Cyclone Testing Station
Wind Engineering Research, Testing and Community Education

JAMES COOK UNIVERSITY AUSTRALIA

CTS report to ICA:

Pilot study: Examination of strata building risks from cyclonic weather by utilizing policy claims data

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SUMMARY

The Insurance Council of Australia engaged the Cyclone Testing Station to conduct a review of insurance claims on strata properties that resulted from recent cyclones. The aim of this study was to identify factors that may be contributing to insurable losses. By increasing the awareness of all parties, including insurers, property owners and strata managers, to some of the key factors that affect losses, it may be possible to focus on opportunities to reduce risk and limit premiums. This pilot study has been based on Terms of Reference developed by the ICA Strata Insurance Working Group, as included within the report. The report also notes issues that are beyond the scope of the report.

It has been shown that the structural provisions in building regulations referenced in the Australian building code and standards are generally appropriate with respect to wind loading for the design strength limit state. Strata property and detached houses are built to the same Australian Building Code and often use the same building materials.

In most respects contemporary houses and strata property should be capable of resisting design wind events if properly designed and constructed. When specific elements are identified that warrant changes to building regulations, an ongoing process is in place to make these changes (e.g. recent changes to Australian standards to improve tile roof, soffit linings and garage doors). It is important to understand, however, that any changes will normally only apply to new properties constructed after the changes are implemented in building regulations.

It is recommended that a process of regular property inspections, with intervals of perhaps once every 7-10 years be investigated. The aim of these inspections would be to identify and prioritise any site-specific factors that might affect building performance in future severe storm events. Works carried out would make the building more resilient. It is proposed that providing an insurer with evidence that an independent inspection has been conducted and actions taken will demonstrate a reduction in risk and a corresponding reduction in premiums and excess. If significant defects of a part of the structure are found (e.g. severe corrosion of cladding) then a grace period of continued insurance should apply while rectification works are undertaken. The inspections would need to relate the structural aspects of the inspections to the building regulations at the time of the building's construction.

Water ingress from wind driven rain has been identified as a key factor in insurance claims. It is recommended that a study should commence as soon as possible, to minimize risk by seeking a greater understanding of relationship to intensity of rain and wind gusts and identify possible economic solutions in reducing the amount of water ingress and resultant damage.

The report supported by previous damage investigation reports has identified for wind speeds less than the strength design wind speed, ancillary items have taken on increasing importance in claims costs. As structural issues have been identified and acted upon, the damage from wind driven rain ingress and the damage to ancillary components (e.g. air conditioners, shade cloth attachments, aerials and fences). The failure of ancillary components has also led to damage to the main structure such as penetrations in cladding allowing further water ingress.

Contents

Limitations

Insurance Council of Australia's Project Terms of Reference (19 Dec 2012)

The Strata Insurance Working Group, comprising members who underwrite strata products in the Australian Market, have developed a Terms of Reference (ToR) aimed at examining the nature of strata property exposures in North Queensland, with a focus on three areas:

1. Current Property Exposures

a. To what extent do structural cyclone building codes create cyclone 'proof' buildings?
b. What residual damage, below the level of structural failure, is typical for strata buildings following a cyclone?
c. Are there common design or material use issues in strata properties that are linked to increased claims following a cyclone?
d. Are there differences in the loss performance of strata complexes that are single storey construction compared to high rise development?
e. Does the year of construction (or significant repair/rebuild) of a property influence the anticipated damage (before structural failure) during a cyclone?

2. Property Risk Controls – best and worst practice

a. Are there examples of strata buildings that are **less** hazard sensitive by virtue of their construction and use of materials?
b. Are there examples of strata buildings that are **more** hazard sensitive by virtue of their construction and use of materials?
c. How can it be determined if a strata building has been constructed to meet, or to exceed, cyclone building codes?
d. Are there common maintenance issues for strata properties that if left unattended may lead to an insurable loss during a cyclone event?
e. How might engineering reports be undertaken to quantify the compliance standards and any vulnerabilities, for property owners seeking to reduce an insurance premium?

3. Future Risk Reduction

a. What physical steps could be taken to improve the resilience of planned strata property to be constructed in cyclone prone regions?
b. What physical steps could be undertaken to retrofit existing older strata property to decrease the probability of damage during extreme weather events?
c. What processes could be undertaken to encourage the upgrading (to code) of strata buildings during major repairs, rebuilding or refurbishment?
d. Could a system of strata property rating and certification, for resilience to extreme weather, assist with identification and mitigation of vulnerabilities?

Pilot study: Examination of strata building risks from cyclonic weather

SECTION 1. Introduction

Strata insurance premiums in the cyclonic regions of Australia have significantly increased over the past 24 months. The ICA advises that the loss experience (loss ratio) of companies covering strata developments in tropical regions has been significant, underscoring the need to better understand the relativities and sources of losses across the strata portfolio. This pilot study is to assist with assessing the hazard in relation to building form and type of damage, and potential measures that may assist with reducing losses. An analysis of policy pricing in relation to claims is outside the scope of this pilot study.

1.1 Background

Findings from damage investigations following severe weather events provide critical information for understanding building performance. CTS damage investigations following cyclones such as Cyclone Larry (Henderson et al, 2006) and Cyclone Yasi (Boughton et al, 2011), have clearly shown a significant improvement in structural performance of housing built after the introduction of the engineered provisions introduced in the early 1980s. The damage investigations did however highlight a few issues with current construction such as loss of soffits and poor performance of roof tiles and roller doors which led to some damage.

Notwithstanding improved structural performance of buildings, the CTS damage investigations of housing construction; Boughton et al. (2011), Henderson et al. (2006) from Tropical Cyclone Yasi and Larry, and Leitch et al. (2010) from Brisbane Gap thunderstorm, have shown that wind driven rain water ingress may cause damage in residential construction. The CTS damage surveys found that that in some cases wind-driven rain passed through the building envelope at openings such as windows and doors (even if closed), around flashings, through linings or where the envelope has been damaged.

This pilot study scope examines the ICA provided data for strata properties with claims and those without claims in the NQ/FNQ region during 2010/11. The claims have been taken following Cyclone Yasi. In addition, the data needs to be related to the impacting local wind speeds which are influenced by terrain and topographic features as well as shielding. By incorporating these factors in concert with the loss data, and property information, damage levels relating to building form may then be robustly compared.

1.2 Report structure

The report is divided into three main components:

- **Section 2** is a review which presents information on the Australian Building Code, and design standards with respect to design wind speed. It also discusses the estimated wind field associated with Cyclone Yasi and findings from damage surveys.
- **Section 3** describes the provided policy data with and without claims, and the analysis in relation to wind speed and building parameters that were derived from the policy data.
- **Section 4** discusses the ICA's Terms of Reference in relation to Sections 2 and 3.

1.3 Requested data

For this pilot study, the data required is the strata book policies that had claims and those that did not for the 2010/11 period. The relevance of the results will be very dependent on the available data contained in the assessors' reports. The comparisons will be taken from policies located in regions affected by Cyclone Yasi. Along with age of property with respect to changes in Codes and Building Standards, other pertinent aspects will also be considered such as geometry, orientation, construction form, attachments, etc depending on available data.

Numerical modeling of hazard's frequency and intensities and climate to develop relativities between events and geographic regions is outside the scope of this proposal. Cost estimates of repairs that are not in the provided data are outside the study scope. Costings or a cost benefit analysis on identified possible remedial actions is not part of this scope for this phase.

Information requested from ICA for each of the Cairns, Cassowary Coast, and Townsville regions:

For each policy:
- Street address
- Town/city/region
- Post code
- Geo-tag (lat/long)
- Age of building
- Building type (e.g. single dwelling, multiple dwelling)
- Description of building (e.g. wall type, roof type, floor type, number of storeys)
- Insurance policy "home" (i.e. structure) Sum insured
- Insurance policy "contents" Sum insured
- Claims amount (if any) for Cyclone Yasi
- Date of claims (if any)
- Description of claim (e.g. cyclone damage from tree; loss of roller door, broken window, loss of roof, etc)

SECTION 2

2.1 Building Code and Standards

The Building Code of Australia's (NCC 2012) objectives, with respect to wind loads, are to;
- Safeguard people from injury caused by structural failure,
- Safeguard people from loss of amenity caused by structural behaviour,
- Protect other property from physical damage caused by structural failure, and
- Safeguard people from injury that may be caused by failure of, or impact with, glazing.

In meeting these objectives, the performance requirements are stated such that a building or structure, to the degree necessary, must;
- Remain stable and not collapse,
- Prevent progressive collapse,
- Minimise local damage and loss of amenity, and
- Avoid causing damage to other properties,

By resisting the wind actions to which it may reasonably be subjected (NCC 2012). These objectives (whether implied in standards or explicit) have been around for several decades within the States and Territories building regulation frameworks.

The Australian Building Codes Board sets the societal risk for the ultimate limit state strength of a structure, in the Building Code of Australia (NCC 2012). The level of risk is evaluated depending on the location and type of structure (refer Table 1). For example, a hospital has a higher level of importance (e.g. Level 3) that an isolated farm shed (Level 1). From Table 2, the design level for housing (Importance level 2 as noted in the NCC 2012 Vol. 2) is to be a minimum annual probability of exceedance of 1:500. The Wind loads for housing standard (AS-4055 2006) derives its wind loads for housing based on housing being Level 2 importance. The Queensland government design guidelines (Qld Govt 2006) require that cyclone shelter buildings should be designed to resist an ultimate limit state wind speed which has an annual probability of exceedance of 1:10,000. A similar rationale is used for designing structures for earthquake loads.

AS/NZS 1170.0provides designers with load combinations including wind actions to be applied on structural components and checked against their design strength. Failure occurs when the combined load exceeds the component's strength. Structures designed according to AS/NZS 1170.0:2002 should have a negligible probability of failure (i.e. < 0.001 or as a percentage, < 0.1 %) at ultimate limit state loads, that is, failures of structural elements would not be expected to occur at the ultimate limit state design load.

Table 1 NCC 2012 Table B1.2a Importance Levels of Buildings and Structures

Importance Level	Building Types
1	Buildings or structures presenting a low degree of hazard to life and *other property* in the case of failure.
2	Buildings or structures not included in Importance Levels 1, 3 and 4.
3	Buildings or structures that are designed to contain a large number of people.
4	Buildings or structures that are essential to post-disaster recovery or associated with hazardous facilities.

Table 2 NCC 2012 Table B1.2b Design Events for Safety

Importance Level	Annual Probability of exceedance			
	Wind		Snow	Earthquake
	Non-cyclonic	Cyclonic		
1	1:100	1:200	1:100	1:250
2	1:500	1:500	1:150	1:500
3	1:1000	1:1000	1:200	1:1000
4	1:2000	1:2000	1:250	1:1500

The 1:500 probability of exceedance is equivalent to saying there is a 10% chance in 50 years the wind speed will exceed the design level. This is the design approach that applies to typical housing.

2.2 Wind load design standard

The Australian and New Zealand Standard for structural design wind actions, AS/NZS 1170.2:2012, divides Australia into several regions, as shown in Figure 1, with the primary categorisation being either cyclonic or non-cyclonic zones. Windstorms can broadly be classified according to their meteorological parameters as, tropical cyclones, thunderstorms, tornados and gales. Thunderstorms and tornados are short-lived local events with their influence affecting distances of up to tens of kilometres. Cyclones generally impact coastal regions in the tropics, and extend hundreds of kilometres, therefore having the potential to cause the most damage. The cyclonic regions, including the intermediate region B, specified in AS/NZS 1170.2 run in a band along the coastline north of 30°S. AS/NZS 1170.2 excludes tornados from its scope of wind actions.

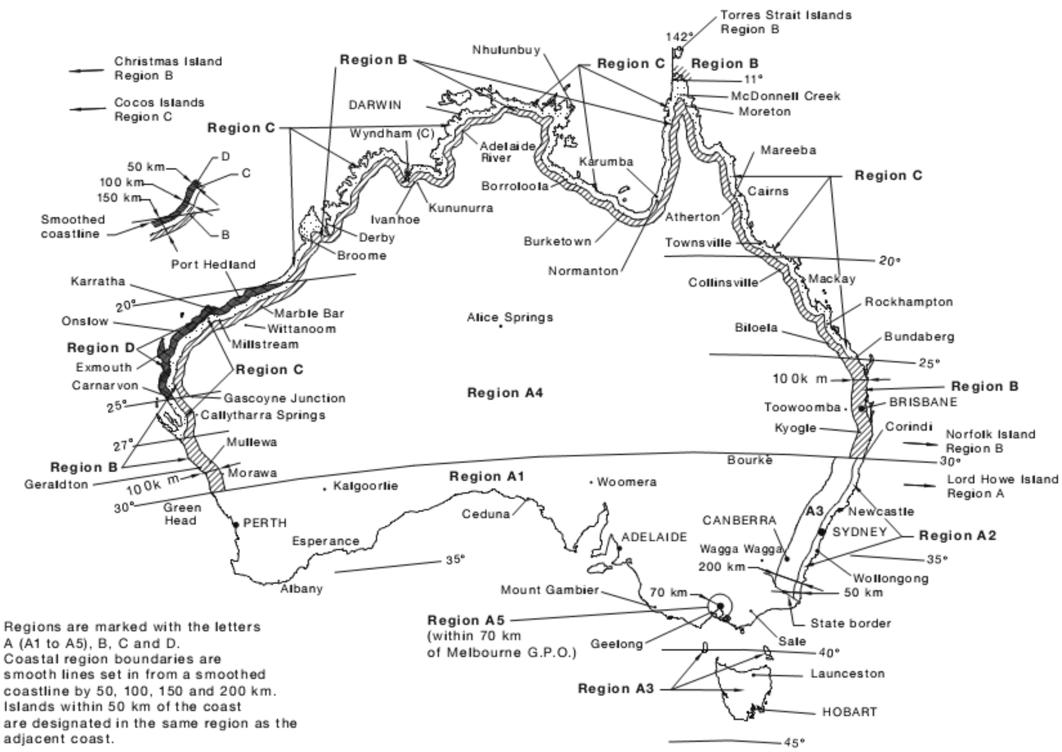

Figure 1 Wind Regions of Australia (AS/NZS 1170.2:2012)

2.3 Cyclonic regions (C and D) and Intermediate region (B)

Tropical cyclones develop over the warm oceans to Australia’s north, during the summer months from November to April, and can generate destructive winds, heavy rain and flooding to many coastal areas in Western Australia, Northern Territory and Queensland. These are severe wind events in which winds rotate clockwise around a low pressure eye with a diameter generally of about 15-50 km, track overland at varying speeds, before decaying into a low-pressure system. The passage of a cyclone past a given location will generate increasing then decreasing winds along with changing wind directions, and subject communities over which they pass to destructive weather for several hours. The impact of a cyclone is generally felt over an area of hundreds of square kilometres, over many days with the most destructive winds experienced just outside the eye. These destructive winds can cause extensive property damage and generate windborne debris. The Bureau of Meteorology categorizes cyclones with increasing severity from Category 1 to 5 according to the maximum expected gust wind speed as shown in Table 3.

Table 3. Bureau of Meteorology Cyclone Categories

Cyclone Category	Gust Wind Speed at 10 m height in flat open terrain			Central Pressure
	km/h	knots	m/s	hPa
1	90-125	49-68	25-35	>990
2	125-164	68-89	35-46	970-985
3	165-224	89-121	46-62	950-965
4	225-279	121-151	62-78	930-945
5	>280	>151	>78	<925

Historical data on tropical cyclones show erratic tracks and varying rates of decay following landfall. There is a scarcity of wind speed measurements, as only a small number of land falling cyclones have passed over meteorological stations. Therefore, probabilistic wind speed forecasts made from this limited data does have a level of uncertainty. In part this is accounted for by using factors when calculating design wind speeds in the wind loading standard, AS/NZS 1170.2 (2011).

2.4 Design for resisting wind loads

A building is required withstand its ultimate limit state design wind speeds thereby protecting its occupants. For cyclonic region C (Figure 1) as defined in AS/NZS 1170.2 (2012), the regional 10 m height gust wind speed (V_R) for a 1:500 probability is 69 m/s. From Table 3 this wind speed is mid-range for a Category 4 cyclone. The 1:500 probability of exceedance is equivalent to saying there is a 10% chance in 50 years the wind speed will exceed the design level.

Earlier forms of the wind loading standard had design criteria wind loads of similar wind speed levels. In the mid-70s following Cyclone Tracy, the standard included a revised wind speed of approximately 77 m/s for cyclonic regions. This was reduced to approximately the current level of 70 m/s in the 1989 edition.

The design V_R wind speed is at 10 m height in open flat terrain. To determine the wind load on a building, factors modifying this 10 m height wind speed need to be applied to reduce or increase V_R depending on several factors that can increase or decrease the winds. These factors include how "rough" the terrain for the wind's approach to the building. The rougher the surface, for example a suburban environment with lots of houses, reduces the wind speed at lower heights than say a large open field or airport. Conversely buildings on hills need to be designed for increased wind speeds relative to the 10 m V_R as there can accelerate up the slope (refer Figure 2)

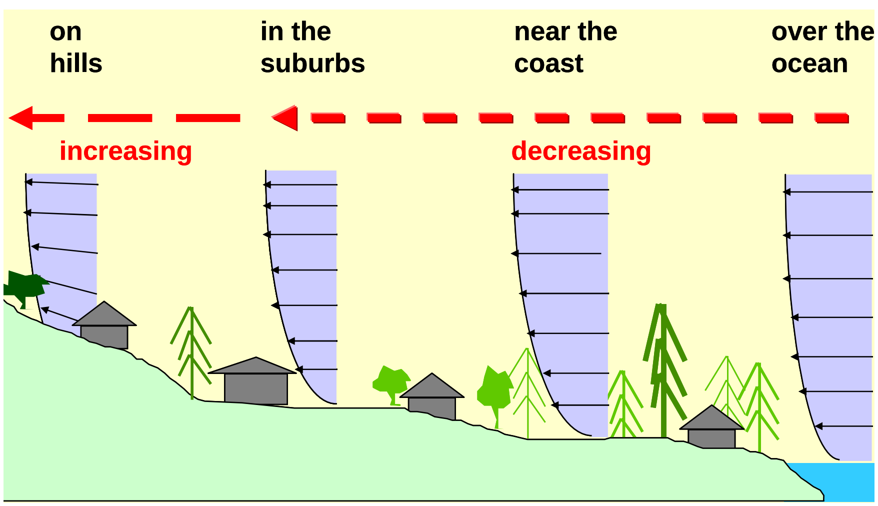

Figure 2 Representation of wind speed slowing for rough terrain and then increasing for the topographic slope

The wind field within a cyclone is a highly turbulent environment. The dynamic fluctuating winds that impact on the house will subject the structure to a multitude of spatially and temporally varying forces. Generally the design of a structure uses the gust wind speed in determining the large positive and negative pressures pushing and pulling on the building.

The wind speed impacting on the building can be related to the pressures exerted on its elements through a series of pressure coefficients defined in the wind loading standard AS/NZS 1170.2:2012. From the equation for the building's design pressure (P_{design}):

$$p_{design} = 0.5\rho V_{des,\theta}^2 C_{fig} C_{dyn}$$

Where;

- ρ is the density of air = 1.2 kg/m^3,
- $V_{des,\theta}$ is the design gust wind speed at mid-roof height of building
- And C_{fig} and C_{dyn} are factors refered to as pressure coefficients accounting for building shape etc.

Since the velocity is squared (as pressure acts over an area) small increases in velocity mean increasingly larger increases in applied pressure.

These pressure coefficients for a large variety of building geometries have been determined over many years by researchers at facilities like the Cyclone Testing Station's boundary layer wind tunnel at JCU (Reardon and Holmes 1981, Holmes 2001). The pressure coefficients take into account many factors such as the buildings overall shape, height, length to breadth ratio, wind ward openings, roof geometry and slope, and orientation to the wind, to name a few.

During a severe cyclone event, a typical house roof truss or rafter support needs to be able to resist forces pulling up on it equivalent to the weight of a small car. Figure 3 and Figure 4 give a representation of the pressures acting on a house. The high suction pressures at the leading edge of the roof can be seen. If there is a breach in the building envelope on a windward face, the interior of the house is suddenly pressurised. These internal loads act in concert with the external pressures greatly increasing the load on the house cladding elements and structure. The building envelope includes windows and doors as well as the walls and roof cladding.

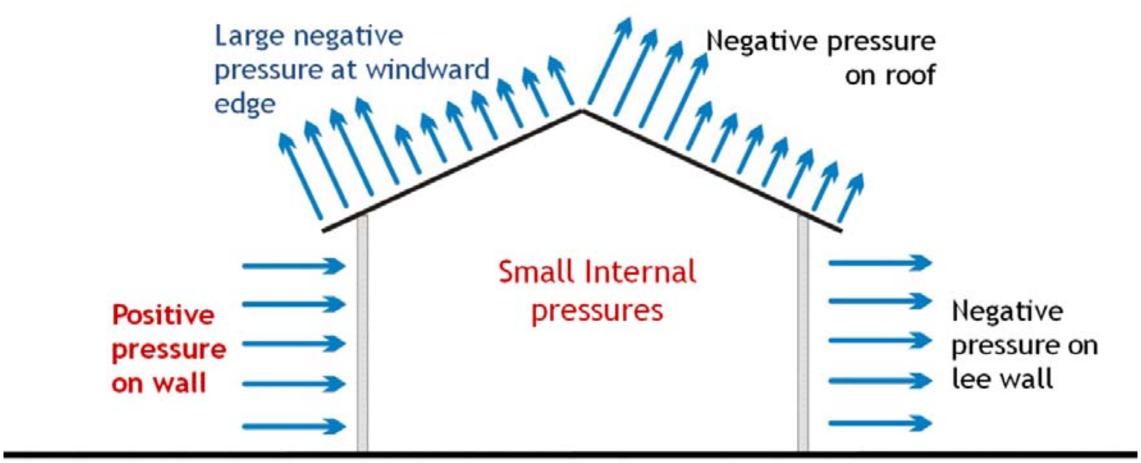

Figure 3 Representation of wind forces on a house

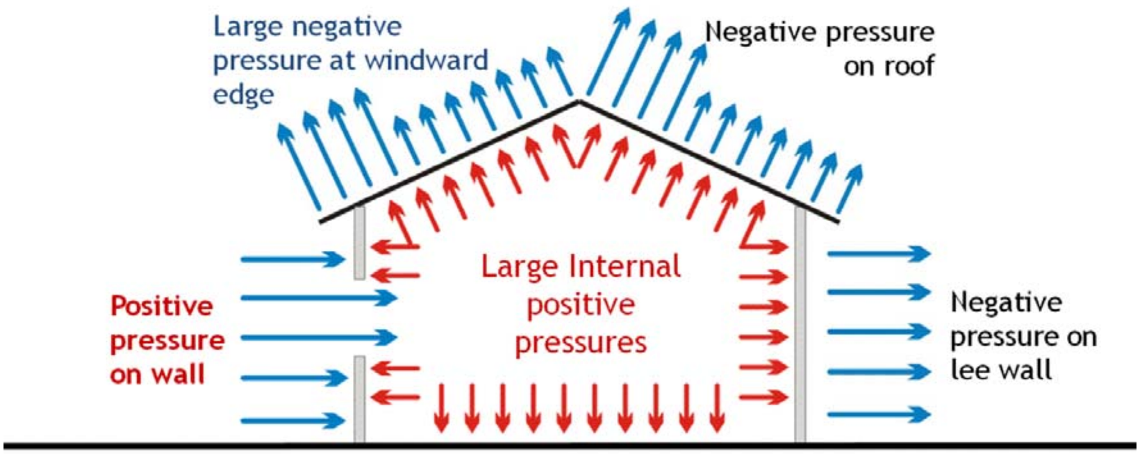

Figure 4 Wind forces with a dominant opening in windward wall

2.5 Damage investigation following Cyclone Yasi

Tropical Cyclone Yasi (TC Yasi) was a severe tropical cyclone with a relatively large diameter that crossed the Queensland coast near Mission Beach in the early hours of Thursday 3 February 2011, as shown in Figure 5. Cyclone Yasi produced structural storm surge damage and structural wind damage at various locations between Innisfail and Townsville. There were evacuations of low-lying areas between Cairns and Townsville. Many houses were also evacuated as people made decisions as to which of their friends' houses looked and felt strongest. There were no deaths caused by wind damage to structures or storm tide. The Insurance Council of Australia (2011) reported that by December 2011, over 72000 claims for a total value of $1.33 Billion had been lodged.

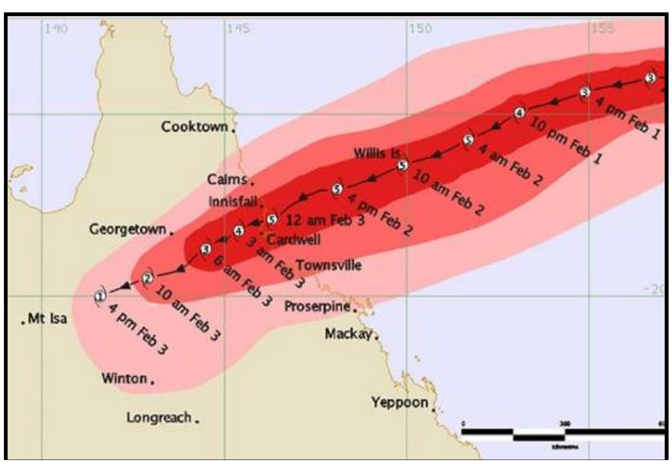

Figure 5 Track and cyclone intensity (Courtesy of Bureau of Meteorology)

Knowledge of the wind speeds impacting our communities during cyclonic events is necessary for examining the effectiveness of current design standards and building regulations. However, due to the large distances between anemometers located along the tropical coast, there were no Bureau of Meteorology anemometers in the eye of Cyclone Yasi's path during its crossing the coast. Therefore estimates of wind speeds were derived from the analysis of wind loads on simple structures such as road signs that had either failed or survived (Ginger *et al* 2012). These speeds were incorporated with a Holland wind field model to estimate, across the study area, the 0.2 second gust wind speeds, as used in AS/NZS1170.2. The method and underlying assumptions are described by Boughton *et al* (2011) and updated by Holmes (2012). The estimates of peak wind speeds are shown in Figure 6. These values have an estimated uncertainty of around -10%.

As shown in Figure 6, the estimated upper bound maximum gusts were 240 km/h. These upper bound estimates are approximately 5% less than the regional design wind speed of 250 km/h (69 m/s) for 10 m height in open terrain.

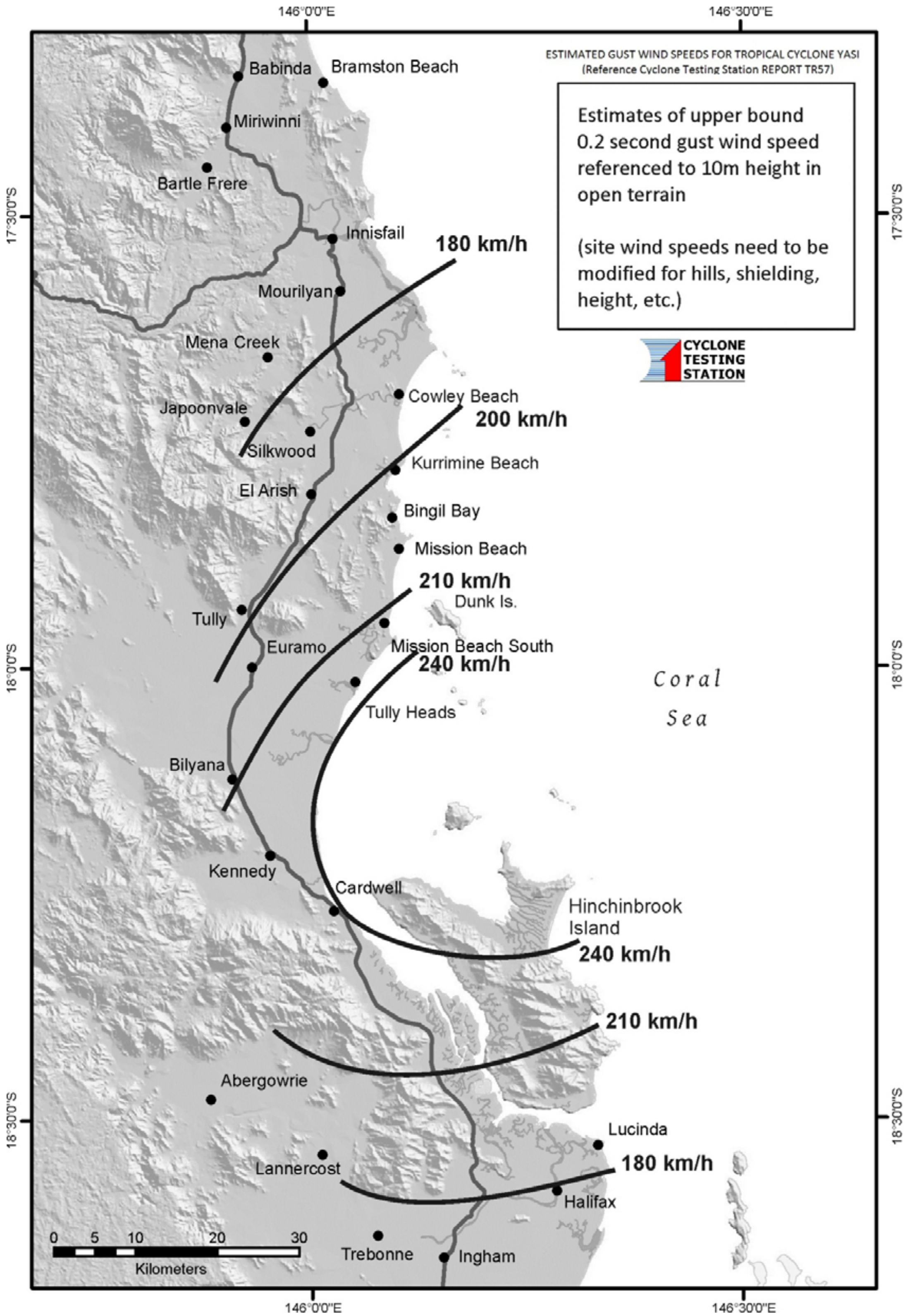

Figure 6 Estimate of 0.2s gust wind speeds during Cyclone Yasi (Boughton *et al* 2011)

Boughton *et al* (2011) conducted an external survey of nearly 2000 houses in order to obtain an overview of the extent of the damage to housing. The survey enabled quantification of the housing stock and the types of damage sustained, in terms of three damage classes for damage to roof, openings and walls as detailed in Table 4. Figure 7 shows the survey data for roof damage. The classification of houses into Pre and Post 1980s construction relates to the introduction of revised engineering deemed to comply provisions in Appendix 4 of the Queensland Home Building Code (1981).

The survey showed that 10 to 20% of houses built prior to the introduction of current building regulations (i.e. Pre-80s) suffered significant roof damage for the worst affected communities. Comparing this to the survey findings of low incidence (less than 3%) of damage to contemporary construction showed that the current building practices are able to deliver a satisfactory outcome for most of the building structure. However, this should be expected since the wind speeds were less than the regions design criteria.

Where significant damage to contemporary construction was investigated, it was observed that the failures were attributed to errors in selection of design parameters, limitations of assumptions in AS4055, poor construction practice and degradation of materials.

There were some common damage associated with building envelope elements. Garage doors (e.g. roller doors) performed poorly with the street survey documenting for houses with roller doors, 29% had door failure. Apart from the formation of a dominant opening with the potential for greatly increasing wind loads on the structure, other consequences of door failure observed included water ingress, consequent damage to structure, cladding and contents from the whipping of the door curtain, or becoming wind-borne debris.

The damage investigation showed for Post-80s house construction, damage to tile roofs was overrepresented when compared to other forms of roofing. Failure modes of the tiles were loss of ridge capping (both apex and hip tiles), loss of tiles near gable ends, and cut tiles associated with hips. On most houses that had lost ridge capping, no mechanical fixings such as clips or screws on the ridge tiles were observed. The dislodgement of the ridge or other tiles generally led to additional damage to the tile roof and to adjacent structures through wind-borne debris.

There were some examples of failures of windows and entrance doors primarily associated with exposed coastal locations or sites on hills. The failures of doors were from inadequate lock and/or drop bolts which were not able to withstand the wind pressure allowing the doors to be pushed open. Similarly, not having the appropriate frame to wall fixings for the windows resulted in the window and frame being “blown” into the house. The door and window failures then caused pressure and wind driven rain to exacerbate internal damage.

Loss of soffits, guttering and fascia was observed which in turn allows pressurisation of roof space and wind driven rain to enter. Boughton *et al* (2011) notes the repair of guttering for two storeys and above buildings requires scaffolding or similar work height protection which greatly increases the cost and time for replacement.

Table 4 Three category Damage Index

	Roof (R)	Openings (O)	Walls (W)
0	None	None	none
1	Gutters downpipes	debris not pierced	debris not pierced
2	Debris damage to roof	debris pierced	debris pierced
3	lifted < 10%	windows/doors leaked	Carport /verandah damage
4	lost roofing < 50%	Windward broken < 30%	One wall panel fallen
5	lost battens < 50%	frames lost < 30%	> 1 wall panels fallen
6	lost battens > 50%	Windward broken 30%-70%	racking damage, cladding attached
7	lost battens > 50% and lifted rafters	Windward broken > 70%	racking damage and lost cladding
8	lost battens > 50% and damaged tie-down	Windward broken > 70% and suction loss	only small rooms intact
9	lost roof structure > 50% including ceiling	100% broken / missing	no walls remaining

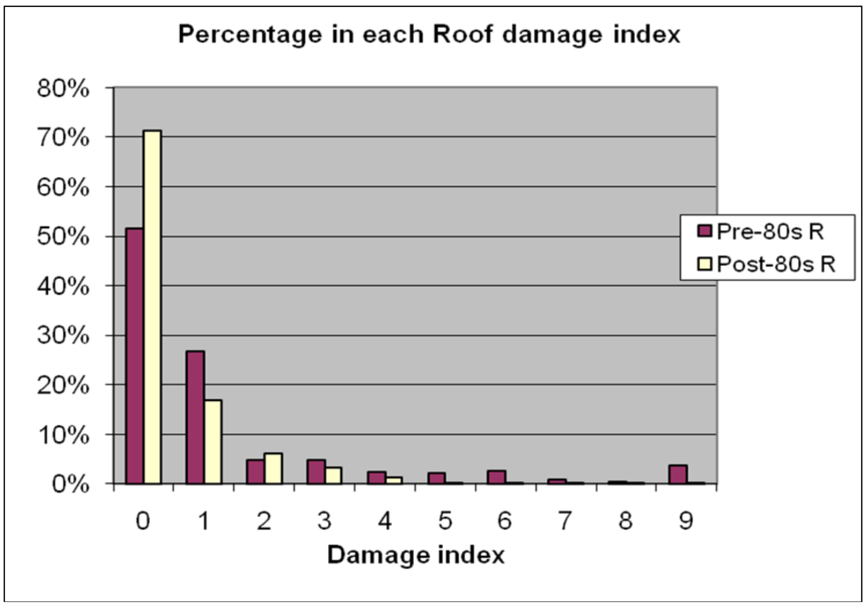

Figure 7 Damage to roof

2.5.1 Storm Tide

The storm tide accompanying a tropical cyclone is a temporary but dramatic change in sea-levels produced by the combination of low pressure and strong winds. Storm tide is caused during the cyclone's approach and passage near the coast by the combination of three different effects which are superimposed on the daily tides:

- The low central pressure can lift the water surface around 1 m.
- The friction from the wind passing over the water forces the water towards the land on one side of the cyclone. This water "piles up" against the land on that side of the crossing point.
- Wave action lifts the water surface, and the waves run up over the water edge under their own momentum. This can further transport the sea water up slopes. The combination of high water levels and wave action can be an extremely destructive force.

Design criteria in the form of building standards for construction of buildings in storm tide prone regions are not available at present. Addressing the risk to the building stock through either avoiding or resisting the loads induced by storm surge will require both planning and building design considerations. Following TC Yasi in 2011, the Queensland Reconstruction Authority (QRA) worked with relevant stakeholders such as the CTS and GHD to produce a non-mandatory guide (QRA 2011) to assist with rebuilding in storm tide prone areas. The guide notes that "*The preferred method of long term defense against storm tide impacts on new communities, especially with the threat of rising sea levels due to climate change, is avoidance of the risks through the use of responsible long term land use planning.*" However, it does provide guidelines and general advice on building design including choice of building materials and the use of "Flow-through" design for parts of the building that may be below storm tide level.

2.6 Wind driven rain – Water ingress

Water ingress in to building remains a recurring issue during windstorms in Australia as well as many other countries. The damage investigations followed by cyclones (Reardon *et al*. (1986), Reardon *et al*. (1999), Henderson *et al*. (2006), Boughton *et al*. (2011) and Leitch *et al*. (2010)) reveal that a significant number of residential construction experienced water ingress in Australia, although most of the houses survived structurally. The water ingress can damage or destroy the building's interior and its contents resulting in significant insurance payouts.

These damage surveys described that wind-driven rain (WDR) passed through the building envelope at openings such as windows and doors (even if closed), around flashings, through linings or where the envelope has been damaged. In some cases, wind-driven rain affected the structural elements of the building (e.g. complete or partial ceiling collapse). Where there was roof or gable damage, water was blown directly into the ceiling space. Loss of eves and garage linings also allowed water entry (Reardon *et al.* 1999). Water entry due to undamaged windows and wall air-conditioning units were significant during Cyclone Winifred (Reardon *et al*. 1986).

A survey (Melita 2007) conducted after Cyclone Larry, detailed building envelope failures, with approximately 75% of post-85 houses suffered water ingress through breaches in the building envelope (broken windows, punctured cladding, failed fascia or guttering, etc) or through window "seals", vents and under flashings. In many cases this has necessitated the refurbishment or replacement of internal linings and building contents.

As described by Boughton *et al.* (2011), a high differential pressure between the inside and the outside of the building can be established in strong winds. This differential pressure can force water through gaps and spaces that it would otherwise not penetrate (Pringle 2003). The air flow around and over a building in an extreme wind event can drag water upwards over the building envelope. The movement in a direction opposite to its normal movement means some flashings that channel downward-moving water away from the envelope, may direct the upward-moving water into the building.

The following points of entry of water into buildings have been observed during the investigation of Cyclone Yasi (Boughton *et al.* 2011);
Through ventilators. Ventilators in gables, soffits or in the roof surface normally keep out driven rain that has a significant downward component to its motion. However in extreme

winds, the upward component in the driven rain means that the water was driven upwards through the soffit ventilators or between the slats in gable ventilators.
Around doors and windows. The high differential pressure across the building envelope drove water through the small spaces around doors and windows and upwards through window weep holes. Some occupants reported a steady spray of water from the base of windows into rooms on the windward side of the house.
Under flashings. Wind-driven rain moving upwards against the building envelope was pushed under flashings and into the building. This effect was particularly noticeable at the top of valley gutters. Water was driven up the valley gutter by wind where the direction of the gutter was aligned with the wind direction, entered the building near the top of the gutter and caused damage to the ceiling.
Through perforations of the envelope. Where the building had performed structurally well but the building envelope had been damaged through either impact of debris or loss of soffit, fascia or guttering, water could bypass all of the normal water-tightness features of the building. Significant quantities of water entered the building by this method.

As described by Boughton *et al*. (2011), Leitch *et al*. (2010) and Henderson *et al*. (2006), regardless of the cladding material, roof complexity adds to the potential for water ingress. Valley gutters, box gutters and parapets, all require additional flashings and therefore more potential locations for water to be driven into the roof space. Sarking under tiled roofs has also been able to redirect water that has overflowed valley gutters and flashings into the eaves gutters. Particular care is needed in detailing of the sarking into the gutters if water entry into the building is to be avoided. However, in some cases where the tiles had been lifted or broken, the sarking was also damaged and this allowed water to penetrate the sarked building.

Regardless of how water enters the roof space, it saturates the ceiling. Where plasterboard is used as the ceiling material, the combination of increased weight and reduced strength means that parts of the ceiling collapse. A number of cases of soffit failure were observed during recent events. Some of these were the soffits under eaves, but an increasing trend is for large areas of soffit under an outdoor entertainment area. Soffit linings and eaves linings are in regions of the building that experience extremes of pressure or suction so need to be designed accordingly!

As observed in many damage investigations such as Walker (1975), Reardon *et al*. (1986), Henderson *et al*. (2006), Leitch *et al*. (2010), Henderson *et al*. (2010) and Boughton *et al*. (2011), damage from windborne debris is a method of water ingress in to the buildings. Debris mainly impacts windward walls (including doors and windows) and the upwind slope of steep pitch roofs. The investigations have shown that building envelopes constructed from fibre cement or metal sheeting, glass windows, roof tiles etc. can be susceptible to debris impact damage and hence increases the water ingress. Minor (2005) discussed from years of damage investigations that the building envelope should be given status equal to the principal structural frame in terms of design attention and windborne debris should be addressed, where appropriate in the design process.

Water ingress and associated damage to non-structural components of the house can be expected when heavy rain occurs with wind speeds greater than about 30 m/s (Henderson and Ginger (2008)). This damage will arise from the wind driven rain with a pressure difference across the envelope (i.e. net positive pressure across the roof and wall). The pressure developed across the building envelope during windstorms frequently exceed the serviceability test pressures specified in AS 2047 (1999) for window resistance to water ingress. The serviceability test pressures are for wind speeds much less than the strength limit wind speeds used for structural design. That is, the windows are not tested for wind driven rain for strength design wind speeds. Therefore if a severe storm event is accompanied by rain, water ingress can be expected.

Boughton *et al.* (2011) described that the only means of minimising water ingress is by incorporating adequate seals for all windows, vents, doors, flashings, etc. However, this solution may be untenable partly because of the prohibitive cost and the impracticality of completely sealing the envelope. Resilience of the building could however be improved by a combination of (a) reducing water ingress by complying with a higher serviceability test pressure, (b) using water resistant internal linings and (c) occupant education to the fact that wind driven rain will enter the house. There is anecdotal evidence of the use of storm shutters or robust sunscreen louvres reducing water ingress via windows by acting as a crude form of rain screen (pressure equalization).

Windows and sliding doors manufactured in recent years should be tested for resistance to both wind and water pressure using a certification system developed by the Australian Window Association (www.awa.org.au). The AWA system for evaluating windows also addresses water ingress. However, under this system windows are only tested for resistance to water ingress based on serviceability pressure differentials. That is, they are tested to show that they can resist water under a differential air pressure that might exist on a normal windy day but they are not tested to ensure that they will not leak in an ultimate limit states design wind event such as a cyclone. Testing for weather tightness at or near the ultimate limit states wind speed will require development of a new test standard.

Where water-tightness requirements are extended to the ultimate limit state wind speed for windows, measures for reducing water ingress through guttering, flashings and vents should also be introduced. Where more rigorous water proofing requirements are not adopted buildings can be made more resilient to the effects of wind-driven rain by selection of materials for linings and furnishings (e.g. floor coverings such as tiles) that do not deteriorate when they get wet.

There are several standards used outside Australia in order to test water penetration of exterior windows, skylights, doors, and curtain walls for static pressure (ASTM E331-00 (2009)) and dynamic pressure (ASTM E547-00 (2009)). The fenestration industry standard used in North America (AAMA/WDMA/CSA 101/I.S.2/A440-05 (2007)) specifies that the minimum water penetration resistance of windows for residential and light commercial buildings shall be 15% of the structural design pressure, which is determined from the wind load provisions in ASCE 7-10 (2010).

SECTION 3 Data

Data on policies and claims was received from three companies over a period of three months commencing in late January 2013.

From the data available, the focus of the project was on the policies during 2010 and 2011 with the claims data coming from those associated with Cyclone Yasi.

3.1 Overview

For the 2010/11 period, from the three companies, a total of nearly 1000 policy records were supplied. Of these, there were approximately 170 claims within the Cairns to Townsville regions. The total sum insured (SI) value was $4 billion with total claims of $12 million. It should be noted that an individual policy record may contain a couple of units (apartments) to over a hundred units (apartments) for that one record.

3.2 Policy data

The level of detail requested in the project scope in relation to the building's geographic location, and parameters such as age, construction type and materials was not able to be achieved by the three companies. For example, building age was only supplied for about two thirds of the policies. The roof and wall type descriptor, when given, was in many cases not representative of the building construction. The number of stories high was mostly supplied by two of the companies but this value was later found to be inaccurate. It is assumed that the policy owners may be submitting the stories high of an individual unit as opposed to the total number of stories of the building. *Awareness by both the policy owners and insurers on the importance and usefulness of correct data needs to be raised. It is recommended that relevant parameters associated with the building be gathered.*

The supplied building data gaps were augmented by using Google Street View to "drive by" the addresses that could be located to try to determine wall and roof construction type along with factors that may influence impacting wind speed such as neighboring properties, open fields and topography.

3.3 Claims data

An important data record for the analysis was the provided "loss description field" where details of damage were recorded. However, the detail in this field varied greatly with entries such as "damage to roof" or "water entry" through to summary lists noting number of windows broken, and damage to elements including sheds, roof aerials and fences. Thus there is no consistency of reporting of damage types. For example, the policy claim record may mention "roof damage from tree" but does not mention either guttering damage or water damage to interior. This does not mean that no guttering or interiors were damaged. Therefore, findings from the claims may identify possible trends but it should be remembered that the recorded data is a subset of the actual damage. Correspondingly if the data does show a trend in damage type, then it is most likely to be reflective of a stronger trend in the actual damage.

Claims Assessors' reports were made available by one of the companies. As with the brief summary of damage description the level of detail across the reports also varied greatly. Some of the reports included photos of the damage which was a definite help. Reproducing some of the damage photos in this report would greatly help to illustrate the good and bad features of building performance, but the photos could be potentially used to identify the claimant and insurer and have therefore not been included in this report in line with the pilot study's terms and conditions.

One of the companies provided a breakdown of possible claims costs which included;
- Repair of primary structure (e.g. roof, guttering, re-painting)
- Repair of internal elements (e.g. plaster board ceilings, fans, built-ins)
- Repair of ancillary structures (e.g. shed)
- Reinstate surrounds (e.g. fencing, gardens and pool)
- Reimbursement of lost rental income.

The claims did not include contents damage.

The range of claims was from less than a thousand dollars to over a million dollars. The average claim amount was approximately $75,000 with a median claim of about $8000.

Details of the policy excess were provided for some of the records. The excess ranged from a few hundred dollars to tens of thousands of dollars. Approximately 5% of the claims were less than their corresponding excess amount and were not paid on.

Table 5 shows number of supplied policies and claims for the three selected regions. Table 6 shows the percentage of claims with respect to each region in relation to postcode for that region.

Table 5 Policies, claims and ratio of claims to sum insured (SI) value

Region	Number of records	% of records with a claim from region	Average of (Claim / SI)	Standard deviation of (Claim / SI)
Townsville region	300	25%	3.5%	0.12
Ingham, Cardwell, Tully, Mission Beach, Innisfail	57	58%	20.7%	0.28
Cairns, Trinity Beach, Port Douglas	507	12%	0.5%	0.01

With reference to Figure 6, the band of high wind speeds from Cyclone Yasi went through the Ingham to Innisfail region. This corresponds to the higher number of claims to total number policies for the region as shown in Table 5.

From damage surveys following Cyclone Yasi, structural damage of housing was surveyed (refer Section 2). The ratio of observed damage to numbers of surveyed housing was much less than the ratios of claims to total policies detailed in Table 5. This is in part due to the structural survey only recording external observations. One of the reasons for the discrepancy in the high ratio of claims when compared with the damage survey is that the claims in addition to damage to structure incorporate a large number of issues such as damage to surrounds (gardens, pools, fences, boardwalks), signage, window screens, water damage from rain, shade sails, and sand and plant matter plastered across walls. Some claims noted damage to large items such as jetties and water damage to lifts. The loss descriptors did not typically provide a breakdown in costs of the various items. The various damage issues are further discussed in Section 3.7 and 3.8.

Table 6 Division of policies and claims from region

Postcode	Number of records	% of records from region	% of claims of the total claims for each of the three regions
4806	3	1%	1%
4807	30	10%	13%
4810	114	38%	47%
4811	6	2%	1%
4812	70	23%	16%
4814	31	10%	5%
4815	8	3%	1%
4817	17	6%	4%
4818	1	0%	0%
4819	20	7%	11%
4849	11	19%	30%
4850	3	5%	3%
4852	33	58%	64%
4854	2	4%	3%
4860	7	12%	0%
4861	1	2%	0%
4868	32	6%	5%
4869	36	7%	16%
4870	234	46%	41%
4871	39	8%	5%
4873	5	1%	0%
4877	28	6%	2%
4878	51	10%	10%
4879	82	16%	21%

Note that the higher percentages of claims in each region, which are a greater percentage of the number of records in the region, are typically associated with suburbs containing coastal urban areas (for example 4810, 4819, and 4852).

3.4 Building types

As discussed in Section 2, damage surveys have shown that different building materials and construction styles can have different performance levels during wind storms. To aid analysis of this study, data groupings of building geometry and construction style were made. As the policy data was limited in regards to many building elements, assumptions were made based on features observed from Google "Street View" for the located claim policies and for all locatable policies in the Townsville region.

The policies were grouped into;
- H1 and H2 representing single and two storey buildings that appeared to have characteristics of typical house construction and geometry
- LR1 and LR2 representing single or two storey low rise buildings but of perhaps reinforced concrete construction and/or large footprint complexes of at least several units
- MR representing medium rise construction which were structures of 3 stories and above

It is assumed that the H1 and H2 groups are constructed to the “Wind loads for housing” standard (AS4055), and relevant structural design standards (e.g. Timber framing manual, Reinforced masonry standard). As noted in Section 2 housing designed in accordance with AS4055 is designed for internal pressures from a dominant opening. The choice of designing for a dominant opening in engineered structures is left to the designer when using the primary standard, AS/NZS 1170.2.

It is assumed that the LR1, LR2 and MR groups which are typically much larger geometry are designed and constructed with the wind loading standard AS/NZS 1170.2 and the relevant steel, concrete and masonry Australian design standards. It is also assumed that these properties would have had a far greater on-site project management and inspection process than house construction.

Table 7 shows the ratio of number of claims to total of assumed building type in each postcode for the Townsville region. For the medium rise building type, it has a higher ratio of claims to non-claims than the other assumed building types. This trend is also apparent in the other regions. Also of interest are the higher ratios of claims to non-claims found in postcodes with coastal urban areas to non-coastal suburbs which are also reflected in Table 6.

Table 7 Ratio of claims to total policies in each postcode for each assumed building type

Postcode	4810	4811	4812	4814	4815	4817	4819
Simplified terrain descriptor	coast, city	suburban	suburban	suburban	suburban	suburban	island
H1, H2	0.1	0.2	0.1	0.0	0.0	0.1	0.5
LR1, LR2	0.2	0.0	0.3	0.4	0.5	0.3	0.2
MR	0.6	-	0.0	-	-	1.0	1.0

3.5 Wind speed and damage

To help with comparisons, a wind speed was calculated for the policies based on their number of storeys, and location with respect to coast, topography and surroundings, as noted in Section 2, with the base wind speeds for the regions taken from the analysis following Cyclone Yasi and detailed in Boughton et al (2011) and Holmes (2012). The wind speeds presented in this study, therefore, are the derived “impacting” wind speeds at the building and not the commonly used wind speed reference standard of “10 m height wind speed in open terrain”.

Figure 8 shows a comparison of the ratio of claim amount versus sum insured with respect to “impacting” wind speed and assumed building type. As per Table 5 it can be seen that the majority of claims to sum insured ratio are small. The ratio increases for increasing wind speed after about 35 to 40 m/s.

It should be noted that the MR claim at about 100% of SI is for a building that would appear to be under-insured. That is, its sum insured value would appear to be far less that indicated by its size and by comparisons with similar sized and located buildings.

Figure 9 presents the same claims in relation to assumed "impact" wind speed but uses the claims amount and not claims/SI ratio. The spread of the medium rise building data (MR) compared with Figure 8 indicates the much larger SI value for these large properties.

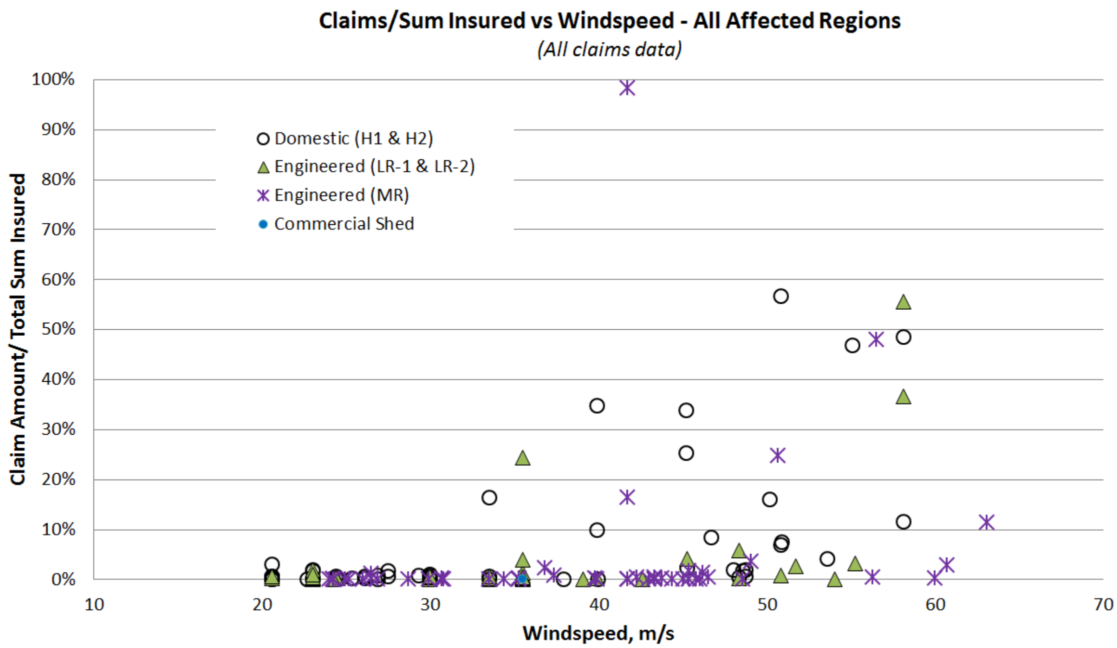

Figure 8 Comparison of ratio of claim to sum insured with derived property wind speed

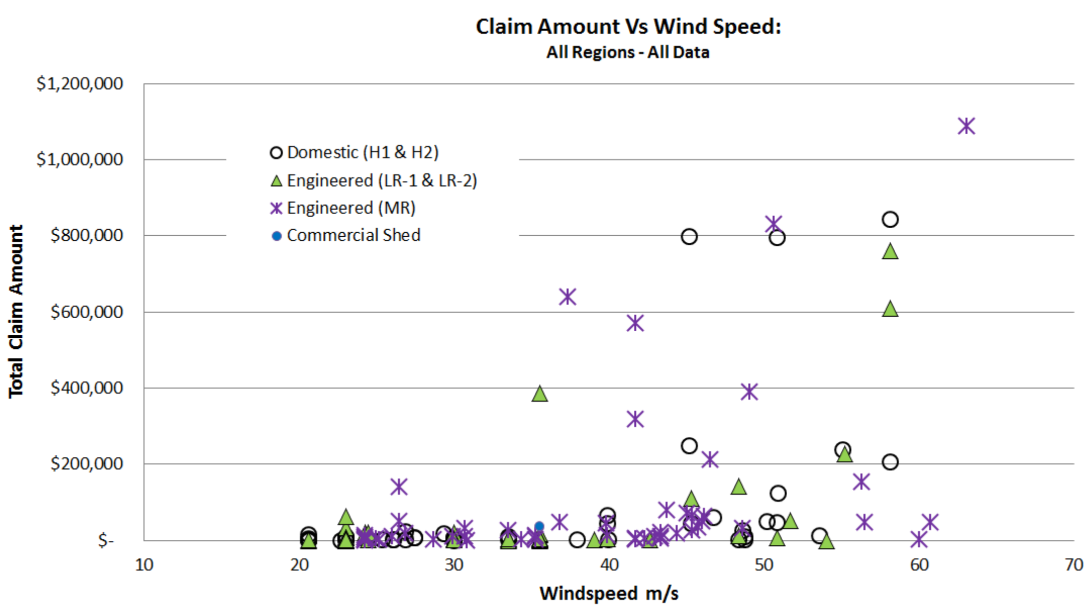

Figure 9 Comparison of claim amount with derived property wind speed

The higher incidences of claims to non-claims for the medium rise buildings (3+ stories) compared with low-rise may be due to factors such as;
- MR may contain a higher proportion of relatively exposed large windows/doors
- it may be a function of higher impacting wind speeds (greater height) causing more wind driven rain ingress through window and door seals and "defects" in building envelope cladding elements
- many of the assessors reports for the medium rise buildings included claims for ancillary elements such pools, fencing, gardens. It may be that the large medium rise complexes also have extensive resort style grounds

3.6 Building age

As detailed in Section 2 the structural performance of a building can be in part governed by the building regulations at its time of construction (i.e. its age). This has been observed in damage investigations, particularly for house construction (Figure 7). Figure 10 shows generalized building parameters for different building ages plotted against claims/SI ratio and wind speed. The trend of increasing claim value to sum insured increases with wind speed for newer construction but there is few pre-1980s buildings in the higher wind speed to enable robust comment. A comparison of ratio of claims to non-claims for the different building ages shows there is a possible trend for a higher claims ratio for newer construction with the ratios being approximately 0.2, 0.25 and 0.35 for the "< 1980s", "1980s to 2000" and "> 2000" periods respectively.

Since the wind speeds are below design event and (accordingly) the primary descriptors of damage are associated with mainly non-structural damage it would be expected that there is less marked difference in damage versus building age. A possible implication of the higher claims versus SI for newer buildings may be the use/introduction of different building materials and styles which could include plaster board linings, metal fascia, larger openings, minimal eaves, large partly enclosed living areas, and complex roof shapes (lots of valleys and ridges). These different features may increase susceptibility to wind driven rain water ingress as described in Section 2.

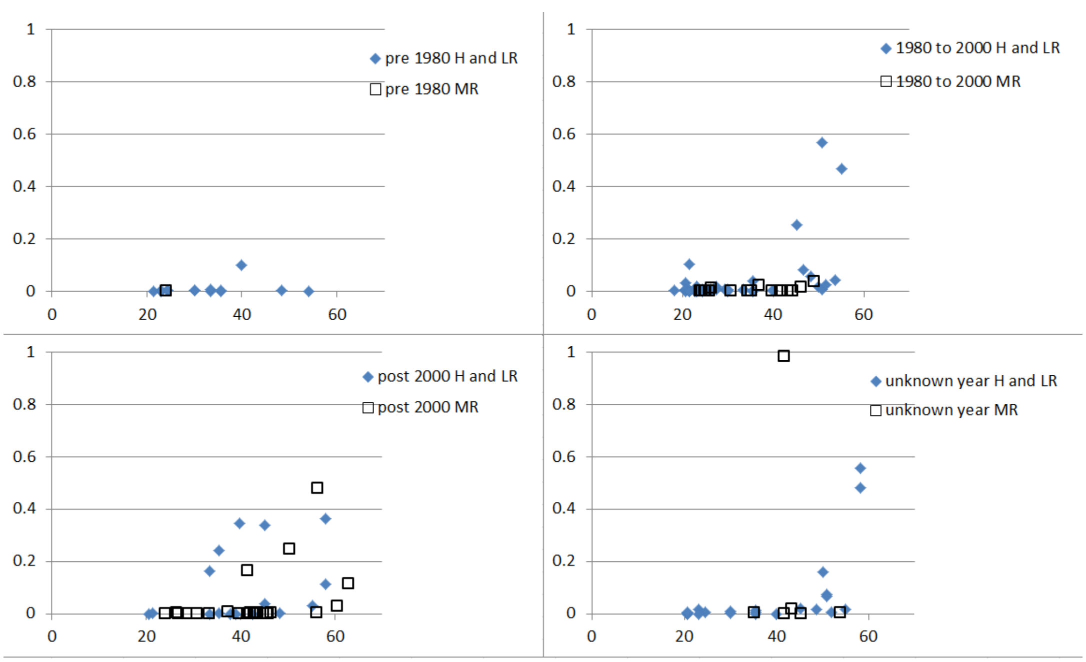

Figure 10 Building type for different years of construction for clams to SI ratio and wind speed

3.7 Wind driven rain water ingress (WDR)

As described in Section 2, wind driven rain is a major contributor to damage in severe storms. Figure 11 compares the claims that mention WDR damage and those that do not mention it. It can be seen that over 80% of the claims noted some form of damage from water ingress. Also in over half the descriptors, the water ingress was associated with entry via roof or doors/windows. (Note that the claims and assessors data is not a yes/no document so if there is no mention of an item it doesn't mean that it didn't happen – it only means that it wasn't written down.) One of the issues as a result of WDR ingress is an inspection of electrical circuits is required, adding further costs to process.

The value of 80% compares with a survey showing 75% of post 80s houses having envelope damage and water ingress following Cyclone Larry (Melita 2007).

From the review of the text boxes in the claims loss descriptor, examples of damage from the water ingress were from many sources and resulted in damage such as;

- Wind driven rain through louvres with damage to floor
- Water entry via roof with replace and repaint ceilings and check of all electrical systems
- Defective roof allowed extensive water to enter with damage to ceilings, floors and walls throughout.
- Water ingress damaged lift motor room and lift

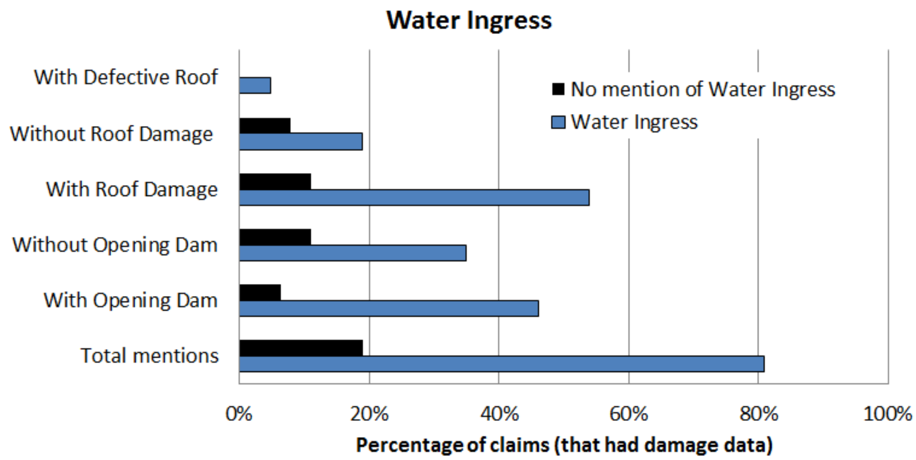

Figure 11 Occurrences of mentions of damage descriptor associated with rain water ingress

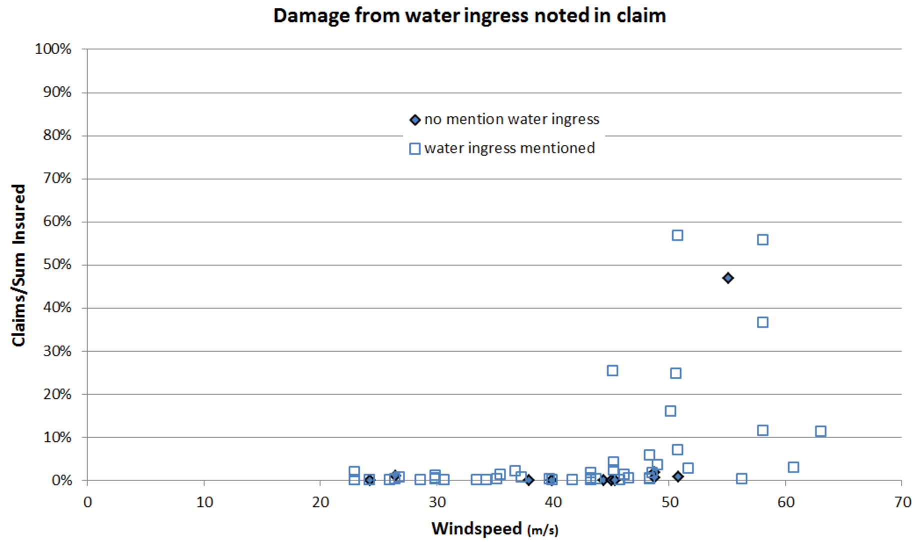

Figure 12 Wind speed at building and if water ingress damage mentioned

3.8 Other damage descriptors

In comparing the different roof materials from the available data there was no standout material (construction method) in terms of claims than the other types. Since the wind speeds were less that the design limit it should be expected that the roof material/structure to not have structural damage due to wind loads. The main descriptor in relation to roof feature was in relation to water damage via roof.

From the notes from assessors reports some common "incidental" damage initiator descriptors were;

- Failure of garage doors
- Fence damage
- Loss of guttering
- Non weather resistant fixtures/kitchenettes with only small eaves or shade cloth for protection from rain and wind in semi-open entertainment areas
- Shade cloth shredded since not taken down prior to event
- Roof mounted antennae damage resulting in damage to roof and subsequent water ingress damage
- Entrance doors blown in as standard lock into jamb could not resist wind loads
- Painted cement render on building sandblasted by winds and small debris

Many of the items such as roof antennas are relatively small cost but if fail can lead to big consequences for further damage.

It is recommended that an awareness program to highlight maintenance issues such as termites, timber decay, corrosion and alterations/additions to structure, be established for property owners. Examples to highlight would could include;

- A common theme for some of the corrosion of posts or timber decay was to do with wetting from garden and or hosing down for cleaning. Education on appropriate paint coatings and treatments is required.

- Importance of a well maintained and installed roof cladding including roof edges.
- Highlight importance of structural system (That is, take remedial action on rods that have been cut due to installation e.g. of windows or air-conditioners)
- Track down and stop water leaks (e.g. from roof or bathroom) and get a building professional to check that no damage to timber, steel or concrete structure has occurred.
- Having an additional lock or drop bolt on doors and casement or hopper windows to help resist wind loads.
- Take down and store shade cloth structures prior to the event

SECTION 4 Questions posed by ICA

4.1 Current Property Exposures

a. *To what extent do structural cyclone building codes create cyclone 'proof' buildings?*

Building regulations do not create "cyclone proof" buildings. Design criteria is based on the risk (e.g. severe wind loads) having a small probability of exceedance. For typical buildings this is a 10% chance of the design level being exceedance in 50 years. When coupled with building material design standards, failures of structural elements would not be expected to occur at the ultimate limit state design load (Refer Sections 2.1 to 2.4). This level of confidence does not apply to wind driven rain and the associated water damage.

Evidence from damage investigations does show that buildings that comply with current building regulations do generally offer acceptable and expected performance. There is evidence that some specific elements, such as tiled roofs and roller doors, may not perform adequately in certain circumstances. In most such cases, work is in progress to address these issues within Standards or building regulations but more work may be required to understand how these issues can be addressed in existing buildings, once identified.

b. *What residual damage, below the level of structural failure, is typical for strata buildings following a cyclone?*

The level of detail provided in the claims loss descriptors was not sufficient to provide a quantifiable percentage. However, there were many instances of water ingress via what is inferred to be "structurally intact" elements (e.g. water via window seals, doors, vents, flashing details etc). Repairing items associated with the policy but not necessarily part of the structure also were included in the loss descriptors for the claims records. These included items such as removing sand and debris from pools, replacement of pool equipment, fences, sheds, (Refer Sections 3.2 to 3.8).

c. *Is there common design or material use issues in strata properties that are linked to increased claims following a cyclone?*

In terms of structural failure of the buildings elements, there was no obvious trend for roof cladding or wall systems. However, in terms of damage resulting from wind driven rain ingress there were several elements that were repeated in the claims loss descriptors (refer Section 3.7) such as replacement of interior wall, ceiling and floor linings along with cupboards and cabinets. Other terms that were repeated in the claims records were items such as guttering, fencing, and garage doors. (Refer Section 3.4 to 3.8) Although a breakdown of associated costs was not part of the project scope, it can be inferred that due to the loss of relatively inexpensive items ranging from TV aerials to guttering to garage doors can cause a snowballing effect on costs with for example TV aerials damaging the roof they are fixed to leading to greater water ingress and subsequent damage to interior. A specific study may be worthwhile on the significance of these "ancillary items" as a part of the total claims costs. Their contribution to loss has grown significantly in recent decades, as structural issues have been addressed and as the extent of these "ancillary items" has grown.

d. *Are there differences in the loss performance of strata complexes that are single storey construction compared to high rise development?*

From the analysis, large multi-storey buildings/complexes have a higher incidence of claims and higher claim amount. Reasons could be due to claims associated with ancillary items (pools, sheds, semi-covered entertainment areas, loss of rent, etc). Also the large multi-storey complexes have greater potential for wind driven rain ingress through their relatively larger percentage of frontal openings (e.g. large window/door). There were a few examples in the claims data of water ingress in a top floor unit impacting on units below (Refer Sections 3.4 to 3.7).

e. *Does the year of construction (or significant repair/rebuild) of a property influence the anticipated damage (before structural failure) during a cyclone?*

From the analysis of the claims and policy data, year of build has less influence on claims than items such as water ingress and damage to ancillary items. (Refer Section 3.6) References to roof damage or water ingress via "corner of roof lifting" do not appear correlated to building age. Damage surveys have demonstrated that domestic construction prior to the 80s is more susceptible to structural damage from severe wind loads (see Section 2.5). This trend is not obvious in the claims data and in fact looks to be increasing claims for newer construction. Possible reasons are; there is not enough data; the older properties were not located in the areas of the very severe wind loads; in the older properties internal lining materials and soffit linings are more weather resilient (e.g. fibre cement as opposed to plasterboard); and being strata properties it may be these older properties are appropriately maintained and systematically upgraded at a higher rate than housing of a similar era.

4.2 Property Risk Controls – best and worst practice

b. *Are there examples strata buildings that are more hazard sensitive by virtue of their construction and use of materials?*

The claims data indicates that multi-floor buildings may have a higher incidence of claims to non-claims than low rise buildings (regardless of age). More analysis is required on this. Possible reasons for this higher incidence of claims and damage cost are discussed in Section 3 and Section 4.1(b-e).

c. *How can it be determined if a strata building has been constructed to meet, or to exceed, cyclone building codes?*

Access to design documentation and building plans as both should document the design load levels (design wind speed) and the applied building design standards. The building regulation and approval processes that are in place should offer assurance that buildings comply with current regulations. It is the responsibility of the building certifier and designer to ensure that this is the case.

d. *Are there common maintenance issues for strata properties that if left unattended may lead to an insurable loss during a cyclone event?*

The claims data mentioned only a few maintenance issues; roof defects including missing fasteners and loose flashing, corrosion, and past water damage. From other damage investigations there are several maintenance issues that have been observed such as corroded structural steel veranda/awning posts, leaking bathroom fittings (internal wall) causing rot/degradation of structural frame, termite damage, rusting or blocked guttering, etc (Refer Section 3.8).

e. *How might engineering reports be undertaken to quantify the compliance* *standards and any vulnerabilities, for property owners seeking to reduce an insurance premium?*

The implementation of an engineering based assessment process for strata property has the potential to significantly reduce insurance risk and could therefore be linked to insurance discounts. In principle, an assessment might be conducted say once every 7-10 years. More frequently is both too costly and unnecessary, while less frequently would miss important degradation. It may still be possible to obtain insurance without an inspection, but offering sizeable discounts with an inspection would encourage the use of reports and associated works.

It is quite logical to pilot the implementation of such a process with strata property, as one inspection and report covers multiple nominally similar properties on the same site, thereby reducing the effective cost per dwelling.

As the analysis of the claims data has shown, losses are not just associated with structural failures. Therefore any engineering report also needs to involve advice on possible water ingress issues, inspections of wall and roof flashing and roof penetrations, inspections of high value items such as jetties and lift room structures and cladding, sheds, shade cloths, etc. The report needs to detail actions to be carried out in a yearly maintenance cycle as well as actions needed prior to land falling cyclone (watch/warning status).

4.3 Future Risk Reduction

a. *What steps could be taken to improve the resilience of planned strata property to be constructed in cyclone prone regions?*

Experience has shown that one of the most important issues is to check carefully that the design of all parts of the building envelope is appropriate for the site wind loads. This means (a) if building is in an exposed location the design wind speed needs to be selected accordingly, and (b) all elements of the building envelope need to be able to resist the design wind loads which includes appropriate door hardware, gutters, flashing, windows, garage doors etc. (Section 2 and 3). As part of the planning and design stage attention needed on areas of possible water entry. For example water resilient internal linings, as opposed to standard plaster board, to be used adjacent to banks of louvres or semi-open corridors/vestibules (i.e. areas of potential water ingress). Other examples include; Shade-cloth structures/attachments to be designed to be removed and stored with relative ease; If internal/box gutters are used their overflow devices correctly designed not be blocked (e.g. by vegetation blown in during early stages of storm); Minimise penetrations and attachments to roof (e.g. design for designated aerial locations and fixings, and similarly for roof mounted air-conditioner or ventilator equipment); Ensure patios/balconies have sufficient drainage for severe weather and there is a step up and seal for balcony door/window; Investigate use of fold away plantation shutters (or roller shutters) to reduce water ingress via large window/balcony glazing.

b. *What physical steps could be undertaken to retrofit existing older strata property to decrease the probability of damage during extreme weather events?*

As noted in Section 2, if the older strata property was designed and constructed to engineering standards, its design level is comparable to current construction. If it was built to housing standards (e.g. possibly an older duplex) it could be upgraded with reference to the Australian Standards Hand Book for upgrading of older houses in cyclonic regions (HB 132.2 1999). To reduce potential water ingress damage, attention should be made to items such as selection of materials and opening protection as noted in Section 4.3(a).

c. *What processes could be undertaken to encourage the upgrading (to code) of strata buildings during major repairs, rebuilding or refurbishment?*

Depending on the extent (proportion of old to new) of the refurbishment/renovations, upgrading to current building regulations may be mandatory. If upgrading to an accepted standard is carried out any existing penalties on insurance premiums associated with "older structure" would need to be reduced accordingly.

d. *Could a system of strata property rating for resilience to extreme weather, assist with identification and mitigation of vulnerabilities?*

A process whereby engineering checks of buildings and ancillary items are inspected once every 7-10 years and a report completed by a person with suitable expertise would help to identify potential vulnerabilities and focus on issues that could be addressed to improve the building's resilience. If it could then be shown that the recommendations of such a report had been followed, this would certainly reduce insurance risk and would therefore justify a reduction in premiums. If reasonable discounts were available in this case, that would help to encourage compliance with the inspection process and associated works. Whether a formal system is required or just awareness of issues the possible benefits of remedial action needs to be propagated. A checklist or similar identifying issues needs to incorporate both structural elements as well as losses associated with water ingress and ancillary items damage (Refer Section 3). Therefore the property rating needs to consider structural and non-structural elements.

SECTION 5 Conclusions and Recommendations

This pilot study has been prepared for the Insurance Council of Australia, based on Terms of Reference developed by the ICA Strata Insurance Working Group. The aim of this study was to identify factors that may be contributing to insurable losses during cyclonic weather.

The study provides an important opportunity to consider building regulations and insurance claims together, thereby highlighting issues that may not arise through considering either regulations or claims in isolation

Damage investigations have shown that the building regulations in terms of the structural provisions/objectives of the Australian building code generally appear to be appropriate with respect to wind loading for the design strength limit state. Strata property and detached houses are built to the same Australian Building Code and often use the same building materials. Both types of structure have a similar vulnerability in a wind event.

In most respects contemporary houses and strata property should be capable of resisting design wind events if properly designed and constructed. When specific elements are identified that warrant changes to building regulations, an ongoing process is in place to make these changes (e.g. recent changes to Australian standards to improve tile roof, soffit linings and garage doors). It is important to understand, however, that any changes will normally only apply to new properties constructed after the changes are implemented in building regulations.

Older properties will have been built to different standards and different regulations. They have also experienced the effects of weathering and may have been compromised if they have not been properly maintained. However, from the analysis of the claims and policy data which is for impacting wind speeds less than design winds, year of build has less influence on claims than items such as water ingress and damage to ancillary items.

It is recommended that a process of regular property inspections, with intervals of perhaps once every 7-10 years be investigated. The aim of these inspections would be to identify and prioritise any site-specific factors that might affect building performance in future severe storm events. Works carried out would make the building more resilient. It is proposed that providing an insurer with evidence that an independent inspection has been conducted and actions taken will demonstrate a reduction in risk and a corresponding reduction in premiums and excess. If significant defects of a part of the structure are found (e.g. severe corrosion of cladding) then a grace period of continued insurance should apply while rectification works are undertaken. The inspections would need to relate the structural aspects of the inspections to the building regulations at the time of the building's construction.

Water ingress from wind driven rain has been identified as a key factor in insurance claims. It is recommended that a study should commence as soon as possible, to minimize risk by seeking a greater understanding of relationship to intensity of rain and wind gusts and identify possible economic solutions in reducing the amount of water ingress and resultant damage.

The report supported by previous damage investigation reports has identified for wind speeds less than the strength design wind speed, ancillary items have taken on increasing importance in claims costs. As structural issues have been identified and acted upon, the damage from wind driven rain ingress and the damage to ancillary components (e.g. air conditioners, shade cloth attachments, aerials and fences). The failure of ancillary components has also led to damage to the main structure such as penetrations in cladding allowing further water ingress.

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