, museums, gyms, stages, football terraces, railway platforms
- Category D – Shopping areas, which is split into two sub categories for retail shops and department stores
- Category E – Industrial storage.

When designing a floor using permissible stress design in accordance with *BS 5268*, the code of practice for dead and imposed loads is *BS 6399*. *BS 6399* has very similar categories of use as *Eurocode 1* with the addition of categories F and G, which are for car parking, driveways, paths with vehicle access and garages.

The selection of wood-based panels for floors subjected to domestic and non-domestic loading is given in *Table 2.1* and *Table 2.2* respectively. It should be appreciated that the designer can design the floor to carry any specified load. More information on loadings for floors is provided in *Eurocode 1* and *BS 6399*.

2.4.1.3 Moisture conditions

Moisture conditions is the third main criterion as they will have markedly different effects on the performance of wood-based panels; these are quantified in terms of Service Classes as described in *Section 2.3*. The selection of panels for floors subjected to the different Service Classes is set out in *Table 2.1* and *Table 2.2*.

Additional considerations might include thermal, acoustic performance and the likelihood of wetting during construction.

2.4.1.4 Thermal performance

In order to meet the requirements of the Approved Documents L1A, L1B, L2A, L2B[35], the corresponding Scottish Technical Handbook Part 6.2,[36] Building Regulations Technical Booklet F1 and F2[37] in Northern Ireland, and Part L in the Republic of Ireland[38], the thickness and thermal conductivity of the panel in combination with the other components of the floor system will need to be considered as a whole during the design phase. This might in some cases increase the dead load, which may require the size or grade of the supporting joists to be increased.

2.4.1.5 Acoustic performance

In order to achieve the requirements of Building Regulations in the UK and Ireland, the thickness of the panel used in the floor system will have to be considered alongside all the other components and design of the floor system. This might in some cases increase the dead load which may require the size or grade of the supporting joists to be increased.

2.4.1.6 Wetting during construction

The time a wood-based panel floor is left exposed to the weather could have an impact on the performance of the board in service if it were to get wet for prolonged periods of time. This issue has been recognised and there are now proprietary products available with protective surfaces, some as a 'peel clean' type coating and joint protection that will protect the floor from weather and/or dirt caused by trades and traffic during the construction phase. This may be a consideration where the floor is built at an early phase of the construction or where it is unlikely that the building will be water tight quickly.

2.4.2 The design of timber floor decking

The various factors to be incorporated in design are set out in *Section 2.2*.

Table 2.1: Panel grades* for domestic floors and the location of design and testing information

Selection	DOMESTIC FLOORS	SERVICE CLASS	PLYWOOD BS EN 636	PARTICLEBOARD BS EN 312	OSB BS EN 300	MDF BS EN 622-5	FIBREBOARD BS EN 622-3,4	CBPB BS EN 634
	Suspended floors	1 2	636-1 636-2	P4 P5	OSB/2 OSB/3	MDF.LA -	MBH.LA 1 -	CBPB CBPB
Design by deemed to satisfy	✓	For the panel products listed in BS 8103-3, tables are present permitting the use of certain thicknesses for different maximum spans						
or Design by performance testing	✓	Test using BS EN 1195 (see manufacturer's test data). Check BS EN 12871 National Foreword for recommendations for designing with wood-based panels in the UK. Design using BS EN 1995-1-1 (Eurocode 5) and any national provisions (in the UK this is PD 6693-1 Recommendations for the design of timber structures to Eurocode 5: Design of timber structures. General. Common rules and rules for buildings)						
	or	Test using BS EN 1195 (see manufacturer's test data). Satisfy the requirements in BS 5268-2. Design using BS 5268-2						
or Design by calculation	✓	Using limit state design in BS EN 1995-1-1 (Eurocode 5) and any national provisions (PD 6693-1 Recommendations for the design of timber structures to Eurocode 5: Design of timber structures. General. Common rules and rules for buildings). Characteristic values for all panels except solid wood panels and CBPB are given in BS EN 12369 Parts 1 and 2; alternatively, characteristic values for all load-bearing panels can be derived using BS EN 789 and BS EN 1058 and may be obtained from the manufacturers. Time modification factors for design for all panels except CBPB are included in BS EN 1995-1-1 (Eurocode 5), or an estimate of them can be derived using BS EN 1156						
	or	Using permissible stress design in BS 5268-2. Stress and moduli are derived from the characteristic values in BS EN 12369 Parts 1 and 2 except solid wood panels and CBPB: grade stresses and moduli for certain specific types of plywoods are also included in BS 5268-2. Alternatively, characteristic values for all load-bearing panels can be derived using BS EN 789 and BS EN 1058 and may be obtained from the manufacturers. Time modification factors for design are included in BS 5268-2 for all panels except CBPB						
Guidance on application	✓	Guidance on the use of load-bearing panels in suspended floors is given in DD CEN/TS 12872						

Selection	DOMESTIC FLOORS	SERVICE CLASS	PLYWOOD BS EN 636	PARTICLEBOARD BS EN 312	OSB BS EN 300	MDF BS EN 622-5	FIBREBOARD BS EN 622-3,4	CBPB BS EN 634
	Floating floors	1	636-1	P4	OSB/2	MDF.LA	MBH.LA 1	CBPB
		2	636-2	P5	OSB/4	-	-	CBPB
Design by performance testing	✓	Test using CEN/TS 13810-2 (see manufacturer's test data). Satisfy the requirements in BS EN 13810-1 (Note that the panels used as a floating floor should be of a load-bearing grade, as in the event of failure the underlying insulation is unlikely to be able to sustain the imposed loads)						
Guidance on application	✓	Guidance on the installation of floating floors is given in the WPIF Industry Standard 3/2018 for particleboard and OSB; this is reproduced in PanelGuide *Annex 3*						

Selection	DOMESTIC FLOORS	SERVICE CLASS	PLYWOOD BS EN 636	PARTICLEBOARD BS EN 312	OSB BS EN 300	MDF BS EN 622-5	FIBREBOARD BS EN 622-3,4	CBPB BS EN 634
	Fabricated underlays (surface on which to lay floor covering), see *Section 2.4.5.3*	1	636-3 conforming to BS 8203 Annex A				HB.H	
		2	636-3 conforming to BS 8203 Annex A				HB.H	
Guidance on application	✓	Fabricated underlays: plywood minimum thickness should be 5.5mm nominal and hardboard 4.8mm nominal where fully supported. The panels must be fixed to prevent lifting at the joints; consideration should be given to the provision of expansion joints (BS 8203).						

* The table provides the minimum grade of panel that satisfies the particular set of requirements: panels of higher quality may be substituted, and their selection may result in a reduction in required thickness.
Although all the panels meeting the grade specifications will satisfy a particular set of requirements, the level of performance of different brands of these panels may vary considerably; some may even be endowed with high levels of properties not directly covered by the table.

The 'deemed to satisfy' approach to the design of non-domestic floors is no longer valid. For domestic floors *BS 8103-3* gives tables where various grades and thicknesses of panels can be used at different maximum spans.

In the absence of 'deemed to satisfy' information, recourse must be made to designing either by prototype testing, or by calculation as detailed in *Section 2.2.1.4* and set out in *Table 2.1* and *Table 2.2*.

The typical panel size for flooring is 2400mm × 600mm, with other sizes available to order. The usual panel width of 600mm makes handling in internal spaces easier and a length of 2400mm suits nominal framing centres of 600mm or 400mm.

Table 2.2: Panel grades* for non-domestic floors and the location of design and testing information

Selection	NON-DOMESTIC FLOORS	SERVICE CLASS	PLYWOOD BS EN 636	PARTICLEBOARD BS EN 312	OSB BS EN 300	MDF BS EN 622-5	FIBREBOARD BS EN 622-3,4	CBPB BS EN 634
	Suspended floors	1 2	636-1 636-2	P6 (P4) P7 (P5)	OSB/4 (3) OSB/4 (3)	- -	MBH.LA 1 -	- -
Design by deemed to satisfy	×	There are no deemed to satisfy routes for non-domestic flooring						
or Design by performance testing	✓	Test using BS EN 1195 (see manufacturer's test data). Check BS EN 12871 National Foreword for recommendations for designing with wood-based panels in the UK. Design using BS EN 1995-1-1 (Eurocode 5) and any national provisions (in the UK this is PD 6693-1)						
	or	Test using BS EN 1195 (see manufacturer's test data). Satisfy the requirements in BS 5268-2. Design using BS 5268-2						
or Design by calculation	✓	Using limit state design in BS EN 1995-1-1 (Eurocode 5) and any national provisions (PD 6693-1). Characteristic values for all panels except solid wood panels and CBPB are given in BS EN 12369 Parts 1 and 2; alternatively, characteristic values for all load-bearing panels can be derived using BS EN 789 and BS EN 1058 and may be obtained from the manufacturers. Time modification factors for design for all panels except CBPB are included in BS EN 1995-1-1 (Eurocode 5), or an estimate of them can be derived using BS EN 1156						
	or	Using permissible stress design in BS 5268-2. Stress and moduli are derived from the characteristic values in BS EN 12369 Parts 1 and 2 except solid wood panels and CBPB: grade stresses and moduli for certain specified plywoods are also included in BS 5268-2. Alternatively, characteristic values for all load-bearing panels can be derived using BS EN 789 and BS EN 1058 and may be obtained from the manufacturers. Time modification factors for design are included in BS 5268-2 for all panels except CBPB						
Guidance on application	✓	Guidance on the use of load-bearing panels in suspended floors is given in DD CEN/TS 12872						
Guidance on application	**Industrial platform floors**	Specific information on mezzanine and raised storage floors is available in BRE Digest 437						

Selection	NON-DOMESTIC FLOORS	SERVICE CLASS	PLYWOOD BS EN 636	PARTICLEBOARD BS EN 312	OSB BS EN 300	MDF BS EN 622-5	FIBREBOARD BS EN 622-3,4	CBPB BS EN 634
	Floating floors	1	636-1	P6	OSB/4	-	MBH.LA 2	CBPB
		2	636-2	P7	OSB/4	-	MBH.HLS2	CBPB
Design by performance testing	✓	Test using CEN/TS 13810-2 (see manufacturer's test data). Satisfy the requirements in BS EN 13810-1 (Note that the panels used as a floating floor should be of a load-bearing grade, as in the event of failure the underlying insulation is unlikely to be able to sustain the imposed loads)						
Guidance on application	✓	Guidance on the installation of floating floors is given in the WPIF Industry Standard 3/2018 for particleboard and OSB; this is reproduced in PanelGuide *Annex 3*						

Selection	NON-DOMESTIC FLOORS	SERVICE CLASS	PLYWOOD BS EN 636	PARTICLEBOARD BS EN 312	OSB BS EN 300	MDF BS EN 622-5	FIBREBOARD BS EN 622-3,4	CBPB BS EN 634
	Raised access floors	Provided the performance requirements set out in BS EN 12825 are met, any panel product may be used						

Selection	NON-DOMESTIC FLOORS	SERVICE CLASS	PLYWOOD BS EN 636	PARTICLEBOARD BS EN 312	OSB BS EN 300	MDF BS EN 622-5	FIBREBOARD BS EN 622-3,4	CBPB BS EN 634
	Fabricated underlays (surface on which to lay floor coverings), see *Section 2.4.5.3*	1	636-3 conforming to BS 8203 Annex A			-	HB.H	
		2	636-3 conforming to BS 8203 Annex A			-	HB.H	
Guidance on application	✓	Fabricated underlays: plywood minimum thickness should be 5.5mm nominal and hardboard 4.8mm nominal where fully supported. The panels must be fixed to prevent lifting at the joints; consideration should be given to the provision of expansion joints (BS 8203).						

* The table provides the minimum grade of panel that satisfies the particular set of requirements: panels of higher quality may be substituted, and their selection may result in a reduction in required thickness.
Although all the panels meeting the grade specifications will satisfy a particular set of requirements, the level of performance of different brands of these panels may vary considerably; some may even be endowed with high levels of properties not directly covered by the table.

Panels may be plain (square) edged, or profiled. Plain edged panels need gaps to be provided between panels (see *Section 2.4.3.6*), and support to be provided by joists or noggings at all edges (see *Section 2.4.3.6*). Profiled edges are usually matching tongue and groove and remove the need to provide support at all edges. For flooring purposes it is recommended that tongued and grooved (T&G) panels with glued joints are used to provide a smooth and stable substrate.

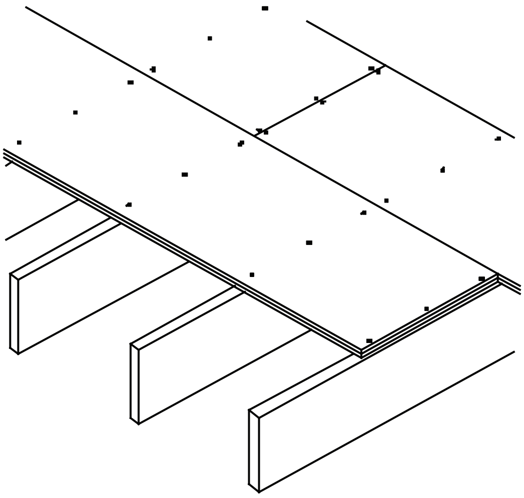


Figure 2.2: Tongued and grooved edge structural decking should be laid across the joists with short edges supported on joists

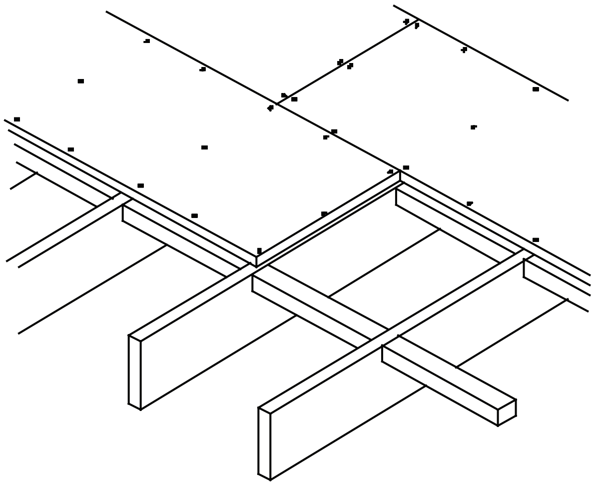


Figure 2.3: Square edge structural decking laid across the joists and supported by noggings

2.4.3 Sitework: floor decking on joists

2.4.3.1 Conditioning

It is important that panels are installed at a moisture content close to that which they will achieve in service. Advice on the conditioning of panels is to be found in PanelGuide *Section 4.2.4*.

2.4.3.2 Preparation of structure

The void beneath a joisted ground floor must be adequately ventilated to comply with the Building Regulations as well as with the requirements of NHBC where required.

Supporting joists, noggings and edge support should be laid to line and level.

Check the moisture content of joists as floor panels should not be laid on joists which have a moisture content above 20% as moisture can migrate into the panels and will cause localised swelling.

Access traps or ducting should be pre-planned and the necessary noggings and edge supports provided at all edges.

Joists and noggings should provide a minimum bearing for panel edges of 18mm (see *Figure 2.4*).

All noggings should be made with timber of 38mm × 38mm (unless otherwise specified by joist manufacturer) and securely fixed to the joists.

2.4.3.3 Laying all types of panel products

T&G and square edge boards should be laid across the joists with both short edges supported on a joist, or other edge support (see *Figure 2.2*). Square edged boards should be continuously supported along all edges so that the short edges are supported on the joists and the long edges by noggings (see *Figure 2.3*). Readers should note that additional materials (not shown in the figure) may be required to meet other requirements such as acoustics, thermal, reaction to fire or resistance to fire.

For all boards, maximum strength and stiffness will be obtained if each panel is continuous over at least two spans between joists.

At floor perimeter, where the floor deck is laid after the wall is in place (ie, not cassette floors), panels should be fixed and supported on noggings between the joists (T&G and square edge panels). However, at the perimeter of a floor, between the first joist and the wall (joist parallel to wall), a 25mm-75mm gap may be allowed to aid floor installation and for services to be installed. The floor decking at the perimeter, in this case, may therefore be laid to overhang the joist up to a maximum of 75mm.

Panels of both edge types should be laid to break joint, ie with staggered short edge joints to avoid lining them up. Ideally, the stagger should be at the mid-point of the adjacent panel for maximum stiffness.

To reduce the risk of creaking in use and enable the joint to have maximum strength, all joints in T&G panelled floors should be glued with at least a durability class D3 adhesive (classified to *BS EN 204 Classification of thermoplastic wood adhesives for non-structural applications*[39]). Glue should be applied liberally to both the tongue and the groove to ensure the entire joint is bonded.

It is further recommended that particleboard and OSB are also glued to supporting timber joists with a durability class D4 (classified to EN 204) adhesive or a proprietary product suitable for that application.

However, where manufacturers supply both panels and adhesive as systems (for example, weather-proof systems), the manufacturer's own adhesives, tapes and fixing instructions should be used.

Where the short edge of a board finishes mid span (ie between joists), while this is not ideal it is possible to use a so-called 'H' nogging to support the short edge of the panel on the horizontal part of the 'H'.

Table 2.3: Spacings of fixings for floor decking

Panel type	Maximum spacings (mm)		
	Perimeter framing	Intermediate framing	Min edge distance (mm)
Particleboard	150–300	300	8
Cement-bonded particleboard	see note	see note	see note
OSB	150–300	300	8
Plywood	150–300	300	8

Note: For cement-bonded particleboard recommended nail spacings and edge distances vary with thickness and from manufacturer to manufacturer – examples of nail spacing range from 200 to 400mm on perimeter framing and from 300 to 610mm on intermediate framing; nail edge distance varies from 15mm for panels less than 12mm and 20mm for thicker panels up to 25mm irrespective of thickness. Panels may need to be pre-drilled or fixed with self-drilling screws to avoid splitting. For fixing cement-bonded particleboard it is therefore essential to obtain and follow the manufacturer's recommendations.

2.4.3.4 Expansion gaps

A gap should be provided around the perimeter of a floor, to upstands or abutting construction, to allow for possible expansion of the decking. This should be a minimum of 10mm at each stage or 2mm per metre run of panel. The gap should be left open and covered by a skirting panel, or filled with a compressible strip such as cork or other suitable material. Larger floors may also require intermediate expansion gaps of a minimum of 20mm at 10-metre intervals.

Where a floor is laid before the wall (often as a pre-fabricated cassette floor), it is possible to omit a perimeter expansion gap and lay the boards to the ends of the joists to fix the wall directly over. This is common practice in 'low' load situations, where 'high' loads are present, for example point loads; the compressive strength should be checked and where required an alternative design detail or product should be employed at the end of the joists where a wall is bearing directly on the panel (see *Figure 2.4*).

A 3mm gap should also be left between each square-edged panel.

Note: For T&G panels or panels that, by design, are tightly butted, special attention must be given to fixing down to avoid buckling.

2.4.3.6 Fixing

Panels should be fixed using corrosion resistant nails or screws. Corrosion resistant materials include galvanised or sheradised steel, austenitic stainless steel, phosphor bronze and silicon bronze.

Screws and flat headed improved nails (such as annular grooved or ringshank) have superior holding power and should be used in preference to plain shank nails.

Screws should be conventional countersunk woodscrews or, where fixing to steel structural frames, self-drilling self-tapping screws.

When fixing to timber, the minimum fixing length should be 50mm or 2.5 times the panel thickness, whichever is

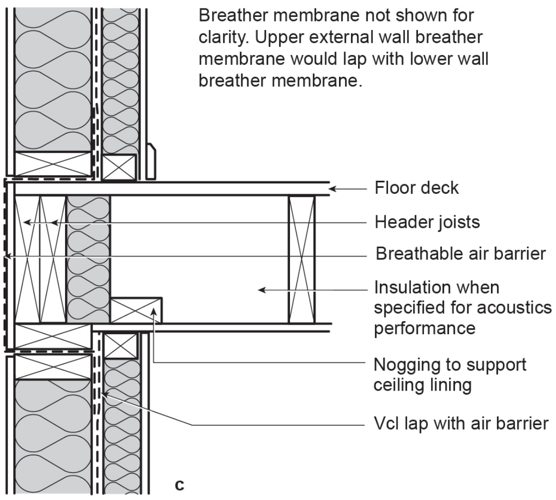


Figure 2.4: Floor/external wall junction showing panel extending beyond room perimeter under the wall

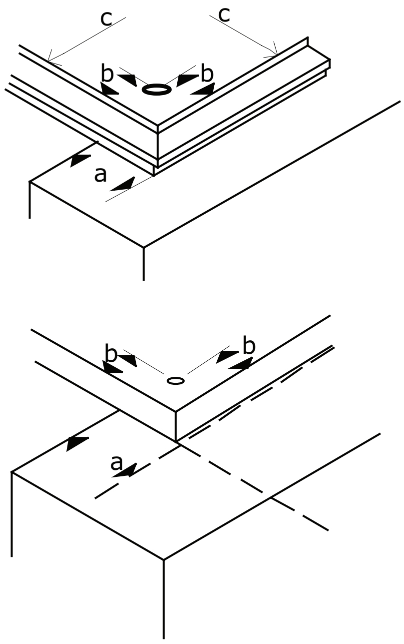


Figure 2.5: A minimum edge nailing distance of 8mm should be maintained and a minimum bearing of 18mm provided to each panel in both T&G panels (top) and square-edged panels (bottom)

greater. The minimum fixing diameter should be 0.16 times the panel thickness.

When fixing into steel, the length of the screw should be sufficient for the threaded shank of the screw to fully penetrate the full thickness of the steel.

The frequency and pattern of nailing to joists and noggings should be as set out in *Table 2.3* unless structural calculations require otherwise. To avoid tear out at panel edges, fixings should not be inserted closer to the edges than the minimum distances given, and as shown in *Figure 2.5*.

All nail heads should be punched home by 2–3mm. Screws should be countersunk.

Where manufacturer's instructions are supplied with the panels their recommendations should be followed. This might include so-called 'glue only' floor system that use a proprietary adhesive to fix the panels to the joists, as well as a reduced amount of mechanical fixing (nails/screws); each manufacturer's fixing requirements may be different with some requiring more or less mechanical fixings than others, in this case no fewer fixings should be used than the instructions require.

After fixing, panel surfaces should be protected with building paper/polythene, or a proprietary panel product may be used (for example, 'peel clean') to prevent damage and the treading in of grit and debris during building works. Heavily trafficked areas should be protected with a temporary panel covering.

2.4.4 Sitework: floating floor decking

Guidance on the installation of floating floors is given in the WPIF Industry Standard No.3/2018 for particleboard and OSB which is reproduced as *Annex 3* of PanelGuide.

2.4.5 Finishing

2.4.5.1 General

Particleboard floors provide a smooth flat surface which is suitable for many types of floor covering, provided that the fixing, edge support and gluing recommendations are followed. Unsanded OSB panels have a surface texture which shows the shape of the wood strands – panels produced for use as flooring usually have a smooth sanded surface.

2.4.5.2 Carpet and sheet floorings

Where carpet is laid over particleboard and held in place using pre-nailed carpet gripper, adequate edge distance must be left for the gripper nails to avoid splitting the panels.

Sheet flooring can be loose laid or bonded directly to most panel surfaces (see *Section 2.4.5.5*).

Thin sheet flooring or thin carpet may allow the panel joints beneath to show through, particularly after trafficking, and may require the use of a fabricated underlay to remove this effect (see *Section 2.4.5.3*).

2.4.5.3 Fabricated underlay

2.4.5.3.1 Materials

The following types of panel product are suitable as a fabricated underlay in dry conditions:

- Plywood conforming to *BS EN 636 Plywood. Specifications*[40]
- Hardboard conforming to *BS EN 622-2 Fibreboards. Specifications. Requirements for dry process boards (MDF)*[42].

Clean plywood or hardboard without any surface sealants, residues or coatings applied are best suited as a fabricated underlay. Fabricated underlay specifications (plywood and hardboard) can be found in BS 8203, which also includes a detailed plywood specification in its Annex A.

2.4.5.3.2 Fabricated underlay application

The purpose of a fabricated underlay is to smooth out any irregularities of a sub-floor before laying a floor covering that may telegraph these imperfections through to the floor surface (for example fully bonded thin vinyl on a particleboard sub-floor may telegraph the joint lines).

It is recommended that the fabricated underlay should ideally have a minimum nominal thickness of 4.8mm for hardboard and 5.5mm for plywood; depending on the level of rigidity required, the underlay may be specified to be slightly thicker and panels as large as possible should be used to minimise the number of joints. It is assumed that underlays will be used on top of an existing structural deck such as particleboard, OSB or floorboards, rather than forming the top layer of a floating floor where thicker panels are usually employed. It is also worth noting that if the underlay becomes too thick it is difficult to cut on site.

All wood-based panel sheets used as fabricated underlays should be loosely stacked in the room where they are to be laid to condition or acclimatise as close to the in-use conditions as possible before laying. Hardboard (unless sold as pre-conditioned) should be pre-conditioned by sponging with water on the mesh side with approximately 1 litre per each full panel (1200mm × 2400mm). The panels should then be stacked for at least 24 and preferably 48 hours before fixing. Following fixing, hardboards should be left to fully dry before fixing the floor covering.

Where possible, hollows in the sub-floor should be brought level by sanding, planing or patch-filling with a suitable proprietary flexible cementitious smoothing underlayment. The fabricated underlay panels should be laid across the line of the panels in the sub-floor.

In order to obtain the best results the fabricated underlay should be laid so that there are no gaps between the joints of the panels, nor any step between each panel. A gap should be provided around the perimeter of a floor to upstands or abutting construction and at door thresholds to allow for possible expansion of the fabricated underlay. This should be a minimum of 10mm at each stage or 2mm per metre run of panel. The gap should be left open and covered by a skirting panel, or filled with a compressible strip such as cork. Joint lines should be staggered and joints in the panel and the timber base should not coincide.

Underlays should be fixed using ringshank nails, screws or screw nails which should be finished flush with the surface. The length of the fixings should be at least 2.5 times the thickness of the fabricated underlay panel but no longer than would allow the fixing to protrude below the sub-floor. Each panel should be fixed at not more than 100mm intervals around the edges of the panel and at 150mm intervals in rows every 400mm across the length of the panel, with the fixing line at a minimum edge distance of 10mm. Fixing of each panel should start at the centre of one edge of the panel and continue across the panel to the other three edges.

2.4.5.4 Tiles

The application of rigid ceramic tiles to wood-based panels requires great care in specification and site practice to avoid cracking at joints or through tiles. Further information is provided in PanelGuide *Section 4.7.5*.

2.4.5.5 Adhesives

Most common floor laying adhesives are suitable for use with wood-based panels; however, water-based adhesives should not be used unless they have a very low water content or the panel surface is sealed with a suitable sealer. This will prevent excessive amounts of water (which may not be able to evaporate through the floor covering being absorbed by the panel) causing swelling and/or distortion if present in sufficient quantities.

An issue with adhesion to panel products that have had their 'peel clean' surfaces removed is possible, it is recommended in these cases to use a fabricated underlay.

2.4.5.6 Sealers and surface finishes

Panels are available pre-finished with a surface seal. Panels may also be site finished with surface coatings to give temporary protection or to give a fully treated decorative finish.

Cement-bonded particleboard surfaces must be primed with an anti-alkali primer before decorating or applying coverings, unless alkali resisting products are being used.

Most types of internal and external paints and stains may be used, in accordance with manufacturers' instructions. Water-based paints may be used on wood chipboard and OSB but may cause unacceptable raising of 'grain' and increase the risk of movement and/or distortion.

2.4.5.7 The use of wood-based panels in under-floor heating applications

2.4.5.7.1 Applications

Wood-based panels are commonly used as the structural floor layer, as a non-structural overlay to under-floor heating systems or in a grooved form as the carrier for under-floor heating pipes.

In their raw form, wood-based panels are rarely used as the finished walking surface, although they are often machined and coated to manufacture decorative flooring products. But when they are covered with thin flexible coverings, such as carpets, they are required to withstand imposed floor loads and to cope with changes in moisture content (see *Moisture content effects* below).

2.4.5.7.2 Grooved panel systems

Wood-based panels used as a structural deck, spanning across joists or battens and carrying imposed floor loads must comply with the relevant clauses of *BS EN 13986*. Where they may be subject to imposed concentrated loads or soft body impacts, they must be tested in accordance with *BS EN 12871* and the performance declared.

Where wood-based panels are grooved and used as a carrier for water pipes, their ability to resist imposed concentrated and soft body impact load is likely to be significantly reduced. They must therefore be tested in accordance with *BS EN 12871* at what is determined as the weakest point on the floor system and assessed against the relevant imposed loads from *Eurocode 1*. For domestic floor loads it is likely that a grooved panel made from a conventional thickness will need an additional structural layer, either under or over the grooved layer, to provide additional support to achieve the imposed design load.

2.4.5.7.3 Moisture content effects

Like all wood products, wood-based panels will be subject to changes in dimensions and moisture content depending upon the environmental conditions to which they are exposed (see PanelGuide *Section 4.2.4*). Where panels are used in conjunction with an under-floor heating system, the final moisture content is likely to be lower than that achieved with other heating systems. It is therefore critically important to consider moisture content related movement issues. In particular:

- Panels must be kept dry prior to installation and not exposed to direct wetting or prolonged periods of high humidity.
- Panels should be assessed for their moisture content and if necessary conditioned prior to installation in a climate as close as possible to the final heated environment.
- Consideration should be given to the likely effects of any shrinkage and expansion that may result from the

use of the underfloor heating system. The moisture content in the wood-based panel may fall to less than 5% when the heating is on and relative humidity is low, but could rise to 9–10% or more when it is switched off in summer and there is greater atmospheric humidity.

Due to this dimensional change, some manufacturers will advise against under-floor heating with their products. In terms of wood-based panels it is therefore advisable to specify flooring of low movement to give more stability to dimensional change.

2.5 Application of panels in flat roof decking

2.5.1 Selection of panels for flat roof decking

The selection of wood-based panels for roof decking depends on a number of factors of which the most important are:

- the type of roof
- the load that the roof deck has to carry.

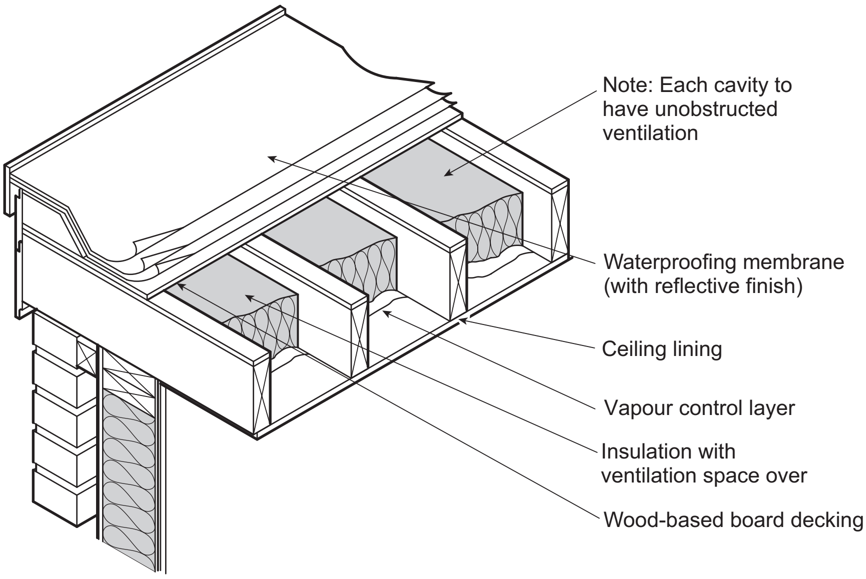


Figure 2.6: Typical cold deck flat roof
a: roof covering, b: roof deck, c: ventilated air space, d: thermal insulation, e: vapour control layer, f: ceiling lining

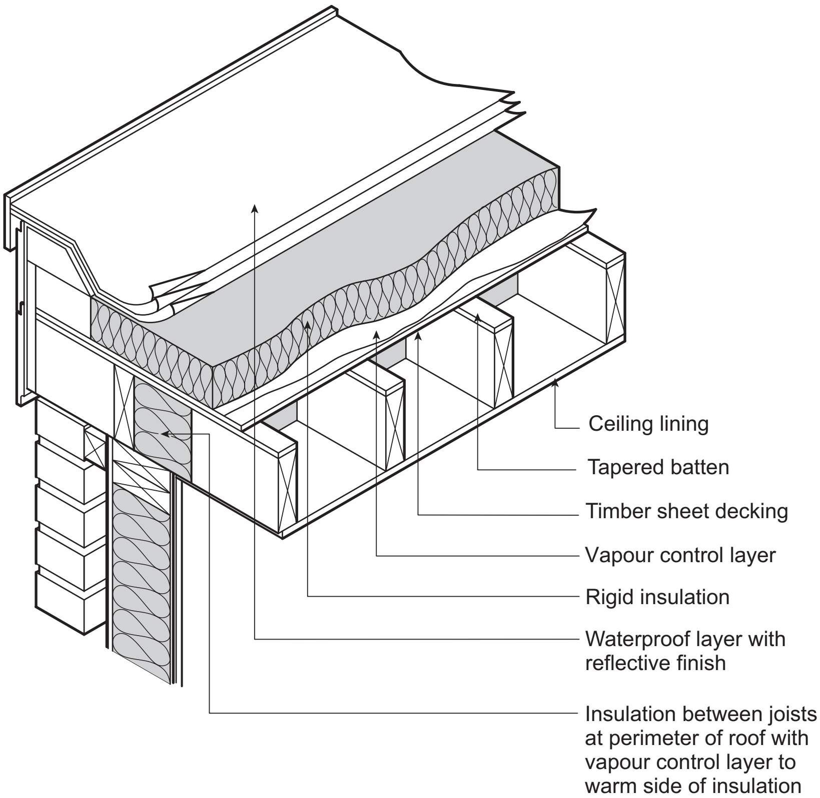


Figure 2.7: Typical warm deck flat roof
a: roof covering, b: overlay panel, c: rigid insulation, d: vapour control layer, e: structural roof deck

Table 2.4: Panel grades* for flat roof decking and the location of design and testing information

Selection	ROOFS	CONSTRUCTION	PLYWOOD BS EN 636	PARTICLEBOARD BS EN 312	OSB BS EN 300	MDF BS EN 622-5	FIBREBOARD BS EN 622-3,4	CBPB BS EN 634
	Flat roof decking	warm deck cold deck	636-2 636-2	P5 P5	OSB/3 OSB/3	- -	- -	CBPB CBPB
Design by deemed to satisfy	✓	For the panel products listed in BS 8103-3 tables are present permitting the use of certain types and thicknesses of plywood, particleboard and OSB for different maximum spans. These are based on historic practice						
or Design by performance testing	✓	Test using BS EN 1195 (see manufacturer's test data). Satisfy the requirements in BS EN 12871. Design using BS EN 1995-1-1 (Eurocode 5)						
	or	Test using BS EN 1195 (see manufacturer's test data). Satisfy the requirements in BS 5268-2. Design using BS 5268-2						
or Design by calculation	✓	Using limit state design to BS EN 1995-1-1 (Eurocode 5). Characteristic values for all panels except solid wood panels and CBPB are given in BS EN 12369 Parts 1 and 2; alternatively, characteristic values for all load-bearing panels can be derived using BS EN 789 and BS EN 1058 and may be obtained from the manufacturers. Time modification factors for design for all panels except CBPB are included in BS EN 1995-1-1 (Eurocode 5), or an estimate of them can be derived using BS BS EN 1156						
	or	Using permissible stress design in BS 5268-2 (now withdrawn). Stress and moduli are derived from the characteristic values in BS EN 12369 Parts 1 and 2 except solid wood panels and CBPB: grade stresses and moduli for certain specific plywoods are included in BS 5268-2. Alternatively, characteristic values for all load-bearing panels can be derived using BS EN 789 and BS EN 1058 and may be obtained from the manufacturers. Time modification factors for design are included in BS 5268-2 for all panels except CBPB						
Guidance on application	✓	Guidance on the use of load-bearing boards in flat-roof decking is given in DD CEN/TS 12872						

* The table provides the minimum grade of panel that satisfies the particular set of requirements: panels of higher quality may be substituted, and their selection may result in a reduction in required thickness.
Although all the panels meeting the grade specifications will satisfy a particular set of requirements, the level of performance of different brands of these panels may vary considerably; some may have performance characteristics not directly covered by the table.

Essentially there are two basic types of flat roof design which have become known as the 'cold deck' and 'warm deck' flat roofs; the distinguishing feature is the location of the insulation relative to the wood panel deck.

In the cold deck flat roof the insulation and vapour control layer is below the roof decking and in order to reduce both the occurrence of condensation and its effect, it is essential that there is a void between the deck and the insulation and that this void is well ventilated (*Figure 2.6*). The cold deck flat roof is not permissible in Scotland.

In the warm deck flat roof the insulation and vapour control layer are above the roof decking thereby almost eliminating the occurrence of condensation within the decking provided sufficient insulation is included (*Figure 2.7*).

The selection of wood-based panels for these two designs of flat roof is given in *Table 2.4*.

The load that the decking has to carry will depend on whether the flat roof has open access or whether access is restricted only to maintenance. Apart from access, the main sources of imposed loads for a flat roof will be snow and wind uplift. Beyond these factors the designer is free to design the roof to carry any specified load, and more information on loadings for roofs is provided in *Eurocode 1* and *BS 6399*.

Moisture conditions will have markedly different effects on the performance of wood-based panels; these are quantified in terms of Service Classes as described in *Section 2.3*. The selection of panels for roofs subjected to the different Service Classes is set out in *Table 2.4*.

Increases in the required level of thermal performance in revisions to Approved Document Part L for England and Wales (with corresponding changes for Scotland and Northern Ireland) may result in the need to increase the thickness of panels above that necessary to sustain the imposed loads. Alternatively, other materials with a higher thermal performance could be incorporated in the design in juxtaposition with the wood-based panel.

2.5.2 The design of flat roof decking

The various factors to be incorporated in design together with the two applicable alternative design concepts for flat-roof decking are set out in *Section 2.2*.

In the absence of 'deemed to satisfy' information, recourse must be made to either designing by prototype testing, or by calculation as detailed in *Section 2.2.1.4* and summarised in *Table 2.4*.

The typical panel sizes for roof decking are 2400 × 600mm or 2400 × 1200mm, with other sizes available to order. A panel width of 600mm makes handling easier and a length of 2400mm suits nominal joist centres of 600mm or 400mm.

Panels may be plain (square) edged, or profiled. Plain edged panels must be supported by joists or noggings at all edges. Profiled edges are usually matching tongue and groove and remove the need to provide support at all edges on plain panels. Panels may be profiled on all four edges or on long edges only.

2.5.3 Sitework

2.5.3.1 Conditioning

It is important that panels are installed at a moisture content as close as possible to that which they will achieve in service. Advice on the conditioning of panels is to be found in PanelGuide *Section 4.2.4*.

2.5.3.2 Preparation of structure

Supporting joists should be laid to line and level. Where firrings are used to create falls, these should be securely fixed to the joists. Falls of at least 1 in 40 are recommended.

Check the moisture content of the supporting timbers, as panels should not be laid on timber sections which have a moisture content above 22% prior to laying the deck, as moisture can migrate from wet joists or rafters into the panels and may cause localised swelling.

Joists and noggings should provide a minimum bearing for panel edges of 18mm.

2.5.3.3 Laying wood-based panels

Tongued and grooved (T&G) and square-edged panels should be laid across the joists with both short edges supported on a joist (see *Figure 2.8* and *Figure 2.9*). Square-edged panels should be continuously supported along all edges (see *Figure 2.9*). For maximum strength and stiffness, each panel should be laid continuously over at least two spans between joists.

Readers should note that additional materials (not shown in the figure) may be required to meet other requirements such as thermal or reaction to fire.

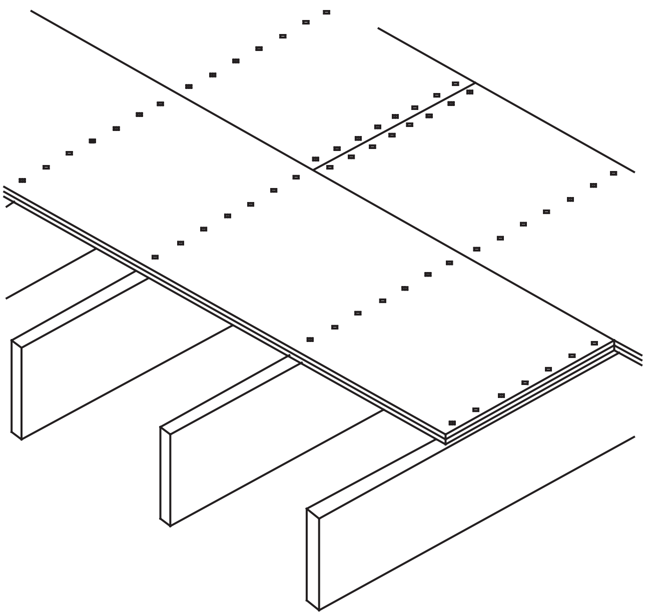


Figure 2.8: Tongued and grooved edge structural decking should be laid across the joists with short edges supported on joists

2.5.3.4 All panels

All perimeter and cut edges, on both T&G and square-edged panels, need to be supported on joists or noggings. Panels of both edge types should be laid to break joint, ie with staggered short edge joints to avoid lining them up.

2.5.3.5 Expansion gaps

A gap should be provided around the perimeter of flat roofs to upstands or abutting constructions to allow for possible expansion of the decking. This should be a minimum of 10mm at each edge or 2mm per metre run of panel. Larger roofs may also need intermediate expansion gaps. A 3mm gap should also be left between each square-edged panel.

For T&G panels or panels which by design are tightly butted, special attention must be given to fixing down to avoid buckling.

2.5.3.6 Fixing

Panels should be fixed using corrosion resistant nails. Corrosion resistant materials include galvanised or sheradised steel, austenitic stainless steel, phosphor bronze and silicon bronze.

Screws and flat headed improved nails (such as annular grooved or ringshank) have superior holding power and should be used in preference to plain shank nails.

Minimum nail length should be 50mm or 2.5 times the panel thickness, whichever is greater. The minimum fixing diameter should be 0.16 times the panel thickness.

Screws should be conventional countersunk woodscrews or, where fixing to steel structural frames, self-drilling self-tapping screws.

The frequency and pattern of nailing to joists and noggings should be in accordance with *Table 2.5* unless structural calculations require otherwise. To avoid tear out at panel edges, fixings should not be inserted closer

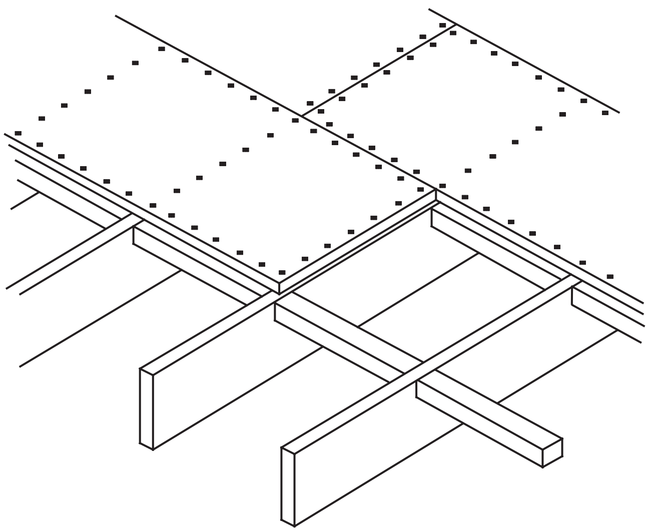


Figure 2.9: Square edge and structural decking laid across the joists and supported by noggings. Noggings are required to the long edges of square-edged panels

Table 2.5: Spacing of fixings for roof decking

Panel type	Maximum spacings (mm)		Min edge distance (mm)
	Perimeter framing	Intermediate framing	
Particleboard	100	100	8
Cement-bonded particleboard	see note	see note	see note
OSB	100	100	8
Plywood	100	100	8

Note: For cement-bonded particleboard, recommended nail spacings and edge distances vary with thickness and from manufacturer to manufacturer – examples of nail spacing range from 200 to 400mm on perimeter framing and from 300 to 610mm on intermediate framing. Nail edge distance varies from 15mm for panels less than 12mm and 20mm for thicker panels up to 25mm irrespective of thickness. Panels may need to be pre-drilled or fixed with self-drilling screws to avoid splitting. For fixing cement-bonded particleboard it is therefore essential to obtain and follow the manufacturer's recommendations.

to the edges than the minimum distances given, and as shown in *Figure 2.10*.

All nail heads should be punched home by 2–3mm. Screws should be countersunk.

Where manufacturer's instructions are supplied with the panels their recommendations should be followed.

2.5.3.7 Coverings

Flat roofs can be covered using traditional multi-layer finishes or proprietary single layer membranes. Built-up felt should be laid to *BS 8217 Reinforced bitumen membranes for roofing. Code of practice*[43], although it should be noted that this still refers to *BS 5268* for design and has not been updated to include references to *Eurocode 5* for design or *BS EN 13986* for wood-based panel material specifications.

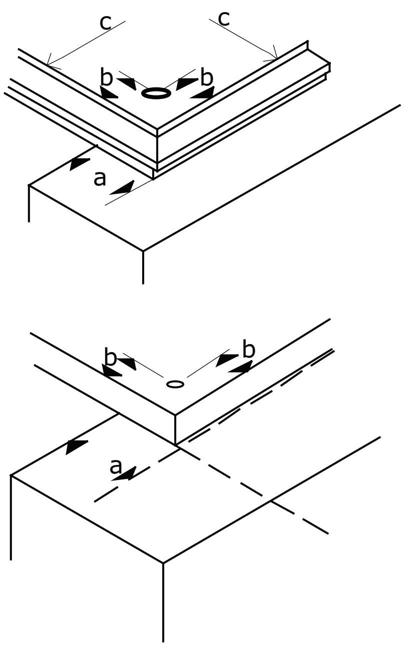


Figure 2.10: A minimum edge nailing distance of 8mm should be maintained and a minimum bearing of 18mm provided to each panel in both T&G panels (upper diagram) and square-edged panels (lower diagram)
a: bearing
b: edge nailing distance
c: face dimension of panel

2.6 Application in pitched roofing (sarking)

2.6.1 Selection of panels for pitched roof sarking

The selection and thickness of wood-based panels for use in pitched roofing as a sarking material depends primarily on whether or not the sarking is undertaking a bracing role (see *Section 2.6.2.1* and *Section 2.6.2.2*).

The term 'sarking' usually refers to panels laid across the top of structural trusses, but wood-based panels are also used in pitched roofing as part of panelised roof systems, such as a Structural Insulated Panel (SIP). These applications are most likely to be system-based and the selection and use of panels is done as part of the system, which is also usually subject to independent assessment or certification.

2.6.2 The design factors relating to sarking

2.6.2.1 Non-bracing sarking (non-structural)

Where panels are used as sarking but are not assumed to be contributing to bracing of the trusses, they can be viewed as non-structural. The choice of panel type is controlled largely by the environmental conditions they are likely to experience in service and the risk of occasional wetting from rain penetrating the outer roof covering. The panels used should therefore be one of the types shown in *Table 2.6*.

The thickness of panel used should take account of the perceived function in the design. Roofers should be warned against stepping on the sarking unless it has been specifically designed for that purpose.

Condensation risk should be assessed in accordance with *BS 5250 Code of practice for control of condensation in buildings*[44].

Possible functions of non-structural sarking are to:

- improve airtightness
- resist wind uplift loads (see *BS 5534 Code of practice for slating and tiling (including shingles)*[45])
- reduce thermal bridging (where insulation is placed between rafters)
- increase thermal resistance of insulated roof

Table 2.6: Panel grades* for sarking and the location of design and testing information

Selection	ROOFS	CONSTRUCTION	PLYWOOD BS EN 636	PARTICLEBOARD BS EN 312	OSB BS EN 300	MDF BS EN 622-5	FIBREBOARD BS EN 622-3,4	CBPB BS EN 634
	Pitched roofs (sarking)	non-bracing	636-2	P5	OSB/3	-	SBH, SB.E, SB.HLS, MBL.H, MBL.E, HB.E, HB.HLA1, HB.HLA2	CBPB
		bracing	636-2	P5	OSB/3	-	-	CBPB
Design by deemed to satisfy	✓	For non-bracing sarking, manufacturer's recommendations should be followed. For sarking that has a bracing role, deemed to satisfy performance requirements are given in BS 5268-3. Although this has now been withdrawn, there are as yet no equivalent recommendations under the Eurocode system. For pitches of less than 10° the roof may be assessed as a flat roof – see *Section 2.5*						
or Design by performance testing	✓	Design by performance testing of a number of components would be possible, but only where the load carrying requirements can be clearly defined						
	for pitch <10°		At low pitches the roof may be assessed as a flat roof. Test using BS EN 1195. Satisfy requirements in BS EN 12871. Design using BS EN 1995-1-1 (Eurocode 5)					
		or	Test using BS EN 1195. Design using BS 5268-2 (now withdrawn)					
or Design by calculation	-	Not available at present						
Guidance on application	✓	Guidance on the use of load-bearing panels as sarking is also given in BS 5534. Control of condensation risk should be carried out in accordance with BS 5250						

* The table provides the minimum grade of panel that satisfies the particular set of requirements: panels of higher quality may be substituted, and their selection may result in a reduction in required thickness.
Although all the panels meeting the grade specifications will satisfy a particular set of requirements, the level of performance of different brands of these panels may vary considerably; some may even be endowed with high levels of properties not directly covered by the table.

- support tiling membranes
- provide fixing for slates (no tiling battens) – but in this case the panel should be viewed as structural
- provide temporary weathertightness during construction until tiles/slates are fixed.

2.6.2.2 Sarking which has a structural role

The sarking may perform a structural function, such as:

- to provide lateral bracing to the rafters
- to resist wind uplift on the roof
- to provide access for roofers.

In this case, the thickness and rafter centres will be interdependent and related to the imposed design loads. The panels used should be one of the types shown in *Table 2.6* and design should be designed in accordance with *Eurocode 5* or *BS 5268*.

Sarking acting as bracing in the plane of the rafters should be specified and fixed in accordance with *BS 5268-3 Annex A*. When such sarking is directly fixed to the top face of the rafters, diagonal, chevron and longitudinal bracing in the plane of the rafters may be omitted. Care should be taken during erection to ensure that the stability, verticality and straightness of the rafters are maintained when the sarking is being installed. The minimum thickness of sarking for bracing purposes, as given in *BS 5268-3* and *PD 6693-1*, is shown in *Table 2.7*. These thicknesses assume that the tiles/slates are independently supported on battens.

Where the panels are subject to other known loads, such as access by roofers, these loads should be taken into account in the selection of a suitable panel thickness related to the rafter spacing.

Typical panel sizes are 2400 × 1200mm and 2400 × 600mm, with other sizes available to order. Panels may be plain (square) edged, or profiled. Profiled edges provide improved weathertightness and remove the need to provide support under the edges of plain panels. Profiled edges may be a form of half-lap joint, grooves to take loose tongues or matching tongue and groove. Panels may be profiled on all four edges or on long edges only.

2.6.2.3 Other design considerations for both bracing and non-bracing sarking

In order to avoid condensation on the underside of the sarking, appropriate ventilation should be provided.

Where sarking is used over a cold roof space with insulation on a horizontal ceiling, the roof space must be adequately ventilated from eaves to eaves, or with addi-

Table 2.7: Minimum thickness of panels used as sarking for bracing purposes as given in PD 6693-1

Panel type	Minimum thickness	Minimum fixings
Plywood	9mm	50mm × 3mm galvanised, round wire nails fixed at a maximum of 200mm centres on each rafter
OSB	9mm	
Particleboard	12mm	

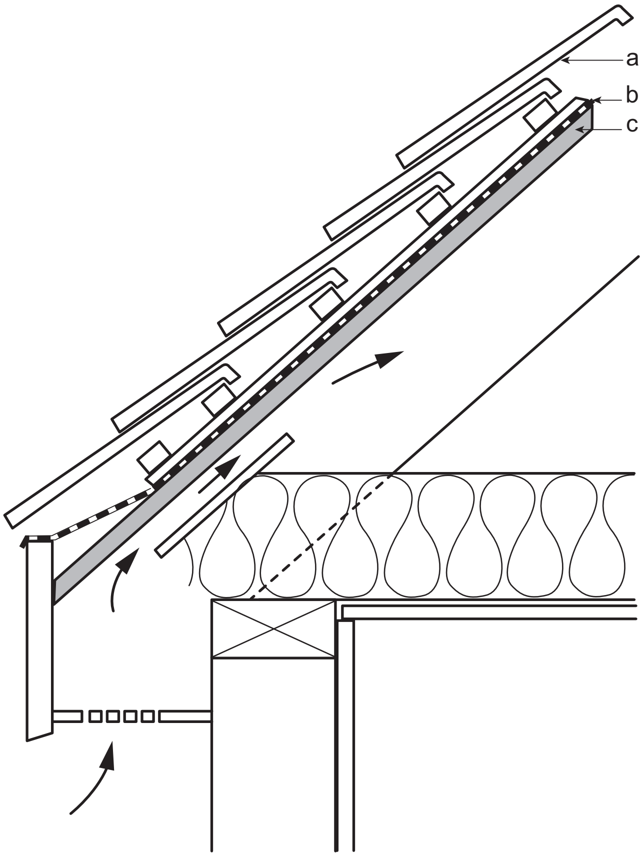


Figure 2.11: Example of a cold roof space with insulation at ceiling level. The roof space must be adequately ventilated
a: tiles on battens and counterbattens
b: tiling underlay
c: sarking

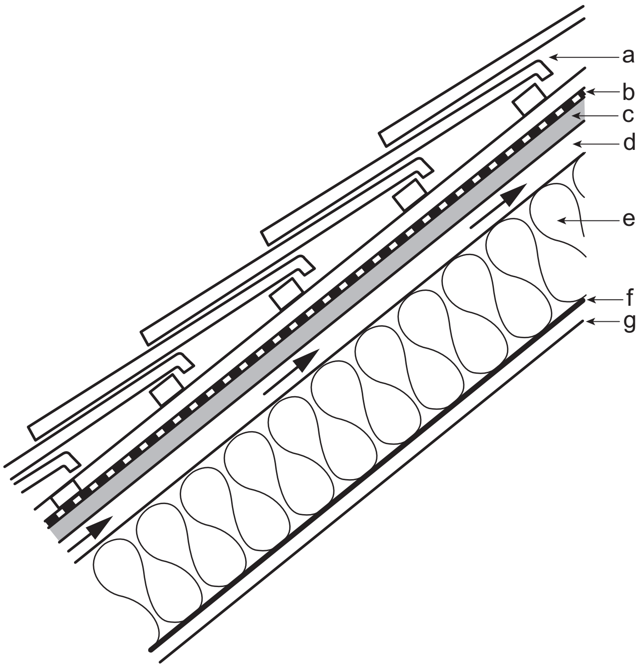


Figure 2.12: Example of a warm roof with sloping ceiling and insulation between rafters. There must be adequate ventilation above the insulation
a: tiles on battens and counterbattens
b: tiling underlay
c: sarking
d: ventilation space
e: insulation
f: vapour control layer
g: ceiling lining

tional ridge vents if desired (see *Figure 2.11*). A condensation risk analysis should be carried out in accordance with *BS 5250*.

It is possible to construct roofs in different ways with the advent of new building products which may allow or require the ventilation to be different to that in *Figure 2.11*. Further information is given in the TRADA publication *Timber frame construction*[46].

Where sarking is used over a warm roof, such as a 'room-in-the-roof', with sloping ceilings and insulation between the rafters, there must be adequate ventilation space to the underside of the sarking over the insulation, ventilated from eaves to ridge, and a vapour control layer positioned on the warm side of the insulation (see *Figure 2.12*).

Detailed recommendations for condensation control are given in *BS 5250*, for various designs of roof. *BS 5250* now refers to *BS EN ISO 13788 Hygrothermal performance of building components and building elements. Internal surface temperature to avoid critical surface humidity and interstitial condensation. Calculation method*[47] as the method of calculation.

2.6.3 Sitework: roof sarking

2.6.3.1 Conditioning

It is important that panels are installed at a moisture content close to that which they will achieve in service. Advice on the conditioning of panels is to be found in PanelGuide *Section 4.2.4*.

2.6.3.2 Preparation of the structure

Supporting rafters should be plumb, in line and level.

Check the moisture content of supporting timbers as panels should not be laid on timber sections which have a moisture content above 22% prior to laying the deck, as moisture can migrate from wet joists or rafters into the panels and may cause localised swelling.

Any rafters or noggings should provide a minimum support width of 18mm for the panel edge.

2.6.3.3 Laying and fixing

Panels should be laid with long edges across the rafters, with short edges supported on rafters. It is recommended that long edges should be either tongued and grooved, supported by proprietary panel clips or by battens/noggins. Where sarking acts as bracing, all edges must be supported and fully nailed.

Panels should be laid to break joint, ie with staggered short edge joints to avoid lining them up.

2.6.3.4 Expansion gaps

A 3mm gap should be left between square-edged panels used as sarking except for impregnated softboard which should be tightly butted.

Table 2.8: Spacings of fixings for sarking

Panel type	Maximum spacings (mm)		
	Panel end rafters	Intermediate rafters	Min edge distance (mm)
Softboard	75	150	8
Mediumboard	150	150	8
Hardboard	150	150	8
Particleboard	200	200	8
OSB	200	200	8
Plywood	200	200	8

Where sarking abuts vertical or parapet walling a perimeter gap should be provided to allow for possible expansion. This should be a minimum of 10mm and, where required, 2mm per metre run of panel between adjacent walling. Larger roofs may also need intermediate expansion gaps.

2.6.3.5 Fixings

Panels should be fixed using corrosion resistant nails or, for softboard, staples. Corrosion resistant materials include galvanised or sheradised steel, austenitic stainless steel, phosphor bronze and silicon bronze.

Screws and flat headed improved nails (such as annular grooved or ringshank) have superior holding power and should be used in preference to plain shank nails.

Minimum nail length is 50mm or 2.5 times the panel thickness, whichever is greater. The minimum fixing diameter should be 0.16 times the panel thickness.

Staples should have as wide a crown as possible (11mm minimum), be not less than 15 gauge and not less than 50mm in length.

The frequency and pattern of nailing to rafters should be as follows unless structural calculations require otherwise. Where manufacturer's instructions are supplied with the panels, their recommendations should be followed. To avoid tear out at panel edges, fixing should not be inserted closer to the edges than the minimum distances given in *Table 2.8*.

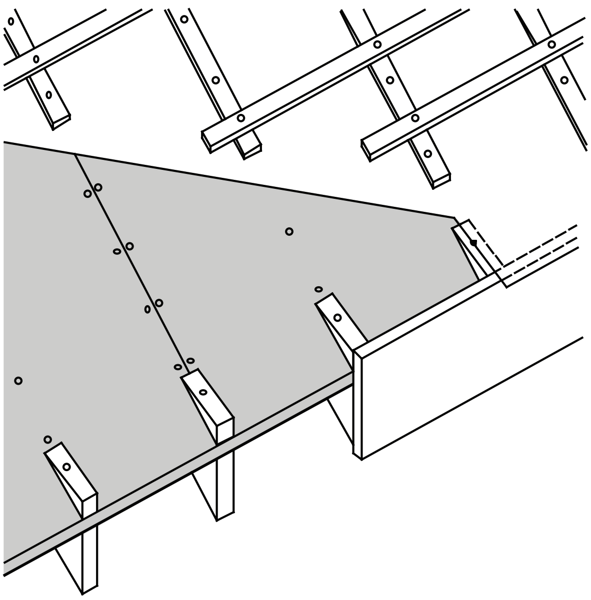


Figure 2.13: Typical pitched roof with sarking board and tiling underlay beneath the counter battens

To avoid buckling of the thinner and more flexible panels, nailing should commence at the top centre and continue outwards and downwards.

2.6.4 Coverings

Tiling or slating should be fixed to tiling battens on counter battens with a roofing underlay.

Battens should not be fixed to the sarking alone but should be fixed through the sarking into the rafters beneath.

The position of the underlay depends on its vapour resistance: if low (<5.7 MNs/g) it can be laid directly on the sarking, under the counter battens; if high (>5.7 MNs/g) it should be laid between the counter battens and tiling battens, forming a cavity to allow ventilation below the tiling underlay. Further guidance can be found in *BS 5250*.

2.7 Application of panels in structural wall sheathing

2.7.1 Selection of panels for sheathing

2.7.1.1 Performance considerations

The selection of panel type depends on an overall assessment of wall performance including:

- strength and stability
- whether the sheathing is to be positioned on the inside or the outside of the framing
- durability
- thermal performance
- interstitial condensation risk
- the possible effects of moisture in service
- other components in the wall such as vapour control layers, insulation type and thickness, breather membranes, cavity barriers.

Strength and stability

Sheathing is primarily used to provide racking resistance and stiffness to a framed structure. Plasterboard and other internal lining boards can also contribute to racking resistance.

Sheathing position

In timber framed structures, sheathing is usually applied to the outside of the framing, where it also acts to provide an early dry envelope to the building, and contain and protect any insulation during construction. Permanent weather protection is usually provided by a breather membrane, exterior cladding and a drained and ventilated cavity.

When sheathing is applied internally to the frame, the advantages of early enclosure may be lost but panel properties of strength, durability and abrasion resistance may be used to provide durable linings, for example in agricultural or industrial buildings, subject to the application of an appropriate flame spread treatment if required.

Durability

The durability of wood-based panels depends on:

- the species of timber used
- the adhesives used to bind the veneers, fibres or particles together
- the conditions of use, in particular with regard to wetting and risk of decay.

The heartwood of the species generally used in all wood-based panels typically has a durability rating of 'moderately durable' or 'slightly durable' and commonly includes a high proportion of sapwood, which, for all species, is rated as 'not durable'. The adhesives can have improved moisture resistance for use in humid or exterior applications, dependent on formulation, and can be modified to include other treatments such as fire retardants or insecticides.

Where panels are used as structural sheathing they are generally at risk of wetting during initial erection and over the remainder of the building process until the cladding is complete. In service the panels are likely to be exposed to high humidity on a regular basis but should not be subject to significant direct wetting. These conditions are unlikely to lead to the prolonged excessive moisture contents which can lead to the onset of decay.

Panels however may occasionally be at risk from wetting in service due to building defects. Good design and workmanship, together with the correct type and grade of panel, will reduce the likelihood and consequences of wetting in service.

There are no requirements for preservative treatment of any wood-based structural sheathing used in a conventional timber frame system. Where wood-based panels are used as external sheathing that is exposed to the weather, the specifier should take account of the degree of exposure and the type of cladding when deciding what type of preservative, if any, should be specified.

Thermal performance

Framed walls using fibreboards, OSB, plywood, CBPB or particleboard sheathing are ideally suited for the inclusion of insulation in the space between the studs.

The U-value (thermal transmittance) of a wall depends on its overall construction including sheathing material type, insulation thickness and cladding. Typical examples for timber framed walls (with all voids filled with mineral wool or cellulose fibre insulation, allowing 15% for the framing) and including claddings and linings, could be as follows:

- 90mm studs – 0.42 W/m^{2}k
- 140mm studs – 0.30 W/m^{2}k
- 195mm studs – 0.22 W/m^{2}k

If a well-fitting, rigid foam insulation, with a λ value not greater than 0.02 W/mk is used, these figures become:

- 90mm studs – 0.27 W/m^{2}k
- 140mm studs – 0.19 W/m^{2}k
- 195mm studs – 0.15 W/m^{2}k

Whatever insulation is used, care is required to cut the insulation accurately to fit each cavity or, if blown into a cavity, to ensure that it is uniformly and completely filled. Any gaps could result in cold bridges with potential for surface condensation and significant losses in thermal performance.

These low values make timber frame wall construction ideal for providing excellent thermal performance using proven technology; conventional construction can easily meet Building Regulation requirements.

The use of engineered timber sections instead of solid timber wall studs when used in conjunction with wood-based panels provides space for a greater thickness of wall insulation resulting in even lower U-values than the examples shown above. Examples of such products would be I-beams, metal web beams or proprietary composite systems.

Moisture in service and condensation risk

When wood-based panels are used as sheathing fixed to the outside of insulated, framed wall panels the internal lining must have higher vapour resistance to control interstitial condensation risk within the wall panel. This is typically obtained by incorporating a separate polyethylene sheet vapour control layer or plasterboard with an integral vapour control layer on the warm (room) side of the insulation. Any wall construction should meet the requirements of *BS 5250*, which now refers to *BS EN ISO 13788* as the method of calculation.

When used as sheathing fixed to the inside of insulated framed wall assemblies, panels with higher vapour resistance, for example OSB as opposed to softboard, may have sufficiently high vapour resistance to act as an adequate vapour check and remove the need for a separate vapour control layer. The outer layers of construction must have a sufficiently low vapour resistance compared to the inner layers to allow the wall to breathe. Condensation risk should be assessed by calculation in accordance with *BS 5250*, which now refers to *BS EN ISO 13788* as the method of calculation.

Breather membrane fixed over the external face of wall assemblies can be used to stop water ingress at panel or wall assembly joints, to protect the panels from wetting during construction, and to improve airtightness. Breather membrane should always be used with particleboard, OSB, plywood and mediumboard sheathing fixed to the outside of framing, but is not needed with impregnated fibreboards or CBPB, unless these materials are used on buildings in areas of severe exposure. The breather membrane should have low

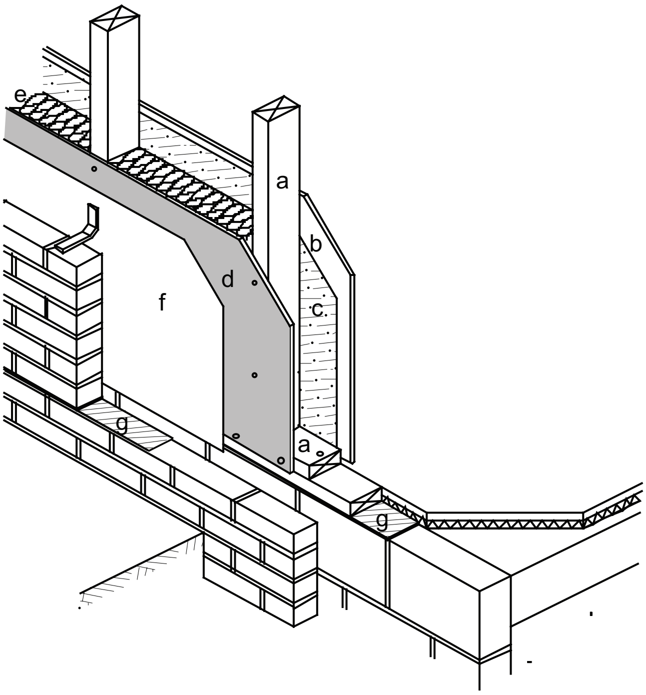


Figure 2.14: Typical timber frame external wall construction
a: stud framing
b: internal lining
c: vapour control layer
d: sheathing on outside face of wall frame
e: insulation
f: breather membrane (when required)
g: damp proof course

vapour resistance (<5.7 MNs/g), to reduce any possible interstitial condensation risk.

Where no breather membrane is used, it is recommended that joints between wall assemblies are taped to stop water ingress and to improve airtightness; panel to panel joints do not need to be taped. Protection against water ingress at floor level also needs to be provided.

Figure 2.14 shows an insulated timber framed wall with wood-based sheathing fixed to the outside of the framing, covered with a breather membrane and clad with brickwork fixed with flexible ties.

2.7.1.2 Panel selection

Given the performance requirements detailed in *Section 2.7.1.1*, the selection of wood-based panels must be made from the list given in *Table 2.9*.

2.7.2 Design of structural sheathing

The various factors to be incorporated in design together with the three alternative design concepts are set out in *Section 2.2*.

For a particular set of conditions, defined in terms of design, load and environmental conditions, long-term experience and test work has demonstrated compliance of certain designs with the relevant requirements. These designs, or values of racking resistance to be used in design, are deemed to satisfy and the now withdrawn *BS 5268-6-6.1 (Table 2)* gives the racking resistance for certain thicknesses of plywood, particleboard, OSB and CBPB.

In those situations where the ‘deemed to satisfy’ approach is inapplicable, recourse must be made to either designing by prototype testing, or by calculation as set out in *Table 2.9* and *Section 2.2.1.4*

Typical panel sizes are 2400 × 1200mm and 2400 × 600mm, with other sizes available to order. Sizes up to 3660mm high are available to allow fabrication of wall assemblies for increased storey heights, or which can accommodate floor joists. The usual panel width in

Table 2.9: Panel grades* for timber frame sheathing and the location of design and testing information

<table>
<tr><th rowspan="2">Selection</th><th>TIMBER FRAME</th><th>SERVICE CLASS</th><th>PLYWOOD BS EN 636</th><th>PARTICLEBOARD BS EN 312</th><th>OSB BS EN 300</th><th>MDF BS EN 622-5</th><th>FIBREBOARD BS EN 622-3,4</th><th>CBPB BS EN 634</th></tr>
<tr><td>Sheathing</td><td>2</td><td>636-2</td><td>P5</td><td>OSB/3</td><td>-</td><td>SB.HLS
MBH.HLS1
MBH.LS2
HB.HLA2</td><td>CBPB</td></tr>
<tr><td>Design by deemed to satisfy</td><td>✓</td><td colspan="7">‘Deemed to satisfy’ performance values for racking resistance are given in BS 5268-6-6.1 (Table 2) for Category 1 panels such as plywood, particleboard, OSB and CBPB. Although this Standard has been withdrawn by BSI, it is still in regular use at present</td></tr>
<tr><td rowspan="2">or

Design by performance testing</td><td>✓</td><td colspan="7">Test using BS EN 594 and BS EN 596. Satisfy requirements in BS EN 12871. Design using BS EN 1995-1-1 (Eurocode 5) in conjunction with PD 6693-1</td></tr>
<tr><td>or</td><td colspan="7">Test using BS EN 594 and BS EN 596. Satisfy the requirements in BS 5268-6- 6.1. Design using BS 5268-6-6.1</td></tr>
<tr><td rowspan="2">or

Design by calculation</td><td>✓</td><td colspan="7">Test using BS EN 594 and BS EN 596. Satisfy requirements in BS EN 12871. Design using BS EN 1995-1-1 (Eurocode 5) in conjunction with PD 6693-1</td></tr>
<tr><td>or</td><td colspan="7">Test using BS EN 594 and BS EN 596. Satisfy the requirements in BS 5268-6-6.1. Design using BS 5268-6-6.1</td></tr>
<tr><td>Guidance on application</td><td>✓</td><td colspan="7">Guidance on the use of load-bearing panels in sheathing is given in DD CEN/TS 12872 and in BS 5268-6-6.1</td></tr>
</table>

* The table provides the minimum grade of panel that satisfies the particular set of requirements: panels of higher quality may be substituted, and their selection may result in a reduction in required thickness.
Although all the panels meeting the grade specifications will satisfy a particular set of requirements, the level of performance of different brands of these panels may vary considerably; some may even be endowed with high levels of properties not directly covered by the table.

this case is 1200mm to suit typical framing centres of 400mm and 600mm.

2.7.3 Sitework

2.7.3.1 Conditioning

It is important that in the construction of wall units, either on site or in the factory, individual panels are fixed at a moisture content close to that which they will achieve in service. Advice on the conditioning of panels is to be found in PanelGuide *Section 4.2.4*.

2.7.3.2 Wall assembly

Wood-based panels can be used as sheathing in wall assemblies made either on site or off site, or in 'stick-built' construction assembled on site.

2.7.3.3 Planning and cutting

Stud spacing shall be related to the sheathing and lining board widths, for ease of fixing and to avoid cutting panels unnecessarily, and are commonly at 400mm or 600mm centres. Openings can be formed by cutting panels to fit around the framed openings or by cutting the required opening in a panel already fixed to the opening framing. Such openings must be framed and need to be accounted for in the design calculations.

2.7.3.4 Assembly

Sheathing, except softboard fixed to the outside of framing, should have gaps of 3mm between adjacent panels to accommodate possible expansion due to moisture content increase. Softboard should be tightly butted. Sheathing fixed to the inside of framing should be tightly butted except in the case of OSB.

All panels should have all edges supported by and fixed to a framing member with minimum bearing of 18mm for the panel edge. At their edges, panels should normally be flush with framing member edges, to ensure adequate anchorage and give protection to the framing from the weather. It is good practice to tape or gasket panel joints where there is no breather membrane.

2.7.3.5 Fixing

Panels should be fixed using corrosion resistant nails, staples or screws. Corrosion resistant materials include galvanised or sheradised steel, austenitic stainless steel, phosphor bronze and silicon bronze. NHBC and Foundation 15 have particular requirements for the material specification for nails and staples.

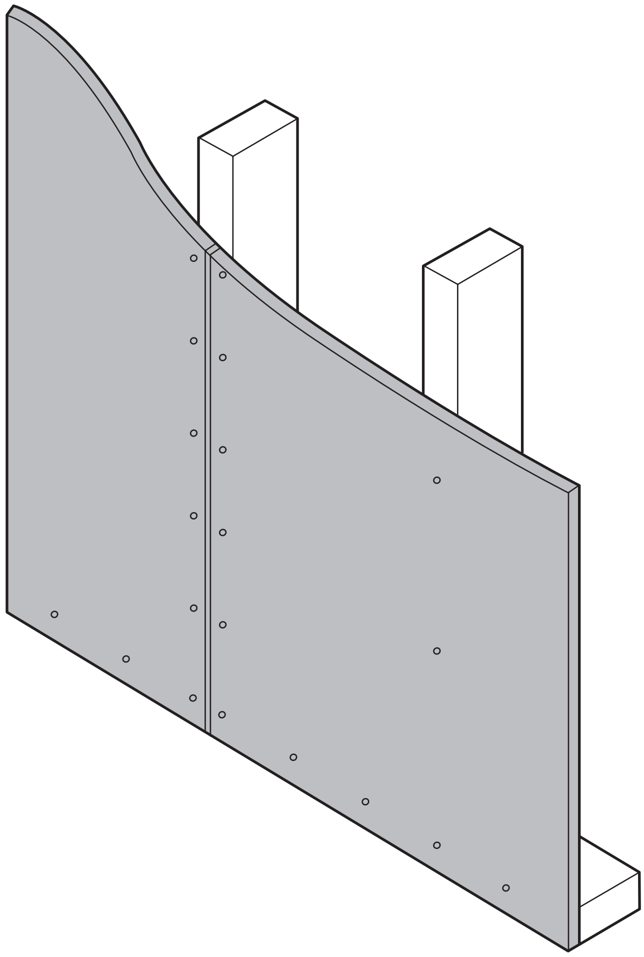


Figure 2.15: Typical sheathing fixings
Minimum edge distance 8mm. Centres of intermediate fixings are generally twice the perimeter fixing centres (see *Table 2.10*)

Minimum nail length should be 50mm or 2.5 times the panel thickness, whichever is greater. The minimum fixing diameter should be 0.16 times the panel thickness.

Staples should have as wide a crown as possible (11mm minimum), be not less than 15 gauge and not less than 50mm in length.

The frequency and pattern of nailing around the periphery and on intermediate studs is given in *Table 2.10* and shown in *Figure 2.15*, and this should be followed unless structural calculations or testing can provide an alternative nailing schedule. Where manufacturer's instructions

Table 2.10: Spacings of fixings in sheathing

Panel type	Maximum spacings (mm)		
	Perimeter framing	Intermediate framing	Min edge distance (mm)
Softboard	75	150	8
Mediumboard	150	300	8
Hardboard	150	300	9
Particleboard	150	300	8
Cement-bonded particleboard*	150	300	8
OSB	150	300	8
Plywood	150	300	8

* Panels may need to be pre-drilled or fixed with self-drilling screws to avoid splitting

are supplied with the panels, their recommendations should be followed. To avoid tear out at panel edges, fixings should not be inserted closer to the edges than the minimum distances given in *Table 2.10*, unless this is supported by test data.

With the thinner and more flexible panels, to avoid buckling, nailing should commence at the top centre and continue outwards and downwards.

2.7.3.6 Handling and storage of fabricated wall assemblies

Where panels are used to form structural wall assemblies, which are then transported to site from the point of fabrication, it is recommended that the following precautions are taken during storage and erection of the wall assemblies, so that they reach site and are installed in the best possible condition.

Transport

- Protect with waterproof coverings during transport.
- Ensure finished panels are fully supported.
- Provide edge protection to avoid banding or strapping damaging panel edges.

Storage

- Store wall assemblies on raised bearers to prevent contact with the ground or with vegetation, and sufficiently clear of the ground to avoid any potential splashing from water on the ground.
- Ensure wall assemblies are fully supported to prevent distortion, sagging or twisting.
- Wall assemblies may be stored horizontally or vertically. If stored horizontally, place them with the sheathing face uppermost to avoid collection of water within the panels.
- Protect wall assemblies from rain saturation.
- Where panels are delivered to site with insulation and internal linings fitted, ensure that the panels are protected from rain at all stages of transport, storage and construction.

Handling

- Take care during lifting to avoid distortion/twisting of panels, straining of fixings and joints, and damage to edges.
- When panels are lifted by crane, use guide ropes to stop excessive sway and to assist in locating panels.
- Ensure panels are not used as 'ladders' to provide temporary access to upper storeys.

2.7.3.7 Erection of wall assemblies

Wall assembly framing should only be notched, cut or drilled if carried out in accordance with the recommendations of the timber frame manufacturer. These recommendations should normally be based on *Eurocode 5* or *BS 5268-2*. Small holes or openings through the sheathing should be framed to support all edges.

Panel to panel nailing and on-site nailing of sheathing to framing should follow nailing schedules.

If wall assemblies are damaged during storage, handling or erection, it is recommended that damaged panels are not patched over but are either partly replaced using appropriate framing to support cut panel edges or completely replaced. In the case of serious damage, consult a qualified structural engineer.

Framed wall assemblies with fibreboard, particleboard, CBPB, OSB or plywood sheathing can be clad with a range of materials including brickwork, render on stainless steel mesh, rendered blockwork, tiles or slates, profiled metal sheet, timber boarding, exterior fibreboard and particleboard cladding, or proprietary wood panel products.

All claddings should incorporate a ventilated and drained cavity between the cladding and the outside of the wall assemblies (see *Figure 2.14*).

Battens for tile-hanging or other claddings should be fixed through the sheathing to the framing, not to the sheathing alone. Where horizontal battens are fixed for tiles or slates, they should be fixed to vertical battens nailed through to the studs. The vertical battens should form a drained and ventilated cavity.

Wall ties for brick or block cladding should be strip ties of austenitic stainless steel, phosphor bronze, or silicon bronze, and should be flexible to allow for differential movement between the structure and the cladding. The ties should be fixed through external sheathing to the stud framing.

CBPB, tempered hardboard, exterior structural plywood and OSB may also be used to act as combined sheathing and cladding in appropriate situations. Careful consideration should be given to joint details and any paint or finishing systems. Where panels are used as combined sheathing/cladding on insulated wall panels, the condensation risk of any paint or finishing system needs to be carefully assessed.

2.8 Application of panels in the production of box beams and I-beams

2.8.1 Selection of panels for box beams and I-beams

Timber I-joists comprise a timber flange (typically solid timber or LVL – laminated veneer lumber) and a panel product web (usually OSB – oriented strand board). Box beams are a similar form but with a web on each side of the flanges. Some of the typical forms of timber box beams and I-beams that have been fabricated using wood-based panels are shown in *Figure 2.16*.

Structurally the I-joist works on the principle that the greatest forces in a beam under bending are at the outer faces. Hence, if the stronger tensile and compressive material is positioned at the outside edges, the central

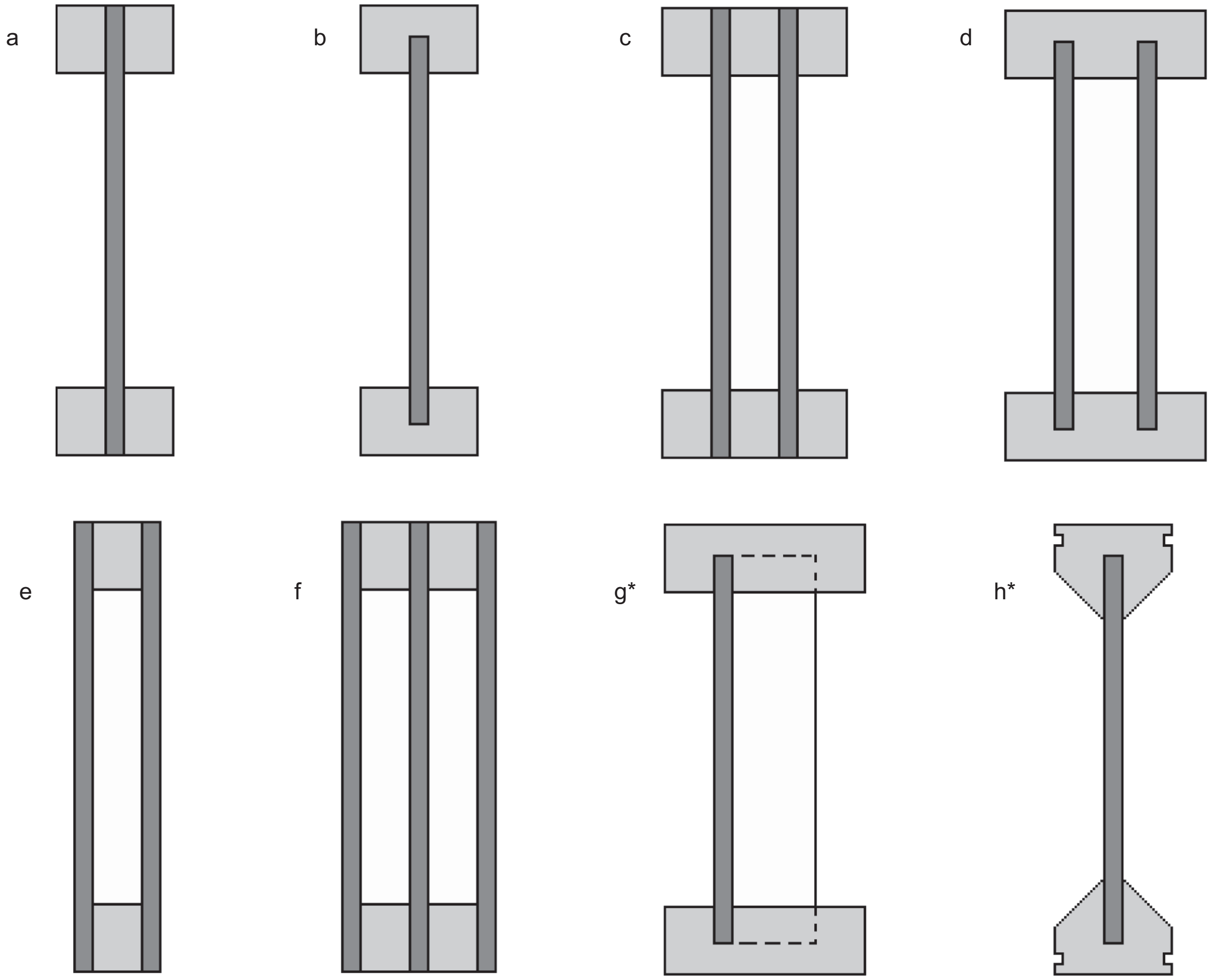


Figure 2.16: Typical forms of timber box beams and I-beams (*patented designs)
a: I-beam – 2 part flange e: box beam
b: I-beam – 1 part flange f: double box beam
c: double I-beam – 3 part flange g: Corply beam* (web zigzags across the flange)
d: double I-beam – 1 part flange h: Tecton beam*

zone can be reduced in size as it carries very little of the bending forces. However, the central zone (web) carries the reaction and shear forces.

Most commercially manufactured timber I-joists are of the form 'b' in *Figure 2.16* and use high-grade timber or structural timber composites for the flanges, routed to accept a timber-based panel web (OSB, hardboard or plywood). The web is secured to the flange by an approved weatherproof, structural adhesive within the rout. Some of the other forms of beam can be made with adhesive or mechanical fasteners. Commercially available products are available in a range of sizes; alternatively 'one-off' products can be designed and manufactured for a specific situation. Further information on timber I-joists can be found in TRADA's *Wood Information Sheet 1-42: Timber I-joists: applications and design*[48].

The selection of suitable wood-based panels for box beams and I-beams depends upon a number of factors including:

- the load the beam has to carry
- the ambient environmental conditions.

The selection of panels meeting these requirements is set out in *Table 2.11*. Some typical details for the use of I-joists for both timber frame and masonry construction in single dwellings are shown in *Figure 2.17* and

Table 2.11: Panel grades* for box beams and I-beams

Selection	BEAM WEB	SERVICE CLASS	PLYWOOD BS EN 636	PARTICLEBOARD BS EN 312	OSB BS EN 300	MDF BS EN 622-5	FIBREBOARD BS EN 622-3,4	CBPB BS EN 634
	Box beams and I-beams	1,2	636-2	P5	OSB/3	-	HB.HLA2	-

*The table provides the minimum grade of panel that satisfies the particular set of requirements: panels of higher quality may be substituted, and their selection may result in a reduction in required thickness.
Although all the panels meeting the grade specifications will satisfy a particular set of requirements, the level of performance of different brands of these panels may vary considerably; some may even be endowed with high levels of properties not directly covered by the table.

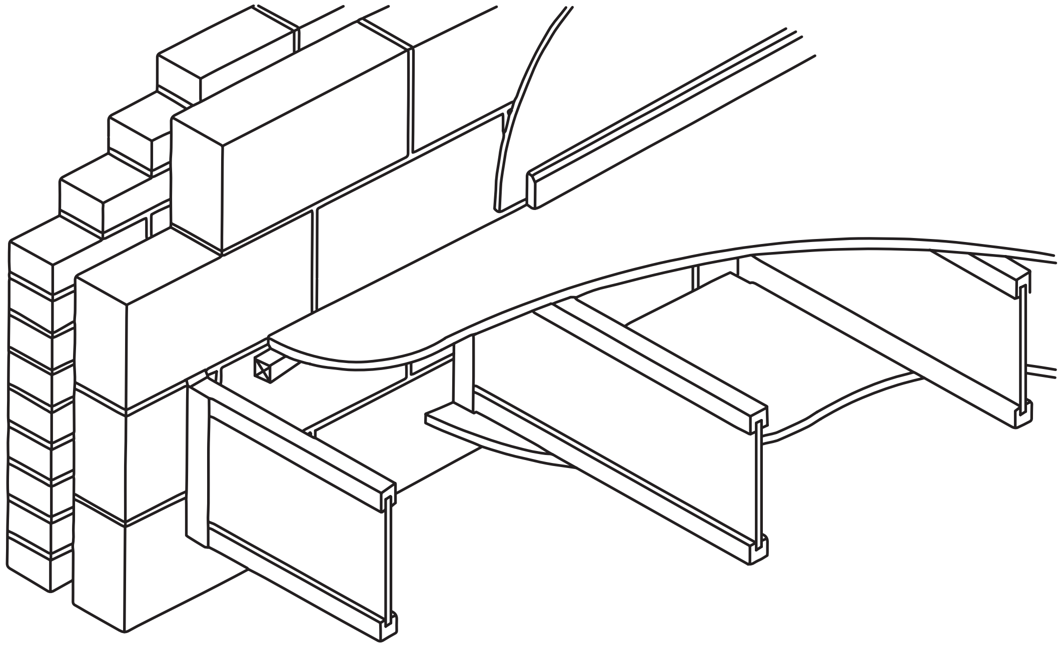


Figure 2.17: I-joists in block wall construction

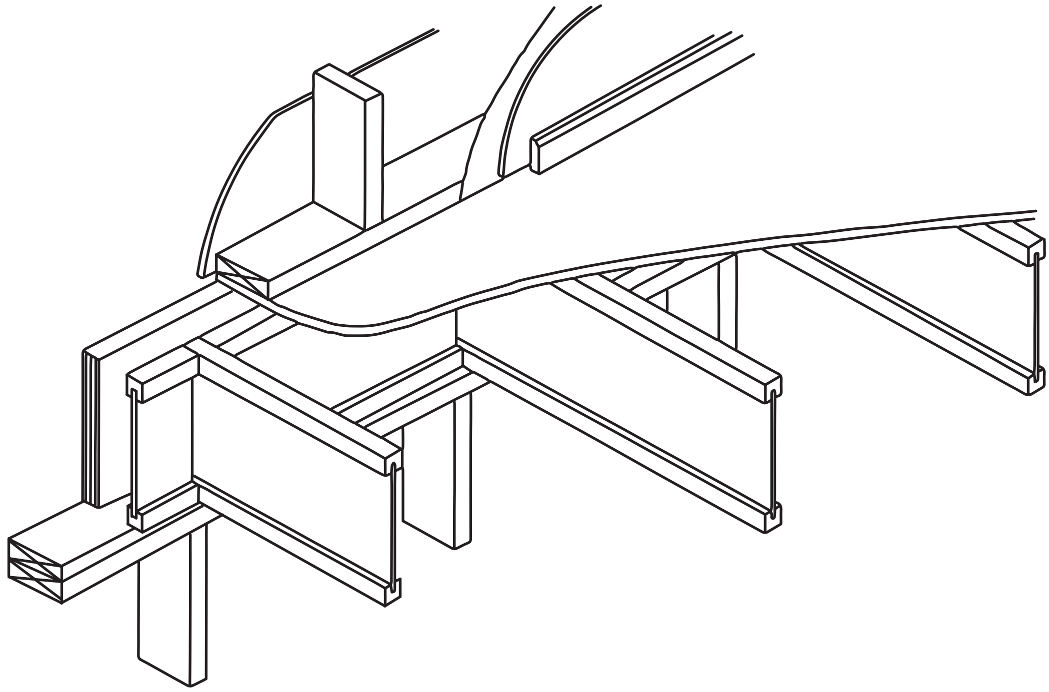


Figure 2.18: I-joists in timber frame construction

Figure 2.18. Note that the drawings are for illustration only and do not show all the constructional details which may be required for a particular floor, such as stiffeners, strutting etc.

2.8.2 The design of box beams and I-beams

There are some aspects of designing with I-joists which require different treatment from solid rectangular timber due to their geometry and the fact that they are a composite assembly of different materials. These affect the actual behaviour of the I-joist in terms of strength and stiffness and the detailing plus handling and storage.

As there is no harmonised European standard for I-joists, the current route to CE marking is by complying with *ETAG 011*[49]. Other certification may be obtained from independent certification bodies. Each I-joist brand therefore has specific strength characteristics, which should be made available by the manufacturer. This contrasts with solid timber which is strength-graded to common grade values presented in British Standards and Eurocodes. Most I-joist manufacturers have comprehensive design and drawing software to produce specifications and cutting schedules.

2.8.2.1 Strength capacity

In common with solid timber, the design strength properties of I-joists may be enhanced where load sharing (as defined in *Eurocode 5*) occurs. However, the enhancement factor established by the third-party certification may differ from that for solid timber. Manufacturers may publish the load sharing factor separately, or may integrate it into their span tables or design software. Strength values determined by a combination of calculation and testing are frequently provided in separate tables for Service Classes 1 and 2. Most timber attains a maximum moisture content of 12% in Service Class 1 and 20% in Service Class 2. I-joists can thus be targeted for both intermediate and ground floors respectively.

2.8.2.2 Control of deflection

The deflection of an I-joist is a combination of strain due to both bending and shear. Unlike solid rectangular sections, shear deflections in I-joists can be over 10% of the total deflection and must be allowed for. For an I-joist under a uniformly distributed load, the maximum mid-span deflection occurs under single span conditions and is given by:

$$W_{inst} = \frac{5F\ell^4}{384EI} + \frac{F\ell^2}{8GA}$$

where W_{inst} is the maximum instantaneous deflection, F is the load per unit length on the beam, ℓ is the span, EI is the bending stiffness and GA is the shear stiffness. Both EI and GA are generally provided by the manufacturer in the certification literature.

In *Eurocode 5* 'instantaneous' deflection is the elastic deflection immediately upon loading. On the other hand 'final' deflection includes creep deflections as well. The instantaneous deflection is usually modified to reach the final deflection for design. The modification factor depends on the load duration and the creep properties of the web material. The value of the modification factor may be quoted within the certification literature, or it may be taken from the design code. It is important to ensure that *Eurocode 5* and *BS 5268* (now withdrawn) design approaches are not mixed.

Under *Eurocode 5*, deflection limits are to be agreed for each project and the Standard provides guidance only. In the UK, the *National Annex to Eurocode 5* specifies a span/250 as an acceptable deflection limit for simply supported floors with a plasterboard ceiling attached. Further guidance on vibration control is also available in *Eurocode 5* and the National Annex.

See TRADA Technology's Engineering Guidance Documents:

- *GD 5: How to calculate deformations in timber structures using Eurocodes*[50]
- *GD 6: Vibration in timber floors (Eurocode 5)*[51].

2.8.2.3 Stability

The efficient shape of I-joists produces a relatively high depth-to-breadth ratio. Therefore, bracing to prevent buckling of the compression flange or rotation of the joist is more important than with solid timber joists.

For example, in England and Wales the requirements for blocking or strutting solid timber I-joists, given in Approved Document A, apply to I-joisted floors, unless the manufacturer of a tested floor system specifically states otherwise. Solid timber blocking and herringbone strutting have also been found to reduce vibrations with frequencies greater than the fundamental frequency. TRADA's *WIS 1-41: Strutting in timber floors*[52] offers further advice.

2.8.3 Storage and installation of box beams and I-beams

For commercial systems, it is important that the manufacturer's guidance on storage and installation is followed but some general advice can also be given.

As with all wood-based products, box beams and I-beams are affected by changes in moisture content and are generally only suited for use in Service Class 1 or 2 conditions. They should be stored in dry conditions, clear of the ground and protected from direct wetting. Beams should generally be handled and stacked in the vertical position, rather than flat.

Beams can be cut with normal woodworking tools and can be fixed in position with nails or screws. Alternatively, specific joist hangers are also available for some commercial products.

If holes need to be cut in the web, for services etc, it is important that these are accounted for in the engineering design or are within limits set by the manufacturer.

2.9 Application of panels in the production of formwork

2.9.1 Selection of panels for formwork

The selection of wood-based panels for formwork depends on a number of factors of which the most important are:

- very high levels of stiffness and strength in bending
- durability
- smoothness of surface.

Wood-based panel products are used in all types of formwork from in-situ concrete construction to modular system formwork for hire or sale and in precast manufacturing units. An indication of the types of panels used in various formwork applications is given in *Table 2.12*.

The choice of lining material is based on a balance between the performance required and cost. The main technical factors affecting choice are considered below.

Figure 2.19: Wood-based panels used in formwork
Photo: UPM-Kymmene Wood Oy

2.9.1.1 Structural performance

The formwork lining is normally required to take the direct load of the concrete during placing and setting and to make a contribution to the structural strength of the form during handling, erection, striking and storage. These loads give rise to both dynamic and static forces, but they are not normally of long-term duration in the accepted structural sense. Moisture contents in excess of 20% can be expected and design procedures must take account of load and moisture content considerations. Wood-based panels are usually required to distribute the superimposed concrete loads to secondary timber or steel framing members at centres characteristically in the range 300–600mm. The formwork may on occasion be designed as a stressed-skin panel where the lining also makes a structural contribution to the 'long-span' strength. Deflection at the form face is likely to be the determining criterion in design.

For more information on the use of wood-based panels in formwork, the Concrete Society publication *Formwork – a guide to good practice*[53] Appendix D is devoted to wood-based panel structural properties.

2.9.1.2 Environmental factors

Normal weathering and proximity to wet concrete gives rise to timber moisture contents normally greater than 20% and up to or above fibre saturation point.

Green, or wet stresses should be used in design calculations. *Eurocode 5* or *BS 5268-2* give modification factors for plywood so that wet stresses can be derived.

Surface or edge sealing of panels will reduce the rate of moisture build up (and probably render this pick-up more uniform throughout the panel – thus reducing distortion) but will not normally prevent a panel reaching fibre saturation during its life as a formwork lining. The onus is therefore on the designer to establish that this will not be the case if he wishes to use design values appropriate to a drier condition.

2.9.1.3 Surface appearance of the concrete

The achievement of a good appearance to concrete in terms of smoothness of surface and uniformity of colour is influenced by the choice of lining material, release agents and by other factors.

2.9.1.4 Re-use potential

Placing and compaction of concrete causes abrasion and possible physical damage to formwork linings. The number of re-uses attained with a particular lining material will be dependent on its resistance to such wear. The majority of in-situ applications require only a limited number of re-uses (usually less than 15) and there are some applications, for example, below ground work, where deterioration of appearance with successive pours would be acceptable. Contract hire modular system formwork, while not often selected where surface finish is the most important criterion, requires a high re-use potential with its functional efficiency unimpaired.

Precast work often requires a consistent high-quality finish over prolonged re-use which justifies the use of higher-quality lining materials.

Table 2.12: Panel grades* for formwork

Selection	FORMWORK	PLYWOOD BS EN 636	PARTICLEBOARD BS EN 312	OSB BS EN 300	MDF BS EN 622-5	FIBREBOARD BS EN 622-2	CBPB BS EN 634
	Low re-use; appearance not important	636-3	P5 +/- coating	OSB/3	-	HB.E	-
	Good surface; up to 15 re-uses	636-3	P5 coated	-	-	-	-
	Good surface; over 15 re-uses	636-3 coated	-	-	-	-	-
	Hire formwork	636-3 +/- coating	-	-	-	-	-
	Precast formwork	636-3 coated	-	-	-	-	-

* Broad guide only; each of the above panel types may be used in specialist, purpose-designed formwork.
The table provides the minimum grade of panel that satisfies the particular set of requirements: panels of higher quality may be substituted, and their selection may result in a reduction in required thickness.
Although all the panels meeting the grade specifications will satisfy a particular set of requirements, the level of performance of different brands of these panels may vary considerably; some may even be endowed with high levels of properties not directly covered by the table.

2.9.2 Sitework

The application of a specified quantity of release agent to the surface of all types of formwork between uses (and after cleaning) facilitates stripping of the form and reduces damage to the concrete surface. Many traditional release agents are oil-based, either in neat form or emulsified with water. These generally contain additives to improve ease of striking and to improve the cast finish. Chemical release agents have also been found to be successful and a wide range of proprietary brands are available. The manufacturer's recommendations should be followed.

2.9.2.1 Assembly of formwork

All wood-based panels accept a wide range of fixings to timber and other sub-frames. The most popular are screws, nails or staples – hand or power driven. When fixing through the face of panels it is good practice to make good the surface over the fixing with a water-resistant filler. Alternatively, back fixing of panels is recommended, particularly where expensive, overlaid panels are concerned and where high quality, multiple re-uses are required. If panels are to be stripped for re-use, fixing with lost-head nails or panel pins facilitates removal with a minimum of panel damage.

2.9.2.2 Edge treatment

All panel edges should be sealed to inhibit moisture uptake and many overlaid panels are supplied with edges ready-sealed. This treatment will not normally prevent ultimate uptake of moisture to fibre saturation, but will delay considerably the rate at which it occurs, thus keeping distortion of the form to a minimum. For the same reason, it is wise to cut panels with sharp tools and to seal any subsequently cut edges, drilled holes etc. There is a variety of effective edge sealers appropriate to site application, for example aluminium primer, neoprene, polyurethane and epoxy paints and cold-set phenol resin. Additional edge protection to panels should be provided if handling problems are likely to occur or where particularly long formwork life is sought.

2.9.2.3 Repair

Edge damage to panels is difficult to repair, so adequate provision should be made at the design stage to minimise it. Particleboard is generally more prone to edge damage than plywood.

Repair of face damage is time-consuming and, although not technically difficult, is often a problem on site. Local areas of damage can be made good, after cleaning and drying the area, by the use of inert fillers such as polyester putty, proprietary wood plugs or metal discs.

Although perfectly practical to make extensive repairs, it is only in the case of more expensive and elaborate forms that such repairs are usually carried out. The repaired area will sometimes give rise to concrete of a different surface finish and colour, particularly if it has a different degree of moisture absorption from the main panel.

2.9.2.4 Storage and handling

Before use, panels should be stored flat and level and under shelter. Between uses, weather protection may be less practical, but after cleaning, the forms should again be stored flat and level and not be subjected to distorting forces. Direct exposure of the casting face of the lining to sunlight should be avoided. Proper mechanical equipment should be used in all handling operations and suitable pick-up attachments should be provided on the forms as part of the standard design procedure.

2.10 Application of panels in cladding, fascias and soffits

2.10.1 Selection of panels for claddings, fascias and soffits

The selection of wood-based panels for claddings, fascias and soffits depends on a number of factors of which the most important are:

- adequate strength, stiffness and impact resistance
- high durability in external environments
- good dimensional stability in the presence of high humidity or liquid water.

The selection of panels from the appropriate European Standards meeting these demanding requirements is presented in *Table 2.13*. It is also important to note that an increasing number of modified wood-based panels are being manufactured specifically to achieve high durability for use in external applications. Such innovative products may initially be covered by recognised third-party certification schemes or European Technical Approvals rather than European Standards. Examples of

Table 2.13: Panel grades* for claddings, fascias and soffits

Selection		EXPOSURE	PLYWOOD BS EN 636	PARTICLEBOARD BS EN 312	OSB BS EN 300	MDF BS EN 622-5	FIBREBOARD BS EN 622-3,4	CBPB BS EN 634
	Claddings and fascias	Full (SC3)	636-3	-	-	-	HB.E	CBPB
	Soffits	Protected (SC2)	636-2	-	OSB/3	MDF.HLS+	HB.Eº MBL.Eº MBH.Eº	CBPB

+ Some manufacturers offer 'exterior' panels, the long-term durability of which is dependent on the presence of a durable coating. In the European specification these panels can only be classed as satisfying a Service Class 2 exposure, which is deemed to be equivalent to protected exterior situation.º These panels are NOT load-bearing.* The table provides the minimum grade of panel that satisfies the particular set of requirements: panels of higher quality may be substituted, and their selection may result in a reduction in required thickness. Although all the panels meeting the grade specifications will satisfy a particular set of requirements, the level of performance of different brands of these panels may vary considerably; some may even be endowed with high levels of properties not directly covered by the table.

Figure 2.20: Wood-based panels used in cladding, fascias and soffits

such products would be thermally modified solid wood claddings and acetylated MDF panels. Some applications are illustrated in *Figure 2.20*.

2.10.2 Design of cladding

2.10.2.1 Sizes and profiles

Typical panel sizes are 2440 × 1220mm, 2400 × 1200mm, 2400 × 600mm and 1200 × 600mm, with other sizes available to order.

Panels may be plain (square) edged, or profiled, usually with matching tongue and groove. Proprietary panels are available pre-finished with grooved profiles to simulate timber boarding.

2.10.2.2 Thickness and support spacing for cladding

Recommended panel types, thicknesses and maximum support spacing (mm) are shown in *Table 2.14*.

Table 2.14: Support spacing

Panel types	Maximum support spacing (mm) for panel thickness (mm)				
	6mm	9mm	12mm	18mm	>20mm
Mediumboard and MDF	400	400	600	600	-
Hardboard	600	600	-	-	-
CBPB	-	-	400	400	600
OSB	-	400	400	600	600
Plywood	-	400	400	600	600

Thicker panels are more rigid and should be used where increased stiffness and impact resistance are required. They are also generally more dimensionally stable.

2.10.2.3 Framing options

There are two main options – fixed to hidden framing or battens, or fitted into exposed framing. Where possible, a drained vented cavity should be provided behind the cladding; however, where cladding also acts as sheathing this is impracticable and care needs to be taken with precautions to prevent water ingress.

Framing and fixing details should accommodate movement where this can occur in the supporting structure.

Hidden framing

The cladding should be fixed to vertical battens or framing at the maximum centres given in *Table 2.14*, with a minimum bearing on framing of 18mm (*Figure 2.21*). All panel edges should be supported.

Panels should be fixed with a 3mm minimum gap between adjacent panels to allow for moisture expansion.

Vertical joints can be left open or covered with weathered cover battens or trim (*Figure 2.22*). Horizontal joints should be gapped to avoid water retention and have a

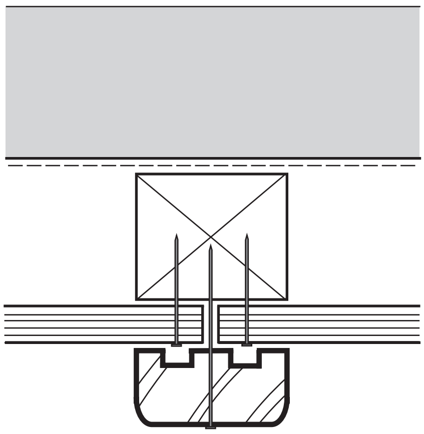


Figure 2.21: Board cladding with vertical battened joints

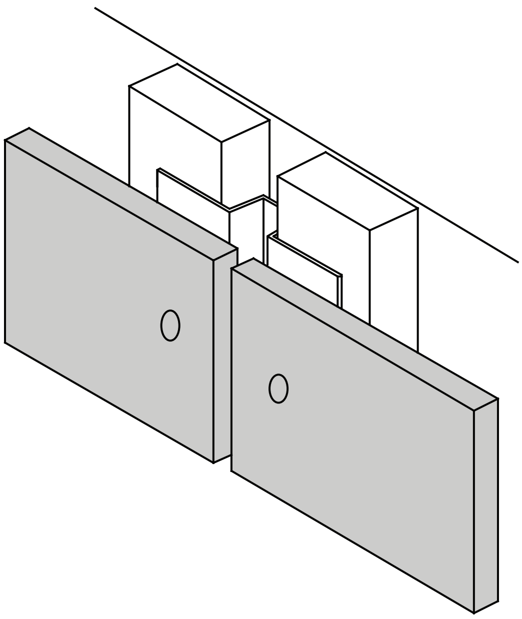


Figure 2.22: Open vertical joint with preformed metal 'top hat' flashing

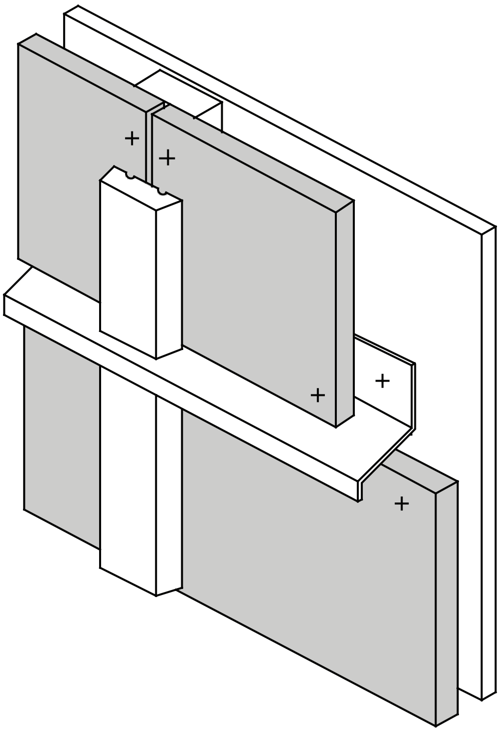


Figure 2.23: Vertical joint with timber cover battens and horizontal joint with preformed metal flashing

flashing dressed over the head of the lower panel; gaps should be wide enough to allow access for application of finishes and redecoration while the flashing should have a cross fall of about 10°. Joints may also be sealed with an appropriate flexible sealant in accordance with the sealant manufacturer's recommendations. Schematic examples of joint details are shown in *Figure 2.21* and *Figure 2.22*.

Exposed framing with rebates/beads

The cladding should be fixed into framing with supports at the maximum centres given in *Table 2.14*. The panels should be fixed into rebates with a minimum height of 15mm.

Where panels are inset into framing, a 3mm minimum gap should be left at the panel perimeters to allow for moisture expansion.

Panels should be fixed to allow for dimensional change due to change in moisture content and retained with metal or timber beading, adequately fixed. The top and sides should be fixed using conventional beads, bedded in mastic or sealant. The bottom edge bead should be omitted to avoid water retention, and the bottom panel edge should be fixed, with a gap to avoid moisture pick-up at the edge. Panel heads should be protected by weathered projecting framing. *Figure 2.24* shows a typical fixing arrangement.

Panels should be bedded on mastic strips on all edges and be sealed at jambs with a non-setting mastic. Edges of panels should be sealed before fixing.

2.10.3 Design of fascias and soffits

These applications are generally satisfied by the use of pre-packaged cut-to-size pieces which may also be pre-finished prior to site delivery. In the case of soffits, incorporation of adequate ventilation slots will be a specified requirement or constitutes good practice, permitting essential air flow to ventilate the roof space. This function is usually achieved by the incorporation of proprietary ventilation strips or inserts.

2.10.4 Site work for cladding, fascias and soffits

2.10.4.1 Conditioning

It is important that panels are installed at a moisture content close to that which they will achieve in service. Advice on the conditioning of panels is found in PanelGuide *Section 4.2.4*.

2.10.4.2 Fixing

Panels should be conditioned, primed (if they are to be painted) and edge sealed before fixing.

Panels should be fixed using corrosion resistant nails, staples or screws. Corrosion resistant materials include galvanised or sheradised steel, austenitic stainless steel, phosphor bronze and silicon bronze.

Screws and flat headed improved nails (such as annular grooved or ringshank) have superior holding power and should be used in preference to plain shank nails.

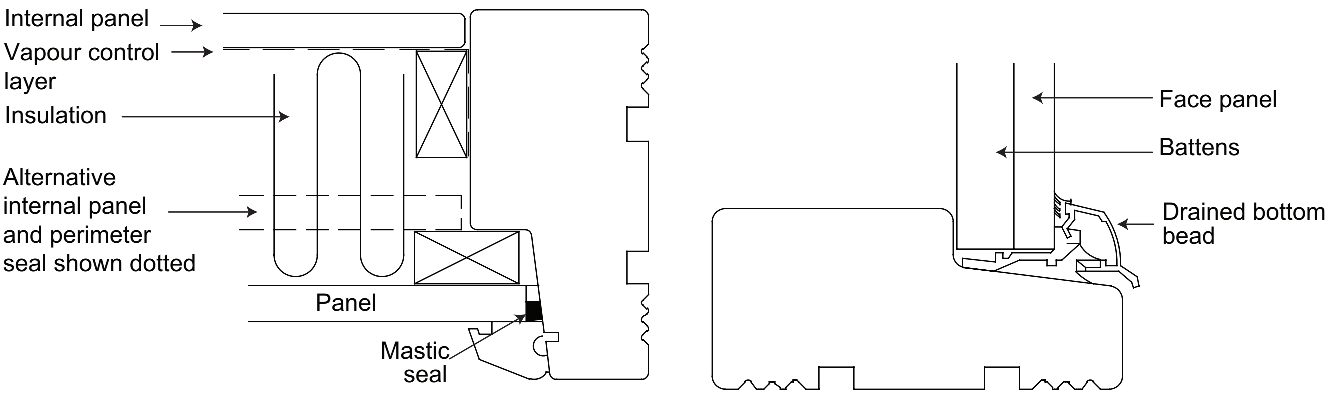


Figure 2.24: Infill panel with exposed framing

Table 2.15: Spacing of fixings for cladding, fascias and soffits

Panel type	Maximum spacing (mm)		
	Perimeter framing	Intermediate framing	Min edge distance (mm)
Mediumboard and MDF	150	300	8
Hardboard	150	300	8
CBPB	see note below	see note below	see note below
OSB	150	300	8
Plywood	150	300	8

Note: For cement-bonded particleboard recommended nail spacing and edge distances vary with thickness and from manufacturer to manufacturer – examples of nail spacing range from 200 to 400mm on perimeter framing and from 300 to 610mm on intermediate framing; nail edge distance varies from 15mm for panels less than 12mm and 20mm for thicker panels up to 25mm irrespective of thickness. Panels may need to be pre-drilled or fixed with self-drilling screws to avoid splitting. For fixing cement-bonded particleboard it is therefore essential to obtain and follow the manufacturer's recommendations.

Minimum nail length should be 50mm or 2.5 times the panel thickness, whichever is greater.

Staples should have as wide a crown as possible (11mm minimum), be not less than 15 gauge and not less than 50mm in length.

Where panels are to be fixed directly to battens or framing, the frequency and pattern of nailing around the periphery and on intermediate framing studs should be as in *Table 2.15*. Where manufacturer's instructions are supplied with the panels, their recommendations should be followed. To avoid tear out at panel edges, fixings should not be inserted closer to the edges than the minimum distances given in *Table 2.15*.

To avoid buckling of the thinner and more flexible panels, nailing should commence at the top centre and continue outwards and downwards.

Where panels are retained by beads or cover mouldings, the panels can be located in position by single fixings at mid-point top and bottom and retained by the beads fixed at 150–200mm centres to the framing.

Edge gaps between adjacent panels and to abutting framing should be provided as given above.

2.10.5 Finishes for cladding, fascias and soffits

See PanelGuide *Section 4.7* for detailed information on decoration and finishing.

Panels are available with various factory applied finishes.

Where unfinished panels are used, they can be decorated with conventional paints and stains, taking care that the appropriate primers are used on tempered hardboard and CBPB.

Premature failure of paint systems on wood-based panels is often due to high moisture content in the panel, impairing adhesion between the paint and the panel. Water ingress usually occurs at joints in panels or through surrounding framework and careful detailing is required.

Coatings technology is constantly evolving and there is a variety of finishing and paint systems suitable for use on wood-based panels, including opaque paints, translucent and opaque stains, and textured coatings. These products are also available in a variety of finishes from gloss through to low sheen and matt finishes. Most systems suitable for external woodwork will be suitable for use with wood-based panels, subject to the use of an appropriate primer for tempered hardboard and alkali compatible finishes for CBPB.

2.11 Application of panels in architectural mouldings and window boards

2.11.1 General

When considering the use of MDF mouldings and window boards there are two options available:

- Select a standard profile, thickness and width (usually primed for painting) from a supplier or builders' merchant.
- Make your own moulding or window board from raw unfinished MDF panels.

Table 2.16: Panel grades* for architectural mouldings and window boards

Selection		CONDITION	PLYWOOD BS EN 636	PARTICLEBOARD BS EN 312	OSB BS EN 300	MDF BS EN 622-5	FIBREBOARD BS EN 622-3,4	CBPB BS EN 634
	Mouldings	New build	636-2	-	-	MDF.H	-	CBPB
		Dry refurbishment	636-1	-	-	MDF	-	CBPB
	Window boards	New and refurbishment	636-2	-	-	MDF.H	-	CBPB

* The table provides the minimum grade of panel that satisfies the particular set of requirements: panels of higher quality may be substituted, and their selection may result in a reduction in required thickness.
Although all the panels meeting the grade specifications will satisfy a particular set of requirements, the level of performance of different brands of these panels may vary considerably; some may even be endowed with high levels of properties not directly covered by the table.

2.11.2 Selection of panels for the production of mouldings and window boards

The selection of wood-based panels for mouldings and window boards depends on a number of factors, of which the most important are:

- Good machining properties of the panel which are a reflection of the evenness and fineness of its texture.
- Resistance to ambient moisture conditions which, in the case of new build, means resistance to high levels of humidity or actual condensation as the building dries out.
- Moderate to high levels of resistance to abrasion which can be met using panels with moderate to high levels of density.

The selection of panels for mouldings and window boards which satisfy the above requirements is set out in *Table 2.16*.

2.11.2.1 Conditioning

It is important in order to prevent buckling of mouldings and window boards, or the development of gaps between sections, that mouldings and window boards are installed at a moisture content close to that which they will achieve in service. Advice on the conditioning can be found in PanelGuide *Section 4.2.4*.

2.11.2.2 Fixing

It is strongly recommended that mouldings and even window boards are fixed with adhesive: nailing should not be adopted. Some prefinished mouldings have an integral clip fixing system.

2.11.2.3 Finishes for mouldings and window boards

Mouldings and window boards are available with various factory applied finishes.

When unfinished mouldings and window boards are used they can be decorated with conventional paints and stains, taking care that the appropriate alkali resistant primer is used on CBPB.

Figure 2.25: Wood-based panels used as wall linings at Copenhagen Opera House
Photo: Coillte Panel Products

As with all painted surfaces, preparation, priming and protection from water ingress are important for the successful application and long-term performance of finishes applied to wood-based panels.

2.12 Application of panels as wall linings and partitions

2.12.1 Selection of panels for wall linings and partitions

The selection of wood-based panels for wall linings, partitions and ceilings depends on a number of factors of which the most important are:

- Moderate to high resistance to impact and abrasion, especially in certain types of public buildings.
- Good dimensional stability in the presence of seasonal changes in relative humidity of the air.
- The ability to reduce either sound absorption or sound transmission in particular applications. Attention is drawn to the acoustic requirements in Approved Document Part E[54] (with corresponding regulations for Scotland and Northern Ireland): wood-based panels can be used or be complemented by other materials in order to satisfy these requirements.
- The ability to receive a variety of finishes including paints and laminates.

Table 2.17: Panel grades* for wall linings and partitions and the reaction to fire Euroclass for specified thicknesses

Selection		SERVICE CLASS	PLYWOOD EN 636	PARTICLEBOARD EN 312	FLAXBOARD EN 15197	OSB EN 300	MDF EN 622-5	FIBREBOARD EN 622-3,4	CBPB EN 634
	Linings Partitions Ceilings	1	636-1	P4	FB3	OSB/2	MDF	MBH	CBPB
		2	636-2	P5	FB4	OSB/3	MDF.H	MBH.H	CBPB
	Reaction to Fire Class* (pr EN 13501-1)	-	See *Annex 2D*	See *Annex 2A*	See *Annex 2G*	See *Annex 2B*	See *Annex 2E*	See *Annex 2F*	-

* The Euroclasses for these panels are available without testing based on Table 1 of the Decision of the Commission 2003/43/EC of 2003-01-17 (see *OJEC L13 of 2003-01-18*), as amended by the Decision 2003/593/EC of 2003-08-07 (see *OJEC L201 of 2003-08-08*) and corrected by the Corrigendum (see *OJEC L331 of 2003-02-08*), and further amended by the Decision 2007/348/EC of 2007-05-15 (see *OJEC L131 of 2007/05-23*) may be classified for reaction to fire performance without further testing (CWFT) in specific classes given therein. These Euroclasses are available in the Annexes of PanelGuide. The important aspect to note is that there are particular fixing conditions that have to be adhered to in order to obtain the Euroclass without carrying out any further testing.

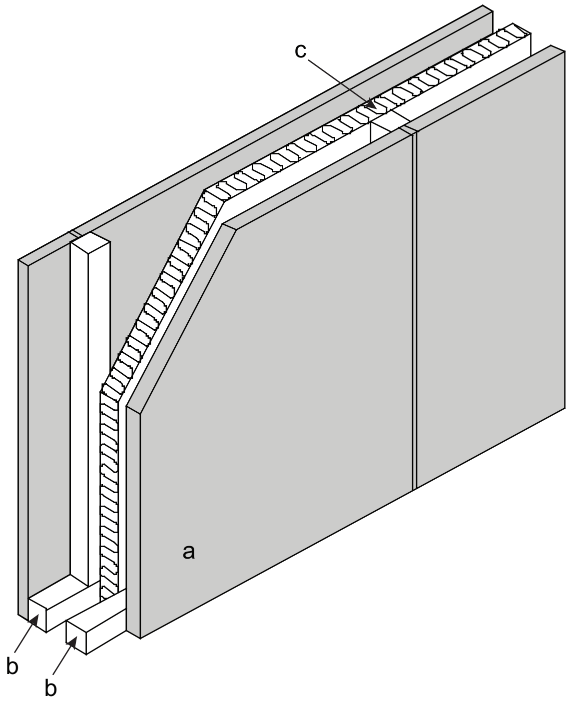


Figure 2.26: Internal partition wall with improved acoustic performance
a: particleboard or CBPB linings fixed to framing with panel joints staggered
b: separate wall framing to each face
c: sound absorbent mineral fibre quilt hung in cavity

- Satisfying the requirements for fire performance (spread of flame and rate of heat release).

The selection of panels for wall linings, partitions and ceilings based on satisfying the above requirements is given in *Table 2.17*. Their use as wall linings is illustrated in *Figure 2.25*.

2.12.1.1 Decorative linings

Most wood-based panels are suitable for use as internal decorative linings for walls and ceilings, both in new construction and in upgrading and refurbishment, subject to meeting the required surface spread of flame aspect of fire performance.

Because the appearance of panels used internally is usually of prime importance, a large number of proprietary profiled, film-faced or laminate-faced and pre-decorated panels are available.

Where internal linings also act as structural sheathing, strength and durability are of prime importance, with appearance and finish of lesser importance, particularly as internal sheathing may also be hidden by other linings.

2.12.1.2 Acoustic linings

Some panels may be used to improve sound absorption within a room, for example fibreboard ceiling tiles ('acoustic tiles'), while other panels may be used to reduce sound transmission between rooms, for example the denser particleboard or cement-bonded particleboard (CBPB), used in conjunction with mineral fibre insulation and other recognised design features for sound resistant partition walls, as shown in *Figure 2.26*.

2.12.1.3 Reaction to fire

Where timber-based products are exposed internally, fire performance must be considered. According to the UK building regulations both the European (*BS EN 13501-1*) and British (*BS 476-6 & 7*) test methods and classification systems are acceptable, however it should be noted that in a declaration of performance for CE marking purposes the European classification and test method must be used.

Note: Deemed to satisfy (classification without testing) reaction to fire performance of wood-based panels under the European system are given in Table 8 of *EN 13986*. These classes are reproduced in *Annexes 2A to 2G* of PanelGuide.

Further information on the reaction to fire testing in both the BS and EN systems is provided in PanelGuide *Section 2.2.3*.

2.12.2 Design factors in linings and partitions

2.12.2.1 Sizes and thicknesses of panels

Typical panel sizes are 2400 × 1200mm and 2400 × 600mm, with other sizes available to order. Sizes up to 3660mm high are available to allow fabrication of wall panels for increased storey heights. The usual panel width is 1200mm to suit framing centres of 400 and 600mm.

Table 2.18: Maximum stud and batten centres (mm) for linings and partitions

Panel types	Panel thickness (mm)						
	3.2	4.8	6.4	9/10	12/13	18/19	>20
Softboard	-	-	-	300	400	600	-
Mediumboard	-	-	400	450	600	600	600
Hardboard	400	500	600	-	-	-	-
MDF	-	-	450	450	600	600	600
CBPB	-	-	450	450	600	600	600
Particleboard	-	-	-	450	600	600	600
Flaxboard	-	-	-		600	600	600
OSB	-	-	-	450	600	600	600
Plywood	-	-	-	450	600	600	600

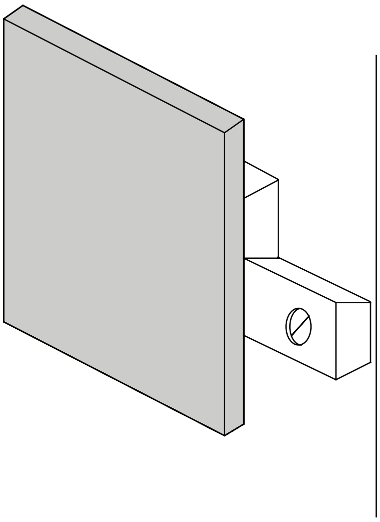


Figure 2.27: Secret fixing using interlocking battens
Upper batten fixed to back of panel and lower batten screwed to wall

Thickness will depend on the location and purpose of the lining or partition, and on the stiffness and impact resistance required.

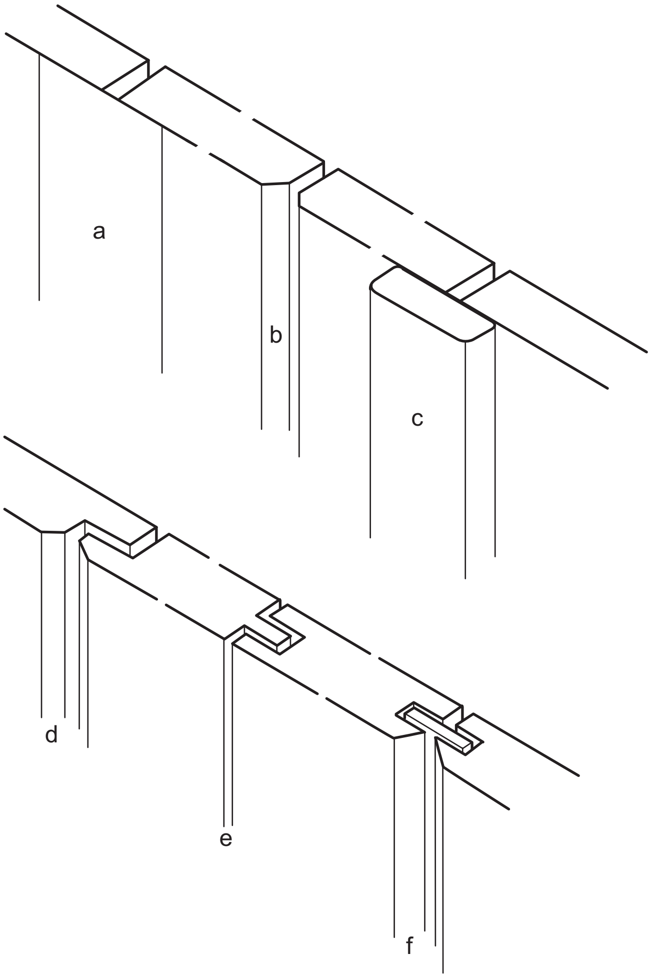


Figure 2.28 :Typical lining panel joints
a: butt joint with scrim tape for plaster skim coat
b: butted 'V' joint for face fixing
c: butt joint with timber or metal cover trim
d: rebated 'V' joint for face fixing
e: secret fixing tongued and grooved joint
f: grooved joint with hardwood tongue

2.12.2.2 Framing and support centres

Non-structural linings and partitions

Conventional framed support is suitable for all panels. Framing should provide support for all panel edges, unless tongued and grooved panels are used.

Intermediate vertical supports should be at the centres shown below depending on panel thickness. For panels of thicknesses <10mm, horizontal supports should be at the same centres as the vertical supports; for panels >10mm, horizontal supports should be at centres no greater than 1200mm.

In order to achieve smooth flat surfaces, maximum stud and batten centres (mm) for panels of given type and thickness should be as given in *Table 2.18*.

Structural sheathing

Where internal linings also act as structural sheathing the recommendations included in *Section 2.7* should be followed.

2.12.2.3 Secret fixing

Panels may also be secret fixed using interlocking framing battens, as shown in *Figure 2.27*. Panels so fixed should also have framing battens fixed at the above centres to provide adequate stiffness.

2.12.2.4 Joints and jointing

To eliminate visually unacceptable gaps at panel joints due to panel shrinkage, it is recommended that provision is made to mask such gaps by using featured joints or cover strips.

Joints can be featured using gaps or profiled edges, cover battens or metal profiles. Examples are shown in *Figure 2.28*.

There is a risk of cracking at flush joints due to unavoidable slight movement of panel substrates caused by changes in temperature and humidity.

2.12.3 Other considerations

Where wood-based panels are applied to upgrade a solid masonry wall or to provide an internally insulated lining, condensation risk should be considered. A vapour control layer should be included on the warm side of the insulation (see *Figure 2.29*). Further information is provided in *BS 5250* which refers to *BS EN ISO 13788* as the method of calculation.

Table 2.19: Spacing of fixings for linings and partitions

Panel type	Maximum spacing (mm)		
	Perimeter framing	Intermediate framing	Min edge distance (mm)
Softboard	75	150	12
Mediumboard	150	300	8
MDF	150	300	8
Hardboard	150	300	8
Particleboards	150	300	8
Flaxboard	150	300	8
CBPB	see note below	see note below	see note below
OSB	150	300	8
Plywood	150	300	8

Note: For cement-bonded particleboard recommended nail spacing and edge distances vary with thickness and from manufacturer to manufacturer – examples of nail spacing range from 200 to 400mm on perimeter framing and from 300 to 610mm on intermediate framing: nail edge distance varies from 15mm for panels less than 12mm and 20mm for thicker panels up to 25mm irrespective of thickness. Panels may need to be pre-drilled or fixed with self-drilling screws to avoid splitting. For fixing cement-bonded particleboard it is therefore essential to obtain and follow the manufacturer's recommendations.

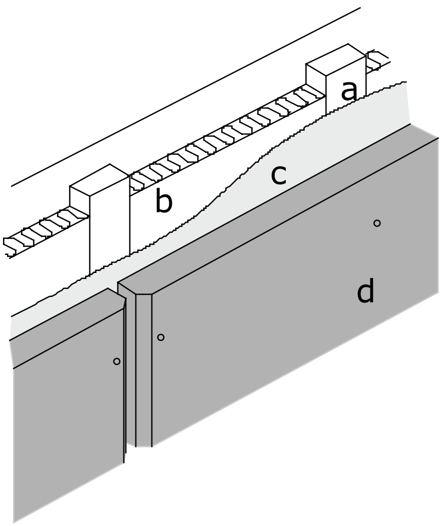


Figure 2.29: Internal lining with thermal insulation
a: battens and counterbattens fixed to wall
b: insulation
c: vapour control layer – typically 500 gauge polyethylene sheet with lapped joints
d: lining board

2.12.4 Sitework

2.12.4.1 Conditioning

It is important that panels are installed at a moisture content close to that which they will achieve in service. Advice on the conditioning of panels is to be found in PanelGuide *Section 4.2.4*.

2.12.4.2 Fixing of panels

Panels should be fixed using corrosion resistant nails, staples or screws. Corrosion resistant materials include galvanised or sheradised steel, austenitic stainless steel, phosphor bronze and silicon bronze.

Minimum nail length should be 50mm or 2.5 times the panel thickness, whichever is greater.

Staples should have as wide a crown as possible (11mm minimum), be not less than 15 gauge and not less than 50mm in length.

The frequency and pattern of nailing around the periphery and on intermediate framing should be as shown in *Table 2.19*. Where manufacturer's instructions are supplied with the panels, their recommendations should be followed. To avoid tear out at panel edges, fixings should not be inserted closer to the edges than the minimum distances given.

With the thinner and more flexible panels, to avoid buckling, nailing should commence at the top centre and continue outwards and downwards.

2.12.5 Finishes

Panels can be pre-decorated or site-finished with a wide variety of finishes including paints, stains, laminates, wallpaper and other coverings, and tiling. These are described in more detail in PanelGuide *Section 4.7*.

2.13 Application of panels in door skins

2.13.1 Selection of panels as door skins

The selection of wood-based panels for door skins depends on a number of factors of which the most important are:

- decorative appearance or design
- adequate strength and stiffness
- moderate to high levels of impact resistance
- good dimensional stability
- excellent surface finish
- ability to take finishes easily.

Table 2.20: Panel grades* for door skins

Selection	DOOR SKINS	SERVICE CLASS	PLYWOOD EN 636	PARTICLEBOARD EN 312	OSB EN 300	MDF EN 622-5	FIBREBOARD EN 622-3,4	CBPB EN 634
	Internal doors	1	636-1	-	-	MDF	HB, MBH	-
	External doors	3	636-3	-	-	MDF.H	HB.H, MBH.H	-

*The table provides the minimum grade of panel that satisfies the particular set of requirements: panels of higher quality may be substituted, and their selection may result in a reduction in required thickness.
Although all the panels meeting the grade specifications will satisfy a particular set of requirements, the level of performance of different brands of these panels may vary considerably; some may even be endowed with high levels of properties not directly covered by the table.

Table 2.21: Panel grades* for staircase treads and risers

Selection	STAIRCASE	SERVICE CLASS	PLYWOOD BS EN 636	PARTICLEBOARD BS EN 312	OSB BS EN 300	MDF BS EN 622-5	FIBREBOARD BS EN 622-3,4	CBPB BS EN 634
	Treads	2	636-2	-	-	MDF.H	-	-
	Risers	2	636-2	P5	OSB/3	MDF.H	-	-

* The table provides the minimum grade of panel that satisfies the particular set of requirements: panels of higher quality may be substituted, and their selection may result in a reduction in required thickness.
Although all the panels meeting the grade specifications will satisfy a particular set of requirements, the level of performance of different brands of these panels may vary considerably; some may even be endowed with high levels of properties not directly covered by the table.

The selection of panels from the appropriate European Standard fulfilling the above requirements is given in *Table 2.20*.

2.13.1.1 Manufacture

It is important in the manufacture of doors that the door skin material is first conditioned to a moisture content close to that which it will achieve in service. Advice in the conditioning of boards is to be found in PanelGuide *Section 4.2.4*.

2.13.1.2 Finishes

Advice on the selection and application of finishes is provided in PanelGuide *Section 4.7*.

2.14 Application of panels for staircase treads and risers

2.14.1 Selection of panels for treads and risers

The selection of wood-based panels for staircase treads and risers depends on a number of factors of which the most important are:

- high levels of strength, stiffness and impact resistance
- high level of abrasion resistance in the case of treads
- smooth surface especially in the case of treads
- moderate levels of resistance to moisture, a feature which is particularly important in the drying out of new build.

The selection of wood-based panels from the appropriate European Standard satisfying the above requirements is given in *Table 2.21*.

2.14.1.1 Manufacture

It is important in the manufacture of staircases that the treads and risers are conditioned to a moisture content close to that which they will achieve in service after the property is fully dry following construction. Once this moisture content is achieved then the finished staircase must be fully protected during delivery and throughout construction in order to maintain dimensional stability.

2.15 References

1 Construction Products Directive (CPD), Council Directive 89/106/EEC (repealed)

2 Construction Products Regulation (CPR), Regulation 305/2011/EU

3 BS EN 13986. Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking, BSI

4 UK Building Regulations Approved Document Regulation 7 – Materials and workmanship, available at www.planningportal.gov.uk

5 BS 5268-2. Structural use of timber. Code of practice for permissible stress design, materials and workmanship [WITHDRAWN], BSI

6 BS EN 1991-1-4. Eurocode 1. Actions on structures. General actions. Wind actions, BSI

7 BS EN 1990. Eurocode. Basis of structural design, BSI

8 BS 6399-2. Loading for buildings. Code of practice for wind loads [WITHDRAWN], BSI

9 BS EN 1995-1-1. Eurocode 5: Design of timber structures. General. Common rules and rules for buildings, BSI

10 BS 8103-3. Structural design of low-rise buildings. Code of practice for timber floors and roofs for housing, BSI

11 BS 5268-6 (Parts 1, 2 and 6.6.1). Structural use of timber. Code of practice for timber frame walls [WITHDRAWN], BSI

12 BS EN 1195. Timber structures. Test methods. Performance of structural floor decking, BSI

13 BS EN 12871. Wood-based panels. Determination of performance characteristics for load bearing panels for use in floors, roofs and walls, BSI

14 UK Building Regulations Approved Document A – Structure, available at www.planningportal.gov.uk

15 BS EN 12369-1. Wood-based panels. Characteristic values for structural design. OSB, particleboards and fireboards, BSI

16 BS EN 12369-2. Wood-based panels. Characteristic values for structural design. Plywood, BSI

17 BS EN 789. Timber structures. Test methods. Determination of mechanical properties of wood based panels, BSI

18 BS EN 1058. Wood-based panels. Determination of characteristic 5-percentile values and characteristic mean values, BSI

19 BS EN 1156. Wood-based panels. Determination of duration of load and creep factors, BSI

20 PD 6693-1. Recommendations for the design of timber structures to Eurocode 5: Design of timber structures. General. Common rules and rules for buildings, BSI

21 BS EN ISO 1182. Reaction to fire tests for products. Non-combustibility test, BSI

22 BS EN ISO 1716. Reaction to fire tests for products. Determination of the gross heat of combustion (calorific value), BSI

23 BS EN ISO 11925-2. Reaction to fire tests. Ignitability of products subjected to direct impingement of flame. Single-flame source test, BSI

24 BS EN 13823. Reaction to fire tests for building products. Building products excluding floorings exposed to the thermal attack by a single burning item, BSI

25 BS EN 13501-1. Fire classification of construction products and building elements. Classification using test data from reaction to fire tests, BSI

26 BS EN ISO 9239-1. Reaction to fire tests for floorings. Determination of the burning behaviour using a radiant heat source, BSI

27 BS 476-4. Fire tests on building materials and structures. Non-combustibility test for materials, BSI

28 BS 476-12:1991. Fire tests on building materials and structures. Method of test for ignitability of products by direct flame impingement, BSI

29 BS 476-5. Fire tests on building materials and structures. Method of test for ignitability, BSI [withdrawn]

30 BS 476-7. Fire tests on building materials and structures. Method of test to determine the classification of the surface spread of flame of products, BSI

31 BS 476-6. Fire tests on building materials and structures. Method of test for fire propagation for products, BSI

32 HSG168 Fire safety in construction: Guidance for clients, designers and those managing and carrying out construction work involving significant fire risks, ISBN 9780717663453, HSE, 2013, available at www.hse.gov.uk

33 Fire Prevention on Construction Sites 8th edition Code and Checklist (FSB9-8COMBO), ISBN 9781902790794, Fire Protection Association/Construction Information Publications, 2012

34 Design guide to separating distances for buildings during construction, UKTFA, Version 1, December 2011, available at www.uktfa.com

35 UK Building Regulations Approved Document L – Conservation of fuel and power, available at www.planningportal.gov.uk

36 Scottish Technical Handbook, Part 6.2, available at www.scotland.gov.uk

37 NI Building Regulations Technical Booklet F1 and F2, available at www.dfpni.gov.uk/building-regulations

38 Republic of Ireland Building Standards Technical Guidance Document Part L – Conservation of Fuel and Energy, available at www.environ.ie/en/TGD/

39 BS EN 204. Classification of thermoplastic wood adhesives for non-structural applications, BSI

40 BS EN 636. Plywood. Specifications, BSI

41 BS EN 622-5. Fibreboards. Specifications. Requirements for dry process boards (MDF), BSI

42 BS EN 622-2. Fibreboards. Specifications. Requirements for dry process boards (MDF), BSI

43 BS 8217. Reinforced bitumen membranes for roofing. Code of practice, BSI

44 BS 5250. Code of practice for control of condensation in buildings, BSI

45 BS 5534. Code of practice for slating and tiling (including shingles), BSI

46 Timber frame construction, ISBN 8791900510820, TRADA Technology, 5th edition, 2011

47 BS EN ISO 13788. Hygrothermal performance of building components and building elements. Internal surface temperature to avoid critical surface humidity and interstitial condensation. Calculation method, BSI

48 WIS 1-42: Timber I-joists: applications and design, TRADA Technology, 2012

49 ETAG 011: Guideline for European technical approval of light composite wood-based beams and columns, European Organisation for Technical Approvals, January 2002

50 Guidance Document 5: How to calculate deformations in timber structures using Eurocodes, 2nd edition, ISBN 1900510480, TRADA Technology, 2006

51 Guidance Document 6: Vibration in timber floors (Eurocode 5), ISBN 1900510057, TRADA Technology, 2008

52 WIS 1-41: Strutting in timber floors, TRADA Technology, 2011

53 Formwork – a guide to good practice, 3rd edition, Concrete Society, 2012

54 UK Building Regulations Approved Document E – Resistance to the passage of sound, available at www.planningportal.gov.uk

3 Panels for non-construction use

3.1 Requirements for non-construction use

The requirements for panels in construction applications are covered in PanelGuide *Section 2*. This section deals specifically with non-construction applications. The term ‘construction’ relates to use in any fixed part of a building or other civil engineering structure. Construction uses can therefore be either load-bearing or non load-bearing and the term ‘construction’ should not be confused with the term ‘structural’. More specifically ‘construction’ refers to any application covered by the Construction Products Regulation (CPR)[1] and the harmonised European standard implemented in the UK as *BS EN 13986*[2]. As explained in *Section 2.1*, wood-based panels intended for construction shall be CE marked, accompanied by a Declaration of Performance (DoP) and impose specific responsibilities on the different economic operators (manufacturer, distributor and importer).

However, the end use of a panel is often unknown at the time of manufacture, and many general purpose products used in non-construction applications may still therefore be those produced in accordance with the requirements of the CPR and *BS EN 13986*. Such non-construction applications include furniture, packaging and transport.

As stated above, for these types of product the CPR is not relevant but the panels used may still be produced to one of the EN specification standards if this suits the control system in operation at the factory. However, this is not compulsory and an alternative specification can be agreed between the customer and supplier. For some end uses there are relevant British Standards or industry standards that give guidance on the use and selection of wood-based panels, but in most cases, the specifier has the option to specify a product in accordance with an existing standard or to produce his own specification. As a result, it is the specifier and his client’s requirements that normally determine the requirements for the panel.

Figure 3.1: Van interior using WISA-Multifloor and WISA-Multiwall panel products
Photo: UPM-Kymmene Wood Oy

3.2 Panels satisfying the requirements for non-construction uses

3.2.1 Introduction

In non-construction applications the panel specifications are determined in accordance with the requirements of the particular end use. The design and selection process for non-construction applications is represented in PanelGuide Section 2, *Figure 2.1*. In general terms, the requirements will be that the panels must:

- have a satisfactory appearance
- be sufficiently strong and stiff to resist the applied loads
- be manufactured with a glue type appropriate to the end-use environmental conditions
- be capable of being easily cut and fixed in place
- have an adequate service life
- be available at an acceptable cost.

While there are many standards relating to non-construction applications, few of these include specific requirements for panel products and the specifier therefore has

Figure 3.2: OSB box
Photo: Norboard

Figure 3.3: Flatbed truck using WISA bonded floor solution
Photo: UPM-Kymmene Wood Oy

to decide upon the panel type that is most likely to meet his performance criteria. In some cases, the specifier may have the option of using one of the many general purpose panels or of selecting a product manufactured specifically for the end-use. *Table 3.1* lists a number of non-construction applications, grouped by category, and indicates:

- the product types that have commonly been found to be suitable
- some of the more important design considerations
- sources of further information.

These applications are also discussed in more general terms in the following sections.

Having selected an appropriate product, the specifier should check that the information available demonstrates that it:

- is capable of performing adequately against his criteria
- can be correctly installed
- is available within his budget and timescales.

Table 3.1: Suitability of wood-based panels for use in non-construction applications
Key: PW = plywood; OSB = oriented strand board; PB = particleboards (including flaxboard); MDF = medium density fibreboard; FB = fibreboard; CBPB = cement-bonded particleboard; FXB = flaxboard

Application	Typical products	Important design considerations	References for further information
FURNITURE			
General	PW, PB, OSB, MDF, FXB	Strength, stiffness, screw holding, impact, surface quality, dimensional stability	BS 4875 [in several parts]. Strength and stability of furniture[3]
Bookcases and shelving	PW, PB, OSB, MDF, FXB	Strength, stiffness, creep	FIRA Bulletin No 57 'Shelf design guide'[4]
Contract and office furniture	PW, PB, MDF, FXB	Strength, stiffness, screw holding, impact, surface quality	BS 5459 [in several parts]. Specification for performance requirements and tests for office furniture[5] BS EN 15372 Furniture. Strength, durability and safety. Requirements for non-domestic tables[6] BS EN 16121 Non-domestic storage furniture. Requirements for safety, strength, durability and stability[7] BS EN 14073-2 Office furniture. Storage furniture. Safety requirements[8] BS EN 14073-3 Office furniture. Storage furniture. Test methods for the determination of stability and strength of the structure[9] BS EN 14727 Laboratory furniture. Storage units for laboratories. Requirements and test methods[10] BS EN 527-3 Office furniture. Work tables and desks. Methods of test for the determination of the stability and the mechanical strength of the structure[11]
Educational furniture	PB, MDF, PW	Strength, stiffness, screw holding, impact, surface quality, dimensional stability, fire	BS 5873-4 Educational furniture. Specification for strength and stability of storage furniture for educational institutions[12] BS 5873-5 Educational furniture. Specification for security of fixed secure storage furniture for educational institutions[13] BS EN 1729-2 Furniture. Chairs and tables for educational institutions. Safety requirements and test methods[14]
Beds	OSB, PB, MDF, FB, PW	Strength, stiffness, stability, screw holding	BS 8509 Children's beds for domestic use. Safety requirements and test methods[15] BS EN 747-1 Furniture. Bunk beds and high beds . Safety, strength and durability requirements[16] BS EN 747-2 Furniture. Bunk beds and high beds. Test methods[17] BS EN 1725 Domestic furniture. Beds and mattresses. Safety requirements and test methods[18] BS EN 1130-1 Furniture. Cribs and cradles for domestic use. Safety requirements[19] BS EN 1130-2 Furniture. Cribs and cradles for domestic use. Test methods[20]
Tables	PB, MDF, PW	Surface quality, dimensional stability, strength, stiffness, screw holding	BS EN 12521 Furniture. Strength, durability and safety. Requirements for domestic tables[21] BS EN 1730 Furniture. Tables. Test methods for the determination of stability, strength and durability[22]
Foil/veneer laminates	PW, PB, MDF, FB, FXB	Surface quality, dimensional stability	BS 4965 Decorative laminated plastics sheet veneered boards and panels[23] BS EN 14322 Wood-based panels. Melamine faced boards for interior uses. Definition, requirements and classification[24] BS EN 14323 Wood-based panels. Melamine faced boards for interior uses. Test methods[25]

Table 3.1: Continued

Application	Typical products	Important design considerations	References for further information
FURNITURE (continued)			
Seating	PW, PB, OSB, MDF		BS EN 12520 Furniture. Strength, durability and safety. Requirements for domestic seating[26] BS EN 16139 Furniture. Strength, durability and safety. Requirements for non-domestic seating[27] BS EN 1728 Furniture. Seating. Test methods for the determination of strength and durability[28]
Kitchen units	PW, PB, MDF, FXB	Strength, stiffness, moisture resistance, surface quality, screw holding	BS EN 14749 Domestic and kitchen storage units and worktops. Safety requirements and test methods[29] BS 6222-2 Domestic kitchen equipment. Fitted kitchen units, peninsular units, island units and breakfast bars. Performance requirements and test methods[30] BS 6222-3 Domestic kitchen equipment. Performance requirements for durability of surface finish and adhesion of surfacing and edging materials. Specification[31]
Storage units	PW, PB, MDF, FXB	Strength, stiffness, moisture resistance	ISO 7170 Furniture. Storage units. Determination of strength and durability[32]
High chairs		Dependent on design	BS EN 14988-1 Children's highchairs. Safety requirements[33] BS EN 14988-2 Children's highchairs. Test methods[34]
Playpens		Dependent on design	BS EN 12227 Playpens for domestic use. Safety requirements and test methods[35]
Children's furniture	PW, PB, MDF	Strength, stiffness, durability, safety	FIRA/FRQG C001 Furniture. Children's domestic furniture. General safety requirements[36] FIRA/FRQG C003 Furniture. Children's domestic furniture. Tables and desks. Requirements for strength, stability and durability[37] FIRA/FRQG C004 Furniture. Children's domestic furniture. Storage furniture. Requirements for strength, stability and durability[38]
Kitchen units – worktops	PW, PB, MDF, FXB	Moisture resistance, surface quality, impact, dimensional stability, strength, stiffness	BS EN 14749 Domestic and kitchen storage units and worktops. Safety requirements and test methods[39] BS 6222-2 Domestic kitchen equipment. Fitted kitchen units, peninsular units, island units and breakfast bars. Performance requirements and test methods[40] BS 6222-3 Domestic kitchen equipment. Performance requirements for durability of surface finish and adhesion of surfacing and edging materials. Specification[41]
Hospital bedside lockers			BS 1765-1 Hospital bedside lockers. Specification for general purpose bedside lockers for patients[42] BS 1765-2 Specification for hospital bedside lockers. General purpose lockers of wooden construction with facilities for hanging day clothes[43]
Upholstered furniture frames	PW, PB, OSB, MDF	Strength, stiffness, screw holding	
PACKAGING			
General	PW, PB, OSB, FXB		BS 3130-6 Glossary of packaging terms. Wooden packaging[44]
Boxes and packing cases	PW, PB, OSB, FXB	Strength, stiffness, fastener performance, impact resistance, moisture resistance	BS 1133-8 Packaging code. Guidance on wooden boxes, cases and crates[45]
Containers for agricultural produce	PW, OSB	Strength, stiffness, fastener performance, impact resistance, moisture resistance, durability	BS 7611 Specification for potato storage boxes for mechanical handling[46]
Pallets	PW, PB, OSB, FXB	Strength, stiffness, fastener performance, impact resistance, moisture resistance, durability	BS EN 12246 Quality classification of timber used in pallets and packaging[47] BS EN 13545 Pallet superstructures. Pallet collars. Test methods and performance requirements[48] BS EN 13698-1 Pallet production specification. Construction specification for 800mm × 1200mm flat wooden pallets[49] BS EN 13698-2 Pallet production specification. Construction specification for 1000mm × 1200mm flat wooden pallets[50]

Table 3.1: Continued

Application	Typical products	Important design considerations	References for further information
SHOPFITTING			
Bars/counters	PW, PB, MDF, FXB	Moisture resistance, surface quality, impact, dimensional stability, strength, stiffness	
Display/exhibition cabinets	PW, PB, MDF, FXB	Strength, stiffness, dimensional stability, impact resistance, surface quality	
Shelving	PW, PB, OSB, MDF, FXB	Strength, stiffness, creep	FIRA Bulletin No 57 'Shelf design guide'[51]
Exterior signs and fascias	PW, MDF, CBPB	Moisture resistance, durability, fastener performance, surface quality, strength, stiffness	BS 559 Specification for the design and construction of signs for publicity, decorative and general purposes[52]
TRANSPORT			
Aircraft	PW		BS 6V 3 Specification for aircraft material. High strength plywood for aircraft[53] BS 2V 35 Specification for plywood for aeronautical purposes[54]
Vehicles and containers (decks, sides etc)	PW, OSB	Strength, stiffness, moisture resistance, durability, impact resistance, fastener performance, abrasion resistance	
Marine craft	PW	Durability, moisture resistance, surface quality, strength, stiffness, impact resistance	BS 1088-1 Marine plywood. Requirements[55] BS 1088-2 Marine plywood. Determination of bonding quality using the knife test[56] BS EN ISO 12215-3 Small craft. Hull construction and scantlings. Materials. Steel, aluminium alloys, wood, other materials[57]
AGRICULTURAL			
Agricultural buildings	PW, OSB, CBPB	Strength, stiffness, moisture resistance, durability, impact resistance	BS 5502-21 Buildings and structures for agriculture. Code of practice for selection and use of construction materials[58] BS 5502-22 Buildings and structures for agriculture. Code of practice for design, construction and loading[59]
Retaining walls	PW, OSB, CBPB	Strength, stiffness, moisture resistance, durability, impact resistance	
Silos/storage bins	PW, OSB, CBPB	Strength, stiffness, moisture resistance, durability, impact resistance	
Fences			BS 1722-11 Fences. Specification for prefabricated wood panel fences[60]
OTHER			
Adhesive			BS EN 204 Classification of thermoplastic wood adhesives for non-structural applications[61] BS EN 205 Adhesives. Wood adhesives for non-structural applications. Determination of tensile shear strength of lap joints[62] BS 1203 Hot-setting phenolic and aminoplastic wood adhesives. Classification and test method[63] BS EN 12765 Classification of thermosetting wood adhesives for non-structural applications[64]

Finally, the specifier should draw up a specification that ensures the requirements are met. The specification should include:

- the product type
- a reference to any appropriate specification standard
- the markings required on the panel
- the need for any independent quality assurance
- the correct installation and maintenance procedures.

If a specific brand of product has been selected then this should be named in the specification and it should be made clear whether or not substitution by similar alternative products is acceptable.

3.2.2 Furniture

Furniture is a major market for wood-based panels. The wood-based panels family has made significant inroads into the traditional solid timber furniture market, with MDF and particleboard in particular securing a large share of the market.

The term 'furniture' encompasses a wide range of products with a correspondingly wide range of end-use requirements but in general terms all these products are required to:

- have a high quality surface appearance
- be strong and stiff
- resist impact and abuse
- have good machining properties (including low grit content)
- have good fastener performance.

In many furniture applications, panels are used with some form of applied facing, which can include: wood veneer, laminate, melamine and many others.

There are many British Standards relevant to furniture, but only some of these are relevant to wood-based panels.

Further specific advice on the use of wood-based panels in furniture can be sought from any of the PanelGuide partners, from FIRA International (Tel: 01438 777700) or from any of the panel manufacturers.

3.2.3 Packaging

Next to furniture, packaging is one of the largest non-construction uses of wood-based panels. The most important criteria for panels used in packaging are:

- strength and stiffness
- impact resistance
- fastener performance
- moisture resistance and durability (depending upon use).

Relevant standards for packaging include:

- *BS 1133* – a multi-part standard covering various forms of packaging and the factors affecting the selection of materials and design of the packaging. *BS 1133-8 Packaging code. Guidance on wooden boxes, cases and crates*[65] deals with wooden boxes, cases and crates and includes information on the use of plywood, particleboard, OSB and fibreboards in packaging.
- *BS 3130* – a glossary of packaging terms. *BS 3130-6 Glossary of packaging terms. Wooden packaging*[66] relates to wooden packaging.
- *BS 7611* – which specifies boxes to contain 1 tonne of potatoes, together with the performance requirements and test methods for three classes of box. Guidance is given on the manufacture of boxes from solid timber or from OSB or plywood. The references to grades of plywood and OSB are still in accordance with the old British Standard and need updating to the new EN specifications.
- *BS EN 12246* – covers the quality classification of timber used in pallets and packaging, but currently only refers to solid timber and not wood-based panels.

3.2.4 Shopfitting

Because of their flexibility and ease of working, wood-based panels are frequently used in shopfitting applications. The range of finishes and sizes available makes panels very suited to the rapid fitting out of large display areas. Panels can be used for a wide range of shopfitting applications including:

- wall panelling
- storage racks
- counters and bars
- special display units.

Figure 3.4: Medite Tricoya® used for exterior shop front signage in Ireland
Photo: Accsys Technologies

Panels can be laminated, painted or stained to create a wide range of finish effects.

MDF in particular is becoming more popular for shopfitting as it allows easy moulding of edges and corners and can be routed to create an embossed relief effect. Panels can also be slotted to carry various forms of display mounts. Products treated to improve their fire performance, termed MDF FR, are also available for applications where this is required in order to meet safety regulations.

In load-bearing situations, such as shelving, it is important that the effects of long-term loads are accounted for in the design. Wood-based panels have a tendency to 'creep' – that is the initial deflection under a given load will increase with time. This can be accounted for in calculations, and guidance on this can be found in the FIRA publication *FIRA Shelf Design Guide*[67]. Alternatively, reference can be made to PanelGuide *Section 2* for design by structural calculation.

Although low formaldehyde panels are widely available, in situations where particularly sensitive items are on display, as in museum work, 'formaldehyde free' or 'zero formaldehyde' panels are now available. These are made using non-formaldehyde resins, such as isocyanates, but such panels can really only be described as very low formaldehyde or 'zero added formaldehyde' as wood itself contains a small amount of naturally occurring formaldehyde.

Exterior grades of panels are also used for exterior signs and fascias, principally using either plywood or 'exterior' grades of MDF, the latter being suitable for use in a Service Class 2 protected exterior environment. *BS EN 622* does not currently include an exterior grade of MDF but there are a number of commercial products on the market. In exterior situations, it is important with all panel types (with the exception of wood-based panels made with acetylated wood) that the faces are suitably coated and the edges sealed to protect the panel from the effects of moisture and sunlight.

3.2.5 Transport

Wood-based panels and plywood in particular have long been used in various transport applications including:

- trucks and trailers
- buses and coaches
- caravans
- small boats
- shipbuilding
- railway goods wagons and passenger carriages
- freight containers
- light aircraft.

In many of these transport applications, panels are used with some form of applied facing, which can include:

- film facing
- laminate facing
- glass reinforced polymer facings.

These help to:

- improve the durability
- reduce the risk of accidental damage
- increase the service life of the panels
- reduce the risk of distortion due to water absorption.

Figure 3.5: Car trailer using WISA Multiwall panels
Photo: UPM-Kymmene Wood Oy

Figure 3.6: WISA Birch panels installed in a bus
Photo: UPM-Kymmene Wood Oy

BS 1088 defines the requirements for 'marine plywood'. The Standard is published in two parts. Part 1 deals with the requirements for marine plywood, which are now based around published European standards and Part 2 describes the use of the traditional knife test as a quality control tool.

BS 1088 specifies a very high quality plywood intended for use in boats and ships, but the material is also used in other applications where a high performance level and long service life are required. The plywood has to be manufactured from virtually defect-free veneers of species with a good durability, using a high quality adhesive. Suppliers should ensure that material supplied is correctly marked by the manufacturer in accordance with the Standard. If the material is to be used in construction applications, it is a legal requirement for it to also comply with the requirements of the Construction Products Regulation (CPR), see *Section 2*.

3.2.6 Agriculture

Agricultural applications include:

- buildings
- animal cubicles
- feed troughs
- gates and fencing
- greenhouses and staging
- hoppers and feed bins
- silage retaining walls
- storage bins
- water tanks.

Most agricultural buildings in the UK are exempt from planning regulations and, in many cases, the requirements of the Building Regulations will not be appropriate unless the building is used as a residence or is heated. As such, they are included here under non-construction uses but they will still in many cases be load bearing. Despite often being outside the scope of Building Regulations, agricultural buildings are subject to the requirements of the CPR and many such structures will still be designed in accordance with *BS EN 1995-1-1* (Eurocode 5)[68] or *BS 5268-2* (now withdrawn)[69].

BS 5502 is the current British Standard dealing with buildings and structures for agriculture. It is a Standard published in more than 80 parts, dealing with different materials and types of structure. Part 21 is a code of practice for the selection and use of construction materials. Part 22 is a code of practice for design, construction and loading. In the case of load-bearing structures the design must ensure that the structure is safe, even if it is not designed in accordance with the structural design codes *Eurocode 5* or *BS 5268-2*.

3.2.7 Other applications

Other applications for wood-based panels include:

- fire surrounds
- toys
- picture frames and backs
- models and moulds
- work benches
- notice boards and signs
- headboards and pelmets
- acoustic insulation
- theatre staging and scenery
- musical instruments.

3.3 References

1 Construction Products Regulation (CPR), Regulation 305/2011/EU

2 BS EN 13986. Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking, BSI

3 BS 4875 [in several parts]. Strength and stability of furniture, BSI

4 FIRA Bulletin No 57 ‘Shelf design guide’ http://www.fira.co.uk/technical-information/article/57/choosing-your-kitchen-furniture

5 BS 5459 [in several parts]. Specification for performance requirements and tests for office furniture, BSI

6 BS EN 15372. Furniture. Strength, durability and safety. Requirements for non-domestic tables, BSI

7 BS EN 16121. Non-domestic storage furniture. Requirements for safety, strength, durability and stability, BSI

8 BS EN 14073-2. Office furniture. Storage furniture. Safety requirements, BSI

9 BS EN 14073-3. Office furniture. Storage furniture. Test methods for the determination of stability and strength of the structure, BSI

10 BS EN 14727. Laboratory furniture. Storage units for laboratories. Requirements and test methods, BSI

11 BS EN 527-3. Office furniture. Work tables and desks. Methods of test for the determination of the stability and the mechanical strength of the structure, BSI

12 BS 5873-4. Educational furniture. Specification for strength and stability of storage furniture for educational institutions, BSI

13 BS 5873-5. Educational furniture. Specification for security of fixed secure storage furniture for educational institutions, BSI

14 BS EN 1729-2. Furniture. Chairs and tables for educational institutions. Safety requirements and test methods, BSI

15 BS 8509. Childrens beds for domestic use. Safety requirements and test methods, BSI

16 BS EN 747-1. Furniture. Bunk beds and high beds . Safety, strength and durability requirements, BSI

17 BS EN 747-2 Furniture. Bunk beds and high beds. Test methods, BSI

18 BS EN 1725. Domestic furniture. Beds and mattresses. Safety requirements and test methods, BSI

19 BS EN 1130-1. Furniture. Cribs and cradles for domestic use. Safety requirements, BSI

20 BS EN 1130-2. Furniture. Cribs and cradles for domestic use. Test methods, BSI

21 BS EN 12521. Furniture. Strength, durability and safety. Requirements for domestic tables, BSI

22 BS EN 1730. Furniture. Tables. Test methods for the determination of stability, strength and durability, BSI

23 BS 4965. Decorative laminated plastics sheet veneered boards and panels, BSI

24 BS EN 14322. Wood-based panels. Melamine faced boards for interior uses. Definition, requirements and classification, BSI

25 BS EN 14323. Wood-based panels. Melamine faced boards for interior uses. Test methods, BSI

26 BS EN 12520. Furniture. Strength, durability and safety. Requirements for domestic seating, BSI

27 BS EN 16139. Furniture. Strength, durability and safety. Requirements for non-domestic seating, BSI

28 BS EN 1728. Furniture. Seating. Test methods for the determination of strength and durability, BSI

29 BS EN 14749. Domestic and kitchen storage units and worktops. Safety requirements and test methods, BSI

30 BS 6222-2. Domestic kitchen equipment. Fitted kitchen units, peninsular units, island units and

breakfast bars. Performance requirements and test methods, BSI

31 BS 6222-3. Domestic kitchen equipment. Performance requirements for durability of surface finish and adhesion of surfacing and edging materials. Specification, BSI

32 ISO 7170. Furniture. Storage units. Determination of strength and durability, BSI

33 BS EN 14988-1. Children's highchairs. Safety requirements, BSI

34 BS EN 14988-2. Children's highchairs. Test methods, BSI

35 BS EN 12227. Playpens for domestic use. Safety requirements and test methods, BSI

36 FIRA/FRQG C001. Furniture. Children's domestic furniture. General safety requirements, FIRA

37 FIRA/FRQG C003. Furniture. Children's domestic furniture. Tables and desks. Requirements for strength, stability and durability, FIRA

38 FIRA/FRQG C004. Furniture. Children's domestic furniture. Storage furniture. Requirements for strength, stability and durability, FIRA

39 BS EN 14749. Domestic and kitchen storage units and worktops. Safety requirements and test methods, BSI

40 BS 6222-2. Domestic kitchen equipment. Fitted kitchen units, peninsular units, island units and breakfast bars. Performance requirements and test methods, BSI

41 BS 6222-3. Domestic kitchen equipment. Performance requirements for durability of surface finish and adhesion of surfacing and edging materials. Specification, BSI

42 BS 1765-1. Hospital bedside lockers. Specification for general purpose bedside lockers for patients, BSI

43 BS 1765-2. Specification for hospital bedside lockers. General purpose lockers of wooden construction with facilities for hanging day clothes, BSI

44 BS 3130-6. Glossary of packaging terms. Wooden packaging, BSI

45 BS 1133-8. Packaging code. Guidance on wooden boxes, cases and crates, BSI

46 BS 7611. Specification for potato storage boxes for mechanical handling, BSI

47 BS EN 12246. Quality classification of timber used in pallets and packaging, BSI

48 BS EN 13545. Pallet superstructures. Pallet collars. Test methods and performance requirements, BSI

49 BS EN 13698-1. Pallet production specification. Construction specification for 800mm × 1200mm flat wooden pallets, BSI

50 BS EN 13698-2. Pallet production specification. Construction specification for 1000mm × 1200mm flat wooden pallets, BSI

51 FIRA Bulletin No 57 'Shelf design guide' http://www.fira.co.uk/technical-information/article/57/choosing-your-kitchen-furniture

52 BS 559. Specification for the design and construction of signs for publicity, decorative and general purposes, BSI

53 BS 6V 3. Specification for aircraft material. High strength plywood for aircraft [obsolescent], BSI

54 BS 2V 35. Specification for plywood for aeronautical purposes [obsolescent], BSI

55 BS 1088-1. Marine plywood. Requirements, BSI

56 BS 1088-2. Marine plywood. Determination of bonding quality using the knife test, BSI

57 BS EN ISO 12215-3. Small craft. Hull construction and scantlings. Materials. Steel, aluminium alloys, wood, other materials, BSI

58 BS 5502-21. Buildings and structures for agriculture. Code of practice for selection and use of construction materials, BSI

59 BS 5502-22. Buildings and structures for agriculture. Code of practice for design, construction and loading, BSI

60 BS 1722-11. Fences. Specification for prefabricated wood panel fences, BSI

61 BS EN 204. Classification of thermoplastic wood adhesives for non-structural applications, BSI

62 BS EN 205. Adhesives. Wood adhesives for non-structural applications. Determination of tensile shear strength of lap joints, BSI

63 BS 1203. Hot-setting phenolic and aminoplastic wood adhesives. Classification and test method, BSI

64 BS EN 12765. Classification of thermosetting wood adhesives for non-structural applications, BSI

65 BS 1133-8. Packaging code. Guidance on wooden boxes, cases and crates, BSI

66 BS 3130-6. Glossary of packaging terms. Wooden packaging, BSI

67 FIRA Bulletin No 57 'Shelf design guide' http://www.fira.co.uk/technical-information/article/57/choosing-your-kitchen-furniture

68 BS EN 1995-1-1. Eurocode 5: Design of timber structures. General. Common rules and rules for buildings, BSI

69 BS 5268-2. Structural use of timber. Code of practice for permissible stress design, materials and workmanship [WITHDRAWN], BSI

4 Storage, handling, cutting, fixing and finishing

4.1 General

Correct handling and transportation of wood-based panels is essential to prevent either damage to the panels or injury to the persons undertaking these operations. It is therefore important that the correct storage, transportation and handling techniques described in *Section 4.2* and *Section 4.3* are employed. Likewise, incorrect cutting and machining can damage the panels or cause injury to the operative. All Health and Safety guidelines must be adhered to when working with wood-based panels, and assistance in this regard is given in PanelGuide *Section 6*. The correct methods for cutting and machining are described in *Section 4.4*.

Being reasonably durable and resilient, most wood-based panels can withstand a certain amount of wear and tear, but lack of care before and during construction can have an adverse effect. In addition to the strength of the panels, the surface appearance can be an important feature of the finished structure. Proper storage, transportation, handling and installation will ensure that the final performance and appearance is as intended.

As a natural material, wood contains moisture and the amount held within it varies with the temperature and relative humidity of the surrounding environment. Wood-based panels are no different from solid wood in this respect and their moisture content will change with changes in relative humidity and temperature. Changes in moisture content result in changes in mechanical properties and in dimensions (length, width and thickness).

It is therefore important that the moisture content of a panel is as close as possible to its final in-service moisture content at the time of installation. In addition, wood-based panels must be given sufficient protection throughout the construction process to ensure final in-service moisture content is maintained. This will, to a large extent, minimise the risk of any in-service distortion problems.

The mechanical properties of wood-based panels also vary with moisture content and in structural applications it is essential that they are installed in the environment for which they have been designed. The moisture resistance of wood-based panels varies with product type, according to the specification, and again the use of a product in the wrong Service Class could lead to poor performance or premature failure.

Further guidance in relation to correct installation and fixing is provided in *Section 4.5* and in relation to decoration and finishing in *Section 4.7*.

4.2 Storage and transportation

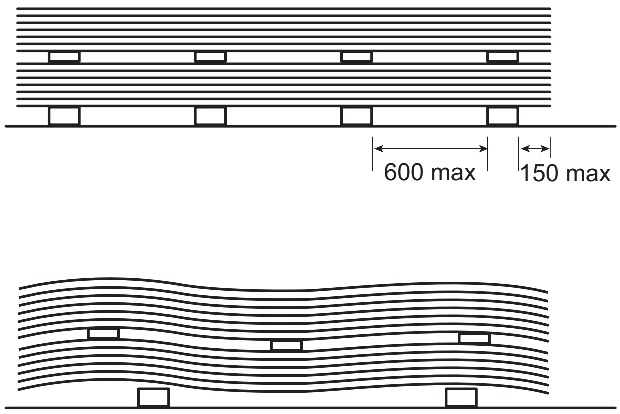
Correct storage is important for all wood-based panels. Care is needed to avoid mechanical damage to panel edges and corners and to avoid damage from wetting or high humidity.

4.2.1 Stacking

Panels should be stacked flat on a level surface with all four edges flush. The panels should be sufficiently clear of the ground to avoid any potential splashing from water on the ground. Stacking of panels on edge should be avoided, whenever possible. The ideal base for the stack is a close boarded or slatted pallet. If this is not possible, then the panels should be carefully stacked on battens of equal thickness at centres not exceeding 600mm, as shown in *Figure 4.1*.

Where thin panels (6mm or less) are being stacked, it is recommended that they are supported under the whole area of the panels by a thicker panel (≥18mm).

Intermediate bearers are recommended every 10 to 15 panels to allow through ventilation. If used, each layer of batten must be placed directly above those in the layers below. The battens should be placed parallel to the short edges of the panels, with ends equidistant from the long edges. Overhang of the panels at the edges and ends of the stack should not exceed 150mm at any point. Where palletised stacks are placed on top of one another, bearers should line up to prevent distortion.



a

b

Figure 4.1: Panel storage
a – correct
b – incorrect (can result in panel damage and deformation)

Where space will only permit stacking on edge, then the edges should not be permitted to come into direct contact with the ground or floor to avoid any possible moisture pick-up or damage to the edges. Panels should not be leant against walls but should be supported by a braced, purpose-made stack using thick (>18mm) base and back panels (see *Figure 4.2*). Edge stacking is not recommended for cement-bonded particleboards.

The top of the stack should be covered with a protective panel to counteract any tendency for the top panel to warp and to protect the stack from mechanical damage.

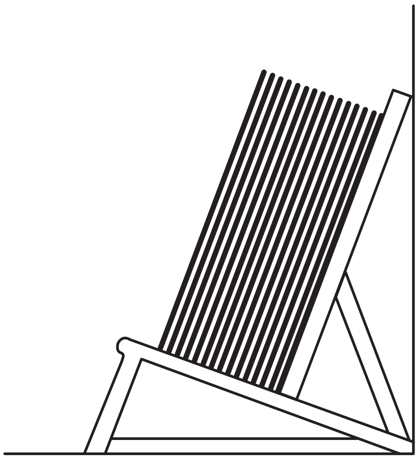


Figure 4.2: Correct method of edge stacking

If panels are to be stacked outside, they should be fully protected by a waterproof covering (see *Section 4.2.3*).

Detailed information on the safe stacking of sawn timber and panel materials is given in the HSE information sheet *Stacking round timber, sawn timber and board materials*[1], which includes information on stacking packs and the storage of panels in racks.

4.2.2 Protection during transport

Panels should be adequately protected during transportation by a waterproof covering. Edges should be well protected from rain, traffic spray or other water and measures taken to reduce the risk of water being blown up under the stack.

Edge protection should be provided to avoid damage by ropes, straps or other banding. This is particularly important with profiled panels, such as tongued and grooved (T&G) flooring. Panels should be fully supported to prevent distortion.

Where panels are banded, the bands should be cut as soon as practicable after delivery in order to prevent them from causing permanent damage to the panels. This is a particular problem if panels are stored in a humid environment, as they can expand due to moisture uptake.

When packs are delivered with edge or face protection boards, these should be left in place until the panels are required for use.

4.2.3 Storage on site

Stacking of panels on site should be in accordance with the recommendations given above.

Panels must be protected from rain and direct wetting at all times. They should ideally be stored in an enclosed building but where a short period of external storage is unavoidable, then stacks should be well covered with opaque, waterproof sheeting. The stacks should be placed on bearers to keep the underside clear of the ground and any vegetation. Measures should be taken to avoid the risk of splashing of the underside of the stack.

Any protective wrapping should be left in place for as long as possible and only removed when the panels are required for conditioning.

4.2.4 Conditioning

Timber and wood-based panels expand on taking up moisture from the surrounding air and shrink on losing moisture. Wood-based panels are manufactured to close dimensional tolerances and excessive changes in moisture content can lead to dimensional changes that can cause problems, such as bowing, in service.

In order to minimise the risk of this occurring, the moisture content of panels at the time of installation should be as close as possible to the in-service moisture content. Panels are normally manufactured at low moisture contents, between 2% and 13%, and may still be very dry at the time of delivery.

Where panels are to be used in warm dry areas, it is important that the moisture content of the panels is kept as low as possible. This requires storage in an internal, dry environment that is preferably heated. Any protective wrapping should be left in place until shortly before installation. If the storage conditions are close to the final in-service conditions, then the panels can be unwrapped and conditioned by loose-laying (on floors) or horizontal stacking with spacers between each panel (following the stacking principles in *Section 4.2.1* and *Figure 4.1*). A minimum conditioning period of 48 hours is recommended but longer periods may be required, depending upon the conditions required and the initial moisture content of the panels.

For some types of panel, conditioning with water is used as a way of increasing the panel moisture content and to encourage expansion before fixing. This is used on some types of hardboard and mediumboard, particularly where they are to be used in unheated or damp conditions. It is important that this is only carried out in accordance with the manufacturer's recommendations, but the normal procedure for doing this is to lay the panels smooth side down on a flat, clean surface in an unheated, draught-free place, under cover and out of direct sunlight. The back (mesh) face of each panel is wetted with a brush or clean mop using approximately 1 litre of clean water. The panels should be uniformly wetted working from the centre outwards. The panels should then be stacked back to back for 48 to 72 hours depending upon the material type and the manufacturer's recommendations.

4.3 Handling

4.3.1 General

When lifting, moving and stacking panels, edge protection should be provided to avoid damage by lifting ropes and/or forklift tines.

When handling pre-finished panels, it is essential to avoid damage or dirt on the finished surfaces. Pre-finished panels should be lifted from the stack and not slid.

Table 4.1: Typical weights of some common panels

Panel type	Thickness	Typical panel weight (kg) for given panel sizes (mm)		
	(mm)	610 × 2440mm	1220 × 2440mm	1220 × 3660mm
Particleboard	15	14	29	43
	19	18	36	55
	25	24	48	72
	32	31	61	92
Flaxboard	15	10	20	30
	19	13	26	38
	25	17	34	50
	32	21	42	62
CBPB	12	21	42	63
	16	29	58	87
	22	39	78	117
MDF	12	14	28	42
	15	17	35	52
	19	22	44	66
	32	37	75	112
OSB	18	17	34	51
Hardboard	6	9	17	26
Softwood plywood	9	8	15	22
	15	12	25	37
Hardwood plywood	9	10	19	28
	15	16	30	45

In the case of manual handling of panels, compliance with the relevant health and safety recommendations should be maintained at all times. This includes wearing appropriate Personal Protective Equipment (PPE) such as suitable gloves and safety shoes. In case of any doubt, guidance can be sought from the UK Health and Safety Executive (HSE). HSE recommends a maximum manual lifting weight at knuckle height of 25kg. In relation to the maximum safe lifting weights, some typical weights of common panels are given in *Table 4.1*.

4.4 Cutting and machining

4.4.1 General

All wood-based panels can be cut or machined by hand or with power tools, but with any such activities, care has to be exercised to avoid injury to the operator or damage to the material and equipment. It is important that operatives have a clear understanding of the operation, follow any manufacturer's specific guidance for their product, and adhere to relevant health and safety guidelines. PanelGuide *Section 6* 'Health and safety' provides generic guidance of the hazards that may be encountered and techniques which can be employed to minimise risk.

When cutting wood-based panels, it is important to pay attention to normal woodworking best practice. Sharp cutters, adequate support close to saws and cutters, elimination of machine vibration, correct allowance for saw kerf etc will all help to ensure that a good result is achieved in a safe fashion.

The quality of cut on a panel is affected by moisture content and therefore where a close fit is an essential requirement, panels should be cut to size after conditioning to their final in-service moisture content. Such panels must then be given sufficient protection throughout the construction process to maintain this in-service moisture content.

4.4.2 Cutting with hand tools

All panel types can be cut to size with conventional hand tools, although some types, for example cement-bonded particleboard (CBPB), are more difficult to cut than others and cutting edges may need regular maintenance. While satisfactory results can be achieved using hand tools, quicker and more consistent results can be achieved using either portable or fixed power tools.

4.4.3 Machining with power tools

Fixed workshop machines are generally most appropriate for cutting and machining wood-based panels, as they provide a better quality finish and allow health and safety requirements to be effectively addressed, particularly in terms of machine guarding, dust extraction and manual handling. Hand-held power tools are generally only appropriate to small volumes of in-situ cutting or final adjustment on site. The rate of feed should generally be slower than that used for natural timber and cutting edges should be kept sharp.

A variety of tooling systems are available for the cutting and machining of wood-based panels ranging in price from standard steel through tungsten carbide tipped (TCT) blades to polycrystalline diamond tipped (PCD). High energy laser beams can also be used for intricate pattern cutting in most types of wood.

Tungsten carbide tipped (TCT) blades are the most common system because of their longer cutting life. Tungsten carbide tipped saws and cutters have a much lower rate of wear than most other types and this offsets their higher initial cost. Polycrystalline diamond tipped (PCD) tools have improved resistance compared to tungsten carbide tools. However, due to their high initial cost their use is generally limited to high volume production.

As the grain directions of the wood particles in fibreboards and particleboards are random, saw blades with cross cutting forms should be used. Certain types of cutter (portable circular saws and jigsaws) cut on the upstroke, and the wanted or decorated face should therefore be placed facing downward (see *Figure 4.3*). Bench circular saws, on the other hand, cut on the down stroke and necessitate feeding in the panel face uppermost.

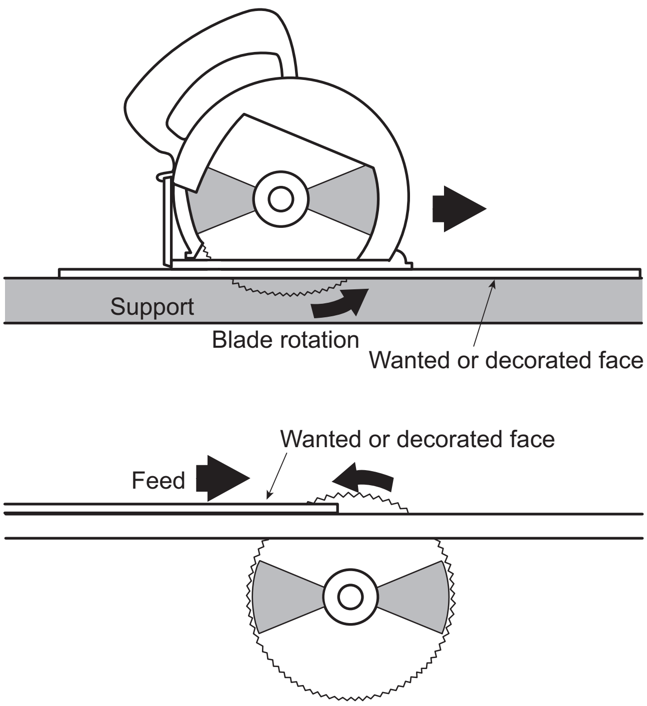


Figure 4.3: Sawing wood-based panels

Circular saw blades should be set as low as possible to prevent chipping and scoring as the panel passes the rear of the saw blade. The height of the saw blade should be positioned so as to maintain the correct hook angle relative to the panel surface (see *Figure 4.4* and *Figure 4.5*). The projection of the saw above the panel has a direct influence on the cleanliness of the cut. Breaking out or chipping of the top surface will occur if it is insufficient and on the bottom if it is too great. If either occurs, the projection should be adjusted accordingly until the defect disappears. If the fault is persistent then the saw speed should be increased or the rate of feed reduced.

If the feed speed is too slow, cutters will have insufficient chip load and the tip of the cutter will wear rapidly. Too great a feed speed will result in rough fibrous cut edges. Control of the panel during machining is important; panels should be properly supported and pressed down firmly against the cutting table and guides to avoid vibration.

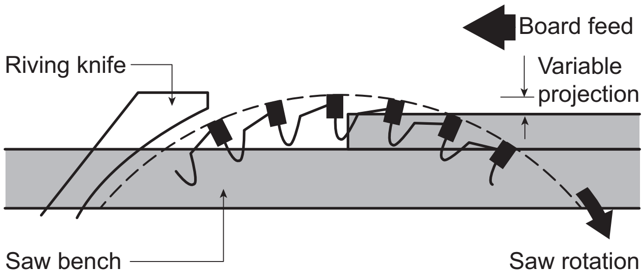


Figure 4.4: Saw blade setting

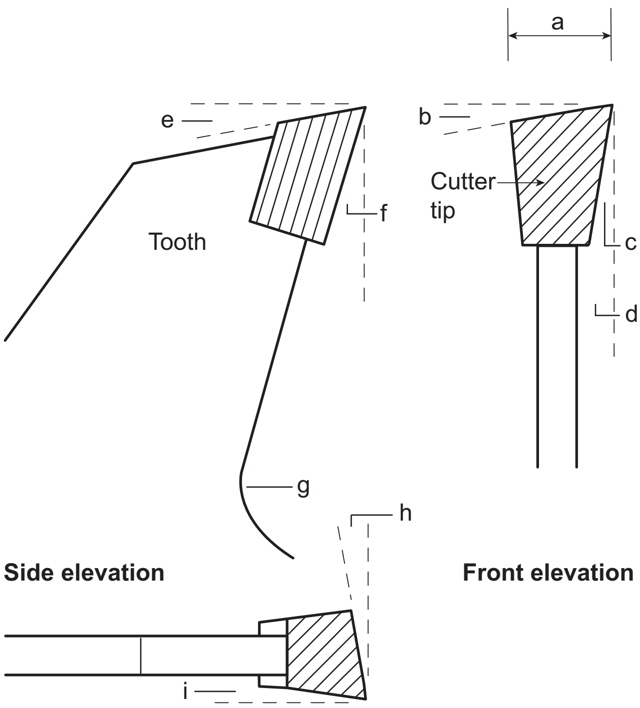


Figure 4.5: Saw blade nomenclature
a) kerf, b) back bevel angle, c) radial clearance, d) tip to body clearance, e) clearance angle, f) hook (rake) angle, g) gullet, h) front bevel angle, i) side (tangential) clearance

4.4.4 Requirements for different panel types

4.4.4.1 Softboard

Cutting and sawing

For softboard up to 19mm thick the most convenient method is to use a trimming knife against a straight edge. To reduce tear-out on the reverse face, the cut should be made onto a flat, rigid backing material. Panels of 19mm or more in thickness should be cut with a fine-toothed hand or power saw.

Routing

Softboard can be cut with a router using normal wood cutting bits but may not give a clean edge.

Drilling

Use a normal hand drill or power drill and bits designed for drilling wood.

Sanding

Sanding is not normally required but softboard can be face or edge sanded by hand or with orbital sanders. Profiled edges are generally not achievable on softboard.

4.4.4.2 Hardboard and mediumboard

Sawing

Hardboard and mediumboard can be cut with a hand saw or powered circular saws, band saws and jigsaws. To prevent chipping, hand saws with 10 or more teeth per 25mm are recommended, held at a low angle of cut to the panel and with minimum tooth set. *Table 4.2* gives guidance on the saw settings (refer to *Figure 4.5* for terminology).

Table 4.2: Recommendations for saws

Saws	
Diameter (mm)	350
Revs per minute	3500 to 4000
Cutter speed (m/sec)	70
Number of teeth	75
Feed speed (m/minute)	20 to 50
Chipload (mm)	0.19
Back clearance angle	10° to 14°
Hook or rake angle	5° to 10°
Tangential clearance angle	3°
Radial clearance angle	1°
Front bevel angle	0 to 5°
Back bevel angle	10° to 15°

Spindle and routing

Hardboard and mediumboard can be routed and moulded using conventional woodworking tools and bits. PDT and TCT cutters should be used. Cutters must be kept sharp as dull cutters will cause edges to 'bell' or spread, causing difficulties with laminating, edging or lipping. General feed speeds should be slower than for solid timber, and cutters should have the largest number of cutting edges possible (see *Table 4.3*).

Table 4.3: Recommendations for spindle moulders

Spindle moulder	
Revs per minute	6000
Cutter speed (m/sec)	30 to 50
Number of teeth	6 to 8
Feed speed (m/minute)	8 to 10

Drilling

For drilling hardboard and mediumboard, drill bits designed for drilling steel are more suitable than those intended for other wood-based materials. Speeds of 3000 to 4000 rpm produce the cleanest cut with least lipping around the hole. Conventional steel drills have bits with a point angle of 118°, increasing this angle to 170° helps to decrease surface lipping (see *Figure 4.6*).

Sanding

Face sanding should not be necessary; edge sanding may be done by hand or with orbital or belt sanders.

4.4.4.3 Dry process fibreboards (MDF)

Sawing

MDF can be sawn with a hand saw or power saws, TCT blades are recommended. Saw blades developed for

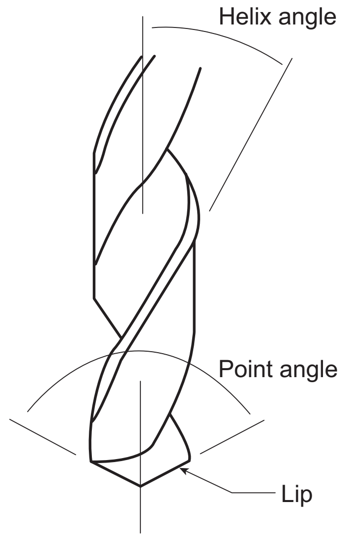


Figure 4.6: Twist drill nomenclature

particleboards will cut MDF with reasonable success but the adoption of alternative top bevels of 15° and an increased tip clearance angle of 20° and 22° will extend saw life between sharpening operations (see *Figure 4.5*).

Chipload should be in a range 0.15 to 0.25mm. When using a 40-tooth saw blade, irrespective of diameter, operating at 3000 rpm, feed speed should be in the range 18m/minute (0.15 chipload) to 30m/minute (0.25mm chipload).

The saw geometry in *Table 4.4* has been found to give satisfactory results.

Table 4.4: Suitable saw geometry for cutting MDF

MDF	
Top bevel angle	15° alternative
Side clearance	2° to 4°
Tip to body clearance	0.25mm to 0.45mm
Clearance angle	20° to 22°
Hook angle	15°

Routing

MDF can be routed and moulded to very accurate and highly finished profiles. TCT cutters should be used. Cutters must be kept sharp as dull cutters will cause edges to 'bell' or spread, causing difficulties when laminating, edging or lipping.

Router cutters generally incorporate cutting angles in the range 15° to 25° and clearance angles in the range 15° to 18°.

Drilling

MDF can be drilled using all types of woodworking drill bits.

Sanding

The faces of MDF are usually pre-sanded by manufacturers with 120 grit abrasive. This provides a smooth surface ideally suited to the direct application of most veneers and plastic foils. Scuff sanding with the object of increasing adhesion may be detrimental. For the economic application of paints or printed effects and for very thin foils a further light sanding with 200 grit abrasive may be advisable.

Excessive sanding of the faces should be unnecessary and because it could unbalance some MDF panels it should be avoided. Silicone carbide abrasives are generally recommended for sanding MDF. Aluminium oxide abrasives tend to dull rapidly, producing burnishing. A 'modified closed coat' abrasive is suggested. High sanding speeds cut the fibres most effectively; for example, with belt sanders, belt speed in excess of 1500 metres per minute is recommended.

Sanding after moulding or routing produces a smoother surface, moulded edges can be sanded using a profiled sander. 80/100 grit abrasives should be used to remove cutter marks, 120/150 grit is required for finish sanding.

4.4.4.4 Particleboard and flaxboard

Sawing

Particleboard and flaxboard can be sawn with normal hand tools or with a power saw using a TCT (or similar hard tipped) blade. Bench saws should preferably have blades of 350mm to 450mm diameter with 75 or 96 teeth. Tooth shape should be in accordance with the saw manufacturer's recommendations. Feed speed should not exceed 15 metres per minute. Projection of the blade above the work surface should normally be between 8mm and 20mm.

Spindle and router

Use TCT cutters. The cutter spindle speed should be 18000 to 24000 rpm and the material feed rate 4.5 to 9 metres per minute.

The edges of particleboard panels can be 'planed' and/or profiled on a spindle machine but the profile should be kept simple to reduce the risk of break out. Feed speeds should be slower than for solid timber and the maximum number of cutting edges provided. The values in *Table 4.5* are suggested.

Drilling

Drill speed and angle of the drill point should be the same as used for natural wood.

Table 4.5: Settings for spindle and router for cutting particleboard

a) Spindle	
Speed	4000 to 6000 rpm
Cutter block	Minimum 4 cutters
Cutters	Toe: 42° Heel: 45°
Feed speed	4 to 5 metres per minute
b) Router	
Speed	1800 to 2400
Cutters	Double-edged bit, min 25mm cutting edge ground to angle of 53°
Feed speed	4 to 5 metres per minute

Sanding

Particleboards are supplied with a sanded finish; sanding is normally necessary only as a finishing process after machining or the fabrication of a component. Where the edge of the particleboard is required as a finished face and the saw cut edge is unsatisfactory, sanding is the preferred method. For finishing work a 120–200 grit abrasive should be used depending upon the degree of smoothness required. Excessive sanding of the faces should be unnecessary and because it could unbalance some particleboards it should be avoided.

4.4.4.5 Oriented strand board (OSB)

Sawing

OSB can be sawn with normal hand tools or with power saws. Tools designed for use with solid timber should be used.

Spindle and router

Simple profiles and routed forms can be produced readily with little risk of break out. The quality of finish increases with spindle speed and the number of cutters utilised.

Drilling

Drill speed and angle of the drill point should be the same as used for natural wood.

Sanding

The manufacture of the panel is such that some looseness of surface strands may occur. Where a smooth surface is required, a sanded panel should be specified or a light sanding given using hand or powered sanders. Excessive sanding of the faces should be unnecessary and, because it could unbalance some OSB panels, it should be avoided.

For general information regarding tip patterns, angles, feed speeds and cutting speeds, contact the tool manufacturer.

4.4.4.6 Cement-bonded particleboard (CBPB)

Sawing

Sawing can be done with a cross cut handsaw or a jigsaw with a coarse blade but is preferably done with a power saw fitted with TCT blades.

Routing

Rebates and grooves should be cut with a heavy duty router (not less than 1200 watt input). Bits should be TCT or high speed steel tipped.

Drilling

Use a normal hand drill or a high speed power drill (not the percussion type). The drill bits should have high speed steel tips. When drilling, a support should be used to ensure a clean hole.

Sanding

Orbital or belt sanders are best although small areas can be sanded by hand. Disc sanders should only be used by skilled operatives as they score the surface easily. Panels can also be worked with mechanical planers to produce featured edge details suitable for joints.

4.4.4.7 Plywood

Sawing

The blade of a circular saw should enter the panel on the good face. This usually means that the panel is face down with a handheld saw and face up on a bench saw. TCT blades are recommended as the adhesives commonly used in plywood can lead to heavy wear. The panel should be supported as close as possible to the blade and best results will be achieved with:

- a fast material feed speed
- counter sawing (panel fed in opposite direction to the saw rotation)
- a minimum protrusion of the saw above the panel surface.

To minimise the risk of splintering the corners of the panel it is best if the cuts at right angles to the face grain are made first and those parallel to the face grain are made afterwards.

When using a band saw, the best results are achieved with the maximum saw speed and a slow feed speed.

Cutting speeds that have been found to be satisfactory are given in *Table 4.6*.

Table 4.6: Cutting speeds found to be suitable for plywood[2]

	Cutter speed	Feed rate
Circular saw	3000–6000m/min	31 m/min
Band saw	3000 m/min	1–7 m/min

Routing

TCT cutters are recommended in order to prolong tool life. A high cutter speed and slow material feed speed usually produces best results.

Drilling

To achieve a clean finish, drilling should start from the good face of the panel. Breaking out on the back of the panel can be avoided by drilling into a backing block.

Sanding

If a smooth surface is required, this can be achieved, depending on the veneer species and quality, by sanding parallel to the face grain with fine grade sandpaper.

4.4.5 Pre-finished and faced panels

For pre-decorated panels it is normal to cut down onto the decorated face. Chipping of the decorated surface can be eliminated by:

- using a saw with 10 or preferably more teeth per inch
- keeping a low angle of cut
- working to a knifed or scored line, the cut being made on the waste side of the line or placing masking tape on the decorated face over the intended line of cut. This makes marking easier (pencil lines can be readily drawn on the tape) as well as reducing chipping.

Face bevel and top bevel angles of saw blades may need adjusting for veneered or other faced panels.

When drilling through melamine faced panels the drill point angle should be between 80° and 90°.

It is recommended that plastic laminate veneered panels are reduced to finished component size by sawing and that spindling and routing cutters are only used on edges when the shape of the panel precludes sawing.

If it is necessary to rough cut oversize, careless cutting can cause hairline cracks in the surface which can lead to chipping on subsequent operations.

4.4.6 Health and safety

Cutting and machining of wood-based panels presents no more risk than that of any other material, provided that health and safety guidelines are followed. Further information on health and safety can be found in PanelGuide *Section 6*.

4.5 Fixing and installation

4.5.1 General

The method of fixing and installation can be critical to the satisfactory performance of wood-based panels in service. Panels can be fixed with nails, screws, staples, bolts, and other proprietary connectors or adhesives (sometimes in combination with fixings). It is important to consult manufacturer's literature in this respect and ensure that the fixing method is adequate for the end use.

Under the Construction Products Regulation[3], all dowel type fasteners (nails, staples, screws, dowels and bolts with nuts) that are manufactured from steel, and which are used in load-bearing timber structures, are required to comply with *BS EN 14592 Timber structures. Dowel type fasteners. Requirements*[4] and carry the CE mark, normally on the packaging. This will require the fastener manufacturer to declare a number of strength properties, one of which is 'characteristic head pull though'. This records the load required to pull the fastener through a wood-based substrate from the point side. OSB is often used as the testing substrate in this case.

4.5.2 Conditioning

Wood-based panels expand on taking up moisture and shrink on losing moisture, be it from or to the surrounding air or from other parts of a structure with which they are in contact. It is important that, prior to fixing, the panels are at a moisture content as close as possible to that which they will attain in service. See *Section 4.2.4* for further information.

4.5.3 Movement gaps

When full panels are fixed in place, it may be necessary to leave gaps at their perimeters to allow for expansion. Two alternative strategies are possible:

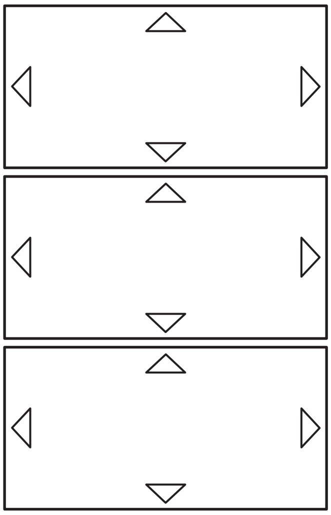


Figure 4.7a: Rigidly fixed panels with movement gaps at joints

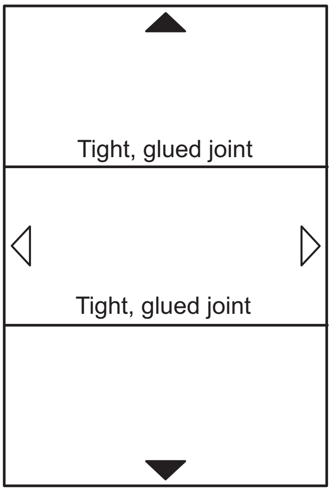


Figure 4.7b: Panels fixed as a composite unit with a movement gap at the perimeter

- If the panels are to be rigidly fixed (eg by adhesive or screws at relatively close centres) to their substrate, a 3mm gap should be left at all edges of each panel (except softboard where no gap is normally required), see *Figure 4.7a*.
- If adjacent panels are rigidly joined together (eg by a glued tongued and grooved joint), and are fixed to the substrate by a method which allows a small amount of movement, such as nails or by the use of angled battens in a wall lining, it is possible to treat a number of panels as a composite unit and transfer the total movement gap to the perimeter of the unit, see *Figure 4.7b*. As a general guide a perimeter gap should be equal to 2mm per metre run and a minimum of 10mm; however for different applications, for example flooring or wall sheathing, the relevant section of PanelGuide should be consulted for more detailed information regarding the size and positioning of expansion gaps.

The above guidance is based on normal practice and should prove adequate; if a manufacturer produces more specific guidance for their products then this should be followed.

4.5.4 Edge distances

Panels should generally be fixed so that all edges are fully supported by a tongued and grooved joint, a joist or by a noggin. Fixing centres for nails and other mechanical fasteners vary for each panel type and its intended use. In general, fixing centres are closer around panel edges than on intermediate framing.

For all panels, nails and other mechanical fasteners should not be inserted close to the panel edges as this can lead to ‘tear out’. Typical minimum edge distances are shown in *Table 4.7*, but the panel manufacturer’s recommendations should be followed if these are available. The minimum dimensions shown are affected by the type of fixing and panel thickness, and smaller dimensions can be achieved in some circumstances. If the dimension shown in the table is less than three times the diameter of the fixing, then the latter figure should be used.

It is necessary to adopt a fixing method which does not cause bow or distortion of the panel, especially with thin panels. It is usually advisable to start from one edge of the panel and work across, ensuring that the panel is kept flat.

4.5.5 Length of fixings

Fixings should have a minimum length of 50mm or 2.5 times the panel thickness, whichever is the greater. Where engineering design requires a certain fastener type and spacing, this must be adhered to.

Nails should generally be punched home by 2 to 3mm and screws countersunk where fixings are visible or are

Table 4.7: Minimum edge distances for fixings in panel face

Panel type	Minimum edge distance (mm)	Minimum distance from corners (mm)
Softboard	8	
Mediumboard	6	
Hardboard	6	
MDF	12	25
Particleboard	8	25
Flaxboard	8	25
OSB	8	25
Cement-bonded particleboard (CBPB)	15mm for panels <16mm thick 20mm for panels <22mm thick	40
Plywood	9	15

likely to cause inconvenience or danger if left protruding from the surface, for example in flooring or furniture.

4.5.6 Nails

There are many types of nail available, some are described below and are shown in *Figure 4.8*.

- **Panel pins** – are suitable for many applications where a concealed fixing is desirable but where there is no likelihood of a 'pull-off' force. They are often used in conjunction with adhesives to give temporary support while the adhesive cures.
- **Round lost head nails** – for flooring and carcassing work these are simply driven flush with the panel surface, but for concealment they should be lightly punched into the panel. Lost head nails are preferred for secret nailing through the tongue of tongued and grooved panels.
- **Headed nails** – headed types of nails are used for general purpose nailing where appearance is not the main factor and particularly where the panel needs to be held firmly against its substrate, in structural uses, or where there is a likelihood of a 'pull off' force being applied.
  The nail should be driven so that the head is tight against the panel since it is the head which provides the grip. If the panel is to be decorated the head may be driven into the panel slightly and then filled. Types include:
  - Round plain head nails: often called round wire nails, are usually made from bright steel, not treated against corrosion.
  - Lath nails: which have a larger head than round head nails and are usually galvanised.

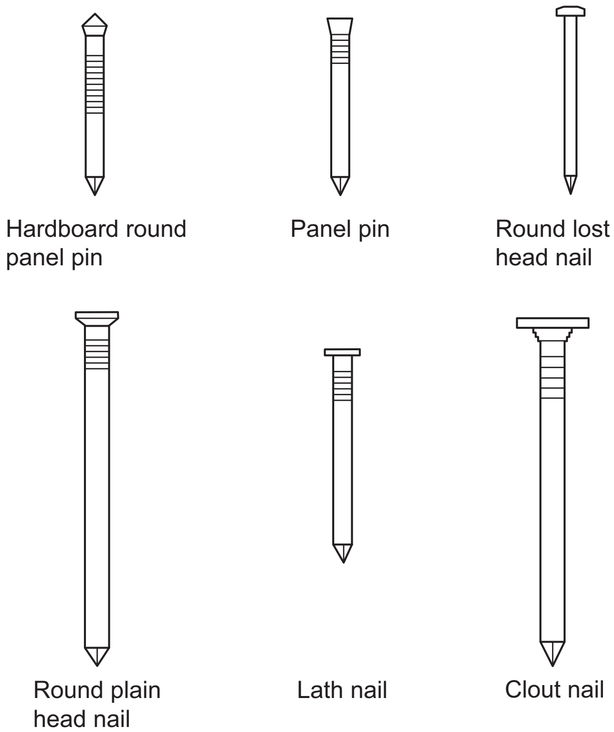


Figure 4.8: Examples of nail types

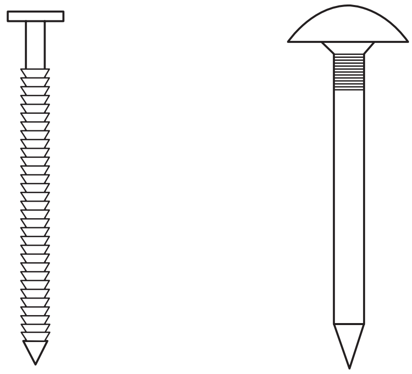


Figure 4.9: Examples of special nails

  - Clout nails: are generally thicker than round plain head nails, have broader heads and are usually galvanised. Because of the head size they are the preferred method of fixing softboard, particularly for structural applications (eg sheathing to timber frame construction).
- **Special nails** – these include nails with improved resistance to withdrawal, improved appearance and for power assisted insertion. Types include:
  - Improved nails including annular ringed shank and square twisted nails: ribs on the shank result in a fixing with improved resistance to withdrawal. They are also preferable in instances where vibration may loosen conventional nails, (eg in flooring) even though there is no axial load on the nail. Plain and non-corroding types are available.
  - Domed head nails: the shank may be plain or annular, though usually the latter. The head may be made from the same material as the shank (ie bright or stainless steel) or may be in an impact resistant plastic cap. These nails are used mainly with pre-decorated panels. For claddings the head is driven tight to the panel but not overdriven, so that any slight thickness swelling of the panel does not cause the nail head to rupture the panel surface.
  - Strip nails: many types of nail are now available in strips for use with electric or pneumatic nail machines.

4.5.7 Screws

Screws provide a higher strength fixing than nails or staples but can be more expensive and time consuming to install. Because of these factors it is customary to use, for a given installation, fewer screws per unit area. This may call for the use of a thicker panel than would be required with high density nailing or gluing. The use of screws is not therefore recommended in large areas of panel which have a thickness less than 6mm. The main types of screws used with wood-based panels are conventional woodscrews, parallel shank woodscrews and double threaded parallel shank woodscrews. For fixings into panels the parallel shank type screw is generally preferable. When screws are used for panel to panel fixings, a slightly oversize hole should be drilled in the uppermost panel.

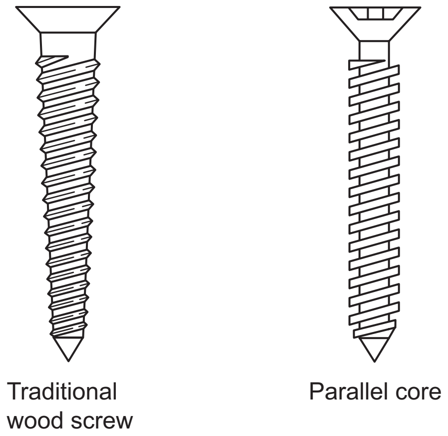


Figure 4.10: Screw types

4.5.8 Staples

Staples are usually simple thin wire U-shapes with two points. Variations include: staples made from thicker flat or oval wire, wide crowns up to 28mm, divergent shank and clinched staples (both of which improve pull out resistance) made from mild steel with protective coatings from stainless steel.

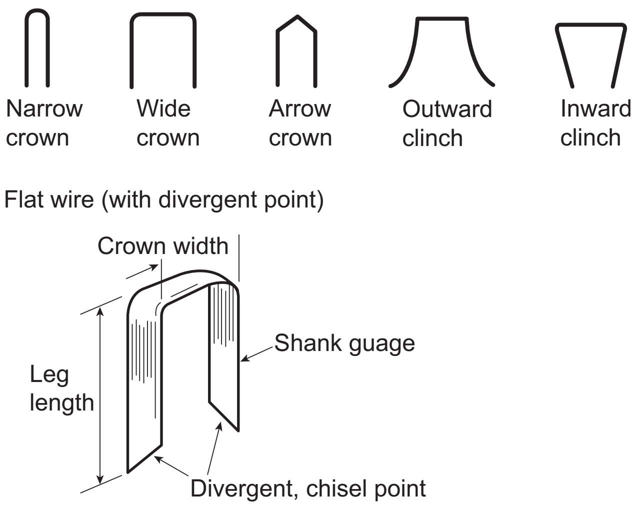


Figure 4.11 Staple types

4.5.9 Special fasteners

There is a wide range of proprietary fasteners designed for particular applications, for example to spread the load over a wider area, for fixing through the face of panels where there is no support behind for a conventional screw fixing and for demountable or knockdown fittings. Some types of fastener which provide a high degree of resistance to withdrawal require a fitting hole larger than the screw or shank diameter and thus lateral location will be less positive than with fasteners which expand or deform.

4.5.10 Adhesives

Adhesives are used for fixing panels in position, joining panels together, and fixing surface laminates, veneers or edge lippings.

Adhesives can be structural or non-structural, used alone or with mechanical fasteners. In the latter case, the mechanical fastener holds panels in position and provides bonding pressure while the adhesive cures.

Traditional animal-based glues have been superseded by the wide range of synthetic adhesives formulated for specific materials, application techniques and end-use requirements. The following notes provide general guidance on choice of adhesives for use with wood-based panels; for specific applications it is recommended that manufacturers and suppliers are consulted.

Adhesives groups include:

- Hot bitumen and bitumen based adhesives. These are used primarily for fixing impregnated softboard in roofing applications.
- Thermoplastics including hot melt adhesives and PVAC (polyvinyl acetate) emulsions. PVAC emulsions are a good general purpose adhesive for internal use in generally dry conditions. Modified PVACs with improved moisture resistance are also available. PVAC has no initial bond so materials must be held in position by clamping or pinning until the adhesive sets.
- Thermosetting resins, primarily formaldehyde-based synthetic resins of urea (UF), melamine (MF), melamine urea (MUF), phenol (PF), resorcinol (RF), resorcinol phenol (RPF) and epoxy resins.
  Formaldehyde-based resins are suitable for use as structural load-bearing adhesives. They can be cured by the application of heat but are available for setting at room temperature. They are available as gap-filling and close contact adhesives.
  UF and MF resins have limited weather resistance and should only be used in internal or protected situations; PF and RF resins have good moisture resistance and give good durability when exposed to the weather.
- Elastomers – solutions in organic solvents. Types include contacts and adhesives for use in thick glue lines of which SBR (styrene butadiene resin) emulsions are an example. Contact adhesives have good initial grab and do not require clamping or pinning before full bond is developed.
- Polyurethane adhesives (moisture curing adhesives) provide a water-resistant bond and some glues can have gap-filling capabilities depending on the formulation of the adhesive.

There are also numerous proprietary products available, often for specific purposes.

In selecting an adhesive some performance aspects to consider are:

- Strength.
- Moisture resistance and long-term durability.
- Ease of use: some adhesives require mixing at the point of use; some require the application of pressure until the bond has developed fully; some applications require the ability to reposition the panel; some have

more arduous health and safety requirements (always obtain a material safety data sheet for the specific adhesive used and follow the guidance therein).

- Curing times.
- Compatibility with panel binders and coatings or impregnation.
- For thin panels, adhesives with fillers may not spread sufficiently when the panel is pressed into position and the spreading pattern of the adhesive may 'grin' through the panel.

4.5.11 Fixing requirements for different products

The above guidance is generally applicable to most wood-based panels, but some particular types have special requirements. The following sections outline some of these, but reference should also be made to any specific guidance provided by the panel/fixing manufacturer.

4.5.11.1 Fixing softboards

Softboards can be fixed with nails, staples and screws; the type used will depend upon the end use. Nails with large heads are recommended and screws should be fitted with cups. Softboard can be bonded with most types of woodworking adhesive and with bitumen adhesives for applications such as roofing. Due to their low density, softboards will not hold fixings satisfactorily when these are loaded. An appropriate type of cavity fixing which will spread the load should be considered.

4.5.11.2 Fixing hardboards and mediumboards

Hardboards can be fixed with panel pins, nails, staples and screws; the type used will depend upon the end use. Screws through thinner hardboards should have cups if 'pull through' is a possibility.

Hardboard and mediumboard can be bonded with most types of woodworking adhesives. Fixings into hardboard and mediumboard should generally use cavity fittings.

4.5.11.3 Fixing MDF

MDF can be fixed with nails, staples and screws. The type of nail used will depend upon the panel thickness and end use. Pilot holes should be drilled for screw fixings. The hole diameter should be larger than those recommended for solid wood and particleboard; typically the holes should be 85 to 90% of the screw core diameter. Fixings into the panel face should not be nearer than 12mm from edges nor 25mm from corners. Screws into the panel edge should be not less than 70mm from corners (see *Figure 4.12*).

MDF can be bonded with all types of woodworking adhesive. The type selected will depend on end use.

MDF provides good holding power for screw fixings into panel faces and edges. Parallel core screws have greater holding power than conventional woodscrews and are recommended for this purpose. A high overall diameter to core diameter ratio is desirable. Nails and staples can

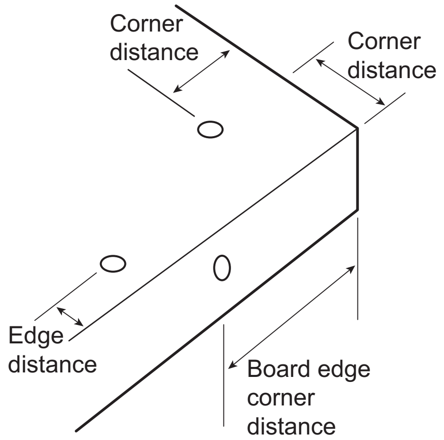


Figure 4.12: Fixing positions

be used for lightly loaded fixings or to hold glued joints while adhesive sets. Edge and corner distances should be as shown above.

Dowel joints can be satisfactorily used with MDF. Multi-grooved dowels are recommended. Dowels and holes should have an 'interference' fit, ie of such size that the dowel can be pushed home by hand but, even without adhesive, not sufficiently loose that it can fall out. Some tolerance must be allowed on the dowel diameter, typically up to 0.2mm oversize. It is desirable to allow for this when drilling the holes. Recommended dowel sizes for different thicknesses of panel are given in *Table 4.8*.

Table 4.8: Dowel diameters (mm) for joints in MDF

Panel thickness (mm)	Dowel diameter (mm)
15 or less	6
16 to 24	6 or 8
25 or more	10

4.5.11.4 Fixing particleboard and flaxboard

Particleboard can be fixed with nails, staples, screws and glue (proprietary systems only). The type of nail used will depend upon the panel thickness and end use. Pilot holes should be drilled for screw fixings. Fixings into the panel face should not be nearer than 8mm from edges nor 25mm from corners.

Particleboard can be bonded with all types of woodworking adhesive. The type selected will depend on end use. Some manufacturers offer proprietary fixing systems (generally for flooring) using glues or a combination of glue and fixings.

Particleboard provides good holding power for screw fixings into panel faces. Parallel core screws are preferable as they have greater holding power than conventional wood screws. Nails and staples can be used for lightly loaded fixings or to hold glued joints while the adhesive sets.

Dowel fixings can be used with particleboard, although they are generally used as a location device in conjunction with appropriate adhesives. They should normally be inserted at 150mm to 200mm centres and penetrate no more than two thirds of the panel's thickness.

4.5.11.5 Fixing cement-bonded particleboard (CBPB)

Panels can be fixed with nails or screws, but because of their high alkalinity, these should be in stainless steel or should be galvanised. Panels up to 12mm thick can be nailed through the face by hand without pre-drilling, thicker panels should be predrilled. Pre-drilling is not required for power nailing.

Pre-drilling is required for screw fixings except when power screwing is used. Where the panel is on the head-side (eg panel on floor joists where floor joist is point-side) of the joints, holes should be slightly oversize to the screw diameter. Edge distance for fixings should not be less than 15mm for panels up to 16mm thickness, not less than 20mm for panels over 16mm and up to 22mm thickness.

CBPB of the appropriate thickness is a suitable substrate for screw fixings.

Because of the relatively high alkalinity (pH) value of CBPB, PVAC and resorcinol adhesives are usually recommended. The panel manufacturer's advice should be sought.

4.5.11.6 Fixing OSB

OSB can be fixed with nails, staples and screws. The type of nail used will depend upon the panel thickness and end use. Pilot holes should be drilled for screw fixings. Fixings into the panel face should not be nearer than 8mm from edges nor 25mm from corners. Edge and corner distances should be as shown in *Figure 4.12*.

OSB can be bonded with all types of woodworking adhesive. The type selected will depend on end use.

OSB provides good holding power for screw fixings into panel faces. Parallel core screws have greater holding power than conventional woodscrews. Nails and staples can be used for lightly loaded fixings or to hold glued joints while adhesive sets.

4.5.11.7 Fixing plywood

Plywood can be fixed by nails, screws, staples or by gluing, depending upon the application and requirements. There are also proprietary fixing systems available. Glued joints provide a higher degree of stiffness than most mechanically fastened joints but it is important that the glue type is appropriate to the end use.

The cross-laminated structure of plywood means that fixings can be inserted quite close to the edges of panels.

4.6 Joints and joint details

4.6.1 Conditioning

Timber and wood-based products expand on taking up moisture from the air and shrink on losing moisture. It is important that panels are installed at a moisture content close to that which they will achieve in service. Such panels must then be given sufficient protection throughout the construction process to maintain this in-service moisture content. *Section 4.2.4* provides further guidance on this topic.

4.6.2 Panel to panel joints

All joints should allow for the small dimensional changes which can occur in the panels, substrate or fixing as a result of changes in temperature and relative humidity. This will be more apparent in external cladding and sheathing than in internal linings where the initial movement to equilibrium moisture content may be the only dimensional change. In certain circumstances it is possible to produce a flush joint (or joints) between several panels without allowing for movement, providing an appropriate allowance is made around the composite panel.

- Joints on internal wall and ceiling linings need to be visually acceptable.
- Joints in external sheathing need to be watertight and airtight as well as providing adequate rigidity for the structure.
- Joints in external cladding need to be visually acceptable and protect the structure beneath from exposure to wind and rain but avoid retention of moisture within the joint, the adjacent panels or any cavity behind.
- Horizontal joints need to be particularly effective, especially at the head of walls or where a façade is interrupted by windows and other openings.
- Joints on surfaces which will be painted need to allow for maintenance of the surface coating within any recesses formed.

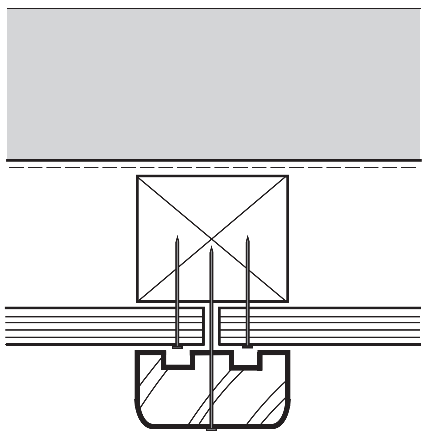


Figure 4.13: External cladding joint sealed with non-setting sealant, backed by foam breaker strip, and with timber cover strip to the joint

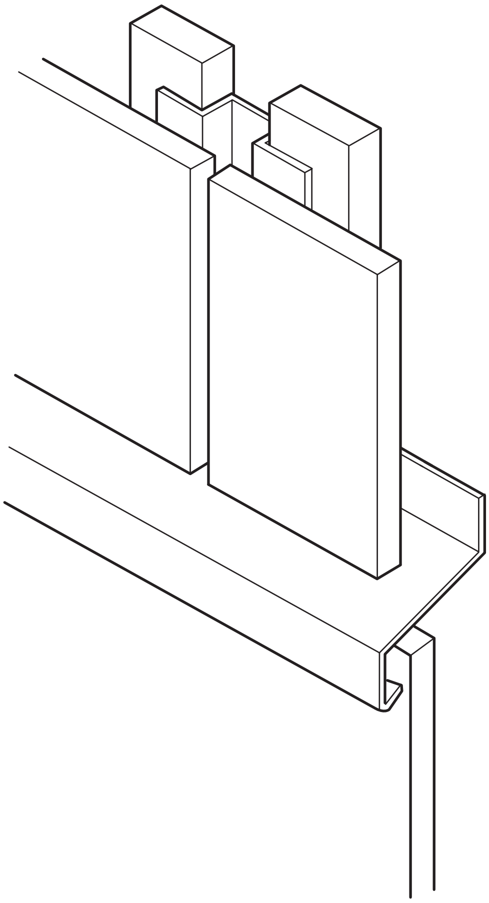


Figure 4.14: Vertical and horizontal external cladding joints using pressed metal 'top hat' and drained bottom bead profiles to allow drained and ventilated cladding

4.6.3 Lining and cladding joint types

As changes in relative humidity result in slight movement in all wood-based panels, it is preferable to design joints in linings and claddings to accommodate this.

Featured joints include: tongued and grooved joints, lapped joints, open or gapped joints, covered with plastic, metal or timber cover strips, or filled with matching or contrasting sealants.

It is important to consider internal and external angles and the relationship with horizontal joints to be used.

Figure 4.13 and *Figure 4.14* show two examples of external cladding joints, one of which is a sealed and bedded joint and the other is a drained and ventilated arrangement. In *Figure 4.13*, the foam breaker strip serves to prevent the sealant adhering to the batten.

Figure 4.15 illustrates a number of alternative internal lining joints where more variation is possible due to the less critical environment to which they are exposed. If internal lining joints are subject to moisture from washing down or similar cleaning, it is suggested that a sealed and bedded joint should always be used.

4.6.4 Carcase joints

Glued joints and proprietary 'knock down' fittings can be used with MDF, particleboard and OSB in the manufacture of furniture and fittings. Joints can be made as unobtrusive as possible, using flush face or edge joints

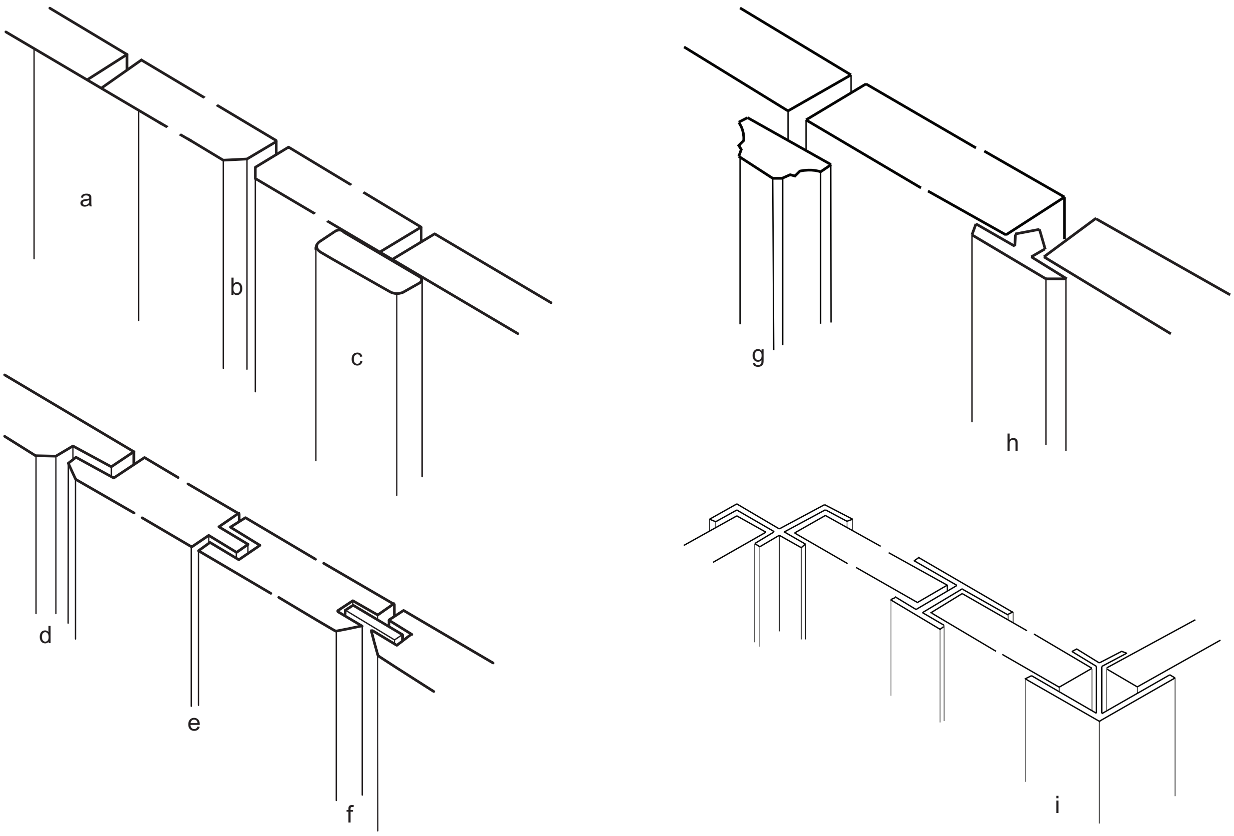


Figure 4.15: Typical internal lining joints
a) butt joint with scrim for plaster skim finish, b) butted V joint for face fixing, c) butt joint with cover strip, d) rebated V joint for face fixing, e) secret fixed tongued and grooved joint, f) V joint with loose tongue, g) butt joint with moulded timber or MDF cover trim, h) butt joint with push fit metal or plastic trim, i) proprietary aluminium or plastic joint system,

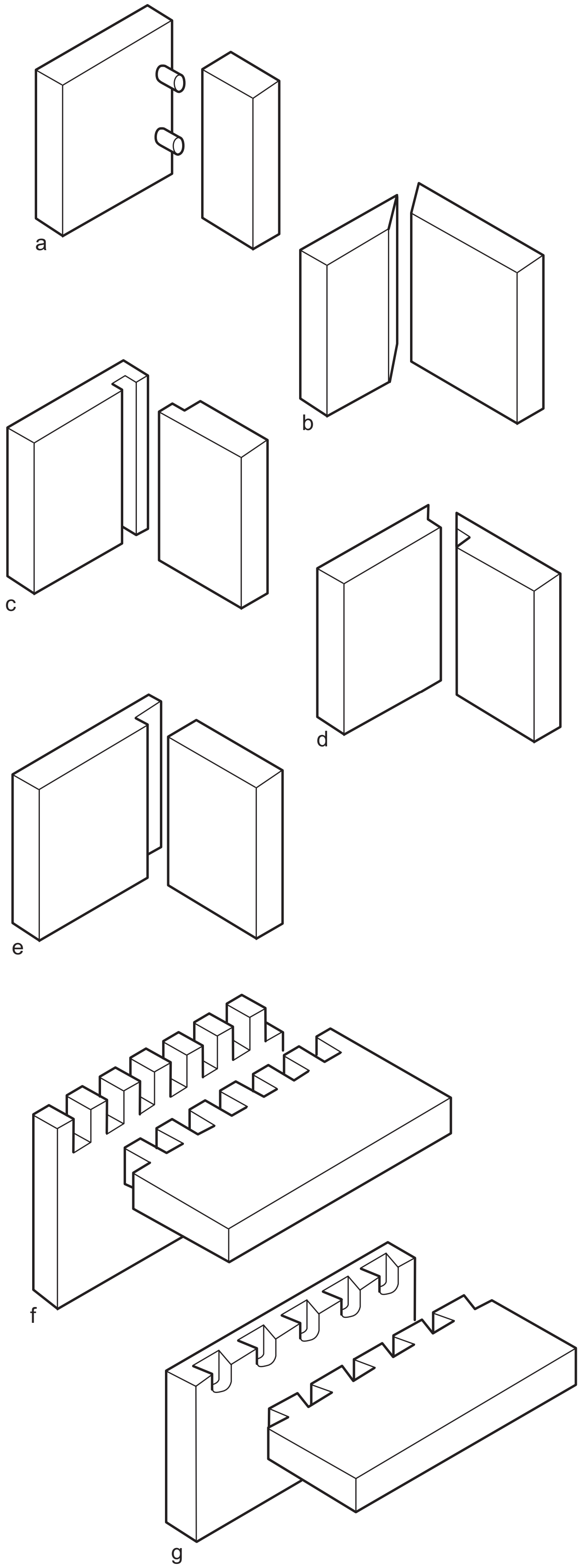


Figure 4.16: Typical joints used in furniture construction
a) dowels
b) mitre
c) tongue and groove
d) lapped mitre
e) rebate
f) comb unit
g) stopped machine dovetail

where only the glue/joint line is visible, or featured by using the component parts to emphasise the joint or by profiling or rebating adjacent to the joint. Examples of joints are shown in *Figure 4.16*. When knock down fittings are used, those which depend upon expansion of a component into the panel edge should be avoided as they can cause delamination of the panel.

Many of the joints used in traditional woodwork can also be used with particleboard and MDF including comb joints, dovetails and tenons.

Provided that edges have been cleanly cut, a plain butt or mitred glued joint provides adequate strength for many situations where the joint remains dry. However, some means of ensuring accurate locations of the components to be joined is often useful in assembly; for example, a rebate, a loose tongue, a biscuit insert or dowels may be incorporated in a straight butt or a mitred joint. Such devices generally assist in locating the components and add to the strength of a joint. Joints may also be held together while the adhesive sets using nails or pins.

Mitre and butt joints are generally not suitable in situations of high or variable moisture content, where movement can lead to failure of the joint.

The width of grooves machined into the edge of panels should not normally exceed one third of the panel thickness and grooves in the depth of the panel should not generally exceed half the panel thickness.

Tongues, biscuits and dowels should fit easily into holes or grooves in the edge of panels, as tight fitting inserts can result in delamination of the panels. Dowels should preferably be of the multi-grooved type and a hole diameter 0.2mm larger than the dowel is generally recommended. The depth of the hole or grooves should also be slightly more than the penetration depth of the insert. Normal woodworking adhesives can be used.

Screw fixings can be made into the faces of particleboard and OSB and the faces and edges of MDF and cement-bonded particleboard. Parallel core screws give better holding performance than traditional woodscrews. Screw fixings should generally have pilot holes. See *Section 4.5* for further information.

4.6.5 Edging and lipping

Particleboard and MDF panels can be finished with decorative edging or lipping to hide or protect the core material, or to match or complement the surface finish. These can be glued or mechanically fixed. Some examples are shown in *Figure 4.17*.

Edge finishes include:

- Edge veneers – provided that the edge has been cleanly cut, further treatment of the edge surface is usually unnecessary. Veneers can be applied by hand or machine.

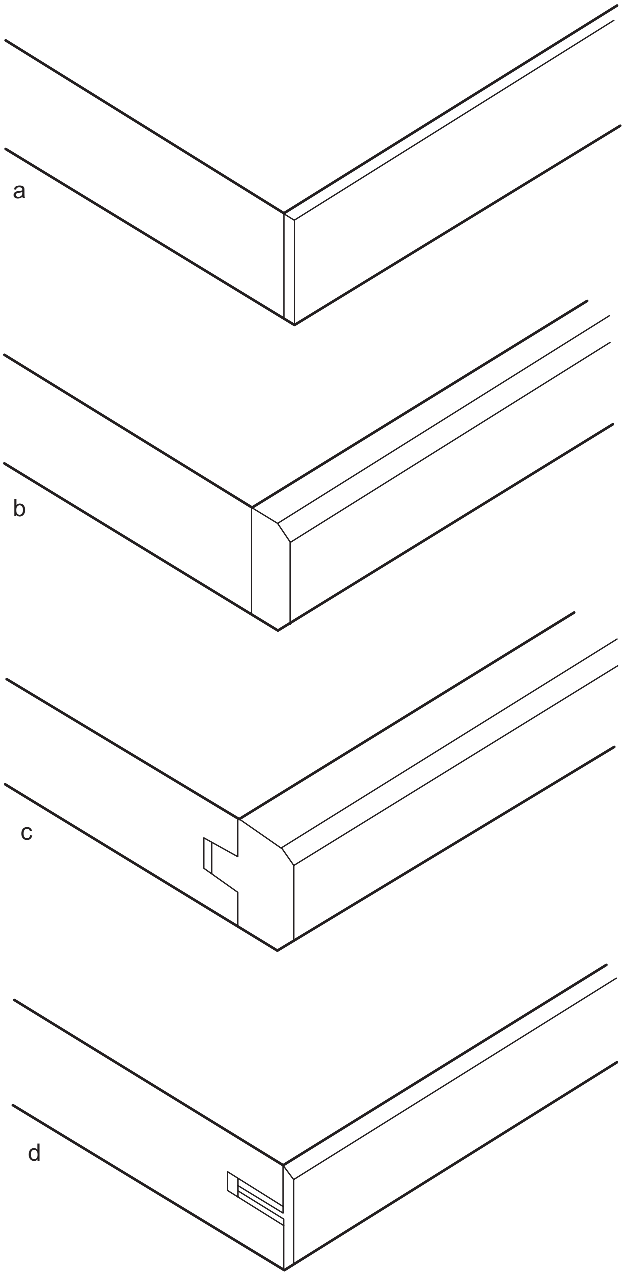


Figure 4.17: Typical edging details
a) edge veneer
b) solid lipping; butt joint
c) solid lipping with tongue
d) toothed metal or plastic lipping

- Solid lipping – these can be glued on with a butt joint, or have a tongue to facilitate location. Lipping is normally applied after panel surfaces are veneered or laminated. Lipping can be applied before veneering or laminating if required, the adhesive should be allowed to harden completely before veneering and sanded down to avoid 'show through' at the glue line.
- Metal or plastic trims – commonly used with laminate finished panels – these can either have a toothed tongue on the back which is pressed into a thin groove in the panel edge, or be face pinned or screwed.
- Profiled edge – the edges of some wood-based panels, especially MDF, can be accurately profiled to a very high standard and can be sealed and painted or veneered to match the face surfaces.

4.7 Decoration and finishing

4.7.1 General

All wood-based panels (except bitumen impregnated fibreboards) provide suitable substrates for paints, stains, varnishes and textured coatings.

Lining materials such as wallpaper, hessian and other fabrics can also be applied providing an appropriate adhesive is used, but they are not generally used on MDF or OSB.

Hardboards, mediumboards, MDF, particleboard, flaxboard, OSB and plywood can be veneered and laminated with high and low pressure laminates, paper and PVC foils, although not all of these can be applied to all types of fibreboard and particleboard. The most common combinations are shown in *Table 4.9* below.

Some types of panel are available pre-decorated or with applied finishes.

4.7.2 Conditioning

Timber and wood-based products change dimensions (length, width and thickness) in response to atmospheric moisture gain and loss – they expand on taking up moisture from the air and shrink on losing moisture. It is

Table 4.9: Suitability of finishes

	Water-based paint	Oil-based paint	Varnish	Stain	Wallpaper fabrics	Plastic laminates	Wood veneer	Foils
Softboard	✓	✓			✓			
Mediumboard	✓	✓			✓	✓	✓	✓
Hardboard	✓	✓			✓	✓	✓	✓
MDF	✓	✓	✓	✓	✓	✓	✓	✓
Particleboard	✓	✓	✓	✓	✓	✓	✓	✓
Flaxboard	✓	✓	✓	✓	✓	✓	✓	✓
OSB	✓	✓	✓	✓			✓	
CBPB	✓	✓			✓	✓	✓	✓
Plywood	✓	✓	✓	✓	✓	✓	✓	✓

Key : ✓ = suitable

Table 4.10: Suitability of adhesives for applying coatings

Adhesive type	Wood veneer	Plastic laminate veneer	Paper foil laminate	PVC foil laminate	Wallpaper, hessian etc
PVAC	✓	✓	✓		
UF	✓	✓	✓		
Neoprene		✓			
Copolymer EVA			✓	✓	
Epoxy				✓	
Polyurethane				✓	
PVAC-based wallpaper adhesive					✓

Key : ✓ = suitable
Note: The alkalinity of cement-bonded particleboard precludes the use of some types of adhesive. The manufacturer's advice should be sought.

important that panels are installed and/or finished at a moisture content close to that which they will achieve in service (see *Section 4.2.4* for further information).

4.7.3 Adhesives

When applying veneers, laminates, paper and PVC foils to fibreboards and particleboards it is essential to select adhesives appropriate to the materials, the scale of the operation and the facilities available to carry out the work. Materials suitable for large-scale factory application are not necessarily suitable for use on site. *Table 4.10* includes general guidance on suitable adhesives, and manufacturer's advice should be sought for further information.

The use of water-based adhesives for applying wallpaper and similar finishes may result in panel distortion, fibre swelling and/or edge swelling unless panels and joints are sealed first.

4.7.4 Painting and sealing

Virtually all paints have a tendency to draw away from a sharp edge or corner. It is therefore recommended that all corners and edges be rounded to a radius of at least 3mm, by machining or light sanding, to enhance paint retention. This is particularly important with panels exposed to exterior conditions.

Where appropriate types of wood-based panels are used, for example as external cladding, infill panels or soffits, it is important that the finish applied is suitable for external use and provides the required protection to the panel. Paints and stains formulated for external use on natural timber can be used on wood-based panels. These should be applied in accordance with the manufacturer's instructions.

The edges of most panel types are more porous than the panel surfaces. As a result, absorption at the edges is greater than on the face and if panels are subject to a changing humid or exterior climate, care must be taken to ensure that the edges are adequately sealed.

For exterior conditions, it is particularly important that all surfaces are effectively sealed before the application of the primer and top coats. Refer to the panel manufacturer or sealant manufacturer's literature for recommendations.

Dry film thickness (build) is critical to performance of a paint coating. Simply applying enough paint to hide the colour of the substrate is not adequate and manufacturer's guidelines should be followed.

Some flame retardant treatments are very alkaline and treated panels may need a special primer before painting. The same is true for cement-bonded particleboard.

Once properly sealed and primed, most wood-based panel products can be top coated with an exterior coating suitable for wood products. The top coat should be applied to all surfaces and edges in accordance with the paint manufacturer's recommendations. Several thin coats of paint normally gives a better performance than a single thick coat, but each coat must be allowed to dry thoroughly before the application of the next.

Under exterior conditions, the following points are particularly important:

- All uncoated edges or surfaces of prefabricated components must be fully coated prior to assembly or exposure to weathering.
- To aid with edge sealing, all edges must be rounded to a minimum 3mm radius.
- Solvent-based sealers are particularly recommended for initial coating of the panel. Water-based sealants may lead to raising of fibres, requiring re-sanding after drying, before subsequent coats.
- Some types of transparent stains are not recommended as they allow degradation by ultra-violet light. Exterior coatings should contain a suitable UV inhibitor.
- The design of components should eliminate potential areas of water collection.
- Both sides of the panel should be evenly coated. Otherwise, differential moisture changes on the two sides of the panel may lead to distortion.

- Mitre joints are not recommended due to the difficulty in coating sharp edges. Edge to face joints offer a similar aesthetic appearance with improved coating and edge protection.
- A coating maintenance programme in accordance with the coating manufacturer's recommendations should be adopted in order to ensure maximum life from the panels.

4.7.5 Ceramic tiling

Ceramic tiling be can successfully applied to wood-based panels in all manner of different situations, but care has to be taken in order to achieve adequate performance.

This is for two reasons:

- Ceramic tiling provides a rigid coating and requires a rigid substrate to prevent cracking of the tiling. This is especially true for floors, because of the movement under load.
- Wood-based panels are subject to changes in dimension as a result of changes in moisture content. This can lead to cracking of the tiling. Also different wood-based panel products will behave differently with respect to the amount of moisture movement they exhibit.

As ceramic tiles tend to be used in areas subject to regular or accidental wetting, such as kitchens and bathrooms, special care should be taken to avoid problems and all use situations should be approached with caution.

The guidance in *BS 5385-1 Wall and floor tiling. Design and installation of ceramic, natural stone and mosaic wall tiling in normal internal conditions. Code of practice*[5] and *BS 5385-3 Wall and floor tiling. Design and installation of internal and external ceramic tiling in normal conditions. Code of practice* [6] and publication *Tiling to timber sheets and board, timber substrates and alternative products*[7] should be consulted for further detailed information on various end-use situations from dry to prolonged contact with water.

4.7.6 Finishing softboard

4.7.6.1 Surface coatings

Softboard can be painted with conventional oil-based and water-based paints, applied by spray, brush or roller. Matt or satin finishes can be obtained. Panels should be brushed free of dust before decoration commences. No rubbing down of the surface should be required.

Natural and ivory faced panels should have a primer or sealer coat applied, a 50/50 mix of emulsion paint and water is suitable for this purpose. White primed softboards can be painted without using a sealer coat.

If further coating is applied, an alkali resisting primer is required and the panel or paint manufacturer's advice should be sought.

If panel edges will be visible after completion it may be necessary to fill these with a wood or cellulose filler prior to the application of finish.

Textured coatings can also be applied. Care is needed in detailing panel joints which should be either scrimmed and filled or featured by leaving small gaps between adjacent panels. Coating manufacturer's recommendations regarding priming of panels should be closely followed. After joint treatment, the paint is applied and textured (stippled, combed etc). The edges are normally finished by using a small brush to produce a plain margin.

4.7.6.2 Paper and fabric finishes

Softboard can be faced with materials such as textured paper, fabric or hessian. This is best done after the panels are fixed into place. When selecting a softboard for wallpapering, the types that have a fine pulp overlay are preferable as these usually have a smoother surface than natural softboard. When using wallpaper, care is necessary to avoid movement at panel joints causing splitting or rucking in the applied finish; a robust textured paper material is usually preferable. When bonding on paper or fabric finishes, the panel will require 'sizing' to prevent excessive absorption of adhesive and to make it easier to remove the lining material at a later date. ('Sizing' is a decorating term which means sealing the surface with a coating of adhesive that is allowed to dry before application of the wallpaper.)

4.7.7 Finishing mediumboard and hardboard

4.7.7.1 Surface coatings

Mediumboard and hardboard can be painted with conventional oil-based and water-based paints, applied by spray, brush or roller. Matt, satin or gloss finishes can be obtained. Little preparation of the surface should be required, dust and grease should be removed from the panel, if necessary using white spirit.

Panels should have a primer or sealer coat applied, this can be a proprietary hardboard sealer or a coat of emulsion paint. Some types of oil-tempered hardboard (which contain natural or added oils) require priming with an aluminium primer or multi-purpose primer.

If panel edges will be visible after completion, it may be necessary to seal these with hardboard sealer or with a wood or cellulose filler prior to the application of the finish.

Textured coatings can be applied but care is needed in detailing panel joints which should be either scrimmed and filled or featured by leaving small gaps between adjacent panels (see *Section 4.5.3* for further information). Coating manufacturer's recommendations regarding preparing and priming of panels should be closely followed. After joint treatment, the paint is applied and textured (stippled, combed etc). The edges are normally finished using a small brush to give a plain margin.

4.7.7.2 Paper and fabric finishes

Hardboard and mediumboard can be faced with materials such as fabric or hessian. This is best done after the panels are conditioned and fixed into place. When using wallpaper, care is necessary to avoid movement at panel joints causing splitting or rucking in the applied finish; robust textured papers and materials are usually preferable. When bonding on paper or fabric finishes, Type MBL mediumboard should be 'sized' before application. For all types of hardboard or mediumboard it is advisable to seal the panel surface first with an acrylic primer or hardboard sealer so that subsequent removal will be easier.

4.7.7.3 Laminates, foils and veneers

Plastics, laminates, foils and veneers can be bonded to hardboard without pre-treatment. Care is necessary to ensure that all materials have similar moisture contents and balancing laminates or veneers will generally be required to avoid panel deformation.

4.7.8 Finishing MDF

4.7.8.1 Opaque surface coatings

MDF can be finished with a wide range of opaque coatings. The surfaces to be finished should be free of dust or sanding marks. The faces of MDF are pre-sanded with 120 grit abrasive which provides a smooth surface suitable for most opaque finishes without further sanding. The use of 200 or 320 grit papers may be advisable when using high gloss finishes or when a minimum coating thickness is required.

Opaque paints are the easiest finishes to apply as their high solids content allows a high build. A base coat and a finish coat are usually all that is required. Pigmented systems can provide single colour finishes; more specialised techniques and lacquers can enable metallic marbled and other finishes to be obtained. The selection of the finishing system will be dependent upon the scale of production, application equipment, drying facilities and the expected performance of the finish in use.

Good results can be obtained using conventional oil-based or water-based paints. Better results can be achieved in a shorter time using lacquers based on nitrocellulose, acid catalysed resins, polyurethane or polyester resins applied by hand spray.

High gloss finishes can be obtained using a high build coating based on polyester resins, possibly with a clear lacquer top coat to protect the surface and enhance the gloss effect.

Panel edges may require sealing with shellac, polyurethane, diluted PVAC, or specially formulated high solid sealers to compensate for their greater absorption.

Flame retardant panels are available to meet Euroclass B or C requirements. If further coating is applied to these, the panel or paint manufacturer's advice should be sought as the coating may affect the reaction to fire properties.

4.7.8.2 Satin or lacquer finishes

Clear lacquers and varnishes can be used on MDF. Application and preparation is similar to that for pigmented finishes. When coloured translucent finishes are required, decorative stain finishes can be used. Solvent-borne stains will wet the surface effectively and ensure an even colour; water-borne stains can also be used but the waxes sometimes added to the hardboard and MDF to reduce water absorption may result in uneven absorption of stain and consequent colour variation. Stained surfaces can be protected by one or two coats of clear lacquer with a light denibbing between coats using 320 grit paper.

As the edges of MDF are more absorbent than surfaces, stain finishes applied to edges may result in darker colours compared to surfaces. Edges can be sealed before staining, using shellac, polyurethane, diluted PVAC or specially formulated high solid sealers to reduce this effect.

4.7.8.3 Laminates, foils and veneers

MDF can be surfaced with plastic laminates, paper and PVC foils and veneers. Wood veneers and foils can also be applied to shallow profile surfaces. Balancing laminates or veneers will generally be required to avoid panel deformation. The inherent smooth surface of MDF also allows heat transfer foils to be applied to both the face and profiled edges of the panel.

4.7.9 Finishing particleboards and flaxboards

4.7.9.1 Opaque surface coatings

Particleboard can be painted with conventional oil-based and water-based paints applied by spray, brush or roller. Matt, satin or gloss finishes can be obtained; textured coatings may also be applied. In order to achieve a high quality paint finish, panels may require filling prior to painting since, although the surface appears to be smooth, it can contain small holes and interstices which become noticeable when paint is applied. Before applying a filler, the panel should first be primed. A normal plaster-based filler is then applied and rubbed down to give the desired surface.

Panels with especially fine surfaces are available and these provide an excellent surface for painting and grain printing without additional filling.

Panels should have a primer or sealer coat applied; conventional wood priming paints are suitable. Water-based primers may cause the surface of the panels to swell slightly giving a textured surface which will not accept gloss finishes satisfactorily.

Flame retardant panels are available to meet reaction to fire Euroclass B or C requirements. If further coating is applied to these, the panel or paint manufacturer's advice should be sought as the coating may affect the reaction to fire properties.

If panel edges will be visible after completion it may be necessary to fill these with a wood or cellulose filler, sand with 180 grit paper and prime prior to the application of finish.

4.7.9.2 Clear seals and varnishes

The surface pattern and colour of particleboards is naturally decorative and the application of a clear sealer or varnish can accentuate this.

For floors, a translucent or transparent flooring grade sealer will provide an excellent hard-wearing and decorative surface.

4.7.9.3 Paper and fabric finishes

Particleboard can be faced with materials such as wallpaper, fabric or hessian. This is best done after the panels are fixed into place and joints between panels should be featured to avoid the potential for splitting or rucking of the finish as a result of slight movement of the panel due to changes in moisture content. It is advisable to seal the panel surface with an acrylic primer or sealer before applying the finish so that subsequent removal will be easier.

4.7.9.4 Laminates, foils and veneers

Plastics laminates, foils and veneers can be bonded to particleboard without pre-treatment. Care is necessary to ensure that all materials have similar moisture contents and balancing laminates or veneers applied to front and back surfaces will generally be required to avoid panel deformation.

4.7.9.5 Finishing flaxboard

Flaxboard can be veneered or faced with laminates in the same way as wood particleboard. It can also be painted and have vinyl or paper overlay applied, but it is not generally used in applications where these types of direct finishing are required.

4.7.10 Finishing OSB

4.7.10.1 Opaque surface coatings

Oriented strand board can be painted with conventional oil-based and water-based paints applied by spray, brush or roller; textured coatings may also be applied. As water-based finishes cause slight increase of the surface texture and may, when the coating is applied to one face only, result in bowing due to moisture uptake, their use should generally be limited to situations where final appearance is not of paramount importance. Oil-based coatings are recommended where appearance is critical.

Where a high-quality finish is required, factory sanded panels should be used. When using unsanded panels it is necessary to rough sand the surface to remove any loose wafers and resin deposits before applying a surface coating.

Panels should have a primer or sealer coat applied, and conventional wood priming paints are normally suitable. Water-based primers may cause the surface of the panels to swell slightly giving a textured surface which will not accept gloss finishes satisfactorily.

Panels can be impregnated or surface treated with intumescent paint or varnish to upgrade surface spread of flame performance. If a further coating is applied, the manufacturer's advice should be sought as the coating may affect the reaction to fire properties.

If panel edges will be visible after installation, it may be necessary to fill these with a wood or cellulose filler, sanding and priming before application of the finish.

4.7.10.2 Clear seals and varnishes

The surface pattern and colour of OSB is naturally decorative and the application of a clear sealer or varnish can accentuate this. If required it can also be coated with spirit-based decorative stain finishes. Factory sanded panels should be used and oil-based sealers and varnishes are preferred as these will not raise the surface texture.

For floors, a translucent or transparent flooring grade sealer will provide an excellent hard-wearing and decorative surface.

4.7.10.3 Laminates and foils

Plastic laminates and foils can be bonded to factory sanded OSB without pre-treatment. Care is necessary to ensure that all materials have similar moisture contents; balancing laminates applied to front and back surfaces will generally be required to avoid panel deformation.

4.7.11 Finishing cement-bonded particleboard (CBPB)

4.7.11.1 General

Due to alkalinity of the panels an alkali resistant finish is recommended. The advice of the panel or finish manufacturer should be sought.

Provided that a special primer is used, CBPB can be painted with conventional oil-based and water-based paints applied by spray, brush or roller; cement-based paints and textured coatings may also be used.

Before applying any finish, dust should be removed from the panel surface using a damp cloth and any holes or surface damage filled with a proprietary filler.

4.7.11.2 Laminates, foils and veneers

Plastic laminates and veneers can be bonded to CBPB. Factory calibrated panels must be used and balancing laminates or veneers are required to avoid panel deformation.

Due to the panel's alkalinity, the manufacturer's advice should be sought with regard to suitable adhesives.

4.7.11.3 Tiling

Before the application of ceramic tiles to CBPB, the rear face of the panel should be sealed using an approved sealer. The tiling adhesive used must be an elastic emulsion adhesive. Reference should be made to the panel manufacturer for specific recommendations. Further guidance can also be found in The Tile Association guidance (www.tiles.org.uk).

4.7.12 Finishing plywood

4.7.12.1 General

As one of the few wood-based panels suitable for permanent use in exterior conditions, the requirements for finishing plywood are more complicated than for most of the other panel types. In interior conditions, most wood finishes are suitable for use on plywood, but the quality of the finish will be a function of the wood species and the quality of the surface veneer. A European guidance standard, *DD CEN/TS 635-4 Plywood. Classification by surface appearance. Parameters of ability for finishing, guideline*[8] gives guidance on the finishing of plywood in relation to the quality of the surface veneers.

Under exterior conditions, plywood will weather to a dull grey colour in the same way as unprotected solid timber. Further weathering can lead to a loss of fibre and checking and splitting of the surface. The application of a suitable finish before weathering occurs can protect the material and enhance its appearance. When used externally, all four edges of plywood should be effectively sealed with a suitable sealing compound.

4.7.12.2 Opaque surface coatings

Plywood can be painted with most types of wood paints but some of these may be unable to tolerate the surface movements of plywood. Some water-based acrylic paints show high levels of extensibility and can tolerate these movements. However, dark colours of such paints should not be used in areas sheltered from rainfall as salt efflorescence can appear on the surface. Low-build exterior wood stains possess certain advantages over film-forming finishes by being more able to cope with the behaviour of exposed plywood. Exterior wood stains will not prevent surface checking but are less likely to flake off than paint. Redecoration with a stain will protect the checked surface and should maintain an acceptable appearance.

Flame retardant panels are available to meet reaction to fire Euroclass B or C requirements. If further coating is applied to these, the panel or paint manufacturer's advice should be sought as the coating may affect the reaction to fire properties.

4.7.12.3 Clear seals and varnishes

The surface appearance of plywood can present an attractive finish and under interior conditions a clear sealer of varnish can accentuate this. For floors, a translucent or transparent flooring grade sealer will provide an excellent hard wearing and decorative surface. Under exterior conditions however, most of these unpigmented products do not offer protection from ultraviolet light and are not normally recommended.

4.7.12.4 Wall coverings and paper overlays

In interior conditions, plywood can be decorated with the normal range of paper and fabric wallpapers.

Plywood is manufactured with a range of paper overlays to protect the panel and enhance its durability, to give a decorative finish or to facilitate painting.

4.7.12.5 Laminates, foils and veneers

As with other wood-based panels, plywood can be finished with decorative laminates, foils or decorative veneers. In order to avoid distortion in service, care must be taken to ensure that the panel construction remains balanced (ie with an equal number and thickness of veneers with similar moisture movement characteristics either side of the core).

4.8 References

1 Stacking round timber, sawn timber and board materials. Safe working practices, HSE Woodworking Information Sheet No 2 (revision 2), HSE, www.hse.gov.uk

2 Handbook of Finnish plywood, Finnish Plywood International, 1991, ISBN 952-90-1976-9

3 Construction Products Regulation (CPR), Regulation 305/2011/EU

4 BS EN 14592. Timber structures. Dowel type fasteners. Requirements, BSI

5 BS 5385-1. Wall and floor tiling. Design and installation of ceramic, natural stone and mosaic wall tiling in normal internal conditions. Code of practice, BSI

6 BS 5385-3. Wall and floor tiling. Design and installation of internal and external ceramic tiling in normal conditions. Code of practice, BSI

7 Tiling to Timber Sheets and Boards, Timber Substrates and Alternative Products, The Tile Association, www.tiles.org.uk [At the time of writing, this document was being updated and may subsequently be published under a different title]

8 DD CEN/TS 635-4. Plywood. Classification by surface appearance. Parameters of ability for finishing, guideline, BSI

5 Environmental aspects

5.1 Sustainability

Wood-based panels have good sustainability credentials. They make efficient use of the forestry resource from the peeling of logs into veneers for plywood, to the utilisation of small diameter roundwood and recycling of post-industrial/consumer wood waste. Wood-based panels have the capacity to store the carbon which is captured from the atmosphere by growing trees as they photosynthesise. Installing wood-based panels into structures such as housing with a design service life can help to provide a longer-term carbon store.

The key sustainability issues related to panel manufacture are:

- Responsible sourcing:
  - ensuring virgin wood raw material inputs are from legal and sustainable sources
  - demonstrating that the nature and environmental suitability of reclaimed post-consumer wood is of an appropriate quality.
- Making sure that environmental, social and health and safety issues/impacts are minimised during the manufacturing process of wood-based panels. This includes issues relating to energy use, dust, noise, and management of effluents and waste products.
- Recyclability of the panels at the end of their life.

Each of these phases impacts environmentally on the community and on the individual consumer, so that the control of wood in manufacture is essential for the purposes of:

- Optimising the standards of environmentally sustainable management; and
- Eliminating environmentally or ecologically undesirable consequences resulting from processed wood materials and products.

5.2 Environmental advantages of wood

Timber has obvious advantages over many other materials: it has the potential to regenerate and therefore offer a continuous supply for our use; wood is also recyclable, waste efficient, bio-degradable and non-toxic. Timber has also proven to be particularly energy efficient in use, and as such can play a major role in combating global warming.

Forest area in temperate and boreal regions continues to increase despite a growth in the volume of timber extracted to meet a rising demand for wood products. Young trees are far more effective absorbers of carbon dioxide (CO_2), the principal greenhouse gas, than mature trees. Thus harvesting mature trees and planting or naturally regenerating replacement forest growth can increase the amount of carbon sequestered from the atmosphere, thereby helping to mitigate the greenhouse effect.

Timber processing achieves high levels of material utilisation due to:

- modern sawing technology
- applications for the so-called sawmilling products (shavings, chips, sawdust etc) in panel production and other products
- the many opportunities to use wood waste for fuel.

Timber has a naturally low thermal conductivity and is an excellent insulator; in this respect it can be approximately 15 times more efficient than concrete, nearly 400 times more efficient than steel and in the order of 1700 times more efficient than aluminium. A 2.5cm timber board has better thermal resistance than an 11.4cm brick wall.

In buildings, as the required operational energy reduces through improved airtightness and insulation, the overall lifetime embodied energy of the building will be reduced. It follows that when less energy is required for the day-to-day running of a building, the embodied energy held within the materials from which it is constructed will have a greater bearing on the total energy invested in a building during its entire lifecycle.

Timber has an advantage in that compared with many competing materials it combines the qualities of lightness with strength. These merits contribute to timber buildings having both low embodied energy and low thermal conductivity, thus reducing energy requirements for construction and enhancing energy efficiency during use. In addition, the benefits offered by timber are further enhanced by the capacity of trees to remove atmospheric CO_2 during plant growth and store the carbon in timber products during their service life, thus further enhancing carbon savings. Timber is therefore an attractive construction material to use in terms of meeting goals for reducing CO_2 emissions to the atmosphere.

The advantages of building with wood in terms of CO_2 saved has been illustrated in a case study 'Open Academy Norwich' published by BSRIA and Bath University[1]. The building in question is made from cross-laminated timber and the consultant in charge of the project demonstrated that, compared with a concrete structure, the timber structure is far superior in terms of embodied tonnes CO_2. When sequestration is included, the timber structure has a negative carbon value of –2100 tCO_2 whereas the same structure made from concrete would have an impact of +1720 tCO_2. This equates to an approximate saving of 3800 tCO_2 compared to the concrete structure.

‘The combined effect of carbon storage and substitution means 1m³ of wood stores 0.9t CO_2 and substitutes 1.1t CO_2 – a total of 2t CO_2’, (Dr A Fruhwald, Hamburg University).

5.3 Raw materials used in the manufacture of wood-based panels

Two potential raw material streams are available:

- Virgin (non-recycled) fibre in the form of veneers, small diameter roundwood or sawmill co-products utilising those elements of the cylindrical log that are not suitable for rectangular sawn or profiled sections.
- Reclaimed post-consumer wood as a recycled and reprocessed raw material of appropriate quality.

5.3.1 Virgin (non-recycled) fibre

The virgin wood fibre used to manufacture wood-based panels is traditionally classified as either hardwood or softwood. Paradoxically this classification does not necessarily indicate the hardness, or softness, of the wood itself. Most (but not all) softwoods are from needle-bearing evergreen trees, and most hardwoods are from broad-leaved trees.

Woody (ligno-cellulosic) materials derived from other plant groups as well as hardwoods and softwoods are used by some producers in the manufacture of particleboards. These include materials such as flax shives (the resultant panels being known as flaxboard), bamboo, rattan, sugar cane residues (bagasse) etc. These materials are not typically used in particleboard and fibreboard manufacture in the United Kingdom but may be found in some imported products.

The relative proportion of softwoods and hardwoods from forest sources that is used in the manufacture of the wood-based panels covered by PanelGuide depends largely on the relative amounts available within economic range of the processing site. In Europe, softwood species are predominately used in the manufacture of particleboards and fibreboards whereas hardwood species are predominately used in European plywood production. Virtually no hardwood is used in the manufacture of particleboards or fibreboards made in the United Kingdom and Ireland, although a small proportion may be included in the recycled timber content of particleboard. Imported boards may come from regions where quite different proportions are used.

The principal concern of the wood-based panel user is not the species from which the panel is made but its inherent properties, appearance and consequent performance.

In addition to the softwood and hardwood logs referred to above, other sources of timber are used in wood-based panel manufacture. These include chipped forest residues (branches and tops), wood products from the sawmilling process (sawmill products) (chips, sawdust, slabs and off-cuts). In addition to these, reclaimed wood from either post-consumer or post-industrial sources is used particularly in the manufacture of particleboard (wood chipboard).

5.3.2 Recycled fibre

The Wood Recyclers’ Association estimates that the UK generates approximately 4.5 million tonnes of wood waste per year of which over 60% (29 million tonnes in 2013) is being recycled or recovered. This represents enormous progress since the Government introduced landfill tax in 1996, when it is believed that the recycling rate was less than 4%. Wood waste that has been diverted from landfill is now exploited in such products as animal bedding, horticultural products (such as mulch, soil conditioners and compost), biomass (for heat and electricity generation) and wood-based panels – in particular, particleboard and medium density fibreboard (MDF).

In 2013, the wood recycling sector produced over 850,000 tonnes of wood fibre for wood-based panel product manufacturers based in the UK, plus a further 165,000 tonnes for the wood-based panel product export market.

The following definitions[2] are recognised by the UK wood-based panel industry:

- Recycled wood: wood, in the form of either:
  - reclaimed pre-consumer by-products from manufacturing processes (for example from the manufacture of wood-based panels, assembled products, building structures) or
  - reclaimed post-consumer wood material (such as pallets or other wood packaging material, demolition waste, used furniture) which after reclamation is recycled as a raw material into the chain of commercial supply and reduced to a raw material form.
- Industrial by-products (pre-consumer recycled wood): wood material in the form of sawdust, fibrous wood, solid wood off-cuts or composite wood off-cuts resulting from any wood transformation or manufacturing process and which may be reclaimed and recycled as raw material for a manufacturing process.
- Sawmill products: a class of virgin wood consisting of chips, slabs, sawdust and the like, co-produced with the cutting of sawn wood from the roundwood log and used as materials for industrial processing or other commercial applications.

5.3.3 Standards governing the quality and safety of recycled wood

The use of recycled wood in the manufacture of particleboard or MDF requires deliveries of the material to the processor to be free from incompatible waste elements such as stone, metal and plastics. It is also desirable that producers and traders should observe state-of-the-art practices to ensure that reclaimed raw materials and the finished panel product are strictly controlled in respect of contaminating chemical elements and compounds that might be present at unacceptable levels in recycled wood.

Freedom from visible and separable physical contaminants is assured by the purchasing and delivery conditions imposed by the panel manufacturer and by the decontaminating and cleansing processes operated by both merchant and manufacturer.

With respect to chemical contamination, a number of national quality control schemes exist, the most prominent in Europe being the German criteria defined for purposes of the RAL-Gütezeichen label 'Recyclingprodukte aus Gebrauchtholz'. In the UK the wood-based panels sector supports the European Panel Federation (EPF) 'Industry Standard for delivery conditions of recycled wood', which is based on a 'responsible care' approach. *Table 5.1* lists the maximum level of various elements and compounds permitted under the EPF Industry Standard.

Table 5.1: The full list of contaminant limit values in g/kg of recycled wood and further extracts from the EPF Industry Standard

Elements/compounds	Limit values (g/kg)
Arsenic (As)	0,025
Cadmium (Cd)	0,050
Chromium (Cr)	0,025
Copper (Cu)	0,04
Lead (Pb)	0,09
Mercury (Hg)	0,025
Fluorine (F)	0,1
Chlorine (Cl)	1
Pentachlorophenol (PCP)	0,005
Creosote (Benzo(a)pyrene)	0,0005

The EPF Industry Standard provides a list of reference test methods for the chemical analysis of recycled wood, and the range of appropriate test methods is in a continuing programme of development and improvement.

Published in the UK under the auspices of WRAP is the BSI's Publicly Available Specification, *PAS 104 Wood recycling in the panelboard manufacturing industry*[3], a specification for quality and guidance for good practice for the supply of post-consumer wood for consumption in the manufacture of panelboard products. Related to this is *PAS 111 Specification for the requirements and test methods for processing waste wood*[4], which provides definitions, minimum requirements and test methods for processing waste wood into materials intended for use in suitable applications or end products including that for use in particleboard manufacture.

5.4 Responsible sourcing

Generally speaking, the temperate and boreal forest areas of the world are increasing in size; as more forests come under active management, they become much more productive in all senses. It is widely regarded that a large proportion of forests in such regions are managed sustainably, with many of them verifying this status through third party auditing of their forest management activities according to industry approved standards such as FSC and PEFC. Northern Europe, including countries such as the UK, Ireland, Scandinavia and Germany, is one example of such a forest area, which provides the significant majority of wood-based panels consumed in the UK.

It is generally accepted that rates of deforestation since 2000 have decreased globally, although it is still an issue that is a cause for concern, not only from a climate change perspective, but also from an increasing loss of biodiversity. In global terms, it is now generally accepted that the main cause of deforestation is not the timber industry but agriculture. With the population of the world expanding fast, large swathes of forest are lost when converted to agricultural production for crops, such as palm oil and soya beans, and livestock.

The timber industry plays its part in deforestation where there is illegal logging; however the main impact of the timber industry is in forest degradation rather than deforestation. This occurs through building logging roads in particular, some of which are then used by the agriculturists as a way into the forests.

The primary areas for concern when it comes to illegal logging or unsustainable practices are mainly in the tropical regions of the world where governance is often weaker and enforcement of forest laws and codes more challenging. Many tropical countries are also categorised as developing countries and therefore also have the challenge of managing their natural resources in a way that supports economic development rather than hindering it.

These key drivers of illegal logging in such countries have been recognised and an international response has been developed, led by the European Union (EU) in 2003, under the auspices of the Forest Law, Enforcement, Governance and Trade (FLEGT) action plan.

5.4.1 International policy response to illegal logging

The FLEGT action plan, developed by the EU in 2003, aims to tackle the problem of illegal logging by supporting responsible trade in forest products. The action plan has a two-pronged approach, shown in *Figure 5.1*.

This guide focuses on the demand-side policy driver that has been developed by the EU to tackle illegal logging, namely the EU Timber Regulation.

5.4.2 EU Timber Regulation

The EU Timber Regulation (EUTR) came into force on 3 March 2013. There are two parts of the EUTR, and

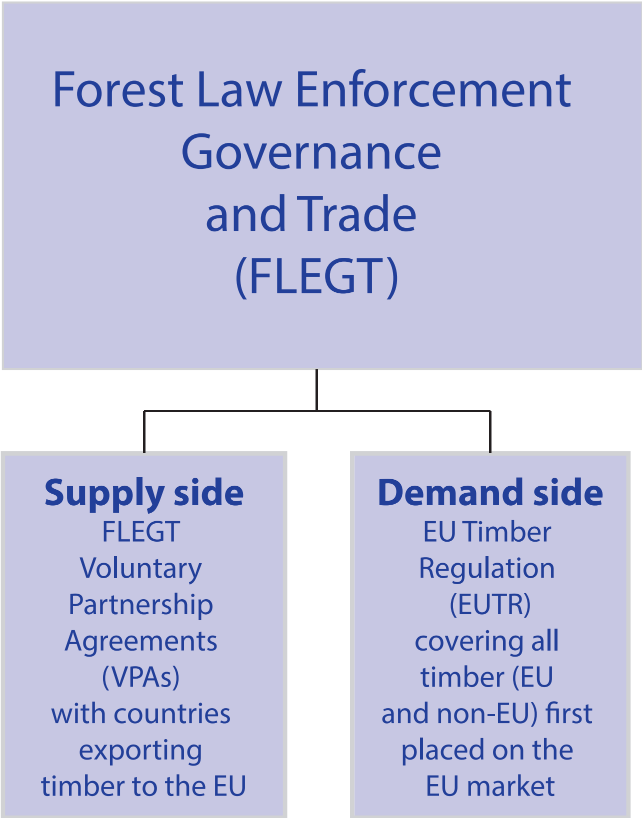


Figure 5.1: The FLEGT action plan

anyone found to be breaking the law could face criminal charges.

1 A prohibition on the 'first placing' of illegally harvested timber and timber products onto the EU market.
2 Operators (First Placers) placing timber and timber products onto the EU market for the first time must exercise due diligence to mitigate the risk that this timber has been illegally harvested. Essentially, they must implement a due diligence system which:
   a. Provides information about the supply of timber products, including description, species, country of harvest, quantity, name and address of supplier and trader and documents indicating compliance with the applicable legislation
   b. Evaluates the risk of placing illegally harvested timber and timber products on the market. Criteria which can be used to assess this risk include:
      i. assurance of compliance with applicable legislation, including certification schemes, third party verification
      ii. prevalence of illegal harvesting of specific tree species
      iii. prevalence of illegal logging in the country of harvest
      iv. UN or EU sanctions on timber imports or exports
      v. complexity of the supply chain
   c. Unless the risk of illegality is negligible, takes steps to mitigate this risk, for example: additional information, third party verification.

In terms of wood-based panels as a whole, a significant proportion of UK consumption is manufactured in the UK or Ireland, with a further proportion coming from other EU Member States. Meeting the requirements of the EUTR in such cases is relatively simple. It is the individual or company harvesting the trees that go into panel production that has the responsibility of undertaking this due diligence. In most cases it will be the forest owner(s) or a company that is managing the forest on behalf of the forest owner(s) that has the responsibility to undertake due diligence. Plywood is the main exception to this sourcing model where global sources contribute significantly to UK consumption.

Where things become more complicated is when panels such as plywood are imported from outside of the EU, from areas such as the Far East, South America or Africa. In such instances it is the job of the panel importer to undertake due diligence to ensure that the products they are purchasing are from legal sources. The job for the panel importer is much more complex as they need to fully understand the supply chain of their product(s), ensuring that the origin of the raw material inputs was legal as well as ensuring strong controls are in place throughout the various processing/manufacturing points in a supply chain to ensure legal raw material is not substituted with illegal material.

Manufacturers and suppliers can provide more information on the responsible sourcing of their products and how they are meeting the requirements of the EUTR.

5.4.3 Certified timber

Certified timber originates from a forest that has been verified to meet suitable sustainability criteria for forest management. Agreed key sustainability principles and criteria are applied through approved forest management criteria which are adapted to meet the needs of the country/region of the world where the certification is applied.

The following identifies the principles that are typically required for sustainable forest management:

- compliance with laws and all sustainability principles
- clear and defined long-term tenure and use rights
- identification of and respect for indigenous peoples' rights
- maintained/enhanced community relations and workers' rights
- maintained/enhanced long-term economic, social and environmental benefits from the forest
- maintained or restored ecosystem, its biodiversity, resources and landscapes, including maintaining high conservation value forests
- management plans with implemented, monitored and documented progress towards objectives in both natural forests and plantations.

Once timber is harvested from a certified forest, companies in the supply chain must have in place an audited Chain of Custody (CoC) management system.

This third party audited CoC system provides buyers with an assurance that individual companies have systems in place to ensure certified and uncertified timber is not mixed, and hence to be sure that the timber they are buying has originated from a certified forest.

There are two main certification schemes that exist internationally and are used commonly in the UK. They are:

- Forest Stewardship Council (FSC), established in 1994: www.FSC.org
- Programme for the Endorsement of Forest Certification (PEFC), established in 1999: www.pefc.org

Each individual company has its own Forest Management or CoC certificate number (eg TT-CoC-1234), which can be verified against each individual scheme's database of certificates.

In the UK, forests will normally be certified as managed in accordance with the UK Woodland Assurance Standard (UKWAS), which was established under the auspices of the Forestry Commission in June 1999 and is recognised by the FSC as consistent with the FSC's own standards of sustainable forest management. Certification to the UKWAS standard by FSC-accredited certifiers therefore entitles a forest management company to label timber sourced in the certified forest with a label incorporating the FSC logo at the point of transfer. The PEFC Council also recognises and approves the UKWAS standard with similar results for any forest requiring a PEFC label and certified by nationally accredited certifiers.

For buyers, purchasing certified timber with full CoC is the best guarantee that timber comes from a legal and sustainable source. For this reason such purchasing forms an important element of responsible sourcing and compliance with the EUTR.

5.5 Environmental performance of products

5.5.1 Introduction

The environmental performance of products and the manufacturers supplying these items is becoming increasingly significant to specifiers and end users when making choices about the combinations of products and designs for buildings. The sequence of stages from raw material extraction through to recycling or disposal is known as the life cycle of the product.

Calculation of the environmental impact of a product at all stages of the life cycle is called Life Cycle Assessment (LCA).There are now well-developed tools and methodologies for collecting LCA data on specific products and calculating the impacts. This data can be verified to produce Environmental Product Declarations (EPDs), a recognised way of demonstrating the impacts of a particular product. A number of wood-based panel manufacturers have invested in this process and buyers will increasingly be able to access EPDs for specific branded products through the sales and marking sections of these companies.

This section gives an overview of a new platform developed by Wood for Good, the Lifecycle Database, and some of the ways in which the UK wood-based panel manufacturers are currently providing this type of information, namely, carbon footprinting and information based on Life Cycle Assessment (BRE Green Guide to Specification).

5.5.2 Carbon footprint calculation

According to the Carbon Trust, the definition of a carbon footprint is 'the total set of greenhouse gas emissions caused directly and indirectly by an [individual, event, organization, product] expressed as CO2e'.

The carbon footprint can be used by manufacturers for benchmarking themselves against other organisations in terms of their greenhouse gas emissions, but only when the same calculation methodology has been used. It is also a useful tool for managing emissions and monitoring their reduction over time as part of an environmental management system. However it is not just manufacturers who have a carbon footprint, it is virtually all of us in our day-to-day lives through the products we consume or use.

In order to calculate an accurate carbon footprint, all possible sources of carbon need to be taken into account. There are three main sources that can be controlled to different degrees:

- direct emissions from an activity that is controlled by the organisation/person
- emissions from electricity
- indirect emissions from products and services.

In order to produce a carbon footprint, the Carbon Trust recommends five different steps to achieve a transparent carbon footprint, these are:

- define the methodology so that a consistent approach can be achieved
- specify the boundary and scope of coverage
- collect the data and calculate the carbon footprint
- verify the results (optional)
- disclose the results (optional).

To help complete the above steps there are a number of useful information sources, these are:

- Green House Gas (GHG) protocol
- BS EN ISO 14064 Parts 1 and 2Greenhouse gases[5]
- DEFRA
- Carbon Trust

5.5.3 Wood for Good Lifecycle Database

5.5.3.1 Introduction

The aim of the Lifecycle Database (formerly known as Wood First Plus) project is to create a free online information hub containing all of the environmental and design data necessary to specify timber as a first choice material. In particular, it focuses on providing generic LCA datasets for key timber products used in the UK.

5.5.3.2 The Lifecycle Database

PE International was engaged by Wood for Good and its industry partners to oversee the collection, analysis and review of existing life cycle assessment (LCA) data for a wide range of timber and timber products. The company has extensive experience in the construction materials sector and in working with the timber industry, having previously completed a major LCA project on US hardwood lumber for the American Hardwood Export Council (AHEC). This data has been used to generate generic LCA datasets for key timber products used in the UK.

The project is a result of ongoing consultation with timber industry organisations and external stakeholders, including contractors' groups, architects, professional institutions and many others. All stakeholders are able to access whole-life information on timber products free of charge through a dedicated website, managed by Wood for Good. Individual timber companies will be able to use these data as a basis for developing specific EPDs for their products and PE International is currently engaged in developing tools to facilitate this process. There are generic data sets freely available for a number of panel products: high density fibreboard (HDF), medium density fibreboard (MDF), melamine coated particleboard, oriented strand board (OSB), particleboard (uncoated) and plywood.

To find out more and to download the generic datasets for free, visit:

http://woodforgood.com/sustainability/lifecycle-database

5.5.4 BRE Green Guide to Specification

5.5.4.1 Introduction

BRE Global and the UK and Ireland wood-based panels sector have worked together to produce generic environmental profiles for particleboard, MDF and OSB produced in the UK and Ireland. These environmental profiles, produced according to BRE Global's updated Environmental Profiles Methodology, have been incorporated into BRE Global's materials environmental profiles database. The data has been used within BRE Global's updated Green Guide to Specification.

5.5.4.2 The Green Guide to Specification

The Green Guide online (www.thegreenguide.org.uk – also available in book form) has been produced by BRE Global to assess building materials and components in terms of their environmental impact within a building construction across their entire life cycle, which is termed as 'cradle to grave'.

The Green Guide is a tool used within BREEAM (BRE Environmental Assessment Method), an accredited environmental rating scheme for buildings, and the Code for Sustainable Homes. The Green Guide contains more than 1200 specifications used in various types of building. Since the previous edition, information on the relative environmental performance of some materials and components has altered, reflecting changes in manufacturing practices, the way materials are used in buildings and our evolving environmental knowledge.

There are currently six different generic types of building reviewed in the Guide:

- commercial buildings, such as offices
- educational
- healthcare
- retail
- residential
- industrial.

The environmental rankings are based on Life Cycle Assessments (LCA), using BRE's updated Environmental Profiles Methodology.

Materials and components are arranged on an elemental basis so that designers and specifiers can compare and select from comparable systems or materials as they compile their specification. The elements covered are:

- external walls
- internal walls and partitions
- roofs
- ground floors
- upper floors
- windows
- insulation
- landscaping
- floor finishes.

This data is set out using an A+ to E ranking system, where A+ represents the best environmental performance/least environmental impact, and E the worst environmental performance/most environmental impact. BRE has provided a summary environmental rating 'The Green Guide rating', which is a measure of overall environmental impacts covering the following issues:

- climate change
- water extraction
- mineral resource extraction
- stratospheric ozone depletion
- human toxicity
- ecotoxicity to freshwater
- nuclear waste (higher level)
- ecotoxicity to land
- waste disposal

- fossil fuel depletion
- eutrophication
- photochemical ozone creation
- acidification.

For more information go to www.thegreenguide.org.uk

5.6 References

1 Prof. Geoffrey Hammond and Craig Jones, Embodied Carbon – The Inventory of carbon and Energy (ICE), Case study 5 – Open Academy Norwich, BSRIA and Bath University

2 Definitions taken from the Industry Standard Code of Practice for the application of wood chain of custody criteria in the sawmilling, wood panelboard and assembled wood product sectors. WPIF/UKFPA/1-2004

3 PAS 104 Wood recycling in the panelboard manufacturing industry. Specification for quality and guidance for good practice for the supply of post consumer wood for consumption in the manufactuer of panelboard products, ISBN 0-580-43531-8 WRAP and BSI, 2004 (www.wrap.org.uk)

4 PAS 111 Specification for the requirements and test methods for processing waste wood, ISBN 978 0 580 69643 5 WRAP and BSI, 2012

5 BS EN ISO 14064-1. Greenhouse gases. Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals and BS EN ISO 1464-2 Greenhouse gases. Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements, BSI

6 Health and safety

6.1 Introduction

Wood-based panels provide the designer, processor and user with a material that is safe. As with any material, risks to the health and safety of a handler or user can arise as a result of particular handling or processing operations.

Because of their size and weight, wood-based panels can present manual handling risks. Cutting operations will release wood dust which also carries certain risks, particularly at the occupational level.

These risks can be controlled by following relatively simple procedures, a useful guide to which is set on the HSE Woodworking website:

www.hse.gov.uk/woodworking/getting-started.htm

This indicates that:

- Operations shall be assessed for risk and appropriately managed.
- Machinery shall be maintained and operated only by trained and competent persons.
- Manual handling, noise, dangerous substances and transport shall be specifically assessed and controlled.

6.2 Health and safety legislation (UK)

The following is not intended to be a definitive list, but instead identifies those regulations that impact significantly on the workplace where activities involving the use or handling of wood-based panels may be undertaken.

6.2.1 Health and Safety at Work Act 1974

This Act sets out the general duties which employers have towards employees and members of the public, and that employees have to themselves and to each other.

It places a duty on each of those parties to 'ensure so far as is reasonably practicable', that health, safety and welfare in the workplace are maintained. The law requires the risks to be identified and appropriately managed.

6.2.2 Management of Health and Safety at Work Regulations 1999

Health and safety in the workplace needs to be managed in order for continuous improvements to be made. The Management of Health and Safety at Work Regulations require employers to:

- Identify and assess risks to their employees and others.
- Introduce effective arrangements to implement appropriate preventative and protective measures to control risk.
- Ensure that risks are periodically reviewed and the effectiveness of control measures regularly checked.

6.2.3 The Construction (Design and Management) Regulations 2007 (CDM)

The CDM Regulations have an impact on all stages of the planning and management of health and safety of a construction project; they place duties on clients, designers and construction organisations.

While a designer cannot eliminate all health and safety risks, he or she can make a significant contribution by:

- tackling risks at source
- giving priority to measures which give protection to everyone affected by the risk
- passing on health and safety information.

Wood-based panels will fall within these Regulations during delivery, handling and site installation. Particular consideration must be given in circumstances where machining or processing operations are undertaken as part of the construction site operations.

6.2.4 Provision and Use of Work Equipment Regulations 1998 (PUWER)

PUWER 1998 applies to the provision of all work equipment, including mobile and lifting equipment. The main objective of PUWER is to ensure the provision of safe work equipment and the safety of its use. The Regulations place a responsibility on the employer to ensure that any work equipment is suitable for the task undertaken, equipment is properly maintained and that appropriate training and instruction is provided.

PUWER originally came into force from 1 January 1993 and are intended to sit alongside and complement other health and safety legislation, in particular: the Health and Safety at Work Act (1974), The Control of Noise at Work Regulations (2005) and The Control of Substances Hazardous to Health Regulations (2002).

6.2.5 Control of Substances Hazardous to Health Regulations 2002 (COSHH)

The COSHH Regulations identify occupational exposure levels (OEL) and workplace exposure levels (WEL) for a range of chemical compounds and some material types (including wood dust) that could cause harm if the exposure levels are exceeded. They set out a system of management including the implementation of the following:

- risk assessment
- control procedure for each risk
- control monitoring
- information, instruction and training for employees
- record keeping

- health surveillance
- review procedures.

6.2.6 Manual Handling Operations Regulations 1992 (MHOR)

These important regulations cover the transporting or supporting of loads by hand or bodily force. They set out a clear hierarchy of measures including:

- Avoid hazardous manual handling as far as is reasonably practicable.
- Assess any hazardous handling operations that cannot be avoided.
- Reduce the risk of injury so far as is reasonably practicable.

6.2.7 Further reading

- Management of health and safety at work. Management of Health and Safety at Work Regulations 1999. Approved Code of Practice and guidance L21 (Second edition), ISBN 978 0 7176 2488 1, HSE Books, 2000, www.hse.gov.uk/pubns/books/l21.htm
- Safe use of woodworking machinery. Provision and Use of Work Equipment Regulations 1998 as applied to woodworking machinery. Approved Code of Practice and guidance, L114, ISBN 978 0 7176 1630 5, HSE Books, 1998, www.hse.gov.uk/pubns/books/L114.htm
- Manual Handling Solutions in Woodworking, INDG318 (rev1), HSE, 2013 www.hse.gov.uk/pubns/indg318.htm

6.3 Hazards associated with wood-based panels

6.3.1 General

The hazards (the way in which an object or a situation may cause harm) associated with wood-based panels can be divided into two categories: handling wood-based panels and cutting wood-based panels.

6.3.2 Handling wood-based panels

The general handling issues that arise in the woodworking industry can equally be applied to the handling of wood-based panels.

Because of their dimensions and weights, incorrectly handling wood-based panels can result in:

- strain and sprain injuries
- hand and back injuries
- lacerations to the hands
- crush injuries.

Poor storage of panels can lead to injury if they become unstable and fall. Consult PanelGuide *Section 4.2* and *Section 4.3*. Detailed information on the safe stacking of sawn timber and panel materials is also given in Health and Safety Executive (HSE) Woodworking Sheet No. 2 (Revised)[1].

6.3.2.1 Assess the risks

The law does not expect you to eliminate all risk, but you are required to protect people as far as is 'reasonably practicable'. The HSE provides guidance on assessing risk in each individual workplace – the HSE document 'Five steps to risk assessment'[2] will guide you through the process of carrying out a risk assessment in the workplace.

6.3.2.2 Handling solutions[3]

Many manual handling solutions involve the use of some form of work equipment. Where you use work equipment to reduce the risks of manual handling, you should ensure that it is safe and suitable for the purpose for which it is intended as required by the Provision and Use of Work Equipment Regulations (PUWER) 1998.

The large size and weight of wood-based panel products presents a real handling hazard: handling a full-sized panel single-handed and without a handling aid is not recommended. There are however a number of solutions to this problem.

Lifting hooks

These enable one person to move smaller panels without the need to bend, and enable the panel to be properly gripped. All that is needed is an adjustable steel rod (60 to 80cm long) with a hook on one end and a handle on the other. A variety of other similar devices are also available for this task, such as handles incorporating roller grips at one end.

Panel trolleys

These are available with locking castors, tilting bed, moveable fence and a rise and fall table. They enable a single machinist to load, manoeuvre and machine a large number of panels.

Vacuum handling system

A wide variety of equipment is available for stacking, handling and turning panel products. These have many uses such as feeding machines including beam panel saws, wall saws and CNC routers.

6.3.3 Cutting wood-based panels

6.3.3.1 Wood dust hazards

When wood or wood-based products are cut, particles of wood dust are released. Exposure to wood dust may irritate the nose, respiratory system, eyes and skin.

Wood dust may act as a carrier for other chemicals that are contained in such things as paints, lacquers, wood preservatives and wood adhesives, which may themselves cause health effects if inhaled.

Some wood species may cause dermatitis and allergic respiratory effects, such as asthma, because of naturally occurring chemicals in them.

A rare type of nasal cancer has been linked to the prolonged exposure (20 to 30 years) to wood dust.

Wood dust is flammable and it can be (under certain industrial processing situations) an explosion hazard.

6.3.3.2 Regulations

The elimination or control of risks from wood dust is required by:

- Health and Safety at Work Act 1974
- Factories Act 1961
- Control of Substances Hazardous to Health (COSHH) Regulations 2002.

The employer (this includes anyone responsible for wood-cutting operations in craft workshops, schools, theatres etc, as well as in factories) has an obligation under COSHH Regulations to assess any risk and prevent exposure to any hazardous substance. If prevention is not reasonably practicable, suitable control measures must be adopted.

Wood dust must be reduced as far as is reasonably practicable below its assigned maximum workplace exposure limit of 5 mg/m^3 (8-hour time-weighted average) by mechanical extraction; if this is not possible or practicable, respiratory protective equipment (RPE) should be used. RPE is in addition to control at source, not in place of it.

Any health risks arising from exposure to wood dust can and should be controlled effectively by compliance with the COSHH Regulations.

An employer has an obligation to provide the necessary control and protection equipment.

Employees and others engaged in woodworking activities must take reasonable care for their own health and safety and that of others who may be affected by their actions.

6.3.3.3 When to take care

Activities likely to produce high levels of wood dust include:

- sawing by machine and by hand
- machinery operations, particularly sawing, routing, turning
- sanding
- hand assembling machined or sanded components
- bagging dust from dust extraction systems
- using a compressed airline to blow dust off furniture and other articles before spraying (to be avoided)
- workplace cleaning, particularly if compressed airlines are used for blowing dust from surfaces etc (to be avoided).

6.3.3.4 How to take care

- Whenever possible, fit dust extraction equipment even when using hand-held machines.
- Where extraction is inadequate or impracticable, wear a suitable respirator.
- Wear the correct clothing and use other safety equipment as necessary.

6.3.4 Respiratory protective equipment (RPE)

RPE must meet approval standards and it must:

- be suitable for the purpose to which it is to be used
- provide effective protection to the wearer
- fit the wearer
- be replaced or maintained according to manufacturers' recommendations
- be supported by appropriate instructions in its use and maintenance.

6.3.4.1 Types of RPE

Factors to consider when choosing appropriate RPE include:

- face size and shape
- facial hair
- spectacles.

Work-related considerations: detailed information on selection and use is given in HSE Wood Working Information Sheet No. 14 'Selection of respiratory protective equipment suitable for use with wood dust'[4].

6.3.5 Hazard assessment summary

In panel or processed form wood-based panels are non-classifiable under the COSHH Regulations. *Table 6.2* summarises the most common hazards and appropriate control methods to minimise the risk of harm actually occurring.

6.4 Formaldehyde and wood-based panels

6.4.1 Formaldehyde release from wood-based panels

In those panel types where a formaldehyde-based synthetic resin binder is used, the amount of free formaldehyde given off by an individual panel can be estimated to be relatively small in respect of overall indoor air concentrations.

Release of free formaldehyde from wood-based panels is influenced by a number of factors including, binder type, temperature, humidity, panel thickness and percentage concentration of formaldehyde. Experiments have demonstrated that in a stable environment (temperature and humidity) formaldehyde release does decrease over time and the low initial values of typical particleboards and MDF will decrease by at least 50% within a few weeks of manufacture.

Under the provisions of the harmonised European standard (hEN) *EN 13986*, (implemented in the UK as *BS EN 13986 Wood-based panels for use in construction.*

Table 6.1: Respirators for wood working

Typical operations	Respirator type		
	Disposable respirator	**Re-usable respirator (half mask)**	**Powered respirator**
All woodworking operations, eg use of routers, lathes, planers, saws and vertical spindle moulders (VSMs)	BS EN 149[5] class FFP2 for low residual dust levels for lower risk woods such as pine	Filter to BS EN 143[6] class P2 fitted to either a half mask to BS EN 140[7] or a full face mask to BS EN 136[8]	Lightweight powered hood, visor or helmet to BS EN 12941[9] class TH1 (equivalent protection to FFP2)
	BS EN 149 class FFP3 for higher residual dust levels such as when sanding (hand, disc, bobbin, pad etc). Also for all work involving MDF plus the more toxic woods such as hardwoods and western red cedar	Filter to BS EN 143 class P3 fitted to either a half mask to BS EN 140 or a full face mask to BS EN 136 Note: A combined organic vapour filter type A (organic), either class 1 or 2, will provide protection against any formaldehyde vapours present from wood-based panels	Lightweight powered visor or helmet to BS EN 12941 class TH2 (equivalent to FFP3)
Changing dust collection bags on simple recirculating dust collectors in the workroom	BS EN 149 class FFP3	Filter to BS EN 143 class P3 fitted to either a half mask to BS EN 140 or a full face mask to BS EN 136	Lightweight powered visor or helmet to BS EN 12941 class TH2
Entry into dust collection room/vaults **Entry into very dusty filter galleries for bag changing** **Work inside heavily contaminated ducts** **Ensure none of these are confined spaces (oxygen deficient atmosphere)**	Disposable respirators not suitable	Filter to BS EN 143 class P3 fitted to a full face mask to BS EN 136	Lightweight powered hood, visor or helmet to BS EN 12941 class TH2

Table 6.2: Common hazards and methods of control

Activity	Hazard	Control
Manual handling (in full panel form)	Large panel sizes present a risk of strain or crush injuries if not handled correctly	• Store carefully in uniform stacks on a flat level base • Use mechanical handling equipment • Adopt correct manual handling procedures
Carpentry work **Activities likely to produce high dust levels include:** • **Sanding by machine and hand** • **Sawing, routing and turning** • **Hand assembling machined or sanded components** • **Cleaning workshop**	• Wood dust in general (including dust from wood-based panels) has health risks • MDF can produce a higher proportion of fine dust compared with other wood products • Wood dust is flammable	• Off site: preparation under exhaust ventilated plant • On site: enclosure and exhaust ventilation • Dust extraction on portable tools • Good ventilation • Respiratory protection equipment (RPE) Note: any health hazards arising from the use of wood-based panels at work can and should be controlled by compliance with the requirements of the Control of Substances Hazardous to Health (COSHH) Regulations 2002
Dust collection bag changing	• Wood dust in general (including dust from wood-based panels) has health risks • MDF can produce a higher proportion of fine dust compared with other wood products • Wood dust is flammable	• Respiratory protection equipment (RPE) • Good ventilation
Dust collection rooms or other very dusty environments (not oxygen deficient atmospheres)	• Wood dust in general (including dust from wood-based panels) has health risks • MDF can produce a higher proportion of fine dust compared with other wood products • Wood dust is flammable	• Respiratory protection equipment • Good ventilation

Characteristics, evaluation of conformity and marking[10]) the formaldehyde release from wood-based panels used in internal applications will be classified as either Class E1 or Class E2.

The test requirements for both initial type testing and factory production control/continuous surveillance are laid down in *Table 6.3* for E1 products and *Table 6.4* for E2 products.

NOTE 1: Boards of Class E1 can be used without causing an indoor air concentration greater than 0.1ppm HCHO. The test requirement does not apply to wood-based panels to which no formaldehyde containing materials were added during production or in post-production processing. These may be classified E1 without testing (see Note 2).

NOTE 2: Examples of such panel products are:

- cement-bonded particle boards (uncoated)
- wet process fibreboard (uncoated), when no formaldehyde emitting resin has been added to the process
- uncoated or coated wood-based panels glued with resins emitting either no formaldehyde or negligible amounts of formaldehyde after production as, for example isocyanate, phenol or phenol-resorcinol glue.

The limit values for the formaldehyde Class E1 are given in *Table 6.3* and for Class E2 in *Table 6.4*.

The *BS EN 120 Wood based panels. Determination of formaldehyde content. Extraction method called the perforator method*[11] values for particleboards and MDF apply to boards conditioned to a moisture content of 6.5%. In the case of particleboards or MDF with different moisture contents, the *BS EN 120* test result (known as the perforator value) should be multiplied by the F factor given in *BS EN 312 Particleboards. Specifications*[12] (particleboard) or *BS EN 622-1 Fibreboards. Specifications. General requirements*[13] (MDF) respectively. The F factors in these two standards are only valid for boards within the specified moisture content ranges given in the two standards.

NOTE 3: Experience has shown that to guarantee compliance with the limits in *Table 6.3* the rolling average of the *BS EN 120* values found from the internal factory control over a period of ½ year should not exceed 6,5mg HCHO/100g panel mass for particleboards and OSB or 7mg HCHO/100g panel mass for MDF.

NOTE 4: The corresponding upper requirement limits for Class E2 boards are found from the *BS EN 120* or *BS EN 717-2 Wood-based panels. Determination of formaldehyde release. Formaldehyde release by the gas analysis method*[14] factory production/external control tests.

Table 6.3: Formaldehyde emission Class E1: classification and control requirements

		Panel product		
		Uncoated	**Coated**	
		Particleboards OSB MDF	Plywood Solid wood panels	Particleboards OSB MDF Plywood Solid wood panels Fibreboards (wet process) Cement-bonded particle-boards
Initial type testing[a]	Test method	BS EN 717-1 Wood-based panels. Determination of formaldehyde release. Formaldehyde emission by the chamber method[15]		
	Requirement	Release ≤ 0,124 mg/m^3 air		
Factory production control	Test method	*BS EN 120*	*BS EN 717-2*	
	Requirement	Content ≤ 8mg/100g oven-dry board (see Note 3)	Release ≤ 3,5 mg/m^2h or ≤ 5 mg/m^2 h within 3 days after production	
[a] For established products, initial type testing may also be done on the basis of existing data with *BS EN 120* or *BS EN 717-2* testing, either from factory production control or from external inspection				

6.5 Exposure to formaldehyde

6.5.1 General

Formaldehyde is a pungent, colourless gas composed of the elements carbon, hydrogen and oxygen. A naturally organic substance that is present all around us, it occurs naturally within wood at a very low level. Formaldehyde does not accumulate in the environment because it is broken down within a few hours by sunlight or by bacteria present in soil or water. It metabolises quickly so it does not accumulate in the body.

For industrial use it is usually sold as a 36–50% solution in water. This solution is known as formalin. Formaldehyde has been used in the manufacture and composition of industrial products for nearly 150 years. It is a raw material in as many as 85 industries and is used for the production of hundreds of everyday products. A

Table 6.4: Formaldehyde emission Class E2: classification and control requirement

			Panel product		
			Uncoated	**Uncoated**	**Coated**
			Particleboards OSB MDF	Plywood Solid wood panels	Particleboards OSB MDF Plywood Solid wood panels Fibreboards (wet process) Cement-bonded particleboards
Initial type testing	Either	Test method	BS ENV 717-1		
		Requirement	Release ≤ 0,124 mg/m^3 air. See Note 4		
	or	Test method	BS EN 120	BS EN 717-2	
		Requirement	Content	Release > 3,5 mg/m^{2}h to ≤ 8 mg/m^{2}h	
			> 8mg/100g to ≤ 30mg/100g ovendry board	or > 5 mg/m^2 h to ≤ 12 mg/m^2 h within 3 days after production	
Factory production control		Test method	BS EN 120	BS EN 717-2	
		Requirement	Content	Release > 3,5 mg/m^{2}h to ≤ 8 mg/m^{2}h	
			> 8mg/100g to ≤ 30mg/100g ovendry board	or > 5 mg/m^2 h to ≤ 12 mg/m^2 h within 3 days after production	

major use is in the manufacture of adhesive resins for woodworking industries. Products such as paper and textiles, cosmetics, disinfectants and medicines, and many paints, varnishes and lubricants may also contain formaldehyde.

6.5.2 Hazards associated with exposure to formaldehyde

Under test conditions, concentrations of formaldehyde vapour in the air is expressed in parts per million (ppm) or milligrams formaldehyde per cubic metre of air (mg/m^3). For formaldehyde 1 mg/m^3 = 0.81ppm. At levels of 1 to 3ppm it can be moderately irritating to the eyes and nose, depending on the sensitivity of the individual. At levels above 10ppm it causes immediate strong discomfort, and long-term continuous exposure at these extreme concentrations would result in serious health effects. There are extreme cases known where highly allergic individuals could be affected by exposure over a wide range of chemicals even at very low concentrations.

Formaldehyde is classed by the International Agency for Research on Cancer as a carcinogen, basing this classification on the possible effects of large doses of formaldehyde to which workers in some chemical and manufacturing plants were formerly exposed. There is no evidence that small dosages (much lower than the World Health Organization (WHO) guideline limit for indoor air) have any carcinogenic effect. A scientific conference in 2007 concluded that 'the common uses of formaldehyde in consumer products and other applications does not pose a risk to human health'[16].

6.5.3 Formaldehyde exposure in the home

Indoor air levels of formaldehyde are not generally the subject of official regulations. However the generally accepted guideline figure for the amount of formaldehyde that should not be exceeded in ambient air from all formaldehyde emitting sources is 0.1 milligrams per cubic metre of air (equivalent to about 0.08ppm) measured over a 30-minute reference period (WHO).

The UK's Building Research Establishment (BRE) has tested the air quality in typical British homes[17,18] and found the average concentration of formaldehyde is less than one quarter of the guideline limit from all formaldehyde emitting sources in the home.

Not all wood-based panels contain added formaldehyde and while it is difficult to make any accurate projection, it has been estimated that the contribution of formaldehyde from wood-based panel emissions to the ambient indoor air level would be less than one-eighth of the WHO guideline limit.

6.5.4 Formaldehyde exposure in the workplace

Under the COSHH Regulations 2002, formaldehyde in the workplace atmosphere has a workplace exposure limit (WEL) of 2 parts per million (determined over both long term (8-hour time weighted average (TWA) reference period) and short term (15-minute reference period)).

6.6 References

1 Stacking round timber, sawn timber and board materials. Safe working practices, HSE Woodworking Information Sheet No 2 (revision 2), HSE, www.hse.gov.uk

2 'Five steps to risk assessment, INDG163(rev3), ISBN 978 0 7176 6440 5, Health and Safety Executive, 2011, www.hse.gov.uk

3 Manual Handling Solutions in Woodworking, INDG318(rev), Health and Safety Executive, 2013 (Contains public sector information published

by the Health and Safety Executive and licensed under the Open Government Licence) www.hse.gov.uk/woodworking/manualhandling.htm http://www.hse.gov.uk/woodworking/wooddust.htm

4 Selection of respiratory protective equipment suitable for use with wood dust, HSE Woodworking Sheet No 14 (revision 1), HSE, www.hse.gov.uk

5 BS EN 149. Respiratory protective devices. Filtering half masks to protect against particles. Requirements, testing, marking, BSI

6 BS EN 143. Respiratory protective devices. Particle filters. Requirements, testing, marking, BSI

7 BS EN 140. Respiratory protective devices. Half masks and quarter masks. Requirements, testing, marking, BSI

8 BS EN 136. Respiratory protective devices. Full face masks. Requirements, testing, marking, BSI

9 BS EN 12941. Respiratory protective devices. Powered filtering devices incorporating a helmet or a hood. Requirements, testing, marking, BSI

10 BS EN 13986. Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking, BSI

11 BS EN 120. Wood based panels. Determination of formaldehyde content. Extraction method called the perforator method, BSI

12 BS EN 312. Particleboards. Specifications, BSI

13 BS EN 622-1. Fibreboards. Specifications. General requirements, BSI

14 BS EN 717-2. Wood-based panels. Determination of formaldehyde release. Formaldehyde release by the gas analysis method, BSI

15 BS EN 717-1. Wood-based panels. Determination of formaldehyde release. Formaldehyde emission by the chamber method, BSI

16 FormaCare: International Science Conference in Barcelona. Formaldehyde on the way to rehabilitation, (Barcelona, 21.09.2007)

17 Berry, R. and V. Brown, Indoor air quality in homes, part 1, ISBN 1-86081-059-4, BRE, 1996

18 Berry, R. and V. Brown, Indoor air quality in homes, part 2, ISBN 1-86081-060-8 BRE, 1996

Annex 1

Glossary of terms

Cement-bonded particleboard (CBPB)	Wood-based panel material (as defined in *BS EN 633 Cement-bonded particleboards. Definition and classification*) manufactured under pressure, based on wood or other vegetable particles bound with hydraulic cement and possibly containing additives.
Flaxboard	Wood-based panel (as defined in *BS EN 309 Particleboards. Definition and classification*) manufactured under pressure and heat from flax shives, with the addition of an adhesive. Flaxboard shall have at least 70% flax content and can contain other raw materials such as particles of wood (wood flakes, chips, shavings, saw dust and similar materials).
Oriented strand board (OSB)	Multi-layered panel (as defined in *BS EN 300 Oriented strand boards (OSB). Definitions, classification and specifications*) made from strands of wood with a binder. The strands in the external layers are aligned and parallel to the board length or width; the strands in the centre layer or layers can be randomly oriented, or aligned, generally at right angles to the strands of the external layers.
Particleboard	Wood-based panel (as defined in *BS EN 309 Particleboards. Definition and classification*) manufactured under pressure and heat from particles of wood (wood flakes, chips, shavings, saw-dust, wafers, strands and similar) and/or other lignocellulosic material in particle form (flax shives, hemp shives, bagasse fragments and similar) with the addition of an adhesive.
Plywood	Wood-based panel (as defined in *BS EN 313-2 Plywood. Classification and terminology. Terminology*) consisting of an assembly of layers bonded together with the direction of the grain in adjacent layers, usually at right angles.
Balanced plywood	Plywood in which the outer and inner layers are symmetrical about the centre layer with respect to thickness and species.
Veneer	Thin sheet of wood not more than 7mm in thickness.
Layer	Either one ply or two or more plies, glued together with their grain direction parallel, or another material.
Ply	Either one single veneer, or two or more veneers joined edge to edge or end to end.
Transverse layer (crossband)	Inner layer having grain direction at right angles to the outer layer.
Longitudinal layer (centre)	Inner layer having grain direction parallel to the outer layers.
Multi-ply	Plywood formed of more than three layers.

Core plywood	Plywood having a core.
Blockboard	Core plywood, the core of which is made of strips of solid wood more than 7mm wide but not wider than 30mm, which may or may not be glued together.
Laminboard	Core plywood, the core of which is made of strips of veneer not thicker than 7mm placed on edge, all or most of which are glued together.
Composite plywood	Plywood, the core (or certain layers) of which are made of materials other than solid wood or veneers. There are at least two crossbanded layers on each side of the core.
Moulded plywood	Plywood which is not flat, made by pressing in a mould.
Sanded plywood	
• Plywood sanded only on one side	Plywood the face or back of which has been smoothed by means of a mechanical sander.
• Plywood sanded on both sides	Plywood the face and back of which have been smoothed by means of a mechanical sander.
Scraped plywood	Plywood the face and/or back of which have been smoothed by means of a mechanical scraper.
Pre-finished plywood	Plywood which has been subjected by the manufacturer to a special surface treatment other than sanding or scraping.
Overlaid plywood	Plywood surfaced with one or several overlay sheets, or one or several films such as: • impregnated paper • plastics • resin film • metal • decorative veneer.
Wood fibreboard (subsequently referred to as 'fibreboard')	Wood-based panel (as defined in *BS EN 316 Wood fibre boards. Definition, classification and symbols*) with a nominal thickness of 1.5mm or greater, manufactured from lignocellulosic fibres with application of heat and/or pressure. Note: The bond is derived: • either from the felting of the fibres and their inherent adhesive properties • or from a synthetic adhesive added to the fibres. Other additives can be included.

Wet process fibreboards

Wood fibreboards with a fibre moisture content of more than 20% at the stage of forming. Wet process boards are classified according to their density, as follows:

Hardboards

(HB, density ≥ 900 kg/m^3)

They can be given additional properties, for example fire retardancy, moisture resistance, resistance against biological attack, work-ability (eg mouldability), either by specific treatment (eg 'tempering', 'oil tempering') or by the addition of a synthetic adhesive or other additives.

Medium boards

(MB, density ≥ 400 kg/m^3 to <900 kg/m^3)

Medium boards are divided into two sub-categories according to their density, as follows:

- low density medium boards
(MBL, ≥400 kg/m^3 to <560 kg/m^3)
- high density medium boards
(MBH, ≥560 kg/m^3 to <900 kg/m^3)

They can be given additional properties, eg fire retardancy, moisture resistance.

Softboards

(SB, density ≥ 230 kg/m^3 to <400 kg/m^3)

These boards have basic properties of thermal and acoustic insulation. They can be given additional properties, eg fire retardancy. Improved moisture resistance as well as enhanced strength properties are usually achieved by the addition of a petrochemical substance (eg bitumen).

Dry process boards (MDF)

Wood fibreboards having a fibre moisture content of less than 20% at the forming stage. These boards are essentially produced under heat and pressure with the addition of a synthetic adhesive.

Dry process fibreboards can be given additional properties, such as fire retardancy, moisture resistance, resistance against biological attack, either by changing the composition of the synthetic adhesive or with the inclusion of other additives.

General terms

Coated panel

(See: Overlaid panel)

Dry conditions (Service Class 1)

Conditions corresponding to Service Class 1 of *EN 1995-1-1* (Eurocode 5) which is characterised by a moisture content in the material corresponding to a temperature of 20ºC and a relative humidity of the surrounding air only exceeding 65% for a few weeks per year.

External conditions (Service Class 3)

Conditions corresponding with Service Class 3 of *EN 1995-1-1* (Eurocode 5) which is characterised by climatic conditions leading to higher moisture contents than in Service Class 2.

Humid conditions (Service Class 2)	Conditions corresponding with Service Class 2 of *EN 1995-1-1* (Eurocode 5) which is characterised by a moisture content in the material corresponding to a temperature of 20ºC and a relative humidity of the surrounding air only exceeding 85% for a few weeks per year.
Overlaid panel (coated panel)	Panel surfaced with one or more overlay sheets or films, for example melamine impregnated paper, plastics, resin film, metal, decorative veneer.
Reaction to fire	The response of a material in contributing by its own decomposition to a fire to which it is exposed, under specified conditions.
Structural floor decking	A flooring assembly of wood-based panels supported on joists. When subjected to load, the decking is free to deflect between the joists.
Structural roof decking	A roofing assembly of wood-based panels supported on joists. When subjected to load, the decking is free to deflect between the joists.
Structural use	Use of a panel under load-bearing conditions as part of a building or other construction.
Structural wall sheathing	Wood-based panel capable of providing mechanical resistance to a wall structure.
Technical class	Class of product performance defined to make it easier to use a standard to relate product performance to its intended use.
Unfaced panel	Wood-based panel without overlaid surfaces.
Wood-based panel (panel)	Plywood, oriented strand board (OSB), resin-bonded particleboard, cement-bonded particleboard (CBPB), fibreboard, flaxboard, LVL, or solid wood panel.
Veneered panel	Wood-based panel overlaid with a veneer.

Annex 2

Annex 2A: Particleboard (wood chipboard)

Description

Particleboard as defined in the European Standard *BS EN 309 Particleboards. Definition and classification*[1] is a: 'panel material manufactured under pressure and heat from particles of wood (wood flakes, chips, shavings, sawdust and similar) and/or other lignocellulosic material in particle form (flax shives, hemp shives, bagasse fragments, straw and similar), with the addition of a polymeric adhesive'. Particleboard should not be mistaken for flaxboards made to *BS EN 15197 Wood-based panels. Flaxboards. Specifications*[2] (see *Annex 2G*). In the UK, particleboard is made from wood and is traditionally known as wood chipboard.

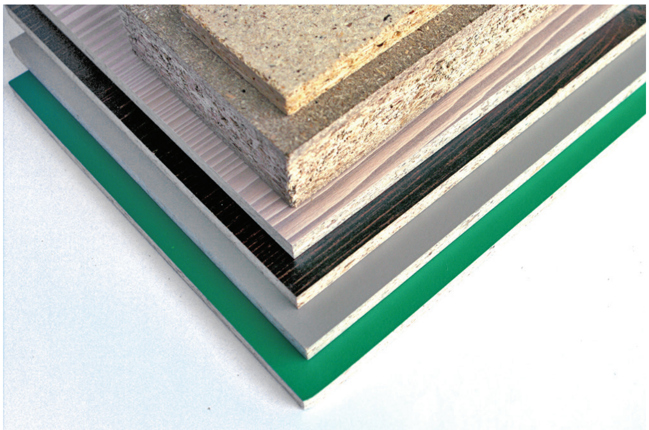


Figure A2.1: Particleboard

The particleboard industry in the UK dates from the 1940s and originated in a time of austerity with the purpose of utilising waste timber. The process of manufacture was quite crude compared to the present time and reproducibility of quality was relatively poor. Over the years the application of new technologies in both production and control, together with the production of tailor-made chips from solid softwood, as well as the use of more sophisticated resin systems, has led to the production of huge quantities of a range of panels having a known and reproducible performance.

Composition

Wood chips comprise the bulk of particleboard and are prepared in a mechanical chipper generally from coniferous softwoods, principally spruce, although pine and fir and hardwoods, such as birch, are sometimes used. Particleboards may also incorporate a large proportion from recycled sources. These chips are generally bound together with synthetic resin systems such as urea-formaldehyde (UF) or melamine-urea-formaldehyde (MUF), though phenol-formaldehyde (PF) and polymeric methylene di-isocyanate (PMDI) are used by a few manufacturers.

The binding system employed depends on the intended end use and the grade of the product. The most common resin employed is urea-formaldehyde, but this is only suitable for use in dry conditions: the other three resin systems confer a measure of moisture resistance to the composite.

Typical constituents of particleboard are of the order (by mass) of:

- wood chips 83% to 88%
- formaldehyde based resin 6% to 8% or PMDI 2% to 3%
- water 5% to 7%
- paraffin wax solids 1% to 2%.

Appearance

Particleboard has smooth, sanded surfaces. In order to achieve this smooth surface, the panel density is increased at the faces by the use of smaller wood particles with a larger percentage of resin binder compared to the core of the panel.

Generally, particleboard has a pale straw colour, but for identification purposes the whole panel, or individual layers of the panel, may be dyed according to industry practices (eg green for panels with enhanced moisture resistance, or red for panels integrally treated with flame-retardant chemicals). The presence of a coloured surface does not in itself infer that these enhanced properties are present and reference should always be made to panel markings or manufacturer's literature to confirm such enhanced performance. Integral colouring is distinct from the voluntary coloured stripe system that may be applied on the outside edge of panels in a pack, at opposite corners, to identify particular grades in accordance with BS EN Standards (for example Annex A of *BS EN 312 Particleboards. Specifications*[3]).

Density, mass and panel size

Panel density (and therefore panel mass) varies depending upon the product, being affected by the timber species and the process used in manufacture. Typical densities are 600 kg/m^3 to 680 kg/m^3. For example a 2400mm × 1200mm × 19mm panel will weigh approximately 36kg.

Panel sizes commonly available are:

- 1830mm × 1200mm
- 2440mm × 1220mm
- 2750mm × 1220mm
- 3050mm × 1220mm
- 3660mm × 1220mm

in thicknesses of: 2.5mm, 3.2mm, 6mm, 9mm, 12mm, 15mm, 18mm, 19mm, 22mm, 25mm, 30mm and 38mm.

Other sizes are available or can be produced to order. Panels are produced with either square or tongued and grooved (T&G) edges.

Applications

The special properties of particleboard have several advantages in a wide range of construction and furniture applications.

In construction applications its good mechanical performance, which is the same along and across the panel, and its availability in large sizes renders it appropriate for use as floor decking, either on timber joists or as a floating floor system. Different grades of the product are available for different environmental conditions and different levels of loading, ranging from domestic to industrial usage, including both platform and raised access floors. The higher grades also find widespread use in industrial storage systems. Guidance on the use of load-bearing grades of particleboard in floors, walls and roofs is given in *DD CEN/TS 12872 Wood-based panels. Guidance on the use of load-bearing boards in floors, walls and roofs*[4], see also PanelGuide *Section 2.2*.

Large quantities of particleboard are also used in the manufacture of kitchen units and worktops, as well as in dining-room and bedroom units; these generally have a veneered or laminated finish.

Specification

Particleboard manufactured in Europe and used in construction must be specified in accordance with *BS EN 312*. As explained in PanelGuide *Section 2*, particleboard that is used in construction must comply (by law) with the Construction Products Regulation (CPR)[5] by compliance with the harmonised European standard (hEN) for wood-based panels (*EN 13986*, implemented in the UK as *BS EN 13986 Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking*[6]); this standard calls up *BS EN 312*, which contains the requirements for the following seven grades (technical classes):

- P1: general purpose boards for use in dry conditions
- P2: boards for interior fitments (including furniture) for use in dry conditions
- P3: non load-bearing boards for use in humid conditions
- P4: load-bearing boards for use in dry conditions
- P5: load-bearing boards for use in humid conditions
- P6: heavy duty load-bearing boards for use in dry conditions
- P7: heavy duty load-bearing boards for use in humid conditions.

Selection of a grade of panel is dependent upon the ambient climatic conditions together with the level of loading that is anticipated.

Guidance on the selection of the different grades of particleboard is given in tabular format in PanelGuide *Sections 2.4 to 2.14*.

Physical properties

Climate

Like other wood-based panel products, particleboard is hygroscopic and its dimensions change in response to a change in humidity. A 1% change in moisture content typically increases or decreases the length, width and thickness of the different grades of particleboard by the amount set out in *Table A2.1*.

Table A2.1: Dimensional change for a 1% change in particleboard moisture content (DD CEN/TS 12872)

Grade	Dimensional change at 1% change in panel moisture content		
	Length %	Width %	Thickness %
P4 and P6	0,05	0,05	0,7
P5 and P7	0,03	0,04	0,5

Table A2.2: Expected moisture content of particleboard

Relative humidity at 20ºC	Approximate equilibrium moisture content
30%	7%
65%	11%
85%	15%

Particleboard, therefore, should be conditioned to bring it into equilibrium with its environment before it is fixed. This is usually achieved by loose stacking the panels in the room where they will be used prior to fixing them. The time required for the panels to achieve equilibrium moisture content will vary depending upon the temperature and relative humidity in the building (*Table A2.3*).

Table A2.3: Likely equilibrium moisture content of particleboards in various conditions

In a building with continuous central heating	7% to 9%
In a building with intermittent central heating	9% to 12%
In an unheated building	up to 15%

When components are factory produced for installation on site, it is essential that the site conditions are suitable to receive the components, with wet trades completed and the building dried out.

Panels with enhanced moisture resistance are not waterproof; the term 'moisture resistant' applies to the adhesive binder which (within limits defined by *BS EN 312*) will not break down in the presence of moisture. Physical wetting of all grades of particleboard should be avoided.

Biological attack

Particleboard will not normally be attacked by wood-boring insects common in temperate climates, but it is susceptible to fungal attack under prolonged wet conditions.

General guidance on the use of preservative treatments for panel products can be found in the Wood Protection

Association Manual *Industrial wood preservation specification and practice. Commodity Specification C11*[7]. This guidance assists with making the correct choice of preservatives for the end use and the panel product to be treated, as not all panel products need to be treated for particular end uses or are indeed suitable for some treatments. It also stresses that the preservative and/or the panel manufacturer should be consulted before any treatment is carried out as treatment may alter the physical and/or visual properties of the panel product.

Water vapour 'permeability'

The value of the water vapour resistance factor (μ) for particleboard varies with density and with the method of determination (*BS EN 12572*) as set out in *Table A2.4*, which is an extract from *BS EN 12524* and *BS EN 13986*.

Table A2.4: Water vapour resistance factor (μ) for particleboard

Mean density	Vapour resistance factor	
Kg/m^3	Wet cup μ	Dry cup μ
300	10	50
600	15	50
900	20	50

Thermal conductivity

The thermal conductivity (λ) of particleboard as determined according to *BS EN 12664* varies with density as set out in *Table A2.5*, which is taken from *BS EN 13986*.

Table A2.5: Thermal conductivity (λ) of particleboard

Mean density ρ Kg/m^3	Thermal conductivity λ W/(mK)
300	0.07
600	0.12
900	0.18

Reaction to fire

Under the Euroclass system for characterising the reaction to fire performance of materials, as taken from *European Commission Decision 2007/348/EC*, an untreated particleboard may be assumed to achieve the reaction to fire performance shown in *Table A2.6*.

If the manufactured product does not satisfy any of these minimum requirements and a reaction to fire claim is to be made in a Declaration of Performance (DoP) for CE marking purposes, then it must be tested and classified according to *BS EN 13501-1 Fire classification of construction products and building elements. Classification using test data from reaction to fire tests*[8]. However if no claim is made in the DoP for CE marking purposes it is still possible to use the British standard system to make a separate claim.

Further information on the reaction to fire testing in both the BS and EN systems is provided in PanelGuide *Section 2.2.3*.

Storage and handling

Careful storage and handling is important to maintain panels in their correct condition for use; it is therefore imperative that particleboard is protected from rain and accidental soaking. During transport, it is particularly important to keep edges well covered. Panels should be stored flat in an enclosed, dry building. When handling panels, the edges and corners should be protected against damage.

Detailed guidance on the storage and handling of wood-based panel materials is given in *DD CEN/TS 12872* and PanelGuide *Section 4*.

Table A2.6: Reaction to fire classification without further testing of untreated particleboard

Product	EN Product standard	End use condition[6]	Minimum density (kg/m^3)	Minimum thickness (mm)	Class [7] (excluding floorings)	Class [8] (floorings)
Particleboard[1],[2],[5]	BS EN 312	Without an air gap behind the wood-based panel	600	9	D-s2,d0	D_{fl}-s1
Particleboard[3],[5]	BS EN 312	With a closed or an open air gap not more than 22mm behind the wood-based panel	600	9	D-s2,d2	-
Particleboard[4],[5]	BS EN 312	With a closed air gap behind the wood-based panel	600	15	D-s2,d0	D_{fl}-s1
Particleboard[4],[5]	BS EN 312	With an open air gap behind the wood-based panel	600	18	D-s2,d0	D_{fl}-s1
Particleboard[5]	BS EN 312	Any	600	3	E	E_{fl}

(1) Mounted without an air gap directly against class A1 or A2-s1, d0 products with minimum density 10 kg/m^3 or at least class D-s2, d2 products with minimum density 400 kg/m^3
(2) A substrate of cellulose insulation material of at least class E may be included if mounted directly against the wood-based panel, but not for floorings
(3) Mounted with an air gap behind. The reverse face of the cavity shall be at least class A2-s1, d0 products with minimum density 10 kg/m^3
(4) Mounted with an air gap behind. The reverse face of the cavity shall be at least class D-s2, d2 products with minimum density 400 kg/m^3
(5) Veneered phenol- and melamine-faced panels are included for class excl. floorings
(6) A vapour barrier with a thickness up to 0,4mm and a mass up to 200 g/m^2 can be mounted in between the wood-based panel and a substrate if there are no air gaps in between
(7) Class as provided for in Table 1 of the Annex to Decision 2000/147/EC
(8) Class as provided for in Table 2 of the Annex to Decision 2000/147/EC
NOTE: The classes given in this table are for unjointed panels, T&G jointed panels installed according to *DD CEN/TS 12872* and fully supported joints installed according to *DD CEN/TS 12872*

Working with particleboard

Particleboard can be cut by a hand saw or power saw and machined (routed, spindled, planed and bored) with normal woodworking machinery. Tungsten carbide cutting edges are recommended for use with power tools.

Further information on working with particleboard is included in PanelGuide *Section 4.4*.

Mechanical joints and fixings

Wherever possible, fittings that depend upon face fixing should be selected; fittings that depend upon the expansion of a component inserted into the panel edge should be avoided.

Conventional woodworking fixings and techniques can be applied to particleboard which provides good holding power for screw fixings into the panel faces; generally, edge fixing is not recommended. Parallel core screws should be used because they have greater holding power than conventional wood screws. A high ratio of overall diameter to core diameter is desirable.

Pilot holes for all screw fixings are required. Typically, the holes should be 85% to 90% of the screw core diameter. Fixings into the panel face should not be within 8mm of edges and 25mm of the corners.

Nails and staples can be used for lightly loaded fixings or to hold glued joints while the adhesive sets.

Further information on fixing particleboard is included in PanelGuide *Section 4.5*.

Adhesive-bonded joints

A wide variety of jointing methods can be used, provided the following simple guidelines are observed:

- Ensure the joint parts are accurately machined.
- Use sharp cutters to avoid tearing or burnishing the surfaces to be bonded.
- Use a high solids content adhesive with low flowing properties such as polyvinyl acetate or urea-formaldehyde.
- Locate mating pieces accurately and hold them under pressure while the adhesive sets.
- Limit the width of grooves machined in particleboard to about one-third of the thickness of the panel. The depth of groove is typically about one-half of the panel thickness.
- Allow adhesive-bonded joints to condition for several days before sanding and finishing; this avoids the appearance of sunken joints and is essential with high-gloss finishes.
- For an efficient tongued and grooved joint ensure the fit of the joints is not too tight, as this can cause a split along the edge.
- For tongued and grooved flooring, apply glue liberally to both the tongue and the groove to ensure the entire joint is bonded.
- When attaching lipping, ensure the tongue is machined on the solid wood piece.

Finishing

The faces of particleboard are usually pre-sanded at manufacture to provide a smooth surface suitable for direct application of most veneers and plastic foils.

Additional information on finishing is provided in PanelGuide *Section 4.7*.

Health and safety

In panel or processed form, particleboard does not present any health or safety risk. Contact with wood products can cause irritation effects but the most significant risks come from mishandling the material.

Dust

Particleboard will generate dust when it is machined which, like any other wood dust, is defined as a potentially hazardous substance and must be controlled. There is no evidence that exposure produces health effects that are different in nature to those associated with exposure to similar levels of dust from other wood sources.

Dust from cutting operations can be controlled adequately by complying with the Control of Substances Hazardous to Health (COSHH) Regulations 2002. Under these Regulations particleboard dust has a Workplace Exposure Limit (WEL) of 5 mg/m^2 expressed as an 8-hour time-weighted average. Exposure must be reduced as far as possible below this limit, usually with properly designed and maintained dust extraction equipment fitted to woodworking machines.

Extraction equipment is often not practicable or even available when using portable or hand-held tools, so a suitable dust mask should be worn. If possible, work in a well-ventilated place.

Further information on dust and dust masks is given in PanelGuide *Section 6.3.3*.

Formaldehyde

Free formaldehyde in the workplace atmosphere has a WEL of 2 parts per million (ppm). However, studies indicate that anyone machining particleboard in mechanically ventilated situations is exposed to levels of free formaldehyde significantly below this.

Two classes of 'in service' formaldehyde potential are specified in *BS EN 13986*, Class E1 and Class E2, E2 being the higher of the two. The test methods available for determining the formaldehyde potential are:

- *BS EN 717-1 Wood-based panels. Determination of formaldehyde release. Formaldehyde emission by the chamber method*[9]
- *BS EN 120 Wood based panels. Determination of formaldehyde content. Extraction method called the perforator method*[10]
- for coated particleboard: *BS EN 717-2 Wood-based panels. Determination of formaldehyde release. Formaldehyde release by the gas analysis method*[11].

Table A2.7: Particleboard – common hazards and methods of control

Activity	Hazard	Control
Manual handling (in full panel form)	Large panel sizes present a risk of strain or crush injuries if not handled correctly	• Store carefully in uniform stacks on a flat level base • Use mechanical handling equipment • Adopt correct manual handling procedures
Carpentry work Activities likely to produce high dust levels include: • Sanding by machine and by hand • Sawing, routing and turning • Hand assembling machined or sanded components	• Wood dust in general (including dust from particleboard) has health risks – it may cause dermatitis and allergic respiratory effects • Wood dust is flammable	• Off site: preparation under exhaust ventilated plant • On site: enclosure and exhaust ventilation • Dust extraction on portable tools • Good ventilation • Respiratory protection equipment (RPE) Note: Any health hazards arising from the use of particleboard at work can and should be controlled by compliance with the requirements of the Control of Substances Hazardous to Health (COSHH) Regulations 2002

Manufacturers in the UK and Ireland do not offer standard grades of particleboard with Class E2 formaldehyde content. Further information on formaldehyde is given in PanelGuide *Section 6.4*.

Hazards and control

In panel or processed form, particleboard is non-classifiable under the COSHH Regulations. However, there may be handling hazards.

COSHH Regulation 6 requires an assessment of health risks associated with wood dust or formaldehyde (normally recorded), together with any action needed to prevent or control those hazards.

Table A2.7 presents the most common hazards and identifies control methods to minimise the risk of harm actually occurring, more detailed information is given in PanelGuide *Section 6.3* and by the Health and Safety Executive.

Annex 2B: OSB (oriented strand board)

Description

OSB is an engineered wood-based panel material in which long strands of wood are bonded together with a synthetic resin adhesive. OSB is usually composed of three layers, with the strands of the outer two layers orientated in a particular direction, more often than not in the long direction of the panel. While there is an orientation, it is often hard to see because there is quite a large degree of variability in this orientation among adjacent strands in the panels from any one production line, as well as between panels from different producers.

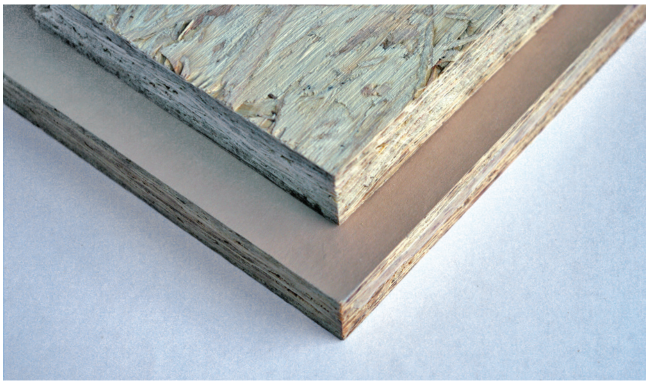


Figure A2.2: OSB

Composition

The timbers used in OSB manufacture include both softwoods (spruce, pine) and hardwood (aspen). Wood strands are cut tangentially from debarked logs which are held longitudinally against rotating knives. The ribbon of flakes produced is usually about 75mm wide and this breaks up on handling to produce individual flakes which are 75mm along the grain and from 5mm to 50mm across the grain.

After drying, these flakes are generally sprayed with a synthetic resin binder and wax, though one or two mills employ powdered resins. One of the important points in OSB manufacture is the removal of fines prior to resin application: this results in the use of lower amounts of resin in OSB (2% to 3%) compared with other resin-bonded panel products.

The three main adhesives used in the production of OSB are phenol-formaldehyde (PF), isocyanates (MDI or PMDI) and melamine-urea-formaldehyde (MUF). These are either used on their own or the core and the surface layers may use two different types of adhesive.

All these resins confer a measure of moisture resistance to the panel.

Before pressing, the strands in the mat are aligned either in each of the three layers of the panel or, more frequently, in only the outer two layers. The degree of orientation varies widely within any one panel, and also in panels from different manufacturers; in panels from different manufacturers it is possible to obtain ratios of property levels in the machine- to cross-direction of 1.25:1 to 2.5:1, thereby emulating the ratios found in plywood.

Appearance

OSB is readily identified by its larger and longer wood strands, compared to particleboard. The orientation of the surface strands is not always visually apparent, especially in small pieces of panel. The panel tends to have a number of holes on the surface due to the overlap of strands, but a smoother surface can be obtained by sanding. However, OSB will never possess the smoothness of surface found in fibreboards and particleboards: rather its merits lie in the field of mechanical performance which is directly related to the use of longer and larger strands of wood.

OSB varies in colour from a light straw colour to a medium brown depending on species used, resin system adopted and pressing conditions employed.

Density, mass and panel size

Panel density (and therefore panel mass) varies depending upon the product, being affected by the timber species and the process used in manufacture. Typical densities are 600 kg/m^3 to 680 kg/m^3. For example, a 2400mm × 1200mm × 12mm panel will weigh approximately 20kg.

Panel sizes commonly available are:

- 2440mm × 1200mm
- 2440mm × 1220mm
- 3660mm × 1220mm

in thicknesses of 6mm, 8mm, 9mm, 11mm, 15mm, 18mm, 22mm, 25mm and 38mm.

Other sizes are available or can be produced to order. Panels are produced with either square or T&G edges.

Applications

Because of its lay-up and composition, OSB is primarily a panel for construction and is widely used for flooring, flat roof decking and wall sheathing. Different grades of the product are available for different levels of loading and different environmental conditions. Guidance on the use of OSB in these load-bearing applications is given in *DD CEN/TS 12872*. Generally, for the same loading conditions, a thinner panel of OSB can be used than a load-bearing particleboard.

There are currently 'deemed to satisfy' tables for domestic floor and roof applications in *BS 8103-3 Structural design of low-rise buildings. Code of practice for timber floors and roofs for housing*[12]. However there is no deemed to satisfy route for non-domestic floor applications at present.

Large quantities of OSB are also used for sarking and industrial packaging and in the construction of site hoardings and pallet tops.

Specification

OSB manufactured in Europe for construction purposes must now be specified in accordance with *BS EN 300 Oriented strand boards (OSB). Definitions, classification and specifications*[13]. As explained in PanelGuide *Section 2*, OSB that is used in construction must comply (by law) with the Construction Products Regulation (CPR) by compliance with the harmonised European standard (hEN) for wood-based panels (*EN 13986*, implemented in the UK as *BS EN 13986 Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking*); this standard calls up *BS EN 300* which contains the requirements for the following four grades (technical classes):

- OSB/1 – General purpose boards, and boards for interior fitments (including furniture) for use in dry conditions
- OSB/2 – Load-bearing boards for use in dry conditions
- OSB/3 – Load-bearing boards for use in humid conditions
- OSB/4 – Heavy-duty load-bearing boards for use in humid conditions.

Selection of a grade of load-bearing panel is dependent upon the ambient climatic conditions together with the level of loading that is anticipated.

Guidance on the selection of the different grades of OSB is given in tabular format in PanelGuide *Sections 2.4 to 2.14*.

Physical properties

Climate

Like other wood-based panel products, OSB is hygroscopic and its dimensions change in response to a change in humidity. A 1% change in moisture content typically increases or decreases the length, width and thickness of the different grades of OSB by the amounts set out in *Table A2.8*.

Table A2.8: Dimensional change for a 1% change in OSB panel moisture content (DD CEN/TS 12872)

Panel type	Dimensional change at 1% change in panel moisture content		
	Length %	Width %	Thickness %
OSB/2	0,03	0,04	0,7
OSB/3	0,02	0,03	0,5
OSB/4	0,02	0,03	0,5

As a guide, OSB can be expected to attain the moisture content under specified conditions shown in *Table A2.9*.

Table A2.9: Expected moisture content of OSB

Relative humidity at 20°C	Approximate equilibrium moisture content
30%	5%
65%	10%
85%	15%

When it leaves the factory, OSB generally has a moisture content of about 2%. Therefore, it must be conditioned to bring it into equilibrium with its environment before it is fixed. This is usually achieved by loose stacking the panels in the room where they will be used prior to fixing them. The time required for the panels to achieve equilibrium moisture content will vary depending upon

Table A2.10: Likely equilibrium moisture content of OSB in various conditions

In a building with continuous central heating	5% to 7%
In a building with intermittent central heating	8% to 10%
In an unheated building	up to 15%

the temperature and relative humidity in the building. The likely equilibrium moisture content of OSB in various conditions is shown in *Table A2.10*.

When components are factory produced for installation on site, it is essential that the site conditions are suitable to receive the components, with wet trades completed and the building dried out.

OSB with enhanced moisture resistance (OSB/3; OSB/4) is not waterproof; the term 'moisture resistant' applies to the adhesive binder which (within limits defined by *BS EN 300*) will not break down in the presence of moisture. Physical wetting of all grades of OSB should be avoided. When wet, OSB will increase appreciably in thickness.

Biological attack

OSB will not normally be attacked by wood-boring insects common in temperate climates, but panels made using aspen and spruce are susceptible to fungal attack under prolonged wet conditions; panels made from pine have moderate resistance to attack.

General guidance on the use of preservative treatments for panel products can be found from the WPA Manual *Industrial wood preservation specification and practice. Commodity Specification C11*. This guidance assists with making the right choice of preservatives for the end use and the panel product to be treated, as not all panel products need to be treated for particular end uses or are indeed suitable for some treatments. It also stresses that the preservative and/or the panel manufacturer should be consulted before any treatment is carried out, as treatment may alter the physical and/or visual properties of the panel product.

Water vapour 'permeability'

The value of the water vapour resistance factor (μ) for OSB varies with the method of determination (*BS EN ISO 12572 Hygrothermal performance of building materials and products. Determination of water vapour transmission properties*[14]) as set out in *Table A2.11* which is an extract from *BS EN 12524 Building materials and products. Hygrothermal properties. Tabulated design values*[15] and *BS EN 13986*.

Table A2.11: Water vapour resistance factor (μ) for OSB

Mean density	Vapour resistance factor	
Kg/m³	Wet cup μ	Dry cup μ
650	30	50

Thermal conductivity

The thermal conductivity (λ) of OSB as determined according to *BS EN 12664 Thermal performance of building materials and products. Determination of thermal resistance by means of guarded hot plate and heat flow meter methods. Dry and moist products of medium and low thermal resistance*[16] is 0.13 W/m.K for a mean density of 650 kg/m³ as set out in *BS EN 13986*.

Reaction to fire

Under the Euroclass system for characterising the reaction to fire performance of materials, as taken from *European Commission Decision 2007/348/EC*, an untreated OSB may be assumed to achieve the performance requirements shown in *Table A2.12*.

Table A2.12: Reaction to fire classification without further testing of untreated OSB

Product	EN Product standard	End use condition(6)	Minimum density (kg/m³)	Minimum thickness (mm)	Class (7) (excluding floorings)	Class (8) (floorings)
OSB(1),(2),(5)	BS EN 300	Without an air gap behind the wood-based panel	600	9	D-s2,d0	D_{fl}-s1
OSB(3),(5)	BS EN 300	With a closed or an open air gap not more than 22mm behind the wood-based panel	600	9	D-s2,d2	-
OSB(4),(5)	BS EN 300	With a closed air gap behind the wood-based panel	600	15	D-s2,d0	D_{fl}-s1
OSB(4),(5)	BS EN 300	With an open air gap behind the wood-based panel	600	18	D-s2,d0	D_{fl}-s1
OSB(5)	BS EN 300	Any	600	3	E	E_{fl}

1) Mounted without an air gap directly against class A1 or A2-s1, d0 products with minimum density 10 kg/m³ or at least class D-s2, d2 products with minimum density 400 kg/m³
(2) A substrate of cellulose insulation material of at least class E may be included if mounted directly against the wood-based panel, but not for floorings
(3) Mounted with an air gap behind. The reverse face of the cavity shall be at least class A2-s1, d0 products with minimum density 10 kg/m³
(4) Mounted with an air gap behind. The reverse face of the cavity shall be at least class D-s2, d2 products with minimum density 400 kg/m³
(5) Veneered phenol- and melamine-faced panels are included for class excl. floorings
(6) A vapour barrier with a thickness up to 0,4mm and a mass up to 200 g/m² can be mounted in between the wood-based panel and a substrate if there are no air gaps in between
(7) Class as provided for in Table 1 of the Annex to Decision 2000/147/EC
(8) Class as provided for in Table 2 of the Annex to Decision 2000/147/EC
NOTE: The classes given in this table are for unjointed panels, T&G jointed panels installed according to *DD CEN/TS 12872* and fully supported joints installed according to *DD CEN/TS 12872*

If the manufactured product does not satisfy any of these minimum requirements and a reaction to fire claim is to be made in a DoP for CE marking purposes, then it must be tested and classified according to *BS EN 13501-1*. However if no claim is made in the DoP for CE marking purposes it is still possible to use the British standard system to make a separate claim.[17]

Further information on the reaction to fire testing in both the BS and EN systems is provided in PanelGuide *Section 2.2.3*.

Storage and handling

Careful storage and handling is important to maintain panels in their correct condition for use; OSB must therefore be protected from rain and accidental soaking. During transport, it is particularly important to keep edges well covered. Panels should be stored flat in an enclosed, dry building. When handling panels, the edges and corners should be protected against damage.

Detailed guidance on the storage and handling of wood-based panel materials is given in *DD CEN/TS 12872* and PanelGuide *Section 4*.

Working with OSB

OSB can be cut by a hand saw or power saw and machined (routed, spindled, planed and bored) with normal wood-working machinery. Tungsten carbide cutting edges are recommended for use with power tools.

Further information on working with OSB is included in PanelGuide *Section 4.4*.

Mechanical joints and fixings

Wherever possible, fittings that depend upon face fixing should be selected; fittings that depend upon the expansion of a component inserted into the panel edge should be avoided.

Conventional woodworking fixings and techniques can be applied to OSB which provides good holding power for screw fixings into the panel faces; generally, edge fixing is not recommended. Parallel core screws should be used because they have greater holding power than conventional wood screws. A high ratio of overall diameter to core diameter is desirable.

Pilot holes for all screw fixings are required. Typically, the holes should be 85% to 90% of the screw core diameter. Fixings into the panel face should not be within 8mm of edges and 25mm of the corners.

Nails and staples can be used for lightly loaded fixings or to hold glued joints while the adhesive sets.

Further information on fixing OSB is included in PanelGuide *Section 4.5*.

Adhesive-bonded joints

A wide variety of jointing methods can be used, provided the following simple guidelines are observed:

- Ensure the joint parts are accurately machined.
- Use sharp cutters to avoid tearing or burnishing the surfaces to be bonded.
- Use a high solids content adhesive with low flowing properties such as polyvinyl acetate or urea-formaldehyde.
- Locate mating pieces accurately and hold them under pressure while the adhesive sets.
- Limit the width of grooves machined in OSB to about one-third of the thickness of the panel. The depth of groove is typically about one-half of the panel thickness.
- Allow adhesive-bonded joints to condition for several days before sanding and finishing; this avoids the appearance of sunken joints and is essential with high-gloss finishes.
- For an efficient tongued and grooved joint, ensure the fit of the joints is not too tight as this can cause a split along the edge.
- For tongued and grooved flooring apply the glue liberally to both the tongue and the groove to ensure the entire joint is bonded.
- When attaching lipping, ensure the tongue is machined on the solid wood piece.

Finishing

Where smooth surfaces are required, pre-sanded panels should be specified.

Additional information on finishing OSB is provided in PanelGuide *Section 4.7*.

Health and safety

In panel or processed form, OSB does not present any health or safety risk. Contact with wood products can cause irritation effects but the most significant risks come from mishandling the material.

Dust

OSB will generate dust when it is machined which, like any other wood dust, is classified as a potentially hazardous substance and must be controlled. There is no evidence that exposure produces health effects that are different in nature to those associated with exposure to similar levels of dust from other wood sources.

Dust from cutting operations can be controlled adequately by complying with the Control of Substances Hazardous to Health (COSHH) Regulations 2002. Under these Regulations OSB dust has a Workplace Exposure Limit (WEL) of 5 mg/m^2 expressed as an 8-hour time-weighted average. Exposure must be reduced as far as possible below this limit, usually with properly designed and maintained dust extraction equipment fitted to woodworking machines.

Extraction equipment is often not practicable or even available when using portable or hand-held tools, so a suitable dust mask should be worn. If possible, work in a well-ventilated place.

Table A2.13: OSB – common hazards and methods of control

Activity	Hazard	Control
Manual handling (in full panel form)	Large panel sizes present a risk of strain or crush injuries if not handled correctly	• Store carefully in uniform stacks on a flat level base • Use mechanical handling equipment • Adopt correct manual handling procedures
Carpentry work Activities likely to produce high dust levels include: • Sanding by machine and hand • Sawing, routing and turning • Hand assembling machined or sanded components	• Wood dust in general (including dust from OSB) has health risks – it may cause dermatitis and allergic respiratory effects • Wood dust is flammable	• Off site: preparation under exhaust ventilated plant • On site: enclosure and exhaust ventilation • Dust extraction on portable tools • Good ventilation • Respiratory protection equipment (RPE) Note: Any health hazards arising from the use of OSB at work can and should be controlled by compliance with the requirements of the Control of Substances Hazardous to Health (COSHH) Regulations 2002

Further information on dust and dust masks is given in PanelGuide *Section 6.3*.

Formaldehyde

Free formaldehyde in the workplace atmosphere has a WEL of 2 parts per million (ppm). However, studies indicate that anyone machining OSB in mechanically ventilated situations is exposed to levels of free formaldehyde significantly below this.

Two classes of 'in service' formaldehyde potential are specified in *BS EN 13986* Class E1 and Class E2, E2 being the higher of the two. The test methods available for determining the formaldehyde potential are *BS EN 717-1*, *BS EN 120* and for coated OSB, *BS EN 717-2*.

Manufacturers in the UK and Ireland do not offer standard grades of OSB with Class E2 formaldehyde content.

Uncoated OSB manufactured using isocyanate resins does not require testing for formaldehyde and is automatically rated as Class E1. Further information on formaldehyde is given in PanelGuide *Section 6.4*.

Hazards and control

In panel or processed form, OSB is non-classifiable under the COSHH Regulations. However, there may be handling hazards.

COSHH Regulation 6 requires an assessment to be made (and normally recorded) of health risks associated with wood dust or formaldehyde, together with any action needed to prevent or control those hazards.

Table A2.13 presents the most common hazards and identifies control methods to minimise the risk of harm actually occurring.

Annex 2C: Cement bonded particleboard (CBPB)

Description

Cement-bonded particleboard (CBPB) was first commercially manufactured in the early 1970s and has continued to be manufactured in relatively small quantities, satisfying the requirements of specialised end-use applications. There are perhaps only about 50 of these mills worldwide, each producing on average only about 200 m^3/day.

The panel is a mixture of wood particles and Portland cement together with some additives. The first impression of the panel is that it is grey in colour, has a smooth almost polished surface and is heavy. This initial assessment of the panel fails to appreciate its outstanding merits especially in terms of reaction to fire, durability, stability, sound insulation and stiffness.

Composition

Following storage for at least 3 months, the debarked softwood logs of selected species are reduced to flakes some 10mm to 30mm in length and 0.2mm to 0.3mm in thickness using drum-knife flaking machines. After passing through a hammermill, the flakes are separated into surface and core material by screening, and are then mixed with Portland cement and water in the ratio by weight of:

- cement 60%
- wood 20%
- water 20%.

Small quantities of chemicals are added to the wet mix; one of their purposes is to accelerate cement setting.

The mat is formed in three layers, the outer layers comprising small chips. Unlike normal particleboard production in a multi-daylight press, the set of cauls in

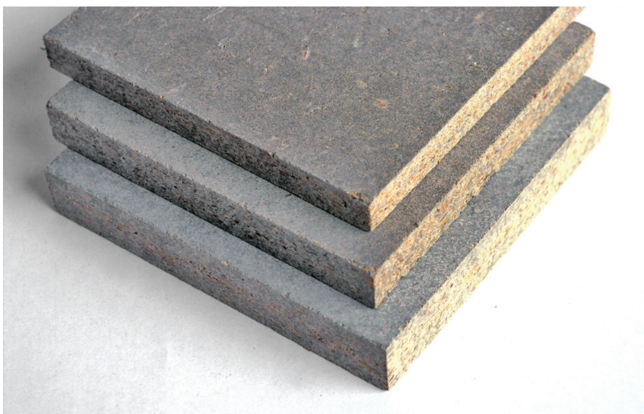


Figure A2.3: Cement-bonded particleboard

CBPB production must be kept under pressure until the cement has set. This is achieved by fixing a set of clamps to each set of cauls while in the press; these clamps are then released some 6 to 8 hours later after the set of cauls has passed through a heated chamber at 70°C to 80°C. The panels are further dried before shipment.

It is the high mass of Portland cement which confers on the product its:

- good reaction to fire behaviour
- very high durability (as a result of the panel having a pH of 11)
- high stiffness (E = 4500 N/mm^2)
- very good sound insulation
- good dimensional stability relative to other wood-based composites.

Appearance

CBPB is readily identified from its mid-grey somewhat polished appearance. The surface is very smooth, cementitious and devoid of wood chips; however, when heavily sanded the surface can appear very similar to that of resin-bonded particleboard. In cross-section the chips, particularly in the middle layer of the panel, can be clearly seen: there are very few holes to be seen with the cement encasing the wood chips.

Density mass and panel size

Panel density is a function of the percentage volume of cement used, together with the degree of pressure exerted on the mat. Most manufacturers produce a panel with a minimum density of 1100kg/m^3. This means that a 2400mm × 1200mm × 12mm panel will weigh approximately 45kg. This can give rise to handling problems, especially with thicker panels.

Panel sizes commonly available are 1200mm × 2440mm and 1200mm × 3050mm in thicknesses of 6mm to 40mm. Square-edged panels are the standard; profiling is done to order.

Applications

Primarily because of its lay-up, composition and mass, CBPB is mainly used for specialised applications in construction. Its outstanding merits (especially in terms of reaction to fire, durability, sound insulation and stiffness) render the product most suitable for internal wall construction in public places, lining of lift shafts, construction of cabling ducts, soffits, motorway acoustic fencing and cladding of prefabricated house units.

Specification

CBPB manufactured in Europe must now be specified in accordance with *BS EN 634-1 Cement-bonded particle boards. Specification. General requirements*[18]. As explained in PanelGuide *Section 2*, CBPB that is used in construction must comply (by law) with the Construction Products Regulation (CPR) by compliance with *BS EN 13986*; this standard calls up *BS EN 634* which is in two parts:

- *BS EN 634-1 Cement-bonded particle boards. Specification. General requirements*
- *BS EN 634-2 Cement-bonded particleboards. Specification. Requirements for OPC bonded particleboards for use in dry, humid and exterior conditions*[19]

Guidance on the selection of CBPB is given in tabular format in PanelGuide *Sections 2.4 to 2.14*.

Physical properties

Climate

Like other wood-based panel products, CBPB is hygroscopic and its dimensions change in response to a change in humidity; in terms of thickness, the extent of dimensional change is only about 5% that of wood-based panels bonded with an organic adhesive. A 1% change in moisture content typically increases or decreases the length, width and thickness of CBPB by the amounts set out in *Table A2.14*.

Table A2.14: Dimensional change of CBPB for a 1% change in panel moisture content (DD CEN/TS 12872)

Specification	Dimensional change at 1% change in panel moisture content		
	Length %	Width %	Thickness %
BS EN 634	0.05	0.05	0.04

As a guide, CBPB can be expected to attain the moisture content under specified conditions in *Table A2.15*.

Table A2.15: Expected moisture content of CBPB

Relative humidity at 20°C	Approximate equilibrium moisture content
30%	5%
65%	10%
85%	14%

Like other wood-based panels, CBPB must be conditioned to bring it into equilibrium with its environment before it is fixed (*Table A2.16*). This is usually achieved by loose stacking the panels in the room where they will be used prior to fixing them. The time required for the panels to achieve equilibrium moisture content will vary depending upon the temperature and relative humidity in the building. It is difficult to achieve an exact equilibrium moisture content with CBPB as, like concrete, it continues to gain weight (and strength) with time, but at an ever-reducing rate, due to carbonation.

Table A2.16: Likely equilibrium moisture content of CBPB in various conditions

In a building with continuous central heating	5% to 7%
In a building with intermittent central heating	8% to 10%
In an unheated building	up to 15%

Biological attack

CBPB because of its high alkalinity (pH 11) will not normally be attacked either by wood-boring insects common in temperate or tropical climates or by fungi even at high moisture contents.

Water vapour 'permeability'

The value of the water vapour resistance factor (μ) for CBPB varies with the method of determination (*BS EN ISO 12572*) as set out in *Table A2.17* which is an extract from *BS EN 12524* and *BS EN 13986*.

Table A2.17: Water vapour resistance factor (μ) for CBPB

Mean density	Vapour resistance factor	
Kg/m³	Wet cup μ	Dry cup μ
1200	30	50

Thermal conductivity

The thermal conductivity (λ) of CBPB as determined according to *BS EN 12664* is 0.23 W/m.K for a mean density of 1200 kg/m^3 as set out in *BS EN 13986*.

Reaction to fire

Under the Euroclass system for characterising the reaction to fire performance of materials, as taken from *European Commission Decision 2007/348/EC*, an untreated CBPB may be assumed to achieve the performance in *Table A2.18*.

If the manufactured product does not satisfy any of these minimum requirements and a reaction to fire claim is to be made in a DoP for CE marking purposes, then it must be tested and classified according to *BS EN 13501-1*. However if no claim is made in the DoP for CE marking purposes it is still possible to use the British standard system to make a separate claim.

Further information on the reaction to fire testing in both the BS and EN systems is provided in PanelGuide *Section 2.2.3*.

Storage and handling

Careful storage and handling is important to maintain panels in their correct condition for use; therefore CBPB must be protected from rain and accidental soaking. During transport, it is particularly important to keep edges well covered. Panels should be stored flat in an enclosed, dry building. When handling panels, the edges and corners should be protected against damage and care should be exercised in the carriage of thin panels.

Detailed guidance on the storage and handling of wood-based panel materials is given in *DD CEN/TS 12872* and PanelGuide *Section 4*.

Working with CBPB

CBPB should be cut by power saw and machined (routed, spindled, planed and bored) with normal wood-working machinery fitted with tungsten carbide cutting edges. Dust extraction equipment must be employed in enclosed spaces.

Further information on working with CBPB is included in PanelGuide *Section 4.4*.

Mechanical joints and fixings

Wherever possible, fittings that depend upon face fixing should be selected; fittings that depend upon the expansion of a component inserted into the panel edge should be avoided.

Conventional woodworking fixings and techniques can be applied to CBPB which provides good holding power for screw fixings into the panel faces. Edge screwing is possible; in panels greater than 16mm in thickness, pre-drilled holes are required. Countersunk parallel core screws should be used in both edge and face fixings because they have greater holding power than conventional wood screws. A high ratio of overall diameter to core diameter is desirable. Because of the high alkalinity of the panel, stainless steel or galvanised screws with a diameter up to 4.2mm should be used.

Drill pilot holes for all screw fixings. Typically, the holes should be 85% to 90% of the screw core diameter. Fixings into the panel face should not be within 15mm of edges of panels up to 16mm in thickness (20mm for panels up to 22mm in thickness) and within 40mm of the corners.

Manual nailing of serrated or twisted nails up to 3.1mm in diameter is possible in panels up to 12mm in thickness. Above 12mm, either pre-drilled manual insertion or non-pre-drilled pneumatic fixing should be used. Nails must

Table A2.18: Reaction to fire classification without further testing of untreated CBPB

Product	EN Product standard	End use condition(2)	Minimum density (kg/m³)	Minimum thickness (mm)	Class (3) (excluding floorings)	Class (4) (floorings)
Cement-bonded particleboard(4)	BS EN 634-2	Without an air gap behind the panel	1000	10	B-S1, d0	B_{fl}-s1

1) Mounted without an air gap directly against class A1 or A2-s1, d0 products with minimum density 10kg/m^3 or at least class D-s2, d2 products with minimum density 400 kg/m^3

(2) A vapour barrier with a thickness up to 0,4mm and a mass up to 200 g/m^2 can be mounted in between the wood-based panel and a substrate if there are no air gaps in between

(3) Class as provided for in Table 1 of the Annex to Decision 2000/147/EC

(4) Class as provided for in Table 2 of the Annex to Decision 2000/147/EC

NOTE: The classes given in this table are for unjointed panels, T&G jointed panels installed according to *DD CEN/TS 12872* and fully supported joints installed according to *DD CEN/TS 12872*

be flat-headed and galvanised, sheradised or of stainless steel.

Panels can also be fitted together using galvanised or stainless steel clips.

Further information on fixing CBPB is included in PanelGuide *Section 4.5*.

Adhesive-bonded joints

A wide variety of jointing methods can be used, provided the following simple guidelines are observed:

- Ensure the joint parts are accurately machined.
- Use sharp cutters to avoid tearing or burnishing the surfaces to be bonded.
- Use a high solids content adhesive with low flowing properties such as polyvinyl acetate or urea-formaldehyde.
- Locate mating pieces accurately and hold them under pressure while the adhesive sets.
- Limit the width of grooves machined in CBPB to about one-third of the thickness of the panel. The depth of groove is typically about one-half of the panel thickness.
- Allow adhesive-bonded joints to condition for several days before sanding and finishing; this avoids the appearance of sunken joints and is essential with high-gloss finishes.
- For an efficient tongued and grooved joint, ensure the fit of the joints is not too tight, as this can cause a split along the edge.
- For tongued and grooved flooring, apply the glue liberally to both the tongue and the groove to ensure the entire joint is bonded.
- When attaching lipping, ensure the tongue is machined on the solid wood piece.

Finishing

Where very smooth surfaces are required, pre-sanded panels should be specified. Further information on finishing CBPB is provided in PanelGuide *Section 4.7*.

Health and safety

In panel or processed form CBPB does not present any health or safety risk. Contact with wood products and cement can cause irritation effects but the most significant risks come from mishandling the material.

Dust

CBPB will generate large quantities of very fine dust when it is machined; this is a potentially hazardous substance that must be controlled.

Dust from cutting operations can be controlled adequately by complying with the Control of Substances Hazardous to Health (COSHH) Regulations 2002. Under these Regulations CBPB dust has a Workplace Exposure Limit (WEL) of 5 mg/m^2 expressed as an 8-hour time-weighted average. Exposure must be reduced as far as possible below this limit, usually with properly designed and maintained dust extraction equipment fitted to woodworking machines.

Extraction equipment is often not practicable or even available when using portable or hand-held tools, so a suitable dust mask should be worn. If possible, work in a well-ventilated place.

Further information on dust and dust masks is given in PanelGuide *Section 6.3*.

Formaldehyde

Uncoated CBPB manufactured using Portland cement does not require to be tested for formaldehyde and is automatically rated as Class E1. Uncoated panels therefore have an E1 rating.

Hazards and control

In panel or processed form, CBPB is non-classifiable under the COSHH Regulations. However, there may be handling hazards, especially so on account of its high density.

COSHH Regulation 6 requires an assessment to be made (and normally recorded) of health risks associated with wood dust or formaldehyde together with any action needed to prevent or control those hazards.

Table A2.19 presents the most common hazards and identifies control methods to minimise the risk of harm actually occurring. More detailed information is given in PanelGuide *Section 6.3* and by the Health and Safety Executive.

Table A2.19: CBPB – common hazards and methods of control

Activity	Hazard	Control
Manual handling (in full panel form)	Large panel sizes and significant weight of CBPB present a risk of strain or crush injuries if not handled correctly	• Store carefully in uniform stacks on a flat level base • Use mechanical handling equipment • Adopt correct manual handling procedures
Carpentry work Activities likely to produce high dust levels include: • Sanding by machine and hand • Sawing, routing and turning • Hand assembling machined or sanded components	• Wood dust in general (including dust from CBPB) has health risks – it may cause dermatitis and allergic respiratory effects • Wood dust is flammable	• Off site: preparation under exhaust ventilated plant • On site: enclosure and exhaust ventilation • Dust extraction on portable tools • Good ventilation • Respiratory protection equipment (RPE) Note: Any health hazards arising from the use of CBPB at work can and should be controlled by compliance with the requirements of the Control of Substances Hazardous to Health (COSHH) Regulations 2002.

Annex 2D: Plywood

Description

Plywood is a versatile product that can combine attractive surface appearance with superior performance under hazardous conditions while retaining comparatively high strength-to-weight ratios. It is available in a range of wood species, including hardwood and softwood species and combinations of the two, and a range of resin types for interior, high humidity and exterior conditions. It was developed to provide panels with dimensional stability and good strength both along and across the panel.

The term 'plywood' includes both the true 'veneer plywood' and also 'core plywood' of which 'blockboard' and 'laminboard' are examples. Typical examples of these products are shown in *Figure A2.4*.

Figure A2.4 Various types of plywood

Veneer plywood, the official term for what is usually called plywood, is defined as plywood in which all the plies are made of wood veneers orientated with their plane parallel to the surface of the panel. In such products the direction of the grain in adjacent plies is normally at right angles, with the outer and inner plies placed symmetrically on each side of a central ply or core. However, as long as veneer plywood is 'balanced' about its centre line, plies may consist of two adjacent veneers bonded with their grain parallel. This structure usually results in plywood having higher mechanical properties in the direction parallel to the grain of the face veneer.

Core plywood, such as blockboard or laminboard, is an assembly of plies bonded together, some or all of which are wood, in the form of veneers, solid strips or battens. Materials other than wood may also be included in various forms to confer specialist properties or performance.

Plywood is produced with resin bonds which range from those suitable only for interior use to those which will withstand elevated levels of humidity in external exposure. Typical adhesives used are:

- urea-formaldehyde (UF)
- phenol-formaldehyde (PF)
- melamine-urea-formaldehyde (MUF).

Plywood is produced on a worldwide basis using a wide range of timber species including softwoods and temperate or tropical hardwoods. These species may be grown in natural forests or increasingly as part of regeneration or plantation forest management systems. Many different species can be used for plywood manufacture with the principal qualification criteria that the log can be reliably peeled or sliced into veneer. Softwood species commonly used include spruce, pine and fir. Hardwood species used include birch, beech, poplar and eucalyptus. The quality of the finished plywood depends both on the quality, species and lay-up of the veneers, as well as on the resin type and bonding quality.

Blockboard and laminboard are 'core plywood' having a core made up of strips of wood, each not more than 30mm wide, or strips of 'on-edge' veneer, laid separately and bonded or otherwise joined together to form a slab, to each face of which is bonded one or more veneers, with the direction of the grain of the core strips running at right angles to that of the adjacent veneers.

Composition

Veneer plywood

Standard plywood veneer is produced using a lathe, which peels a log in a similar manner to a blade pencil sharpener, but with the blade parallel to the log. Most decorative veneer is sliced from flitches after the log is cut into quarters. Prior to peeling or slicing, the logs are normally soaked or steamed in order to increase the moisture content. This helps to produce a smoother veneer. The veneers are then dried to a moisture content of about 4%–8%. In some cases, small strips of veneer may be jointed into full-size sheets by edge gluing, stitching or using perforated paper adhesive tape. Open defects, such as knot holes, may be repaired using plugs or filler to upgrade the panel in accordance with grading rules. The dried, clipped or reconstituted veneers are sorted into grades, usually by visual inspection.

Synthetic resin adhesive is applied to the veneers by roller spreader, spray, extrusion or curtain coating and veneers are assembled with the grain of each normally at 90° to the adjacent veneer. Plywood with special characteristics is produced when this rule of bonding at right angles is not followed. The resultant assembly is known as a lay-up.

The main types of resin used for plywood manufacture are:

- Urea-formaldehyde (UF): panels made with this type of resin are normally only suitable for interior use.

Some panels may also be suitable for use in humid environments but not for use in exterior situations.
- Phenol-formaldehyde (PF): this type of resin produces bonds which have greater moisture resistance and therefore panels made with this type of resin are normally suitable for use in humid or in exterior situations. The durability of the veneer species must also be taken into account when selecting plywood for uses where it may be exposed to prolonged high moisture content (see *DD CEN/TS 1099 Plywood. Biological durability. Guidance for the assessment of plywood for use in different use classes*[20] for guidance on plywood durability).
- Melamine-urea-formaldehyde (MUF): this third type of adhesive, urea-formaldehyde fortified with melamine and known as 'MUF', is used in some types of plywood. Bonds traditionally tend to be between UF and PF in resistance to moisture/weather. However, resin technology is constantly evolving with some manufacturers able to make exterior or even marine plywood using a melamine-based adhesive.

The lay-ups are then subjected to pressure and heat in batches, most commonly in a multi-opening (multi-daylight) press. This results in a compressed and cured panel which, after cooling, is trimmed to size and, if necessary, sanded.

In some forms of plywood, particularly those from China, further face and back veneers may be added later in a separate processing operation. Such veneers are generally very thin in nature but will normally be of a high quality in order to retain their form and integrity. Because of their thin nature, the resins used to bond these outer veneers may be of a different type to those used to bond the main structure of the panel.

Core plywood (blockboard/laminboard)

The technique of manufacturing blockboard and laminboard developed alongside the plywood industry from the turn of the last century. Blockboard uses strips of wood about 25mm wide for its core, while laminboard cores are composed of strips of veneer on edge (or occasionally strips cut from plywood). Plywood mills may introduce block or laminboard manufacturing facilities to use residues and to produce lower cost utility types of panels suitable for some interior purposes. The method of production is similar to that for plywood and the 'wet' stages of veneer manufacture are identical. The resins used to bond the plies are also potentially the same. However, as utility panels, most will use the lower cost UF resins and therefore such products are generally only suitable for interior applications.

Appearance

Surface appearance

The surface appearance of plywood depends upon the species and grade of veneer used for the surface layers. The classification of surface appearance is covered in the five parts of *BS EN 635 Plywood – Classification by surface appearance*, as follows:

- *BS EN 635-1 Plywood. Classification by surface appearance. General*[21].
- *BS EN 635-2 Plywood. Classification by surface appearance. Hardwood*[22].
- *BS EN 635-3 Plywood. Classification by surface appearance. Softwood*[23].
- *DD CEN/TS 635-4 Plywood. Classification by surface appearance. Parameters of ability for finishing, guideline*[24].
- *BS EN 635-5 Plywood. Classification by surface appearance. Methods for measuring and expressing characteristics and defects*[25].

The characteristics listed in *BS EN 635-1, 2 & 3* include:

- knots
- splits
- insect holes
- bark and resin pockets
- decay
- veneer joints
- repairs
- edge defects.

Limits are set for five different grades of veneer, with the best grade 'E' being virtually clear of all defects. The limits vary between softwood (*BS EN 635-3*) and hardwood (*BS EN 635-2*), so care has to be taken to select the correct definition of the grades. The final colour of the panel is also affected by any finish applied and by the effects of weathering and ageing. These factors are also affected by the species of veneer used.

DD CEN/TS 635-4 deals with parameters that affect the surface finishing/coating of plywood and includes factors such as:

- surface, eg sanded
- minimum appearance class
- thickness of face veneer
- defects in first inner ply
- bonding class.

Although the quality of veneer used in the manufacture of plywood will affect its mechanical properties, the veneer classes given in *BS EN 635* are intended only for use in determining the visual appearance of the panel. They are not intended to be used as a basis for defining a structural grade of plywood, as the inherent strength of the species being used will be a significant determining factor.

Edge appearance

An examination of the edges of plywood panels can quickly distinguish between veneer plywood and core plywood. Veneer plywood will be seen to be constructed from a series of veneers laid with their plane parallel to the panel surface. In core plywood, the core material (solid strips or strips of veneer glued face to back and laid on edge) can normally be clearly seen beneath the surface veneers.

Density, weight and sizes

The density of plywood is not normally controlled as part of the product specification but is a function of the species of timber used. Most construction plywood will have a density in the range of 400 kg/m^3 to 700 kg/m^3. Thus a 2400mm × 1200mm × 12mm panel could typically weigh between 14kg and 24kg. However, as most plywood is manufactured from a single species or a limited range of species, the production from a particular manufacturer will fall within a defined density range and therefore reference should be made to the manufacturer's documentation or packaging for further information and handling data.

Some highly compressed, specialist plywood can have densities in excess of 1000 kg/m^3 and some may even be designed with 'bullet resistant' qualities.

Plywood is available to order in thicknesses ranging from 1.5mm to 40mm or greater but the most commonly available nominal thicknesses generally held in stock in the UK will be:

3mm, 4mm, 6mm, 9mm, 12mm, 15mm, 18mm, 22mm, 25mm, 32mm.

Common panel sizes are:

- 2440mm × 1220mm
- 2440mm × 610mm (normally T&G)
- 2500mm × 1220mm
- 3050mm × 1525mm
- 3050mm × 1220mm

Some specialist plywood products, for applications such as lorry sides, are available to order in much larger sizes of up to 14m × 3m. Some manufacturers and most importers or distributors will offer panel cutting services to meet the customer's specific needs.

The density range of blockboard/laminboard is not significantly different from that of plywood, the density being largely controlled by the species and form of the core material. Some panels with low density cores are available for applications where weight is critical. Panels are available in thicknesses ranging from about 10mm up to 30mm. Common sheet sizes are 2440mm × 1220mm and 3050mm × 1525mm.

Applications

The range of species and bond qualities means that plywood can be engineered to have specific properties, making it suitable for a wide range of applications. It is the only wood-based panel with established design values that can be used in structural applications under external conditions in accordance with *BS EN 1995-1-1 Eurocode 5. Design of timber structures. General. Structural fire design*[26] or *BS 5268-2 Structural use of timber. Code of practice for permissible stress design, materials and workmanship*[27] (now withdrawn). Some of the typical 'types' of plywood and their applications are listed below.

Structural plywood

Plywood for use in construction must meet the requirements of the Construction Products Regulation (CPR). The most straightforward route to demonstrating this is by complying with the requirements of the harmonised standard for wood-based panels *BS EN 13986*, which in turn references *BS EN 636 Plywood. Specifications*[28]. See PanelGuide *Section 2* for further guidance on complying with the CPR.

For structural design in accordance with *BS EN 1995-1-1* (*Eurocode 5*), characteristic values can be taken from *BS EN 12369-2 Wood-based panels. Characteristic values for structural design. Plywood*[29], if a manufacturer has assigned the product to one of the strength classes included in that standard. Alternatively values can be calculated following testing and calculation in accordance with *BS EN 789 Timber structures. Test methods. Determination of mechanical properties of wood based panels*[30] and *BS EN 1058 Wood-based panels. Determination of characteristic 5-percentile values and characteristic mean values*[31]. Whichever method is used, the manufacturer should provide details of the characteristic values in a Declaration of Performance (DoP) to accompany the product.

Permissible design stresses for a range of plywood types are included in *BS 5268-2*. Although this standard has now been withdrawn, it is still being used by some designers. The products listed are manufactured to national standards that ensure minimum strength properties in the finished product and which are subject to approved quality control procedures. Currently such plywood is available from Canada, Finland, Sweden and the USA. Such plywood will also need to demonstrate compliance with the CPR, by meeting the requirements of *BS EN 13986*, or by other means. If characteristic values are provided for a particular plywood, conversion factors in *BS 5268-2* allow these characteristic values to be converted to permissible stresses.

Common uses for structural plywood are in:

- floor decking
- wall sheathing
- flat roofing
- concrete formwork
- external cladding.

Marine plywood (BS EN 1088)

Marine plywood to *BS EN 1088* is manufactured using timbers having a durability rating of Class 3 (moderately durable) or better in accordance with *BS EN 350-2 Durability of wood and wood-based products. Natural durability of solid wood. Guide to natural durability and treatability of selected wood species of importance in Europe*[32]. Exceptionally, low density species such as gaboon, with a durability rating of Class 4 (slightly durable) or better may also be used, but the product must then be marked with 'LW' to signify light weight. In both cases, high quality veneers are used and must be bonded using a resin to meet bonding Class 3 of *BS EN 314-2 Plywood. Bonding quality. Requirements*[33]. In most circumstances this would be a phenolic resin or a modified melamine-formaldehyde resin.

Marine plywood was developed for ship/boat building and has a very high performance under severe exposure conditions. It is also commonly used in construction applications where high performance is required or where the cost of replacement or consequences of failure warrant the additional cost. In the case of construction applications, the plywood must also demonstrate compliance with the CPR. As described in PanelGuide *Section 2* compliance with the CPR requires the inclusion of a CE mark and provision by the manufacturer of a Declaration of Performance (DoP).

Utility plywood

Utility plywood comprises a range of products specifically intended for non-construction applications which are available in surface appearance grades suitable for joinery, furniture and limited exterior uses. Such plywood has traditionally been available from East and South East Asia, Brazil, France, Israel, Bulgaria, Czechoslovakia, Romania, Spain, Portugal, West Africa and more recently China.

Speciality plywood

There is a wide range of speciality plywood products available aimed at specific applications and end uses. These range from flexible plywood, which can be bent into complex curves, to highly compressed, 'bullet proof' plywood. Lightweight panels and panels with an aggregate or non-slip finish are also available. All these products should be used in accordance with the manufacturer's specification.

Blockboard/laminboard

These products are targeted at applications requiring a product similar to plywood in appearance but at a lower cost. They are normally restricted to interior applications such as joinery, door blanks, furniture and shopfitting.

Specification

Plywood used in the UK is sourced from all over the world and has traditionally been manufactured to overseas standards. While this may still be the case for some applications, plywood manufactured for construction purposes must now meet the requirements of the Construction Products Regulation (CPR) and this means that manufacture must meet the requirements of the harmonised European standard *BS EN 13986* and the specification must be in accordance with the product standard *BS EN 636*. Products claiming compliance with this standard must also carry the specified markings, which include a reference to *BS EN 636*.

The most recent edition of *BS EN 636* retains the designations -1, -2 and -3 from the previous three-part standard to represent dry, humid or exterior conditions of use.

The environmental conditions for which each of these types of plywood are considered suitable are defined according to the parameters laid down for Use Classes in *BS EN 335 Durability of wood and wood-based products. Use classes: definitions applicable to solid wood and wood-based products*[34]:

- Dry conditions: for interior applications with no risk of wetting, defined in Use Class 1, with a moisture content corresponding to environmental conditions of 20°C and 65% relative humidity.
- Humid conditions: for use in protected exterior applications as defined in Use Class 2, with a moisture content corresponding to environmental conditions of 20°C and 85% relative humidity.
- Exterior conditions: for use in unprotected external applications, as defined in Use Class 3, where the moisture content will frequently be above 20%.

BS EN 636 also introduces bending strength and modulus classes based on bending tests to *BS EN 310 Wood-based panels. Determination of modulus of elasticity in bending and of bending strength*[35]. These give a designated strength (F) and modulus (E) for both parallel and perpendicular to the face grain directions. An example designation would therefore be F10/20, E30/40. *BS EN 636* gives minimum values for each of the classes and *BS EN 12369-2 Wood-based panels. Characteristic values for structural design. Plywood*[36] gives corresponding characteristic values for use with each of these classes. *Table A2.20* shows requirements for plywood defined in *BS EN 636*.

Three bonding classes are defined in *BS EN 314-2*. The bonding classes relate to the use classes laid down in *BS EN 335 Durability of wood and wood-based products. Use classes: definitions, application to solid wood and wood-based products*[37]. Under *BS EN 314-1 Plywood. Bonding quality. Test methods*[38], samples of plywood are tested to evaluate the glue bond performance following exposure to conditions appropriate to the end-use environment class.

For structural applications, design may currently be carried out in accordance with *BS EN 1995-1-1* (*Eurocode 5*) or *BS 5268-2*. For floors, walls and roofs compliance with *BS EN 13986* requires performance tests for point load and soft body impact to be carried out in accordance with *BS EN 12871 Wood-based panels. Determination of performance characteristics for load bearing panels for use in floors, roofs and walls*[39].

BS 5268-2 lists a series of plywood types, from North America and Europe, that are considered suitable, are subject to acceptable quality control procedures and for which design stresses are given. The products must also

Table A2.20: Requirements for plywood as defined in BS EN 636

Property		Standard	Plywood type to BS EN 636		
			Dry	Humid	Exterior
Dimensional tolerance		BS EN 315	✓	✓	✓
Bonding quality		BS EN 314-2	Bonding Class 1	Bonding Class 2	Bonding Class 3
Mechanical properties	Structural • Characteristic values • Bending strength	BS EN 636/ BS EN 310/ BS EN 12369-2 or BS EN 789/BS EN 1058	✓	✓	✓
	Non-structural • Bending strength	BS EN 310	✓	✓	✓
Formaldehyde emission	Construction	BS EN 13986	E1 or E2	E1 or E2	E1 or E2
	Non-construction	BS EN 636/ BS EN 717-1/ BS EN 717-2	E1 or E2	E1 or E2	E1 or E2

demonstrate compliance with the CPR, by compliance with *BS EN 13986*.

Where characteristic values are available either from testing to *BS EN 789 Timber structures. Test methods. Determination of mechanical properties of wood based panels*[40] or from *BS EN 12369-2 Wood-based panels. Characteristic values for structural design. Plywood*[41], *BS 5268-2* gives conversion factors to enable them to be used with that standard.

Alternative justification, such as load testing, is another option if plywood is to be used in specific structural applications.

Marine plywood manufactured to *BS EN 1088* is also available in the UK. Marine plywood was developed for ship/boat building and has a very high performance under severe exposure conditions. It is also commonly used in construction applications where high performance is required or where the cost of replacement or consequences of failure warrant the additional cost. Marine plywood must demonstrate compliance with the CPR if it is to be used in construction.

For non-structural/non-load-bearing applications, there are many types/grades of plywood available on the market, from various sources. Where these are to be used in construction, they must meet the requirements of the CPR, which can be demonstrated by the use of the CE mark and provision of manufacturer's Declaration of Performance (DoP). Where these products are not used in construction users should still satisfy themselves that the manufacturing specification, be it a national or industry standard, provides a product suitable for the end use. Particular attention should be paid to the glue bond quality if the product is to be exposed to moisture.

Blockboard and laminboard are not commonly marketed as being in accordance with any particular standard. However, blockboard and laminboard are covered by the definition of plywood and should comply with the CPR if they are to be used in construction.

Physical properties

Climate

Like other wood-based panel products, plywood is hygroscopic and its dimensions will change in response to changes in humidity. However, wood tends to shrink/expand much more across the grain than along the grain and the cross-laminated structure of plywood means that the longitudinal veneers in one ply tend to restrain the perpendicular veneers in the adjacent ply. As a result, the dimensional movement of plywood is quite small: typically, a 1% change in moisture content increases or decreases the length and width of plywood by about 0.15mm per metre run. The corresponding change in thickness is likely to be in the region of 0.3% to 0.4% per 1% change in moisture content. These figures should be taken as a guide only as they will vary with the species and lay-up of the plywood concerned.

Table A2.21 gives approximate moisture contents likely to be attained by plywood in certain environments.

Table A2.21: Expected moisture content of plywood

Relative humidity at 20°C	Approximate equilibrium moisture content
30%	7%
65%	12%
85%	18%

Like all wood-based materials, the strength and stiffness of plywood will vary with moisture content. In structural design this is accounted for by applying modification factors to the material properties. Relevant factors are given for plywood in *BS EN 1995-1-1* (*Eurocode 5*) and in *BS 5268-2*.

Biological attack

The overall durability of plywood is a function not just of the glue bond quality, but of the durability of the veneers used and of the lay-up of the plywood.

The risks of biological attack of plywood are given in *BS EN 335* in relation to Use Classes 1, 2 and 3. The use of plywood in Use Class 4 (in contact with ground or fresh water) and Use Class 5 (in contact with sea water)

Table A2.22: Reaction to fire classification without further testing of untreated plywood

Product	EN Product standard	End use condition[5]	Minimum density (kg/m^3)	Minimum thickness (mm)	Class [6] (excluding floorings)	Class [7] (floorings)
Plywood[1],[2],[4]	BS EN 636	Without an air gap behind the wood-based panel	400	9	D-s2,d0	D_{fl}-s1
Plywood[3],[4]	BS EN 636	With a closed air gap behind the wood-based panel	400	15	D-s2,d1	D_{fl}-s1
Plywood[3],[4]	BS EN 636	With an open air gap behind the wood-based panel	400	18	D-s2,d0	D_{fl}-s1
Plywood[4]	BS EN 636	Any	400	3	E	E_{fl}

(1) Mounted without an air gap directly against class A1 or A2-s1, d0 products with minimum density 10 kg/m^3 or at least class D-s2, d2 products with minimum density 400 kg/m^3

(2) A substrate of cellulose insulation material of at least class E may be included if mounted directly against the wood-based panel, but not for floorings

(3) Mounted with an air gap behind. The reverse face of the cavity shall be at least class D-s2, d2 products with minimum density 400 kg/m^3

(4) Veneered phenol- and melamine-faced panels are included for class excl. floorings

(5) A vapour barrier with a thickness up to 0,4mm and a mass up to 200 g/m^2 can be mounted in between the wood-based panel and a substrate if there are no air gaps in between

(6) Class as provided for in Table 1 of the Annex to Decision 2000/147/EC

(7) Class as provided for in Table 2 of the Annex to Decision 2000/147/EC

NOTE: The classes given in this table are for unjointed panels, T&G jointed panels installed according to *DD CEN/TS 12872* and fully supported joints installed according to *DD CEN/TS 12872*

is noted as being appropriate only if the inherent and/or conferred properties of the panels are adequate.

Some guidance on the selection of plywood for use in different environmental conditions, ie use classes, is included in *DD CEN/TS 1099*. The durability of plywood is affected by the wood species used in the plies, the veneer thickness and the type of resin used. In *DD CEN/TS 1099*, for resistance to fungal attack, the durability class of the wood species used in the plies (from *BS EN 350-1 Durability of wood and wood-based products. Natural durability of solid wood. Guide to the principles of testing and classification of the natural durability of solid wood*[42]) is related to the use class in which the plywood is to be used. Recommendations as to whether the natural durability of the plywood is sufficient or whether preservative treatment is advisable or required are included. Ratings for the resistance of plywood to common species of insects, including termites and marine borers are included.

General guidance on the use of preservative treatments for panel products can be found from the WPA Manual *Industrial wood preservation specification and practice. Commodity Specification C11*. This guidance assists with making the right choice of preservatives for the end use and the panel product to be treated, as not all panel products need to be treated for particular end uses or are indeed suitable for some treatments. It also stresses that the preservative and/or the panel manufacturer should be consulted before any treatment is carried out as treatment may alter the physical and/or visual properties of the panel product.

Water vapour permeability

Water vapour permeability will vary with plywood species, density and structure, but the water vapour resistance factor (μ) will generally be between 50 and 110 when tested in accordance with *BS EN ISO 12572* using test conditions C (the wet cup method). This equates to a range of 150 to 250 when using test conditions A (the dry cup method). Values of vapour resistance factors for various densities of plywood are given in *BS EN 13986*.

Thermal conductivity

The thermal conductivity of plywood is dependent on its density and is likely to be in the range 0.09 to 0.24 W/mK. Values for thermal conductivity for various densities of plywood are given in *BS EN 13986*.

Reaction to fire

Table A2.22 shows what untreated plywood may be assumed to achieve under the Euroclass system for characterising the reaction to fire performance of materials based on *European Commission Decision 2007/348/EC*.

If the manufactured product does not satisfy any of these minimum requirements and a reaction to fire claim is to be made in a DoP for CE marking purposes, then it must be tested and classified according to *BS EN 13501-1*. However if no claim is made in the DoP for CE marking purposes it is still possible to use the British standard system to make a separate claim.

Further information on the reaction to fire of the various panel products in both the BS and EN systems is provided in PanelGuide *Section 2.2.3*.

Storage and handling

Correct handling and transportation of wood-based panels is essential to prevent either damage to the panels or injury to the operatives undertaking these operations. It is therefore important that the correct storage, transportation and handling techniques described in PanelGuide *Section 4.2* and *Section 4.3* are employed. Being reasonably durable and resilient, most timber products can withstand considerable wear and tear, but lack of care before and during construction can adversely affect wood products.

Plywood should be stored flat and dry, off the ground, with all four edges flush. Storage in a dry enclosed building is preferable and external storage should be avoided whenever possible, as should stacking on edge. Panels should be stacked on a close-boarded or slatted pallet, or if this is not possible on battens at no more than 600mm centres. The battens should all be of equal thickness and should be vertically aligned with any others in the same stack, in order to avoid distortion of the panels.

Panels should be fully protected by a waterproof covering during transport and the edges properly covered. Edges should also be protected against damage by lashings or other banding, this is particularly important for panels with profiled edges such as tongued and grooved panels. Plywood with 'dry' *EN 636-1* or 'humid' *EN 636-2* bond qualities must be protected from wetting during storage and construction. While 'humid' panels *EN 636-2* may tolerate limited wetting and 'exterior' panels *EN 636-3* will tolerate a high level of wetting, these circumstances should still be avoided as far as possible during transport and construction in order to minimise problems with delamination, distortion and discolouration.

All panels should be installed at a moisture content as close as possible to that which they will attain in service. This is particularly applicable if they are being installed under internal heated conditions or are to be coated following installation. Manufacturers can accept no responsibility for plywood exposed to standing water during the construction process. Allowing 'exterior' plywood to become wet during construction can lead to severe construction delays: the necessary drying out period will be prolonged, as the plywood must return as close as possible to its final in-service moisture content before it is covered or fully enclosed. Failure to meet this requirement will result in discolouration and potentially fungal decay.

Once on site, it is preferable for individual panels to be 'stickered' before installation in order to allow air to circulate and to allow the panels to attain a moisture content as close to their final in-service moisture content as possible.

Further guidance on storage and handling can be found in PanelGuide *Section 4*.

Working with plywood

Cutting

Fixed workshop machines are generally most appropriate for cutting and machining wood-based panels, as they provide a better quality finish and allow health and safety requirements to be effectively addressed, particularly in terms of machine guarding, dust extraction and manual handling. Hand-held power tools are generally only appropriate to small volumes of in-situ cutting or final adjustment on site. Satisfactory results on single panels can be achieved using hand tools. When hand sawing, use a cross-cut saw of 10 to 15 TPI for best results.

When a circular saw is used, the saw blade should enter the panel on the good face. A tungsten carbide tipped (TCT) saw will give good performance. The best finish will be obtained using a fast material feed speed in the opposite direction to the saw rotation and with minimum protrusion of the saw above the panel surface. The panel should be supported as close as possible to the blade. To minimise the risk of splintering the corners of the panel, it is best if the cuts at right angles to the face grain are made first and those parallel to the face grain are made afterwards.

When using a band saw, the best results are achieved with the maximum saw speed and a slow feed speed.

Where material routing or moulding is required, the cutter type, tool and material feed speed all affect the quality of the finish. Trials may be required to establish the optimum conditions.

Fixing

Plywood normally has higher mechanical properties in a direction parallel to the face grain; this means the direction in which the panels are to be laid must normally be specified. This is particularly so in structural applications, such as floors, walls and roofs where the direction of installation must be as assumed in the design calculation.

If panels are laid edge to edge, such as in a floor, it is essential that suitable expansion gaps are provided to allow for any (moisture related) dimensional movement during service. Guidance on the necessary allowances can be found in PanelGuide *Section 4.5.3*.

Plywood can be fixed by nails, screws and staples or by gluing, depending upon the application and requirements.

The structure of plywood makes it possible to use nails and other mechanical fastenings quite close to the panel edges without the risk of pull out. While pre-drilling is required for screws and larger connectors, nails can normally be driven without pre-drilling. When fastening plywood to timber, ring shank nails give improved performance over plain wire nails. More guidance on fastener sizes and spacing for specific applications can be found in PanelGuide *Section 2*.

Glued joints provide stiffer joints than ones made with mechanical fixings alone. A wide range of adhesive types is available but care should be taken to ensure that the adhesive used is suitable for the environmental conditions of the end use.

Finishing

The quality of the surface finish of plywood is affected by the species and the grade of the surface veneer. Manufacturers may produce either sanded or un-sanded products according to their manufacturing needs and end-user requirements. Where sanding is undertaken only in order to improve the appearance of repairs to the surface veneers, plywood may be described as 'touch sanded'. In such panels areas of the surface will be untouched by sanding operations.

When exposed to weather in an unprotected state, plywood will weather to a dull grey colour at the same rate as would be expected of solid wood of the same species. Further weathering can result in checking and splitting of the surface and the loss of wood fibre. The application of a suitable finish following installation can protect the material and enhance its appearance. The application of a finish to plywood under interior conditions is normally only for decorative purposes.

The surface finish that can be achieved will vary with species. Fine grained species such as birch can have a very finely textured surface, whereas coniferous species tend to be more heavily textured.

A range of paints, stains and varnishes are suitable for use on plywood, but care should be taken to ensure that the finish is suited to the end use. Products used in exterior or other changeable environmental conditions require a flexible coating to accommodate dimensional changes. If the plywood is installed in a heated environment, it is important that the moisture content is allowed to stabilise before the coating is applied.

Plywood with a medium density paper overlay is specially designed to be painted and subjected to fully exposed service. With normal plywood, adequate performance of the finish requires great care with design, surface preparation and application of the finish, if surface checking is to be avoided. Low-build exterior wood stains possess certain advantages over film-forming finishes by being more able to cope with the behaviour of exposed plywood. Exterior wood stains will not prevent surface checking but are less likely to react to it by flaking off than paint. Redecoration with a pigmented product will protect the checked surface and should present an acceptable appearance.

Some water-based acrylic paints show high levels of extensibility and can tolerate the surface movements of plywood. However, dark colours of such paints should not be used in areas sheltered from rainfall as salt efflorescence can appear on the surface. Blockboard and laminboard are not intended for use in exposed exterior applications.

Guidance on the specification of plywood on the basis of surface appearance and its ability for finishing is given in *BS EN 635 Plywood. Classification by surface appearance*. TRADA Wood Information Sheet *WIS 2/3-1 Finishes for external timber*[43] also gives guidance on the use of timber finishes under exterior conditions.

Under exterior conditions, it is important to coat both surfaces of the plywood panel and to effectively seal the panel edges with a suitable sealing compound. There are many materials that have a potential edge sealing role, including liquids, pastes and hot melts, but none should be relied upon to compensate for poor design or detailing. Designers should seek to ensure that the wetting of panel edges is minimised, for guidance see TRADA Wood Information Sheet *WIS 4-28 Durability by design*[44].

Ineffective edge sealing can result in dimensional changes/swelling due to water ingress and can lead to staining, failure of the coating, decay, delamination and ultimately to premature failure of the plywood. Further guidance can also be found in TRADA Wood Information Sheet *WIS 2/3-11 Specification and use of wood-based panels in exterior situations*[45].

Health and safety

Dust

In common with other wood products, plywood is safe when it is handled and used correctly. Contact with some species of timber can cause irritation to sensitive individuals, but such species are rarely used in the manufacture of plywood.

When cutting or machining plywood, wood dust is produced and as this can be hazardous, measures must be taken to control the dust. This is normally carried out with the use of suitable dust extraction systems in a workshop environment.

Dust from cutting operations can be controlled by complying with the Control of Substances Hazardous to Health (COSHH) Regulations 2002. Under these Regulations, wood dust has a Workplace Exposure Limit (WEL) of 5 mg/m^2, which is appropriate to wood dust from the machining of plywood. Exposure must be reduced as far as possible below this limit.

Formaldehyde

The formaldehyde content of plywood is normally very low and emission of formaldehyde is not often an issue with plywood. Free formaldehyde in the workplace atmosphere has a WEL of 2 parts per million (ppm). However, when machining plywood in mechanically ventilated situations, it is expected that exposure to levels of free formaldehyde would be significantly below this.

Two classes of 'in service' formaldehyde potential are specified in *BS EN 13986*, Class E1 and Class E2, E2 being the higher of the two. The test methods available for determining the formaldehyde potential are *BS EN 717-1*, and for coated plywood, *BS EN 717-2*. Manufacturers claiming compliance under the Construction Products Regulation (CPR) must test and declare formaldehyde emission potential Class E1 or Class E2 for their products. This information forms an element of the CE mark and will appear on the Declaration of Performance (DoP) for the plywood product.

Table A2.23: Plywood – common hazards and methods of control

Activity	Hazard	Control
Manual handling of full sheets	• Large sheet sizes present a risk of strain or crush injuries if not handled correctly	• Store carefully in uniform stacks on a flat level base • Use mechanical handling equipment • Adopt correct manual handling procedures
Carpentry work Activities likely to produce high dust levels include: • Sanding by machine and hand • Sawing, routing • Hand assembling machined or sanded components	• Wood dust in general (including dust from plywood) may cause dermatitis and allergic respiratory effects • Wood dust is flammable	• Off site: preparation under exhaust ventilated plant • On site: enclosure and exhaust ventilation • Dust extraction on portable tools • Good ventilation • Respiratory protection equipment (RPE) Note: Any health hazards arising from the use of plywood at work can and should be controlled by compliance with the requirements of the Control of Substances Hazardous to Health (COSHH) Regulations 2002

As with all wood-based panels, there may be manual handling hazards and COSHH Regulation 6 requires an assessment to be made, and recorded, of health risks associated with wood dust and handling. Common risks and control measures are shown in *Table A2.23*.

Annex 2E: Dry process fibreboards (MDF)

Description

Dry process fibreboards (MDF) are engineered wood-based panel materials made by bonding together wood fibres with a synthetic resin adhesive.

Since 1966 when the first MDF was produced commercially in Deposit, New York State, USA, the market for MDF has increased dramatically worldwide. MDF was first produced in Europe in 1973.

Because of its availability in a wide range of thicknesses and the ability to be machined and finished to a high standard, MDF has been accepted in a wide range of applications both in construction and also furniture, where in both cases it has substituted solid timber and also other wood-based panels in particular applications.

The development of value added variants with enhanced mechanical performance and improved performance in the presence of moisture and fire have further aided the applications available.

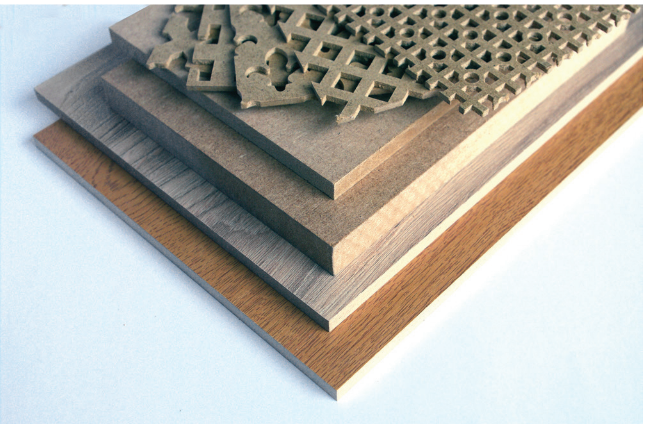


Figure A2.5: Dry process fibreboard (MDF)

MDF can be manufactured with either softwood or hardwood species. Most MDF is composed primarily of softwood, although some individual brands may contain a higher percentage of temperate hardwood, depending on the location of the factory to the local forest resource.

The constituents of a typical standard MDF manufactured in the United Kingdom or Ireland are:

- 82% virgin wood fibre (wholly or mainly softwood)
- 10% synthetic resin binder, 7% water
- less than 1% paraffin wax solids
- less than 0.05% silicon.

The most common binder is urea-formaldehyde, although, depending on the grade and end use of the product, other binders may be used, such as melamine-urea-formaldehyde, phenolic resins and polymeric methylene di-isocyonate (PMDI).

A typical process involves reducing wood down to small chips, which are then thermally softened and mechanically refined into fibres. These are then mixed with a synthetic resin binder. The resinated fibres are dried and then formed into a mattress ready for pressing. The mattress is pressed between heated polished press plates to the desired thickness. For thick boards more than one mattress may be 'piggy backed' together. Historically, MDF was manufactured in multi-daylight presses, but most modern plants now use continuous presses, where the mat is compressed to the finished thickness between two converging steel belts.

Appearance

MDF has smooth sanded surfaces; it has a homogeneous construction and is typically pale straw in colour. For identification purposes the whole panel, ie individual layers of the panel, may be dyed according to industry practices (for example green for panels with enhanced moisture resistance, or red for panels integrally treated with flame-retardant chemicals), however this is not a requirement of the standard and is becoming less common practice. Integral colouring is distinct from the voluntary coloured stripe system that may be applied on the outside edge of panels in a pack at opposite corners to identify particular grades in accordance with EN standards. The presence of an integral colour does not guarantee that enhanced properties are present, and reference should be made to panel markings or manufacturer's literature to verify this.

Density, mass and panel size

Standard forms of MDF typically have densities as follows:

- Average density: 700 kg/m³ to 800 kg/m³
- Core density: 600 kg/m³ to 700 kg/m³
- Face density: 1000 kg/m³ to 1100 kg/m³

MDFs can have densities that range from below 550 kg/m³ up to 800 kg/m³ and above.

Due to variation between brands, the weight of MDF is not constantly proportional to thickness.

Table A2.24: Typical weights, based on standard MDF with average density 750 kg/m³

Thickness	Mass per unit area
6.5mm	5.0 kg/m²
9.0mm	6.3 kg/m²
12.0mm	8.4 kg/m²
16.0mm	11.0 kg/m²
19.0mm	14.0 kg/m²

MDF is available in an extensive range of thicknesses, 1.8mm to 60mm. The most common panel sizes are: widths 1220mm, 1525mm and 1850mm and lengths up to 3660mm with the most common being 2400mm.

Other sizes are available or can be produced to order (minimum order conditions exist).

With the exception of the largest users, such as volume furniture manufacturers, MDF in common with other wood-based panels would generally not be supplied direct by the manufacturer but instead, depending on the volume and specification, could be supplied through a distributor or merchant.

Applications

Due to the particular machining and finishing attributes combined with good working properties and its availability in a wide range of panel thicknesses and sizes, MDF is used in a wide range of construction and furniture applications. It is used increasingly for interior design and building applications such as skirting panels and architraves, windowboards, wall linings and decorative facades, as well as the core material for some floorings.

MDF can be cut without breakout or splintering and it can be profiled on the edges and surfaces. The smooth and relatively dense surface provides an excellent base for painting, veneering and laminating. Consequently MDF is used extensively in furniture production and, with the range of value added variants, its use is being extended into shopfitting and display, interior fitments, exterior application (such as signage and shop fronts) as well as components within numerous other products.

Specification

MDF manufactured in Europe for use in construction must be specified in accordance with *BS EN 622-1 Fibreboards. Specifications. General requirements*[46] and *BS EN 622-5 Fibreboards. Specifications. Requirements for dry process boards (MDF)*[47]. As explained in PanelGuide *Section 2*, MDF that is used in construction must comply (by law) with the Construction Products Regulation (CPR) by compliance with the harmonised European standard for wood-based panels (*BS EN 13986*); in relation to MDF, this standard calls up Parts 1 and 5 of *BS EN 622*.

Selection of a particular grade is dependent upon the ambient climatic conditions together with the level of loading that is anticipated.

Table A2.25: Grades of MDF as described in BS EN 622-5

Grade	Use and climatic condition
MDF	General purpose boards for dry conditions
MDF.H	General purpose boards for humid conditions
MDF.LA	Load-bearing boards for dry conditions
MDF.HLS	Load-bearing boards for humid conditions (These panels are restricted under humid conditions to instantaneous or short periods of loading)
L-MDF	Light MDF boards for dry conditions
L.MDF.H	Light MDF boards for humid conditions
UL1-MDF	Ultra-light MDF boards for dry conditions
UL2-MDF	Ultra-light MDF boards for dry conditions
MDF.RWH	MDF for rigid underlays in roofs and walls

The requirements given in *BS EN 622-5* are not specific to any particular application and so it is appropriate to refer to Codes of Practice or the manufacturer's literature when considering a particular application (refer to PanelGuide *Section 2* and *Section 3*).

For construction applications some selection guidance is given in *DD CEN/TS 12872*.

BS EN 622-5 specifies properties for each type of MDF grade: swelling in thickness, internal bond, bending strength and modulus of elasticity (not design values). In addition supplementary properties which may be specified are identified although no values are given, ie surface soundness, axial withdrawal of screws, surface absorption and dimensional changes. Panel manufacturers generally provide values for these properties.

Physical properties

Climate

Like other wood-based panel products, MDF is hygroscopic and its dimensions change in response to a change in humidity. Typically a 1% change in moisture content increases or decreases the length and width by 0.4mm per metre run.

Table A2.26: Expected moisture content of MDF

Relative humidity at 20ºC	Approximate equilibrium moisture content
30%	5%
65%	8%
85%	12%

When components are factory produced for installation on site it is essential that the site conditions are suitable to receive the components, with wet trades completed and the building dried out.

Panels with enhanced moisture resistance are not waterproof; the term 'moisture resistant' applies to the adhesive binder which (within limits defined by *BS EN 622-5*) will not break down in the presence of moisture. Physical wetting of all grades of MDF should be avoided.

Biological attack

MDF will not normally be attacked by wood-boring insects common in temperate climates, but is susceptible to fungal attack under prolonged wet conditions.

General guidance on the use of preservative treatments for panel products can be found from the WPA Manual *Industrial wood preservation specification and practice. Commodity Specification C11*. This guidance assists with making the right choice of preservatives for the end use and the panel product to be treated, as not all panel products need to be treated for particular end uses or are indeed suitable for some treatments. It also stresses that the preservative and/or the panel manufacturer should be consulted before any treatment is carried out, as treatment may alter the physical and/or visual properties of the MDF.

Water vapour permeability

The value of the water vapour resistance factor (μ) for MDF varies from a value of 2 at a density of 250 kg/m³ to 20 at a density of 800 kg/m³, when tested in accordance with *BS EN ISO 12572*, using test conditions C (the wet cup method). Dry cup values vary from 5 at a density of 250 kg/m³ to 30 at a density of 800 kg/m³. Values for various densities of fibreboard are given in *BS EN 13986*.

Thermal conductivity

The thermal conductivity (λ) of MDF varies from 0.05 W/mK for a panel density of 250 kg/m³ to 0.14 W/mK for a panel density of 800 kg/m³. Values for various densities of fibreboard can be found in Table 11 of *BS EN 13986*.

Reaction to fire

Under the Euroclass system for characterising the reaction to fire performance of materials, as taken from *European Commission Decision 2007/348/EC*, an untreated MDF may be assumed to achieve the performance in *Table A2:27*.

If the manufactured product does not satisfy any of these minimum requirements and a reaction to fire claim is to be made in a DoP for CE marking purposes, then it must be tested and classified according to *BS EN 13501-1*. However if no claim is made in the DoP for CE marking purposes it is still possible to use the British standard system to make a separate claim.

Table A2.27: Reaction to fire classification without further testing of untreated MDF

Product	EN Product standard	End use condition(6)	Minimum density (kg/m³)	Minimum thickness (mm)	Class (7) (excluding floorings)	Class (8) (floorings)
MDF(1),(2),(5)	BS EN 622-5	Without an air gap behind the wood-based panel	600	9	D-s2,d0	D_{fl}-s1
MDF(3),(5)	BS EN 622-5	With a closed or an open air gap not more than 22mm behind the wood-based panel	600	9	D-s2,d2	-
MDF(4),(5)	BS EN 622-5	With a closed air gap behind the wood-based panel	600	15	D-s2,d0	D_{fl}-s1
MDF(4),(5)	BS EN 622-5	With an open air gap behind the wood-based panel	600	18	D-s2,d0	D_{fl}-s1
MDF(5)	BS EN 622-5	Any	400	3	E	E_{fl}
			250	9	E	E_{fl}

(1) Mounted without an air gap directly against class A1 or A2-s1, d0 products with minimum density 10 kg/m³ or at least class D-s2, d2 products with minimum density 400 kg/m³
(2) A substrate of cellulose insulation material of at least class E may be included if mounted directly against the wood-based panel, but not for floorings
(3) Mounted with an air gap behind. The reverse face of the cavity shall be at least class A2-s1, d0 products with minimum density 10 kg/m³
(4) Mounted with an air gap behind. The reverse face of the cavity shall be at least class D-s2, d2 products with minimum density 400 kg/m³
(5) Veneered phenol- and melamine-faced panels are included for class excl. floorings
(6) A vapour barrier with a thickness up to 0,4mm and a mass up to 200 g/m² can be mounted in between the wood-based panel and a substrate if there are no air gaps in between
(7) Class as provided for in Table 1 of the Annex to Decision 2000/147/EC
(8) Class as provided for in Table 2 of the Annex to Decision 2000/147/EC
NOTE: The classes given in this table are for unjointed panels, T&G jointed panels installed according to DD CEN/TS 12872 and fully supported joints installed according to DD CEN/TS 12872

Further information on the reaction to fire testing in both the BS and EN systems is provided in PanelGuide *Section 2.2.3*.

Storage and handling

Careful storage and handling is important to maintain panels in their correct condition for use; it is therefore imperative that particleboard is protected from rain and accidental soaking. During transport, it is particularly important to keep edges well covered. Panels should be stored flat in an enclosed, dry building. When handling panels, the edges and corners should be protected against damage.

'Humid' MDF panels can tolerate inflated humidity conditions such as can be found in kitchens and bathrooms but direct contact between the unprotected panel and water should be avoided.

Detailed guidance on the storage and handling of wood-based panel materials is given in *DD CEN/TS 12872* and PanelGuide *Section 4*.

Working with MDF

Satisfactory results can be achieved using hand tools but quicker and more consistent results can be achieved using either portable or fixed power tools. When using power tools, tungsten carbide tipped (TCT) tools will give better cutting performance.

Where material routing and moulding is required, the cutter type, tool and material feed speed all affect the quality of finish. Cutters must be kept sharp, as dull cutters will cause edges to 'bell'. While all MDF generally machines well, the density profile through the thickness of the panel will differ between brands and this may influence the quality of finish.

MDF can be drilled using all types of woodworking drill bits.

Mechanical joints and fixings

MDF can be fixed using all conventional woodworking fixings and techniques. It provides good holding power for screw fixings into panel faces and edges. Parallel core screws should be used because they have greater holding power than conventional wood screws. Typical screw withdrawal values tested to *BS EN 320 Particleboards and fibreboards. Determination of resistance to axial withdrawal of screws*[48] are:

- Face: 1050N
- Edge: 850N

A high overall diameter-to-core diameter ratio is desirable. Nails and staples can be used for lightly loaded fixings or to hold glued joints while adhesive sets.

Drill pilot holes for screw fixing. Typically, the holes should be 85% to 90% of the screw core diameter. Fixings into the panel face should not be within 12mm of edges

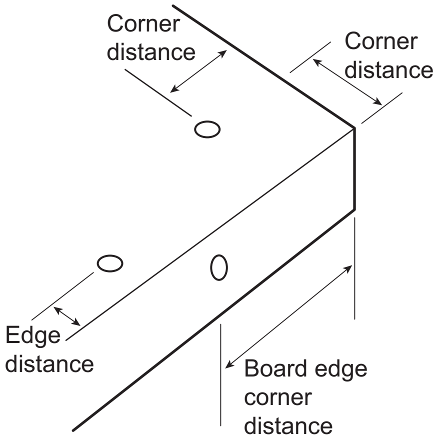


Figure A2.6: Edge distances for fixings

and 25mm of corners. Screws into the panel edge should not be within 70mm of corners.

Mechanical fittings can be applied to MDF with the following recommendations:

- Wherever possible, select fittings that depend upon face fixing. Avoid fittings that depend upon the expansion of a component inserted into the panel edge.
- When using screws, use recommended pilot hole dimensions.
- When fixing MDF as wall panelling or cladding, it is important to leave a small expansion gap between adjacent panels. The gap should be 2.5mm per metre minimum; often a feature gap is used, for example 10mm or 12mm, with or without coverstrip.

Adhesive-bonded joints

MDF can be bonded with all types of woodworking adhesive. The appropriate type depends on end use.

Dowel joints can be used satisfactorily with MDF. Multi-grooved dowels are recommended. Dowels and holes should have an interference fit that is of such size that the dowel can be pushed home by hand but, even without adhesive, is not sufficiently loose that it can fall out. Allow some tolerance on the dowel diameter, typically up to 0.2mm oversize.

A wide variety of jointing methods can be used, provided the following simple guidelines are observed:

- Ensure that the joint parts are accurately machined.
- Use sharp cutters to avoid tearing or burnishing the surfaces to be bonded.
- Use a high solids content adhesive with low flowing properties such as polyvinyl acetate or urea-formaldehyde.
- Locate mating pieces accurately and hold them under pressure while the adhesive sets.
- Ensure the the width of grooves machined in MDF are limited to about one-third of the thickness of the panel. The depth of groove is typically about one-half of the panel thickness.
- Allow adhesive-bonded joints to condition for several days before sanding and finishing; this avoids the

appearance of sunken joints and is essential with high-gloss finishes.

- For an efficient tongued and grooved joint, ensure the fit of the joints is not too tight, as this may cause a split along the edge.
- For tongued and grooved flooring, apply the glue liberally to both the tongue and the groove to ensure the entire joint is bonded.
- When attaching lipping, ensure the tongue is machined on the solid wood piece.

Finishing

Sanding

The faces of MDF are usually pre-sanded by manufacturers with 120 grit abrasive. This provides a smooth surface ideally suited to the direct application of most veneers and plastic foils. Scuff sanding with the objective of increasing adhesion may be detrimental. For the economic application of paints or printed effects and for very thin foils, a further light sanding with 200 grit abrasive may be advisable. Excessive sanding of the faces should be unnecessary and, because it could unbalance some MDF panels, it should be avoided.

Silicone carbide based abrasives are generally recommended for sanding MDF. Aluminium oxide abrasives tend to dull rapidly, producing burnishing. A 'modified close coat' abrasive is suggested. High sanding speeds cut the most efficiently; for example, with belt sanders, belt speeds in excess of 1500 metres per minute are recommended.

Sanding after moulding or routing produces a smoother surface. Moulded edges can be sanded using a profiled sander. 80/100 grit abrasives should be used to remove cutter marks, 120/150 grit is required for finish sanding.

Coatings

MDF can be finished with a wide range of coatings.

Because the edges of MDF are more absorbent than the surfaces, they may require sealing with shellac, polyurethane, diluted PVAC, or specially formulated, high solid content sealers; these compensate for their greater absorption.

Opaque paints are the easiest finishes to apply as their high solids content allows a high build. A base coat and a finish coat are usually all that is required.

Pigmented systems can produce single colour finishes; more specialised techniques and lacquers can produce metallic, marbled and other finishes.

Conventional oil-based or water-based paints give good results; better and quicker results can be achieved using lacquers based on nitrocellulose, acid catalysed resins, polyurethane or polyester resins applied by hand spray.

High-gloss finishes can be obtained using a high-build coating based on polyester resins, possibly with a clear lacquer top coat to protect the surface and enhance the gloss effect.

Clear lacquers and varnishes can be used. Application and preparation is similar to that for pigmented finishes. When coloured translucent finishes are required, decorative stain finishes can be used. Solvent-borne stains will wet the surface effectively and ensure an even colour; water-borne stains can be used but the waxes added to MDF to reduce water absorption may result in uneven absorption of stain and consequent colour variation. One or two coats of clear lacquer can protect stained surfaces. As the edges of MDF are more absorbent than the surfaces, stain finishes applied to edges may result in darker colours compared to surfaces.

Depending upon the finishing system used, it may be necessary to sand between coats using a fine-grit paper. Water-based systems in particular tend to raise the fibres.

Health and safety

In panel or processed form, MDF does not present any health or safety risk. Contact with wood products can cause irritation effects but the most significant risks come from mishandling the material.

Dust

Very fine dust is produced when MDF is machined. Just like any other wood dust, this is classified as a potentially hazardous substance and it must be controlled. There is no evidence that exposure produces health effects that are different in nature to those associated with exposure to similar levels of dust from other wood sources.

Dust from cutting operations can be controlled adequately by complying with the Control of Substances Hazardous to Health (COSHH) Regulations 2002. Under these Regulations, wood dust has a Workplace Exposure Limit (WEL) of 5 mg/m^3; this is the relevant limit for controlling exposure to MDF dust.

Exposure must be reduced as far as possible below this limit, usually with properly designed and maintained dust extraction equipment fitted to woodworking machines.

Extraction equipment is often not practicable, or even available, when using portable or hand-held tools, so a suitable dust mask should be worn. If possible, work in a well-ventilated place.

Further information on dust and dust masks is given in PanelGuide *Section 6.3*.

Formaldehyde

Free formaldehyde in the workplace atmosphere has a WEL of 2 parts per million (ppm). However, studies indicate that anyone machining MDF in mechanically ventilated situations is exposed to levels of free formaldehyde significantly below this.

Table A2.28: MDF – common hazards and methods of control

Activity	Hazard	Control
Manual handling (in full panel form)	Large panel sizes present a risk of strain or crush injuries if not handled correctly	• Store carefully in uniform stacks on a flat level base • Use mechanical handling equipment • Adopt correct manual handling procedures
Carpentry work Activities likely to produce high dust levels include: • Sanding by machine and hand • Sawing, routing and turning • Hand assembling machined or sanded components	• Wood dust in general (including dust from MDF) has health risks – it may cause dermatitis and allergic respiratory effects • Wood dust is flammable	• Off site: preparation under exhaust ventilated plant • On site: enclosure and exhaust ventilation • Dust extraction on portable tools • Good ventilation • Respiratory protection equipment (RPE) Note: Any health hazards arising from the use of MDF at work can and should be controlled by compliance with the requirements of the Control of Substances Hazardous to Health (COSHH) Regulations 2002

Two classes of 'in service' formaldehyde potential are specified in *BS EN 13986*, Class E1 and Class E2, E2 being the higher of the two. The test methods available for determining the formaldehyde potential are *BS EN 717-1*, *BS EN 120* and for coated MDF, *BS EN 717-2*.

Manufacturers in the UK and Ireland do not offer standard grades of MDF with Class E2 formaldehyde content. Further information on formaldehyde is given in PanelGuide *Section 6.4*.

Hazards and control

In panel or processed form, MDF is non-classifiable under the COSHH Regulations. However, there may be handling hazards.

COSHH Regulation 6 requires an assessment to be made (and normally recorded) of health risks associated with wood dust or formaldehyde together with any action needed to prevent or control those hazards.

Table A2.28 gives the most common hazards and identifies control methods to minimise the risk of harm actually occurring. More detailed information is given in PanelGuide *Section 6.3* and by the Health and Safety Executive.

Annex 2F: Wet process fibreboards

Description

A wood fibre board (fibreboard) is defined as a panel material with a nominal thickness of 1.5mm or greater, manufactured from lignocellulose fibres with application of heat and/or pressure. This generic product type 'fibreboards' can be classified according to the production process and in this regard there are two classifications:

- Wet process fibreboards
- Dry process fibreboards (MDF).

Dry process fibreboard (MDF) is described separately in *Annex 2E* of PanelGuide.

Wet process fibreboards can be classified according to their density:

- Hardboards $\geq 900\,kg/m^3$
- Medium boards* $\geq 400\,kg/m^3$ to $<900\,kg/m^3$
- Softboards $\geq 230\,kg/m^3$ to $<400\,kg/m^3$

*Mediumboard (which should not be confused with Medium Density Fibreboard – MDF) can be sub-divided into:

- Low density mediumboard $400\,kg/m^3$ to $<560\,kg/m^3$
- High density mediumboard $560\,kg/m^3$ to $<900\,kg/m^3$

Composition and manufacture

Wet process fibreboards can be made using either softwood or temperate hardwood species (or both) (some low density mediumboards are made from recycled paper fibre). Wood chips are thermally softened in water and then mechanically refined into fibres. The wet fibres are formed into a mat which is either rolled (softboards), or rolled and then pressed, at a high temperature to the desired thickness. The primary bond is generally derived

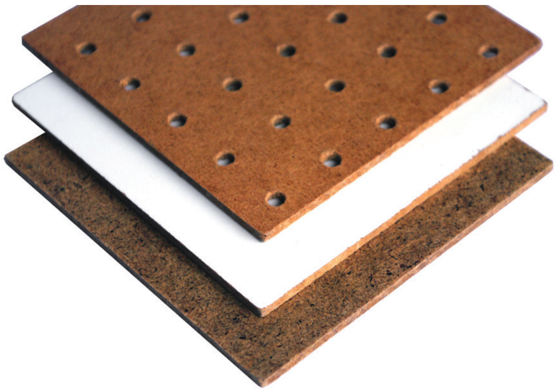


Figure A2.7: Hardboard

Figure A2.8: Mediumboard

Figure A2.9: Softboard

from the felting together of the fibres and their inherent adhesive properties, although in some instances a synthetic adhesive may be added to the fibres. Other additives such as wax, bitumen emulsion, natural oil or fire retardant chemicals may also be added.

The differentiating feature between a wet process and dry process fibreboard is that wet process fibreboards have a fibre moisture content of more than 20% at the forming stage whereas dry process fibreboards have a fibre moisture content of less than 20% at the forming stage and they are produced with the addition of a synthetic resin binder.

There is currently no UK production of wet process fibreboards.

Appearance

Hardboard

Surface appearance of hardboards is usually smooth on one side and a fine mesh pattern on the reverse. Duo faced hardboards (smooth both sides) are also available. The colour of panels ranges from light gold to dark brown. Special panels are available including painted, plastic faced, printed with wood grain, embossed/textured (plain, primed or pre-decorated) and perforated. Enhanced strength and durability characteristics may be imparted by impregnation with hot oil or resin and subsequent heat curing; these panels are usually referred to as tempered hardboard.

Mediumboard

The surface texture is usually smooth on one side with a fine mesh pattern on the reverse. High density mediumboard usually has a hard, shiny surface whereas low density mediumboards have a matt surface. Colour ranges from mid grey to dark brown.

Softboard

The surface texture for unfaced natural panels is open and fibrous. Paper-faced or fine pulp overlaid softboards have smooth or lightly dimpled faces, or a slight mesh pattern on one or both sides. The colour of most panels is various shades of light brown, others are cream or off-white. Some panels are covered with a white primer or bleached pulp for painting. Softboards with enhanced durability and moisture resistance are produced. Currently these enhanced properties are imparted by impregnating the fibres with a bitumen emulsion; a spray coating on one or both surfaces may also be applied. The same characteristics can be imparted with the inclusion of phenolic resins. Typical bitumen impregnated panels are dark brown to black in colour.

Density, mass and panel size

Panel density and the panel mass varies according to the product, being affected by the timber species and the process used in manufacture.

- Softboard – densities range typically from 230 kg/m^3 to 400 kg/m^3. A 2400mm × 1200mm × 13mm panel will weigh approximately 10kg.
- Mediumboard – low density: densities vary typically from 400 kg/m^3 to 560 kg/m^3. A 2400mm × 1200mm × 6.4mm panel will weigh approximately 10kg.
- Mediumboard – high density: densities vary typically from 560 kg/m^3 to 900 kg/m^3. A 2400mm × 1200mm × 6.4mm panel will weigh approximately 15kg.
- Hardboard – densities vary typically from 900 kg/m^3 to 1100 kg/m^3. A 2400mm × 1200mm × 3.2mm panel will weigh approximately 9kg.

Panel sizes

Typical panel sizes are shown in *Table A2.29*.

Other sizes are available or can be produced to order.

Table A2.29: Wet process fibreboard panel sizes

Panel type	Thickness range mm	Typical sizes mm
Hardboard	1.2 to 9.5	1220 × length up to 3660
Mediumboard	6.0 to 12.0	1220 × lengths up to 3660
Softboard	8.0 to 25.0	600 to 1220 × lengths up to 3660

Applications

Wet process fibreboards find use in a wide range of construction and furniture related applications.

Hardboards

Hardboards are used in furniture as drawer bottoms and unit backs, as door facings, caravan interiors and floor coverings, as well as in shopfitting and display work. Standard hardboard is generally not recommended for exterior use or for use in areas subject to direct wetting or high humidity conditions.

Enhanced performance hardboards can be used for applications where higher strength properties and resistance to abrasion above that of standard hardboard is required. These panels find applications as components within structural members such as custom-made beams, exterior applications such as soffits and signage, and for uses in packaging, agriculture and flooring overlays.

Table A2.30: Types and grades of wet process wood fibreboard

Panel type	Grade	References
Softboard		
General purpose (for use in dry conditions)	SB	
General purpose (for use in humid conditions)	SB.H	
General purpose (for use in exterior conditions)	SB.E	BS EN 622-4
Load bearing (for use in dry conditions)	SB.LS	
Load bearing (for use in humid conditions)	SB.HLS[a]	
Low density mediumboard		
General purpose (for use in dry conditions)	MBL	
General purpose (for use in humid conditions)	MBL.H	BS EN 622-3
General purpose (for use in exterior conditions)	MBL.E	
High density mediumboard		
General purpose (for use in dry conditions)	MBH	
General purpose (for use in humid conditions)	MBH.H	
General purpose (for use in exterior conditions)	MBH.E	
Load bearing (for use in dry conditions)	MBH.LA1	BS EN 622-3
Heavy duty load bearing (for use in dry conditions)	MBH.LA2	
Load bearing (for use in humid conditions)	MBH.HLS1[a]	
Heavy duty load bearing (for use in humid conditions)	MBH.HLS2[a]	
Hardboard		
General purpose (for use in dry conditions)	HB	
General purpose (for use in humid conditions)	HB.H	
General purpose (for use in exterior conditions)	HB.E	BS EN 622-2
Load bearing (for use in dry conditions)	HB.LA	
Load bearing (for use in humid conditions)	HB.HLA1	
Heavy duty load bearing (for use in humid conditions)	HB.HLA2	

[a] These panels are restricted under humid conditions to instantaneous or short periods of loading

Mediumboards

Low density mediumboards have particular application as pinboard and as components of partitioning systems. They can also be found in shopfitting and display applications and as a floor underlay material. High density mediumboards have been used as wall and ceiling lining panels and as a sheathing material in timber frame construction; however, their use today in UK construction is limited.

Softboards

Like mediumboards, the range of applications for softboards today has diminished; however, they do find application as pinboard, underlay materials and as an acoustic absorbent. Impregnated softboards have been used as a sheathing material in timber frame construction and as a protective overlay in some forms of flat roofing. In pitched roof construction in Scotland, impregnated softboards are used as a sarking material and heavily impregnated brands find application as joint fillers.

Specification

Wet process

Fibreboards manufactured in Europe must now be specified in accordance with European Standards. The UK versions of these are *BS EN 622* Parts 1 to 4. As explained in PanelGuide *Section 2*, fibreboards used in construction must comply, (by law) with the requirements of the Construction Products Regulations (CPR) by compliance with the harmonised European standard for wood-based panels (*BS EN 13986*).

This standard calls up the following parts, relating to wet process fibreboards:

- *BS EN 622-1 Fibreboards. Specifications. General requirements*[49]
- *BS EN 622-2 Fibreboards. Specifications. Requirements for hardboards*[50]
- *BS EN 622-3 Fibreboards. Specifications. Requirements for medium boards*[51]
- *BS EN 622-4 Fibreboards. Specifications. Requirements for softboards*[52]

Selection of a grade of panel is dependent upon the ambient climatic conditions together with the level of loading that is anticipated (see *Table A2.30*).

Guidance on the selection of different grades of fibreboard is given in tabular format in PanelGuide *Sections 2.4 to 2.14*; additional selection guidance is given in *DD CEN/TS 12872*. The requirements specified in *BS EN 622* are not specific to any particular application.

Physical properties

Climate

Like other wood-based panel products, fibreboards are hygroscopic and their dimensions change in response to changes in humidity. Typically a 1% change in moisture content results in an equivalent change of 0.4mm per metre in length and width of the panel. As a guide, wood fibreboard can be expected to attain the following moisture content under the conditions specified in *Table A2.31*.

Table A2.31: Expected moisture content of wood fibreboard

Relative humidity at 20ºC	Approximate equilibrium moisture content
30%	5%
65%	8%
85%	12%

Biological attack

Fibreboards will not normally be attacked by wood-boring insects in a temperate climate. Panels intended for internal uses are susceptible to fungal attack under prolonged wet conditions. Some types of hardboard and bitumen impregnated softboard (>25% impregnation) have been shown to have improved durability against wet rot fungi, over standard grades.

General guidance on the use of preservative treatments for panel products can be found from the WPA Manual *Industrial wood preservation specification and practice. Commodity Specification C11*. This guidance assists with making the right choice of preservatives for the end use and the panel product to be treated, as not all panel products need to be treated for particular end uses or are indeed suitable for some treatments. It also stresses that the preservative and/or the panel manufacturer should be consulted before any treatment is carried out as treatment may alter the physical and/or visual properties of the panel product.

Water vapour permeability

The value of water vapour resistance factor (μ) for fibreboards varies according to density (*Table A2.32*). Water vapour resistance factors are given as dry cup and wet cup values according to *BS EN ISO 12572*.

Table A2.32: Water vapour resistance factor (μ) for fibreboards
The values given are extracted from *BS EN 13986*

Wood-based panel	Density kg/m³	Vapour resistance factor	
		Wet cup μ	Dry cup μ
Fibreboard BS EN 622	250	2	5
	400	5	10
	600	12	20
	800	20	30

Thermal conductivity

The thermal conductivity of fibreboards (λ) varies depending on density (*Table A2.33*).

Reaction to fire

Under the Euroclass system for characterising the reaction to fire performance of materials, the deemed to satisfy ratings shown in *Table A2.34* are given in *European Commission Decision 2007/348/EC*.

Table A2.33: Thermal conductivity (λ) of fibreboards
The values given are extracted from *BS EN 13986*

Wood-based panel	Density kg/m³	Thermal conductivity λ W/(m.k)
Fibreboard BS EN 622	250	0.05
	400	0.07
	600	0.10
	800	0.14

If the manufactured product does not satisfy any of these minimum requirements and a reaction to fire claim is to be made in a DoP for CE marking purposes, then it must be tested and classified according to *BS EN 13501-1*. However if no claim is made in the DoP for CE marking purposes it is still possible to use the British standard system to make a separate claim.

Further information on the reaction to fire testing in both the BS and EN systems is provided in PanelGuide *Section 2.2.3*.

Storage and handling

Fibreboards should be stored flat and dry, off the ground, with all four edges flush. Storage in an enclosed building is preferable and external storage should be avoided. Stacking on edge should also be avoided wherever possible. Panels should be stacked on a close-boarded or slatted pallet, or if this is not possible on battens at no more than 600mm centres. The battens should all be of equal thickness and should be vertically aligned with any others in the same stack, in order to avoid distortion of the panels.

Panels should be protected by a waterproof covering during transport and the edges properly covered. Edges should also be protected against damage by lashings or other banding, this is particularly important for softboards. All panels should be installed at a moisture content as close as possible to that which they will attain in service in order to minimise any movement problems.

Once on site, it is preferable for individual panels to be ‘stickered’ before installation in order to allow air to circulate and to allow the panels to attain a moisture content as close as possible to the final in-service moisture content. Further guidance on storage and handling can be found in PanelGuide *Section 4*.

Working with fibreboards

Fibreboards can be sawn, routed, spindled or drilled. Satisfactory results can be achieved using hand tools, but quicker and more consistent results can be achieved using either portable or fixed power tools.

When cutting wood-based panels it is important to pay attention to normal good practice, sharp cutters, adequate support close to saws and cutters, elimination of machine vibration and correct allowance for saw kerf.

The quality of cut is dependent on the cutter type, tool and material speed and also on the material type and

Table A2.34: Reaction to fire classification without further testing of fibreboard

Product	EN Product standard	End use condition(6)	Minimum density (kg/m^3)	Minimum thickness (mm)	Class (7) (excluding floorings)	Class (8) (floorings)
Fibreboard, hard(1)	BS EN 622-2	Without an air gap behind the panel	900	6	D-s2,d0	D_{fl}-s1
Fibreboard, hard(3)	BS EN 622-2	With a closed air gap not more than 22mm behind the wood-based panel	900	6	D-s2,d2	-
Fibreboard, hard & medium(1),(2),(5)	BS EN 622-2 BS EN 622-3	Without an air gap behind the wood-based panel	600	9	D-s2,d0	D_{fl}-s1
Fibreboard, hard & medium (3),(5)	BS EN 622-2 BS EN 622-3	With a closed or an open air gap not more than 22mm behind the wood-based panel	600	9	D-s2,d2	-
Fibreboard, medium(4),(5)	BS EN 622-3	With a closed air gap behind the wood-based panel	600	15	D-s2,d0	D_{fl}-s1
Fibreboard, medium(4),(5)	BS EN 622-3	With an open air gap behind the wood-based panel	600	18	D-s2,d0	D_{fl}-s1
Fibreboard, hard(5)	BS EN 622-2	Any	900	3	E	E_{fl}
Fibreboard, medium(5)	BS EN 622-3	Any	400	9	E	E_{fl}
Fibreboard, soft	BS EN 622-4	Any	250	9	E	E_{fl}

(1) Mounted without an air gap directly against class A1 or A2-s1, d0 products with minimum density 10 kg/m^3 or at least class D-s2, d2 products with minimum density 400 kg/m^3
(2) A substrate of cellulose insulation material of at least class E may be included if mounted directly against the wood-based panel, but not for floorings
(3) Mounted with an air gap behind. The reverse face of the cavity shall be at least class A2-s1, d0 products with minimum density 10 kg/m^3
(4) Mounted with an air gap behind. The reverse face of the cavity shall be at least class D-s2, d2 products with minimum density 400 kg/m^3
(5) Veneered phenol- and melamine-faced panels are included for class excl. floorings
(6) A vapour barrier with a thickness up to 0,4mm and a mass up to 200 g/m^2 can be mounted in between the wood-based panel and a substrate if there are no air gaps in between
(7) Class as provided for in Table 1 of the Annex to Decision 2000/147/EC
(8) Class as provided for in Table 2 of the Annex to Decision 2000/147/EC
NOTE: The classes given in this table are for unjointed panels, T&G jointed panels installed according to *DD CEN/TS 12872* and fully supported joints installed according to *DD CEN/TS 12872*

density. Tools must be kept sharp, as dull cutters will cause edges to 'bell'.

Fibreboards can be drilled using all types of woodworking drill bits.

Fixing fibreboards

Hardboards and mediumboards can be fixed with panel pins, nails, staples, and screws; the type used will depend upon the end use. Screws through thinner hardboards should have cups if 'pull through' is a possibility. Hardboard and mediumboard can be bonded with most types of woodworking adhesives. Fixings into hardboard and mediumboard should generally use cavity fittings.

Softboards can be fixed with nails, staples and screws; the type used will depend upon the end use. Nails with large heads are recommended and screws should be fitted with cups. Softboard can be bonded with most types of woodworking adhesive and with bitumen adhesives for applications such as roofing. Due to their low density, softboards will not hold fixings satisfactorily when these are loaded. An appropriate type of cavity fixing which will spread the load should be considered.

Finishing

Fibreboard (except bitumen impregnated fibreboards) provides a suitable substrate for paints, stains, varnishes and textured coverings. Lining materials such as wallpaper, hessian and other fabrics can also be applied, providing an appropriate adhesive is used.

Hardboards and mediumboards can be veneered and laminated with high and low pressure laminates, paper and PVC foils.

Some brands of fibreboard are available pre-decorated.

Surface coatings

Mediumboard and hardboard can be painted with conventional oil-based and water-based paints, applied by spray, brush or roller. Matt, satin or gloss finishes can be obtained. Little preparation of the surface should be required; dust and grease should be removed from the panel, if necessary using white spirit.

Panels should have a primer or sealer coat applied, this can be proprietary hardboard sealer or a coat of emulsion paint. Some types of oil-treated hardboard, which contain natural or added oils, require priming with an aluminium primer or multi-purpose primer.

If panel edges will be visible after completion it may be necessary to seal these with hardboard sealer or with a wood or cellulose filler prior to the application of finish.

Softboard can be painted with conventional oil-based and water-based paints, applied by spray, brush or roller. Matt or satin finishes can be obtained. Panels should be brushed free of dust before decoration commences. No rubbing down of the surface should be required.

Table A2.35: Fibreboards – common hazards and methods of control

Activity	Hazard	Control
Manual handling (in full panel form)	Large panel sizes present a risk of strain or crush injuries if not handled correctly	• Store carefully in uniform stacks on a flat level base • Use mechanical handling equipment • Adopt correct manual handling procedures
Carpentry work Activities likely to produce high dust levels include: • Sanding by machine and hand • Sawing, routing and turning • Hand assembling machined or sanded components	• Wood dust in general (including dust from fibreboards) has health risks – it may cause dermatitis and allergic respiratory effects • Wood dust is flammable	• Off site: preparation under exhaust ventilated plant • On site: enclosure and exhaust ventilation • Dust extraction on portable tools • Good ventilation • Respiratory protection equipment (RPE) Note: Any health hazards arising from the use of fibreboard at work can and should be controlled by compliance with the requirements of the Control of Substances Hazardous to Health (COSHH) Regulations 2002

Natural and ivory faced panels should have a primer or sealer coat applied, a 50/50 mix of emulsion paint and water is suitable for this purpose. White primed soft-boards can be painted without using a sealer coat.

If further coating is applied, an alkali resisting primer is required and the panel or paint manufacturer's advice should be sought.

If panel edges will be visible after completion it may be necessary to fill these with a wood or cellulose filler prior to the application of finish.

Textured coatings can also be applied, care is needed in detailing panel joints which should be either scrimmed and filled or featured by leaving small gaps between adjacent panels.

Coating manufacturers' recommendations regarding priming of panels should be closely followed. After joint treatment, the paint is applied and textured (stippled, combed etc). The edges are normally finished by using a small brush to produce a plain margin.

Further details concerning cutting, fixing and finishing are given in PanelGuide *Section 4*.

Health and safety

In common with other wood products, fibreboards are safe when they are handled and used correctly.

When cutting or machining fibreboards, wood dust is produced and as this can be hazardous, measures must be taken to control the dust. This is normally carried out with the use of a suitable personal dust mask or by dust extraction systems in a workshop environment.

Dust from cutting operations can be controlled by complying with the Control of Substances Hazardous to Health (COSHH) Regulations 2002. Under these Regulations, wood dust has a Workplace Exposure Limit (WEL) of 5 mg/m^2, which is appropriate to wood dust from the machining of fibreboards. Exposure must be reduced as far as possible below this limit.

The formaldehyde potential of wet process fibreboards can be considered to be extremely low and may be considered to be within the lowest class specified in European Standards without testing.

As with all wood-based panels, there may be handling hazards and COSHH Regulation 6 requires an assessment to be made, and recorded of health risks associated with wood dust and handling. Common risks and control measures are shown in *Table A2.35*.

Annex 2G: Particleboard – flaxboard

Description

Flaxboard, like particleboard, is an engineered panel material in which shives from the stalk of the flax plant are bonded together with a synthetic resin adhesive. Flax shives are in fact a by-product of the linen industry.

Flaxboard is defined as a particleboard in *BS EN 309* and is specified in *BS EN 15197 Wood-based panels. Flaxboards. Specifications*[53] as containing at least 70% flax and can also contain other raw materials such as particles of wood.

The flaxboard industry in Europe dates from the late 1950s and until recently, flaxboard was only available in standard panel sizes because it was produced by daylight presses. Now the technology has developed to produce a continuous panel in various lengths, which enables it to be cut into many possible sizes without wastage. Flaxboard can show excellent surface properties and offers numerous benefits. It is a lightweight

Figure A2.10: Flaxboard

panel and has natural characteristics which aid fire resistance. Although flaxboard is similar in some ways to particleboard, it has different properties and applications and so users should check technical performance data against the intended end-use application. The specification for flaxboard is given in *BS EN 15197* as non-load-bearing which in terms of the Construction Products Regulation (CPR) would define the product as non-structural.

Composition

Flax shives from the stalk of the flax plant comprise the bulk of flaxboard and are prepared in a mechanical chipper. The product may also contain a small percentage of other raw materials such as particles of wood (wood, flakes, chips, shavings, saw dust and similar materials). These chips are compressed and are generally bound together with synthetic resin systems such as urea-formaldehyde (UF) or melamine-urea-formaldehyde (MUF), though phenol-formaldehyde (PF) and polymeric methylene di-isocyanate (PMDI) are used by some manufacturers.

The binding system employed depends on the end use intended and the grade of the product. The most common resin employed is urea-formaldehyde, but this is only suitable for use in dry conditions: the other three resin systems, mentioned above, confer a measure of moisture resistance to the composite.

Some manufacturers of flaxboard produce a three-layer type, obtained through the separate gluing of the coarse and fine fractions of flax shives.

Typical constituents of a flaxboard are of the order (by mass) of:

- at least 70% flax shives and which can also contain other raw materials such as particles of wood (wood flakes, chips, shavings, saw dust and similar materials), with the addition of a polymeric adhesive
- 6% to 8% formaldehyde based resin or 2% to 3% PMDI
- 5% to 7% water
- 2% to 3% nitrated ammonium
- 1% to 2% paraffin wax solids.

Appearance

Flaxboard can have smooth, sanded surfaces similar in appearance to particleboard if required. In order to achieve this smooth surface, the panel density is increased at the faces by the use of small particles of wood with a larger percentage of resin binder compared to the core of the panel. If flaxboard is to be covered, for instance for use as door cores, it does not necessarily need a smooth finish. Generally, flaxboard has a pale straw colour.

Density, mass and panel size

Panel density (and therefore panel mass) varies depending upon the thickness and end use. Typical densities are 350 kg/m^3 to 600 kg/m^3. For example, a 2440mm × 1220mm × 19mm panel will weigh approximately 26kg.

Panel sizes (length × width) commonly available are:

- 1830mm × 1200mm
- 2440mm × 1220mm
- 2750mm × 1220mm
- 3050mm × 1220mm
- 3660mm × 1220mm
- 6200mm × 1280mm
- 6250mm × 2620mm

in thicknesses from 12mm up to 60mm. Several manufacturers specialise in 'door-sizes' to avoid wasteful cutting: 1850mm × 1220mm, 1895mm × 600m, 1895mm × 840mm.

Other sizes are available or can be produced to order. Panels are produced with either square or post form edges.

Applications

The special properties of flaxboard have several advantages in a wide range of non-load-bearing applications. Its lightweight properties and natural characteristics, which aid fire resistance, make it a natural choice for fire resistant door cores and partitions. Different grades of the product are available for different environmental conditions, ranging from general purpose panels for use in dry conditions (for filling purposes and veneering) to non-load-bearing panels for use in humid conditions. The higher grades also find use for interior fitment (including furniture and worktops). Flaxboard can also find uses for acoustic doors and partitioning, packaging in the form of protection panels and profiled pack bearers, table tennis tables, warehouse shelves and worktops.

Specification

Flaxboard manufactured in Europe and used for general purposes, non load-bearing applications and interior fitments in dry conditions, and flaxboards for non load-bearing applications for use in humid conditions may now be specified in accordance with *BS EN 15197*. As explained in PanelGuide *Section 2*, flaxboard that is used in construction must comply (by law) with the Construction Products Regulation (CPR) by compliance with the harmonised European standard for wood-based panels (*BS EN 13986*); this standard calls up *BS EN 15197* which contains the requirements for the following four grades (technical classes):

- FB1: general purpose flaxboard for use in dry conditions (usually for filling purposes)
- FB2: non-load-bearing flaxboard for use in dry conditions (usually for further processing, such as veneering)
- FB3: flaxboard for interior fitment (including furniture) for use in dry conditions
- FB4: non-load-bearing flaxboard for use in humid conditions.

Table A2.36: Dimensional change for a 1% change in panel moisture content (based on unofficial data)

Type of panel	Grade	Dimensional change at 1% change in panel moisture content		
		Length %	Width %	Thickness %
Flaxboard to BS EN 15197	FB1, FB2 and FB3	0,05	0,05	0,7
	FB4	0,03	0,04	0,5

Dry conditions are defined in terms of Service Class 1 of *BS EN 1995-1-1 (Eurocode 5)* which is characterised by the moisture content in the material corresponding to a temperature of 20ºC and a relative humidity of the surrounding air only exceeding 65% for a few weeks per year. Panels of this type are only suitable for use in Use Class 1 of *BS EN 335*. Humid conditions are defined in terms of Service Class 2 of *BS EN 1995-1-1 (Eurocode 5)*, which is characterised by a moisture content in the material corresponding to a temperature of 20ºC and relative humidity of the surrounding air only exceeding 85% for a few weeks per year.

Guidance on the selection of the different grades of flaxboard is given in tabular format in PanelGuide *Sections 2.4 to 2.14*.

Physical properties

Climate

Like wood-based panel products, flaxboard is hygroscopic and its dimensions change in response to a change in humidity. A 1% change in moisture content increases or decreases the length, width and thickness of the different grades of flaxboard by the amount set out in *Table A2.36*.

As a general guide, flaxboard can be expected to attain the following moisture content under the conditions specified in *Table A2.37*.

Table A2.37: Flaxboard expected moisture content

Relative humidity at 20ºC	Approximate equilibrium moisture content
30%	7%
65%	11%
85%	15%

Flaxboard, therefore, should be conditioned to bring it into equilibrium with its environment before it is fixed. This is usually achieved by loose stacking the panels in the room where they will be used prior to fixing them. The time required for the panels to achieve equilibrium moisture content will vary depending upon the temperature and relative humidity in the building (*Table A2.38*).

When components are factory produced for installation on site, it is essential that the site conditions are suitable to receive the components, with wet trades completed and the building dried out.

Table A2.38: Likely equilibrium moisture content of flaxboards in various conditions

In a building with continuous central heating	7% to 9%
In a building with intermittent central heating	9% to 12%
In an unheated building	up to 15%

Panels with enhanced moisture resistance are not waterproof; the term 'moisture resistant' applies to the adhesive binder which (within limits defined by *BS EN 15197*) will not break down in the presence of moisture. Physical wetting of all grades of flaxboard should be avoided.

Biological attack

Flaxboard will not normally be attacked by wood-boring insects common in temperate climates, but is susceptible to fungal attack under prolonged wet conditions.

General guidance on the use of preservative treatments for panel products can be found from the WPA Manual *Industrial wood preservation specification and practice. Commodity Specification C11*. This guidance assists with making the right choice of preservatives for the end use and the panel product to be treated, as not all panel products need to be treated for particular end uses or are indeed suitable for some treatments. It also stresses that the preservative and/or the panel manufacturer should be consulted before any treatment is carried out as treatment may alter the physical and/or visual properties of the panel product.

Water vapour 'permeability'

There is no data currently available on the vapour resistance of flaxboard.

Thermal conductivity

In generic terms, flaxboard can be considered to be a poor thermal conductor because of its relatively low density. Individual manufacturers are obliged to provide performance data in this area where claims are made under the Construction Product Regulations (CPR).

Reaction to fire

Under the Euroclass system for characterising the reaction to fire performance of materials, as taken from *European Commission Decision 2007/348/EC* untreated flaxboard may be assumed to achieve the performance shown in *Table A2.39*.

If the manufactured product does not satisfy any of these minimum requirements and a reaction to fire claim is to be made in a DoP for CE marking purposes, then it must be tested and classified according to *BS EN 13501-1*. However if no claim is made in the DoP for CE marking purposes it is still possible to use the British standard system to make a separate claim.

Table A2.39: Reaction to fire classification without further testing of untreated flaxboard

Product	EN Product standard	End use condition[6]	Minimum density (kg/m^3)	Minimum thickness (mm)	Class [7] (excluding floorings)	Class [8] (floorings)
Flaxboard [1],[2],[5]	BS EN 15197	Without an air gap behind the wood-based panel	600	9	D-s2,d0	-
Flaxboard[3],[5]	BS EN 15197	With a closed or an open air gap not more than 22mm behind the wood-based panel	600	9	D-s2,d2	-
Flaxboard[4],[5]	BS EN 15197	With a closed air gap behind the wood-based panel	600	15	D-s2,d0	-
Flaxboard[4],[5]	BS EN 15197	With an open air gap behind the wood-based panel	600	18	D-s2,d0	-

(1) Mounted without an air gap directly against class A1 or A2-s1, d0 products with minimum density 10 kg/m^3 or at least class D-s2, d2 products with minimum density 400 kg/m^3
(2) A substrate of cellulose insulation material of at least class E may be included if mounted directly against the wood-based panel, but not for floorings
(3) Mounted with an air gap behind. The reverse face of the cavity shall be at least class A2-s1, d0 products with minimum density 10 kg/m^3
(4) Mounted with an air gap behind. The reverse face of the cavity shall be at least class D-s2, d2 products with minimum density 400 kg/m^3
(5) Veneered phenol- and melamine-faced panels are included for class excl. floorings
(6) A vapour barrier with a thickness up to 0,4mm and a mass up to 200 g/m^2 can be mounted in between the wood-based panel and a substrate if there are no air gaps in between
(7) Class as provided for in Table 1 of the Annex to Decision 2000/147/EC
(8) Class as provided for in Table 2 of the Annex to Decision 2000/147/EC
NOTE: The classes given in this table are for unjointed panels, T&G jointed panels installed according *to DD CEN/TS 12872* and fully supported joints installed according to *DD CEN/TS 12872*

Further information on the reaction to fire testing in both the BS and EN systems is provided in PanelGuide *Section 2.2.3*.

Storage and handling

Careful storage and handling is important to maintain panels in their correct condition for use; therefore flaxboard must be protected from rain and accidental wetting. During transport, it is particularly important to keep edges well covered. Panels should be stored flat in an enclosed, dry building. When handling panels, the edges and corners should be protected against damage.

Detailed guidance on the storage and handling of wood-based panel materials is given in *DD CEN/TS 12872* and PanelGuide *Section 4*.

Working with flaxboard

Flaxboard can be cut by a hand saw or power saw and machined (routed, spindled, planed and bored) with normal woodworking machinery. Tungsten carbide cutting edges are recommended for use with power tools.

Mechanical joints and fixings

Wherever possible, fittings that depend upon face fixing should be selected; fittings that depend upon the expansion of a component inserted into the panel edge should be avoided.

Conventional woodworking fixings and techniques can be applied to flaxboard which provides good holding power for screw fixings into the panel faces; generally, edge fixing is not recommended. Parallel core screws should be used because they have greater holding power than conventional wood screws. A high ratio of overall diameter to core diameter is desirable.

Pilot holes for all screw fixings are required. Typically, the holes should be 85% to 90% of the screw core diameter. Fixings into the panel face should not be within 8mm of edges and 25mm of the corners.

Nails and staples can be used for lightly loaded fixings or to hold glued joints while the adhesive sets.

Further information on working with flaxboard is included in PanelGuide *Section 4.4*.

Adhesive-bonded joints

A wide variety of jointing methods can be used, provided the following simple guidelines are observed:

- Ensure the joint parts are accurately machined.
- Use sharp cutters to avoid tearing or burnishing the surfaces to be bonded.
- Use a high solids content adhesive with low flowing properties such as polyvinyl acetate or urea-formal-dehyde.
- Locate mating pieces accurately and hold them under pressure while the adhesive sets.
- Ensure the width of grooves machined in flaxboard is limited to about one-third of the thickness of the panel. The depth of groove is typically about one-half of the panel thickness.
- Allow adhesive-bonded joints to condition for several days before sanding and finishing; this avoids the appearance of sunken joints and is essential with high-gloss finishes.
- For an efficient tongued and grooved joint, ensure the fit of the joints is not too tight as this can cause a split along the edge.
- When attaching lipping, ensure the tongue is machined on the solid wood piece.

Table A2.40: Flaxboard – common hazards and methods of control

Activity	Hazard	Control
Manual handling (in full panel form)	Large panel sizes present a risk of strain or crush injuries if not handled correctly	• Store carefully in uniform stacks on a flat level base • Use mechanical handling equipment • Adopt correct manual handling procedures
Carpentry work Activities likely to produce high dust levels include: • Sanding by machine and hand • Sawing, routing and turning • Hand assembling machined or sanded components	• Wood dust in general (including dust from flaxboard) has health risks – it may cause dermatitis and allergic respiratory effects • Wood dust is flammable	• Off site: preparation under exhaust ventilated plant • On site: enclosure and exhaust ventilation • Dust extraction on portable tools • Good ventilation • Respiratory protection equipment (RPE) Note: Any health hazards arising from the use of flaxboard at work can and should be controlled by compliance with the requirements of the Control of Substances Hazardous to Health (COSHH) Regulations 2002

Finishing

The faces of flaxboard are usually pre-sanded during manufacture to provide a smooth surface suitable for direct application of most veneers and plastic foils.

Additional information on finishing is provided in PanelGuide *Section 4.7*.

Health and safety

Dust

Flaxboard will generate dust when it is machined which, like wood dust, is a potentially hazardous substance and must be controlled. There is no evidence that exposure produces health effects that are different in nature to those associated with exposure to similar levels of dust from conventional wood sources.

Dust from cutting operations can be controlled adequately by complying with the Control of Substances Hazardous to Health (COSHH) Regulations 2002. Under these Regulations flaxboard dust has a Workplace Exposure Limit (WEL) of 5 mg/m^2 expressed as an 8-hour time-weighted average. Exposure must be reduced as far as possible below this limit, usually with properly designed and maintained dust extraction equipment fitted to woodworking machines.

Extraction equipment is often not practicable or even available when using portable or hand-held tools, so a suitable dust mask should be worn. If possible, work in a well-ventilated place.

Further information on dust and dust masks is given in PanelGuide *Section 6*.

Formaldehyde

Free formaldehyde in the workplace atmosphere has a WEL of 2 parts per million (ppm). However, studies indicate that anyone machining flaxboard in mechanically ventilated situations is exposed to levels of free formaldehyde significantly below this.

Two classes of 'in service' formaldehyde potential are specified in *BS EN 13986*, Class E1 and Class E2, E2 being the higher of the two. The test methods available for determining the formaldehyde potential are *BS EN 717-1*, *BS EN 120* and for coated flaxboard, *BS EN 717-2*.

European manufacturers of flaxboard offer standard grades of flaxboard with Class E1. Further information on formaldehyde is given in PanelGuide *Section 6.4*.

Hazards and control

In panel or processed form, flaxboard is non-classifiable under the COSHH Regulations. However, there may be handling hazards.

COSHH Regulation 6 requires an assessment to be made (and normally recorded) of health risks associated with wood dust or formaldehyde, together with any action needed to prevent or control those hazards.

Table A2.40 presents the most common hazards and identifies control methods to minimise the risk of harm actually occurring, more detailed information is given in PanelGuide *Section 6.3* and by the Health and Safety Executive.

References

1 BS EN 309. Particleboards. Definition and classification, BSI

2 BS EN 15197. Wood-based panels. Flaxboards. Specifications, BSI

3 BS EN 312. Particleboards. Specifications, BSI

4 DD CEN/TS 12872. Wood-based panels. Guidance on the use of load-bearing boards in floors, walls and roofs, BSI

5 Construction Products Regulation (CPR), Regulation 305/2011/EU

6 BS EN 13986. Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking, BSI

7 WPA Manual: Industrial wood preservation specification and practice, 2nd edition, Wood Protection Association, April 2012

8 BS EN 13501-1. Fire classification of construction products and building elements. Classification using test data from reaction to fire tests, BSI

9 BS EN 717-1. Wood-based panels. Determination of formaldehyde release. Formaldehyde emission by the chamber method, BSI

10 BS EN 120. Wood based panels. Determination of formaldehyde content. Extraction method called the perforator method, BSI

11 BS EN 717-2 Wood-based panels. Determination of formaldehyde release. Formaldehyde release by the gas analysis method, BSI

12 BS 8103-3. Structural design of low-rise buildings. Code of practice for timber floors and roofs for housing, BSI

13 BS EN 300. Oriented strand boards (OSB). Definitions, classification and specifications, BSI

14 BS EN ISO 12572. Hygrothermal performance of building materials and products. Determination of water vapour transmission properties, BSI

15 BS EN 12524. Building materials and products. Hygrothermal properties. Tabulated design values, BSI

16 BS EN 12664. Thermal performance of building materials and products. Determination of thermal resistance by means of guarded hot plate and heat flow meter methods. Dry and moist products of medium and low thermal resistance, BSI

17 BS EN 13501-1. Fire classification of construction products and building elements. Classification using test data from reaction to fire tests, BSI

18 BS EN 634-1. Cement-bonded particle boards. Specification. General, BSI

19 BS EN 634-2. Cement-bonded particleboards. Specification. Requirements for OPC bonded particleboards for use in dry, humid and exterior conditions, BSI

20 DD CEN/TS 1099. Plywood. Biological durability. Guidance for the assessment of plywood for use in different use classes, BSI

21 BS EN 635-1. Plywood. Classification by surface appearance. General, BSI

22 BS EN 635-2. Plywood. Classification by surface appearance. Hardwood, BSI

23 BS EN 635-3. Plywood. Classification by surface appearance. Softwood, BSI

24 DD CEN/TS 635-4. Plywood. Classification by surface appearance. Parameters of ability for finishing, guideline, BSI

25 BS EN 635-5 Plywood. Classification by surface appearance. Methods for measuring and expressing characteristics and defects, BSI

26 BS EN 1995-1-1. Eurocode 5. Design of timber structures. General. Structural fire design, BSI

27 BS 5268-2. Structural use of timber. Code of practice for permissible stress design, materials and workmanship, BSI (withdrawn)

28 BS EN 636 Plywood. Specifications, BSI

29 BS EN 12369-2. Wood-based panels. Characteristic values for structural design. Plywood, BSI

30 BS EN 789. Timber structures. Test methods. Determination of mechanical properties of wood based panels, BSI

31 BS EN 1058. Wood-based panels. Determination of characteristic 5-percentile values and characteristic mean values, BSI

32 BS EN 350-2 Durability of wood and wood-based products. Natural durability of solid wood. Guide to natural durability and treatability of selected wood species of importance in Europe, BSI

33 BS EN 314-2. Plywood. Bonding quality. Requirements, BSI

34 BS EN 335. Durability of wood and wood-based products. Use classes: definitions applicable to solid wood and wood-based products, BSI

35 BS EN 310. Wood-based panels. Determination of modulus of elasticity in bending and of bending strength, BSI

36 BS EN 12369-2. Wood-based panels. Characteristic values for structural design. Plywood, BSI

37 BS EN 335. Durability of wood and wood-based products. Use classes: definitions, application to solid wood and wood-based products, BSI

38 BS EN 314-1. Plywood. Bonding quality. Test methods, BSI

39 BS EN 12871. Wood-based panels. Determination of performance characteristics for load bearing panels for use in floors, roofs and walls, BSI

40 BS EN 789. Timber structures. Test methods. Determination of mechanical properties of wood based panels, BSI

41 BS EN 12369-2. Wood-based panels. Characteristic values for structural design. Plywood, BSI

42 BS EN 350-1. Durability of wood and wood-based products. Natural durability of solid wood. Guide to the principles of testing and classification of the natural durability of solid wood, BSI

43 WIS 2/3-1: Finishes for external timber, TRADA Technology, 2012

44 WIS 4-28: Durability by design, TRADA Technology, 2012

45 WIS 2/3-11: Specification and use of wood-based panels in exterior situations, TRADA Technology, 2013

46 BS EN 622-1. Fibreboards. Specifications. General requirements, BSI

47 BS EN 622-5. Fibreboards. Specifications. Requirements for dry process boards (MDF), BSI

48 BS EN 320. Particleboards and fibreboards. Determination of resistance to axial withdrawal of screws, BSI

49 BS EN 622-1. Fibreboards. Specifications. General requirements, BSI

50 BS EN 622-2. Fibreboards. Specifications. Requirements for hardboards, BSI

51 BS EN 622-3. Fibreboards. Specifications. Requirements for medium boards, BSI

52 BS EN 622-4 Fibreboards. Specifications. Requirements for softboards, BSI

53 BS EN 15197. Wood-based panels. Flaxboards. Specifications, BSI

WOOD
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Code of Practice for Particle Board & Oriented Strand Board (OSB) Floating Floors

WPIF INDUSTRY STANDARD
IS (WPIF) 3/2018

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Note

The European specification for the performance of floating floors is BS EN 13810-1 and this is the specification to which reference should be made in the UK for the requirements and design of floating floors.

Guidance on the installation of floating floors is provided in Annex A of the above specification, while the method of testing the performance of floating floors is given in DD CEN/TS 13810-2.

The Wood Panel Industries Federation industry standard for floating floors is reproduced below as it contains considerably more detailed guidance on the installation of floating floors than is contained in BS EN 13810-1, thereby complementing the European standard.

FOREWORD

The preparation of this Code of Practice IS (WPIF) 3/2018 as an Industry Standard has been undertaken by the Wood Panel Industries Federation (WPIF) under the direction of the Technical Committee of the WPIF.

As a Code of Practice, IS (WPIF) 3/2018 contains recommended provisions.

It should be noted that compliance with this standard, even where it is specified in a contract, does not itself confer immunity from legal obligations arising from common law or statute. Neither does the Wood Panel Industries Federation, in establishing the standard for the commercial assistance of buyers and sellers, enter into any legal commitment or incur any commitment other than advisory thereby.

SECTION 1: GENERAL

1.1 Scope

This Code of Practice IS (WPIF) 3/2018 gives recommendations for the selection of materials in, and the construction of, particleboard (wood chipboard) and Oriented Strand Board (OSB) floating floors, with boarding either continuously supported or self-supporting. Floating floors are suitable for use on ground or intermediate floors provided in the former the performance requirements in Approved Document Parts E (acoustics) and L (thermal) are satisfied. **It applies only to domestic floating floors subject to an imposed load not exceeding 1.5kN/m^2 (BS 5268 and Eurocode design) and 2.0kN pointload (Eurocode design): however, the concepts are applicable to other building types provided the floor loading and acoustic requirements are satisfied.**

Floating floors of the type described can contribute to the thermal performance and attenuation of sound transmission performance of floors, but the specifier must ensure that the required performance is met in all aspects. The design detailing shown in IS (WPIF)3/2018 is intended to maximise performance from the wood-based panel floating floor overlay, and although some of the concepts are applicable to both thermal and acoustic floors, the detailing shown in IS (WPIF)3/2018 would not necessarily satisfy all thermal or acoustic requirements nor any requirements of the supporting or adjoining structures.

1.2 Definitions

1.2.1 Continuously supported (IS (WPIF) 3/2018)

A floor system in which the wood-based panel overlay has uninterrupted support from beneath. Support is provided by a structural subfloor and insulation material is placed between the subfloor and the overlay.

1.2.2 Self supporting (IS (WPIF) 3/2018)

A floor system in which the wood-based panel overlay has discontinuous support from beneath at predetermined and regular intervals. Support is usually provided by timber battens or joists. The system may incorporate insulation material between the supports.

1.2.3 Damp-proof membrane (DPM)
Layer or sheet of material within a floor or similar construction, or vertically in a wall to prevent the passage of moisture.

1.2.4 Fabricated Underlay (BS 8203)
Wood-based panel applied to a subfloor/base/floating floor to provide a smooth, even surface suitable for the installation of a floor covering.

1.2.5 Base
Building element that supports the screed and/or the floating floor and the floor finishes.

1.2.6 Floating floor (adapted from BS EN 13810-1)
Decking of wood-based panels supported by one or more insulation materials, without being fixed to the base/subfloor.

1.2.7 Oriented strand board (OSB) (BS EN 300)
Multi-layered board made from strands of wood of predetermined shape and thickness together with a binder. The strands in the external layers are aligned and parallel to the board length or width; the strands in the centre layer or layers can be randomly oriented, or aligned, generally at right angles to the strands of the external layers.

1.2.8 Particleboard (BS EN 309)
Panel material manufactured under pressure and heat from particles of wood (wood flakes, chips, shavings, sawdust, wafers, stands and similar) and/or other lignocellulosic material in particle form (flax shives, hemp shives, bagasse fragments and similar) with the addition of an adhesive.

1.2.9 Pre-cast concrete floors
Includes concrete beams with infilling blocks; concrete planks and other types of suspended pre-cast floors.

1.2.10 Screed (BS EN 13318)
A layer or layers of screed material laid in situ, directly onto a base, bonded or unbonded, or onto an intermediate layer or insulating layer, to obtain one or more of the following purposes:

- **to obtain a defined level;**
- **to carry the final flooring;**
- **to provide a wearing surface.**

1.2.11 Levelling screed (BS 8204)
A screed suitably finished to obtain a defined level and to receive the final flooring

1.2.12 Slab
Concrete base cast as part of the building construction.

1.2.12 Subfloor
See 1.2.5 base.

1.2.14 Suspended floor
Layer or sheet of material within a floor or similar construction, or vertically in a wall to prevent the Subfloor that spans between (local) supports.

1.2.15 Vapour control layer (VCL)
Material or part of a construction element that offers a high resistance to the passage of water vapour.

Section 2: Selection of Suitable Materials

2.1 Particleboard (wood chipboard)
Particleboard should conform to BS EN 312 and be of grade P5 or P7 and be tongued and grooved on all four edges.

Panel thickness is dependent upon the specification and panels may have surface protection if required.

- **Note** *P5 is the most commonly available grade.*

2.2 Oriented strand board (OSB)
Oriented strand board should conform to BS EN 300 type OSB/3 or OSB/4 and be tongued and grooved on all four edges.

Panel thickness is dependent upon the specification and panels may have surface protection if required.

- **Note** *OSB/3 is the most commonly available grade.*

2.3 Vapour control layer (VCL)
A VCL providing a vapour resistance of not less than 200 MNs/g should be provided, e.g. 250 micron (minimum 1000 gauge) polythene.

2.4 Damp-proof membrane (DPM)
Materials and methods for damp-proofing solid floors are described in CP102, BS 8102 and BS 8215 and it should not be assumed that existing ground supported concrete floors are adequately damp-proofed.

Table 1: *Typical alternative methods of providing a DPM for concrete floors*

Below The Slab	On The Slab Surface	Between The Floor Slab And The Screed
Membrane not less than 300 micron (1200 gauge) or 250 micron (1000 gauge) if BBA certified *Bitumen sheet to BS 6398 "Materials for damp-proof courses for masonry"*	*Hot applied asphalt to BS 6925 or pitch mastic* *Cold applied pitch/ epoxy resin*	*Any sheet material given in the previous column* *Hot applied asphalt to BS 6925, pitch or bitumen* *Three full coats of cold applied bituminous solutions, cold tar, pitch or rubber emulsion* *Composite polyethylene and bitumen self-adhesive not less than 0.6mm thick*

2.5 Timber Battens

When used on concrete ground floors battens should be preservative treated with a suitable treatment (treat as if sole plates) for the desired service life. On timber floors and all upper floors, battens need not be treated unless there is a risk of insect attack or as insurance against premature failure (e.g. fungal attack due to prolonged unseen leakage from pipes). Factors in determining the need for treatment based on risk, consequence of failure, service life and also specifying a treatment are given in BS 8417. Battens shall have a moisture content not exceeding 20% at the time of installation. Where battens have been treated with a water-borne preservative they should be re-dried to a moisture content not exceeding 20%.

Battens should be not less than 45mm wide finished and where insulation is used the depth should be greater than the insulation thickness to allow for shrinkage of the batten resulting from drying to its equilibrium moisture content.

Where timber battens act structurally (i.e. spanning between supports) they must be strength graded and capable of withstanding the relevant ultimate (ULS) and serviceability (SLS) limit states.

- **Note** *For the improvement of acoustic properties battens often have a layer of resilient material on the bottom face.*

2.6 Insulation

Insulation materials may include the following (see Table 2), however the insulation manufacturer should be consulted regarding suitability for the floor performance requirements e.g. load, sound and thermal performance (see 1.1).

Table 2: *Insulation materials and densities for use in floating floors*

Material	Continuously supported Minimum Density kg/m³	Self supporting Minimum Density kg/m³
Expanded polystyrene	*15*	*15*
Extruded polystyrene	*25*	*25*
Mineral wood slab	*150*	*80*
Mineral wool quilt	-	*12*
Polyurethane foam board	*26*	*26*
Phenolic foam board	*40*	*40*

- **Note 1** *Dwellings will have to comply with building regulations which use the Standard Assessment Procedure (SAP) tool for calculating the energy efficiency of the building, CIBSE Guide A Environmental design may also be used for the design of the building with respect to insulation performance requirements.*

- **Note 2** *The insulation layer should be continuous i.e. without gaps. When fitting insulation between battens it is essential to avoid gaps which would create cold bridges.*

- **Note 3** *Proprietary pre-bonded flooring products are available which combine the insulation with the wood-based panel floating floor overlay.*

SECTION 3: TRANSPORT, HANDLING AND STORAGE

3.1 General

Panels are designed for use in a dry and humid conditions (according to Eurocode 5 service classes 1& 2). However precautions should be taken during storage prior to delivery, during transport, and on site, to ensure that the panels are adequately protected from damage and wetting.

3.2 Transport and delivery

Panels should be adequately protected by a waterproof covering during all transportation and should be fully protected from damage by lashings or other bindings and should be loaded to avoid distortion.

3.3 Storage

Panels should be stored undercover and should be stacked flat, off the ground on a dry level surface, with all four edges flush. The height off the ground should be sufficient to avoid rain splashback.

The top of the stack should be covered with a weighted protective covering to counteract any tendency of the topmost panel to warp.

- **Note 1** *The ideal base is a close boarded or slatted pallet. If this is not possible the panels should be carefully stacked on battens of equal thickness at centres not exceeding 600mm. Where stacks are placed on top of one another, bearers should line up to prevent localised distortion.*

  Where storage outside is unavoidable, stack on dry level ground and protect with a waterproof sheet. Ensure all edges are covered and secured to avoid lifting by the wind.

  Containerised storage is recommended.

- **Note 2** *PanelGuide section 4 has further information on the transportation, storage and handling of wood based panels.*

Section 4: Construction of base

4.1 Surface finish and levels

The surface finish of a concrete or screed base should be similar to that produced by a float finish. Surface regularity should be class SR2 or better to BS 8204 part 1, i.e. maximum 5mm deviation from under a 2 metre straightedge. Particular attention should be paid to movement joints and to screed and bay junctions so as to avoid undulations and other surface irregularities.

Pre-cast concrete floors should have a level flat surface (see figure 2). If deviations occur a levelling screed may be required.

- **Note 1** *Where deviations occur in the base, these can be telegraphed into the particleboard or OSB overlay (this applies particularly to isolated deviations even where they may be within the allowable tolerance).*

- **Note 2** *Consideration should be given at the design stage to allow for any loading restrictions that may be encountered with block and beam construction.*

- **Note 3** *Certain floor coverings or acoustic battens may require surface regularity of SR1 i.e. 3mm deviation from under a 2 metre straightedge.*

4.2 Protection against ground water and construction moisture

In all cases where floating floors, as described in this standard, are used over an in-situ concrete slab construction (with or without a screed), a DPM (See 2.4) should be positioned over the slab or screed to protect the floating floor from moisture.

Where a pre-cast concrete upper or a suspended ground floor (with or without a screed), is considered wet i.e. greater than 75% RH when tested according to Annex A of BS8201, or in case of doubt, a DPM should be placed over the screed or subfloor surface before laying the floating floor.

- **Note 1** *A DPM above the slab or screed may not be necessary if there is a DPM below the slab or screed and the slab or screed moisture content has been determined by test as being below 75% relative humidity when tested according to Annex A of BS 8201.*

  It is possible to estimate drying times for purposes of planning and decision making but are influenced by many variables and therefore cannot substitute testing. For example a cement-sand screed laid directly over a DPM, one day drying time should be allowed for each millimetre up to 50mm and thicker than 50mm the drying will slow. A 150mm concrete base drying from one surface could take up to a year to dry sufficiently (visual inspection should not be used, as a slab can have a relatively high moisture content even when the surface appears dry).

- **Note 2** *Where block and beam construction is used at ground floor level (suspended floor), the void beneath should be fully ventilated in accordance with the Building Regulations and recommendations in BS 5250. A DPM is required above a block and beam floor if the minimum clearance is below 75mm, or the void is unventilated or the ground in the void is below the surrounding ground level and not effectively drained.*

- **Note 3** *Where a suspended timber ground floor is present it is essential for there to be an adequate ventilation (see BS 5250) and other preventative measures to reduce the risk of build-up of moisture and resultant decay in the construction. Aspects to consider are the distance between the ground cover and the timber joists in the sub floor (normally 150mm minimum), the minimum amount of free flowing cross ventilation for the size of the floor, the*

SECTION 5: GENERAL REQUIREMENTS FOR THE INSTALLATION OF PARTICLEBOARD AND ORIENTED STRANDBOARD FLOATING FLOORS

5.1 Protection

Unless otherwise advised by the manufacturer, panels should not be laid until all wet trades are completed and the building has dried out. In wet construction (i.e. brick and block work) the floating floor should not be installed until the latest opportunity. In dry conditions, e.g. Timber Frame, the floating floor should only be installed as a working platform once the building is watertight. After laying, the floor should be protected from dirt and moisture. Any factory applied temporary protective layer should be retained in place for as long as possible.

5.2 Moisture content

Panels should be conditioned to a moisture content appropriate for the intended use. When conditioning, packs should be opened, panels separated to allow free air movement and left in the building where they are to be fitted for at least 48 hours before laying (preferably 1 week).

- **Note** *Particleboard and OSB (as given in 2.1 & 2.2) can have an ex works moisture content of 5% to 13% and 2% to 12% respectively but is typically 7%-10% and 5% to 9% respectively. When installed into the building the moisture content can increase to around 16% in a building under construction during winter months. After completion, the moisture content of the particleboard and OSB will generally reduce to a value of between 6 to 10%.*

  As a guide, a change in moisture content of 1% typically results in a corresponding dimensional increase or decrease in length and width of 0.3mm per metre.

  Although expansion is the most usual movement encountered, in areas with higher than average temperatures, shrinkage can occur e.g. nursing homes.

SECTION 6: INSTALLING A CONTINUOUSLY SUPPORTED FLOATING FLOOR (Typical construction is shown in Figures 1 and 2 below)

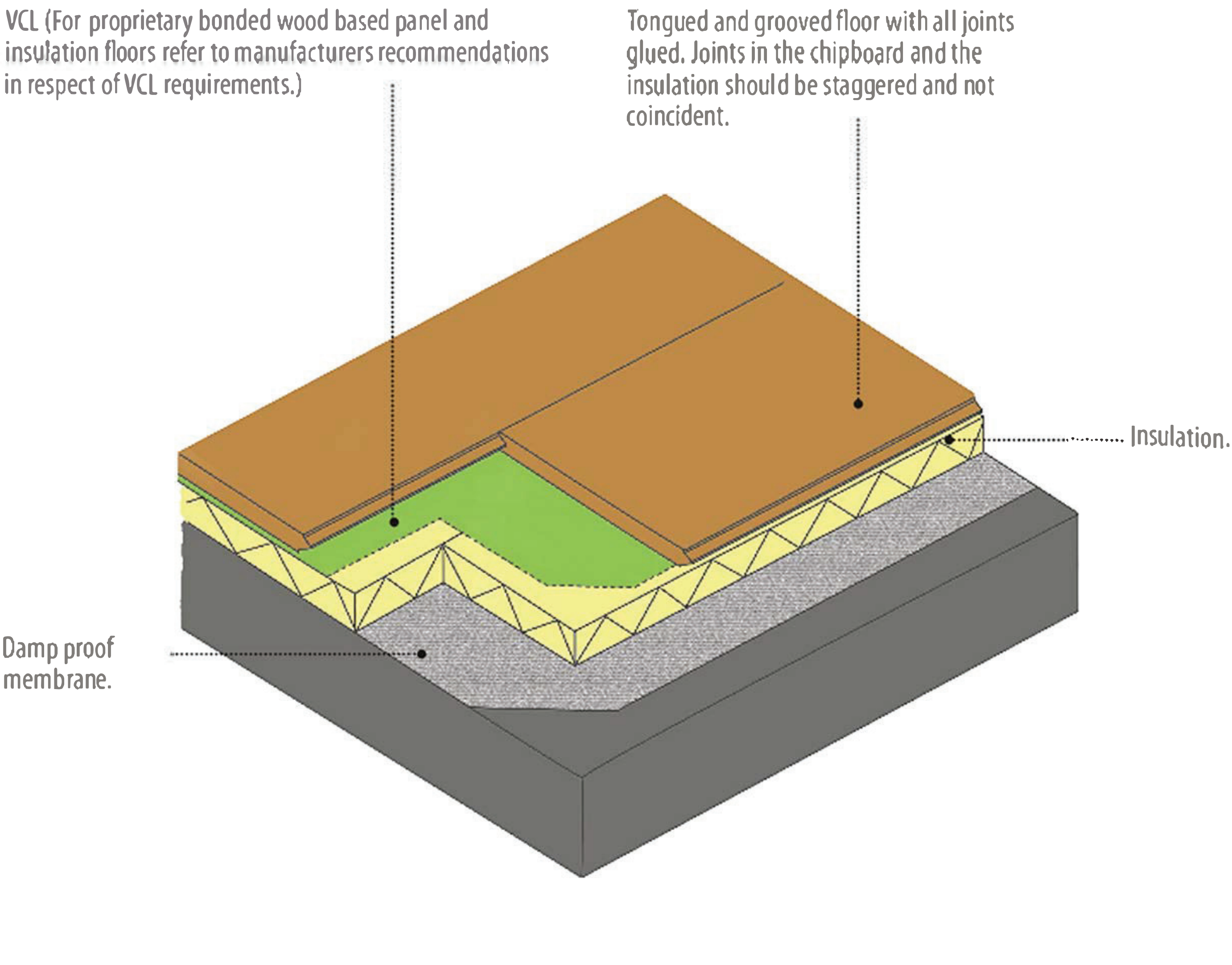

Figure 1: Floating floor on an in situ concrete slab

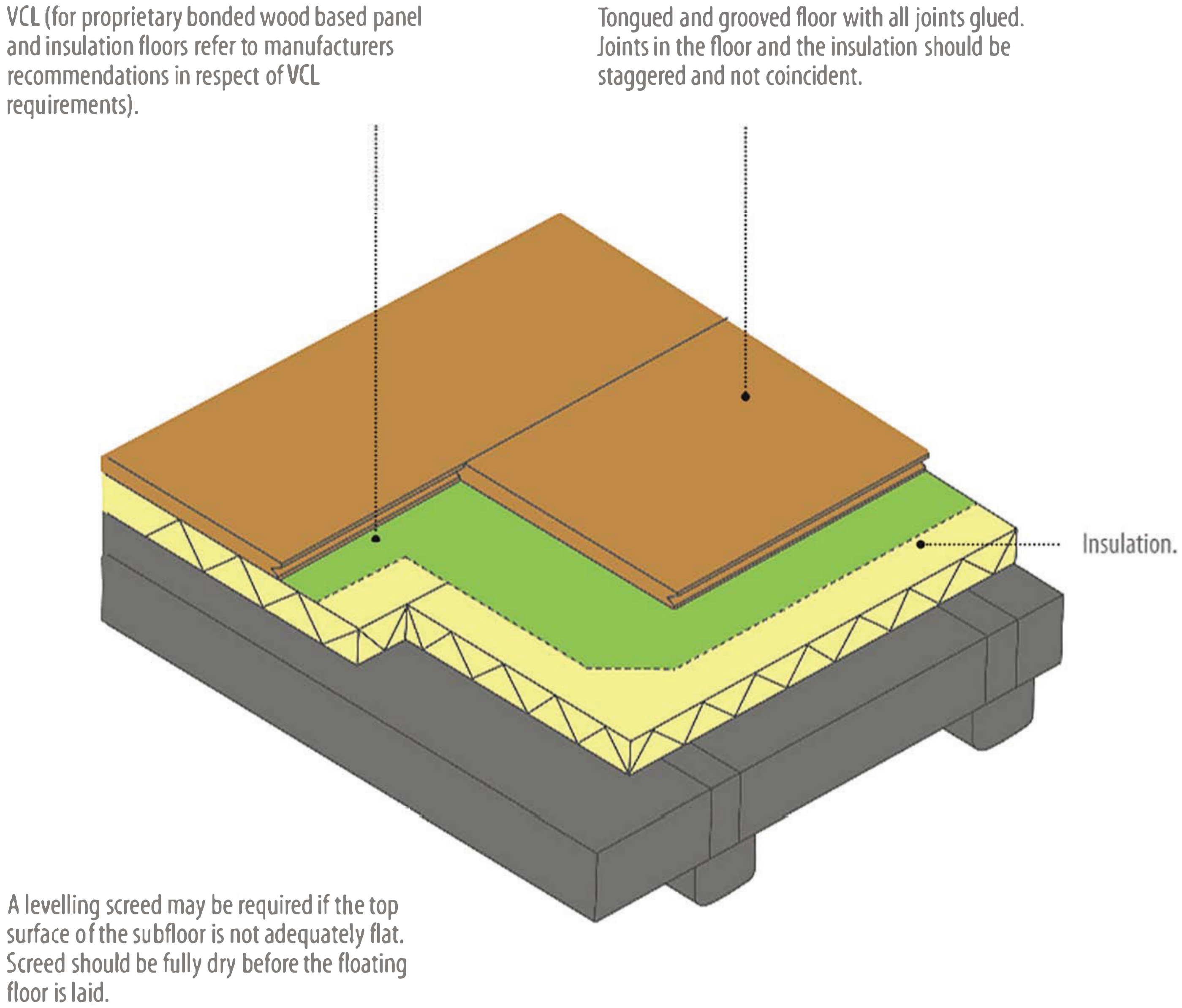

Figure 2: Floating floor on a precast concrete substructure

6.1 Insulation

The insulation should be placed on the subfloor, butting the joints tightly together with no gaps between adjoining sections (see clause 2.6). Battens should be provided where recommended by the insulation manufacturer, at room perimeters, access traps, thresholds etc. (see Figure 3). Sheets should be laid so that joints will not be coincident with the wood-based panel floating floor overlay. Additional advice on the positioning of insulation is given in the BRE Publication "Thermal insulation: avoiding risks".

- **Note** *The thickness of insulation is dependent upon the U-value required and the insulation type specified (see clause 2.6).*

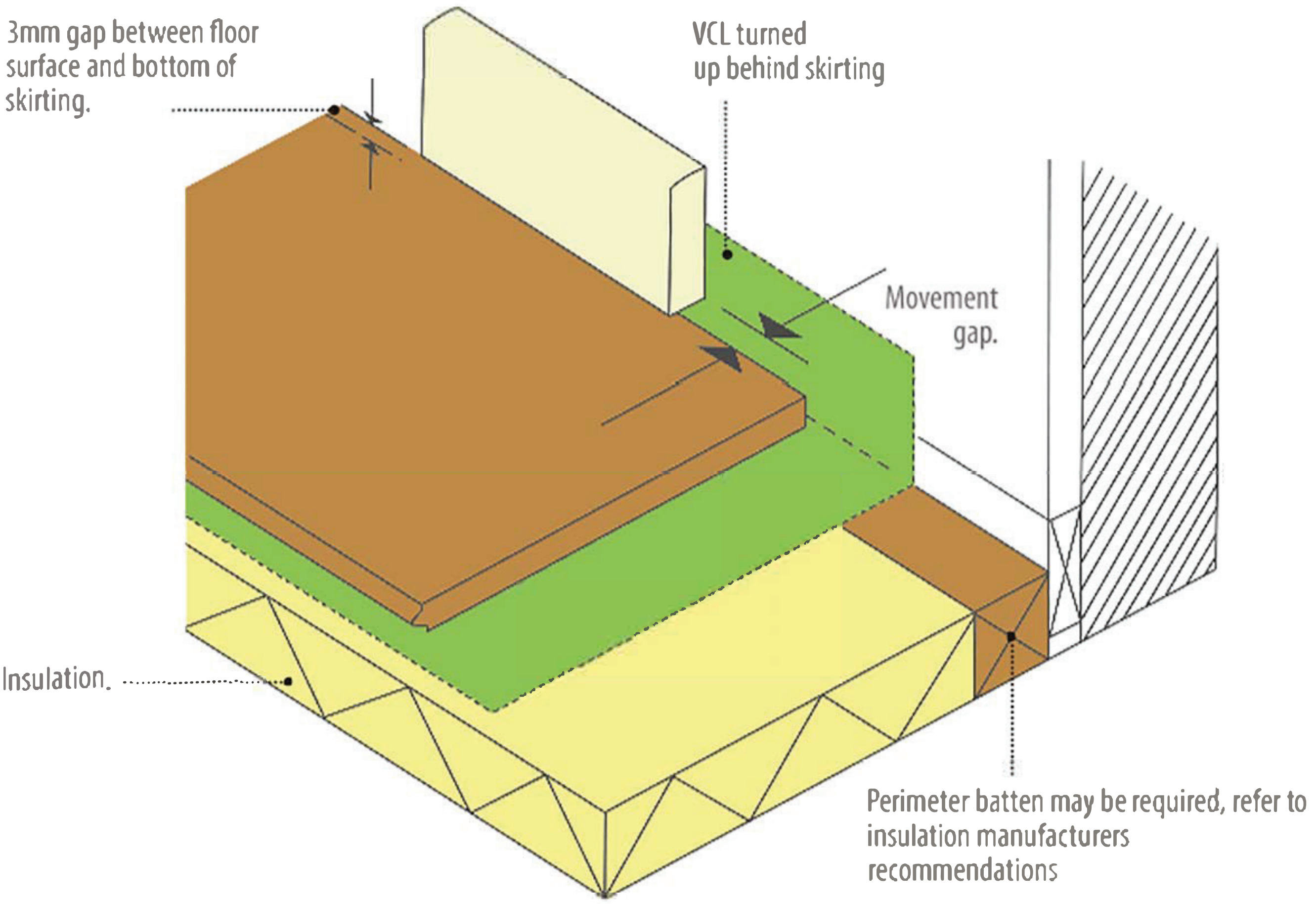

Figure 3: Detail of perimeter floor

6.2 Vapour control layer (VCL)

All floating floors should incorporate a VCL. A VCL providing a vapour resistance of not less than 200 MNs/g e.g. 250 micron (minimum 1000 gauge) should be laid above the insulation layer and should be upturned by at least 38mm around perimeter walls. Any joints in the sheet should be lapped 150mm (minimum) and the joints taped with a vapour resistant tape.

For proprietary composite floor panels with pre bonded insulation, the manufacturer's recommendations should be sought as to the VCL requirement and specification.

- **Note** *Where a self supporting floating floor is installed above ground floor level for acoustic purposes, a VCL is not be necessary. It is however still recommended for continuously supported floating floors as it can act as a 'slip' layer between the wood-based panel overlay and the insulation.*

6.3 Particleboard & OSB floating floor overlay

Only particleboard types P5 or P7 or OSB/3 or OSB/4 (see clause 2.1 and 2.2) should be used as the wood-based panel floating floor overlay on a continuously supported floor. For domestic use, panels of not less than 18mm for particleboard and 15mm for OSB should be used. (For floors requiring restricted deflection, panels of not less than 22mm for particleboard and 18mm for OSB should be used).

Panel joints should be staggered and should not coincide with the joints in the insulation. All tongued and grooved joints should be glued with an adhesive conforming to at least durability class D3 of EN 204. Adhesive should be liberally applied so as to coat both surfaces of the tongue and groove. Where manufacturer's flooring systems are used, their products (panel and adhesives etc…) and installation requirements should be followed.

- **Note** *For non-domestic floors, the wood-based panel floating floor overlay will need to be assessed to ensure compliance with the loading and deformation requirements (ultimate limit state and serviceability limit state – Eurocode design) for a given thickness of wood based panel floating floor overlay.*

6.4 Plasterboard planks

There are many different systems available on the market where plasterboard planks are used to provide added acoustic performance for floating floors. Where a plasterboard plank is employed, the planks should be at 90° and the joints should not coincide with the wood-based panel floating floor overlay above.

Manufacturer's instructions should be followed for the fixing details and materials used for their particular system.

- **Note** *Where a VCL is employed it should be placed below the plasterboard planks and the wood-based panel floating floor overlay.*

6.5 Movement gaps

It is essential to allow for possible expansion by providing a gap wherever panels abut any rigid upstand such as a perimeter wall/internal load-bearing walls, column, pipes or fireplace surround. The gap at each edge of the floor should be equal to 2mm/metre run of floor but not less than 10mm wide. Movement gaps should be kept free of debris. For floors where the movement gap cannot be dealt with at the perimeter alone or which are in excess of 10 metres long e.g. corridors, intermediate movement gaps (minimum 10mm) should be incorporated (see Figure 4).

- **Note 1** *Intermediate movement gaps should be filled with resin bonded cork, impregnated softboard or equivalent, (maximum density 160kg/m^3) or covered with cover strip. It may be necessary to increase the size of the movement gap to allow for the relative compressibility of the different filler materials that may be used.*

- **Note 2** *Where manufacturer's instructions are supplied with the panels, their recommendations should be followed.*

- **Note 3** *Packers or wedges should be used to maintain perimeter gaps and can also be used to assist in tightening board joints. Packers or wedges should be removed immediately once the adhesive has set. The floor should be kept free of pedestrian traffic before the adhesive has set.*

- **Note 4** *Floor expansion is the most common effect encountered, however in areas with higher than average temperatures e.g. nursing homes, hospitals etc shrinkage can occur.*

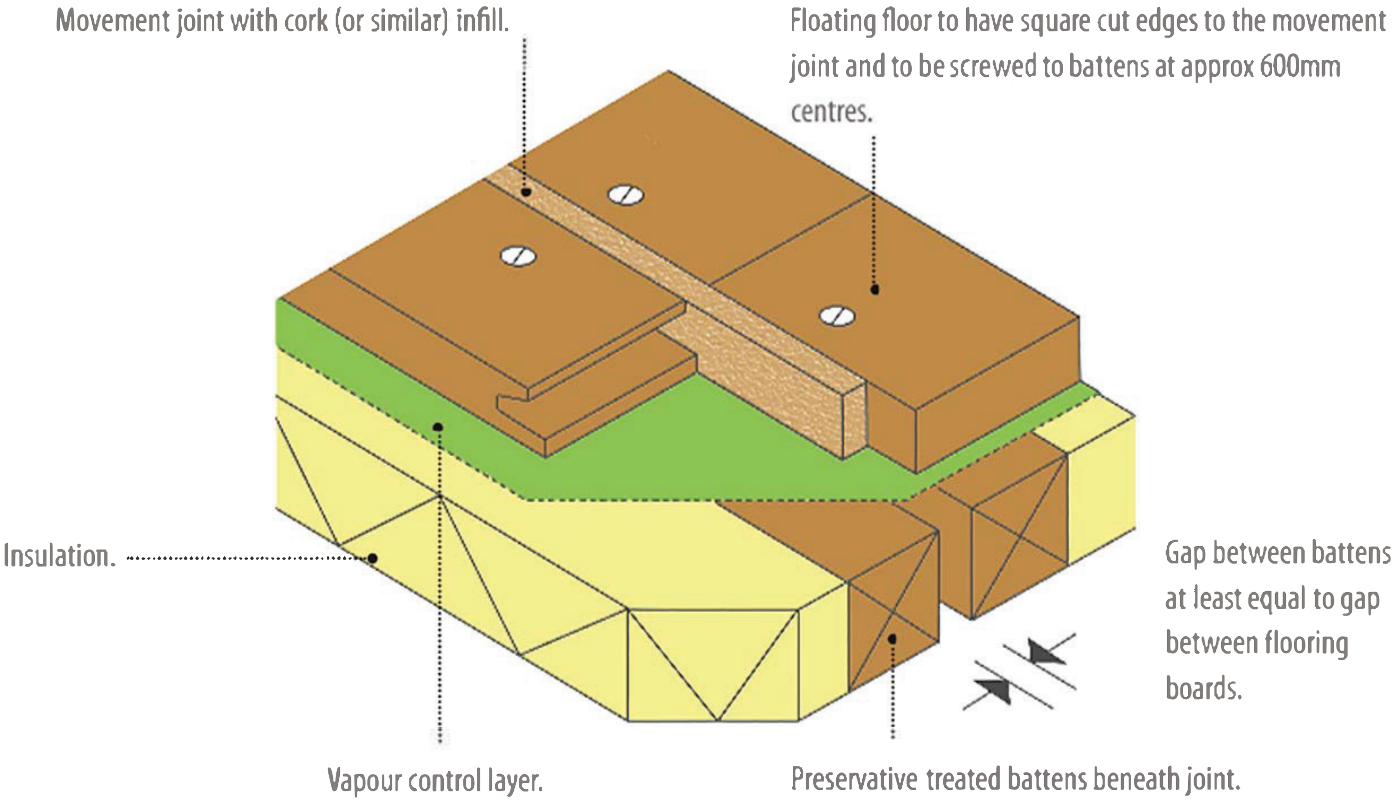

Figure 4: Detail of typical intermediate movement joint

6.6 Access to pipes and services

Before laying the floating floor, consideration should be given to the provision of access to pipes and services.

Proprietary systems or square edged panels screwed to timber battens to allow access should be used (see Figure 5).

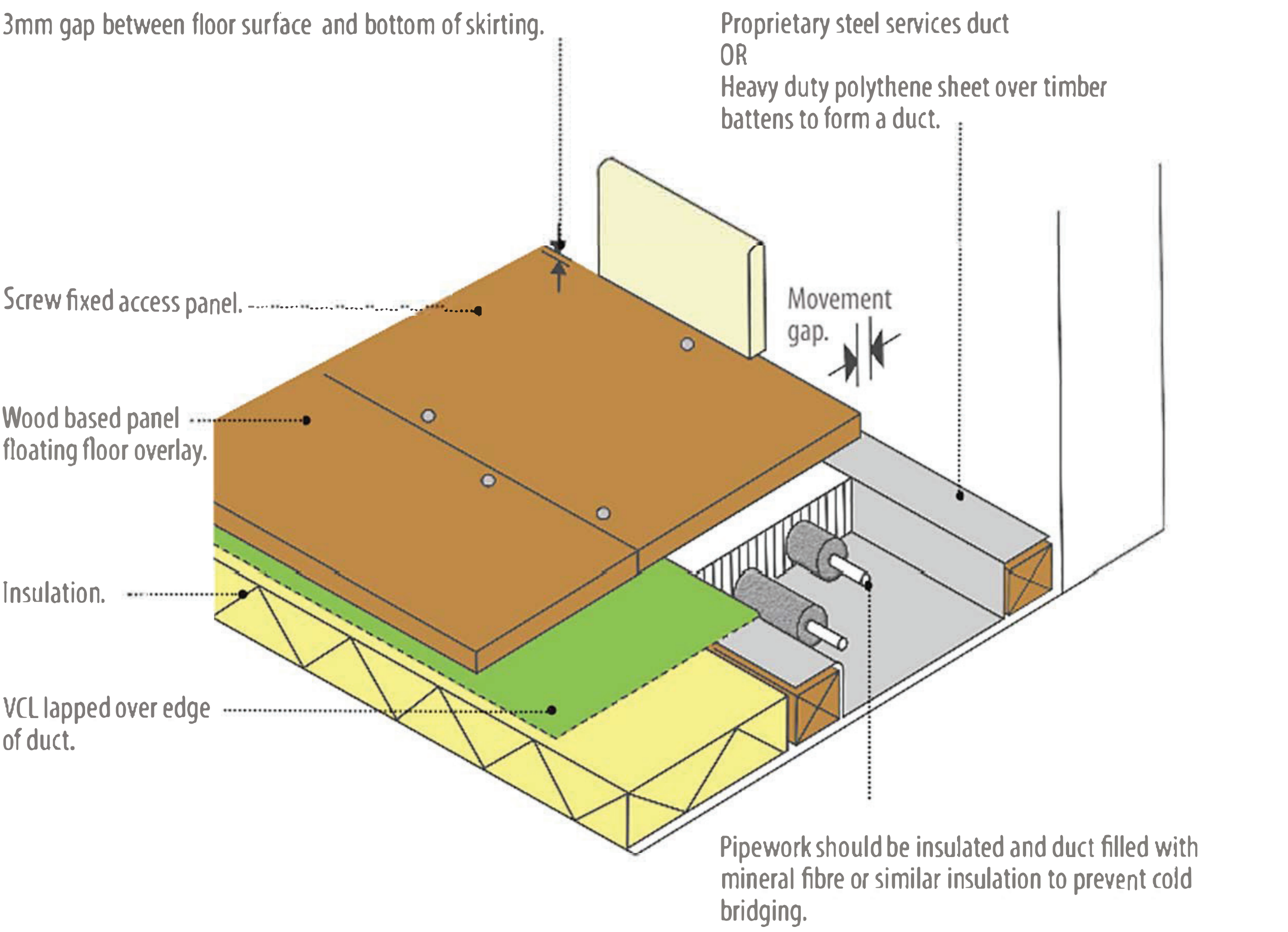

Figure 5: Typical service duct detail

6.7 Thresholds

At openings in walls built directly off the concrete substructure a movement gap should be installed. Battens should be inserted beneath the floating layer at the point of loading in order to counteract localised compression and to provide support beneath the cut edges of the floating floor (see Figure 6).

- **Note** *In a non-load-bearing wall condition where the floating floor is continuous beneath the wall, (as shown in Fig. 8) the floor can continue beneath the door opening without incorporating a movement gap.*

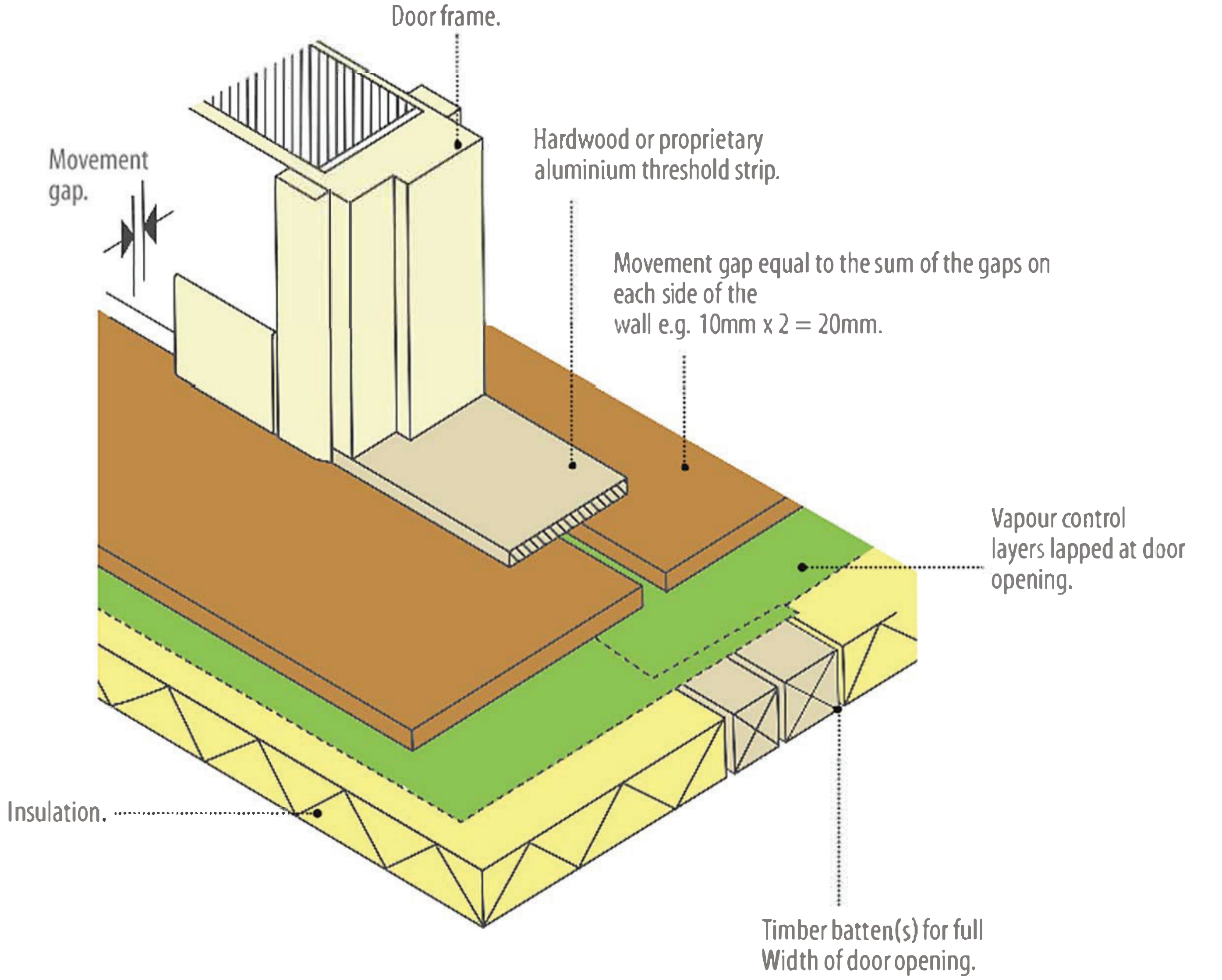

Figure 6: Details at the threshold of a doorway in a wall which is built off the supporting concrete structure when a continuously supported floor is used.

6.8 Partition loading

Load-bearing partitions should not be built on top of a floating floor, but should be continuously supported from beneath (as Figure 7). It is essential that care is taken in setting out partitions in order to ensure that the floor support is in the correct position.

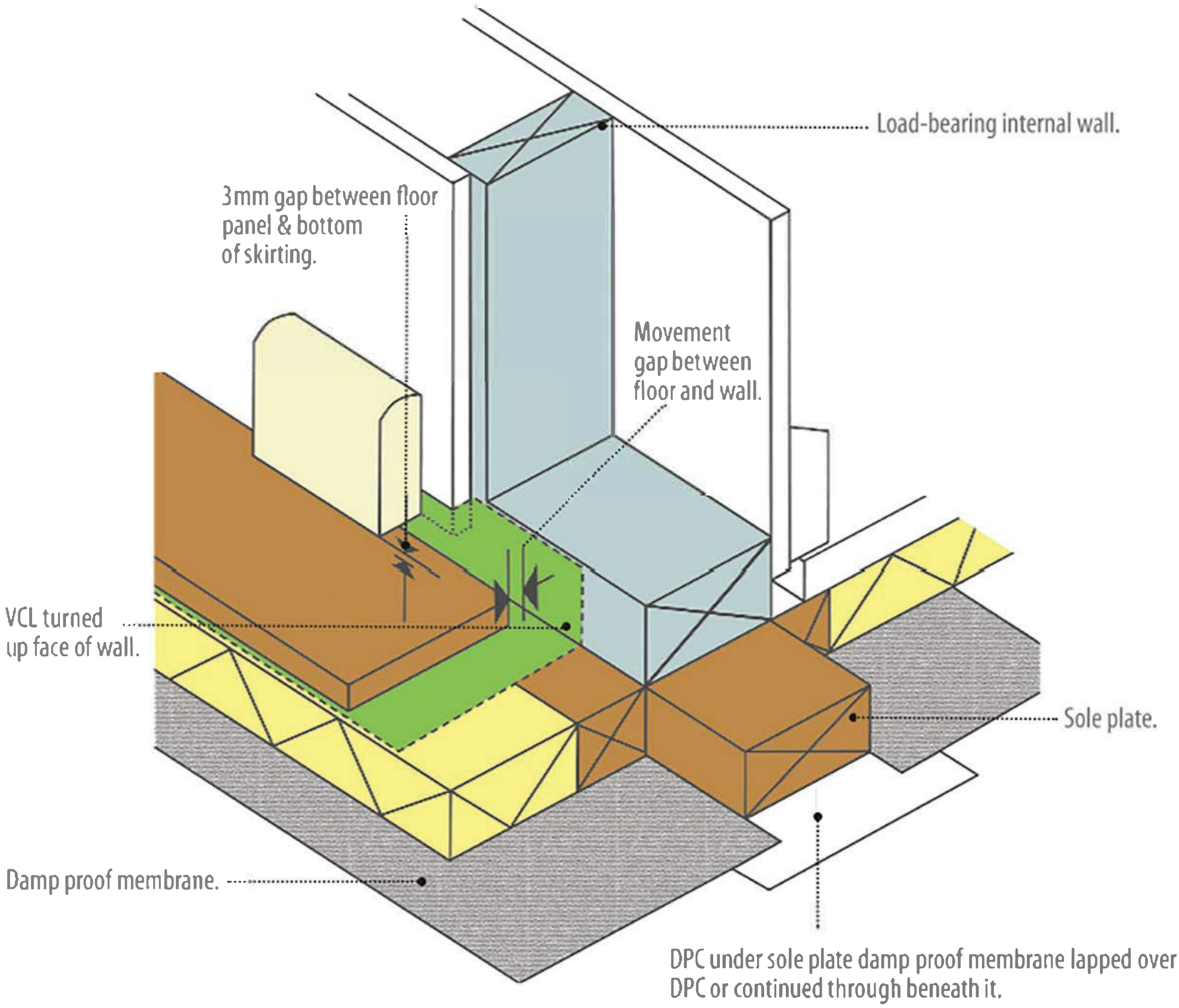

Figure 7: Detail at a load-bearing wall.

Non-load-bearing partitions can be built directly on top of the floating floor (see Figure 8) provided that the insulation is specifically manufactured for this end use and the loads that it will subject to. Where the insulation is not rigid enough for the weight of the partition, timber battens under the partition are recommended (see figure 7).

Where intermediate expansion gaps are required, i.e. in a large floor area, it may be possible to position them under non-load-bearing partitions.

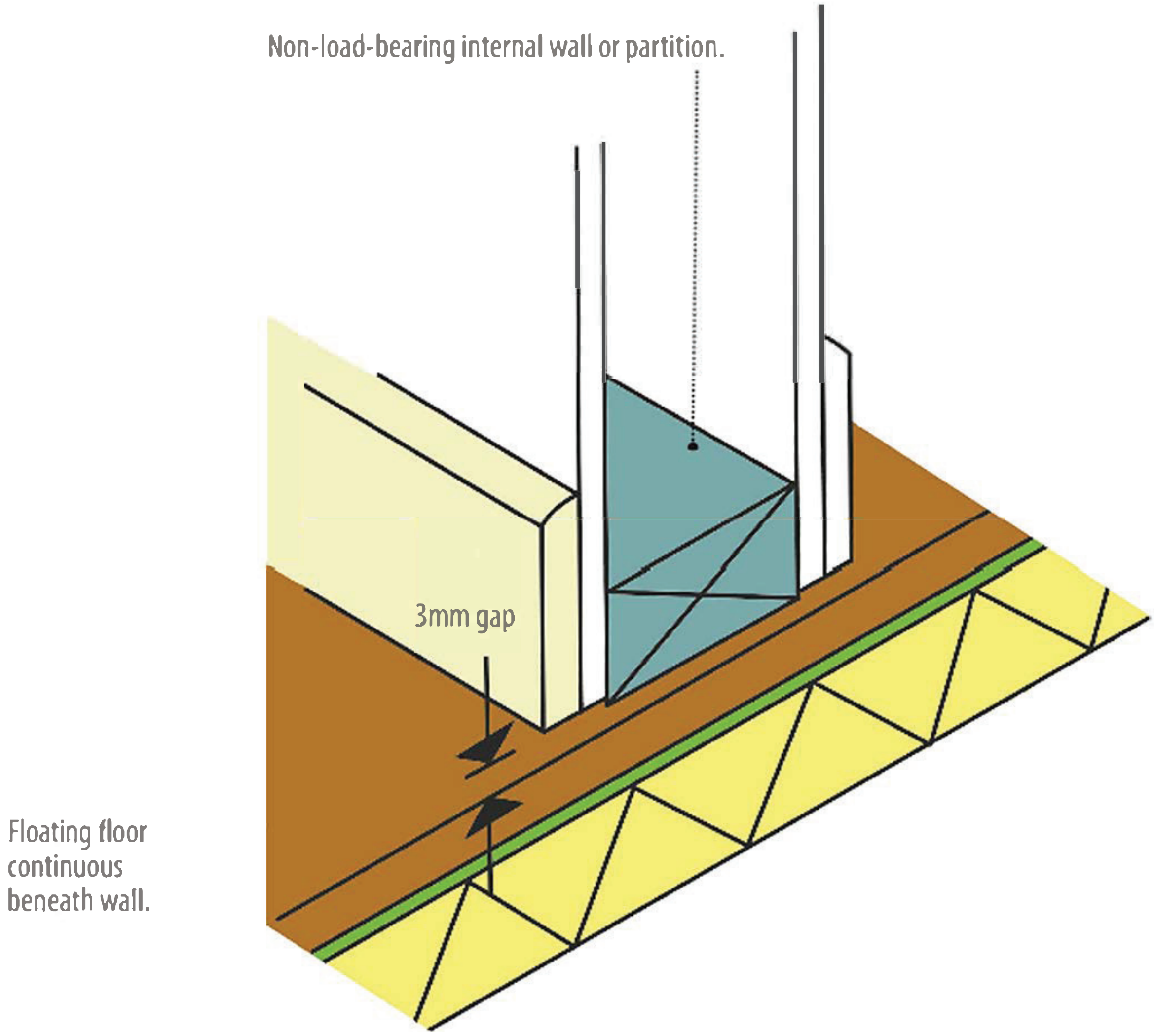

Figure 8: Supporting a non-load-bearing wall.

SECTION 7: INSTALLING A SELF-SUPPORTING FLOATING FLOOR (WITH BATTENS)

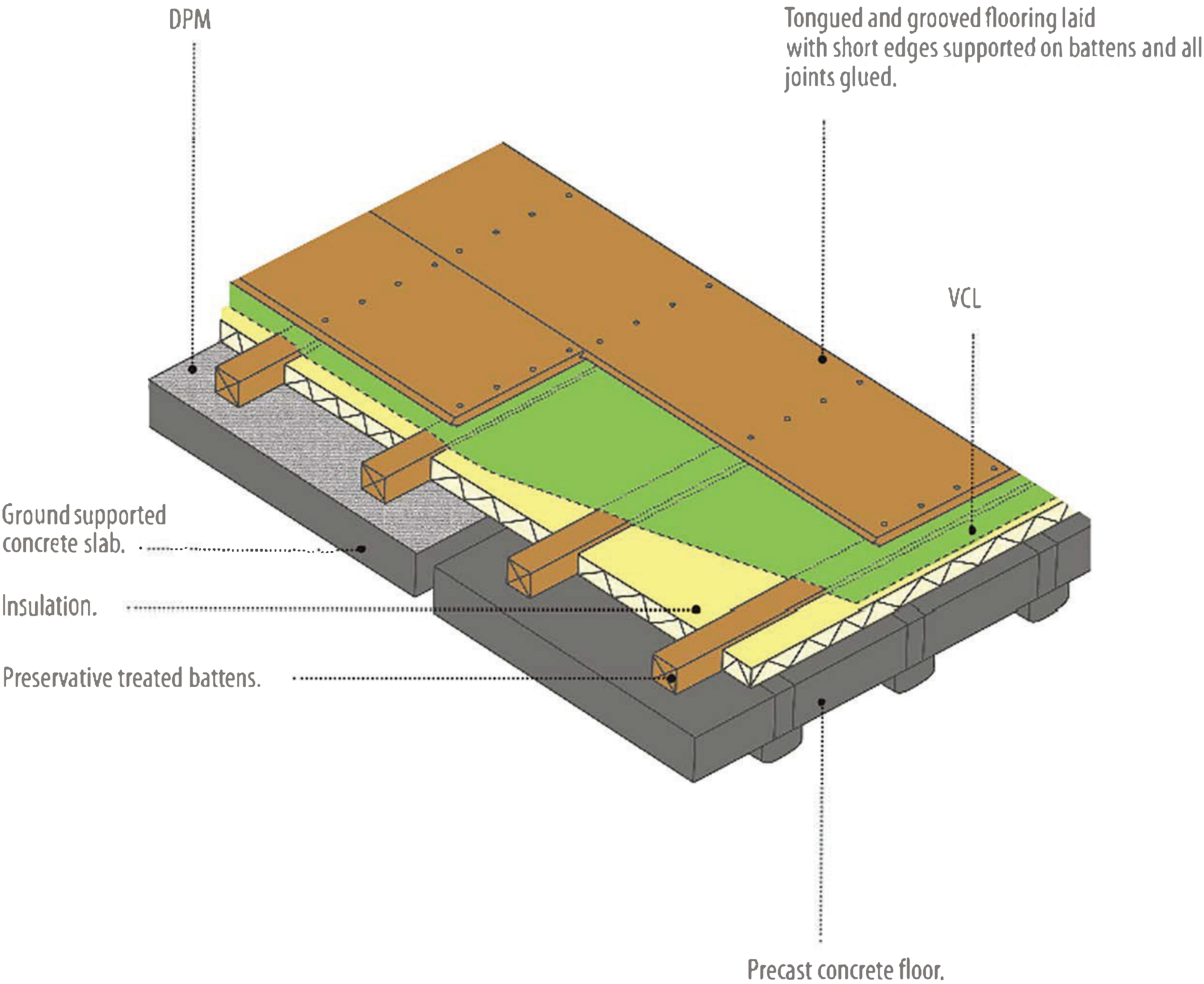

Figure 9: Self-supporting OSB or particleboard floating floor over ground supported concrete slab and precast concrete floor.

7.1 Timber battens

When installing a self-supporting floating floor timber battens as described in clause 2.5 should be used.

The appropriate centres for different wood based panel floating floor overlay panels are 450mm (maximum) centres for 18mm particleboard or 15mm OSB and 600mm (maximum) centres for 22mm particleboard or 18mm OSB.

For a self-supporting floating floor that is installed over a timber subfloor, the battens of the floating floor should be at 90º to the joists of the timber subfloor below (see figure 10). Where the timber subfloor decking is either non-structural, in the case of a working deck, or its structural capabilities are unknown, a batten and an appropriate thickness wood-based panel floating floor overlay capable of withstanding the relevant ultimate (ULS) and serviceability (SLS) limit states should be used.

- **Note 1** *Any gaps beneath the battens caused by unevenness in the sub structure should be packed with a durable rigid material (e.g. preservative treated timber, tempered hardboard, dry mix sand and cement mortar).*

- **Note 2** *Timber battens can be laid in the same direction as, and directly over the joists below the timber deck, but achieving this over the whole area of a floor can be difficult.*

  If the battens were to be laid parallel to the joists below, falling in between the joists, it may lead to excessive deflection of the timber subfloor decking. In this case calculations should be carried out to demonstrate that the subfloor has acceptable load capacity and deformation levels (ultimate limit state and serviceability limit state – Eurocode design) to avoid unacceptable deflection and sagging of the floating floor.

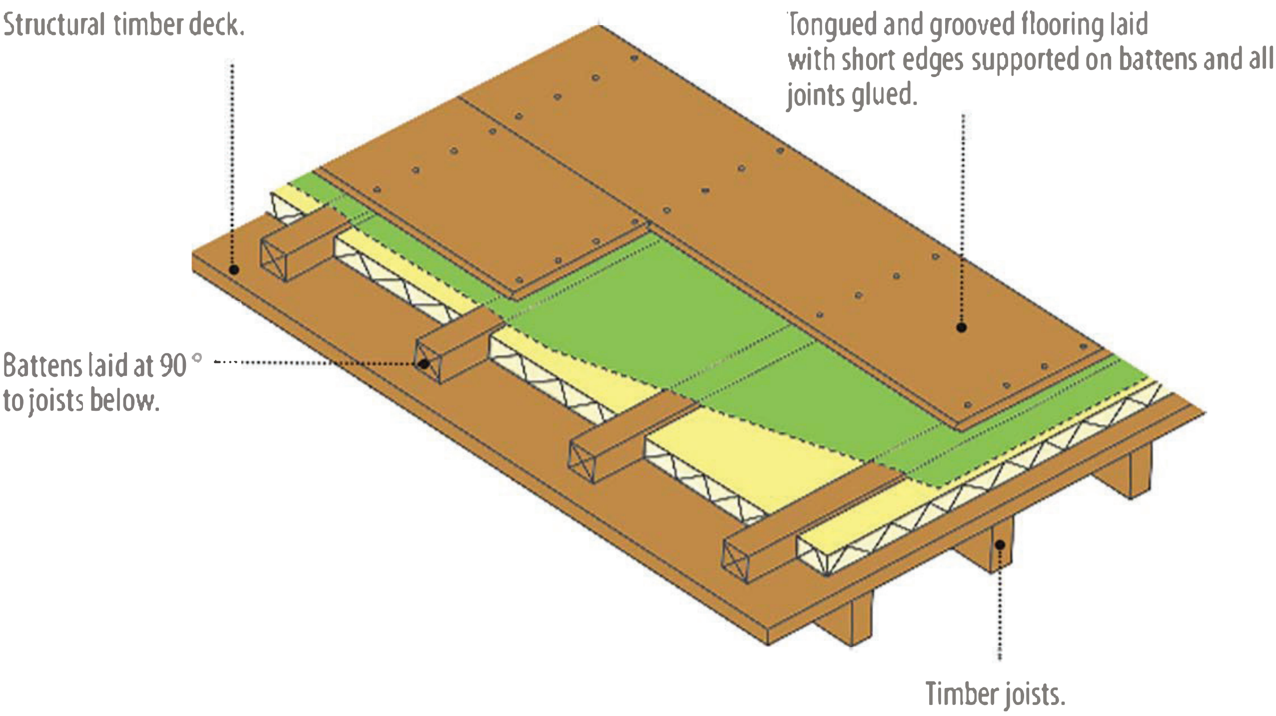

Figure 10: Self-supporting OSB or particleboard floating floor over timber sub-floor.

7.2 Insulation

The insulation should be placed between the battens, butting all joints tightly together with no gaps (see clause 2.6).

7.3 VCL

All floating floors should incorporate a VCL. A VCL providing a vapour resistance of not less than 200 MNs/g e.g. 250 micron (minimum 1000 gauge) should be laid above the insulation layer and should be upturned by at least 38mm around perimeter walls. Any joints in the sheet should be lapped 150mm (minimum) and the joints taped with a vapour resistant tape.

- **Note** *Where a self supporting floating floor is installed above ground floor level for acoustic purposes, a VCL is not be necessary. It is however still recommended for continuously supported floating floors as it can act as a 'slip' layer between the wood-based panel overlay and the insulation.*

7.4 Particleboard and OSB floating floor overlay

Only types P5 or P7 particleboard (see clause 2.1) and types OSB/3 or OSB/4 oriented strand board (see clause 2.2) should be used as the floating floor overlay panel on a self-supporting floor. For domestic use, particleboard of not less than 18mm and OSB of not less than 15mm should be used at 450mm (maximum) centres and 22mm particleboard or 18mm OSB for 600mm (maximum) centres. For floors requiring restricted deflection, panels of not less than 22mm for particleboard and 18mm for OSB should be used.

The panels should be laid with their long edges across the supporting battens. The short edges should be supported along the centre line of a batten. Short edge joints should be staggered and the panel length should be not less than two batten spacings. It is essential that the edges around the perimeter of the floor are continuously supported by battens.

All tongued and grooved joints should be glued with an adhesive conforming to at least durability class D3 of EN 204. Adhesive should be liberally applied to the tongue and to the groove.

Panels should be fixed to battens using mechanical fixings as specified by the manufacturer. When nails or screws are specified, use corrosion resistant fixings. Corrosion resistant materials include brass, galvanised steel, sheradised steel or austenitic stainless steel.

When nailing, flat headed annular grooved or ringshank nails, or other improved nails which have superior holding power should be used. Minimum nail length should be 2.5 times the panel thickness, and minimum diameter 3mm or 0.16 times the thickness whichever is the greater.

Mechanical fixings should be 300mm centres (max) and the minimum edge distance should be 8mm. All nail heads should be punched home by 2-3mm. Screws should be countersunk below the top surface.

Where manufacturer's flooring systems are used, their products (panel and adhesives/fixings etc…) and installation requirements should be followed.

- **Note** *For non-domestic floors, the floating floor will need to be assessed to ensure compliance with the loading and deformation requirements (ultimate limit state and serviceability limit state – Eurocode design) for a given thickness of floating floor overlay and batten spacing.*

7.5 Plasterboard planks

Where a plasterboard plank is employed between the batten and the floating floor wood-based panel overlay, the plasterboard should be laid at 90° to the battens below, the wood based panel overlay should be laid in the same direction but the joints should not coincide with those of the plasterboard planks.

Manufacturer's instructions for the plasterboard plank system being used should be followed for details on fixing and the materials to be employed.

- **Note** *The VCL should be placed below the plasterboard planks and the wood-based panel overlay.*

7.6 Movement gaps

It is essential to allow for possible expansion by providing a gap wherever panels abut any rigid upstand such as a perimeter wall/internal load-bearing walls, column, pipes or fireplace surround. (See clause 6.5).

7.7 Access to pipes and services

Before laying the battens and the floating floor wood-based panel overlay, consideration should be given to the provision of access to pipes and services (see clause 6.6).

7.8 Thresholds

At openings in walls built directly on the concrete substructure a movement gap should be provided. Treated timber battens should be inserted beneath the floating floor wood-based panel overlay at the point of loading in order to counteract localised compression and to provide support beneath the cut edges of the particleboard (see Figure 11).

7.9 Partition Loading

Load-bearing partitions should not be built on top of the floating floor wood-based panel overlay, unless continuously supported from beneath. Non-load-bearing partitions may be built directly on top of the wood-based panel overlay without continuous support, provided it is on top of, and at right angles to the batten support and any resilient material on the battens is designed to withstand the imposed loads. It is essential that care is taken in setting out of partitions in order to ensure that the floor support is in the correct position.

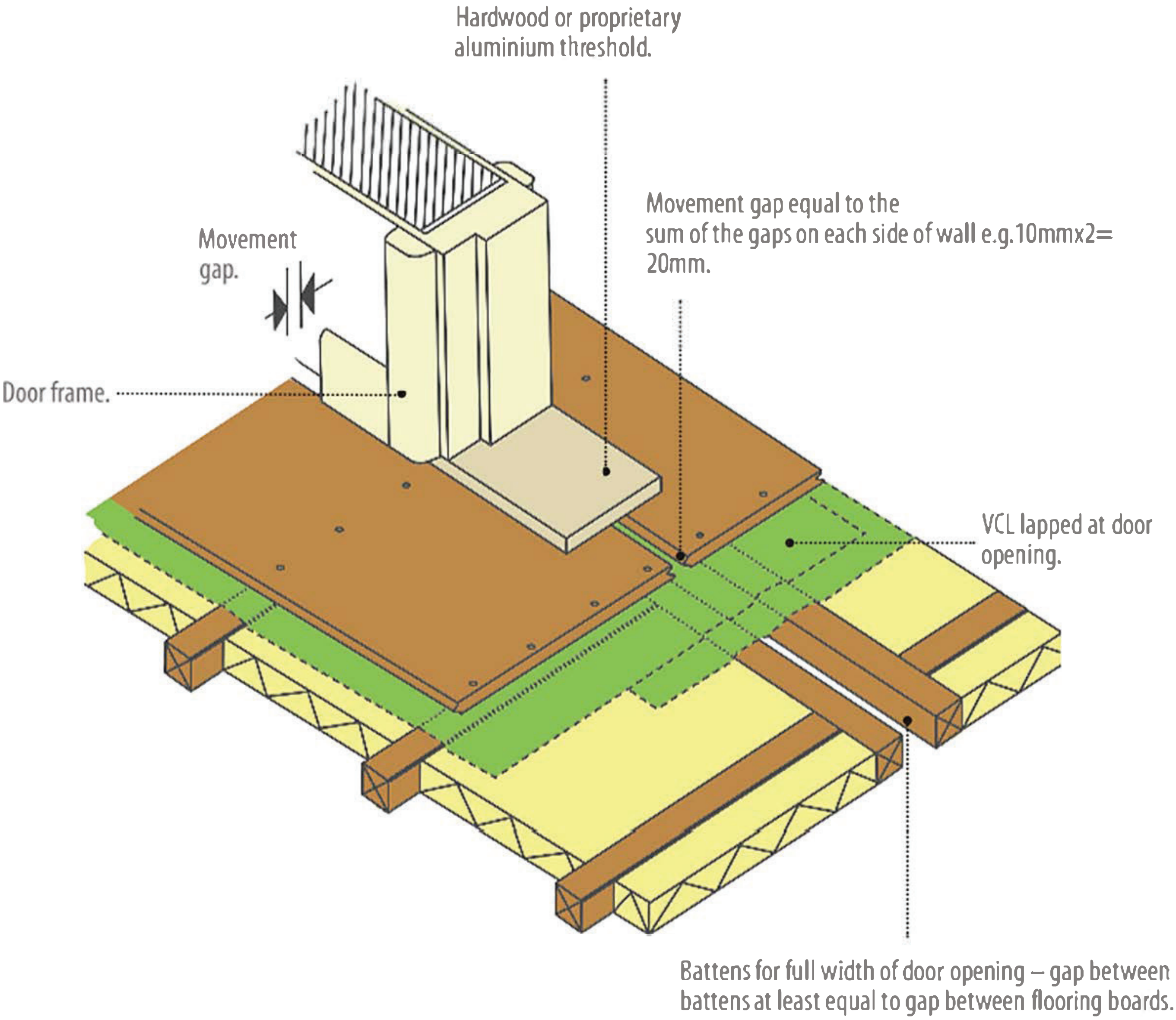

Figure 11: Detail of the threshold of a doorway in a wall which is built off the supporting concrete structure when a battened floor is used.

Section 8: Finishing

8.1 Carpet and sheet flooring

The recommendations given in BS 8203 should be followed. Where carpet is to be laid over the wood panel floating floor and held in place using pre-nailed carpet gripper, adequate edge distance (minimum 25mm from the edge of the panel) should be left for the gripper nails to avoid splitting the panels.

Sheet flooring (resilient or textile flooring) can be loose laid or bonded directly to the panel surface, however BS 8203 (resilient floor covering installation code of practice) recommends that particleboard and OSB should have a 'fabricated underlay' (thin plywood or hardboard specified in BS 8203) laid before laying the floor covering to avoid the panel joints in the particleboard or OSB floating floor beneath the floor covering showing through after trafficking. BS8203 also recommends that uneven timber floors may be sanded or patch filled with suitable proprietary flexible cementitious smoothing underlayment prior to laying the fabricated underlay (the degree of surface regularity needed will be dependent on the thickness and type of floor covering used).

When using a fabricated underlay, large panels should be used and laid at right angles to the particleboard or OSB floating floor surface below. The joints of the floating floor surface and the fabricated underlay should not coincide with each other where possible and all expansion gaps should be the same as the floating floor beneath.

- **Note 1** *It is essential that the fabricated underlay is properly conditioned prior to laying. Conditioning, fixing and specifications for fabricated underlays are given in BS 8203 and/or reference should be made to the resilient or textile floor covering manufacturer's recommendations.*
  Sanding off more than 1mm from a raised joint may weaken the joint.

- **Note 2** *Thin plain coloured vinyl or carpet will tend to show small irregularities in a floor surface, to a greater extent than thicker, patterned or textured finishes.*

- **Note 3** *Where fully bonded floor coverings ride over intermediate movement joints, any resulting movement may cause the covering to stretch or ridge.*

8.2 Ceramic tiling

Tiling onto wood-based panel floating floors is not recommended.

The main issue with ceramic tiling to wood-based panel floating floors is the potential movement, leading to cracking in the tiles or grout. This movement can come from loading (dynamic and static), in particular the dynamic loading when walked upon. Movement due to moisture content changes in the wood can also lead to problems following installation/during use.

Guidance on tiling to fixed timber substrates is given in the Tile Association publications "Internal Ceramic Tiling to Sheet and Board Substrates."

- **Note** *There are proprietary systems or products offered by manufacturers that enable tiling to floating floors using specific materials and preparation with the floors needing to meet strict requirements in order for them to be successful.*

Appendix A Publications referred to in this Code

CP102	Code of Practice for the protection of building against water from the ground.
BS EN 204	Classification of non-structural adhesives for joining of wood and derived timber products.
BS EN 300	Oriented Strand Board (OSB) – Definitions, classification and specifications.
BS EN 309	Wood Particleboards – Definition and classification.
BS EN 312	Particleboards – Specifications Part 5: Requirements for load-bearing boards for use in humid conditions.
BS EN 312	Particleboards – Specifications Part 7: Requirements for heavy duty load-bearing boards for use in humid conditions.
BS EN 1995-1-1:2004 +A2:2014	Eurocode 5: Design of timber structures. General. Common rules and rules for buildings.
BS 3837	Expanded polystyrene boards.
BS 5268	Structural use of timber. Part 5: Code of practice for the preservative treatment of structural timber
BS 6398	Specification for bitumen damp-proof courses for masonry.
BS 6925	Specifications for mastic asphalt for building and civil engineering.
BS 8102	Code of practice for protection of structures against water from the ground.
BS 8201	Code of practice for flooring of timber, timber products and wood-based panel products.
BS 8203	Code of practice for installation of resilient floor coveringspartitions in order to ensure that the floor support is in the correct position.
BS 8204	Screeds, bases and in-situ floorings Part 1: Code of Practice for concrete bases and cement sand levelling screeds to receive floorings.
BS 8215	Code of practice for design and installation of damp-proof courses in masonry construction.

Appendix A Publications referred to in this Code

BS 8417	Preservation of wood. Code of practice.
BS EN 13318:2000	Screed material and floor screeds. Definitions.
EN ISO 13788	Hygrothermal performance of building components and building elements. Internal surface temperature to avoid critical surface humidity and interstitial condensation. Calculation methods.
BS EN 13810	Part 1: Wood-based panels. Floating floors. Performance specifications and requirements.
DD CEN/TS 13810	Part 2: Wood-based panels. Floating floors. Test methods

PanelGuide - Published by the Wood Panel Industries Federation, TRADA Technology Ltd (a BM TRADA company), and the National Panel Products Division (a division of the Timber Trades Federation).

CIBSE Guide A3	Thermal properties of building structures 1980

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Annex 4: Acknowledgements

The PanelGuide Project Partners extend their thanks and appreciation to the following individuals and organisations who have contributed to the production of PanelGuide.

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British Wood Preserving and Damp-proofing Association

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