Improving the Resilience of Existing Housing to Severe Wind Events

Research advisory forum / 2018

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Business Cooperative Research Centres Programme







- Identify Vulnerable House Types Assess Vulnerability
- Propose Structural Retrofit
- Develop Software Package VAWS
- Advice to Home owners on how to improve the resilience of their homes
- Insurance have a better understanding of the risk and the impact of retrofit on reducing that risk
- Community and government reduced costs associated with response following windstorms –overall resilience of the community is increased at the individual house owner level









Damage Surveys – Cyclone Yasi

Pre-85 Houses







Damage Surveys – Cyclone Yasi

Post-85 Houses



Damage Data – Cyclone Yasi



Post 80s (current construction)

- <3% major roof damage
- ~30% all roller doors damaged
- But many houses had water ingress

Pre 80s (older housing)

- >12% major roof damage
- ~2% damaged by large debris
- May have hidden damage

Lower levels of damage of "newer" housing similar pattern in other surveys (e.g. Cyclone Winifred Cyclone Vance, Cyclone Larry)

Lessons have been learnt since Cyclone Tracy!

House Types – Cyclone & Non Cyclone Regions











House Types





SOUTH ELEVATION



Wind tunnel Model Testing





					Wind Direction																														
	0°				40°				90°				140°			180°			220°			270°				320°									
	-1.48	-1.45	-1.54	-1.99		-1.52	-1.58	-1.53	-1.42		-1.27	-1.22	-1.05	-0.92		-2.33	-2.69	-3.47	-3.26	-1.88	-1.90	-2.18	-2.43	-6.11	-7.22	-0.54	10.16	3.65	4.07	4.67	-3.33	2.99	-3.47	4.55	-5.81
$^{\rm C_p}$	-1.01	-0.99	-1.24	-1.72		-1.07	-1.09	-1.18	-1.18		-0.89	-0.87	-0.84	-0.75		-2.34	-2.71	-2.85	-2.48	-1.87	-1.98	-2.13	-2.33	-5.50	-5.19	-5.10	10.78	-3.21	3.77	-4.34	-4.67	4.71	-2.63	-3.81	-4.88
	-0.81	-0.95	-1.12	-1.64		-0.99	-0.95	-1.07	-1.11		-0.90	-0.78	-0.76	-0.71		-2.51	-2.69	-2.51	-2.62	-1.96	-2.06	-2.12	-2.30	-3.89	-3.38	-4.87	7.45	3.09	3.76	-4,40	-4.49	1.26	-2.38	-3.54	-4,42
	-0.73	-0.79	-1.05	-1.59		-0.87	-0.95	-1.04	-1.09		-0.74	-0.79	-0.75	-0.57		-2.55	-2.53	-2.42	-2.62	-2.07	-2.12	-2.09	-2.37	-2.82	-3.49	-4.65	5.37	з.н	3.81	-4.39	-4.50	0.95	-1.91	-3.42	-6.01
Ξ.	-0.63	-0.79	-0.95	-1.72		-0.87	-0.97	-0.97	-1.16		-0.75	-0.90	-0.73	-0.76		-2.25	-2.25	-2.29	-2.59	-2.08	-2.08	-2.05	-2.49	-2.64	-3.40	-4.05	4.42	3.05	3.82	4.55	-4.69	0.76	-1.32	-3.46	-4.12
Σ	-0.84	-0.89	-0.96	-1.71		-1.11	-1.14	-1.05	-1.15		-0.73	-0.78	-0.69	-0.58		-2.01	-2.10	-2.19	-2.24	-1.95	-2.00	-1,84	-2.69	-2.72	-3.21	-4,48	4.10	2.86	3.55	-4,30	-5.07	0.78	-0.91	-2.71	-4,18
	-1,47	-1.57	-1.40	-1.78		-1,68	-1.82	-1.62	-1.50		-0.88	-0.91	-0.83	-0.81		-1.96	-2.04	-1.99	-2.05	-2.07	-2.05	-1.95	-2.54	-2.56	-2,78	-3,19	4.00	2.91	3.23	-3.91	-5.71	1.47	-1.47	-1,40	-3,18
	-2.09	-2.58	-2.92	-3.38		-2.32	-2.68	-2.97	-4.97		-1.11	-1.28	-1.35	-1.30		-2,40	-2.67	-2.77	-2.97	-2.55	-2.69	-2.61	-2.96	-2.24	-2.55	-3,48	4.17	2.92	3,44	-3,89	-4.88	2.03	-2.35	-2.36	-2.75



Testing Connections







Mathematical Model

Probability of failure



$$p_f = \int_{-\infty}^{\infty} F_R(W) f_W(W) dW$$



Damage Comparison



Failure of structural connections in older housing at wind speeds less than design



VAWS (Vulnerability and Adaptation to Wind Simulation)



Software developed by GeoScience Australia in collaboration with CTS & JDH





Example of gust wind speed at the failure of roof cladding fixings



300 331 362 393 42.4 46.5 48.6 51.7 54.8 57.9 61.0 64.1 67.2 70.3 73.4 76.6 79.7 82.8 85.9 89.0 92.1 95.2 98.3 101.4 10.4.5 107.6 11.0.7 11.3.8 11.6.9 120 Wind speed (m/s)

Example of gust wind speed at the failure of roof batten to truss connection



30.0 33.1 36.2 39.3 42.4 45.5 48.6 51.7 54.8 57.9 61.0 64.1 67.2 70.3 73.4 76.6 79.7 82.8 85.9 89.0 92.1 95.2 98.3 101.4 104.5 107.6 110.7 113.8 116.9 120.0

Retrofits- HB132



Overbatten: or steel any ra pa 12 m (Turn than slack 10 x into min. maso

IS HB132 EFFECTIVE?

HB132 Over-batten

Cladding connection improved during reroof but... ...moved failure to next link in chain – the batten / truss joint



Strap each batten to rafter connection

New collar ties

Top plate to stud connection



Wall cavity rods





Household Resilience Program

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Mitigation options to be covered by the program include:

- 1. Roof replacement and roof structure tie-down upgrades (e.g. strapping of battens to rafters and rafters to top plates) to AS 1684.3:2010
- Roof structure tie-down upgrades using an external over-batten system installed to: HB 132.2 Structural Upgrading of older Houses, Part 2: Cyclone Areas
- Window protection including cyclone shutters or screens to withstand debris impact tests (AS/NZS 1170.2) and wind pressure tests to AS 4055 Wind Loads for Housing
- 4. Replacement of garage doors and frames, to withstand wind pressure tests from AS/NZS 4505 wind rated garage doors
- 5. Tie downs of external structures (e.g. sheds) to withstand wind loads from AS 4055 Wind loads for housing
- 6. Replacement of external hollow core doors with solid core external grade doors including upgrade of lockset and reinforce door frame



Roof replacement and roof structure tie-down upgrades



Upgrades and retrofitting to AS1684

Work certified to NCC reference documents





Household Resilience – Latest Statistics



Reduce drivers of loss (and increase resilience)

Mitigation needs:

- 1. For older houses Upgrading of roof structure (with focus on work occurring during typical renovations) (Examples in HB132.2 and on QBCC web site)
- 2. Opening protection (i.e. windows, doors, etc.) (applies to all building types and ages for helping to reduce water ingress)
- 3. Community education to promote preparedness including maintenance (applies to all building types and ages)
- 4. On-going education for builders, trades, engineering/design, and product suppliers (re: Standards and practices)



