Additional construction requirements

BCA Part 3.10 Additional construction requirements

To address design requirements for increased structural loading conditions that may occur due to geographical, topographical or climatic conditions that are not covered in other parts of the BCA, Part 3.10 is provided to address the following:

- Part 3.10.1 High wind areas,
- Part 3.10.2 Earthquake areas, and
- Part 3.10.3 Flood hazard areas.

High wind areas

Introduction
High wind pressures cause enormous damage each year to buildings and structures that have not been designed with adequate bracing, fixing and/or tie-downs for the conditions experienced.

Building code requirements
The BCA (Volume 2) Part 3.10.1 ‘High wind areas’ gives a map of Australia indicating affected areas and outlines the construction principles for buildings to be able to resist high velocity winds. While NSW codes have usually been written for wind speeds of 33 and 41
metres/second, in cyclonic areas of northern NSW and Queensland, design wind speeds of 50 or 60 metres/second are common.

For residential construction, the BCA calls up AS 1684–2010 *Residential Timber-framed Construction* which provides detailed design, bracing and connection procedures for wind classifications N1 to N4 and C1 to C4. The Standard is in four parts:

- AS 1684.1 Part 1: Design criteria
- AS 1684.2 Part 2: Non-cyclonic areas
- AS 1684.3 Part 3: Cyclonic areas
- AS 1684.4 Part 4: Simplified – non-cyclonic areas

Timber construction within lower wind areas (N1 and N2) can be determined from Part 4, although these may not always be the most economical designs.

**Standards**

Two Standards are commonly used in association with AS 1684 Parts 1–3, with either one used to determine the wind classifications.

- AS 4055 Wind loads for housing

This Standard is used for residential buildings with maximum height of 8.5 metres, building width of 16 metres and maximum roof pitch of 35°.

- AS 1170.2 Structural design actions - Wind actions

**Wind classification of building sites**

This system ensures that all buildings will be exposed to approximately the same level of risk of wind damage. Designers are able to select construction sizes and details from codes and manufacturers' literature to a known standard.

There are four steps in determining the wind classification:

1. Check the building conforms to geometric limitations.
2. Determine site factors.
4. Check that this classification is the maximum for all four directions.

**Geometric limitations**

For a simple wind loading analysis, the plan needs to be:

- essentially square, rectangular, L-shaped or a combination
- maximum two storeys in timber framing; maximum width 16 metres; maximum floor to ceiling for any storey 3 metres
• maximum roof pitch 35°
• common roof types
• building mass appropriate to the loads.

**Site factors**

There are four components to be considered.

- **Geographic region**

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 A4: 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.

These are as defined in AS 1170.2 and in the following table:

<table>
<thead>
<tr>
<th>Region</th>
<th>Location</th>
<th>Types of wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>A—normal</td>
<td>Southern and central Australia</td>
<td>Storms and gale force winds</td>
</tr>
<tr>
<td>B – intermediate</td>
<td>Tropical – 50 to 100 km from coast, north from Hervey Bay, Qld.</td>
<td>Lesser tropical cyclones, storms and gale force winds</td>
</tr>
<tr>
<td></td>
<td>Sub-tropical – 100 km from coast, north from Coffs Harbour, NSW</td>
<td></td>
</tr>
<tr>
<td>C, D – tropical cyclones</td>
<td>Tropical – 50 km from coast</td>
<td>Tropical cyclones, storms and gale force winds</td>
</tr>
</tbody>
</table>
Terrain category

As wind passes over the ground, its speed is slowed by the roughness of the terrain, creating turbulence. This ranges from TC1 (the smoothest and most open terrain), TC1.5, TC2, TC2.5, TC3 to TC4 (with numerous obstructions). The nature of the surrounding development (now and anticipated) must be considered within 500 metres.

For example, 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 classification

Wind approaching a building is affected by the localised shielding offered by large objects (typically buildings and trees) nearby. The shielding characteristics vary between Regions A and B (the most common categories) and cyclonic areas (Regions C and D). There are three categories:

- **NS** – no shielding (meaning fullest exposure to wind)
- **PS** – partial shielding
- **FS** – full shielding (the most protected).

![House sites in suburban areas are generally considered to have full shielding](image)

• Topographic classification

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 AS4055 *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.
Select wind classification

Engineering design from AS 1170.2 tables (incorporating the above) gives a composite result for wind classification such as W41N (wind 41 m/s, non-cyclonic). The simplified approach of AS 4055 *Wind Loads for Housing* for Regions A and B (most common areas) works on maximum design gust wind speed (metres/second), pressure (kPa) on building elevations and uplift force (kN). Table 1 shows the wind speeds applicable to the wind classification N1 to N4.

**Table 1:** Maximum design gust wind speed (metres/second)

<table>
<thead>
<tr>
<th>Wind classifications regions A and B</th>
<th>Max. design gust wind speed (m/s - Permissible stress method)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N1</td>
<td>28 (W28N)</td>
</tr>
<tr>
<td>N2</td>
<td>33 (W33N)</td>
</tr>
<tr>
<td>N3</td>
<td>41 (W41N)</td>
</tr>
<tr>
<td>N4</td>
<td>50 (W50N)</td>
</tr>
</tbody>
</table>

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.
Check maximum of all directions

It is necessary to check that the classification chosen is the maximum for all four directions and that design is performed to resist all failure mechanisms – racking or distortion, overturning, sliding and uplift.

Bracing and tie-downs are needed from footings through to roof to resist racking forces, shear and uplift.

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.

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.

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.

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.
Severity Categories
Cyclone categories 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.

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.

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, 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. 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.
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 for 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.

Earthquake areas

Part 3.10.2 of the BCA Volume 2 addresses the acceptable construction requirements for Class 1 and 10 buildings constructed in areas subject to seismic activity. It specifies that the performance requirements are satisfied if they are constructed in accordance with the acceptable construction manuals listed in Part 3.11. It also notes, in the Explanatory information that most domestic structures are not required to be specifically designed for earthquake, because the construction system already in place for wind resistance is usually adequate for earthquake resistance.

The acceptable construction manual relating specifically to earthquake design is AS/NZS 1170.4 Structural design actions – Earthquake actions in Australia. This document would most likely be used by engineers for design where earthquake actions need to be considered. However, as a building surveyor, you should be aware of this Australian Standard and how it applies to residential buildings. We will provide a brief overview of the general principles involved.
Construction requirements for earthquake areas

As mentioned before, most residential construction conforms to earthquake design because the bracing that is used to provide stability against wind also provides stability against earth movement. However, construction details need to be considered for buildings within areas of significant seismic activity. Two different areas are categorised using an acceleration co-efficient:

- equal to 0.12 but less than 0.15, or
- 0.15 or greater.

The acceleration co-efficient is a number which indicates the expected severity of the earthquake ground movement as determined under AS 1170.4. The map below indicates the distribution of acceleration coefficients across Australia.

Dwellings which are to be constructed in earthquake areas with a seismic activity acceleration coefficient of 0.12 or more satisfy performance requirements when:

- the soil profile of the site does not have more than 5 m of soft clay, loose sand, silt or uncontrolled fill;
- the proposed dwelling does not exceed a rise of one storey;
- the roof is not to be clad with concrete or terracotta roof tiles; and
- the proposed dwelling does not possess masonry chimneys, parapets or other masonry projections.
Acceleration coefficients between 0.12 and 0.15

To comply with building regulations, buildings in areas where the acceleration coefficient is between 0.12 and 0.15 have additional requirements that must be met.

Footings

Additional requirements specify that:

- piers must be steel, reinforced concrete or timber,
- floor beams must be fixed to the top of stumps with M10 bolts or equivalent fixing,
- bottom plates of framed structures fixed to a concrete slab or strip footing must be fixed with M10 bolts or masonry anchors at no more than 1.2 m centres,
- concrete strip footings must be continuously reinforced with two layers of reinforcement comprising two 12 mm diameter bars per layer and tied with R6 ligatures at centres not exceeding 2.5 times the depth of the footing,
- raft slabs must incorporate monolithic edge beams.

Framed walls

There are details provided in AS 1170.4 for metal and for timber framing.

Metal framing

- the metal in the framing elements must not be less than 1.2 mm thick (other than bracing)
- the framing must have wall plates that are continuous between cross walls or spliced to maintain strength

Timber framing

- must be fixed with timber framing connectors nailed with not less than three 2.8 mm diameter x 30 mm long nails to each fixing plate of the connector
- must be constructed of seasoned timber, fixed with at least two 2.8 mm diameter nails, machine nailed through the top or bottom wall plate into the stud
- and must use wall plates that are continuous between cross walls or spliced to maintain strength.

There are additional requirements for unreinforced masonry pertaining to:

- internal or external walls (e.g. the mortar mix)
- bricks (e.g. how they are laid)
- reinforcement (e.g. where it is used, size)
- continuous reinforcement (e.g. where placed)
• detailing of fixing of top wall plates

More information is provided in AS 3700 *Masonry structures*.

**Veneers**

Veneers that comprise an external leaf or masonry connected to internal walls of timber or metal framing must be fixed in accordance with AS 3700.

**Roof framing**

Additional requirements specify that roof framing:

- must be fixed with timber framing connectors nailed with three or more 2.8 mm diameter x 30 mm long nails to each fixing plate of the connector, and
- must incorporate roof bracing to transfer all horizontal loads directly to cross walls.

**Acceleration coefficients greater than 0.15**

Buildings in areas where the acceleration coefficient is greater than 0.15 have the same requirements for footings, framed walls and roof framing as for those in areas where the acceleration coefficient is between 0.12 and 0.15. The additional requirements for veneer on frame and metal framing construction are:

- further details on the wall plates (e.g. to transfer lateral loads between frames)
- further details on how the external walls must be fixed to supporting cross walls.

Masonry veneer must not be placed over openings or in gables.

You should access the Australian Standard AS 1170.4 and browse its contents so that you are familiar with the terminology and the concepts that are addressed in this code.

**Flood hazard areas**

There are two documents that you should read to provide you with a comprehensive overview of the requirements for the construction of Class 1 buildings. They are:

- the ABCB Standard for Construction of Buildings in Flood Hazard Areas
• and the ABCB Information Handbook for Construction of Buildings in Flood hazard Areas

The first of these can be downloaded from the ABCB website at:


You can find the other handbook by entering the title into your search engine. Both documents are downloadable as PDF files.