CI/SfB Xi (A3) (L8)
Uniclass C651 : N34 : P5

Wood Information Sheet WIS 4-28

Subject: Exterior uses
Reviewed: March 2019
with minor corrections

Durability by design

Designers can considerably extend the life of timber components by attention to detail. Achieving 'durability by design' requires the designer to understand the performance requirement for the component.

In order to define performance, designers must:

- identify an appropriate service life for the structure and components, taking into account the acceptable maintenance and possible replacement of parts
- understand the hazards likely to be encountered during the life of the component or structure
- understand the capability of materials exposed to such hazards to meet these expectations.

The performance can then be matched to appropriate specifications and protective design detailing.

This Wood Information Sheet (WIS) focuses on timber's resistance to weathering, adverse atmospheric conditions and fungal and insect attack. Fire also threatens the 'durability' of a structure. WIS 4-11 *Wood-based panel products and timber in fire* [1] deals with specifying for fire resistance.

This WIS is an overview of the subject with signposts to more detailed sources that are listed at the end.

BM TRADA recommends *Eurocode 5* [2] for structural design of timber. However, this WIS includes a summary of variations when using BS 5268-2 *Structural use of timber. Code of practice for permissible stress design, materials and workmanship* [3].

Contents

Figure 1: The Welcome Building, National Arboretum, Westonbirt.
Photo: Paul Miller

Key points

- Following some simple design principles for protecting timber can make a significant difference to the life expectancy of components in use at relatively little additional cost.
- The client should define the design life (and the desired service life) of the building or structure.
- The choice between specifying high-quality, durable components, undertaking scheduled maintenance or replacing accessible components is part of the designer's responsibility in risk assessment and life-cycle costing.
- Because it shrinks or swells in response to changes in its moisture content, it is important that timber is dried to a moisture content appropriate to its intended use before installation. The moisture content also affects timber's mechanical and strength properties.
- Susceptible species of timber may decay as a result of fungal attack if the moisture content is sustained above 20%.
- Timber is resistant to mild acids and mild alkalis, and is more resistant to salt atmosphere and acids than steel.
- Timber exposed to the weather loses colour and becomes grey. In some species the surface fibres may become loose and eventually erode, which could lead to the development of surface checks and splits.

Expected life and component sensitivity

The 'design life' of a building or component is the period of use intended by the designer as stated to the client.

The 'service life' ('working life' in European documents) is the period of time after installation during which a building or its parts meets or exceeds the performance requirements.

The 'predicted service life' is the service life predicted from performance recorded over time, in accordance with BS ISO 15686-2 [4].

The 'reference service life' is the service life of a product, component, assembly or system that is known to be expected under a particular set, that is a reference set, of in-use conditions. It can form the basis for estimating the service life under other in-use conditions.

The 'estimated service life' is the service life that a building or parts of a building would be expected to have in a set of specific in-use conditions, determined from the reference service life data after taking into account any difference from the reference in-use conditions.

BS 7543 *Guide to durability of buildings and building elements, products and components* [5] outlines the principles.

Some components within a building may be considered replaceable. The choice between specifying high quality, durable components, undertaking scheduled maintenance or replacing accessible components is part of the designer's responsibility in risk assessment and life-cycle costing.

The client should communicate the design life requirement to the designer. *Table 1* offers categories for identifying an appropriate design life.

Table 1: Categories of design life
(based on Table 1 in the 2015 edition of BS 7543)

Category description	Life	Typical examples
Short-term	Shorter life than the building and readily replaceable	Door actuators and motors, taps
Replaceable	Shorter life than the building and replacement can be envisaged at design stage	Most floor finishes and services installation components
Maintainable	Lasts, with periodic treatment, for the life of the building	Most external cladding, doors and windows
Lifelong	Lasts for the life of the building	Foundations and main structural elements

The function of a component will determine its service life or design life, that is whether maintenance and/or replacement is a possible option. The component will be subject to different hazards during its life cycle, such as during manufacture, during construction, and in use. The designer and client must consider the cost implications of any agreed service life, balancing initial costs against those of maintenance, removal, replacement and disturbance to other parts of the building. WIS 4-31 *Life-cycle costing* [6] explains the principles.

Table 2 describes the relationship between design life and service life for various types of components.

Table 2: Component function and related sensitivity to design life or service life

Timber component function	Design life and service life
Loadbearing members such as studs, lintels, ground beam, wood piles, joists, rafters, roof trusses	Design life = service life High sensitivity as maintenance or replacement is difficult.
Non-loadbearing external wall components such as external cladding and louvres	Design life = service life + maintenance or replacement Design life typically 30 to 40 years. However, where maintenance is difficult design life = service life.
Non-loadbearing internal walls	Design life = service life High sensitivity related to maintenance or replacement. Design life typically 12 to 18 years for commercial and 30 to 70 years for domestic buildings (obsolescence driven).

(Table 2 continues)

Timber component function	Design life and service life
Roof covering such as timber shingles, boarding	Design life = service life + maintenance or replacement Design life typically 30 to 60 years. Maintenance typically 5- to 10-year cycles.
Finishes such as paints, stains and floor finish	Design life = service life + maintenance or replacement Full maintenance typically 5 to 12 years, depending on quality and exposure.
Removable elements such as windows, doors, cladding panels	Design life = service life + maintenance or replacement Design life ranges from 10 to 60 years, depending on quality and maintenance.

Hazards and material behaviour

Materials differ in their susceptibility to different types of hazard. The properties of timber vary from species to species (and also to a lesser extent within the same species). This section describes the significant hazards for timber.

Weathering

Weathering (external exposure) is a combination of the effects of:

- rain or snow (wetting and drying – see *Moisture*, below)
- freezing and thawing
- ultraviolet light.

Timber exposed to the weather loses colour and becomes grey. In some species the surface fibres may become loose and eventually erode, which could lead to the development of surface checks and splits.

WIS 2/3-60 *Specifying timber exposed to weathering* [7] explains the causes of weathering and its significance to timber performance.

Moisture

After they are felled, trees contain large amounts of water. This evaporates, either naturally by air-drying or assisted by kiln-drying, until the moisture remaining in the timber is in equilibrium with that in the surrounding air. As timber dries below a moisture content of 25%–30% it starts to shrink as moisture is lost from within the structure of the cell walls.

Because timber is a hygroscopic material (it gains or loses moisture in response to the humidity of the surrounding air) it will continue to shrink or swell in response to changes in its moisture content. It is therefore important that timber be dried to a moisture content appropriate to its intended use before installation. If wet timber is used, the design must take into account the shrinkage which will occur as timber dries, especially between components. Conversely, if timber is installed at too low a moisture content it will swell in service.

Shrinkage occurs across the grain of section; longitudinal movement is negligible.

Structural implications

The moisture content of timber also affects its structural properties. Generally, strength and hardness increase as the timber dries. This is reflected in the design strength values. For example, *Eurocode 5* relies on the mechanical and strength properties of timber given in BS EN 338 *Structural timber. Strength classes* [8] that gives characteristic values for timber at or below a moisture content of 20%. *Eurocode 5* gives a factor for deriving the strength for wet exposure conditions.

Variation when using BS 5268

BS 5268-2 gives 'dry' stresses for timber at or below a moisture content of 20% and 'wet' stresses for any moisture content above this level.

Fixings can also be affected by moisture. Most timbers are slightly acidic (pH 3–6). Contact between mild steel and moisture will initiate corrosion of the metal, which in turn can cause some strength loss in the surrounding timber, often indicated by dark staining around the fastener. Some species, such as oak, Western red cedar and Douglas fir, have high tannic acid content. In these species, avoid ferrous fastenings (even if plated because installation can damage the coating) as corrosion will cause iron staining of the wood.

WIS 4-14 *Moisture in timber* [9] provides basic information for the specifier and user on the facts and importance of the moisture content of wood.

Fungal and insect attack

Moisture also has other implications for timber including fungal and insect attack. Susceptible species of timber with a moisture content which is sustained above 20%–22% may decay as a result of fungal attack. Symptoms include loss of strength, softening or disintegration and discolouration.

Damage to timber by insect attack is normally inflicted by the larvae of beetles. The different species of insect are fairly selective about the type of timber they will attack, with some preferring softwoods and others hardwoods, often preferring the sapwood. In general, insects can attack timber at a lower moisture content than that required for fungal growth. However, insect attack is often associated with timber in damp conditions or already affected by fungal decay.

WIS 2/3-32 *Fungi and insect pests in timber* [10] outlines the more important types of fungi and insects which can affect timber.

Table 3 of BS 8417 *Preservation of wood. Code of practice* [11] contains guidance for specifying an appropriate durability class for a particular use class and desired service life.

Physical parameters

Timber is an orthotropic material in that the mechanical properties in each axis – parallel to the grain, perpendicular to the grain, radial or tangential to the growth rings – are all independent characteristics (see *Moisture,* above). In addition, the orientation of the timber section as sawn from the log can affect the shape of the member due to any moisture variation.

The strength properties of timber vary with species but, in general terms, are related to density. Timber, when first loaded, deforms elastically, and, after a period of time, an additional deformation occurs, known as creep. The structural design takes account of creep. In existing timber structures, creep deflections may already have occurred and may be regarded as a characteristic nature of the structure. Creep will increase under fluctuating moisture conditions. Resistance to abrasion and impact is important for items such as flooring, decking and cladding, and it generally relates to the hardness and density of the timber.

BS EN 350 *Durability of wood and wood-based products* [12] gives densities and data on the natural durability of many timber species.

BS 8201 *Code of practice for installation of flooring of wood and wood-based panels* [13] offers guidance on wear resistance and timbers suitable for flooring.

Chemicals and ultraviolet light

Timber is resistant to mild acids and mild alkalis. However, strong acids (pH less than 2) and strong alkalis (pH more than 10) can cause degradation of its chemical structure. Some timbers contain tannin which will exude from the wood as it dries. In external situations, this can stain surrounding components or possibly attack metal components such as flashings, if permanently exposed to a high moisture content. Timber, however, is more resistant to salt atmosphere and acids than steel.

Coatings used to protect the surface of timber from the effects of ultraviolet (UV) light can create their own problems. Dark colours exposed to the sun can create high timber surface temperatures, leading to increased surface fissures and resin exudation from some softwoods. Vapour-resistant coatings such as varnish or oil paint can trap any moisture within the timber component. Therefore, use only flexible vapour-permeable coatings for wood exposed to UV light. Alternatively, specify species that can be left unfinished to weather and bleach naturally.

Specification

Some aspects of specification are fundamental to ensuring adequate performance and fitness for purpose. This section lists the key points to consider when specifying.

Specifying timber species

General information on timber properties is given in:

- WIS 2/3-10 *Timbers – their properties and uses* [14]
- WIS 2/3-28 *Introducing wood* [15]
- various product-specific WISs
- British Standards relating to product specification.

Where there is a risk of fungal or insect attack, specify naturally durable species with sapwood excluded or preservative treatment. Species modified by heat or chemical treatment can also be specified as an alternative. Follow guidance on these aspects in BS 8417, which relates to:

- BS EN 335 *Durability of wood and wood-based products. Use classes: definitions, application to solid wood and wood-based products* [16]
- BS EN 460 *Durability of wood and wood-based products. Natural durability of solid wood. Guide to the durability requirements for wood to be used in hazard classes* [17]
- BS EN 599-1 *Durability of wood and wood-based products. Efficacy of preventive wood preservatives as determined by biological tests. Specification according to use class* [18].

Specify abrasion resistant species for decking, flooring and seating, consider impact resistance where this risk exists and use splinter-free material for handrails.

Where dimensional changes due to moisture variation would be critical, specify species with small movement characteristics. WIS 4-14 lists movement characteristics of common species.

Specifying wood-based panels

This relates not only to the type of panel but also, importantly, to the grade of material appropriate to use. Follow guidance in the following standards:

- *Eurocode 5*
- BS EN 300 *Oriented strand boards (OSB). Definitions, classification and specifications* [19]
- BS EN 312 *Particleboards. Specifications* [20]
- BS EN 335 *Durability of wood and wood-based products. Use classes: definitions, application to solid wood and wood-based products*
- BS EN 622-1 *Fibreboards. Specifications. General requirements* [21]
- BS EN 622-2 *Requirements for hardboards* [22]
- BS EN 622-3 Requirements for medium boards [23]
- BS EN 622-4 *Fibreboards. Specifications. Requirements for softboards* [24]
- BS EN 622-5 *Requirements for dry process boards (MDF)* [25]
- BS EN 634-1 *Cement-bonded particle boards. Specification. General requirements* [26]
- BS EN 636 *Plywood. Specifications* [27].

Specifying moisture content

Follow guidance in:

- WIS 4-14 *Moisture in timber*
- British Standards relating to product specification
- various product-specific WISs.

Specifying other materials

Other materials whose specification may affect the design or service life of timber components include:

- adhesives
- seals
- fixings and hardware
- flashings
- surface coatings
- insulated glazing units.

Principles for protective detailing

Following some simple design principles for protecting timber can make a significant difference to the life expectancy of components in use at relatively little additional cost. In this section, *Tables 3 to 5* summarise the design principles that address the hazards outlined earlier.

Consult the following BM TRADA publications for specific applications:

- *Timber frame construction* [28]
- *Wood windows* [29]
- *External timber cladding* [30]
- *Timber decking manual* [31]
- various product-specific WISs.

Design against weathering

Table 3: Protective design against surface weathering

Principle	Details and examples
Allow natural surface weathering	Select adequately durable timber to BS EN 350 or specify appropriate preservative treatment. Further guidance is given in British Standards, Wood Protection Association publications (at www.wood-protection.org) and BM TRADA publications. Some softwoods may be unsuitable without protective coating because of the extent of degradation due to weathering.
Apply protective coatings	Provide protective treatment to avoid surface degradation, such as pigmented micro-porous exterior wood stain applied to exterior joinery or cladding. WIS 2/3-1 *Finishes for exterior timber* [32], offers advice.
Shelter/ shielding	Provide a physical barrier to ultraviolet light and rain with large overhangs and cappings, louvres, screens, pergolas or trees. If the timber is intended to weather naturally, physical barriers are not appropriate because shading will prevent bleaching and extractives on the surface will not be removed by rain, resulting in a poor appearance. Overhead protection can extend the life of surface coatings.

Design against wetting

Table 4: Protective design against sustained wetting

Principle	Details and examples
Separate from wet materials	Isolate timber from the ground and from moisture-retaining materials or wet surfaces with impermeable damp-proof membrane or, preferably, by providing sufficient air gaps to prevent absorption or capillary action *(Figure 2)*. Ventilate timber that is exposed to moisture. For example, ventilated cavities in external walls *(Figure 3)*. Protect the end grain of timber from wetting and, where there is high risk, protect the end grain with additional coats of sealant. Leave sufficient gaps for access for maintenance, such as repainting.

(Table 4 continues)

Principle	Details and examples
Prevent water traps and capillary paths	Provide sufficient slope to 'horizontal' surfaces to prevent water lying on the surface *(Figures 4 and 5)*. Provide pressure relief grooves to prevent moisture being driven into joints under pressure *(Figure 6)*. Provide drainage to any enclosed positions where moisture can be driven in by wind. Provide drip grooves underneath horizontal surfaces to prevent water running back on the underside. Provide adequate anti-capillary grooves to prevent moisture being drawn back by capillary action between close surfaces. Chamfer the underside of cut ends to ensure moisture does not 'hang' underneath and be drawn up into end grain *(Figure 7)*.
Protection from direct wetting	Use large eaves and verge overhangs *(Figure 8)*. Protect exposed 'horizontal' members with ventilated cappings. In exposed locations, shield sides of building, for example by screens or appropriate planting. Set doors and windows back from outer face of building. Provide wood or metal cappings to exposed end grain, such as posts.
Protection from indirect wetting, such as rainwater splashing	Raise any external timber above splash zone, that is at least 200mm (250mm preferred) from ground or horizontal surfaces such as roofs *(Figure 9)*. Use gravel or drainage channels to reduce water splash below wood cladding or joinery. Ensure that flashings below wood components do not project to the extent that rain will splash back onto surfaces above. If protection is necessary, angle the surface sufficiently to deflect water. Support timber posts or columns on steel brackets out of ground contact and above splash level *(Figure 10)*.
Joint detailing	Design joints for anticipated moisture movement, for example by using slots or oversize holes in connections to accommodate this. In structures designed using 'green' timber, make provision for joints to be tightened as the timber dries. Steel connections are better located in the centre of a section rather than on the outside faces, to reduce effects of any shrinkage. Provide drainage to ensure that junctions between exposed components and connections, such as lattice beams, do not become water traps.

Examples of protective design against wetting

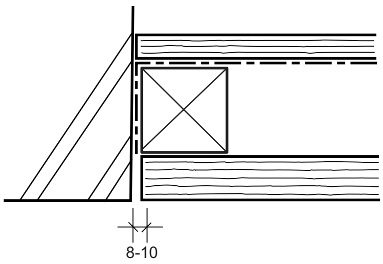

Figure 2: Separation gap between timber and other components.

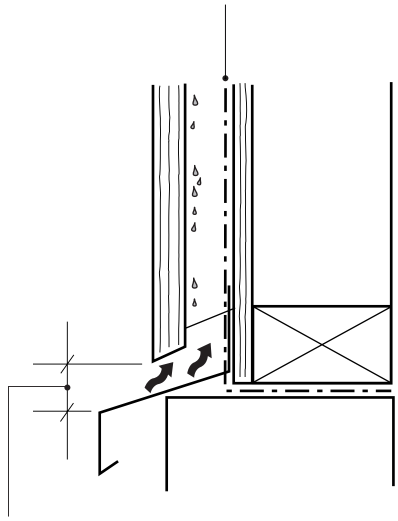

Figure 3: Ventilated cavity behind timber cladding.

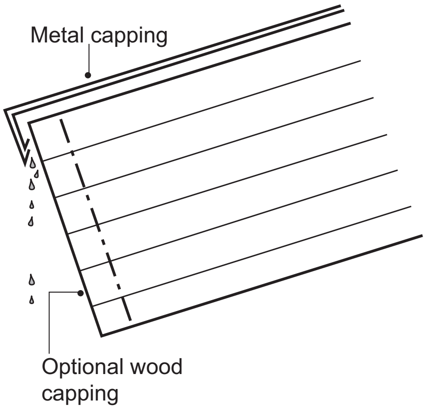

Figure 4: Sloping ventilated capping on an exposed beam.
The upper surfaces of exposed timber or timber composite beams may be protected by preformed metal capping with an airspace between, to provide ventilation and drain away any condensation. Protect the exposed end grain of timbers by sealing or with wood or metal cappings.

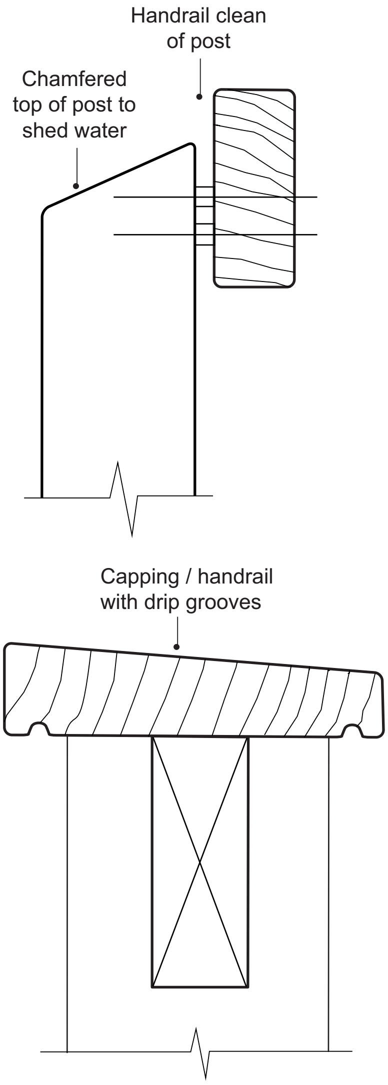

Figure 5: Handrail and post details to protect end grain of timber
Metal or wood capping; minimum of 1:10 slope to shed water.

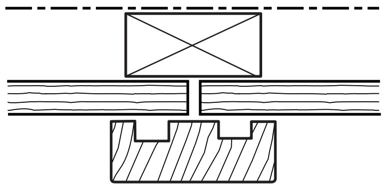

Figure 6: Pressure relief grooves in timber cladding.

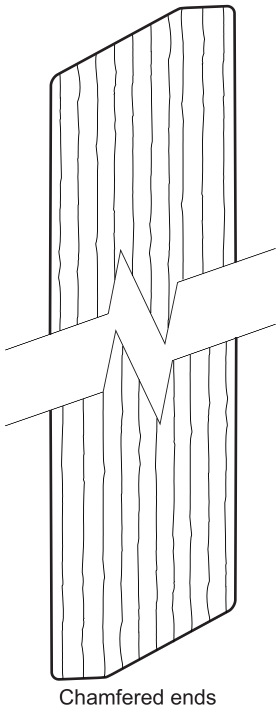

Figure 7: Top and bottom chamfer.

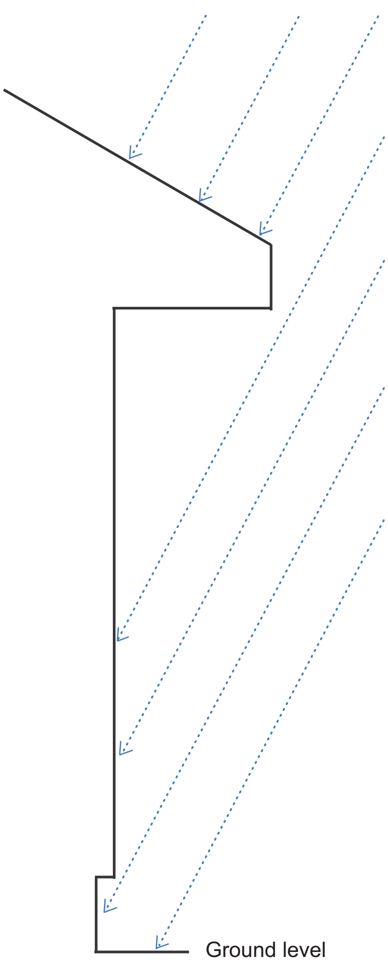

Figure 8: Protection afforded by roof overhangs. Not all wall surface will be protected by overhangs. Avoid projections if cladding is to be left unfinished to bleach.

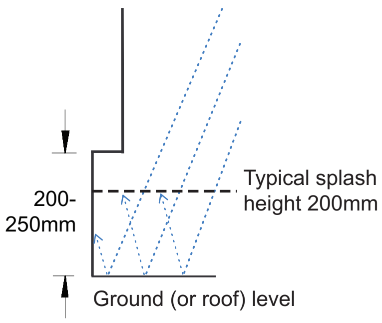

Figure 9: Timber raised above splash zone.

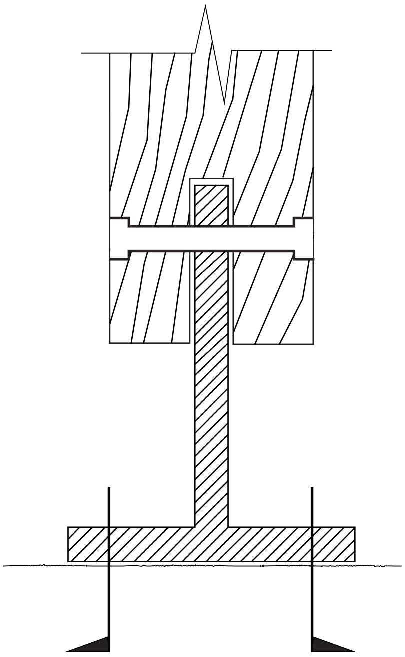

Figure 10: Typical post base to avoid trapped water and splashing.

Examples of protective design against moisture-induced movement

Figures 11, 12 and 13 show examples of design that accommodates inevitable movement.

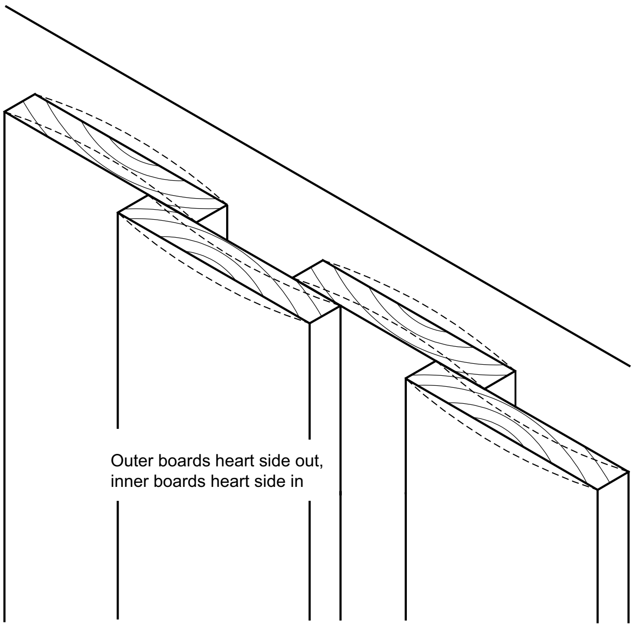

Figure 11: Some movement of wood can be beneficial. When installing board-on-board cladding or roofing, use the natural tendency to bow or cup to improve water shedding.

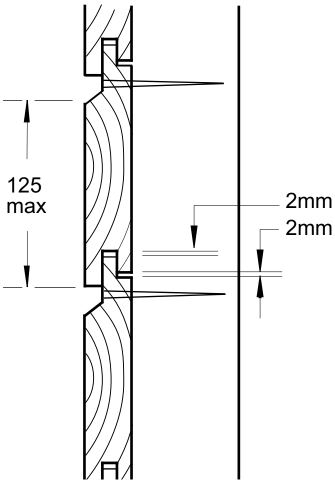

Figure 12: Movement in tongued and grooved cladding boards.
Allow sufficient length of tongue for shrinkage and sufficient gap for expansion to accommodate changes in moisture content. Avoid 'secret' nailing of tongued and grooved boards more than 125mm in width.

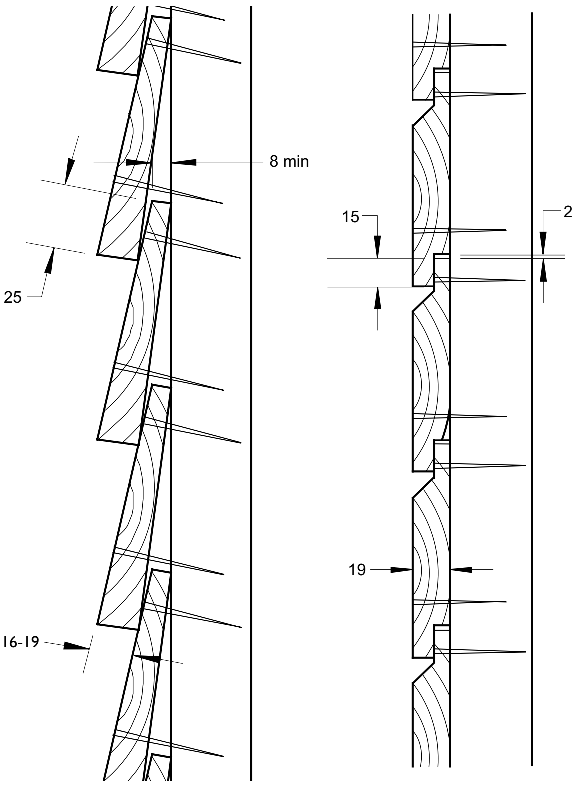

Figure 13: Overlap joints preferred in external cladding.
Overlapped boards, such as feather edge and shiplap, tolerate movement better than tongued and grooved types and provide better protection to the joint in horizontal boarding. Allow sufficient overlap for shrinkage, as well as sufficient gap between boards for swelling.

Design against indirect moisture build-up

Table 5: Protective design against indirect moisture build-up

Principle	Details and examples
Provision of ventilation	Where there is any risk of moisture build-up or condensation in inaccessible locations, provide ventilation in the form of free air movement, for example: • Ventilate and drain cavities behind cladding *(Figure 14).* • Ventilate below ground floors. • Ventilate roof spaces/voids. In cavities, the breather membrane can protect timber-based sheathing or insulation. But if mortar droppings are allowed to build up on cavity ties, the moisture is unable to drain away and will cross the cavity.
Avoidance of interstitial condensation	In the UK the vapour pressure in winter is usually higher inside a building than out, resulting in vapour flow from the inside to the outside. *Figure 15* shows how the correct positioning of a vapour control layer (VCL) behind the plasterboard lining prevents interstitial condensation. Therefore, in walls and roofs, ensure that water vapour diffuses outwards by specifying progressively more permeable barriers to water vapour towards the outside (cold side). Vapour resistance on the inside (warm side) should exceed that on the outside, preferably by a ratio of 5:1. Correct use of vapour control layers and breather membranes can ensure that this 5:1 rule is met. Mastic seals, such as those used around windows, may act as vapour barriers preventing water vapour diffusing to outside. Use a vapour permeable foam strip or cover batten to allow for vapour diffusion as well as providing weather protection. If any vapour resistant material (such as felt, glass, metal and plastics) is used on the 'cold' side of construction, a ventilated cavity between this and the insulated construction on the inside is particularly important. Where components need protection from occasional wetting (such as sheathing or insulation behind a rain screen), ensure that any protective layer has sufficient vapour permeability, for example a breather membrane.

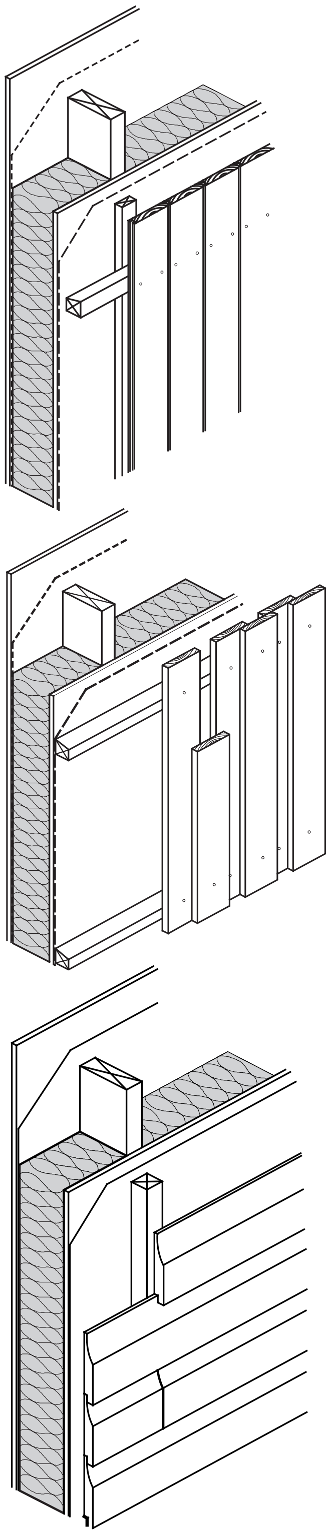

Figure 14: All cavities should be drained and ventilated.
(top) Vertical timber boarding is supported on horizontal battens and requires vertical counter battens to provide a clear ventilation and drainage path.
(middle) Counter battens are not required with most board on board vertical cladding.
(bottom) Horizontal boarding is supported on vertical battens only and the ventilation path is therefore unrestricted.

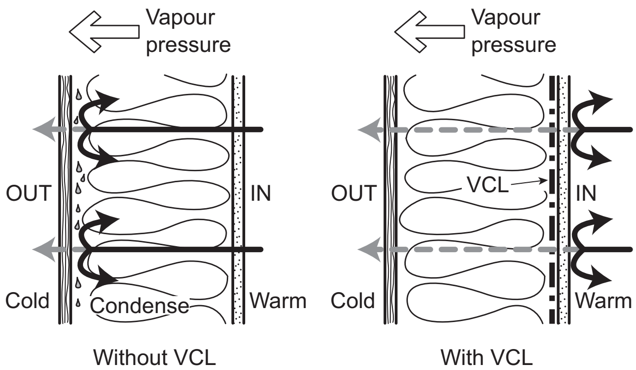

Figure 15: Vapour control layer prevents interstitial condensation. In the left detail, condensation forms within the external wall as moisture encounters the cold outside face. In the right detail, the VCL inhibits the passage of warm vapour into the wall.

Conflicts with fire resistance

Where barriers are needed to limit the transmission of fire via cavities, details should reflect the need to maintain ventilation as well as fire resistance. Proprietary solutions may be effective.

Treatment for preservation and spread of flame (combustibility) may not be compatible. Consult manufacturers before specifying treatments.

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About BM TRADA

BM TRADA, part of the Element Group, specialises in providing a comprehensive range of independent testing, inspection, certification, technical and training services. We help organisations to demonstrate their business and product credentials and to improve performance and compliance. We exist to help our customers make certain that the management systems, supply chain and product certification schemes they operate are compliant and fit for purpose.

Specific services that we sell for the timber and building industries include:

- Design reviews
- Product testing and certification
- Management systems certification, including timber chain of custody
- Site surveys and inspections
- Expert witness

To find out more, please contact our technical advice line on:

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