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Suncorp Group Limited

Cyclone Resilience Research – Phase II

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Executive Summary

Housing vulnerability is a large contributor towards high claims costs for Suncorp, and the subsequent premium affordability issues for consumers. Reducing this vulnerability will decrease the risk associated with severe wind events, which can then be reflected in pricing for consumers.

In 2014, Suncorp commissioned the Cyclone Testing Station (CTS) at James Cook University to conduct a comprehensive study to enhance Suncorp's understanding of the vulnerability of houses in North Queensland to natural hazards, particularly tropical cyclones and thunderstorms. The study involved the analysis of insurance claims for residential homes in North Queensland (NQ) after Cyclone Yasi. Key drivers of cyclone-induced losses were identified in the Phase I analysis. As a recent extension of that work, the current study (Phase II) builds on the Phase 1 by estimating the reduction in losses based on retrofit and mitigation solutions for the typical loss drivers.

The cost-benefit analysis was conducted through collaboration between Suncorp, CTS and economic consultant Urbis. The primary objectives for the CTS Phase II report included the following:

- Identify a sample-set of mitigation solutions
- Estimate the benefits of each solution (i.e. reduced loss) for a range of wind speeds
- Estimate the cost of each solution

As Urbis conducted the economic modelling aspect of cost-benefit analysis, those results are not discussed herein. Instead, the methodologies used to develop the basis of the cost-benefit model are presented.

In addition, a literature review of mitigation programs used internationally is presented from a consumer engagement perspective. The success/failures of these programs are identified (where possible) and applicability to Northern Australia is emphasized.

Finally, conceptual frameworks for a mitigation program are presented, illustrating how the process of inspections, reporting, mitigation and interaction with insurers may work.

Key Outcomes

- Three mitigation solutions are presented based on the Phase I report
- The report shows that there is scope for further development of these options and others (e.g., more aesthetic alternative to overbattens)
- Based on a review of the literature and discussions with building industry, Northern Australia is well poised to become a leader in resilience and mitigation
- There is much that can be learned from other work abroad but regional aspects must be considered

Estimation of Vulnerability

To estimate the benefits of the selected mitigation solutions, vulnerability of North Queensland homes to cyclone-induced damages was estimated (before and after mitigation upgrade) based on year of construction. Three groups were established (pre-1960s, 1960-80s, post-1980s) based on typical construction trends in each era. Three mitigation solutions were analysed:

1. Structural roof upgrading (i.e. connection upgrades, etc.) (pre-1960s and 1960-80s only)
2. Opening protection (i.e. window shutters, roller door bracing, etc.)
3. Community preparedness (i.e. unblocking roof-gutters, removing shade coverings, etc.)

The cost of implementing mitigation solutions was estimated via component costs, claims data, and scenario based estimates by selected builders and assessors.

Existing Mitigation Programs

Research found that the presence of coordinated, planned and implemented programs in Australia with the aim of increasing homeowner engagement in mitigation strategies to strengthen their home is lacking. Also a "one size fits all" approach to mitigation programs is not appropriate as individuals are motivated by different incentives.

Programs must be appropriately marketed to individuals and communities based on identified key motivators for engaging in mitigation strategies. These motivators will differ between individuals and communities based on their level of experience with extreme weather events, perceptions of risk and responsibility, connectedness and trust towards others and the availability of assistance and resources. Research is needed to characterize key motivators for Northern Australia communities so that a future mitigation program is efficient and optimized for community engagement. A scope for this research is discussed.

Proposed Mitigation Programs

Based on the literature review and CTS experience as a long-term proponent for cyclone mitigation practices, two conceptual frameworks for a mitigation program are outlined. The first includes a more traditional approach where inspections are completed by a qualified inspector, while the second makes use of smart-phone technologies allowing consumers to "self-assess" with periodic "spot checks" for quality assurance and continued improvement to the process. An effective mitigation program may also require a combination of the options considered.

Community Engagement Considerations

There is an opportunity for the whole community to benefit from an increased focus on mitigation:

- Homeowner – increased security during storm, promoted increase in house market value if retrofits undertaken, reduction in insurance premiums
- Government – reduction in drain on community services during and after severe event, more resilient community
- Industry – niche market for retrofitting and upgrading products as well as the building trades to professionally undertake retrofitting

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Limitations

The Cyclone Testing Station (CTS) has taken reasonable steps and due care to ensure that the information contained herein is correct at the time of publication. CTS expressly exclude all liability for loss, damage or other consequences that may result from the application of this report. This report may not be published except in full unless publication of an abstract includes a statement directing the reader to the full report.

1. Introduction

The current mitigation-focused work builds on the Phase I study conducted by CTS and Suncorp which analysed insurance claims from Cyclone Yasi to determine typical drivers of insured loss (i.e. roofing failures, etc.) for residential housing. The scope of the current project (Phase II) includes cost-benefit analysis of mitigation solutions selected as a result of loss drivers identified in the Phase I work.

The CTS role in the cost-benefit analysis included engineering analysis to estimate the benefits of selected mitigation options. Typical methods of vulnerability modelling are discussed in detail to provide context for the empirical methodology selected for this study. The overall strategy was to use the Suncorp Cyclone Yasi claims data (Phase I) to estimate the vulnerability of non-mitigated structures. Then, using a structural engineering software package (SPACE GASS), simplified roof systems were analysed with and without upgrading to estimate the relative change in load at critical connections. This information was combined with survey results from builders and assessors to estimate the reduced vulnerability of the same set of properties with mitigation. The results were used to estimate the intensity and frequency of damage before and after mitigation for a range of wind speeds. This information was provided to Urbis for economic modelling.

A literature review of mitigation programs used internationally is also discussed with emphasis on a consumer engagement perspective. Programs in Australia are discussed where possible, however the majority of works originate from the cyclone-prone southeastern coast of the United States. The applicability of these programs to a Northern Queensland context is emphasized. Based on the literature review, a research schema is proposed to identify drivers of mitigation action in Northern Queensland homeowners in order to optimize the effectiveness of a future mitigation program.

Finally, conceptual frameworks for a mitigation program in Northern Queensland are discussed. A more traditional approach is presented, utilizing qualified personnel to perform inspections. Alternatively, a more contemporary approach is discussed, making use of smart-phone technologies to educate homeowners about mitigation and efficiently transfer information back to insurers and researchers.

2. Background Information (Vulnerability Modeling)

Performance modeling of buildings during extreme natural hazards has become an essential part of modern catastrophe insurance analysis, and is largely related to the development of performance based design in structural engineering. Modern insurance catastrophe models are typically comprised of a series of sub-models that produce probabilistic estimations for: (1) the occurrence of an event, (2) the associated hazards, (3) the properties of interest in terms of characteristics deemed to affect their vulnerability to damage, and (4) the vulnerability of particular sets of building characteristics in terms of predicted insured loss (i.e. vulnerability model) as a function of the associated hazards of the event (Walker 2011).

Most commercial catastrophe models used in the insurance industry utilize vulnerability models based primarily on an empirical approach originally developed by Friedman (1975). He developed a procedure for estimating probable maximum insurance losses from hurricanes in which the vulnerability curves were developed from superimposing the estimated contours of maximum wind speeds from actual events on maps of the portfolio of the insurance company which had been exposed to the event. The vulnerability curves were derived by analyzing the ratio of an individual property's loss to its insured value. This ratio was termed the damage loss ratio, and was computed as a function of the estimated maximum wind speed which the individual properties had experienced.

Insurance vulnerability models for wind are meant to simulate the pattern of wind damage arising from a separately defined wind field. The most common method of expressing damage is by the cost of repairing or replacing the damaged building. Vulnerability models do not generally provide accurate simulation of damages to individual properties but rather they are expected to simulate the overall pattern of damage to the entire population of properties exposed to the wind event in terms of major statistical characteristics. Typically this pattern may be represented for a particular building classification by a plot of the observed damage loss ratio of individual properties versus the maximum wind speed experienced by them, where the damage loss ratio is the ratio of damage repair costs to the replacement cost of the property.

Figure 1 gives an example of loss ratio versus increasing wind speed for a fully engineered steel structure building and a residential house. The broader foot of the residential curve (Walker) indicates a greater variability in performance than that of the steeper engineered curve.

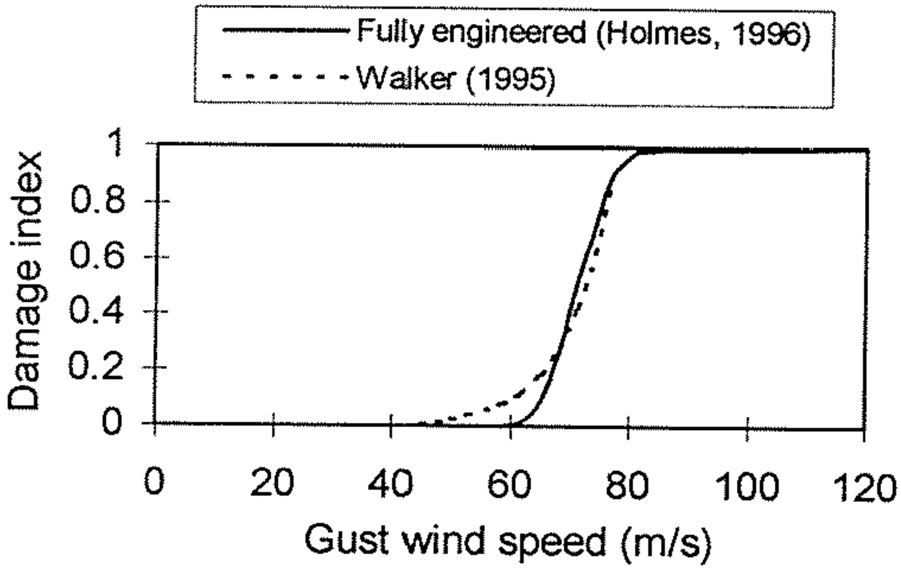

Figure 1. Example of "vulnerability" curves: An increasing damage ratio with increasing wind speed (Holmes 2007)

2.1. Empirically-Based Vulnerability Relationships

Vulnerability models used by the insurance industry are primarily empirical models based on fitting curves to damage data at individual building level, generally as a damage loss ratio, as a function of wind speed estimates for the given location. This approach relies on large amounts of loss data. Separate models are developed for various building classifications (i.e. single family dwelling, multi-story reinforced concrete, timber frame, etc.). Often there is sufficient data on all buildings to establish a general curve but insufficient data to produce individual curves based on data for individual building types alone. In these cases empirical models are derived for a few broad building classifications, with allowance for modification for differences within the broad classification that have been observed to result in increases or decreases in damages, based on both expert opinion and statistical analysis. Khanduri and Morrow (2003) present a good example of this approach.

The most extensive development of empirical vulnerability models utilizes the relatively large amount of data for hurricane losses in the US. Development of models for other countries has been more difficult due to relatively smaller amounts of data on losses from severe weather events. Further, direct application of US models in other countries is difficult due to differing forms of construction, building regulations, construction quality, etc. Adding to the complexity, standards of building construction often change in response to observed damage trends after a severe event which ties loss data to the set of standards used in a that time period.

An approach used commonly outside the US has been to assume the shape of US based vulnerability curves for building types that are considered to be similar, with adjustment to fit available data on losses or by utilizing engineering judgment and expert opinion. A similar approach was used in Northern Australia in the 1990s by modifying the Sparks and Bhindarwala

(1993) model for Hurricane Andrew to produce estimates of loss from Cyclones Tracy and Althea that were similar to recorded values for losses from these events.

The advantage of empirical models is that they inherently incorporate many of the uncertainties in the relationship between damage loss ratio and wind speed, especially if based on data from several different events for a similar type of building construction. For example, in the US where hurricane damage is relatively frequent in the same areas, or in areas of similar forms and standards of building construction and where hundreds of thousands of individual records of insurance loss data have been accumulated in recent years, it is expected that modelers with access to this data would be able to produce relatively reliable empirical models for estimating insurance losses for this area. The weakness of these models lies in their lack of applicability to other regions due to differences in construction standards.

Another typical issue with empirical models is the accuracy at higher wind speeds as the data is generally sparse at the high end of the scale because high-wind events are relatively uncommon. Consequently empirical models are generally more accurate at lower wind speeds. This has implications to estimating losses for extreme winds. Varying construction costs also introduce further uncertainty.

Outside of the limited areas where large loss information data sets are available, empirical vulnerability models are relatively unreliable, making them the most unreliable component of the overall catastrophe loss model. However, being based directly on insurance loss data they can still provide very useful information for computing insurance risk provided they are primarily used for aggregating risk as opposed to calculating the specific risk at a local level.

2.2. Engineering-Based Vulnerability Relationships

Engineering based vulnerability relationships rely on estimations of damage level for different hazards based on scientific engineering knowledge of the structural and material behaviors of building components and then estimations for cost of repairing that damage. This methodology relies on a high level of understanding of the mechanics of wind flow around a structure and the resultant forces on different building components including time dependent effects (e.g., fatigue loading) and redistribution of forces after local building element failures. Vickery, Lin, et al. (2006) and Vickery, Skerlj, et al. (2006) review the basic elements that should be included for the development of fully engineering based vulnerability relationships.

Even if the objective is a deterministic vulnerability model, its development should be undertaken in a probabilistic manner because of the non-linearity of the relationships between wind speed and wind loads, and between wind loads and damage (Walker 2011). The consequence of these non-linear relationships is that actual mean damage loss can be much greater than that estimated based solely on the estimated mean wind speed and mean building response.

There is also considerable uncertainty associated with the estimation of actual wind loads on a structure based on a given wind speed and angle of incidence. These loads vary based on housing construction, surrounding terrain, cladding elements, building height, etc. Partial damages (i.e. failure of door/window) and wind borne debris can also have dramatic effects on load magnitude and damages, and can only be modelled in a probabilistic sense. Because of these uncertainties, the development of fully engineered vulnerability models is a very difficult task that requires large amounts of research on wind load interactions with buildings and the associated structural responses. There has been quite a bit of research completed to date but the focus has been more so on improving design parameters rather than estimated building losses (Walker 2011).

Several approaches to developing engineering based vulnerability relationships have been explored over the last four decades (Hart 1976; Stubbs and Boissonnade 1993; Chiu 1994), however, Sciaudone et al. (1997) and Unanwa et al. (2000) are considered landmark papers in this field. While earlier papers were deterministic, both Sciaudone et al. (1997) and Unanwa et al. (2000) incorporated the probabilistic nature of the problem. These models still incorporated a large amount of expert engineering judgment where statistical knowledge of the components was not available; however, they represented a great step forward and set the framework for subsequent research in this field.

Pinelli et al. (2004) developed a vulnerability model in Florida for the Florida Public Hurricane Loss Model (FPHLM) based on the work of Unanwa et al. (2000). A follow-up paper (Pinelli et al. 2008) describes how the model was calibrated against recorded loss data from Hurricane Andrew and then the three damaging hurricanes that crossed Florida in 2004. This paper also provides insight into the model including allowances for contents losses and different building standards.

Vickery et al (2006a, 2006b) describe the methods used in development of the HAZUS hurricane model for the US Federal Emergency Management Agency (FEMA). These papers provide a comprehensive overview of what is likely the most well developed engineering based vulnerability model to date. Included is the modelling of debris damage, internal pressurization due to building envelop failure, contents loss as a result primarily of water damage, and modelling of associated rainfall.

Henderson and Ginger (2007) provide an example of this approach applied to the development of a vulnerability model for a typical Australian house built prior to current building standards and included consideration of progressive failure and the effects of windborne debris and internal pressurization. For example (Figure 2), analysis was conducted for a structure that began in an undamaged state and depending on the probability of failure of the difference building components damage and ultimately failure could progress via roof or wall structure of pier (stump) failure. Reasonable agreement was found when comparing recorded information from damage surveys undertaken following major tropical cyclones that have impacted northern Australia.

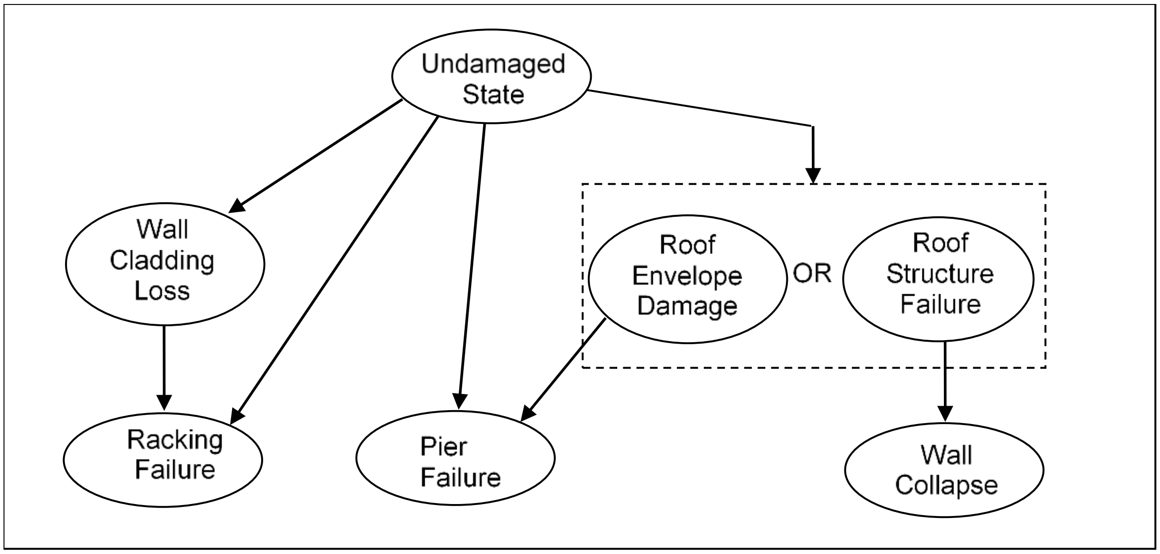

Figure 2. Possible damage propagation paths for Pre-1980s high-set house model (Henderson and Ginger 2007)

Engineering models are far more complex to develop than empirical ones, but they do have the great advantage of being able to investigate various scenarios as demonstrated in Figure 3 (King et al. 2013). The figure shows the capability of engineering based models to perform analysis for specific changes to the structural system (e.g., mitigation upgrades to roof and batten), versus empirical models that are based solely insurance claim data. A similar approach for developing vulnerability relationships for a timber framed house in the US including the effects of windborne debris has also been published (Apirakvoropinit and Daneshvaran 2009).

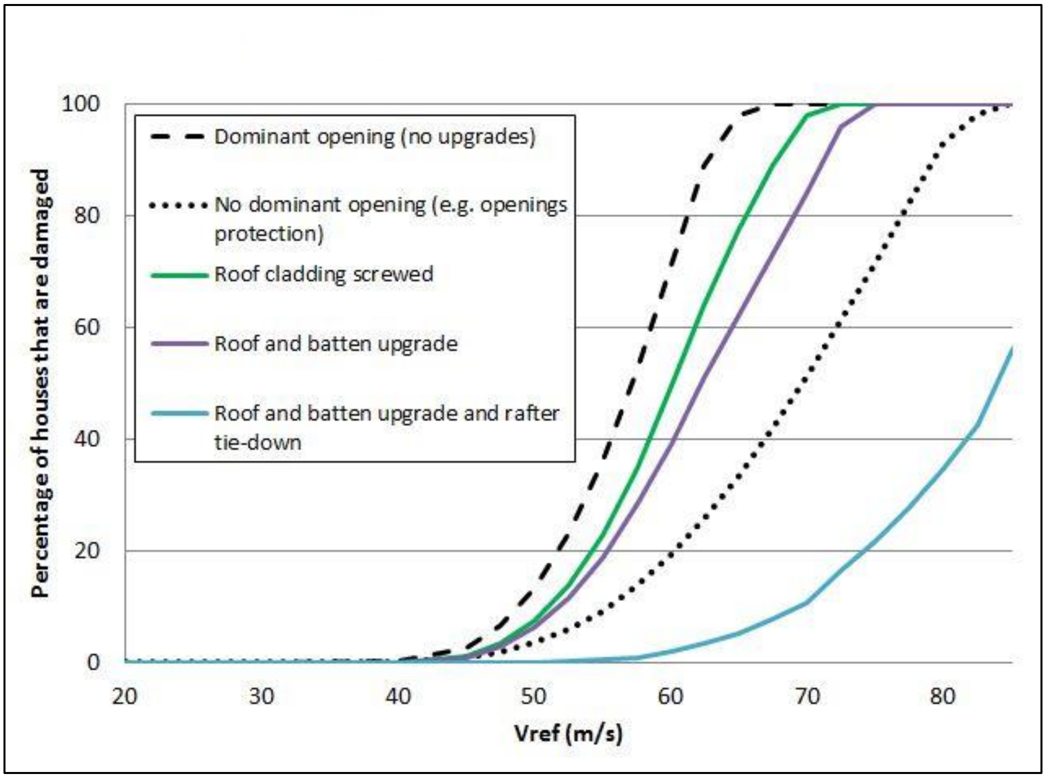

Figure 3: Estimated damage from wind loads to houses with different structural adaptation measures for house model as shown in Figure 2 (King et al. 2013)

While most engineering based vulnerability model investigations have focused on residential structures, Pita et al. (2009) describes an application to low-rise commercial buildings in Florida.

2.3. Water Ingress

As demonstrated by many damage investigations following windstorms, damage to building contents is strongly related to wind-driven rain and water ingress. Estimation of interior damage relies on expert opinion (Unanwa et al. 2000), engineering judgments (Pinelli et al. 2008), insurance data (Sparks, Schiff, and Reinhold 1994) or a combination these (Vickery, Skerlj, et al. 2006). Some of these approaches calculate the interior damage as a function of the exterior damage.

Dao and van de Lindt (2010) discussed a methodology to develop fragility curves and fragility surfaces for the volume of rainwater intrusion and demonstrated this on an example structure. They combined nonlinear structural analysis, computational fluid dynamics, and reliability theory with particle dynamics for rainwater trajectory modelling. It was assumed that the rainwater intrudes only through the roof-sheathing panel at one roof corner. However, they mentioned that the probability of rainwater intrusion should be estimated for different areas of the roof system, and then combined together statistically to determine intrusion for the overall roof system.

Pita et al. (2012) proposed a new approach based on an estimation of rain entering through envelope breaches and building deficiencies. Their approach consists of three steps: (1) estimation of the rain impinging on the building, (2) computation of wind-driven rain inside the building, and (3) conversion of the water ingress to interior damage. A flowchart of their detailed model is shown in Figure 4 with an example of model output shown in Figure 5. This approach has also been implemented in the Florida Public Hurricane Loss Model (FPHLM) (Hamid et al. 2010). However, these models have not yet been validated due to limited availability of full scale studies and insurance claim data.

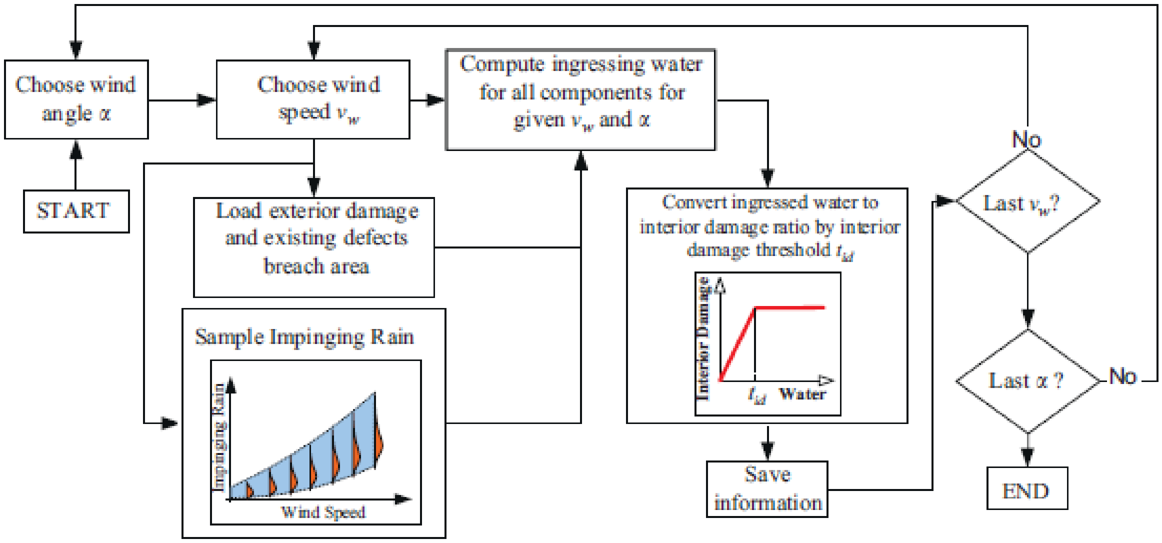

Figure 4. Flowchart of interior damage probabilistic model by Pita et al. (2012)

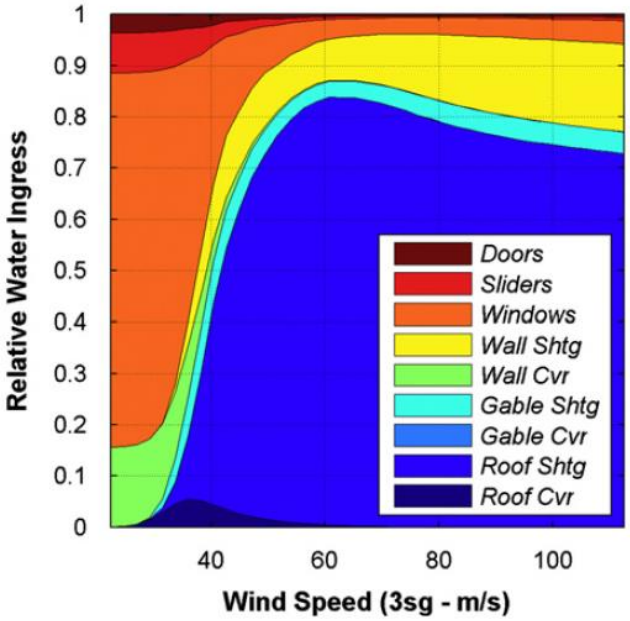

Figure 5. Relative contribution of each envelope component to “amount” of water ingress for increasing wind speeds by Pita et al. (2012)

2.4. Method of Analysis for Current Study

An empirical based analysis has been employed for the derivation of loss for increasing wind speeds for selected “generic” house types. The analysis uses the Suncorp policy and claims data from TC Yasi period (both policies with claims and without claims). The use of such data for modelling does not take into account ongoing incremental improvements to new buildings (i.e. changes to the garage door standard and roof tile Australian Standards should result in reduced damage to new housing with these components).

3. Fragility Analysis based on Suncorp Data

3.1. Overview

A computer algorithm program was developed to perform fragility analysis for the Phase II work. Using Suncorp policy data from TC Yasi as a proxy for future performance of the greater Queensland cyclone region coastal population, proportions of homes expected to incur varying levels of loss for a given wind speed were estimated for four mitigation actions:

1. No mitigation upgrading
2. Structural roof upgrading (applies to pre-60s and 1960-80s housing)
3. Opening protection for windows and roller doors (applies to all housing ages)
4. Community preparedness upgrades (applies to all housing ages)

The effect of combinations of each mitigation upgrade (items 2-4 above) were also estimated. The program was written based on five variables from the Suncorp data including:

- Age of construction (in three bins: pre-1960, 1960-80s, post-1980)
- Estimated wind speed during TC Yasi (km/h)
- Sum insured value ($)
- Claim value ($, includes null claims)
- Loss ratio (computed as Claim value / Sum insured value)

From the unaltered Suncorp data, a baseline performance case for non-mitigated structures (item 1 above) was generated by assuming that policies had not been upgraded (by the methods above) prior to TC Yasi. At each of six wind speed ranges (60-100, 100-120, 120-150, 150-180, 180-210, 210-240 km/h), the proportion of homes within four loss ratio groups (0, 0-0.1, 0.1-0.5, >0.5) were determined for each of the three housing age groups.

The effects of mitigation were simulated by modifying claim values in the original data set, and re-evaluating proportions of homes falling into the various loss ratio groups. The criteria for modifying claim values were dependent on the type of mitigation action, age of construction, estimated wind speed, and loss ratio (as an indication of more/less extreme damage modes). The criteria and assumptions used for applying modifications are detailed in the following sections.

Statistical assumptions (see Table 2, Table 3, Table 4) for “Proportions of claims affected” (e.g., the proportions of policies with avoided damage, i.e. mitigated loss) are estimated based on damage modes extracted from assessor’s reports from Cyclones Yasi and Larry (Table 1). Format and content were non-uniform across the selected reports (e.g., if a report didn’t mention roofing damage, it does not mean that roofing damage did not occur).

The number of available reports on claims with high loss ratios was limited (see Table 1), with care therefore being needed in the extrapolation of statistics from these samples to larger claims sets in the fragility analysis. However, these values provide a baseline from which higher a fidelity analysis could be built.

Table 1. Damage modes (by word mention) from claim assessor's reports for Cyclones Yasi and Larry grouped by loss ratio and analysis region

Loss Ratio	Cyclone/ Region	# of Claims	Tree	Roof	Window	Ceiling	Roller Door	Water Damage
0-.09	TC Yasi/ Townsville	157	21%	31%	15%	17%	2%	30%
0.1-.49	TC Yasi/ Townsville	9	22%	89%	33%	67%	0%	78%
0.1-.49	TC Larry/ Innisfail	43	14%	91%	67%	56%	16%	88%
>= 0.5	TC Larry/ Innisfail	13	15%	100%	77%	69%	31%	92%
>= 0.5	TC Yasi/ N. QLD	13	31%	100%	85%	100%	8%	100%

3.2. Mitigation Action #1 - Structural Roof Upgrades

Damage to the roofing structure is a well-known driver of loss during cyclones and other high-wind events. In addition to direct loss, roofing damage often leads to water ingress and additional wind-borne debris. The basic engineering design principles for wind loads on roofing structures require that each element of the system (i.e. cladding, battens, and rafters) be connected to each other and to the foundation of the structure through supports in the wall system. This design configuration is meant to ensure that wind loads on cladding elements are transferred to the supporting members below (i.e. battens, rafters) and on to the stronger foundation region of the house.

Roofing failures generally occur when one or more of the connections in the system fails. Contemporary housing is generally constructed with stronger connections than legacy housing (pre-1980s) due to enhanced building standards. Therefore, Mitigation Action #1 is focused on the following roofing connection upgrades in pre-1960s and 1960-80s housing:

1. Strapping at batten/rafter and ridge connections (pre-1960s and 1960-80s)
2. Collar ties between rafters (pre-1960s)
3. Vertical tension members between rafters and ceiling joists (1960-80s)

3.2.1. Basic Structural Analysis Modeling

In order to quantify basic estimates for the performance increase achieved by structural roof upgrading, simple structural analysis models were generated for Pre-1960s and 1960-80s typical roofing shapes using a structural engineering software package (SPACE GASS). Using SPACE GASS, before -and after- upgrade versions of a simple two-dimensional roof systems were subjected to wind uplift loads based on approximations from AS/NZS 1170.2. As severe roofing failures typically occur due to failed connections (e.g., batten/rafter, ridge, etc.), the mitigation upgrades are designed to disperse loading throughout the roofing structure and down to the foundation supports, thus reducing the concentrated loads at critical connections.

The upgrades also strengthen the load capacity of critical connections (via strapping). The combination of these effects creates a situation where the strength of connections are increased AND the load they are required to resist is decreased.

Pre-1960s roofing structures (Figure 6 and Figure 7) generally consist of high-slope, pitched frame hip construction (see Phase I report). The mitigation upgrades selected for this roofing type include additional strapping at batten/rafter and ridge connections as well as collar ties to join rafters (where not already installed).

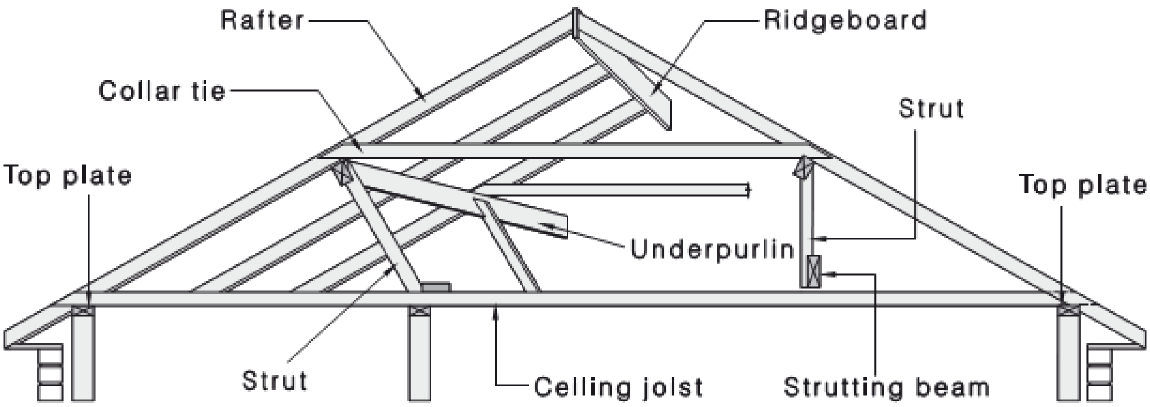

Figure 6. Arrangement for typical pitch frame construction (Source: AS1684.3)

Figure 7. Example of typical pitch frame construction (pre-1960s)

Roofing structures from the 1960-80s (Figure 8) generally consist of low-slope, pitched frame gable construction (see Phase I report). The mitigation upgrades selected for this roofing type include additional strapping at batten/rafter and ridge connections as well as tension members to join rafters down to ceiling joists.

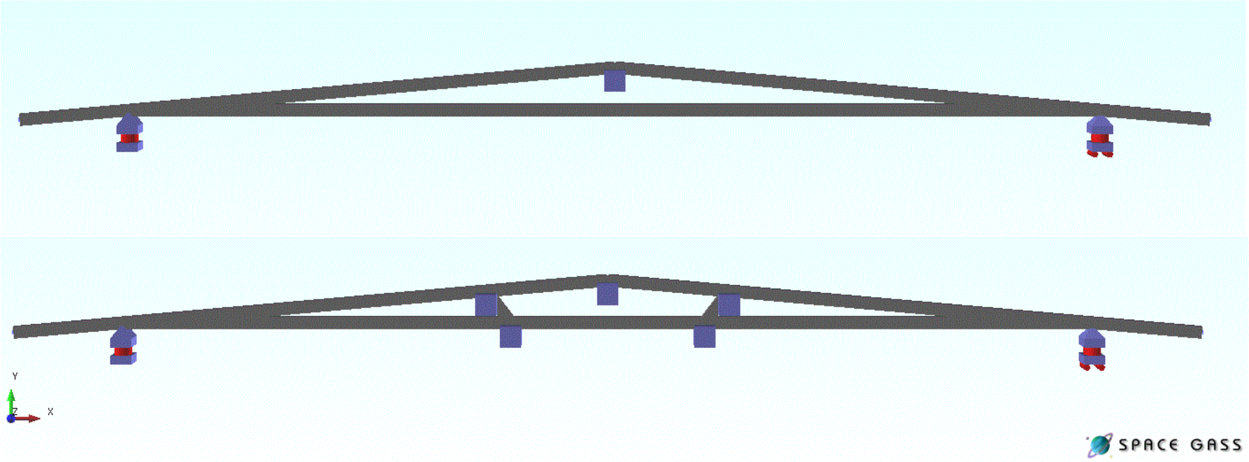

Figure 8. Basic structural analysis modeling of before (top) and after (bottom) upgrading a typical 1960-80s roofing structure

To estimate the performance benefits of upgrading, the loads at the rafter/batten interface (a critical connection for wind uplift) were estimated for a range of wind speeds (10 m height, suburban terrain) both before and after the upgrades. The performance trends are shown in Figure 9.

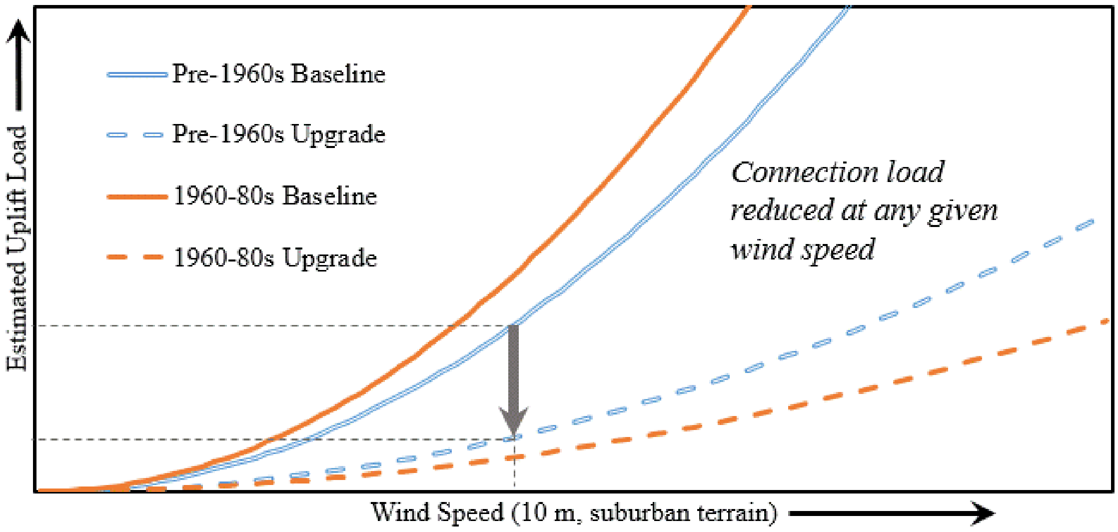

Figure 9. Estimated uplift load trends at batten/rafter connections for Pre-1960s and 1960-80s housing before and after structural roofing upgrades

3.2.2. Fragility Estimation

In order to simulate the effects of these upgrades during Cyclone Yasi, educated assumptions were made about the likelihood of roofing failure and severity of loss, based on the wind speed and loss ratio of any given policy in the Suncorp data set. These assumptions were used to form criteria for modifying policy claim values based on the estimated loss mitigation resulting from the upgrade. From the Phase I report (see Table 1) on Suncorp claims data from Cyclone Yasi, the following statistical assumptions were made for claims with pre-1960s and 1960-80s housing:

- 30% in the lowest wind band (80-145 km/h) and in the lowest loss ratio band (0-0.1) had minor roofing damage
- 40% in the medium wind band (145-170 km/h) and in the lowest loss ratio band (0-0.1) had minor roofing damage
- 50% in the highest wind band (>170 km/h) and in the lowest loss ratio band (0-0.1) had minor roofing damage
- 90% in the low/medium wind speed bands and the medium loss ratio band (0.1-0.5) had moderate roofing damage
- 100% in large loss ratio band (>=0.5) had severe roofing damage

From these assumptions, and correspondence with claims assessors in Queensland, the criteria for reducing claim values (i.e. simulating loss mitigation) in the Suncorp data set were established. Specifically, the mitigated loss value (claim reduction value in $) and the proportion of policies it applies to were estimated for various combinations of wind speed and loss ratio (Table 2).

Table 2. Applied criteria for reducing claim values based on structural roofing mitigation upgrades (applies to pre-1960s and 1960-80s housing)

Wind Speed (km/h)	Loss Ratio (%)	Proportion of Claims Affected	Mitigated Loss ($)
80-145	<10	30%	2,000
	10-50	90%	25,000
	>50	100%	70,000
145-170	<10	40%	2,000
	10-50	90%	30,000
	>50	100%	100,000
>170	<10	50%	2,000
	10-50	90%	70,000
	>50	100%	150,000

3.3. Mitigation Action #2 - Opening Protection

Damage to openings in the external shell of a building (e.g., windows, roller doors, etc.) during cyclonic or severe storm events often exposes the interior of the home to both wind and water ingress. Wind flow into the building can create positive internal pressure, adding to the overall loads on cladding elements (i.e. roofing, etc.) and increasing the likelihood of roofing or other failures.

Water ingress into the building can cause extensive damage to building contents and is well-known to dramatically increase insurance losses. Mitigation Action #2 is focused on reducing the likelihood of these damages by protecting vulnerable openings (i.e. windows, roller doors) from wind-borne debris impact and pressurized water ingress. The types of mitigation upgrades that can be used to protect windows differ from those of roller doors and thus the two upgrades are discussed in separate sections below.

3.3.1. Roller Doors

Roller door failures generally occur due to loads generated by wind-induced pressures. At lower wind speeds, damage is typically limited to buckling failure. However, at higher wind speeds buckled doors can become dislodged from tracks, causing additional damage to the surrounding structure and becoming wind-borne debris in some cases. To mitigate these damages, the upgrade model for roller doors includes aftermarket bracing to retrain the door from buckling in either the inward or outward direction.

Based on construction experience in Queensland, the CTS estimates that approximately ~20% of Pre-1960s and 1960-80s housing is equipped with a roller door. Alternatively, ~90% of Post-1980s housing are equipped with a roller door. Therefore, the mitigation benefits of roller door upgrades were applied to these proportions of claims for each age group. For example, of all the

Suncorp claims for Post-1980s housing, a random subset including 90% of those claims was selected, to which the mitigation criteria in Table 3 were applied. From the Phase I report (see Table 15) on Suncorp claims data, the following statistical assumptions were made to form the mitigated loss criteria:

- 2% in the low loss ratio band (0-10%) had roller door damage
- 15% in the medium loss ratio band (10-50%) had roller door damage
- 30% in the high loss ratio band (>50%) had roller door damage

Table 3. Applied criteria for reducing claim values based on roller door mitigation upgrade (applies to all housing ages)

Wind Speed (km/h)	**Loss Ratio (%)**	**Proportion of Claims Affected**	**Mitigated Loss ($)**
80-145	<10	2%	1500
	10-50	15%	1500
	>50	30%	1500
145-170	<10	2%	3000
	10-50	15%	5000
	>50	30%	5000
>170	<10	2%	3000
	10-50	15%	8000
	>50	30%	10000

3.3.2. Windows

Window-related damage modes may include direct damage from wind-borne debris, which can also increase the likelihood of roofing failure from internal pressure increases, and water ingress damage to the building walls and contents from poor window casing or sealing performance. The primary damage mode varies by wind speed, the amount of wind-borne debris or rain, etc.

For modeling, the window mitigation upgrade was assumed to effectively reduce the loss associated with each of these damage modes, the positive benefits of which increase with wind speed. The upgrades include plywood covering (installed DIY) and commercially available shuttering systems. From the Phase I report (see Table 15) on Suncorp claims data, the following statistical assumptions were made to form the mitigated loss criteria:

- 15% in the low loss ratio band (0-10%) had window related damage
- 50% in the medium loss ratio band (10-50%) had window related damage
- 80% in the high loss ratio band (>50%) had window related damage

Table 4. Applied criteria for reducing claim values based on structural roofing mitigation upgrades (pre-1960s and 1960-80s housing)

Wind Speed (km/h)	Loss Ratio (%)	Proportion of Claims Affected	Mitigated Loss ($)
75-145	<10	15%	1,000
	10-50	50%	2,000
	>50	80%	5,000
145-170	<10	15%	2,000
	10-50	50%	5,000
	>50	80%	10,000
>170	<10	15%	5,000
	10-50	50%	10,000
	>50	80%	15,000

3.4. Mitigation Action #3 – Community Preparedness

From the Phase I report, minor claims represent 86% of the total number of filed claims for Cyclone Yasi in the North Queensland Coastal Region. These minor claims typically include damage shade sails, minor water ingress, minor debris damage, etc.

Community education/awareness campaigns, with emphasis on cyclone preparation (e.g., removing shade sails, pruning trees, removing debris and unsecured items from the yard, etc.), may be an effective method of reducing the frequency of claims of this size. Past experience suggests that 100% implementation of these "preparation upgrades" is unlikely, and actual implementation rates will be much lower, depending on the method of dissemination adopted by the community outreach campaign. Therefore, for modeling purposes, it was assumed that the positive benefits of these upgrades were realized in only 30% of claims. The magnitude of these benefits were assumed to increase with wind speed as shown in Table 5.

Table 5. Applied rules for modifying claim values based on community awareness upgrades (all housing ages)

Wind Speed	Loss Ratio (%)	Proportion of Claims Affected	Mitigated Loss ($)
All	<10	30%	2000
	10-50		3000
	>50		5000

The costing associated with a community awareness campaign for cyclone preparedness upgrades is outside the CTS scope of work and will be undertaken by Urbis during cost-benefit analysis.

Additional Assumptions for Fragility Analysis

- All policies were assumed to be without any mitigation upgrades at the time of TC Yasi
- Future wind and rain conditions are similar to the those generating loss during TC Yasi
- All adjustments that result in claim values below zero were assumed equal to zero
- Storm tide damaged properties not considered

4. Damage Repair Cost Estimation

The following damage scenarios were presented to assessors, builders and engineers to provide estimates of cost of repair based on their experience. The estimates were used for the modelling of mitigated loss (i.e. claim reduction) for each upgrade solution in the fragility analysis. For each of the four 3 sec gust wind speed scenarios discussed (Australian Bureau of Meteorology Cyclone Categories 2-4), damage modes are based on typical damages noted during post-event field survey by the CTS and the Suncorp claims data for Cyclone Yasi. Items covered under a contents policy (e.g. furniture, white goods, etc.) were not included in the estimations.

4.1. Category 2 (125-165 km/h)

4.1.1. Fence Damage

Removal and replacement of a treated timber (pine) paling fence (15 m length x 1.8 m tall) that has been blown over.

Cost: $1,500 (~$100.00 per m) to $2,250

4.1.2. Shade-Cloth Damage

A shade-cloth (5 m x 3 m) is attached to two poles and at two locations on the side of single storey masonry block house. The cloth breaks loose from pole attachments and “flaps”, causing paint damage to blockwork wall and guttering on that side of house. Repair includes shade-cloth replacement, guttering (7 m length assuming Colorbond match exists), and wall repaint.

Cost: $3,650 to $4,000

4.1.3. Garage Door Damage

A double width (4.8 m) roller door is buckled/creased from wind pressure on a 1990s single storey block work house. Interior water or impact damage doesn’t occur as a result of the buckled door.

Cost: $1,500 to $3,200

4.1.4. Wind Driven Rain Damage to Modern House

Wind driven rain enters under a sliding glass window in the bedroom and another door in the living room of a contemporary single storey masonry block house. Walls and ceiling are internally lined with plasterboard. Floors are tiled in the living room but carpeted in the bedroom. Skirting boards are damaged (separating/bowing from wall linings) 2 metres either side of the door and under the window. Wall lining painting is blistered under window. Water has soaked the carpet to 2 metres out from the window. Water runs down over the electrical power point in the bedroom wall near the window. No water damage is observed in the ceiling. Electrical wiring must be checked.

Cost: $3,000 to $4,400

4.1.5. Gutter Loss to High-Set 1970s Home

Replacement for missing quad-guttering from one side (12 m) and both down-pipes of a high-set (elevated) 1970’s house.

Cost: $1,500 to $2,500 (high-set) and $600 to $750 (low-set)

4.1.6. Roofing Damage to High-Set 1920s Home

Loss of roof cladding and battens along one side including the gutter. Rain has damaged the kitchen cupboards and electrics. No damage to floor coverings. No damage below the house. (refer Figure 10)

Cost:

$15,000 (if not required to upgrade, repair battens and replace affected roof sheeting)

$35,000 to $50,000 (if upgrade required, full roof replacement, roof structure upgrade and tie down with certification)

Note: Responses commented that about 20% of the roof area is affected which is potential trigger point for minor (no upgrade work) or major work (upgrade work with full roof replacement). One respondent noted that it appears more than 20% of the roof area is affected but not 20% of the roof structure so it could be major/minor depending on the certifier and assessor. This contrasts current advice from the QBCC which states that roof cladding is a structural component and that with 20% of cladding damaged, a certified upgrade is required.

Figure 10. Wind-induced roofing damage to high-set 1920s home as presented to builders, assessors, and engineers for experience based estimates of repair cost

4.2. Category 3 (165-224 km/h)

4.2.1. Garage Door Damage

Replacement of a torn and buckled double width (4.8 m) roller door on a 1990s single storey masonry block house. As the door is failing it scratches the paint on the block work wall supporting the tracks. There is also damage to the internal fibre cement ceiling with gouges and marks. Paint on the ceiling and the rear FC timber framed wall has water marks and blistering.

Cost: $3,000 to $5,000 (includes a cyclone rated door per latest building standard)

4.2.2. Wind Driven Rain Damage to Modern House

Wind driven rain enters underneath the sliding glass door in the living room of a 2000s single storey L-shaped masonry block house. The dimensions of living room are 4 metres x 6 metres with 2.7 metre wall height. Walls and ceiling are internally lined with plasterboard and the floor is tiled. Wind driven rain is "pushed" up the valley gutter, overflowing the pans (no sarking) and entering into the roof space causing ceiling damage (refer Figure 11 for an example). Ceiling damage extends in roughly a 2 metre radius from the centre of the room with partial collapse in this area. A light fixture is in the affected area. Skirting boards and the lower 200 mm of wall lining are damaged to 2 metres on either side of the door. There is access to roof space via manhole.

Cost: $4,500 to $8,000

Figure 11. Wind driven rain damage to a modern (2000s) masonry block home as presented to builders, assessors, and engineers for experience based estimates of repair cost

4.2.3. Roofing Damage to Low-Set 1930s Home

Replacement for loss of roofing and battens on a low-set timber clad 1930s house (assuming central area 8 m x 8 m with 3 m wide "enclosed sleep outs"). Refer to Figure 12 as an example. AC ceilings have been damaged in the living room. The floors are polished timber in most rooms with linoleum in the kitchen and bathroom. The kitchen and bathroom cabinets are water damaged (chipboard). The walls are lined with masonite.

Cost: $55,000 to $75,000 (average of approx. $70,000)

Figure 12. Wind-induced roofing damage to a low-set 1930s home as presented to builders, assessors, and engineers for experience based estimates of repair cost

4.2.4. Roofing Damage to High-Set 1970s Home

Loss of roofing and battens from a fibro clad elevated 1970s house (assume 12 m long x 8 m wide) with low pitch gable roof. AC ceilings have been holed in living room. The floors are polished timber in most rooms with linoleum in the kitchen and bathroom. Kitchen and bathroom cabinets are water damaged (chipboard). Walls lined with Masonite. Assume no damage to under the house.

Cost: $65,000 to $87,500 (full wrap scaffolding needed, assumption of extra $15,000 above low-set in previous scenario)

Figure 13. Wind-induced roofing damage to a high-set 1970s home as presented to builders, assessors, and engineers for experience based estimates of repair cost

4.3. Category 4 (225-279 km/h)

4.3.1. Garage Door Damage

Replacement for a torn and buckled double width (4.8 m) roller door on a 1990s single storey masonry block house. As the door is failing it completely tears loose and in doing so punches holes in the fibre cement ceiling, dents the guttering and roof cladding and marks the block work wall adjacent to where the tracks are fixed. There is water damage to the fibre cement lining, the ceiling and the back wall.
Cost: $6,800 to $10,000

4.3.2. Wind Driven Debris Damage to Modern Home

A neighbouring legacy home loses part of its roof and generates debris. Repair is needed for the 12 m long wall of an elevated steel framed house (assume rectangular wall and not the “gable” as shown in Figure 14). The wall cladding has been damaged, causing marks across the building wall. Guttering and downpipes have been removed. The eave lining needs replacement (assume 900 mm wide). The steel frame of the home is undamaged and internal water damage has not occurred.
Cost: $23,200 to $55,000

Figure 14. Wind driven debris damage to a modern home as presented to builders, assessors, and engineers for experience based estimates of repair cost

4.3.3. Roofing and Wall Damage to Low-Set 1930s Home

Loss includes all of the roof structure and half of the front wall for a timber clad low-set 1930s house (Figure 15). Extensive water ingress occurs in all rooms and damages the kitchen and bathroom cabinets (chipboard). All of the internal doors have delaminated. There are no built-in wardrobes in the bedrooms. The floors are polished timber in most rooms with linoleum in the kitchen and bathroom. The walls are lined with masonite. It is assumed that no damage occurs under the house. Respondents were asked to consider whether this scenario is a rebuild or a demolition.

Cost:
$120,000 to $165,000 (low-set repair) and $130,000 to $175,000 (high-set repair)
~$195,000 (low-set rebuild) and ~$250,000 (high-set rebuild)

Note: One responder noted that in their opinion it is faster to repair this style of house than demolish and build a new house (with estimate of a new build being $200,000 to $250,000) while another response noted demolition with a new build with estimate of $195,000 for low-set and $250,000 for high-set house.

Figure 15. Roofing and wall damage to a low-set 1930s home as presented to builders, assessors, and engineers for experience based estimates of repair cost (high-set costs were also evaluated)

4.3.4. Roofing and Wall Damage to High-Set 1970s Home

Loss of roofing, part of the roof structure and half of the front wall from a fibro clad elevated 1970s house (assume 12 m long x 8 m wide) with a low pitch gable roof (e.g. Figure 16). Extensive water ingress occurs in all rooms, damaging the kitchen and bathroom cabinets (chipboard). All internal doors have delaminated. There are no built-in wardrobes in the bedrooms. The floors are polished timber in most rooms with linoleum in the kitchen and bathroom. The walls are lined with masonite. It was assumed that no damage occurred underneath the house.
Cost: $155,000 to $200,000

Note: Responses included comment "should be able to be repaired and brought up to code without demolition, depending on the lower wall structure construction type"

Figure 16. Roofing and wall damage to a high-set 1970s home as presented to builders, assessors, and engineers for experience based estimates of repair cost

5. Retrofit Upgrade Cost Estimation

The selected mitigation solutions (roofing upgrades and opening protection only) were presented in "scenario" format to assessors, builders and engineers to provide cost estimates for implementing each solution in an undamaged structure (i.e. prior to a severe wind event). The roofing upgrades were applied only to pre-1960s and 1960-80s housing while the opening protection upgrades were applied to all housing ages. The first roof upgrade scenario includes replacement of the metal cladding and then strapping of the rafter to top plates. The second roof upgrade method is per HB132.2: Structural Upgrading of Older Housing and includes an external over-batten (steel angle 100 x 50 x 5mm or steel pipe 55mm OD) and threaded rod running down the exterior of the wall.

5.1. Cladding Replacement and Strapping of Roof Members

Replacement of the roof cladding (assume existing 75 x 50 mm hardwood battens are in good condition and correct spacing) and upgrade to roof structure connections via strapping. A rectangular housing plan of 12 m x 8 m was assumed with a hip roof 22.5 degree slope. Specifically the costing scenario included the following:

- Battens to be strapped or batten-screwed to rafters (Figure 17 and Figure 18)
- Collar ties installed for each rafter pair
- Strapping at rafter to top plate connections (Figure 19)
- Strap struts at ridge to hip beams down to ceiling joists

Cost: $30,000 to $53,200

Based on the costing feedback, the following values were provided to Urbis for economic cost-benefit modelling:

Pre60s housing

- Scenario 1 - $30,000 for complete roof replacement and strapping upgrades
- Scenario 2 - $3,000 for strapping upgrades (assuming upgrade when owner is replacing roof for other reasons)

1960-80s housing

- Scenario 1 - $27,000 for complete roof replacement and strapping upgrades
- Scenario 2 - $3,000 for strapping upgrades (assuming upgrade when owner is replacing roof for other reasons)

Figure 17. Batten screw from battens to rafters (pre drill before installing batten screws)

Figure 18. Example of nailed strapping for batten to rafter connection

Figure 19. Typical example of strapping for rafter to top plate connections

5.2. Over-batten Installation (HB132.2)

Over-batten construction for both a pre-1940s high-set house and a 1970s high-set house. The upgrade includes 12 mm tie rods at less than 3 m spacing. It was assumed that the pre-1940s house had a rectangular plan of 12 m x 8 m and a hip roof with 22.5 degree slope. The cost estimate includes over-batten installation for all four sides of the home. The 1970s house was assumed to have a low pitch gable roof (12 m x 8 m) with over-battens only needed along the two 12 m sides (e.g. Figure 20).

Cost: $11,000 to $17,000

Note: One of the responses included a comment that in their experience, the overbatten solution would not be preferred and should be improved as clients always want their home to appear equal or better than its appearance prior to repair.

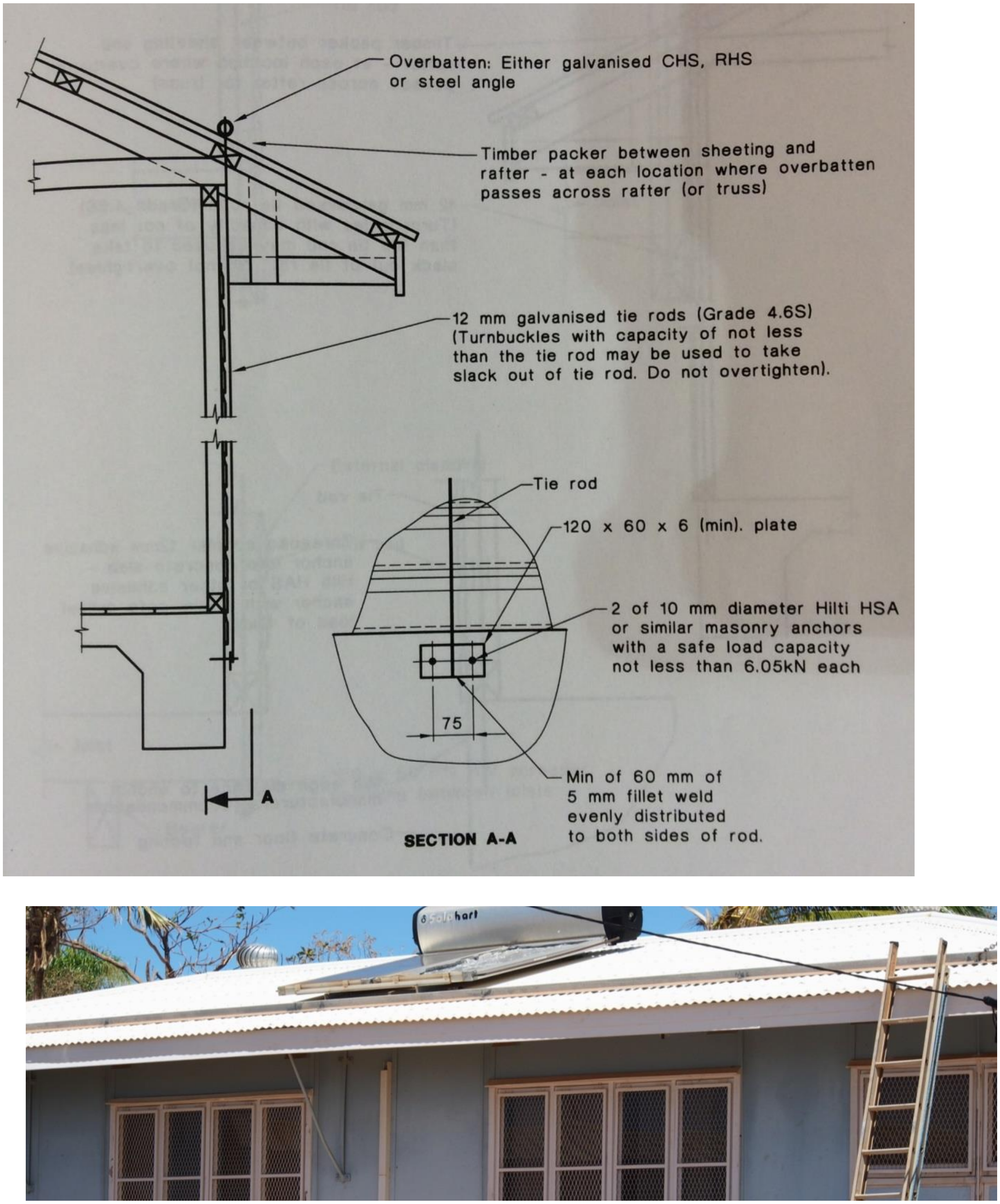

Figure 20. Drawing from Australian Standard’s Handbook HB132.2 and Typical over-batten installation per HB132.2 Structural Upgrading of Older Houses

5.3. Opening Protection: Roller Door Upgrade

The costs associated with roller door upgrading were estimated at $300 for aftermarket supports (on a per house basis) from discussions with product manufacturers.

5.4. Opening Protection: Window Protection

The costs associated with window upgrading were estimated (on a per house basis) from correspondence with building contractors in Queensland and provided to Urbis for cost-benefit analysis. Each home was assumed to have eight windows and where upgrades were applied to all windows. It was assumed that the number of windows, window performance, and cost of upgrading were independent of the building age or construction type. The two upgrading scenarios (plywood vs commercial systems) were assumed to have the same performance benefits once installed (e.g. Figure 21). The costing was estimated as follows:

- Scenario 1 - Plywood shutters, $170/window for materials (DIY, not costing labour) = $1,360
- Scenario 2 - Commercial window protection shutters/screens, $400/window with labour = $3,200

Figure 21. Examples of plywood (DIY install) (left) and commercial (center and right) shutters for window protection

6. Literature Review: Drivers of Community Engagement in Mitigation

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In addition engineering analysis for mitigation solutions, a literature review of mitigation programs used internationally was conducted to inform the implementation of a Northern Australia program. The review emphasizes the consumer engagement perspective. Programs in Australia are discussed where possible, however the majority of works originate from the cyclone-prone southeastern coast of the United States. The applicability of these programs to Northern Queensland are discussed. The following are provided:

- A critical summary of the key facilitators of behavioural preparedness or mitigation action
- A summary of existing programs (emphasizing parallel work in Florida, USA)
- Recommendations for enhancing the effectiveness of mitigation programs in Queensland

6.1. Introduction

In Australia, extreme weather events have brought to focus the need to ensure that the communities in these vulnerable regions are appropriately prepared (Boon et al. 2012). Between November 2014 and May 2015 there have been eight natural disasters declared in Queensland (e.g., Tropical Cyclone Marcia, Brisbane floods, etc.), resulting in government funding assistance activations for people and communities adversely affected (Queensland Government 2015). These regions in Queensland are therefore increasingly vulnerable not only due to high frequency and intensity of extreme weather events but also due to increasing population density particularly near exposed coastal regions. This increased population density has resulted in a larger proportion of people, built environments and infrastructure at risk of negative physical, mental, social and economic outcomes (Middelmann 2007).

Increased vulnerability of built environments and infrastructure yields larger post-event financial costs in repair and recovery. Cyclone Yasi in Queensland was estimated to have cost $800 million in rebuilding assets and providing community support (The Queensland Cabinet and Ministerial Directory 2011). Research has suggested that the extent of damage experienced and the costs of repair and recovery can be minimised if appropriate mitigating actions are taken (Pinelli et al. 2009). Appropriate and effective mitigating actions include strengthening the house structure (Leatherman, Chowdhury, and Robertson 2007; Lavelle and Vickery 2013). It is therefore imperative that communities and individuals in these vulnerable regions are aware of the risks and are engaging in appropriate mitigation strategies to effectively prepare for an event.

In terms of human factors, preparedness is a building block of psychological resilience which in turn contributes to the mitigation of harm to mental, physical, social and economic wellbeing post-event (Ramirez, Antrobus, and Williamson 2013; Poussin, Botzen, and Aerts 2014; Boon et al. 2012). Building psychological resilience is particularly important due to the interconnectedness of these wellbeing outcomes. For example, poor emotional wellbeing has been associated with delayed recovery from economic loss potentially due to associated stressors of being financially restricted and as such inhibiting individual capacity to recover, rebuild and move on.

There are some suggestions that Queenslanders are relatively well prepared for the impacts of seasonal cyclonic events such as cleaning up yards, preparing food, water and medical provisions and securing furniture and belongings (King, Goudie, and Dominey-Howes 2006; The Office of the Inspector-General Emergency Management 2014). Yet this preparedness is limited in the context of structural mitigation actions (Poussin, Botzen, and Aerts 2014; The Office of the Inspector-General Emergency Management 2014).

A challenge to identifying facilitators of different preparedness behaviours is that these facilitators are typically situationally and contextually specific. **Factors affecting the success of a mitigation strategy differ by region, event type and targeted behaviour.** This review is specifically aimed at identifying facilitators to increasing homeowner engagement in strengthening or retrofitting homes vulnerable to tropical cyclones in Queensland. From the literature, the situational and contextual factors that influence the level of preparedness (Sattler, Kaiser, and Hittner 2000; Terpstra 2011; Pennings and Grossman 2008; Poussin, Botzen, and Aerts 2014; Norris et al. 2002; Bonanno et al. 2007) in this region include:

1. Existing community experience with event
2. Defined roles of responsibility for preparedness
3. Existing strategies
4. Policies and legislation that provides standards for preparedness
5. Quality of existing horizontal and vertical social and community relationships that influence responses to communicated preparedness messages

6.2. Facilitators of Preparedness Behaviour

Research investigating behavioural responses to threat suggests that adaptive responses are influenced by an individual’s perceptions of vulnerability to and severity of the impact of the threat as well as their assessment of their perceived capacity to mitigate the negative impact of the threat event (Witte 1992; Grothmann and Reusswig 2006; Poussin, Botzen, and Aerts 2014; Maloney, Lapinski, and Witte 2011).

Research suggests that if an individual’s appraises the likelihood of a threat as very low, then they will tend not respond to the threat (Maloney, Lapinski, and Witte 2011; Witte 1992). Similarly, if the individual’s appraises the likelihood of the threat as high yet the perception of their ability to cope with these impacts is low, their response will tend to be one of fear and disengagement (Witte 1992; Maloney, Lapinski, and Witte 2011). Therefore, though it is important that a person perceives personal vulnerability to a threat, their perceived capacity to mitigate the negative outcomes of the threat must be higher than that of their perceived vulnerability in order for effective actions to be initiated. **This process of risk assessment can be conceptualised as a cost-benefit analysis.** However it needs to be noted that not all people assess risk similarly, particularly when taking into account specific contextual and situational factors.

Residents of Queensland face extreme weather event threats, such as cyclones and flooding, on an annual seasonal basis (Middelmann 2007). The events often have distinct warning periods, suggesting that people are aware of the likelihood of a future event and the regional vulnerability to an immediate event. However, not all warnings eventuate into actual events due to, for example, the size of the watch and warning zones and the directional changes of the cyclone path. This ratio of warning to event differs for different regions within Queensland, with some areas experiencing a high number of warnings and very low numbers of events. These contextual and situational factors result in a particular profile for residents of this region, (e.g., residents of Queensland have a high level of experience with disaster or potential disaster events).

Research has demonstrated that those who have had prior experiences with disaster events are more likely to respond adaptively to an event threat (Boon et al. 2012; Paton, Smith, and Violanti 2000). As a result of these past experiences and the seasonality of the potential events, residents are likely to expect future actual or potential events to occur and expect that they may be personally affected by this. However, residents differ in terms of their analysis of the risk involved and the cost-benefit of preparing for a potential event. This difference in analysis can be a result of multiple factors (e.g., complacency due to high warning/low event experience and low damage/high event experience). For example, research by Terpstra (2011) found that within communities who had experienced extensive flooding, those who had higher trust in public flood protection strategies reported lower personal preparedness intentions. These past experiences of few events or low levels of damage following a threat warning reinforces the perceptions of low personal vulnerability to an event (Pennings and Grossman 2008; Usher et al. 2013), even though perceptions of the probability of a severe event occurring may be high.

In a recent survey of household preparedness in Queensland it was found that though Queenslanders undertook basic preparedness activities, they also tended to overestimate their level of preparedness and, for some Queenslander's, their complacency was a major barrier in adequately preparing for an event (The Office of the Inspector-General Emergency Management 2014). **Therefore, the challenge lies in increasing preparation behaviour in a population that is highly vulnerable to an event but has great individual differences in the manner in which risk is perceived and the way the costs and benefits of preparations is evaluated.**

Research suggests that evaluation of risks and benefits of potential actions is influenced by the source of the message, the type of action being requested and the associated outcomes of that action. For instance, an individual's relationship with others in the community may influence the perceived quality and importance of the message being delivered (Ramirez, Antrobus, and Williamson 2013; Pennings and Grossman 2008). This relationship to community, sometimes called social capital, encompasses a person's sense of shared experience, reciprocity and trust towards others within their community (Cocklin and Alston 2002; Malecki 2011).

Social capital can include bonds between familiar in-groups such as family, peers and neighbours as well as horizontal connections towards unfamiliar out-groups such as the broader residential homeowner community or other regional residential communities vulnerable to the threat event (Woodhouse 2006; Woolcock and Narayan 2000; Pretty 2003). Further, social capital can include the vertical connections with unfamiliar out-groups such as an individual's trust and perceived connection to local government or state and national organisations (Szreter and Woolcock 2004; Pretty 2003). For example, if there was low vertical social capital between homeowners within a Queensland community and the State government, then homeowners may not attend to the government's message requesting homeowners to access services to assess the structural integrity of their homes to minimise risk of damage from cyclonic winds.

Establishing trust and connectedness between the target population and the source of the message influences attention and adherence to preparation advice (Ramirez, Antrobus, and

Williamson 2013). Yet attending to messages is only the beginning. **Research has also clearly established that though the target audience may attend to a message of behaviour change and acknowledge the adverse outcomes of not adapting, such attention does not necessarily translate into action (Witte 1992; Maloney, Lapinski, and Witte 2011).**

As mentioned previously, the second stage of threat appraisal is that of assessing levels of personal skills, resources and capacity to engage in the target behaviour (Maloney, Lapinski, and Witte 2011; Witte 1992; Poussin, Botzen, and Aerts 2014). It is therefore important to identify the factors that facilitate the acquisition of such skills, resources and capacity. These facilitators may include the acquisition of knowledge that increases confidence and capability of performing the behaviour or it may be receiving necessary support to complete the requested action. For instance, research by Mishra and Suar (2012) on flood and heatwave preparedness in India found that those who had greater preparedness education and greater access to resources, such as income, education and social resources, were more likely to be adequately prepared than those who had lower preparedness education and access to resources. Further, preparedness education and access to resources was found to mediate the relationship between anxiety and preparedness behaviour, with higher education and resources related to lower levels of anxiety.

As discussed previously, lowering anxiety or fear responses to potential threats are important in facilitating a positive assessment of a person's capacity to cope with the threat and consequently increases the likelihood of responding adaptively to a threat (Witte 1992; Maloney, Lapinski, and Witte 2011).

As stated, access to resources can help increase the uptake of preparedness actions. Yet access to resources seems particularly important if the intended mitigating behaviour is costly. For instance, research has suggested that the provision of financial subsidies is an important facilitator for engaging in structural mitigation behaviours (Poussin, Botzen, and Aerts 2014). Further, the personal time required for the mitigating behaviour also comes into the decision process. However, the decision to engage in the mitigating action is not only influenced by the cost of engaging but also the perceived beneficial outcomes (Poussin, Botzen, and Aerts 2014). Such beneficial outcomes can include the degree to which the behaviour is perceived to be effective in increasing resilience to negative outcomes.

Perceived effectiveness of outcomes can be influenced by, as previously discussed, the level of existing community connectedness and cohesion as well as the trust in those communicating the preparedness message (Ramirez, Antrobus, and Williamson 2013). Other beneficial outcomes for engage in preparedness behaviours may be the perceived usefulness of increased skills or knowledge that enhances the individual's ability to respond to a disaster or the beneficial financial outcomes of the preparedness action, such as a reduction in insurance costs (Poussin, Botzen, and Aerts 2014). For instance, research by Botzen, Aerts, and van den Bergh (2009) found that a majority of respondents from flood prone regions in the Netherlands were willing to undertake structural mitigation measures in exchange for reduction on insurance premiums.

These findings emphasize that although factors that facilitate mitigation action may be complex, targeted strategies that communicate the multiple benefits of undertaking action can be successful in changing behaviour.

6.3. Existing Programs and Strategies for Increasing Preparedness

The review of programs and incentives for homeowners to retrofit or strengthen their homes against extreme weather events is limited to storms and flooding since the process of risk assessment and cost-benefit analysis differs for different types of disaster events. Programs, policy and legislation for mitigation strategies that have been developed for increasing the resilience of residential structures against extreme wind conditions (and flooding) are discussed. Clear themes emerged for the types of strategies employed internationally including legislated building codes, funding opportunities for homeowners, financial incentives and community workshops.

6.3.1. Legislated Building Codes

Minimum building standard legislation and policy was the most common strategy employed by governments to decrease the vulnerability of communities to the adverse impacts of an extreme weather event (e.g. Office of Disaster Preparedness and Emergency Management, Jamaica, 2015; Department of Environment and Heritage Protection, Queensland, 2012; Florida Division of Emergency Management, US, 2011) (Department of Environment and Heritage Protection (Queensland) 2012; Florida Division of Emergency Management (USA) 2013; Office of Disaster Preparedness and Emergency Management (Jamaica) 2008).

This strategy predominantly involved outlining a minimum building standard with which new structures needed to comply. Failure to comply meant owners would be subjected to infringement fines and possibly prosecution. However, while these initiatives were often based within state-level government legislation, enforcement of the standards was a local-level government responsibility, as in the case of Queensland (Middelmann 2007). This suggests a potential for discrepancy of the operationalization of building standards between regional council communities due to differences in resource availability and therefore enforcement of the standards.

Additionally, in many cases where building standards are used as a mitigation strategy, the standards applied to only new building structures and are not retroactive. For example, residents of houses built prior to the standards implemented in 2002 in Florida, are not legally required to retrofit their homes to meet the post-legislative standards. Therefore, if this type of legislation and policy is the only residential building mitigation strategy in place in a vulnerable region, owners of older houses within these regions do not necessarily have adequate incentive to upgrade their homes. Further, if homeowners trust current mitigation strategies for associated extreme weather event impacts (e.g. flood management, warning systems, emergency relief and evacuation) to be adequate to protect them against substantial impacts, this may also reduce their willingness to undertake additional preparedness action (Terpstra 2011).

The level of action required to strengthen a home may require substantial costs and as such clear benefits, adequate perceived personal risk and adequate knowledge on how to respond must be communicated to homeowners (Witte 1992; Maloney, Lapinski, and Witte 2011; Poussin, Botzen, and Aerts 2014). Legislation- and policy-based mitigation on its own is probably not sufficient to engage homeowners in strengthening their homes against potential extreme weather events. This could be partially addressed by amending legislation to require homeowners of older homes to upgrade the building structure if the homeowner had, for example, replaced the roof of the house. However, this still requires homeowners to see the value in investing in a new roof, which may be further impeded by the additional costs that the amended legislation would require.

6.3.2. Funding Opportunities for Homeowners

Most mitigation programs and strategies identified originated from the USA, particularly Florida where there has been an increasing focus on mitigation strategies to protect against the adverse human and financial impacts of natural disasters (e.g., cyclones, thunderstorm, etc.). Funding opportunities varied with some opportunities originating from private companies/organisations in the form of long-term loans to strengthen and retrofit homes, while others were offered by government as a small grant.

For example, the PACE (Property Assessed Clean Energy) funding program was developed and delivered by a private company who offers loans to homeowners to make improvements on their homes (Florida PACE Funding Agency 2015). Originally developed in California for earthquake mitigation, the PACE program operates in conjunction with local governments in Florida to provide loans to eligible residents to undertake home improvements through state-approved contractors. The loans are available to commercial or residential buildings as long as there is existing insurance for the building. The government also provides financial security for mortgage lenders to reduce financial risks associated with defaults on mortgages. The length of the loan is approximately 15-20 years and is attached to the building, not the owner, and has repayment priority over the mortgage. These conditions have generated concern about the financial risk involved for an individual undertaking the loan and thus may make the program unattractive in the long term (Federal Housing Finance Agency 2010; Moody's Investors Service 2014). The conditions also present barriers to those who have limited financial security and therefore cannot undertake the additional financial burden.

Though a review of the effectiveness of the PACE program in Florida cannot be identified, past evaluations in other states in the USA have reported success in the uptake of the program by residents as well as considerable economic benefits for the immediate community and broader population (Goldberg, Cliburn, and Coughlin 2011; Saha 2012). For example, in the Boulder County, Colorado, the PACE-funded program funded $US9.8 million in residential retrofit projects in the first phase of the program’s delivery (Goldberg, Cliburn, and Coughlin 2011). It was estimated that delivery of this program contributed to $US14 million in economic activity in the county. Therefore, despite the concerns raised regarding the financial risk for homeowners, the PACE program can be considerably beneficial for regional communities not only through reducing structural vulnerability but enhancing the economic wellbeing of the region.

The ‘My Safe Florida Home’ project by the Florida Department of Financial Services offered Floridian homeowners the opportunity to apply for a $US5000 grant to retrofit their homes (Sink 2013). This program also offered a free house assessment for structural vulnerabilities to wind, with the findings provided to the homeowner in a report. The report outlined the appropriate structural improvements that could be undertaken, the cost of these improvements and the associated discount in insurance premiums if improvements were undertaken. This program targeted residents who were owners of a single-family, site-built home, living in a high risk region for wind damage who had had an older home and were of a lower-socio economic status. The targeting of residents of lower financial security who lived in older homes in a high risk area would help to reduce the impact of adverse outcomes to one of a region’s most vulnerable populations.

As highlighted previously, financial limitations can be a major barrier to undertaking recommended actions to effectively prepare for a potential event (Poussin, Botzen, and Aerts 2014; Mishra and Suar 2012). Therefore, this type of targeted provision of assistance is a more equitable approach to enhancing the strength of homes to those who would otherwise be unable to afford to do so. As of 2008 there were 179,390 inspection applications submitted from across Florida, with 109,000 of these applicants eligible for funding (Sink 2008). It was estimated that on average homeowners saved $US224 in insurance costs, with a potential state-wide insurance savings of $US24.5 million (Sink 2008). A study by Chatterjee and Mozumder (2014) found that residents who were more likely to seek home inspection as a part of the My Safe Florida Home program had home insurance, prior experience with damages and a higher sense of vulnerability.

However, these strategies of providing funds to homeowners to enhance the strength of their home may not be attractive to all homeowners. For example, low trust in the source of the support can result in this support being seen as undesirable (Pennings and Grossman 2008; Ramirez, Antrobus, and Williamson 2013). Therefore, other strategies need to be used to increase engagement from homeowners that are not attracted to offers of financial assistance.

6.3.3. Insurance Premium Reductions

As demonstrated in the ‘My Safe Florida Home’ program, one possible incentive for homeowners to strengthen their homes is that of reduced insurance premiums. In Florida, it is now a legislated requirement for insurance companies to provide homeowners with reduced premiums based on the evaluated strength of the structure. In some programs for reduced insurance premiums, these reductions can differ depending on the level of structural strengthening in place. For example, the Fortified program developed by the Insurance Institute for Business and Home Safety provides gold, silver and bronze standards for insurance companies and residents which provide guidelines of home strength (Insurance Institute for Business and Home Safety 2013). Insurance premiums are then reduced based on the level of standard followed, with a gold standard having the highest level of protection/strength against potential damaging weather events.

A public opinion survey of Floridian residents indicated that for 40% of respondents, the reduced insurance premiums were a key motivator for homeowners in undertaking improvements on their home (Sink 2008), a finding which is consistent with past research (Botzen, Aerts, and van den Bergh 2009). Results also indicated that it was important to respondents that this option was something they could choose to do rather than being forced upon them (Sink 2008). This may be analogous to residents feeling a sense of control over the suggested action. Control over choice is consistently associated with increased likelihood of performing an action (Brody, Grover, and Vedlitz 2011; Sattler, Kaiser, and Hittner 2000). Taking up the option would also tend to enhance confidence in the resident’s control over adverse outcomes. Further, 40% of respondents also reported that they were more likely to undertake improvements if others in their community were also strengthening their homes (Sink 2008). This is consistent with research that reports people are more likely to respond in a manner similar to those with whom they have connections and that they trust (Ramirez, Antrobus, and Williamson 2013), which is more likely to be ‘familiar others’, such as neighbours and friends, than ‘unfamiliar others’ such as hypothetical exemplars in promotional materials.

These types of insurance incentives seem to be a predominately American technique though some alternative forms of financial incentives are evident in the Australian context. For example, the Victorian Country Fire Authority and the Building Commission developed a set of guidelines for renovating and rebuilding homes in areas highly vulnerable to destruction from bushfires (Department of Environment and Heritage Protection (Queensland) 2012; Victoria Building Authority 2015). The guideline offers a list of recommendations for strengthening homes against bushfire impacts. Though insurance premium reductions are not offered, homeowners are informed that the environmental rating of the home would be improved and outcomes are operationalised in terms of dollars as reductions in heating and cooling energy costs. Despite this incentive, some anecdotal evidence suggests that homeowners in bushfire vulnerable regions of Australia are not upgrading homes to the highest level of protection due to the misconception that the suggested mitigation strategies are too costly (Weir 2015).

It is argued that if the benefits of these strategies were appropriately communicated, then there would be a higher uptake in homeowners strengthening their home. This again supports research evidence regarding the importance of social capital in communication (Ramirez, Antrobus, and Williamson 2013; Pennings and Grossman 2008; Szreter and Woolcock 2004).

6.3.4. Two Example Programs in USA

Two mitigation programs from Florida, USA are provided as examples. The first is a previously active program that assumes a key motivator will be insurance savings and uses a form of self-assessment. In this quasi-government run program, homeowners answer a series of questions about their property to understand the insurance savings that they may currently be entitled to from different insurers. A link to the assessment tool is provided below:

http://www.floridadisaster.org/wisc/

The second program identifies similar mitigation features to those relevant in Australia and includes a funded mitigation program based on retrofitting key items, as outlined below and illustrated in Figure 22:

Benefits of Wind Mitigation (from program website)

- Protects the homeowners family and the home’s value
- Reduces disruption of communities, Improves health and safety
- Reduces or eliminates the need for post-storm sheltering costs
- Potentially reduces hurricane insurance premiums
- Creates jobs and revenue in the community
- Reduces financial impact on state and federal treasuries
- $1 spent on mitigation saves $4 in response and recovery costs (FEMA estimate)

Figure 22. Illustrative example of a USA mitigation program that offers funding for upgrading (http://retrofitswfla.org/)

Both these mitigation programs have relevant components to older building issues in Australia but need to be explored to determine whether outcomes were/are successful.

6.4. Communication with Target Communities

As research has repeatedly demonstrated, developing and delivering programs and services does not necessarily result in people being aware of the existence of, or understanding, the benefits of using the service (Updegraff et al. 2007; Terpstra, Lindell, and Gutteling 2009; Kellens, Terpstra, and De Maeyer 2013; Hawkins et al. 2008). Therefore for a program to be successful it needs to be effectively communicated to the target audience. For example, in Florida the government has also developed a number of community programs and workshops that aim to enhance resident knowledge and understanding of the assistance and services available for them to improve their homes as well as providing a cost-benefit analysis for engaging such assistance and services (Florida Division of Emergency Management (USA) 2013). This is a similar strategy employed by the Queensland Government for disaster preparedness (e.g. Get Ready Qld program) with the exception that in Queensland the focus is on communicating information rather than providing incentives. For example, in the lead up to the start of the cyclone season in Queensland, local and state government work in coordination to deliver preparedness information at local community events (Disaster Management 2015).

This type of strategy employed by the Florida government can achieve a number of outcomes. First, the knowledge that is being disseminated to residents provides them with a better understanding of their personal risk in an extreme weather event. Second, it provides an avenue to increase understanding of the nature of effective actions that can be taken to reduce such risk. It is this type of information that is critical in building self-efficacy and resilience. Third, the cost-benefit analysis that individuals engage in when deciding whether or not to engage in preparatory actions can be guided so as to optimise the performance of desirable behaviours. Direct interaction with community members also helps identify those most at need of particular assistance allowing better match between the individual and the program, therefore contributing to improved distribution of resources.

6.5. Summary

This review has highlighted a number of factors. First, though there are a number of programs existing internationally, particularly in the United States, there are no coordinated, planned and implemented programs in Australia with the aim of increasing homeowner engagement in mitigation strategies to strengthen their home. Secondly, of the programs and services reviewed, it is clear that a “one size fits all” approach is not appropriate as individuals are motivated by different incentives. Third, using only one approach may also not be sustainable over longer periods of time, such as the provision of government grants. Fourth, programs must be appropriately marketed to individuals and communities based on identified key motivators for engaging in mitigation strategies. These motivators will differ between individuals and communities based on their level of experience with extreme weather events, perceptions of risk and responsibility, connectedness and trust towards others and the availability of resources (Bonanno et al. 2007; Sattler, Kaiser, and Hittner 2000; Poussin, Botzen, and Aerts 2014; Pennings and Grossman 2008; Terpstra 2011).

6.6. Recommendations and Suggested Research

To inform an effective mitigation program, it is recommended that homeowners in Queensland be profiled based on their likelihood of accepting different types of incentives. Profiles of owners who do, and do not, perform different types of damage mitigation behaviours will be interviewed, enabling the delivery of targeted communication and tailored incentive programs aiming to increase desirable behaviours. For example, younger homeowners with less experience of extreme events and high intentions to sell properties in the near future, may find ‘cash back’ offers for retrofitting more attractive than decreases in insurance premium costs over the longer term. Further, individuals in areas where residents have strong community ties may respond to communications inviting social comparisons (“What are your neighbours doing about this?”) more favourably than residents in areas without such linkages.

Using a survey methodology, the suggested research would investigate how social and community characteristics, information seeking behaviour and preferences, past extreme weather event experiences, and perceptions of threat and risk, influence behavioural preparedness. The interaction of such variables and demographic characteristics of individuals should also be investigated. It is suggested that at least three different communities be targeted based on differences in objective levels of vulnerability to adverse outcomes from an extreme weather event. This will enable inclusion in the design consideration of objective risk of extreme weather events, types of housing stock, and the experience of the residents with extreme events. To ensure adequate sampling of individuals, a research team at JCU has in the past used a combination of ‘pen and paper’ and electronic delivery of survey instruments. Both have advantages and both tend to reach different segments of the population.

Predictive modelling should be used to examine the interrelationships between the assessed variables and the behavioural outcomes. This will allow the relative contribution of variables to the desired outcomes to be assessed and enable the resulting model of behaviour to be refined. This procedure provides evidence of causal relationships and identifies possible intervention points. Profiles of homeowner typology should then be developed using a cluster analysis technique. This analysis technique is routinely used in marketing research to develop profiles of particular types of individuals from known standing on a set of descriptive variables (e.g., gender, income, age) with reference to standing on an measure of consumer behaviour (e.g., purchase of a type of car). This latter technique provides a rich picture of population segments in terms of the variables known to be related to behaviour.

Along with appropriate knowledge of the relevant evidence base, the research should have a history in the practice of survey design, implementation and data analysis. Ideally, they will have worked with communities within the North Australia area and have links to community and government organisations within the region. Such linkages are important to the implementation phase where community good will is essential for promoting the research and gaining adequate and representative sampling of individuals and households.

7. Proposed Mitigation Program Framework

Building on the analysis and information from the literature provided herein, conceptual frameworks for the inspection and reporting aspects of a mitigation program in north Queensland were developed in a preliminary sense. In this first instance, it was assumed that the sample-set of mitigation solutions discussed in Section 3 are to be implemented. The outcomes are presented with the understanding that they may inform the development of comprehensive programs for north Queensland in the near future. Two concepts were considered, the first includes a more traditional approach where inspections are completed by a qualified inspector, while the second makes use of smart-phone technologies allowing consumers to "self-assess". An alternative framework for a current program in the US is also discussed. It is important to note that an effective mitigation program may require a combination of each of the options considered.

7.1. Option A: Formal Inspections

The evaluation is based on assessment of risk via property inspections conducted by a suitably qualified inspector. This could be (a) government funded, (b) from the insurer or agent or (c) a third party on behalf of owner. Inspectors would need to demonstrate an adequate level of current knowledge and may need additional training for this work.

This option is similar in principle to what has been proposed by CTS to the Insurance Council of Australia for strata properties in cyclonic regions. Details of the inspection process including the survey scoring system, required level and content of training of the inspectors, and possible administration are documented in the following reports:

CTS report TS899: *Pilot study: Examination of strata building risks from cyclonic weather by utilizing policy claims data*
www.insurancecouncil.com.au/assets/report/Independent%20strata%20study.pdf

CTS Report TS948: *A scheme to estimate the resilience of strata properties in cyclonic areas*
www.insurancecouncil.com.au/assets/media_release/2014/July%202014/100714%20Report%20JCU%20Engineering%20Inspection%20Scheme.pdf

The survey process as described in the reports to ICA for strata properties is by necessity more detailed that what would be required for a formal survey/inspection for housing. Nevertheless, the process would deliver an overall building rating for the estimated resilience of the property and provides details on possible areas/components of concern. Mitigation options could be provided based on the survey results. It is estimated that each survey would cost in the order of $500.

Benefits of this work extend beyond the potential for reduced premiums and the increased understanding of an insurer's own portfolio. The process will improve the resilience of the wider community through both increased awareness and building maintenance/retro-fitting. The survey of buildings will allow a comprehensive assessment of building performance and potential issues. Remediation of the identified building elements that may limit strength or amenity will result in lower damage bills and a more resilient community.

In terms of housing, it has been considered too expensive to conduct individual property inspections as part of the insurance of residential property. However, with premiums in the order of $3000 a reduction of 20% will “pay” for the survey over one to two years. Most of the information that is captured in an inspection will not change from year to year, so a repeat inspection may only be necessary every 7-10 years, with additional inspections after any significant mitigation process. Given these factors, it may be possible to contain the cost of inspections to 2-3% of the premiums paid over the same period.

In cases where an inspection shows that risks were adequately controlled, this information might help to justify a reduction in premiums such that the inspection cost was met in the first year, with savings to the homeowner in subsequent years along with confidence that the insurer was not overly exposed to risk.

Where inspections result in a recommendation for mitigation actions, there would need to be adequate incentive to encourage the homeowner to take action. The insurer may be prepared to share some percentage of the initial cost, along with agreeing to a discount on premiums if the mitigation work is completed. It may also be possible to encourage governments to assist in the cost of inspections, retrofitting programs, interest free loans, etc., all with the outcome that will improve the communities’ resilience.

To enable the formal inspection process to provide confidence to owners, insurers and regulators, specific guidance in the form of AIBS webinars will need to be provided to qualified building inspectors/certifiers as explored in the ICA strata reports. In addition to the training, a Queensland Building Code form for structural retrofitting/renovation will be needed. It is envisaged that this would be a modified form of existing compliance forms (e.g. Form 21) where the level of retrofitting is inspected and “signed off”. In discussions with the QBCC, a modified version of the form was seen as an appropriate path with the process also improving inspection processes for the reroofing of housing following wind storms.

7.2. Option B: Self-Assessment

The second option considered is based on supplying additional information about property resilience to the insurer, through a combination of self-assessment by the property owner and some level of auditing by the insurer or their agent.

7.2.1. The Self-Assessment Form

It is proposed that a self-assessment form be developed, to allow property owners to report on key factors about their property. In addition to traditional paper format, a mobile application software tool for self-assessment (and mitigation action decision support) could be developed. In both formats, the captured information can be used to inform insurance pricing.

The self-assessment process could be supported by some level of auditing. The extent of this auditing may vary depending upon the initial results. While the auditing may help to improve confidence in the data, the main intent of the auditing would not be to act as a “policeman” but rather to refine the self-assessment process to ensure that homeowners are capable of answering the questions easily and reliably.

The challenges in developing a self-reporting form is to focus only on those factors that are easy for the homeowner to answer, while capturing key information that is relevant to the resilience of the property. To do this, the CTS suggests drawing on experience from previous damage investigations, as well as insurance claims data, to categorise the key areas of vulnerability. Some considerations that may be used to develop the self-assessment form include:

- The age of the property can affect its performance for a number of reasons
- There are specific vulnerabilities in new construction that may affect property resilience (e.g., water ingress around windows and doors)
- Construction quality affects performance
- Property maintenance affects performance
- Additions to homes that are not to the same standard as the original dwelling, or that have not been formally approved, generally do not perform as well as the original dwelling
- Specific construction details can affect water ingress, which is a significant driver of loss

7.2.2. A Mobile Application Tool for Self-Assessment

The development and near ubiquitous adoption of smartphones in Australia make it an ideal platform for enabling homeowner self-assessment and mitigation decision support. Research has also established the effectiveness of smartphones as mobile education devices (Wood et al. 2012) and has proposed the use of smartphones in disaster communication (Riddell et al. 2011; Meltzer et al. 2014). A smartphone application is proposed as a self-assessment tool that also educates and engages homeowners in cyclone-prone regions to make better decisions regarding mitigation.

The CTS suggests leveraging the efforts already invested in a US-based version of a similar application, entitled “ResilientResidence”, and currently in development phase in the State of Florida. The framework for the app, currently provides a personalized wind risk assessment of the user’s home, including the anticipated losses that would occur in a scenario event (e.g., Category 5 cyclone). Further, based on the self-assessment data supplied by the user, the app provides retrofit solutions that are specifically tailored to reducing wind-induced losses for that home. The core objective of application is to promote decision-support for homeowners to engage in mitigation activities and to information reporting. The self-assessed information recorded by the application can be aligned with the paper format version of the self-assessment form and transmitted to the insurer and collated at aggregate level for research. The app concept hinges upon the idea that mitigation information presented in abstract, large-scale terms is often less impactful to an individual’s mitigation decision-making process than specific, personalized content (Wood et al. 2012).

The current wireframe version of the app (Figure 23) allows individual homeowners to define the location (using either location based services or user input) and structural characteristics of their homes through an interactive series of questions, and then receive an engineering assessment (in simplistic format) of the expected damage their home would receive during a Category 1 through Category 5 cyclone event. The app then recommends three retrofit options that are likely to minimize the loss potential for the home, showing the homeowner the estimated reduction in expected losses from a cyclone for each retrofit. Homeowners are provided with helpful hints and graphics throughout the process in order to educate them on construction features deemed critical for wind-resistance. In addition, there are options for contacting a team of experts to answer questions.

Upgrade to High Rated Shingles ☑

Upgrade Roof to 8D Nails ☑

Install Roof-to-Wall Straps ☑

Estimated $91k damage as is.

Reduced to $58k with retrofits.

Your annual risk of a category 4 hurricane is 10%.

Figure 23. Images of the “ResilientResidence” mobile application. A user supplies resilience-essential information about the home (left), and retrofits are recommended with estimated loss reduction of each for varying cyclonic events

8. Summary and Recommendations

Mitigation pricing and associated reductions in loss for cyclone intensities were estimated from Suncorp claims data, and estimates from assessors, builders and manufacturers.
The mitigation measures costed were;

- retrofitting to roof structure for pre 1980s houses (upgrading roof framing connections),
- Protection of windows and doors to reduce wind driven rain ingress and reduce likelihood of a windward dominant opening forming, and
- Community awareness measures (effective ongoing maintenance of house, dismantle shade cloth awnings, unblock gutters, prune trees away from house, appropriate tie down for garden sheds, etc.)

The pricing and loss data were supplied to Urbis to conduct a cost-benefit analysis. The cost baselines (numbers and amount of damage) are based on the TC Yasi Suncorp claims data. The data is provided as reductions in percentages of loss ratio.

It is recommended that the models be developed further to include probabilistic components for both wind speed, and capacity and damage/loss of building elements. The resultant models could be (a) validated with other cyclone loss data, and (b) include other loss reduction measures such as ongoing improvements in building codes (e.g. changes to garage door standard following Cyclone Yasi).

Community awareness mitigation programs

In terms of a community awareness program for mitigation, the literature review noted a “one size fits all” approach to mitigation programs is not appropriate as individuals are motivated by different incentives (e.g. financial, level of hassle, engagement with the neighbours). The incentives and motivators will differ between individuals and communities based on their level of experience with extreme weather events, perceptions of risk and responsibility, connectedness and trust towards others and the availability of resources. Further research (e.g. via online and phone polls) to ascertain most effective motivators for different demographic groups is required.

Community Engagement Considerations

There is an opportunity for the whole community to benefit from an increased focus on mitigation:

- Homeowner – increased security during storm, promoted increase in house market value if retrofits undertaken, reduction in insurance premiums
- Government – reduction in drain on community services during and after severe event, more resilient community
- Industry – niche market for retrofitting and upgrading products as well as the building trades to professionally undertake retrofitting

Proposed “structural” mitigation programs

Based on the literature review and CTS experience as a long-term proponent for cyclone mitigation practices, two conceptual frameworks for a mitigation program were developed. The first includes a more traditional approach where inspections are completed by a qualified inspector, while the second makes use of smart-phone technologies allowing consumers to “self-assess”. It is important to note that an effective mitigation program may require a combination of each of the options considered.

It is recommended that further investigation be conducted into;

- Engagement with QBCC regarding development of a targeted building certification form for retrofitting work to older housing to allow insurers and home owners to demonstrate effective structural mitigation.
- Collaboration with building product manufacturing associations to explore economies of scale for components for retrofitting (e.g. roof space framing connectors, door braces, gutter brackets, fence supports, shed tie-down, etc.)
- Continued discussions with building associations (MBA, HIA) to promote skills and market niche branding for structural retrofitting of older housing

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