Timber windows and doors

Technical Desktop Guide

Window

A window is an opening in the wall or surface of a building that allows the passage of light and, if not closed or sealed, air and sound. Windows are usually glazed or have inserts of other transparent or translucent material. A window is also the frame, sashes, and panes of glass intended to fit such an opening.

Windows are used to control the physical atmosphere within a space admitting light and ventilation and excluding wind, rain and drafts. They act as a barrier to noise. Windows also have an aesthetic role in creating an impression of what lies beyond the room or space, establishing a connection between the internal and external.

Door

A door is a movable barrier, either solid or glazed, used in an opening or entranceway in walls or partitions of a building and in furniture such as cabinets. When open, they permit access and admit ventilation and light. A door can be opened and closed more or less securely using a combination of latches and locks. Doors act as a barrier to noise and a filter to sound. Doors are also used to screen areas of a building for aesthetic purposes, keeping different areas separate, while creating an impression of what may lie beyond.

Window and door components

A window or door is a combination of two primary elements: the frame with a sash or sashes for windows, and the frame with a leaf or leaves for doors. The frame is the assembled timber components that enclose and support the sashes or leaves, and are fixed to the surrounding building envelope. The frame consists of:

- the ‘head’, the top horizontal component,
- the ‘sill’, the bottom horizontal component,
- ‘jambs’, the vertical side components, and
- ‘mullions’ and ‘transoms’, the intermediate vertical and horizontal elements.

Windows sashes or door leaves are the generally movable components of the unit supported by the frame consisting of:

- ‘stiles’, the vertical edge pieces;
- ‘rails’, the horizontal members of a sash, door, screen or other assembly. Depending on their location, they may be called top, bottom or chair rails, and
- ‘mullions’, the intermediate elements in the sash or leaf.

While the sashes or leaves can be solid and opaque, glass or other transparent or translucent material is often set into them to provide light and a view outside.

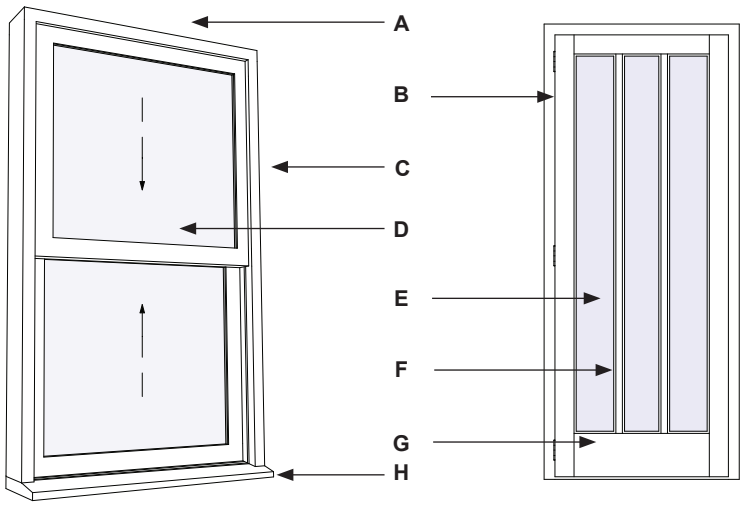
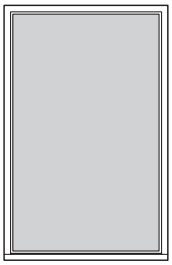


Figure 1. Unit components
(A) head, (B) stile, (C) jamb, (D) sash, (E) leaf, (F) mullion, (G) rail, (H) sill

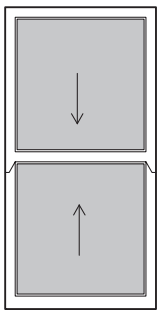
Window configuration

Fixed glass or light	A fixed pane of glass held in a wood frame. The glass can be set directly onto a rebate or stop on the window frame, or set into a fixed sash (fixed light), and fixed in the frame.



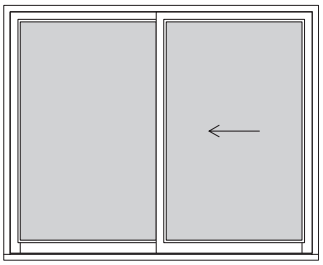
- ☑ Provides light and view
- ☑ Economic
- ☑ Weather proof
- ☑ Air tight
- ☑ Secure
- ☑ Suitable for high wind areas.
- ☒ Easy to operate
- ☒ Easy to clean
- ☒ Good ventilation

Double hung window	Two sashes set to slide past each other vertically within the frame. The weight of a individual sash is held by mechanical balances or counterweights on each side. The unit can also be arranged so that one sash moves over a fixed sash or glass.



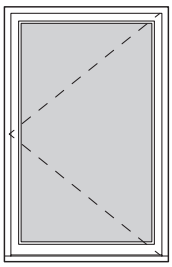
- ☑ Provides light and view
- ☑ Economic with conventional mechanical balances
- ☑ Easy to operate
- ☑ Good ventilation
- ☑ Weather proof
- ☑ Secure
- ☒ Economic with traditional weights
- ☒ Easy to clean
- ☒ Air tight
- ☒ Suitable for high wind areas.

Sliding windows	Two or more sashes set to slide past each other horizontally within the frame. Several sashes can also slide past each other to stack to one side of the opening. To shed water efficiently, the openings sashes should slide outside the fixed sashes.



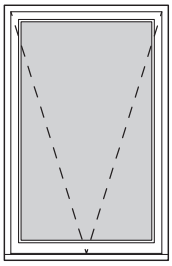
- ☑ Provides light and view
- ☑ Economic
- ☑ Easy to operate
- ☑ Good ventilation
- ☑ Weather proof
- ☑ Secure
- ☒ Easy to clean
- ☒ Air tight
- ☒ Suitable for high wind areas.

Casement window	A sash hung to open from one side, usually with hinges along the vertical edge of the frame, or friction stays on the top and bottom of the sash. The sash generally opens out, but can open in. If opening out, screens and security can only be fitted internally.



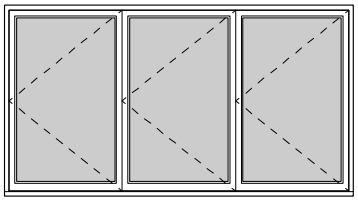
- ☑ Provides light and view
- ☑ Economic
- ☑ Easy to operate
- ☑ Easy to clean
- ☑ Good ventilation
- ☑ Weather proof
- ☑ Air tight
- ☑ Secure
- ☑ Suitable for high wind areas.

Awning windows	A sash hung to open out from the bottom, usually with hinges along the top edge of the frame or friction stays along the sides of the sash. Some stays allow complete reversal of the window. Screening and security can only be fitted internally. Awnings hung to open out from the top are called hopper windows.



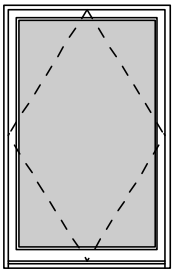
- ☑ Provides light and view
- ☑ Economic
- ☑ Easy to operate
- ☑ Easy to clean
- ☑ Good ventilation
- ☑ Weather proof
- ☑ Air tight
- ☑ Secure
- ☑ Suitable for high wind areas.

Bi-fold windows	Two or more window sashes alternately hinged so they fold against each other to the sides of the opening, providing a full and unobscured opening. Bi-folds can be supported on an overhead track or, if there are only two sashes per side, hung without a track.



- ☑ Provides light and view
- ☑ Good ventilation
- ☑ Weather proof
- ☑ Secure
- ☒ Economic
- ☒ Easy to operate
- ☒ Easy to clean
- ☒ Air tight
- ☒ Suitable for high wind areas.

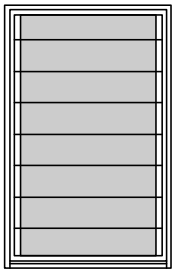
Pivot windows	A sash that rotates on pivot hinges in either the horizontal or vertical plane. The pivot line can be central to the sash or off-set.



- ☒ Economic
- ☒ Weather proof
- ☒ Air tight
- ☒ Suitable for high wind areas.

- ☒ Economic
- ☒ Weather proof
- ☒ Air tight
- ☒ Suitable for high wind areas.

Louvre windows	Sets of glass, timber or aluminium blades arranged horizontally across the frame. Fixed louvres can be rebated at each end into the frame. Moveable louvres fit into mechanical louvre galleries. With moveable louvres, the blades' angle of inclination is adjustable to allow more or less light or air into the enclosure.

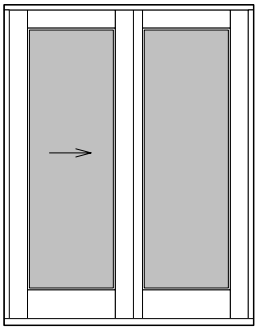


- ☑ Provides light and view
- ☑ Economic
- ☑ Easy to operate
- ☑ Easy to clean
- ☑ Good ventilation
- ☑ Weather proof

- ☒ Weather proof
- ☒ Air tight
- ☒ Secure
- ☒ Suitable for high wind areas.

Door configuration

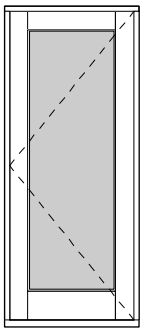
Sliding doors	Two or more leaves set to slide past each other horizontally within the frame. Several leaves can also slide past each other to stack to one, or both sides of the opening. They are suitable for large openings but the sliding leaves have to be stacked in the door frame, reducing the overall opening size.



- ☑ Provides light and view
- ☑ Economic
- ☑ Easy to operate
- ☑ Easy to clean
- ☑ Good ventilation
- ☑ Weather proof
- ☑ Air tight
- ☑ Secure

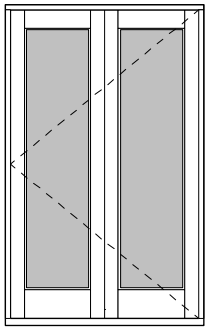
- ☒ Suitable for high wind areas.

Hinged doors	A door leaf hung along a vertical edge of a frame with hinges and opening inwards or outwards. Pairs of doors hung on either side of the frame and meeting with a rebated central join are called French doors.



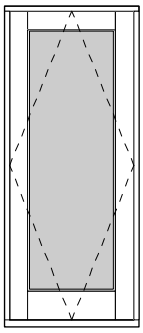
- ☑ Provides light and view
- ☑ Economic
- ☑ Easy to operate
- ☑ Easy to clean
- ☑ Good ventilation
- ☑ Weather proof
- ☑ Air tight
- ☑ Secure
- ☑ Suitable for high wind areas.

Bi-fold doors	A series of doors, alternately hinged so they fold against each other on one or both sides of the opening, providing a full and unobscured opening. Bi-folds can be supported on an overhead track or, if there are only two doors per side, hung without a track.



- ☑ Provides light and view
- ☑ Easy to clean
- ☑ Good ventilation
- ☑ Weather proof
- ☑ Secure
- ☒ Economic
- ☒ Easy to operate
- ☒ Air tight
- ☒ Secure

Pivot doors	Pivot doors rotate in the vertical plane on hinges at the top and bottom. They can pivot in either one direction or in both directions, giving a wide, generous opening.



- ☑ Provides light and view
- ☑ Easy to operate
- ☑ Easy to clean
- ☑ Good ventilation
- ☑ Secure
- ☒ Economic
- ☒ Weather proof
- ☒ Air tight
- ☒ Suitable for high wind areas.

Configuration and performance

The performance of windows and doors varies with the configuration of the unit and its construction quality. While it is not possible to compare the effects of construction quality, it is possible to compare the general performance of windows and doors of different configuration.

Ventilation

The door and window configuration affects the degree to which the unit opens and the potential ventilation provided. In practice, the level of ventilation safely available from hinged units, such as casement and awning windows is highly dependant on the hardware: the stays, winders or hooks. The potential ventilation provided by type is listed in Table 1.

Table 1. Ventilation potential for windows

	VENTILATION POTENTIAL*	NOTES
WINDOW TYPE		
Fixed Glass or light	0 %	
Double Hung Windows	~ 45 %	The opening is easily variable. Ventilation is available at both the top and bottom of the opening.
Sliding Windows	~ 45 %	The opening is easily variable. Ventilation is available at one side of the opening only.
Casement Windows	~ 95 %	The opening is variable. Hardware selection affects the extent and safety. Hinged units can be opened to their full size but this is restricted practically by the capacity of winders and other hardware.
Awning Windows	~ 95 %	The opening is variable. Hardware selection affects the extent and safety. Frictions stays can allow full opening. Hinged units can be opened to their full size but this is restricted practically by the capacity of winders and other hardware.
Bi-folding Windows	~ 95 %	The opening is variable but requires the operation of bolts for each unit opened.
DOOR TYPE		
Sliding Doors	~ 45 %	The opening is easily variable. Ventilation is available at one side only.
Hinged Doors	~ 95 %	The opening is variable but is generally restricted to being latched fully open.
Bi-fold Doors	~ 95 %	The opening is variable but requires the operation of bolts for each unit opened.
Pivot doors rotate	~ 95 %	Hardware selection affects the extent and safety. Location control pivot hinges or floor bolts are required if the door is left open.

*Approximate figure based on the percentage of sash or leaf area

Infiltration rates

As shown in Table 2, different types of windows and doors tend to have different infiltration rate. Hinged units, such as casement, awning and hopper windows, are efficient as they close by pulling the sash against a rebate and any seals in the frame. The performance of units that slide, such as double hung and sliding windows, is not as good as hinged units. It is difficult to seal around the unit as the sashes needs space around them to slide freely.

Table 2. Comparative infiltration rates

WINDOW TYPE	COMPARATIVE AIR INFILTRATION LEVELS (l/s m2)
Timber: Casement	1.01
Timber: Awning	1.74
Timber: Double Hung	2.42
Timber: Sliding	3.33

Results are averages of 2009 WERS test results for single and double glazed units of each product type from up to 6 companies.

Screens

Windows and doors only provide ventilation when they are open, but when open, the privacy, security or protection they normally provide is compromised or lost. To maintain security and privacy, windows and doors can be fitted with security screens or shutters. Not all types of windows and doors can be screened easily. Table 3 list the potential location of screens.

Table 3. Potential location for screens

SCREEN LOCATIONS	WINDOW AND DOOR TYPE
Outside screens	WINDOWS: fixed glass or light, double hung, inward opening casement, sliding DOORS: inward opening hinged, sliding
Inside screens only	WINDOWS: outward opening casement, awning and hopper DOORS: outward opening hinged
Difficult to screen	WINDOWS: bi-fold, pivot DOORS: bi-fold, pivot

Timber for windows and doors

Timber is an ideal material for manufacturing windows and doors. It is a light, strong, natural and renewable material that can be moulded to almost any shape. Timber is a natural material and the character of the wood changes with the species of the tree, the tree's age and condition, and the location of the wood in the trunk.

The frames, sashes and leaves of timber windows and door can be made from solid timber, laminated timber, and other materials. Solid timber elements are available in a wide range of species and sizes. A unit can be made from a single species or combinations of different timber species can be selected to maximise utility and economy: sills of a durable species, the remainder of the frame in a more economical timber and sashes or leaves from a light and highly stable species.

Glue laminated timber is pieces of timber assembled with an adhesive to create a large section. They range from single elements of solid timber glued together to large section glue-laminated elements of finger-jointed material. Glue lamination uses high quality sections of timber efficiently and glue laminated material is often stronger and has more consistent properties than solid timber.

Composite elements have timber section faced with a metal profile. This can be simple aluminium or stainless steel sections or specialist extrusions produced to integrate the timber and aluminium materials as effectively as possible. In both cases, the metal sections are incorporated to reduce maintenance. The size of timber and aluminium composites is restricted by the size of available aluminium extrusions.

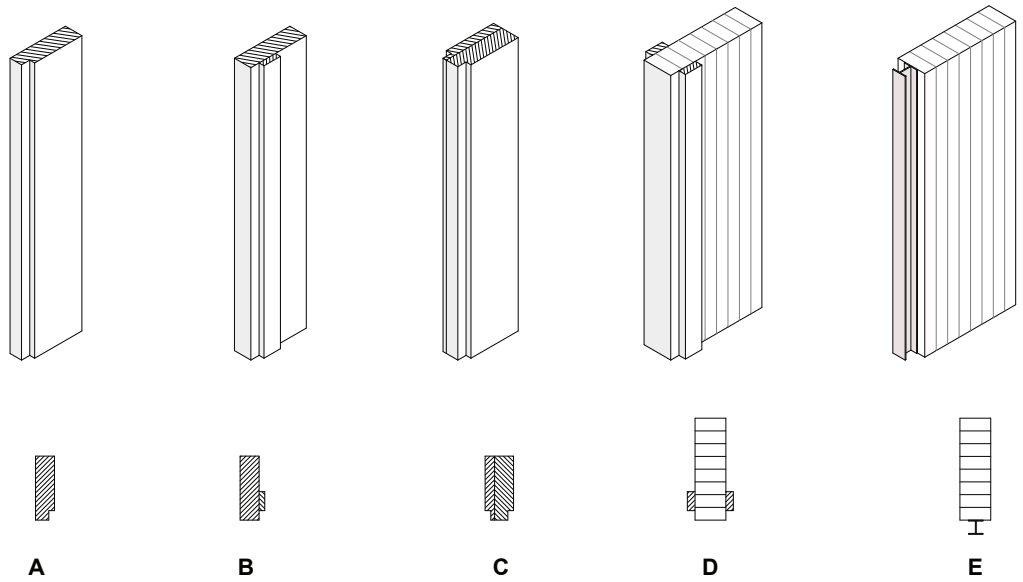


Figure 2. Timber frame arrangements
(A) rebated solid timber, (B) solid timber with a stop, (C) rebated laminated timber, (D) glue laminated timber with stop, (E) glue laminated timber with an extruded glazing section

Timber quality and properties

Only some species and some timber of those species match the performance requirement of windows and doors, primarily durability, stability and appearance. Window and door joinery generally requires straight grain timber that is seasoned to a consistent moisture content and stable throughout. If the joinery is to be part of the external envelope, the timber should also be relatively durable or be treated to be durable. Solid section timber of this type generally comes from relatively large logs of relatively slowly grown trees. Timber from smaller logs of more quickly grown trees tends to be less stable and more variable. It may also be less durable. Laminated sections of timber can be suitable for joinery if the sections are stable and the timber is naturally durable, treated to be durable or used internally.

Timber distortion

AS 2047 – 1999 Windows in buildings - Selection and installation, applies constraints on the bow, spring and twist of particular elements for windows. The allowable limits are:

Table 4. Allowable bow, spring and twist in timber for windows

	HEAD, JAMB, MULLION AND TRANSOM					SASH	SILL			
LENGTH	BOW		SPRING	TWIST		ALL	BOW	SPRING	TWIST	
Board width	t=<2/3w	t>2/3w		100	150				100	150
1.2	2	1	2	1	1	0	2	2	1	1
1.8	3	2	3	1	1	0	6	3	2	2
2.7	6	3	6	1	2	0	13	6	2	3
3.6	11	6	11	2	2	0	22	11	3	4

Feature and colour

Timber is a natural material that contains features reflecting the life of the tree before it was harvested. Some features, such as hob-nail or tight gum vein have little or no affect on the performance of the wood and should be included. Some reduce durability or increase instability and should be excluded. This includes large or loose knots and major gum vein or voids.

Natural timber always has some colour variation between or within an individual piece and unreasonable expectation of colour can lead to irresponsible waste. The colour variation in timber can be moderated by: grouping timber of similar colour together before assembly; using grain fillers, selected to match the timber and the intended finish; or staining, either before the timber is finished, or as part of the finishing process.

Species performance

The main properties of major Australian and imported species are listed below.

Table 5. Properties of major Australian timbers

NAME	ORIGIN	COLOUR	SUPPLY	FOREST CERTIFICATION	DURABILITY (out of ground contact)	DENSITY (Kg/m³)	HARDNESS (kN Janka)	WORKABILITY
Blackbutt	NSW & SE Qld	Yellow to brown	Readily available	Available	1	930	8.9 - Hard	Good
Hoop pine	NSW & Qld	Pale cream to yellow	Readily available	Available	4	550	3.4 - Soft	Very good
Jarrah	WA	Dark red	Available	Available	2	835	8.5 - Hard	Good
Karri	WA	Pink to reddish brown	Limited availability	Available	2	900	9 - Hard	Moderate
Radiata pine	All states	Shades of yellow to brown	Readily available	Available	4	~ 500	3.3 - Soft	Good
Silvertop ash	Tas, Vic, NSW	Pale to dark brown.	Limited availability	Available	2	820	9.5 - Hard	Moderate
Spotted gum	Tas, Vic, NSW	Pale to dark brown.	Readily available	Available	1	~ 950	10.1 - Very hard	Good
Tallowwood	NSW & Qld	Pale to dark yellow brown	Limited availability	Available	1	1010	4.5 - 8.0 - Medium	Good
Tasmanian oak	Tas	Straw to pale reddish brown	Readily available	Available	3	530 - 800	4.5 - 8.0 - Medium	Very good
Victorian ash	Vic	Straw to pale reddish brown	Readily available	Available	3	530	4.50 - Medium	Very good

Table 6. Properties of major imported timbers								
NAME	ORIGIN	COLOUR	SUPPLY	FOREST CERTIFICATION	DURABILITY (out of ground contact)	DENSITY (Kg/m³)	HARDNESS (kN Janka)	WORKABILITY
Amoora	SE Asia	Red brown	Available	Occasionally available	4	550	3.8 - Firm	Good
Douglas fir / Oregon	USA / Canada	Yellowish to orange	Readily available	Occasionally available	4	560 – 480	3 - 3.4 - Firm	Good
Hemlock	Canada / USA	Straw to pale brown	Available	Available	4	500	2.7 to 3 - Soft	Good
Kapur	SE Asia	Red brown	Available	Unknown	2	750	5.4 - Moderate	Good
Kwila / Merbau	SE Asia	Yellow brown to orange brown	Readily available	Occasionally available	1	830	8.6 - Hard	Moderate
Meranti	SE Asia & Pacific	Pale to dark red / straw to yellow	Readily available	Occasionally available	Generally 3 – 4	523 - 900	Varied	Good
New Guinea rosewood	Pacific	Golden brown or a dark blood-red	Available	Occasionally available	2	650	4.7- Moderate	Very good
Silky oak, southern		Pinkish brown	Limited availability	Occasionally available		620	3.7	
Surian	SE Asia & Pacific	Light red to red brown	Readily available	Occasionally available	1	480	Very soft	Very good
Western red cedar	Canada / USA	Pale to dark brown	Readily available	Available	2	380	1.5 - Very soft	Very good
White oak, American	USA / Canada	Light to mid dark brown	Available	Available	4	750	6 - Medium	Very good
Yellow cedar	Canada / USA	Pale yellow to cream	Available	Available	1	500	2.6 - Soft	Very good

Table 7. Description of timber characteristics	
TERM	DESCRIPTION
Name	Common species name
Origin	The region that is the general sources of the timber
Colour	The colour of the majority of the heartwood of the timber. The sapwood may be paler.
Supply	A general indication of supply levels for the species.
Forest Certification	A general indication of supply levels for the species.
Durability	Durability class outside above ground to *AS 5604*.
Density	kg/m3 of wood seasoned to a moisture content of 12%.
Hardness	Janka hardness to *Australian Standard/NZ 1080 Methods of testing timber.*
Workability	The stability and general machining characteristics

Standard timber sizes and configurations

Timber is milled from logs into rectangular sections that can be dressed into a finished size or moulded into the desired shape. The actual sizes of timber available for joinery vary with the stage of production and the timber's country of origin.

While timber may be referred to as a particular size (or nominal dimension), the piece is generally not exactly that size. The sawn dimension of timber is the size the board is cut to allow it to shrink during production to the nominal dimension. As shrinkage is not always uniform, the board after drying is often marginally larger than the nominal dimension. The machined dimension is the measured size of a piece of timber, once it has been milled to a dressed size.

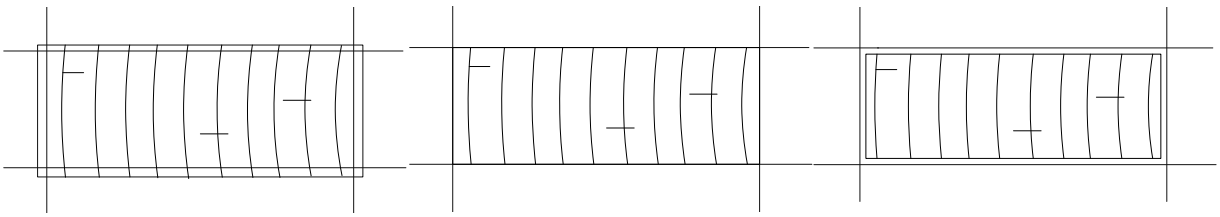


Figure 3: Timber sizing: sawn, nominal, and machined

Generally, the practical maximum size of sawn and milled sections is approximately 300 mm wide, 50 mm thick and 4.8 m long. Using large section sawn timber requires caution. High quality pieces of large section timber are difficult to obtain and larger pieces tend to distort. Smaller pieces can be glue laminated into stable large section timber and these are available in widths to 1.8 m, thicknesses to 0.6 m and lengths to 12 m and beyond.

Standard sizes for Australian produced sawn timber

Timber in Australian is generally milled to metric sizes with nominal thicknesses of 25 mm, 38 mm and 50 mm and nominal widths from 50 mm to 300 mm, generally in increments of 25 mm. Sawn hardwood over 50 mm thick is only sold unseasoned and is unsuitable for window and door construction. Thicker sections of dry Australian hardwoods are glue laminated. The maximum milled component size available from a given nominal thickness and width is shown in the Tables below. Note that the wider the board, the more material may need to be milled off to consistently produce the final machined dimension.

Table 8. Maximum size of timber milled from nominal 38 mm thick Australian timber	
NOMINAL THICKNESS	DRESSED
38 mm	31 mm, 32 mm, 33 mm
RANGE OF NOMINAL WIDTH	MAXIMUM COMPONENT SIZE
75 mm	65 mm x 32 mm
125 mm	115 mm x 32 mm
150 mm	135 mm, 136 mm x 31 mm

Table 9. Maximum size of timber milled from nominal 50 mm thick Australian timber	
NOMINAL THICKNESS	DRESSED
50 mm	40 mm, 41 mm, 42 mm
RANGE OF NOMINAL WIDTH	MAXIMUM COMPONENT SIZE
100 mm	85 mm x 42 mm
150 mm	135mm, 136 mm x 41 mm
175 mm	165 mm x 40 mm

Standard sizes for North American produced timber.

Timber imported from North American is generally milled to Imperial sizes. The maximum milled component size available from a given nominal thickness and width is shown in the table below

Table 10. Maximum size of timber milled from standard North American timber sizes	
NOMINAL THICKNESS (mm)	MAX. COMPONENT THICKNESS (mm)
45 mm (1 3/4 ”)	38 mm
50 mm (2 ”)	42 mm
65 mm (2/5 “)	54 mm
75 mm (3 ”)	65 mm
NOMINAL WIDTH	MAXIMUM COMPONENT SIZE
63 mm (2 1/2 “)	54 mm
75 mm (3 “)	65 mm
100 mm (4 ”)	90 mm
125 mm (5 “)	110 mm
150 mm (6 “)	140 mm
200 mm (8 “)	190 mm

Standard size for Australian produced glue laminated timber.

Glue laminated timber is made up of multiple layers of boards milled to exact tolerances. While sizes vary between producers and species, common dressed beam sizes of material are included in the tables below.

Table 11. Common glue laminated beam radiata pine sizes	
WIDTH	DEPTH
65 mm	130, 165, 195, 230, 260, 295, 330, 360, 395, 425 mm
85 mm	130, 165, 195, 230, 260, 295, 330, 360, 396, 425, 460+ mm
135 mm	130, 165, 195, 230, 20, 295, 330, 360, 396, 425, 460+ mm

Table 12. Common glue laminated beam hardwood sizes	
WIDTH	DEPTH
45 mm	120, 140, 170, 190, 222, 240, 290 mm
65 mm	120, 155, 185, 215, 245, 270, 300, 330, 360, 390, 420, 450, 480 mm
85 mm	120, 155, 185, 215, 245, 270, 300, 330, 360, 390, 420, 450, 480+ mm
135 mm	120, 155, 185, 215, 245, 270, 300, 330, 360, 390, 420, 450, 480+ mm

Sizes will vary with product and process type.

Durability of the timber frame

The durability of the timber frame is affected by the hazard presented by the surrounding environment, the resistance of the timber to decay and weathering, the arrangement of species, the quality of assembly and any coating or treatment on the timber.

Hazard classes and natural life expectancy

AS 1604 -1997 - Timber - Preservative-treated - Sawn and round classifies the hazard for timber in window and door as Hazard Class H3 for units exposed outside above ground; and Hazard Class H1 for units exposed inside, fully protected from the weather and termites.

The timber can resist these hazards naturally or with the help of preservative chemical treatments.

The natural durability of a piece of timber, its resistance to decay, is generally a characteristic of the species. Timber species are rated in one of four durability classes in ***Australian Standard 5604-2005 - Timber – Natural durability ratings***, based on years of comparative tests. Two ratings are available for the heartwood of most species: d***urability in-ground contact*** and durability ***exposed out-of-ground contact***. These rating only refer to the performance of heartwood, with any sapwood either excluded or treated. The sapwood from all species is rated as Durability Class 4.Preservative treatment to increase life expectancy

Table 13. Timber durability life expectancy

	PROBABLE HEARTWOOD LIFE EXPECTANCY (YEARS)	
NATURAL DURABILITY CLASS	HAZARD CLASS 1	HAZARD CLASS 3
	Fully protected from the weather and termites	Above ground exposed to the weather but protected from termites
Class 1 (HIghly durable)	50 +	40 +
Class 2 (Durable)	50 +	15 to 40
Class 3 (Moderately durable)	50 +	7 to 15
Class 4 (Non-durable)	50 +	0 to 7

Timber's natural durability can be enhanced by adding preservative chemicals to the wood. ***AS 1604 - 2005*** specifies the requirements for preservative treatment including the penetration and retention of chemicals in the timber. Treatment options are generally targeted at achieving resistance in particular Hazard Classes. For example, low durability timber can be treated to H3.

The main types of preservative treatments for joinery timber in Australia are combination of insecticides and fungicides applied by dip diffusion or by commercial pressure treatment. They are

- Water borne preservatives applied to unseasoned timber, generally boron-based mixtures
- Light organic solvent-borne preservatives (LOSP) applied to seasoned timber and finished product. Current commercial treatments include azole or tri-butyl tin combined with a pyrethroid.

Not all timber can be successfully treated to the level required by *AS 1604*. Generally, the sapwood of all species can be treated to H3 but the heartwood of most species resists consistent treatment. These pieces only receive a surface coating While water-borne boron treatment is applied to unseasoned timber, envelope LOSP treatment is applied to milled material ready for assembly. If cut, the exposed ends should be dipped in preservative to maintain the envelope protection.

AS 2047 – 1999 Windows in buildings - Selection and installation, requires that timber windows be constructed of either:

- Durability Class 1 or 2 timber,
- Timber treated in accordance with AS 1604 - 1997 - Timber - Preservative-treated - Sawn and round, or
- Of any durability class provided that it is protected by ingress of moisture by appropriate joint details, and either the application of a protective coating or installation under a protective shelter, such as a verandah.

Table 14 lists the preferred species arrangement for commercial and high exposure residential projects.

Table 14. Preferred species arrangement for commercial and Exposure Zone D residential projects				
ELEMENT	RELATIVE EXPOSURE	BUILDING EXPOSURE	FINISH	TIMBER**
Sill	High	Normal	Painted or stained	Durability Class 1 or 2 timber
Sill	High	Normal	Painted	Durability Class 1 or 2 timber or commercially treated LOSP (azole) hardwood
Frame (excluding the sill)	Medium	Normal	Painted or stained	Durability Class 1 or 2 timber, or commercially treated LOSP (azole) hardwoods, or VPI boron treated hardwoods
Frame (excluding the sill)	Medium	Normal	Painted	Durability Class 1 or 2 timber, or commercially treated LOSP (azole) hardwoods, or VPI boron treated hardwoods, or H3 treated softwood
Sash or door*	Medium	Sheltered	Unfinished	Durability Class 1 or 2 timber
Sash or door*	Medium	Normal	Painted or stained	Durability Class 1 or 2 timber, or commercially treated LOSP (azole) hardwoods, or VPI boron treated hardwoods, or H3 treated softwood
Sash or door*	Medium	Normal	Painted	Durability Class 1,2 or 3 timber, or H3 treated softwood

* Timber for sashes and doors have specific stability requirements that need to be met.

** If any treatment timber is cut, the end-grain needs to be re-treated to maintain the treatment envelope.

Compliance with standards and codes

Standards and codes establish specific requirement for windows and doors in buildings. The major standards are:

- AS 2047-1999 Windows in buildings - Selection and installation
- AS 1288-2006 Glass in buildings - Selection and installation
- AS 3959-2009 Construction of buildings in bushfire-prone areas.
- The Building Code of Australia (BCA)

AS 2047: Windows in buildings - Selection and installation

This standard specifies requirements for materials, construction, installation and glazing for windows, sliding doors, adjustable glass louvres, shopfronts, and window walls with one-piece framing elements

Structural building loads

Windows and doors may generate significant loads onto the surrounding structure, both as wind loads or direct gravity loads. This is particular the case with bi-fold and top-hung sliding units.

Generally, timber window and door units do not carry structural building loads but act as non-loading bearing insertions into the load bearing frame of the building. If the joinery units are to carry structural building loads, member sizes and jointing must be determined in accordance with AS 1720 - Timber structures, and AS 1684 - 2006 - National Timber Framing Code - Residential timber-framed construction and allied standards.

Wind loads

Windows and door units have to resist wind loads applied to the assembly. AS 2047–1999 - Windows in buildings - Selection and installation, requires windows to perform satisfactorily to particular design wind pressures. For building other than housing, these pressures are provided in AS/NZS 1170.2:2002 Structural design actions – Wind actions. For housing, the design and ultimate strength test pressures are:

Table 15. Window rating for housing

WINDOW RATING	SERVICABILITY DESIGN WIND PRESSURE (Pa)	ULTIMATE STRENGTH WIND PRESSURE (Pa)
N1	500	700
N2	700	1000
N3	1000	1500
N4	1500	2300
N5	2200	3300
N6	3300	4500

Source: *AS 2047–1999*, Table 2.1 & 2.5

Under the applicable design wind pressures, the maximum allowable deflection of a structural element in the unit is:Air-infiltration rates

Table 16. Allowable deflection under design wind pressure	
BUILDING CLASS	DEFLECTION LIMIT
Class 1 (Residential)	Span/150
Class 2, 3 & 4 (Multi-residential apartments, hotels etc.)	Span/180
Class 5, 6, 7, 8 & 9 (Commercial and public buildings)	Span/250

Source: *AS 2047–1999*

The standard establishes maximum air infiltration rate for particular window or building types. Under the applicable test procedures, the maximum allowable air infiltration rates in the unit are:

Table 17. Maximum air infiltration rates			
BUILDING OR WINDOW TYPE	PRESSURE DIRECTIONS	MAXIMUM AIR INFILTRATION (l/s m2)	
		Test pressure 75 Pa	Test pressure 150 Pa
Air-conditioned	Positive, Negative	1.0	1.6
Non-air-conditioned	Positive	5.0	8.0
Louvre window	Positive	20.0	n/a
Adjustable louvres, residential and commercial building	Positive	20.0	32.0

Source: *AS 2047–1999, Table 2.3*

AS 1288-2006 Glass in buildings

All glass used in windows and doors in Australia, needs to comply with AS 1288-2006 - Glass in buildings - Selection and installation. The standard regulates the size and type of glass according to the required structural capacity of the glass and the safety of occupants. The thickness of glass for structural adequacy depends on the type of glass, the size of the pane and the exposure of the location to wind loads.

Safe glazing

Building occupants can be injured or killed if they hit or run into the glass in windows and doors. To reduce this risk, building regulations limit the types of glass used in areas susceptible to human impact. These are defined in *AS 1288-2006.* Generally, safety glass is to be used where there is a chance of human impact, specifically in:

- glazing in doors and sidelights
- windows capable of being mistaken for an opening, and glazing within 500 mm of the floor
- generally or within 1000 mm of the floor in schools and childcare buildings
- shop fronts, internal partitions, and
- windows in bathroom.

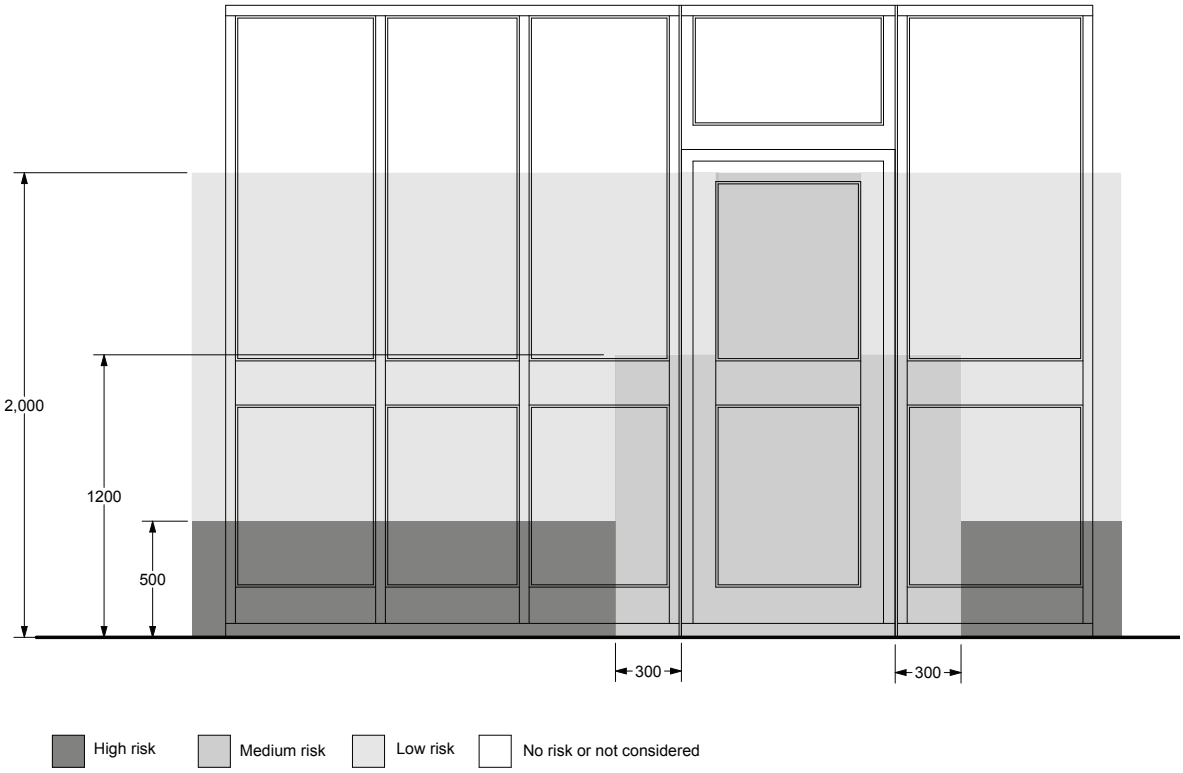


Figure 4: Level of risk of injury from human impact. Source: AS 1288-2006

AS 1288-2006 recognises two grades of safety glass manufactured to AS/NZS 2208-1996. Grade A offers a high level of protection against injury and includes laminated, toughened and toughed laminated glass. Grade B provides lesser protection and includes wired safety glass.

Laminated glass is two or more sheets of glass joined with adhesive inter-layers of transparent plastic. If broken, the glass sticks to the interlayer and generally stays in the glazed unit. Toughened glass is glass that is heated treated. This increases its strength beyond that of typical glass and determines its behaviour when it breaks. When shattered, it breaks into small, relatively safe pieces. Toughening glass is also called tempered glass.

Mechanical protection can also be provided to the glazing. Also, the glass can be made more visible or obvious. AS 1288-2006 requires that glass that may be mistaken as an opening be marked to increase it visibility.

AS 3959-2009 Construction of buildings in bushfire-prone areas

This Standard specifies requirements for the construction of buildings in bushfire-prone areas in order to improve their resistance to bushfire attack from burning embers, radiant heat, flame contact and combinations of the three attack forms.

Areas likely to experience bushfires can be designated bushfire prone areas under state or local planning regimes. This designation requires any new and significantly altered building in these areas to comply with the provisions of *Australian Standard 3959 Construction of buildings in bushfire prone areas*. After the 2009 Victorian bushfires, all or large areas of several states have been designated bushfire prone.

Compliance with *AS 3959* requires establishing the threat level for the site and then detailing the building envelope to resist that threat. The standard establishes six possible Bushfire Attack Levels (BAL) for a site. There are described in Table 18. As windows and door can provide a weak point in the fire resistance of the external envelope, limits are placed on their arrangement and construction. The requirements vary with the assessed BAL of the site and whether the window or door is protected by a bushfire shutter or screen.

The requirements set restrictions on the species of timber and the glass used in the unit and the clearance between the doors and their frames.

Table 17. Bushfire attack level and levels of exposure

BUSHFIRE ATTACK LEVEL	DESCRIPTION OF PREDICTED BUSHFIRE ATTACK AND LEVELS OF EXPOSURE
BAL - LOW	Insufficient risk to warrant specific construction requirements
BAL - 12.5	Ember attack
BAL - 19	Increasing level of ember attack and burning debris ignited by windborne embers together with increasing heat flux between 12.5 and 19 kWm^2
BAL - 29	Increasing level of ember attack and burning debris ignited by windborne embers together with increasing heat flux between 19 and 29 kWm^2
BAL - 40	Increasing level of ember attack and burning debris ignited by windborne embers together with increasing heat flux between 29 and 40 $kWm^2$with the increased likelihood of exposure to flames
BAL - FZ	Direct exposure to flames form fire front in addition to heat flux $>$40 $kWm^2$and ember attack

Table 19. Bushfire requirements for doors and windows			
BUSHFIRE ATTACK LEVEL	EXTERNAL DOORS	EXTERNAL WINDOWS	BUSHFIRE SHUTTERS
BAL - LOW	No special requirements	No special requirements	No special requirements
BAL - 12.5 & 19	Bushfire shutters or screen and any timber frame or door assembled with bushfire resisting timber or timber species from E2	Bushfire shutters or screen and any timber frame or window assembled with bushfire resisting timber or timber species from E2	Non-combustible material, bushfire resisting timber or timber species from E1
BAL - 29	Bushfire shutters and any timber frame or door assembled with bushfire resisting timber	Bushfire shutters and any timber frame or window assembled with bushfire resisting timber	Non-combustible material or bushfire resisting timber.
BAL - 40 & FZ	Bushfire shutters and any timber frame	Bushfire shutters and any timber frame	Non-combustible material

As set out in Table 19, as the assessed BAL increases, the fire resistance of the timber used in the frame increases. Timber can also be used to make the fire-shutters up to BAL 29. The standard correlates fire resistance to density and timber species are broken into four major groups:

- low density timber species
- timber species with a density of 650kg/m3 or greater, listed in *AS 3959-2009*, Table E2
- timber species with a density of 750kg/m3 or greater, listed in *AS 3959-2009*, Table E1, and
- fire resistant timber

Common species in each of these groups are listed in Table 20.

Table 20. Density and fire resistance of major species	
REQUIREMENT	COMPLIANT SPECIES
'Bushfire resistant' timbers:	*Blackbutt, Spotted Gum, Red Ironbark, River Red Gum, Silvertop Ash, Turpentine, Kwila* (Merbau)
Timber species* from E1 - density 750kg/m3 or greater include:	*Silvertop Ash, Blackbutt, Brownbarrel, Sydney Blue Gum, Grey Gum, Manna Gum, River Red Gum, Spotted Gum, Grey Ironbark, Red Ironbark, Jarrah, Kwila* (Merbau), *Messmate*.
Timber species* from E2 - density 650kg/m3 or greater include:	All species from E1 (above), also: *Alpine Ash, Mountain Ash, White Cypress, Shining Gum, Celery-top Pine, Slash Pine*

* a more complete list of species is included in Appendix E of *AS 3959-2009* .

The Building Code of Australia (BCA)

The Building Code of Australia (BCA), the national regulations for all new building in Australia, includes provisions that influence the specification, construction or installation of windows and doors in addition to the standards above. Its major provision concern safe movement and access, and thermal performance.

Safe movement and access

Part D.2 of Volume 1 of the BCA and Part 3.9 of Volume 2 impose requirements to ensure safe movement and access. The major provisions affecting door and windows deal with access to pool areas and the extent that upper storey windows can open.

Access to a pool area is restricted and must comply with AS 1926 *Swimming pool safety.* Any access door and window opening to the pool area must be protected with child-resistant door sets and child-resistant openable portions to the window. For windows, this limits the opening of particular sections of the window to 100 mm or protection of openable portions of the windows with bars or suitable mesh.

Doors and windows on the external wall of an upper storey form part of the system of barriers that prevent occupants from falling out. As such, they need to comply with general provisions for balustrades included in the BCA. These require that a continuous balustrade or other barrier be provided across the window if its level above the surface beneath is more than 4 m and it is possible for a person to fall through it. The height of a balustrade or other barrier must be not be less than 1 m above the floor and it must be constructed so that any opening in it does not permit a 125 mm sphere to pass through it. To comply, a window must provide the same performance: any sashes below 1 m above the floor needs to be constrained to limit its opening so that 125 mm sphere limit cannot pass through.

Thermal performance

Part J of Volume 1 of the BCA and Section 3.12 in Volume 2 establish detailed requirements on a building's thermal performance. Both set limits on the amount of glazed areas included in the facades of a building, with the limits dependent on the building's location and the orientation, shading and thermal properties of the glazed unit. To show compliance, the glazed unit's U-value and Solar Heat Gain Coefficient (SHGC) is needed.

The U-value and SHGC of a glazed unit is highly dependant on the configuration of framing material and particularly the type of glass used. The results of generic test are included in Table 21.

Table 21. Performance of different window types							
Hampton: Using Generic WERS Data							
		COOLING	HEATING	Total Window System Values - ANAC			
Glazing ID	Frame	%impr.	%impr.	Uw	SHGCw	Tvw	Air Inf.
GENERIC STANDARD INDUSTRY TYPICAL WINDOW - SINGLE GLAZED							
3Clr	Generic: Aluminium	0%	0%	5.84	0.859	0.75	5
3Clr	Generic: Timber	15%	15%	4.24	0.736	0.72	5
5Gn	Generic: Timber	30%	6%	4.21	0.586	0.39	5
5EG	Generic: Timber	35%	3%	4.21	0.542	0.59	5
6.38CP	Generic: Timber	42%	17%	3.07	0.492	0.47	5
GENERIC STANDARD INDUSTRY TYPICAL WINDOW - DOUBLE GLAZED							
3/6/3	Generic: Aluminium	11%	17%	4.34	0.777	0.68	5
3/6/3	Generic: Timber	26%	31%	2.82	0.659	0.65	5
3/12/3	Generic: Timber	27%	35%	2.56	0.659	0.659	5
5Gn/6/5	Aluminium – thermally broken	35%	13%	3.56	0.549	0.36	5
5Gn/6/5	Generic: Timber	43%	20%	2.8	0.486	0.34	5
Notes: Uw is the whole window U-value, SHGCw is the whole window solar heat gain coefficient, and Tvw is the whole window visible (light) transmittance							

Key:			
GLAZING ID	GLAZING DESCRIPTION	GLAZING ID	GLAZING DESCRIPTION
3Clr	3mm single clear	3/6/3	3/6/3 clear IG, air fill
6.38CP	single solar control, pyrolytic low-e	3/12/3	3/12/3 clear IG, air fill
5Gn	5mm toned	5Gn/6/5	5/6/5 toned IG with air fill
5EG	5mm supertoned		

Source: WERS 007 Generic Product Directory. www.wers.net