



# Cyclone Resilient Building Guidance

*for Queensland Homes*

**Get Ready Queensland**

*Preparing for a stronger, more Resilient Queensland*



bushfire & natural  
**HAZARDS CRC**





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#### More information

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## Introduction

**Cyclones are powerful weather systems that can cause significant damage to the built and natural environments. They generate severe winds, strong rain, riverine and flash flooding, as well as storm tides. This document provides information about building or modifying homes to strengthen their resilience to cyclonic winds.**

Using resilient building design can significantly reduce the effort, cost and time to return people to their homes and workplaces following natural disasters. It is one of the many ways Queenslanders can build their resilience to natural disasters.

This *Cyclone Resilient Building Guidance for Queensland Homes* (Guide) provides information about improving the wind resilience of Queensland homes located in cyclone prone areas. It contains information about the impacts of cyclones and guidance for strengthening the wind resilience of new and existing homes.

This Guide is designed for use by homeowners as well as the building, design and construction industry. Homes located near beach fronts and tidal creeks also need to withstand storm tide. Further guidance is available at [www.qra.qld.gov.au/Resilient-Homes](http://www.qra.qld.gov.au/Resilient-Homes) and includes:

- *Storm Tide Resilient Building Guidance for Queensland Homes*
- *Flood Resilient Building Guidance for Queensland Homes*

Improving the resilience of Queensland homes is another way we can work together to make Queensland the most disaster resilient state in Australia.

### Get Ready Queensland

**It is vital that you understand whether you are able to shelter in your home during a cyclone.**

**You must evacuate your home if:**

- you live in a storm tide prone area and are directed to leave by emergency services
- you do not have confidence that your home will resist the expected winds.

#### Seeking shelter at home

**Take shelter in a small room with few windows such as the bathroom.**

**For more information visit**

**<https://getready.qld.gov.au/natural-disasters/cyclones>**

Queenslanders are disaster resilient when...





## Acknowledgements

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- Queensland Government
- Bureau of Meteorology
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- Local Government Association of Queensland
- Queensland Building and Construction Commission
- Australian Institute of Building Surveyors
- Suncorp Insurance
- Cassowary Coast Regional Council
- Douglas Shire Council
- Hopevale Aboriginal Shire Council
- Isaac Regional Council
- Livingstone Shire Council
- Mackay Regional Council
- Rockhampton Regional Council
- Townsville City Council
- Whitsunday Regional Council.

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# 1 Introduction to wind resistant housing

This Guide provides information about designing and building wind resilient homes in cyclone prone areas, including:

- key issues associated with living in or building in a cyclone prone area
- design and building advice to minimise damage caused by cyclones.

This Guide is non-mandatory and can be considered in line with the Building Assessment Provisions contained in the *Building Act 1975* and *Queensland Development Code Mandatory Part (QDC) MP 3.5*.

This Guide does not replace the need to evacuate prior to a cyclone. If you live in a cyclone prone area it is important to always be prepared in case you need to evacuate quickly.

For more information visit <https://getready.qld.gov.au/natural-disasters/cyclones>

If you live in, or are planning to build in a cyclone prone area, it is recommended you refer this Guide to contractors involved in the design, construction or repair of your home.

## 1.1 Existing design and building standards for cyclone prone homes

If your home was constructed after the mid-1980s, it should have been designed and built for the wind speed specific to its particular location.

Homes constructed using the correct wind classification and to current codes and standards have generally performed well in recent events such as Severe Tropical Cyclone Larry (2006), Severe Tropical Cyclone Yasi (2011) and Severe Tropical Cyclone Debbie (2017). However, the varying size and intensity of cyclones means that it is not possible to guarantee a home is completely cyclone-proof. It is likely that during a severe tropical cyclone most homes will suffer at least some minor damage such as lost gutters, damaged awnings and aerials, and some water inundation. In general terms, homes built before 1985 usually sustain more damage during a cyclone than more recently built homes. This Guide provides valuable information for improving the resilience of all homes and reducing damage caused by cyclones.



Examples of cyclone damage to Queensland homes

## 1.2 Building assessment provisions for building certifiers

The Building Assessment Provisions contained in section 30 of the *Building Act 1975* dictate the laws and other documents for consideration by a building certifier for a building development approval to be issued.

These include:

- *Building Act 1975*
- *Building Regulation 2006*
- *Queensland Development Code (QDC) MP 3.5* and other relevant parts
- *National Construction Code* (Building Code of Australia).

Refer to **page 47** for information about building codes and standards for cyclone prone areas.

## Finding a licensed professional

Ensure only licensed professionals are involved in the repair or rebuild of your home by checking their credentials. Visit the following websites to find a licensed professional in your area:

### Licensed builders, tradespersons, and building certifiers and designers

Queensland Building and Construction Commission

[www.qbcc.qld.gov.au](http://www.qbcc.qld.gov.au)

### Licensed coastal and structural engineers

Board of Professional Engineers Queensland

[www.bpeq.qld.gov.au](http://www.bpeq.qld.gov.au)

### Licensed architects

Queensland Board of Architects

[www.boaq.qld.gov.au](http://www.boaq.qld.gov.au)

## 2 Understanding cyclones

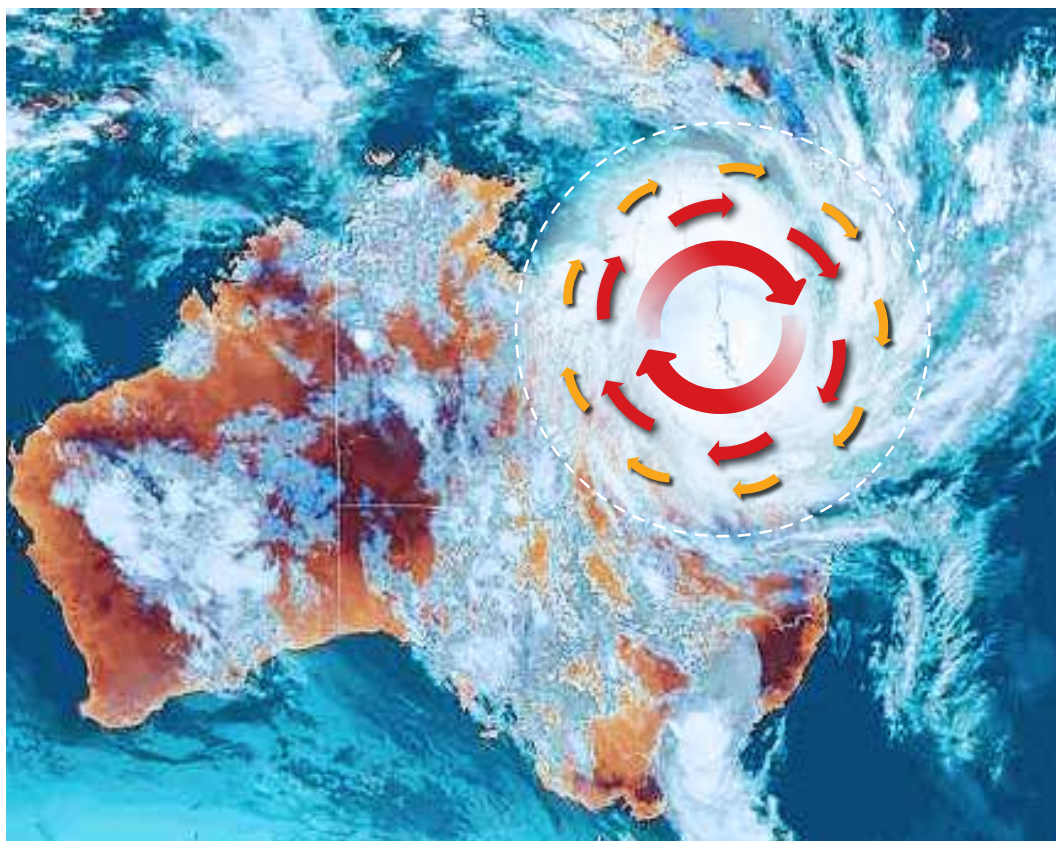
**Cyclones are a part of life for people living in Queensland coastal areas. Homes within 50 kilometres of the Queensland coastline north of Bundaberg need to be strong enough to withstand winds from severe tropical cyclones.**

### 2.1 About cyclones

Cyclones are low pressure systems that develop over warm oceans in the tropics, and generally intensify over several days. Cyclones produce very strong and potentially destructive winds that rotate clockwise around a calm centre (the 'eye'). Strong winds over the ocean can raise the level of waves breaking onto the coast, causing storm tides and inundation of coastal areas.

Cyclones can affect large areas of land, bringing heavy rainfall and potential flooding. They start to weaken as they cross the coastline. However, heavy rainfall and winds can continue for hundreds of kilometres inland.

Cyclones are often hundreds of kilometres wide. They can travel several hundred kilometres and affect thousands of square kilometres of land. The strongest winds are experienced just outside the eye, and the peak gust wind speed decreases the further from the edge of the eye's centre.



*Image courtesy of Bureau of Meteorology*



## 2.2 Cyclones in Queensland – what to expect

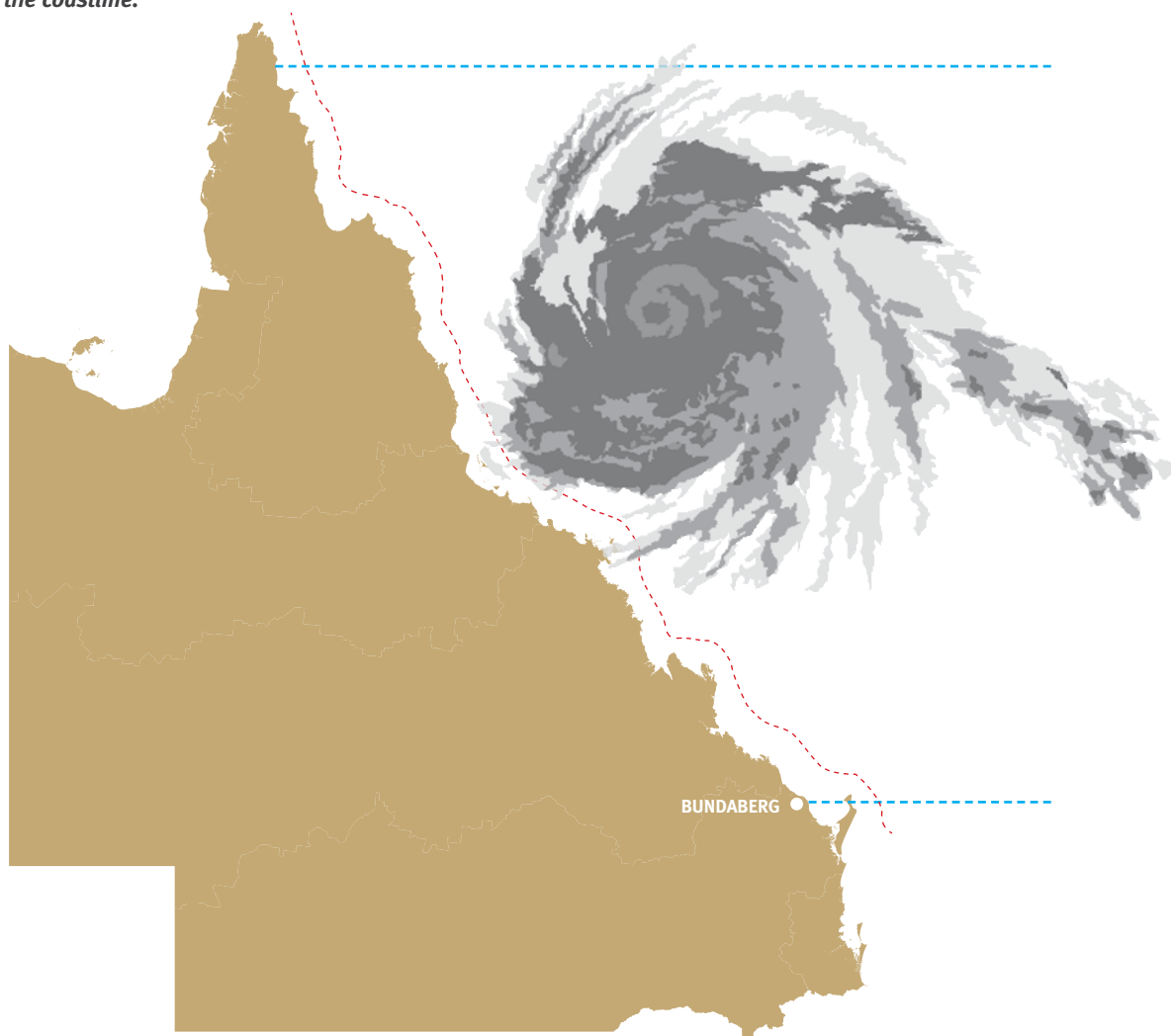
Australia's cyclone season occurs between November and April each year along the coastlines of Queensland, the Northern Territory and Western Australia. In Queensland, the coastal areas north from Bundaberg are most susceptible to cyclones. However, cyclones have occurred along the entire Queensland coast and the accompanying wind and rain from weakening cyclones can affect communities throughout all parts of Queensland.

The Bureau of Meteorology (Bureau) provides up-to-date information about the expected path and severity of cyclones that may impact Australia. The Bureau issues different levels of warnings as a cyclone forms, intensifies and approaches the coast. You will have time to prepare to shelter in your home, or evacuate if you are in a storm tide area, or move to other shelter if you are concerned your home is not able to withstand the expected winds.

As a cyclone approaches, the wind and rain gradually increases over several hours. Winds caused by the cyclone are powerful enough to break large trees, roll over sea containers and blow away unsecured caravans, garden sheds and poorly constructed roofed patios. Slow moving cyclones can take many hours to move past a particular location, causing extreme wind and rain that lasts up to 12 hours.

Strong winds associated with cyclones can cause extensive property damage and turn loose items into wind-borne debris that can further damage buildings.

***Cyclones are strongest in Central and North Queensland (north of Bundaberg) within 50 kilometres of the coastline.***



## 2.3 Categories of cyclones

The Bureau predicts the severity of a cyclone using a five-category system based on the maximum expected gust wind speed at the edge of the eye of the cyclone. The wind speed at your home can be different to the wind speeds reported by the Bureau. The five cyclone categories are outlined in the table below.

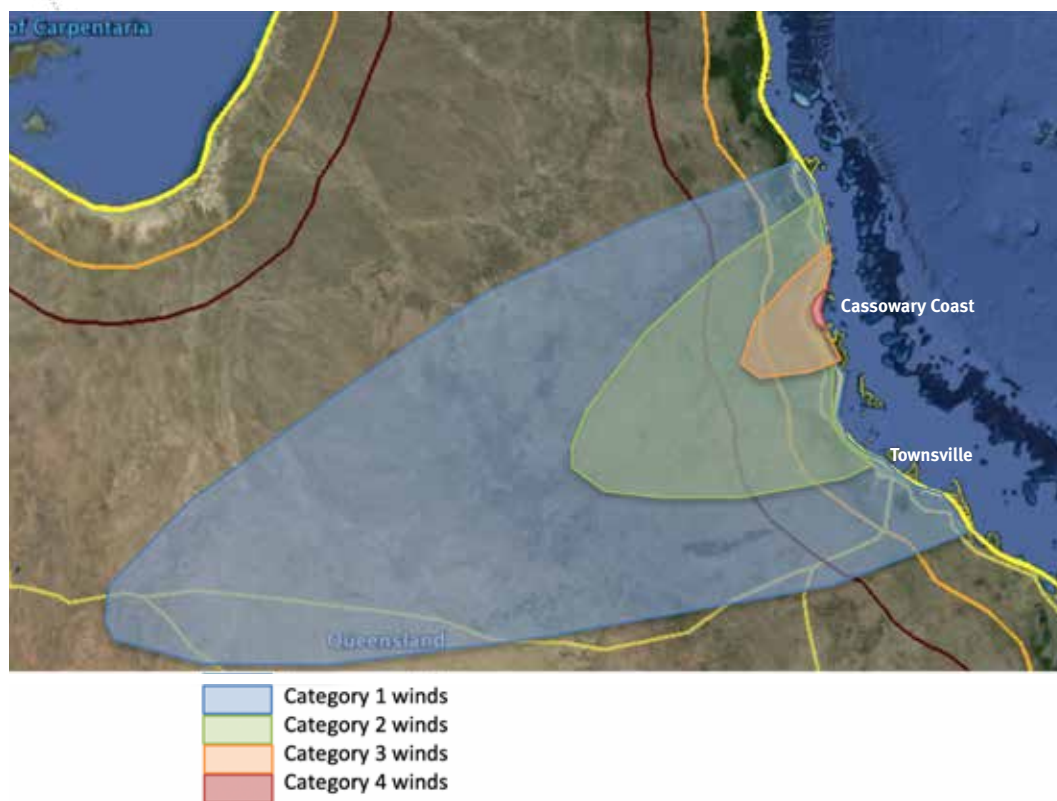
### Cyclone categories from the Bureau of Meteorology

Cyclone category	Strongest gust (km/h)	Typical effect (indicative only)
<b>One</b>	less than 125 km/h	<ul style="list-style-type: none"><li>• minimal damage to homes</li><li>• damage to some crops, trees and caravans</li><li>• boats may drag their moorings</li></ul>
<b>Two</b>	125-169 km/h	<ul style="list-style-type: none"><li>• minor damage to homes</li><li>• significant damage to signs, trees and caravans</li><li>• severe damage to some crops</li><li>• risk of power failure</li><li>• small boats may break moorings</li></ul>
<b>Three</b> (severe)	170-224 km/h	<ul style="list-style-type: none"><li>• damage to some roofs</li><li>• structural damage to older homes that haven't been upgraded and maintained</li><li>• destruction of some caravans</li><li>• likely power failure</li></ul>
<b>Four</b> (severe)	225-280 km/h	<ul style="list-style-type: none"><li>• significant loss of roofing</li><li>• significant structural damage to older homes that haven't been upgraded and maintained</li><li>• many caravans destroyed and blown away</li><li>• dangerous airborne debris</li><li>• widespread power failures</li></ul>
<b>Five</b> (severe)	greater than 280 km/h	<ul style="list-style-type: none"><li>• extremely dangerous with potential for widespread damage to buildings</li></ul>

Maximum wind speeds decrease as the eye of the cyclone moves inland. Generally, the wind speeds near the eye drop as the cyclone travels inland and wind speeds are reduced further from the eye.

Weakened cyclones frequently pass into non-cyclonic areas, but by then the wind speeds are much lower than when they crossed the coastline. For example, Severe Tropical Cyclone Yasi was a Category Five cyclone that formed over the Coral Sea and crossed the coastline with wind gusts in the Category 4 range. Homes located approximately 50 kilometres from the eye of the cyclone experienced winds equivalent to a Category 3 event. As the cyclone tracked further inland, the cyclone weakened and gust wind speeds decreased. The media referred to Severe Tropical Cyclone Yasi as “Category 5 STC Yasi”, but the majority of homes did not experience Category 4 or 5 wind speeds – for example those in Townsville experienced Category 1 or 2 wind speeds.

*Estimated maximum gust wind speeds in Queensland from Severe Tropical Cyclone Yasi (2011)*



## Cyclone categories for recent Queensland events

Severe Tropical Cyclone	Year	Area	Impact
<b>Debbie</b>	2017	Whitsundays	<ul style="list-style-type: none"> <li>Airlie Beach (Category 1)</li> <li>Proserpine (Category 2)</li> <li>Bowen (Category 2 and 3)</li> </ul>
<b>Marcia</b>	2015	Rockhampton	<ul style="list-style-type: none"> <li>Shoalwater Bay (Category 4)</li> <li>Rockhampton (Category 1 and 2)</li> <li>Yeppoon (Category 2 and 3)</li> </ul>
<b>Yasi</b>	2011	Cassowary Coast	<ul style="list-style-type: none"> <li>Cassowary Coast (Category 3 and 4)</li> <li>Townsville (Category 1 and 2)</li> </ul>
<b>Larry</b>	2006	Innisfail	<ul style="list-style-type: none"> <li>Innisfail, Babinda and Kurramine Beach (Category 3)</li> </ul>

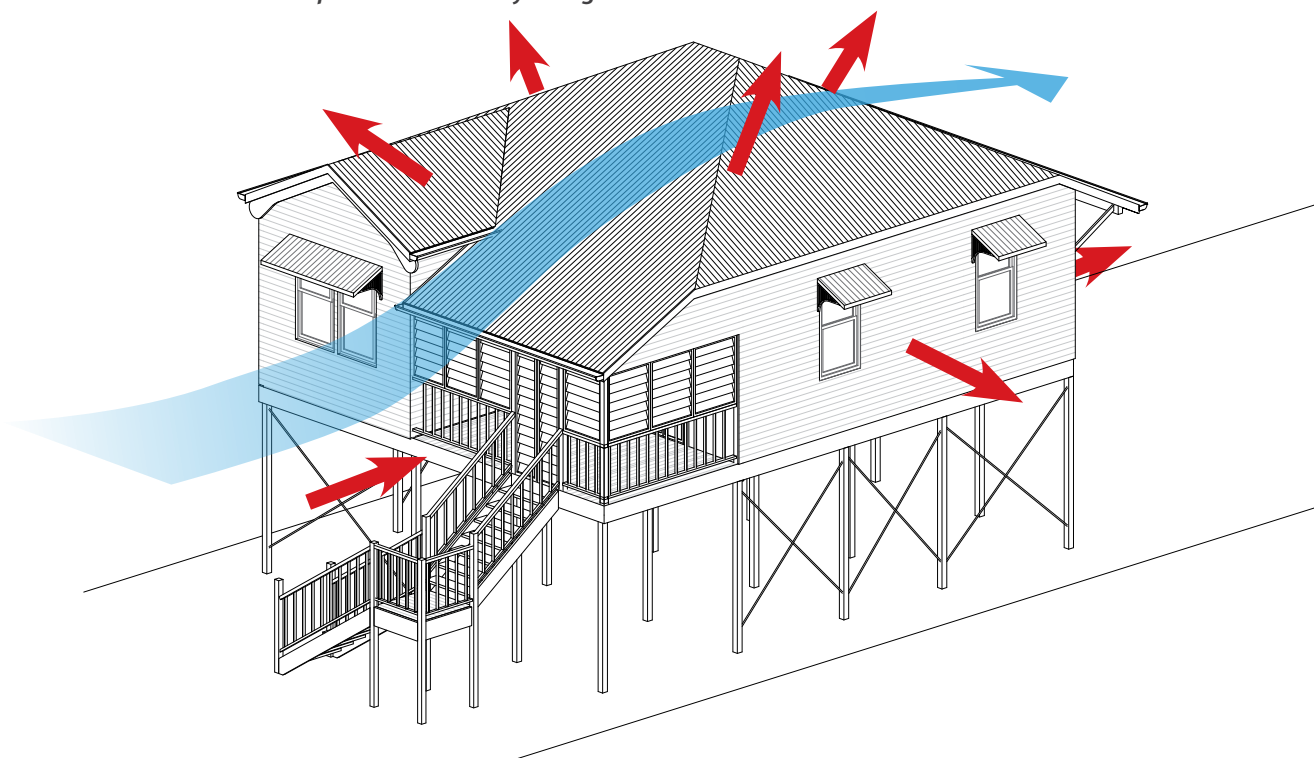
### 3 Impacts from cyclones

Strong winds will generate pressures on both the inside and outside of a home, which will result in building damage if the structure is not built to withstand those pressures.

#### 3.1 External wind pressures

Wind applies inward pressure and outward suction to different external surfaces of a home. It places pressure on the wall facing the wind (windward wall) and suction on all other walls and the roof. Wind pressure tends to push the windward wall into the home, while suction tends to pull the other walls and roof outwards and upwards. These pressures act directly on the external cladding materials and are transferred by nails, screws or bolts to the structural elements underneath them.

*External wind pressures caused by strong winds*



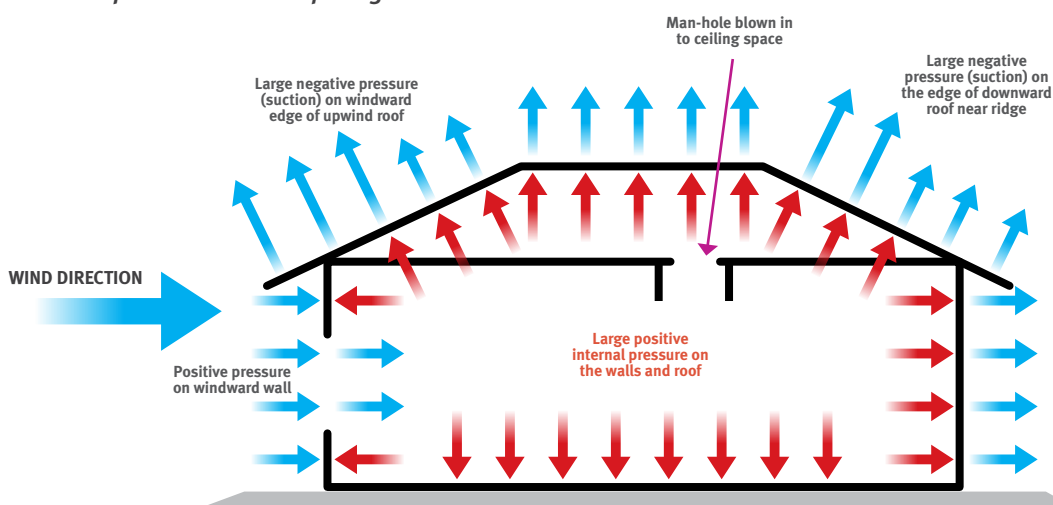


### 3.2 Internal wind pressures

Openings in the windward wall will allow wind to enter the home, causing high internal pressures. The internal pressures push upwards on the underside of the roof, which adds to the upward forces caused by suction on the external roof surfaces. These openings are most often windows, doors or holes in cladding that can be caused by:

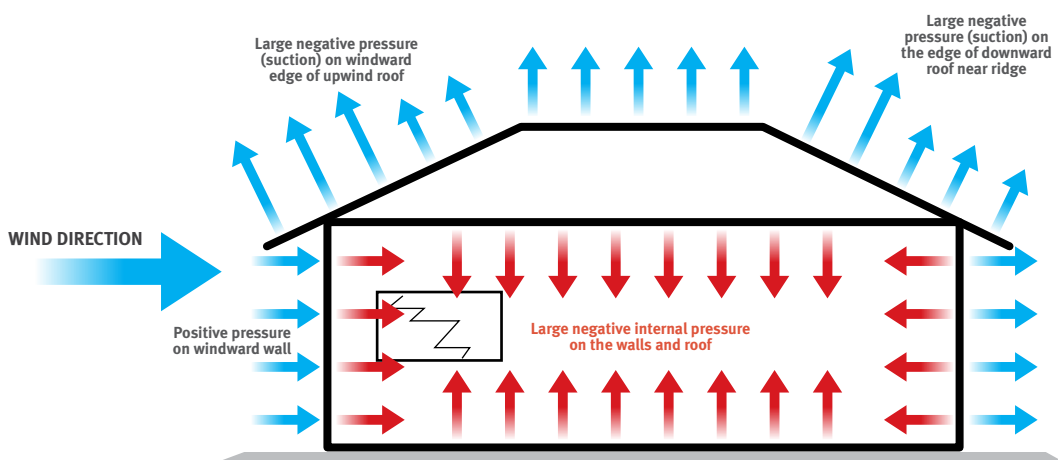
- failure of building elements that are not strong enough to withstand the wind loads
- wind-borne debris that can break windows or doors and fracture wall cladding
- failure of door and window latches or hinges
- leaving a door or window open.

#### *Internal pressures with an opening on windward wall*



Openings on other walls will cause suction on all internal surfaces. The combination of suction on internal surfaces and pressure on the windward wall increases the loads on windows and other elements on the windward wall.

#### *Internal pressures with an opening on a side wall*

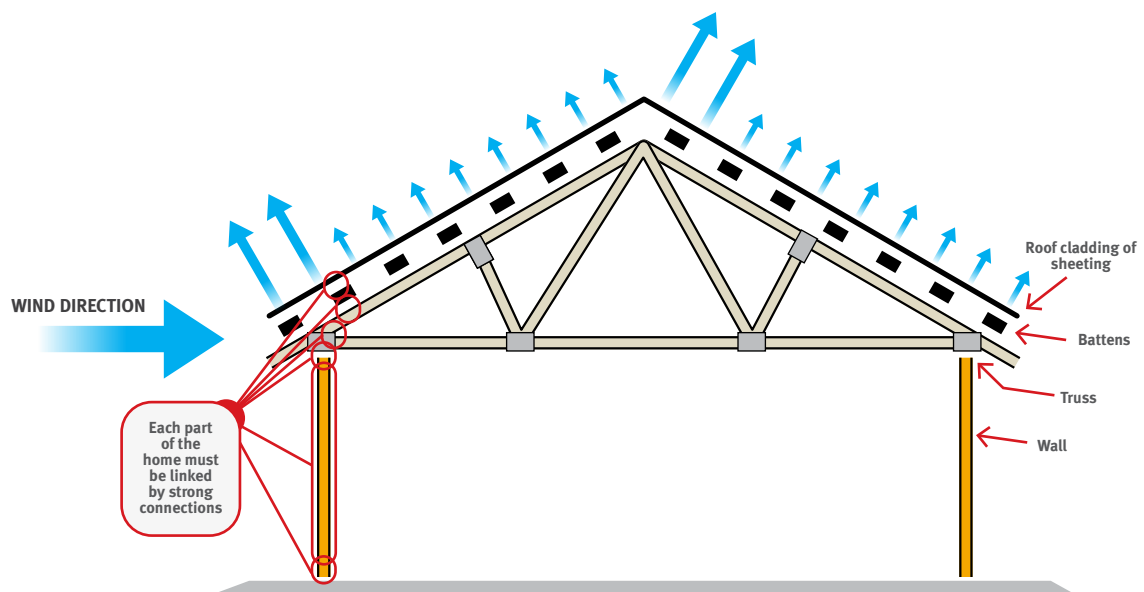


### 3.3 Wind loads on homes

Wind pressure on both the inside and outside of a home create forces that must be transferred by structural members (e.g. trusses, wall studs) and connections (e.g. straps, framing anchors) all the way to the ground.

The image below illustrates the concept of a continuous chain of structural elements and connections that transmit the forces from the roof cladding to the ground. Each link in the chain is vital as it only takes one weak connection for cyclonic winds to damage a home.

*Structural elements carry wind loads to the ground through a continuous chain of structural links provided by strong connections between each part of the home*



### 3.4 Wind damage to homes

If there is a weakness in the building structure, wind can lift off all the elements above that weakness. This is illustrated in the following sequence of photos taken during investigations of damage following cyclones.

The image below shows a home with roof sheeting that was not properly fixed to the roof structure. As a result, the main damage to the home was loss of roof sheeting.

*Roof fasteners were not installed in accordance with manufacturer recommendations. As a result, cyclone winds caused loss of roof cladding.*



The image below shows a home with the roof sheeting properly fixed to the battens. However, the battens were not adequately fixed to the trusses. As a result, cyclone winds lifted the battens and roof sheeting from the home.

*Inadequate batten to rafter connections – a common issue in older homes.*





The images below are of homes with roof sheeting that was properly fixed to the battens and the battens properly fixed to the trusses. However, the trusses were not correctly fixed to the walls enabling cyclone winds to lift the entire roof from both homes, including trusses, battens and roof sheeting.

***Homes with inadequate roof truss anchorage***



The image below shows a home where the whole roof was properly connected together, but problems existed in the way the walls were fixed to the floor. As a result the wind lifted the whole roof and most of the walls.

***Inadequate tie-down through the entire structure.***



The key to minimising damage to your home during a cyclone is to have a qualified building professional check that the chain of connections between the roof cladding and the ground has been properly designed and constructed, and that all elements are kept in good condition through appropriate inspections and maintenance.

**If you have had any damage at all in a previous cyclone, engage a qualified building professional to inspect your home. Ask them to clearly list the items that can be repaired and those that need to be replaced.**



### 3.5 Myth busters

There are a number of urban myths around effective cyclone preparation that have been disproved following experiences during past cyclone events.

Myth	True or false
<b>Taping an 'X' on your window will prevent it from breaking.</b>	<b>False</b> – this will not prevent your window from breaking. <b>Useful tip</b> – <i>tape a plastic sheet to the edge of the window frame on the inside to reduce wind-driven rainwater coming into the home. Refer to <b>Section 3.7</b>.</i>
<b>Open windows on the lee side and close them on the windward side of the home.</b>	<b>False</b> – this would require you to continually monitor the wind direction and would put you at risk of injury if debris breaks a door or window. <b>Useful tip</b> – <i>shelter in a small room with no or small windows to keep safe from injury.</i>
<b>Debris screens are only needed on the side of the home facing the ocean.</b>	<b>False</b> – wind directions often change during a cyclone. <b>Useful tip</b> – <i>install debris screens on all windows. Refer to debris screens in <b>Section 9.10</b>.</i>
<b>Whirlybirds (small roof top ventilators) help keep your roof on.</b>	<b>False</b> – whirllybirds can be damaged by wind or debris and allow both wind and water to enter into your roof. <b>Useful tip</b> – <i>install a close-fitting, heavy duty plastic bag around the whirllybird to help minimise damage during a cyclone.</i>

### 3.6 Debris

Debris from damaged buildings, broken trees or loose objects can be picked up by strong winds and become dangerous projectiles, which pose a safety risk and cause damage to homes.

**Clean up your property at the start of the cyclone season. Remove any loose items in your yard, and securely tie down caravans and boats when a cyclone alert is issued.**

The images below are examples of damage caused by debris. Debris can be any shape or size, from broken roof tiles to small boats, and has the potential to significantly damage homes or cause severe injury. Debris can only collide with walls and roofing located on the windward side, so people should stay well away from windward walls and windows during a cyclone.

*Examples of damage caused by debris during a cyclone*



Debris can create openings in the walls and roof of a home. It is therefore important that homes in cyclone areas are designed to cope with the increased internal pressure caused by damage to openings from debris.

### 3.7 Wind-driven rain

Cyclonic winds produce pressure differences between the inside and outside of a home, particularly on the windward wall. The pressure difference can force rainwater through gaps and spaces that it would otherwise not penetrate. The airflow around and over the home can also drag rainwater upwards, therefore flashings that are designed to channel downward-moving water away from the building are less effective during cyclones.

Rain entering homes through damaged linings, under flashings or through windows and doors can often damage plasterboard wall linings and ceilings, floor coverings and personal belongings, even when no structural damage has occurred.

Significant volumes of water can enter the windward side of undamaged homes as follows:

- through weep holes in frames of windows and glass sliding doors
- through worn or damaged seals on windows and doors
- through windows or glass sliding doors with flexible sashes
- around flexible, inward opening swinging doors
- up valley gutters
- under flashings at the junction of walls and the roof, or walls and balconies, or around windows.

The images below are examples of damage caused by rainwater entering homes during a cyclone.

*Rainwater bubbling through weep holes in windows*



*Water on timber floor*



*Damage to plasterboard ceiling*



*Mould on ceiling*



**Do not stand in front of windows to mop up water during a cyclone. You could be badly injured if wind-borne debris breaks the window.**

The best way to reduce water coming through undamaged windows is to tape a plastic sheet to the inside of the frame before the cyclone approaches. The tape needs to provide a good seal along the edges and across the bottom of the frame. The plastic sheet should be the full width along the window frame and at least 400 mm high. Water that is blown through the weep holes can be trapped behind the plastic and drain back out through the sill to the outside when there is a break in the wind.

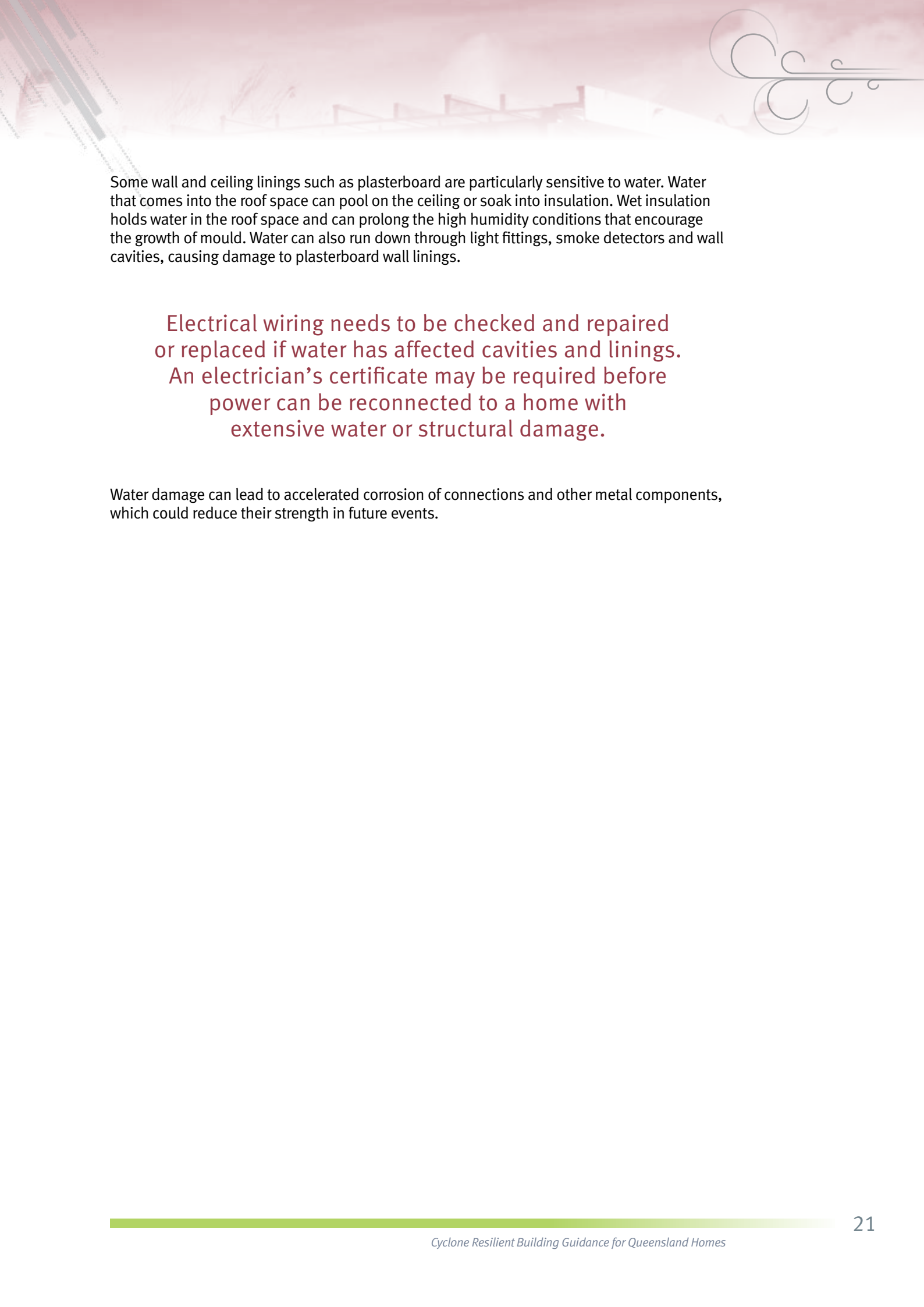
*Window with a plastic sheet taped on the edges of the inside of a window*



Even minor damage to the surface of your home can allow significant volumes of water in. For example:

- inadequately fastened flashings can be ripped from roofs and cause partial loss of roof sheeting, which allows water to enter into the roof space
- damaged soffits and eaves can allow water blowing up the outside of the windward wall to enter the roof space
- broken windows or doors can allow water to be blown directly inside
- loss of gutters can allow water to be blown into the roof space.





Some wall and ceiling linings such as plasterboard are particularly sensitive to water. Water that comes into the roof space can pool on the ceiling or soak into insulation. Wet insulation holds water in the roof space and can prolong the high humidity conditions that encourage the growth of mould. Water can also run down through light fittings, smoke detectors and wall cavities, causing damage to plasterboard wall linings.

**Electrical wiring needs to be checked and repaired or replaced if water has affected cavities and linings. An electrician's certificate may be required before power can be reconnected to a home with extensive water or structural damage.**

Water damage can lead to accelerated corrosion of connections and other metal components, which could reduce their strength in future events.

## 4 Understanding your risk

All new homes built in Australia must be assigned a wind classification or the engineer must calculate design wind pressures. This classification is used by engineers and builders to make sure your home is properly designed and constructed. Homes built before the 1990s may not have a wind classification.

### 4.1 Wind loading standards

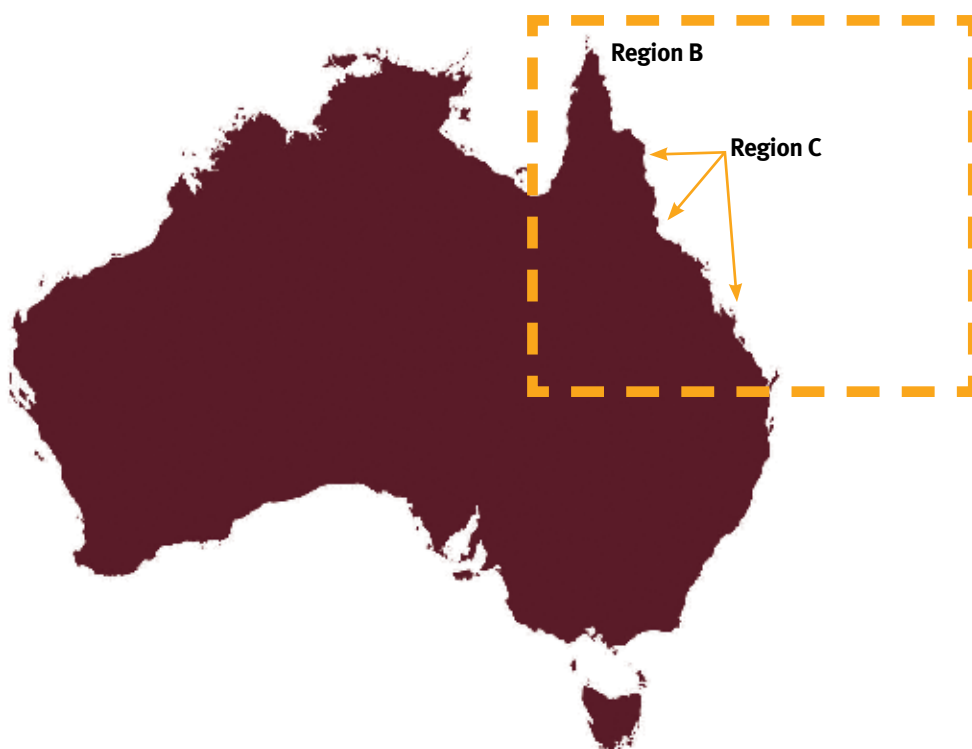
There are two wind loading standards that can be used in the structural design of homes in Australia:

- **AS/NZS 1170.2 – Design actions, Part 2 wind actions.** This is a general wind load standard used by engineers for most types of buildings. It can be used for all homes regardless of size.
- **AS 4055 – Wind loads for housing.** This standard can only be used for one and two storey homes. Most homes can be designed using AS 4055. However, if a home has three storeys, a large floor area or is an unusual shape, engineers must design your home to wind loading standard AS/NZS 1170.2.

Designing your home for high internal pressures is a sound investment in strengthening the wind resilience of your home. It is recommended you discuss this with your licensed builder.

### 4.2 Wind classifications in cyclone prone areas

Coastal areas north of Bundaberg are classified as Wind Region C. Homes in this area are designed to resist a cyclone with winds of 250 kilometres per hour, which the Bureau of Meteorology classifies as a mid-category four.



Homes in Wind Region C that are designed using AS 4055 have a cyclone classification of C1, C2, C3, or C4 depending on the local features at the site such as:

- proximity to large bodies of water or open country
- whether or not it is on a hill
- whether it is surrounded by other buildings.

Homes built on hillsides or on open terrain are exposed to stronger winds and must be designed and built for a higher wind classification than homes built on flatter land surrounded by other buildings.

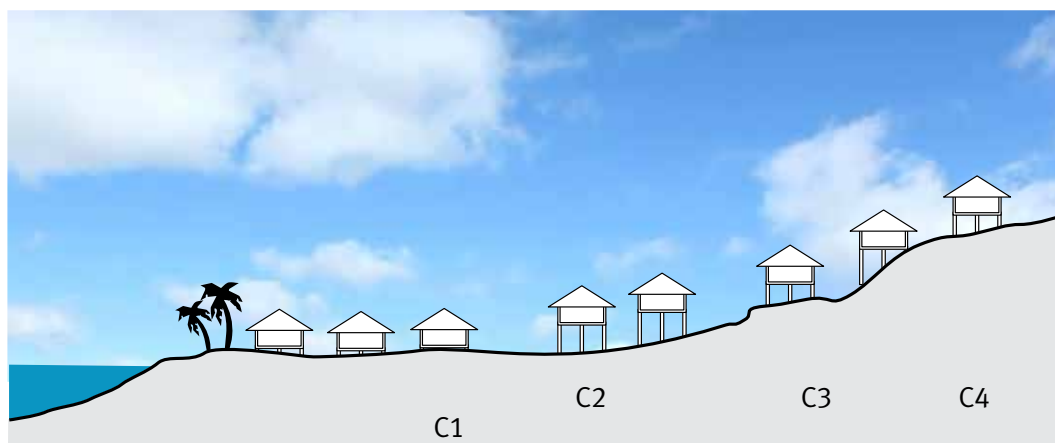
The Wind Region C classification relates to the wind speed expected at the roof level of the home site for a cyclone with gusts of 250 kilometres per hour. C1 and C2 classifications are used for less exposed sites and C3 and C4 are used for more exposed (open) sites.

### Wind classification categories based on expected wind speeds

Wind classification	Design site wind speed (Vh)		Bureau measured wind speed
	m/sec*	km/h	km/h
<b>C1</b>	50	180	250 (Category 4)
<b>C2</b>	61	220	250 (Category 4)
<b>C3</b>	74	267	250 (Category 4)
<b>C4</b>	86	310	250 (Category 4)

Homes located on hilltops can experience much higher wind gusts than those on lower lying flat land. As a general rule, the wind classification is related to the view from the home – the better the view, the higher the wind classification.

#### *Examples of wind classifications for different locations*





### 4.3 Estimating your wind classification

As a general guide, your wind classification can be related to the view from your home as follows:

- **No view – usually C1.** This classification is used only for homes situated on flat land that is located away from the shoreline and surrounded by many other buildings.
- **Some view – usually C2.** This is the most common classification for homes in cyclone prone areas in Queensland. It is appropriate for homes with a view past the surrounding homes on gently rising ground. It is also used for homes located a street or two away from the coastline.
- **Good view – usually C3.** This classification is used for homes with a view over the surrounding streets or out to sea.
- **Really great view – at least C4.** This is the highest cyclone wind classification and applies to homes built on the tops of hills or on rising land near the coast. An engineer may be required to design all structural elements in these homes.

The wind classification is determined by a trained building professional such as an engineer, builder or building certifier. The wind classification is used by all designers and construction trades to select appropriate building components such as roofing, structural connections, windows or garage doors to resist the wind forces likely to be experienced over the lifetime of your home.

You can improve the wind resistance of your home by asking your builder to use the products and details for a higher wind classification. For example, if your home is classified as C1, request that it be designed and built using C2 details.



## 5 Resilient building design principles

The National Construction Code provides minimum construction requirements for safe housing. If you choose to do more than the minimum requirements for some features, the additional cost can be much lower than the cost of replacing the same items on a completed home or repairing the damage to floor coverings and linings caused by a cyclone.

### 5.1 Resilient building options

Discuss the following options with your builder. Some of these items are in addition to those addressed in building codes and standards.

**Resilient building options table**

Option	Benefit
Consider the water penetration performance of different windows with the required wind rating. Some materials and systems allow less water into a home under severe wind loads than others. Consider: <ul style="list-style-type: none"><li>• different window seals</li><li>• types and configuration of weep holes.</li></ul>	Reduced water damage to linings and contents
Install additional bolts and stronger hinges to entrance doors so they are less likely to blow open during a cyclone.	Reduced internal water damage
Strengthen the walls and ceiling of one or two rooms located at the centre of the home to create a strong compartment that can be used for shelter during a cyclone. Remember, sheltering inside the home is only applicable if you are not located in a storm tide zone.	Provides safe shelter in even very severe cyclones and in the event the home is struck by wind-borne debris
Install additional clips on gutters so that they are less likely to blow off during a cyclone.	Reduced internal water damage and reduced repair costs
Install suitable cyclone screens or shutters to protect windows from debris.	Protects windows from debris. Shutters can also reduce entry of wind-driven rainwater.
For homes close to seawater, use components and connections that have higher levels of corrosion resistance.	Slower deterioration of building elements to maintain the strength of your home
Design for a higher wind classification.	Reduced level of damage in all cyclones



## 6 Building new homes to resist wind

When building a new home, your builder must ensure the following:

- it is designed to current standards
- it complies with the National Construction Code
- it has council approval.

The correct wind classification for your home should be marked on the building plans or contract. Homes located in higher exposure areas (e.g. on hills or facing large open bodies of water) must be designed to resist larger wind forces and should have a higher wind classification as outlined in **Section 4** of this Guide.

Structural connections and details must be selected based on the correct wind classification. All windows and garage doors must also be rated to the wind classification shown on the plans.

### 6.1 Building in storm tide-prone areas

If your site is located close to a shoreline or tidal creek, your home will require additional features to minimise damage caused by storm tide. For further information, refer to the *Storm Tide Resilient Building Guidance for Queensland Homes*.

## 7 Improving the resilience of existing homes

Regular inspection and maintenance of your home is critical to maintaining cyclone resilience.

Homes built before the mid-1980s are generally at higher risk of damage in cyclones than newer homes. If you live in an older home, it is important to seek advice from an engineer or builder to identify ways to reduce the vulnerability of your home. A professional will inspect and assess the structure of your home and provide recommendations for maintenance or upgrades that strengthen the wind resilience of your home during a cyclone.

The wind classification of your home may not have been determined at the time it was built. A building professional can assess your site and determine the wind classification, which can then be used to select the appropriate connections, materials and products that will help keep you and your family safe in a cyclone.

The Cyclone Testing Station has several useful videos on building, maintaining and renovating homes in cyclone areas. For more information visit [www.jcu.edu.au/cyclone-testing-station/videos](http://www.jcu.edu.au/cyclone-testing-station/videos)

### 7.1 Regular inspection and maintenance

Some building materials can deteriorate over time. Examples include:

- corrosion of steel elements including structural members, straps and connections, or concrete reinforcement
- rot or termite attack in timber.

The rate of deterioration depends on several factors including proximity to salt spray, moisture levels and coating protection on metal elements. Inspection and maintenance of key structural elements by a building professional should be undertaken for all homes at the following times:

- after a cyclone has damaged buildings in your community
- whenever roofing is removed (such as when replacing roof sheeting)
- every seven to ten years.

**Engage a certified building inspector or licensed building professional to inspect your home and ask them to clearly list the items that can be repaired and those that need to be replaced.**

If an inspection uncovers building elements that do not meet the requirements for the wind classification of your home, upgrades should be undertaken to improve wind resistance in future events.

## 7.2 Structural and general maintenance

The ability of a home to withstand a cyclone can be reduced if building elements have corroded or rotted due to lack of building maintenance

### *Roof loss caused by corroded roofing screws*



The above image shows roof damage from a cyclone as a result of screws becoming corroded, making them ineffective against strong winds. Routine roof maintenance should include the replacement of corroded fasteners to prevent this type of damage from occurring.

The image below was taken during an inspection of damage following a cyclone. From the outside the home appeared to have no damage. However, closer inspection identified that many batten-to-rafter connections had started to fail and needed to be upgraded with screws or straps to reduce the risk of the roof lifting off in future cyclones.

### *Partial failure of batten to rafter connections during a cyclone*



Structural inspections will help identify any elements that may not function properly in a future cyclone. The following rusted or rotted members should be replaced:

- structural elements within the roof space such as roofing screws, batten to rafter/truss connections and roof to wall connections
- verandah posts and connections
- sub-floor structures, home stumps, sub-floor bracing and steel bolts.



General maintenance activities include:

- tightening bolts and screws
- reapplying protective coatings to metal and timber elements so they remain in good condition
- replacing any elements that have broken, been incorrectly installed or have deteriorated.

*Corrosion at the base of veranda post – the post needed to be replaced, not just painted over.*



*Rot in part of the sub-floor structure. The timber needs to be replaced, not just painted over.*



*Rotten members such as this veranda post may fail under strong wind loads.*





### 7.3 Renovations and additions

Most renovations and additions involve removing part of the external and/or internal cladding. This provides an opportunity to check exposed structural connections and identify any deficiencies. If an inspection identifies deficiencies in an existing part of the home, it is important to upgrade this section of the home before continuing with new work.

Designers and builders will need to check the wind classification of your home in order to draw up plans with the correct details for the site. All new building work will require approval by council or private building certifier.

### 7.4 Replacing roof cladding

When replacing old roof cladding it may be necessary to upgrade the existing roof structure. Ask a qualified builder to assess the entire roof structure (e.g. batten to rafter/truss connections, and rafter/truss to wall connections) to check whether the tie-downs are appropriate for the wind classification of the home, and upgrade if necessary. It would be futile to install a new roof if the underlying roof structure is inadequate.

If you are changing the type of roof cladding such as a tiled roof to a sheet roof ask the qualified building professional to assess the whole roof structure to ensure it is safe for the new roofing material to be installed. Sheet metal roofs are lighter than tile roofs so the net uplift is greater. Sheet roofs also require stronger tie-downs for the battens to rafters/trusses and rafters/trusses to the walls.

### 7.5 Roof upgrades

Common upgrades to improve the resilience of your roof include:

- replacing rusted or deteriorated roof sheeting or roofing screws
- replacing deteriorated or split battens
- replacing nails with screws or straps in batten-to-rafter/truss connections under sheet metal roofs
- replacing skew nails with straps or bolts in rafter/truss to wall connections.

## 7.6 Garage doors

Older garage doors are vulnerable to damage during cyclones. Where the wind blows a garage door in, there is potential for damage to contents in the garage, and in some cases the large opening contributes to higher internal pressure that can cause damage to the rest of the home.

### *Cyclone damage to older garage doors*



Since 2015, all new garage doors installed in cyclone areas must comply with AS/NZS 4505. These doors have features such as wind locks that make it harder for the doors to blow in.

Garage door upgrade options include:

- replacing with doors that comply with AS/NZS 4505
- fitting certified temporary braces that strengthen the existing door.

The Standards Australia Handbook, *HB 132.2 Structural upgrading of older houses – Part 2: Cyclone Areas*, contains useful information for builders and designers about upgrading the structural elements of a home.



## **7.7 Other building upgrades to increase wind resilience**

Other work that will improve the resilience of your home includes installing the following:

- window shutters or screens to protect windows from debris (they need to be rated for cyclone debris resistance and have different features from security screens)
- solid front and back doors with drop bolts and heavy duty hinges
- cross-bracing for stumps of high-set homes.



## 8 Repairing or rebuilding wind-damaged homes

### 8.1 Immediately after the cyclone

Significant clean-up and maintenance checks are needed following a cyclone and will reduce the chance of further deterioration in the long term.

#### Seek professional advice

- ☐ Contact your insurance company for assessment of any claims against your policy.
- ☐ Contact a qualified building professional for advice on repairs to the roofing, roof structure, gutters or flashings.
- ☐ Contact a licensed electrician to check electrical wiring if water has come through light fittings or penetrated the roof space or wall cavities.

#### Dry out your home

- ☐ Mop up any water that has entered through windows, doors or ceilings and dry everything out. Pay particular attention to floor coverings, ceilings, insulation and wall linings.
- ☐ When it is not raining, open windows to allow air flow to further dry out internal spaces.
- ☐ Open cupboard doors to allow the inside of the cupboards to dry out. Check the condition of particleboard in built-in cupboards. If damp, take out heavy items such as plates to avoid shelves collapsing.
- ☐ If possible, undertake temporary repairs to make the home watertight. Note: in the long-term, building approvals will be required for permanent repair.

## 8.2 Planning repairs

Repairing a cyclone damaged home requires expert advice from a qualified building professional. Replacing like-for-like will not improve the resilience of your home to future cyclones. A registered builder can provide you with advice to ensure the repairs or rebuild will withstand future cyclones.

It is important to be aware that although the cyclone may have been a Category 4 at another location, the actual wind speeds experienced at the location of your home may have been in a lower category range. Any damage that has occurred at wind speeds significantly lower than the design wind speed for your home, indicates a structural weakness that needs to be addressed as part of the repairs.

### Repair checklist

Before commencing repairs, you should discuss the following issues with your builder or insurer:

- ☐ **Asbestos** – identify if asbestos needs to be safely removed before work commences.
- ☐ **Wind classification** – check the wind classification for your home is correct.
- ☐ **Appropriate connections and elements for the wind classification** – if elements failed because they were not strong enough, they need to be replaced with stronger ones.
- ☐ **Ask the builder to do a thorough inspection of the damaged and undamaged parts of your home** – where the wind forces damaged only some connections in your home, but the same details are repeated throughout the rest of the home, then the remaining connections may be susceptible to damage in future events unless they are also upgraded. Remember that the wind direction may be different in a future cyclone, and may put loads on connections that were not affected during the cyclone that caused the original damage.
- ☐ **Check and upgrade the whole structural system if part of the structure is damaged** – Partial loss of your home's structure may mean that elements lower in the home were not subjected to the full load. If the damaged elements are replaced with stronger ones (e.g. batten to truss connections), but the elements lower in the structure are left unimproved (e.g. truss to wall connections), then the weak link may now be lower in the building.
- ☐ **Corrosion resistance** – if your home is near saltwater, the fasteners and connectors should be of a higher corrosion resistance than normal.
- ☐ **Replacing a damaged garage door** – ask for doors that are designed to resist the design wind speed suitable for your location. These doors may have wind locks or other bracing systems. The wind locks transfer extra load from the ends of the garage doors into the tracks and then to mullions in the wall. The walls also need to be strengthened to resist this additional load.
- ☐ **Electrical and safety devices** – check that Residual Current Devices and other safety devices such as smoke detectors are working correctly.

Even if your home shows no obvious signs of damage from the outside, it is wise to arrange for a structural inspection to check there is no hidden damage in the roof structure, particularly for older homes that have not had recent structural upgrades.

### 8.3 Reconstruction

Approval is required if your home requires demolition. Building and planning approval is also required before rebuilding.

The reconstructed home must comply with the current requirements of the National Construction Code whilst considering the non-mandatory resilient design principles and materials outlined in this Guide.

## Finding a licensed professional

Ensure only licensed professionals are involved in the repair or rebuild of your home by checking their credentials. Visit the following websites to find a licensed professional in your area:

#### **Licensed builders, tradespersons, and building certifiers and designers**

Queensland Building and Construction Commission

[www.qbcc.qld.gov.au](http://www.qbcc.qld.gov.au)

#### **Licensed coastal and structural engineers**

Board of Professional Engineers Queensland

[www.bpeq.qld.gov.au](http://www.bpeq.qld.gov.au)

#### **Licensed architects**

Queensland Board of Architects

[www.boaq.qld.gov.au](http://www.boaq.qld.gov.au)

## 9 Resilient building materials and systems

This section provides information on the structural elements in your home and issues to discuss with a builder.

### 9.1 Selection of cyclone resilient products and materials

Building products used in cyclone regions must:

- comply with relevant Australian Standards
- have the appropriate wind rating for the location of the home
- be durable enough to perform to the required level in future cyclones  
e.g. resist corrosion, termites and rot.

They should also:

- minimise the volume of wind-driven rainwater that enters your home
- withstand water and dry out without deteriorating.

Building standards and product installation guides provide information about correct installation of building elements. A building certifier can check the design and construction of your home is in accordance with the relevant standards.

For existing homes, refer to **Section 7** for information about maintaining and renovating older homes. For homes built before the mid-1980s, it is important to consult a qualified building professional (a builder, engineer, certifier, surveyor) to carefully check the connections are strong enough and the members are still serviceable to carry future wind loads.

### 9.2 Roof cladding

During a cyclone, the uplift forces on roof cladding will exceed the weight of the roofing, which is why appropriate roofing fasteners are essential. There are hundreds of roof fasteners in a home and each one is important in helping to keep the roof on during a cyclone.

Manufacturer documentation provides information about the correct type of screws and washers required to fix metal cladding into battens for each wind classification. In the case of roof tiles, every tile should be secured to the battens by an appropriately rated clip or fixing.

**Do  
you live  
less than one  
kilometre from a  
shoreline?**

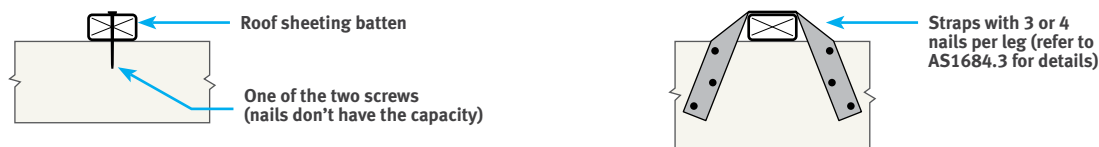
The National Construction Code requires homes within one kilometre of the shoreline to use heavily galvanised steel or stainless steel structural elements that are installed in accordance with manufacturer specifications, and should be inspected regularly.



### 9.3 Roof battens

Roof battens must be securely anchored to the roof structure to carry all of the forces from the roof cladding. Roof battens that are poorly connected to rafters/trusses are a common weakness in older homes and are at risk of failure during a cyclone. Higher uplift forces are experienced by battens near the edge or the ridge of roofs, and therefore may require stronger connections.

*Examples of batten to rafter connections appropriate for C1 and C2 wind classifications*



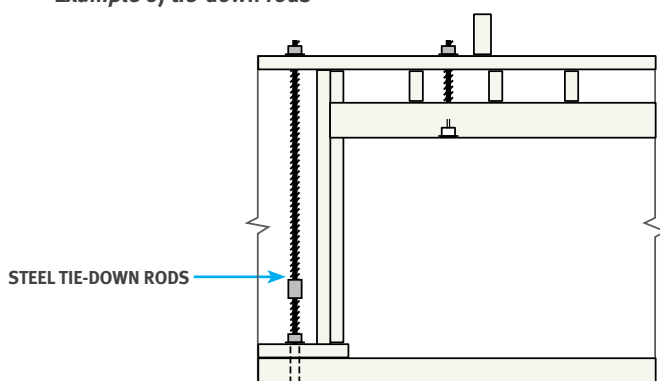
### 9.4 Rafters or trusses

Trusses or rafters must be the correct size, installed at the correct spacing and securely tied down to the top of the walls using details that are appropriate for the wind classification of that location. Girder trusses (large trusses that support smaller trusses) require even stronger tie downs than regular trusses.

### 9.5 Tie down through walls

Tie-down rods in timber framed construction, steel frame elements and steel reinforcement in reinforced masonry construction, transmit uplift forces from the roof down through the wall structure to the ground. Wall systems must be correctly anchored to the subfloor, including concrete slabs for slab on ground construction. Stronger tie-downs are also required on both sides of large openings such as glass sliding doors.

*Example of tie-down rods*





## 9.6 Bracing

Wind pushes on the sides of your home and unless there is adequate bracing in the walls, the top can move relative to the bottom of the home. Bracing systems still have to perform even if they get wet. Discuss the resilience of different types of bracing panels with your builder.

Bracing elements in walls transmit lateral load from the roof level to the floor. Bracing can be provided by bracing panels such as plywood, or by elements such as steel cross-bracing straps or timber bracing.

High-set homes require bracing elements between the floor and the ground. The bracing on the stumps of high-set homes performs an important role during cyclones and should not be removed or modified without having an engineer design an alternative bracing system.

## 9.7 Wall cladding and linings

External wall cladding must withstand wind pressures and may also be subject to impact from wind-borne debris. Discuss the strength and impact resistance of wall cladding with your builder.

Internal wall linings may get wet during a cyclone even if there is no structural damage to the home. Even minor damage such as loss of flashings or gutters, may cause large volumes of water to come into the home. Resilient linings that do not deteriorate when wet, require less repair work after cyclones.

## 9.8 Windows and doors

Windows and doors need to withstand inward wind forces on the windward wall and outward forces on the other walls (leeward and side walls).

All glass needs to be the correct thickness and type for the wind classification. All window assemblies must comply with Australian Standards, have the correct wind classification for your location and be securely fastened to the building structure.

A window supplier can provide information about the level of water tightness that various window options can provide during a cyclone. Different types of windows deliver different levels of resistance to wind-driven rain, which can limit the amount of water that comes into your home during a cyclone.

Standard entrance door locks may not be adequate to withstand cyclonic wind loads, particularly for double doors. Additional support for external doors such as bolts into the floor and head of the door frame may be required.

When ordering doors or windows, it is necessary to indicate the wind classification and whether or not the window or door will be close to a corner of the building. This is because wind pressures on windows and doors are higher near corners.

*A door that had inadequate fixing to the wall frame and inadequate door latches*



## 9.9 Garage doors

Garage doors must comply with AS/NZS 4505 and have the correct wind rating for the location of the home. In some cases, garage walls may need to be strengthened to withstand the extra loads from the wind-rated doors.

Some existing garage doors may not be wind rated, but can be strengthened using wind locks or temporary braces that are installed as part of preparing your home for an approaching cyclone.

## 9.10 Debris protection

Installing debris shutters or screens on windows and doors can improve the debris resistance of your home. It is important to note that debris screens are different from sun screens and security screens. Effective debris screens are rated by testing to indicate their resistance to impact from debris.

Shutters and screens are more effective when they are installed with an adequate space between the glass and the screen. Shutters are solid plates that are mounted in front of windows and doors. They can absorb some of the energy from wind-borne debris and also reduce the volume of water reaching the opening.

Temporary shutters can be as simple as sheets of plywood securely fastened across the window.

### *Temporary shutters installed before a cyclone*



Debris screens are open, grid-like elements that when fitted on windows and glass doors can absorb the impact of debris and lessen the chances of glass breaking. They are not effective at preventing wind-driven rainwater entry. Debris screens can be permanently fixed screens that may double as security screens, or can be temporary fitted before a cyclone.

### *Fixed debris screens*



Products that have a debris rating should have been tested to demonstrate their effectiveness against small or medium-sized debris, but this does not guarantee that the home will be protected from all debris. It should be noted that extremely large debris will exceed the capacity of most screens, and may damage external walls.

Impact from large debris increases the risk of harm to people who are sheltering inside the home. However, strengthening the small rooms where people will shelter during a cyclone reduces the risk to occupants. Incorporating plywood and/or sheet metal in the walls and ceiling linings of those rooms will strengthen them to resist debris impact. It also increases resistance to wind uplift and racking forces, and therefore, provides a strong compartment for emergency shelter.

### 9.11 Footings

Footings connect your home to the ground. They transmit lateral forces and must have sufficient weight and be deep enough to resist wind uplift forces. For example, isolated footings under verandah posts must be designed to resist the wind uplift forces from the section of roof supported by the post.

### 9.12 Sheds

Sheds are usually light-weight and subject to similar wind pressures as your home. They must be designed for the same wind classification as your home, be fastened together securely and be anchored to a footing system that can resist the substantial uplift loads. Sheds should be designed for internal pressures that may be caused by failure of their windows or doors. Poorly tied-down sheds can create wind-borne debris that can damage nearby homes. For more information visit [www.shedsafe.com.au](http://www.shedsafe.com.au)

### 9.13 Other outdoor structures

Outdoor structures and objects such as fences, shade sails, aerials, satellite dishes, solar panels, guttering and water tanks will be subjected to significant wind pressures during a cyclone. These outdoor objects should be installed and/or constructed to reduce the potential for them to become wind-borne debris.

#### Fences

It is difficult to design fences capable of resisting the lateral forces of wind loads. However, it is possible to design the base of the posts of fences so that if they fail, they remain attached to the footings. This means that the fence may blow over, but it will not become wind-borne debris. Wind forces on open mesh fencing are significantly lower than on paling fences.

#### Gutters

Gutters can unclip during heavy winds and as a result water can enter the home. Gutters may also become wind-borne debris. The cost of repairing gutters can be substantial if scaffolding is required. However, doubling the number of gutter clips will mean it is less likely to be blown off your home.

*Damaged gutters following a cyclone*





### Window, wall and roof flashings

Flashings are thin sheets of metal that keep out water around windows and the edge of roof and wall panels. Wind pressure can rip them off if they are not properly fastened. This allows wind-driven rain to damage ceiling and wall linings inside your home. It is important that all faces of the flashing are securely fastened with screws.

#### *Damage to flashings (inset shows water damage to ceiling)*



### Aerials, satellite dishes and solar panels

Aerials, satellite dishes and solar panels attract significant wind loads during cyclones. These objects should be fastened to the roof structure through the cladding rather than just fastened to the cladding. The connections should be appropriate for the wind classification of the home.

### Shade sails

Shade sails are not designed to resist cyclonic wind forces and should be taken down as part of preparation for an approaching cyclone. Flapping of unsecured shade sails during cyclones can cause significant damage to nearby windows and wall cladding.

### Rainwater tanks

Full water tanks often have sufficient weight to resist wind forces. However, empty or partially full tanks can buckle or overturn. Tank stands and their footings should be appropriately designed and constructed for cyclonic wind loads.

### Whirlybirds

Whirlybirds can spin excessively fast during a cyclone, which causes them to change shape or blow off the roof. If they are damaged, water can get into the roof space. Installing a close-fitting, heavy duty plastic bag around the whirlybird as part of preparations for an approaching cyclone can help minimise damage during a cyclone.

### Air conditioner units

Single-unit wall or window-mounted air conditioners can let through large volumes of wind-driven rain. Installing a close-fitting, heavy duty plastic bag around the air conditioner unit as part of preparations for an approaching cyclone can help minimise damage during a cyclone.





## 10 Building approvals, codes and standards

Building approvals are required from your local council or private building certifier before building a new home or upgrading and repairing an existing home.

### 10.1 Planning approvals

Planning approvals are required for most construction work. They determine what uses and activities can occur on the land to minimise any potential impact on surrounding properties. An application for a planning approval is assessed against your council planning scheme.

### 10.2 Building approvals

A building development approval from a local government or private building certifier is required for a new home or upgrading and repairing an existing home. A private building certifier is required to lodge the approval documents with the relevant local government.

Exemptions apply for minor upgrades that do not affect more than 20 per cent of the building's structural components of the same type. Refer to your local council for advice on whether a building approval is required for any planned work on your home.

Building surveyors assess the plans submitted to council to confirm they comply with the relevant codes and standards such as the National Construction Code and Queensland Development Code. This ensures that appropriate materials, products and details used in the design and construction of your home comply with the necessary standards.

### 10.3 Building approval process

A building approval is granted by a building certifier and/or your local council. The role of the Building Certifier is to confirm the proposed building complies with the relevant building codes and standards before construction can commence. They are also required during construction to inspect that the home is being built to the relevant codes and standards.

Homes in areas prone to cyclones should be designed in accordance with relevant codes and standards as indicated in this Guide. Builders should refer to a Building Certifier or local council to confirm the individual requirements for your home.

Ensure all designers, architects, builders and contractors are aware of the issues raised in this Guide.

## 10.4 Building codes and standards

Australia's comprehensive and effective building codes and standards include requirements that homes are constructed to be strong enough to withstand the wind loads for the area in which they are built for your specified design level. New construction, major renovations and repairs all require building approval and must comply with the current codes and standards. Using the current codes and standards for any repairs or rebuilding after wind damage will also give your home the best chance of performing well and safeguarding the lives of you and your family during future cyclones.

The following codes and standards may be used by your designer or builder:

1. National Construction Code; Volume 2: Building Code of Australia, Class 1 and Class 10 Buildings, Australian Building Codes Board, Canberra.
2. AS/NZS 1170.2 Structural design actions Part 2: Wind actions. Standards Australia, Sydney NSW, Australia.
3. AS 4055 Wind Loads for Housing. Standards Australia, Sydney, NSW.
4. AS 1684.3 Residential timber-framed construction – Cyclonic areas. Standards Australia, Sydney, NSW, Australia.
5. HB 39 Installation code for metal roof and wall cladding. Standards Australia, Sydney, NSW
6. AS 2050 Installation of roof tiles. Standards Australia, Sydney, NSW
7. HB 132.2 Structural upgrading of older homes – Part 2: Cyclone areas. Standards Australia, Sydney, NSW
8. AS/NZS 4505 Garage doors and other large access doors Standards Australia, Sydney, NSW.





## 11 Resources

### **Cyclone Testing Station Technical Reports**

James Cook University

[www.jcu.edu.au/cyclone-testing-station/research/reports](http://www.jcu.edu.au/cyclone-testing-station/research/reports)

### **Cyclone Testing Station videos on building, maintaining and renovating houses in cyclone areas**

[www.jcu.edu.au/cyclone-testing-station/videos-And-resources/for-the-home-owner-And-occupier](http://www.jcu.edu.au/cyclone-testing-station/videos-And-resources/for-the-home-owner-And-occupier)

### **Housing and Public Works – Building Legislation and Policy**

<https://www.hpw.qld.gov.au/services/building-plumbing>



## 12 Technical resources

### Queensland specific

#### **Cyclone Testing Station Technical Reports**

James Cook University

[www.jcu.edu.au/cyclone-testing-station/research/reports](http://www.jcu.edu.au/cyclone-testing-station/research/reports)

#### **Natural Disaster Resilience Program Storm Tide Hazard Interpolation Series**

Department of Environment and Science

[www.data.qld.gov.au/dataset/ndrp-storm-tide-hazard-interpolation-series](http://www.data.qld.gov.au/dataset/ndrp-storm-tide-hazard-interpolation-series)

#### **Coastal Hazards and Mapping**

Department of Environment and Science

[www.qld.gov.au/environment/coasts-waterways/plans/hazards](http://www.qld.gov.au/environment/coasts-waterways/plans/hazards)

#### **Storm tide monitoring sites in Queensland**

Department of Environment and Science

[www.qld.gov.au/environment/coasts-waterways/beach/storm/storm-sites](http://www.qld.gov.au/environment/coasts-waterways/beach/storm/storm-sites)

#### **National Committee on Coastal and Ocean Engineering – Publications and resources**

Engineers Australia

[www.engineersaustralia.org.au/Communities-And-Groups/National-Committees-And-Panels/Coastal-And-Ocean-Engineering/Publications-Resources](http://www.engineersaustralia.org.au/Communities-And-Groups/National-Committees-And-Panels/Coastal-And-Ocean-Engineering/Publications-Resources)

#### **Queensland Climate Change and Community Vulnerability to Tropical Cyclones – Ocean Hazards Assessment – stage 1 report, March 2001**

Queensland Government

[www.data.longpaddock.qld.gov.au/static/publications/vulnerability-to-cyclones/stage1.pdf](http://www.data.longpaddock.qld.gov.au/static/publications/vulnerability-to-cyclones/stage1.pdf)

#### **Guidances for Responding to the Effects of Climate Change in Coastal and Ocean Engineering**

Engineers Australia

[www.eabooks.com.au/Guidances-for-Responding-to-the-Effects-of-Climate-Change-in-Coastal-and-Ocean-Engineering](http://www.eabooks.com.au/Guidances-for-Responding-to-the-Effects-of-Climate-Change-in-Coastal-and-Ocean-Engineering)

### International

#### **US Geological Survey**

[www.coastal.er.usgs.gov/hurricanes/ike/photo-comparisons/bolivar.html](http://www.coastal.er.usgs.gov/hurricanes/ike/photo-comparisons/bolivar.html)

#### **US Federal Emergency Management Agency**

[www.fema.gov/media-library/assets/documents/3293](http://www.fema.gov/media-library/assets/documents/3293)

#### **FEMA Coastal Construction Manual Volume II**

US Federal Emergency Management Agency

[www.fema.gov/media-library-data/20130726-1510-20490-1986/fema55\\_volii\\_combined\\_rev.pdf](http://www.fema.gov/media-library-data/20130726-1510-20490-1986/fema55_volii_combined_rev.pdf)





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For more information

-  [www.qra.qld.gov.au/Resilient-Homes](http://www.qra.qld.gov.au/Resilient-Homes)
-  [info@qra.qld.gov.au](mailto:info@qra.qld.gov.au)
-  1800 110 841