Structural and supporting systems

Flooring systems

There are two main types of flooring system:

1. Those in contact with the ground
2. Suspended floors.

The choice of floor system depends upon a number of factors; the structural system of the building, the types of floor finish required, the thermal performance required, the sound insulation required, the ease of erection and economy.

Different floor systems
Floors in contact with the Ground

This generally means a slab-on-ground. A slab on ground can be one of a number of different types of slab such as a raft slab, waffle pod slab, slab with dropped edge beams or a reinforced slab on fill. These have already been discussed as this type of floor also encompasses the footing of the building.

Suspended Flooring System

These are usually suspended concrete slab or timber floors. These are used in both ground floor and upper floor levels. With a suspended flooring system moisture penetration is less of a problem than heat loss. Damp will not enter the building through the floor itself but can enter through the supporting walls as rising damp and therefore the placement of the damp course is very important (see figure below).

Timber is the most common form of suspended floor and can be either of the following:

- Cut-in floors in which the floor is fixed in position after the walls are erected. In double brick buildings all timber floors are cut in.
- Platform floors in which the floor is placed before the walls have been erected.
Unlike floors on the ground in which the load bearing capacity of the ground provides structural support, in suspended floors the system has a support structure that carries and transfers the load to the footings.

The structural support for suspended slabs for the ground floor is usually dwarf masonry walls. For timber floors the sub-structure generally consists of joists, bearers and engaged piers along the external walls and isolated piers internally as shown in the figure below.

To prevent dampness causing timber deterioration the sub-floor area must be ventilated. To prevent rising damp affecting the timber the piers must have a damp proof course or ant cap.

Minimum sizes and spacing for timber members for the floor can be found in AS 1684 – Residential Timber Framed Construction. Acceptable Standards of Construction has tables derived from AS1684 that provide a quick reference for bearer and joist size and spacing combinations for various timber grades.

Timber flooring may be either solid timber floor boards or engineered timber floor sheeting.

**Strip flooring (floor boards)**

Timber strip flooring is of two main types, tongued and grooved or specially tongued to permit secret nailing. Flooring is normally 19 mm thick by 50, 100 or 150 mm wide.

The choice of timber most suited to needs is generally determined by the location, usage and the floor finish required. The most common and cheapest timber used for floor boards in
Laying of timber flooring

As timber boards expand and contract according to the moisture level in the environment, it is necessary for boards to be left to acclimatise in their final position.

The tongue is inserted into the groove and boards are clamped together to ensure a tight fit. The boards are then nailed to the joists, twice at each joist crossing, and nails punched to below the surface. A gap should be left between the edge of flooring and walls to allow for expansion of the flooring with changes in moisture content.

The floor is then sanded to give a level surface and if the floor is to be sealed or polished additional fine sanding is needed.

Floor boards may also be laid over a concrete slab or sheet flooring. Fixing is by direct gluing or by fixing to battens. Allowance for moisture movement is critical.

Engineered Timber Sheet flooring

Platform flooring materials such as particleboard or plywood flooring is commonly used as a base for floor finishes such as carpet, vinyl and tiles. The sheets have tongue and grooved edges for ease of fixing and sheet sizes and thicknesses are available to suit different joist spacing.

Waterproof particleboard and plywood may be used in wet areas such as bathrooms.

Installation is strictly in accordance to manufacturer’s written instructions.

Autoclaved aerated concrete, or AAC, is concrete that has been manufactured to contain lots of closed air pockets. Lightweight and fairly energy efficient, it is produced by adding a foaming agent to concrete in a mould, then wire-cutting blocks or panels from the resulting ‘cake’ and ‘cooking’ them with steam (autoclaving). AAC can be used in panel form for floor and roof construction. It has a long life and does not produce toxic gases after it has been put in place.

Hebel floor panels

CSR Hebel Floor Panels are reinforced AAC panels designed as loadbearing components in commercial, industrial and residential construction applications. They are manufactured in various thicknesses for specific load/span configurations and provide an instant dry floor with excellent thermal and acoustic properties.

The panels can be from 150 mm to 250 mm thick depending on the load requirement. Floor panels are 600 mm wide and up to 6 metres in length. Unsupported spans up to 5.85 metres can be achieved.
Hebel SoundFloor / PowerFloor

In a typical bearer and joist construction, Hebel SoundFloor® (PowerFloor®) is used to provide thermal and acoustic insulation. SoundFloor® panels are glued and screwed directly to timber or steel joists. Hebel flooring is lightweight - 25% the weight of conventional concrete.

The surface is smooth and flat, providing a stable substrate for tile, slate, marble and other hard surface flooring including for bathrooms, laundries and other wet areas. Other floor finishes include carpet, vinyl, timber boards, parquetry and decorative plywood flooring.

(From http://hebel.com.au/sites/default/files/PowerFloorDIGuide.pdf)

NOTE: Patching of recesses at fixings or localised chipping may be required prior to installation of floor coverings.

(From http://hebel.com.au/sites/default/files/PowerFloorDIGuide.pdf)
Wall and floor systems are dependent on each other structurally. Floors may provide support for walls while walls may provide support for floors. The most common wall systems are brick cavity wall, brick veneer and timber framed clad walls.

Wall Construction

Most walls are a composite construction, that is, they are made of more than one type of material. Most of these walls have a structural component and a protective component which has the purpose of resisting weather, thermal extremes, noise transfer, insect attack and fire.

The principal wall systems used in houses are:

- **framed wall systems**—hardwood, softwood, engineered timber or lightweight steel
- **solid wall systems** made from masonry - cavity brick or solid brick; concrete or AAC block; stone; straw bale; etc.

Other systems that are used include:

- post and beam – timber, steel or reinforced concrete structure with infill walls
- portal frame – timber or steel with infill walls (commonly used for industrial buildings)
- tilt-slab—vertical concrete slabs (commonly used for industrial buildings)

The areas applying to the walls of buildings that the drafter or building designer needs to pay particular attention to as part of the building design are:

- water and moisture entry into the interior of the building
- moisture entering timber plates from slab floors, masonry supports and wet areas
- fixing of member to member for stability of the structure in relation to bracing and tie-down requirements

Framing Methods

Framed walls are the most common wall system used in residential construction in Australia. This system uses thin vertical members (called studs) fixed top and bottom to long horizontal (sometimes the top will be sloping) members (called plates).

Framed walls generally consist of a basic frame which bears the loads with cladding on the external face of the frame and lining on the internal faces of the external wall, and both faces of the internal walls. Additionally there is insulating sheeting between the frame and the lining.

Timber is the most commonly used framing material; however steel is gaining a share of the marketplace as the cost of timber increases.

Timber wall frames are easy to build and alter on site with a minimum amount of easily transportable equipment. Factory built frames are also commonly used, especially in project homes.

Steel frames can be built on-site, but often require special tools for fixing. More usually, steel frames are built in a factory on special jigs then delivered to site and then erected.
Examples of wall construction systems
Typical timber framed wall components

Timber framed wall system

Timber frame sizes are dependent on the loads they are required to carry and are designed as per AS 1684 Residential Timber Framed Construction. Wall frames must be able to support roof loads as well as floor loads from upper levels, and they must also be braced to be able to resist lateral loads which come mainly from wind loads. Some examples are shown below.
There are two types of bracing visible in this residential building project: double diagonal metal strap bracing and compressed board sheet bracing.
Section through a timber framed, weatherboard clad building wall
Steel framed wall systems

Steel framed construction is not common, but is gaining popularity

These are not widely used but are more common now than a few years ago. Frame systems in steel and aluminum are light, strong, stable and quick to erect. The principal of metal framing is the same as for timber although generally the components vary in profile. The diagram below shows the arrangement of a metal frame.
Steel framing is versatile, light and strong and has time and labour savings. It is not attacked by termites.

Complete, integrated metal framing systems are available which include the floor, wall and roof framing. The framing systems are engineered and result in structurally sound construction with economic use of materials. The spacing of members is similar to that of conventional timber framing.

Steel framing can be used with a wide range of architectural materials and styles including timber floor and concrete slab-on-ground construction, timber roofs with tiles, steel or other roof coverings, brick veneer, weatherboard, metal or any other sheet cladding.

The individual members of a steel frame are channels of various shapes and depths. Refer to figure for a summary of these. Different manufacturers may produce different profiles. Members may be joined by bolting, welding, screwing or clipping together.
Steel floor framing is used with the whole range of conventional footings, dwarf walls, piers, timber or concrete stumps. Any of the sheet flooring materials is suitable for use with steel floor bearers and joists.

Sheet flooring is laid and fixed over the entire floor in the same way as for timber framed floors and then the wall frames are erected. This method is called platform floor construction and it gives the builders a good surface on which to work. The floor sheets are fixed with screws and adhesives in accordance with the manufacturer’s specifications.

Metal framing parallels conventional construction in its use of wall plates, studs, noggings and bracing. Metal wall frame members are usually 75 mm thick. Economies can be achieved in metal wall framing by simplifying construction and fabrication and, for example, using trussed lintels over openings to save on materials. Wall frames can be pre-fabricated or assembled on site.

Standard roof truss designs are prefabricated for a range of roof spans and pitches. Steel trusses are light but strong and easily handled. They are bolted or screwed to the top plate. Steel tiling battens are then screwed to the trusses and tiles fixed using spring clips.
A resource for more information on steel framing is the National Association of Steel Framed Housing (NASH) or the Australian Institute of Steel Construction (AISC) or the Australian Steel Institute (ASI).

Brick Wall Systems

**Brick Veneer**

This is the combination of a single brick skin, a cavity and a timber or steel frame. Brick veneer construction is an Australian development. It combines masonry construction from England and lightweight timber frame construction from California.

The brickwork is used as a cladding only and generally preforms *no structural function* for the building. As a cladding, it is there to protect the building and the occupants from the weather.

![Brick Veneer – Sketch Section](image)

*Cavity Brick* (‘double brick’ or ‘full brick’)

Another form of structural wall system is brick work. Bricks are essentially burnt clay consisting of aluminium silicates whether alone or combined with such impurities as iron, lime soda, potash or magnesium in the relative proportions of which the character, quality and colour of the brick to a great extent depend.
A standard brick in Australia is 230 x 110 x 76 mm. The following terms are related to brickwork:

- A **course** is a horizontal layer of bricks, including the bed.
- The **joint** is the horizontal mortar bed between each course of bricks.
- A **perpend** is the vertical joint between the bricks. The perpend in adjacent bourse will be staggered where bonding is correctly observed.
- A **header** is a brick laid with its length running across the wall, hence it can only be employed in walls of 230 mm or more in thickness.
- A **stretcher** is a brick laid with its length running in the same direction as the wall, hence a 110 mm wall must of necessity be composed solely of stretchers.
- A **frog** is the indentation on one side of a brick.

Cavity systems are a masonry constructed wall with mortar as the bonding agent. They have an inner and an outer masonry wall separated by an air gap or cavity. The two walls (called ‘leaves’ or ‘skins’) are held in place by metal ties (called cavity ties) fixed into the joints between courses of masonry. The outside leaf is the weather wall while the cavity should prevent any water that penetrates the outside wall from reaching the interior.

![Cavity Brick wall Construction](image)

Bricks are not moisture resistant and need to be protected from water to stop dampness entering the dwelling. Methods used to stop moisture entering the dwelling through the wall is to have a cavity (a gap of 50-60mm) between the two leaves of brickwork to break the contact and not permit the water to enter the inside face. To stop rising damp from the foundation a damp course must be placed above the ground level but below the floor level.

The down side of a cavity is that you end up with two thin walls unable to rely on each other for structural stability; therefore wall ties are introduced to improve stability. The inner wall is the one on which the load is supported (although in older homes, it was often the outer skin) and therefore may need strengthening by tying to the outer wall.

**Solid wall systems**

Solid wall systems can include concrete blockwork, brickwork or autoclaved aerated concrete (AAC). Other systems are available with most provided by specialists or may be covered by proprietary patents.

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Topic 1.4 Structural and supporting systems CPCCBS6001 Ed 1

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• **Mud brick** (adobe)—bricks usually made one or two at a time from mud and straw. Cement or bitumen can also be added to improve serviceability. The wall is then laid similarly to solid blocks. Go to [http://www.yourhome.gov.au/materials/mud-brick](http://www.yourhome.gov.au/materials/mud-brick) to find out more about mud brick.

• **Rammed earth** (pisé)—stabilised (that means with cement/bitumen added to the mix) earth is pneumatically rammed into vertical forms in layers to form the walls. Go to [http://www.yourhome.gov.au/materials/rammed-earth](http://www.yourhome.gov.au/materials/rammed-earth) to find out more about rammed earth.


**Other solid wall systems**

Other solid wall systems include concrete blockwork and autoclaved aerated concrete (AAC) construction. To prevent water or moisture penetration to the interior of solid wall systems, a weatherproof exterior skin or coating is required.

**Blockwork**

Hebel (AAC) Block Wall Systems are loadbearing external wall solutions for homes as an alternative to traditional double brick construction. The systems consist of a single skin external wall, typically constructed from 200 mm Hebel Blocks and internal walls using a single skin of 100 – 125 mm Hebel Blocks or 150 mm Hebel Blocks for loadbearing walls. Hebel Lintels are also available to negate the need for steel over window and door openings.

**Hebel Block construction**

For detailed information and technical specifications on AAC Hebel blockwork construction, go to the following website: [http://www.hebelaustralia.com.au](http://www.hebelaustralia.com.au)
For single skin solid wall systems there is a huge range of coating systems available and care should be taken in selecting a coating system for the appropriate application or as recommended by the manufacturer.

**Portal frame**

The portal frame is a combined wall and roof system. It is made up of a frame composed of vertical side columns fixed to either a single run rafter or two pitched rafters. The area between the portal frames is in-filled with a non-loadbearing wall.

Portal frames (uncommon in houses) are usually made from laminated timber beams, ply box beams or more commonly from structural steel sections. Portal frames are used extensively in industrial buildings, prefabricated metal sheds and garages or where large open spans are required.

**Post and Beam**

In this method of construction the wall itself bears no vertical loading apart from its own weight. The posts are the load bearing structure. However the walls have to contend with wind loads. The figure below shows a typical post and beam construction. This method can be used to permit the inclusion of large areas of glass or other lightweight material. That is why they are mostly used in verandas. This form of wall system uses large sections (200 x 200 or 250 x 150 or spaced double 250 x 50) and loadbearing posts or poles (150 to 300 diameter) spaced at 2.4 m up to 6.0 m intervals.

Single or double beams run from post to post to support the floor and/or roof structure. Like the portal frame system, the spaces between the posts are in-filled with non-loadbearing walls.

Structural steel is also used for this form of construction.

This type of construction requires that the joints are built to be rigid (that is they cannot rotate) by using a minimum of two bolts per joint, or some alternative form of bracing is used.

The main function of a roof system is to:

- Provide protection from rain and snow
- Provide shade
- Help maintain thermal comfort
- Resist uplift forces from wind
The most common roof structure is timber or metal with a variety of roof coverings. The diagram below shows common roofing types.

The roof structure of a building supports the roof cladding, the principle barrier against the elements for the building and the occupants. The roof structure is designed to support the weight of the roof cladding and resist the forces created by wind and in some areas snow.

Construction techniques include:

- **conventionally framed**, pitched roof with separate rafters and ceiling joists which may be joined at the base to form a tied, triangle shape called a **coupled** roof.
- **roof beams (rafters)** - either flat, vaulted or skillion (on-the-rake) with roofing and ceiling lining (if used) supported by the same member.
- **trussed** roof.
- **rafter and purlin**—used mainly with portal frames

**Roof Terminology**

The following terms are used in roof structures and are important to be familiar with:

- **A wall plate**: is a timber beam bedded in mortar on top of the inner skin of a cavity wall.
- **A common rafter**: is a sloping timber member placed from the wall plate to the ridge to carry the loads from tiles and wind etc. Long rafter need intermediate support which is purlins.
- **Jack rafter**: timber rafter cut between either a hip or valley rafter.
- **Underpurlins**: horizontal beams providing intermediate support to the underside of rafters, thus preventing deflection or sag in the roof.
- **Ceiling joist**: timber connecting the feet of the common rafter at wall plate level. These support the weight of the ceiling finish and insulation.
- **Struts**: timbers used to support rafters via the underpurlins and/or the ridgeboard. Usually set at right angles to the roof slope.
- **Ridge**: is the uppermost part of the roof. The ridgeboard or ridge beam is usually a horizontal member.
- **Hanging beam**: horizontal member to provide intermediate support for ceiling joists.
- **Fascia**: Usually a planed timber member used to close off the ends of the rafters, to support the soffit, to support the last row of tiles and to carry the gutter.
- **Valley**: is the intersection of two roofs creating a valley.
- **Barge board**: a piece of planed timber which is in fact a sloping fascia often fitted to gable ends

Residential roof structures are made from either timber or steel, with timber being the most common.
Different types of roof structure

Roof types

*Flat / Skillion Roof*

The basic components of flat and skillion roof are rafters and battens. The rafters bear on the top plate with a birds mouth joint and are skew nailed. In high wind areas the top plate and rafters must be strapped down the full depth of the wall. In cavity brick and brick veneer the roof is usually always supported by the inner skin leaving the outer skin free to expand and contract without affecting the roof structure.
**Gable Roof**

A gable roof comprises of rafters which are pitched against a ridge. To stop rafters from spreading outwards joists are used. Rafters act like beams as they carry the load of the roof. Under load they may sag or deflect if not sized adequately. Another way besides adequate sizing to stop excessive deflection is to use intermediate supports called underpurlins. Underpurlins are supported by struts which are supported by internal walls or strutting beams.

Joists have the dual purpose of preventing the rafters from spreading and carrying the ceiling loads. The load of the ceiling could cause sagging of the joist. To prevent this, a hanging beam can be added spanning between walls with the joists tied to it.

**Hip Roof**

Another type of roof is the hip and valley. This consists of a series of intersecting, equally pitched planes, forming a series of hips and valleys. These roofs have essentially the same components as gable roofs.
Components of a hipped roof frame

![Components of a hipped roof frame](image)

Hip and valley roof that is being conventionally framed (not a trussed roof)

**Trussed roofs**

Trussed roofs are now often prefabricated and are composite members performing the work of larger single members. They are fabricated to strict engineered guidelines so materials used can be minimised. The essential components of a truss are the top chord, the bottom chord and intermediate members which may be either struts or ties. Trusses require no support from internal walls and are specifically designed to span to the external walls and should not be supported by internal walls.

A trussed frame is composed of a series of triangles welded, bolted, riveted or nailed together to form an integral unit that:

- Need only be supported on columns or perimeter walls,
- Will carry the combined weight of itself and the roof covering,
- Will span across openings

Trussed roofs can be covered by any of the conventional roof coverings such as tiles and metal sheets, however, the type of covering will govern the spacing of the trusses. Often ceiling battens are fixed directly to the underside of the bottom chord.
The introduction of steel multi-tooth connectors (commonly known under the brand name of “Gang-Nail”) for the manufacture of lightweight prefabricated timber trusses, revolutionised house construction in Australia in the 1960s. Before prefabricated trusses were available, all house carpentry was carried out on site. The prefabrication of roof trusses (and wall framing) for houses enables faster and cheaper construction and better quality control.

Many roof truss shapes can be achieved and designed for a variety of roof loadings with spans up to 30 metres.

Main components of a roof truss

A nailplate (multi-tooth connector)
Gable End Roof Truss System
(MiTek Gang-Nail Truss)
In domestic trussed roof construction only the perimeter walls need to be designed as load-bearing walls when roof trusses are used. Internal walls become simple partitions and can be arranged without the need to provide supports for propping beams, hanging beams, etc. The sub-floor structure is simplified as stumps and bearers don’t need to be arranged under internal non load-bearing walls and where concrete slab floors are used, the arrangement of internal beams is simplified.

Cyclones

Tropical cyclones are giant whirlwinds of air and dense cloud spiralling at over 120 km/h around a central ‘eye’ of extreme low pressure. They often produce winds in excess of 200 km/h and gusts can exceed 280 km/h. This can cause extensive damage to property and turn debris into dangerous missiles. Most deaths from cyclones occur as a result of drowning, collapsed buildings, or flying debris which becomes lethal in high winds.

As a building surveyor, it is important to be aware of the threats posed by cyclones. It is important to be able to evaluate and apply cyclone-resistant construction practices to buildings. In this topic we will be looking at cyclone categories, methods of tie down and bracing, and the requirements of the BCA for cyclonic regions.
In Australia, cyclones mainly affect coastal areas north of Perth along the WA and NT coasts, most of the Qld coast and occasionally the far northern NSW coast. The greatest threat lies north of the Tropic of Capricorn.

Cyclones occur frequently in the southern hemisphere, with an average of ten per year being tracked by the Bureau of Meteorology in the Australian region alone. Of these, six may be expected to cross the Australian coast each year.

Cyclones approach from the sea bringing with them torrential rains, extreme winds and sometimes storm surges. Damage caused by each cyclone varies widely depending on its path, but can include buildings, crops and boats at sea. Most deaths from cyclones occur as a result of drowning (both at sea and during floods), collapsed buildings, or from impact of debris which become lethal projectiles carried along by the extreme winds.

Severity Categories

These range from:

1 for weak tropical cyclones (strongest wind gusts less than 125 km/h); minimal house damage, but damage to crops, trees, etc.

2 winds are destructive at 125-164 km/h; minor house damage, significant damage to crops, trees, signs, etc.

3 for severe tropical cyclones with very destructive winds of 165-224 km/h.

4 for severe cyclones causing significant roofing and structural damage, and dangerous airborne debris. Winds to 279 km/h

5 for the most severe cyclones (wind gusts more than 280 km/h). Extremely dangerous with widespread destruction.

Part 3.10.1.0 of the BCA

As indicated the explanatory information supporting Part 3.10.1 of the BCA, prepared by the ABCB,
"The intent of building construction in high wind areas is to ensure the structure has sufficient strength to transfer wind forces to the ground with an adequate safety margin to prevent the collapse of the building and the building being lifted, or slid off its foundations."

To resist these forces it is necessary to have:

- an anchorage system, where the roof is connected by walls to the footings by a chain of connections; and
- a bracing system to prevent horizontal collapse due to wind forces; and
- continuity of the system where each structural element is interlocked to its adjoining structural element throughout the building.

Factors affecting wind velocity

It should be obvious that the amount of force exerted by wind on a building is related to its speed or velocity. These four factors affect the wind velocity and must be assessed to determine the wind classification for a housing site:

- geographical location,
- topographical features,
- terrain, and
- amount of shielding.

Geographical location

For the determination of wind classification, Australia is divided into four regions, according to recorded average wind speeds. The Australian/New Zealand Standard 1170.2-2011 sets out the wind speeds to be used for design purposes.

Regions B, C and D cover the coastal regions north of the 30 degree latitude which are prone to tropical cyclones. Above the 30 degree latitude, the regions are designated as:

- Region A: from a distance greater than 150 km from a smoothed coastline;
- Region B: within the distance of 100 to 150 km from a smoothed coastline;
- Region C: within the distance of 100 to 50 km from a smoothed coastline; and
- Region D: within the distance of 0 to 50 km from a smoothed coastline.
**Topographic features**

A house site located on a hill, ridge or escarpment experiences different average wind speeds depending on the height and steepness of the hill, ridge or escarpment and whether the house is located near the base, half-way up or on the crest.

In *AS 4055 Wind loads for housing* five levels are ascribed to the effects of topography ranging from T1 to T5. T1 is the classification designated to sites located on the lower third of hills, ridges or escarpments and to sites with gentle grades or low overall heights. T5 is assigned where the house site is on the upper third of hills, ridges or escarpments with slopes greater than or equal to 1 in 3. If the site is in the mid-third of a hill, ridge or escarpment of slope between 1 in 3 and 1 in 5, then it is given a classification of T2.

**Terrain**

The site of a house is given a terrain category TC1, TC2, TC2.5 or TC3. Terrain category takes account of the number of obstructions within a radius of 500 metres, such as trees and houses, which can substantially reduce wind speeds.

A terrain category of TC3 applies to sites having numerous obstructions that are close together, such as is generally the case for urban areas. A site located in open plains with few trees would have a category of TC1.

**Shielding**

Shielding also affects wind speed. It is also due to the number of obstructions but is a more local effect than is considered when assessing the terrain category. A classification of FS (or full shielding) would apply where a site is surrounded by at least two rows of houses (or permanent obstructions of similar size). Sites may also be classified as having partial shielding (PS) or no shielding (NS).
House sites in suburban areas are generally considered to have full shielding. A consideration of each of these factors in respect of a site, allows the determination of a wind classification designation of N1 to N6 (for non-cyclonic) or C1 to C4 (for cyclonic). Note that the wind classification system outlined in AS4055 can only be applied in certain circumstances including:

- maximum building height of 8.5 metres,
- maximum floor to ceiling height of 2.7 metres,
- roof pitch not more than 35 degrees,
- width not greater than 16.0 metres, and
- length not more than five times the width.

Wind Loads

Wind typically applies a force over an area. The whole of the side of a building experiences the force due to the wind and so does the whole of the roof.

Mostly wind forces are expressed as a pressure, a force over an area, in units of pressure which is the pascal, although typical wind loads are usually large enough to be in the order of kilopascals (kPa).

The roof of a house can be subjected to external suction wind pressures or to positive pressures. During a severe cyclone event, a typical truss or rafter support needs to be able to resist pulling forces upon it.

The diagram below indicates the pressures acting on a house showing the suction pressures that can occur over the roof and on the leeward side.
In addition, if there is a breach in a building on the windward face, such as from a broken window, the interior of the house can be pressurised. Internal pressures created in this way can greatly increase the load on the cladding and structure.

**Wind Load Design Considerations**

The Building Code of Australia, in particular Part 3.10.1- High Wind Areas, stipulates the design considerations for the majority of buildings in Australia. These requirements are met by compliance with a range of Standards relating to building and construction.

**Tie down and structural bracing**

Anchorage of the building is achieved by using a variety of proprietary connectors. Each connector must be capable of carrying the uplift force, because the ability of the building to resist the wind forces is directly related to its weakest link. The Australian Standards listed in Part 3.10.1.0 of the BCA specify tie down and bracing requirements.

**Requirements for bracing and anchorage**

As previously mentioned, compliance with the BCA is achieved when the work is carried out in accordance with the specified *acceptable construction manual* (i.e. nominated Standards). *AS1684.3-2010 Residential timber-framed construction – Cyclonic areas* specifies the requirements for the construction of timber framed buildings in cyclone regions:

- Section 8 - looks at the requirements for ‘Racking and Shear Forces (bracing)
- Section 9 - focuses on ‘Fixing and tie down design’

It is recommended that you spend some time reading AS1684.3 to become familiar with the requirements for tie down and bracing for timber framed domestic construction in cyclone areas.

**Alternative solutions to those prescribed in AS 3.10.1.0 of the BCA.** Any alternative method of construction in high wind areas must comply with performance requirement P 2.1.1 and must be determined in accordance with 1.0.10 of the BCA. Generally, the alternative solution would be designed by a suitably qualified structural engineer.

Part 3.10.1 of the BCA specifies the additional construction requirements for high wind areas. You should spend some time now reading this Part of the BCA.

There is a presentation written by Dr David Henderson on the performance of buildings in cyclones that is well worth looking through. Type “building performance in cyclones David Henderson” into your search engine and look for the PDF article.

*The Australian House building Manual*, by Allan Staines, has some excellent drawings and information. Borrow a copy from your local library and read

- Chapter 1 Typical Construction Methods
- Chapter 4 Wall framing, and
- Chapter 5 Roof construction

Also read the following sections in *Building Your Own Home*, George Wilkie:

- Topic 33 Walls – Introduction
- Topic 34 Timber wall framing
- Topic 35 Metal wall framing
- Topic 37 Autoclaved Aerated Concrete
- Topic 41 Solid masonry construction
- Topic 45 Roofs
- Topic 46 Conventional roof frames
To learn more about timber framing, you should familiarise yourself with *AS1684 Residential timber framed construction*. Part 2 of this Australian Standard deals with construction in non-cyclonic areas of Australia. Part 3 covers timber design for cyclonic areas. For an introduction to timber framing you could watch some YouTube clips such as:

- [https://www.youtube.com/watch?v=RO7Hp8ms9Bg](https://www.youtube.com/watch?v=RO7Hp8ms9Bg)
- [https://www.youtube.com/watch?v=zgTbYTt97dU](https://www.youtube.com/watch?v=zgTbYTt97dU)

and the series produced by Buildsum starting with [https://www.youtube.com/watch?v=2cszaf5IM3s](https://www.youtube.com/watch?v=2cszaf5IM3s)