Improving the Resilience of Existing Housing to Severe Wind Events

AFAC / **2019**

Prof John Ginger / Cyclone Testing Station – James Cook University

Dr Korah Parackal / Cyclone Testing Station – James Cook University

Dr David Henderson / Cyclone Testing Station – James Cook University

Dr Hyeuk Ryu / Geoscience Australia

Martin Wehner / Geoscience Australia

Mark Edwards / Geoscience Australia

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Australian Government Department of Industry, Innovation and Science

Business Cooperative Research Centres Programme

Improving the Resilience of Existing Housing to Severe Wind Events

- Post windstorm Damage investigations following have shown that Australian houses built prior to the mid 1980s do not offer the same level of performance as houses constructed to contemporary building standards.

- The primary objective of this project is to develop cost-effective strategies for mitigating damage to housing from severe windstorms across Australia. These strategies will be

  a) tailored to aid policy formulation and decision making in government and industry and

  b) provide guidelines detailing various options and benefits to homeowners and the building community for retrofitting typical at-risk houses in Australian communities.

Cyclone Tracy 1974

Cyclone Yasi 2011

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Pre-80s Houses

Post-80s Houses

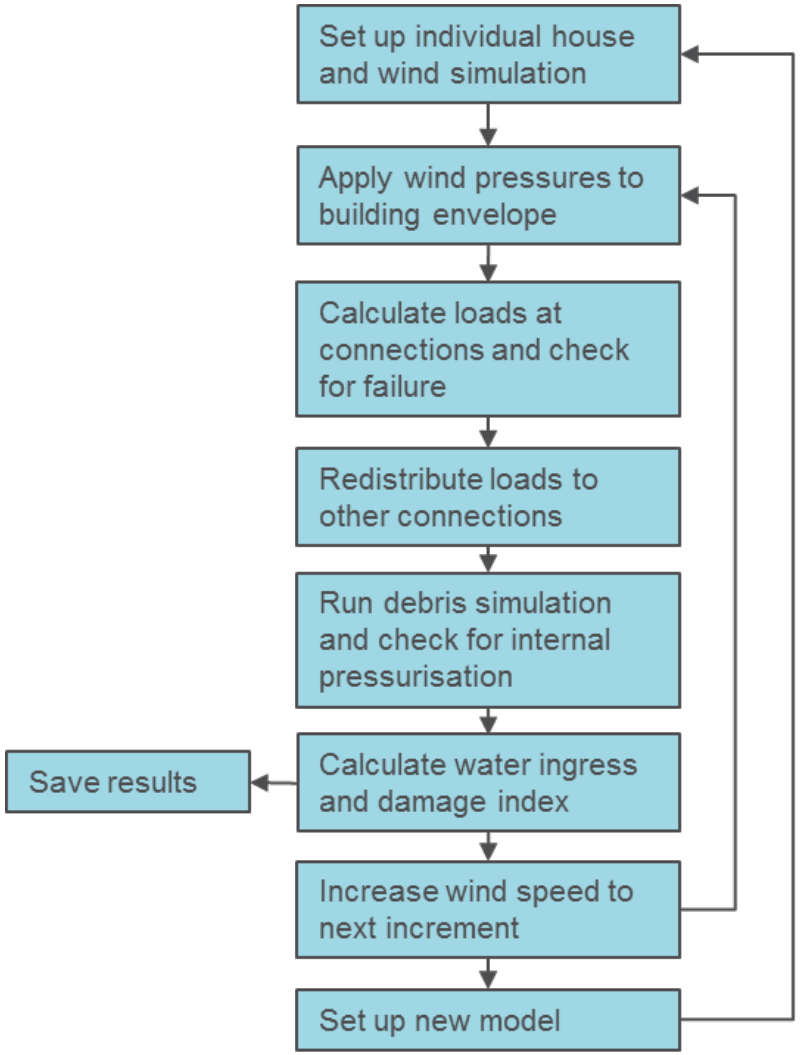
Brisbane Thunderstorm 2008

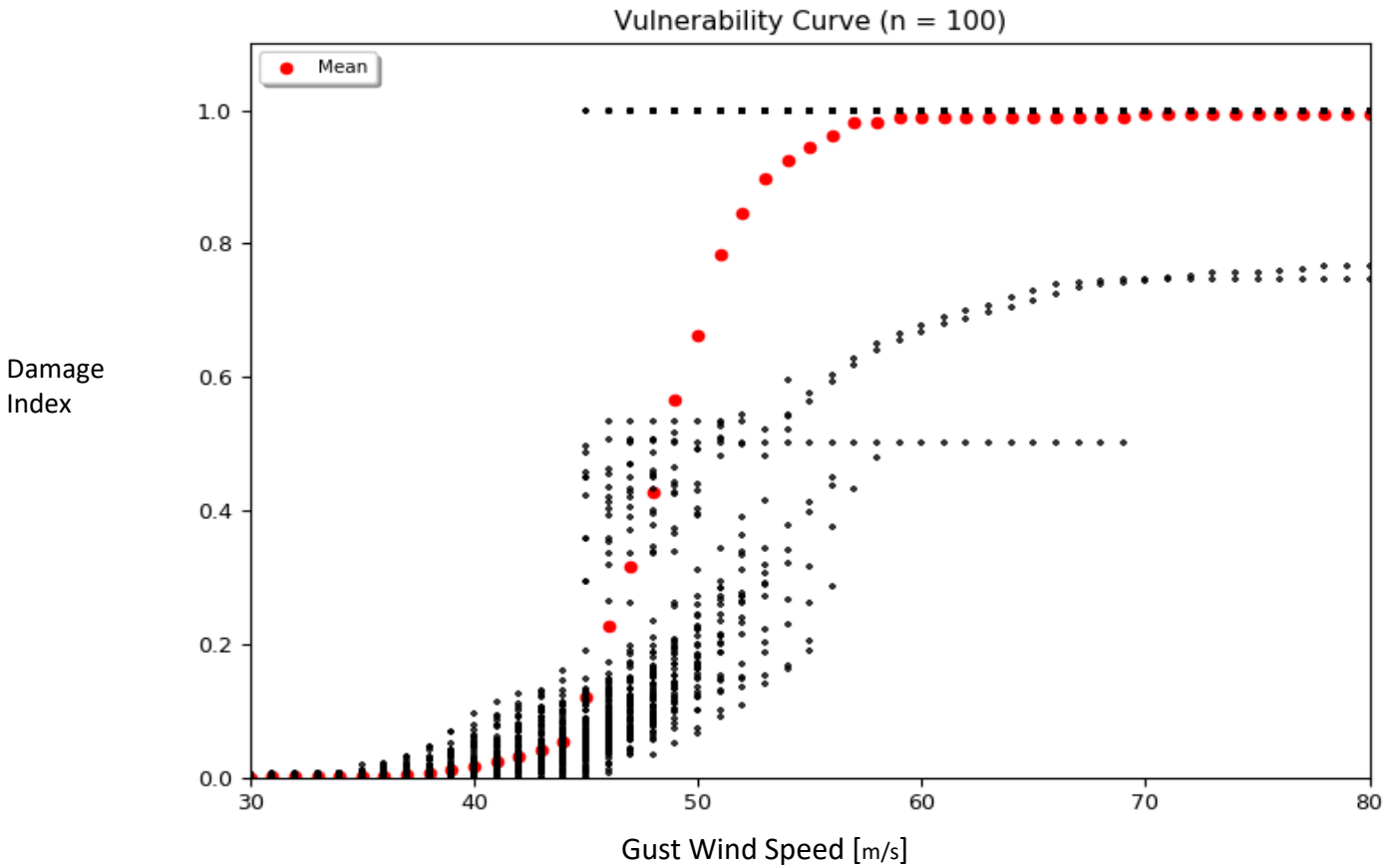
Overall project method

1. Characterise housing stock into a limited number of generic house types
2. Develop retrofitting details together with installation costs and changes in capacity
3. Quantitatively estimate vulnerability both prior to retrofit and afterwards
4. Assess the cost-benefit of installing the retrofit through reductions in future loss afforded by the increased resilience

To achieve step 3 the project requires a way to quantitatively estimate vulnerability of houses to severe wind. To this end we have developed a software package (VAWS) as empirical models cannot account for the change in vulnerability afforded by retrofit.

The VAWS Software





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House Types to Study the Effectiveness of Retrofit

- 10 generic house types of simple geometry based on surveys from different parts of Australia, interviews and exposure databases

Generic house type	Vintage	Wall construction	Roof material	Roof shape
1	Legacy	Fibro (high set)	Metal sheeting	Gable, low pitch
2	Modern	Reinforced block	Metal sheeting	Gable, medium pitch
3	Legacy	Double brick	Metal sheeting	Gable, medium pitch
4	Legacy	Double brick	Tile	Gable, medium pitch
5	Legacy	Double brick	Metal sheeting	Hip, medium pitch
6	Legacy	Double brick	Tile	Hip, medium pitch
7	Legacy	Brick veneer	Metal sheeting	Gable, medium pitch
8	Legacy	Brick veneer	Tile	Gable, medium pitch
9	Legacy	Brick veneer	Metal sheeting	Hip, medium pitch
10	Legacy	Brick veneer	Tile	Hip, medium pitch

Case Study – The Group 4 House

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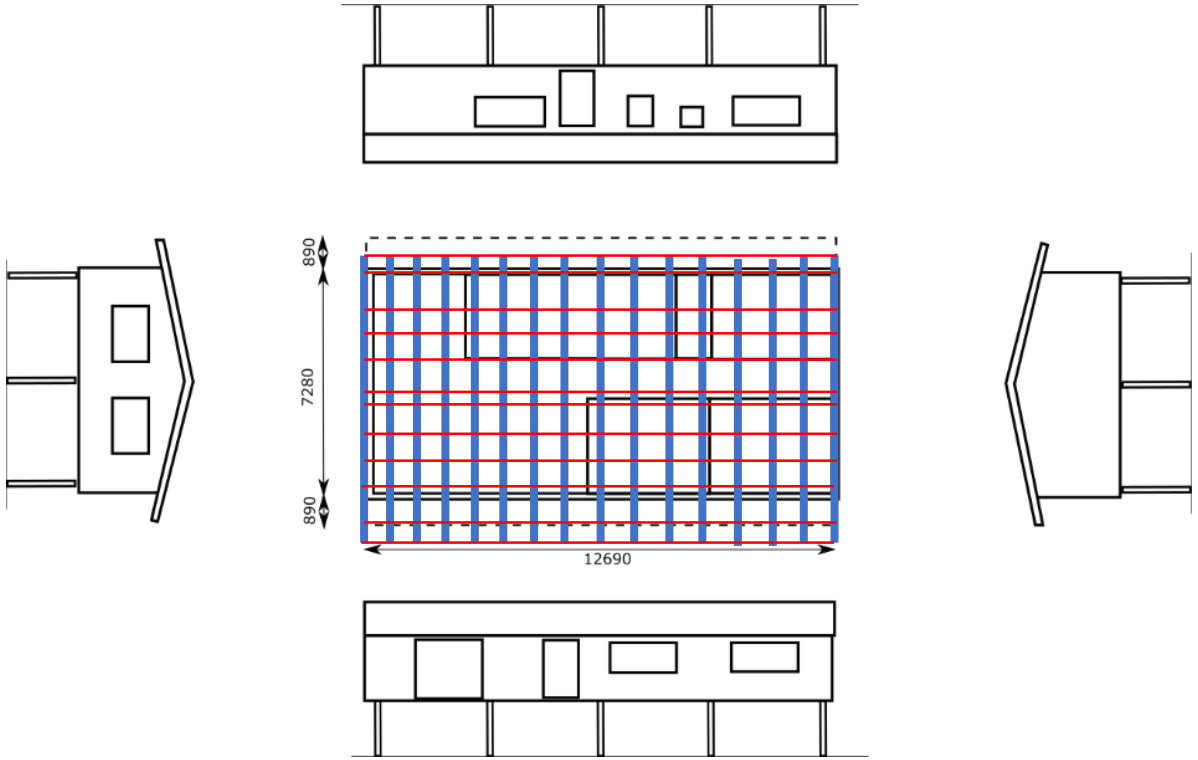
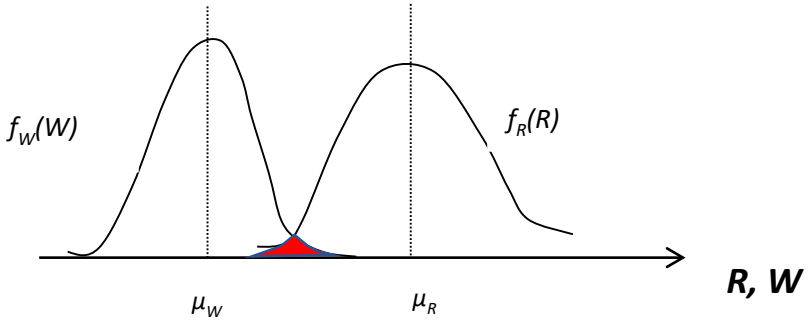


Connection Type	Mean Strength (kN)	CoV
Sheeting (For approx. 4 fasteners)	2.7	0.1
Batten to Rafter	1.5	0.3
Rafter to Top Plate	5	0.3

Failure when the load >strength: Failure Modes– Roof cladding: Batten-Rafter: Rafter-top plate:

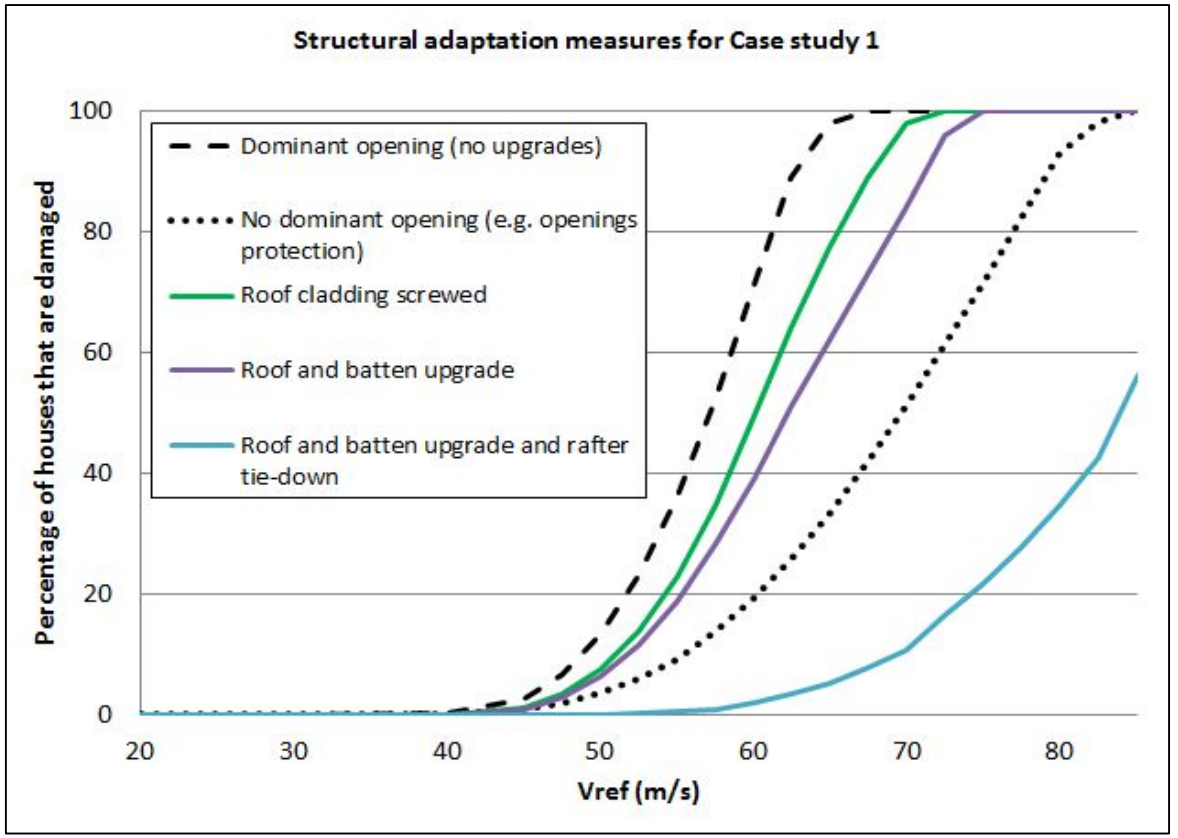
Progression of failure – Load redistribution

Loads, Resistance & Probability of Failure



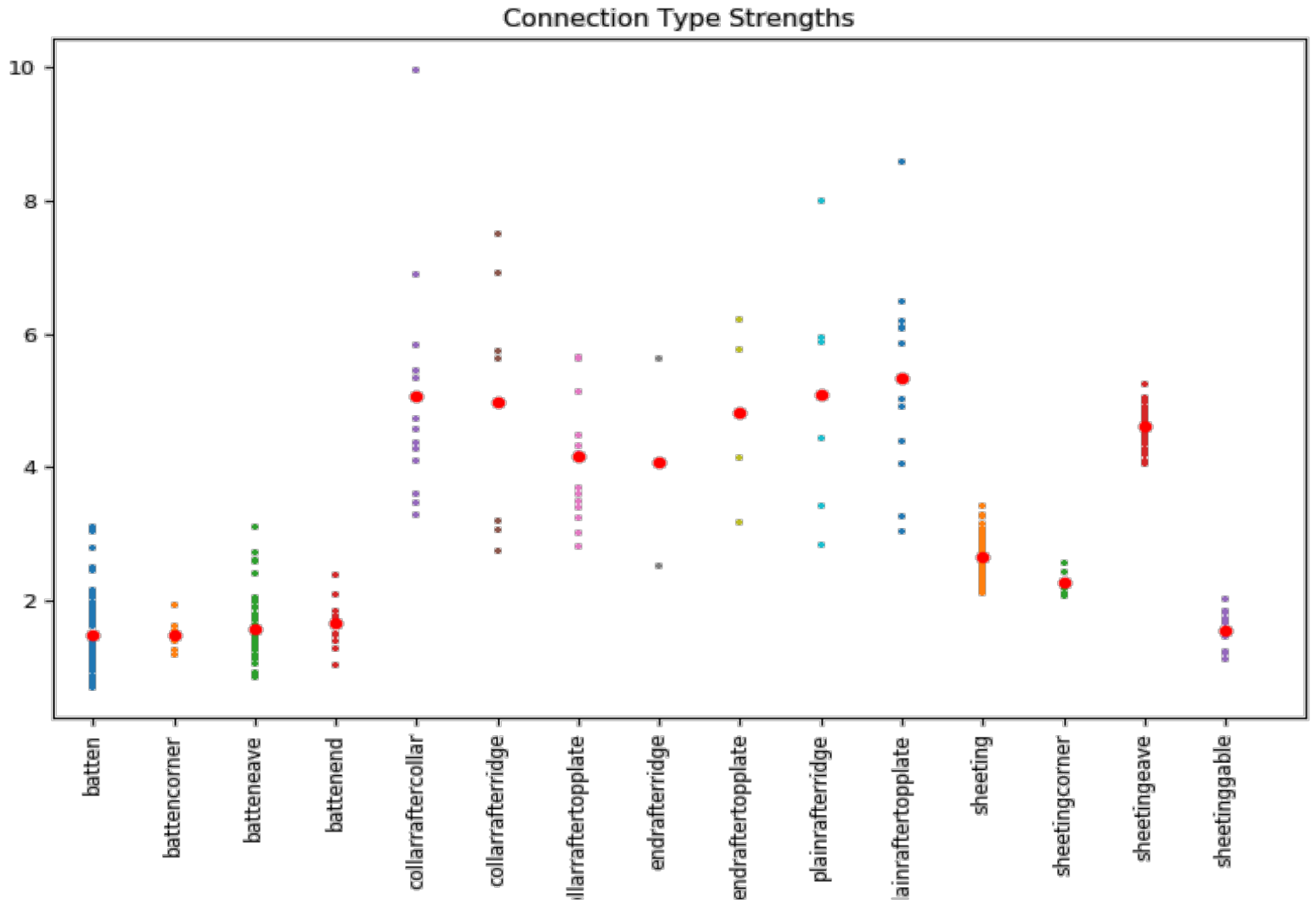
$$p_f = \int_{-\infty}^{\infty} F_R(W) f_W(W) dW$$

$$F_R(W) = \int_{-\infty}^{W} f_R(R) dR$$



Connection Strengths

Connection Strength (kN)



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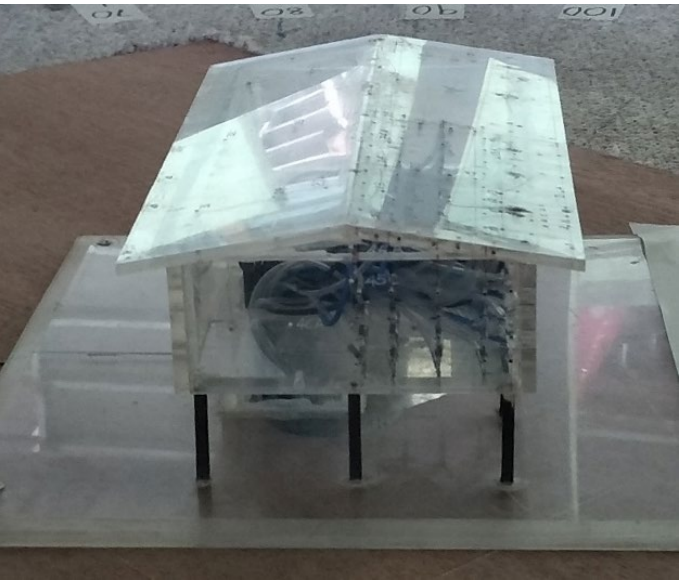
Wind Tunnel Model Tests



Tests in Wind Tunnel at the Cyclone Testing Station, James Cook University. On representative houses at a length scale (L_r) of 1/50

$$X_i = \left(\sum_{j=1}^{N} \beta_j \, A_j p_j\right) = \left(\sum_{j=1}^{N} \beta_j \, P_j\right)$$

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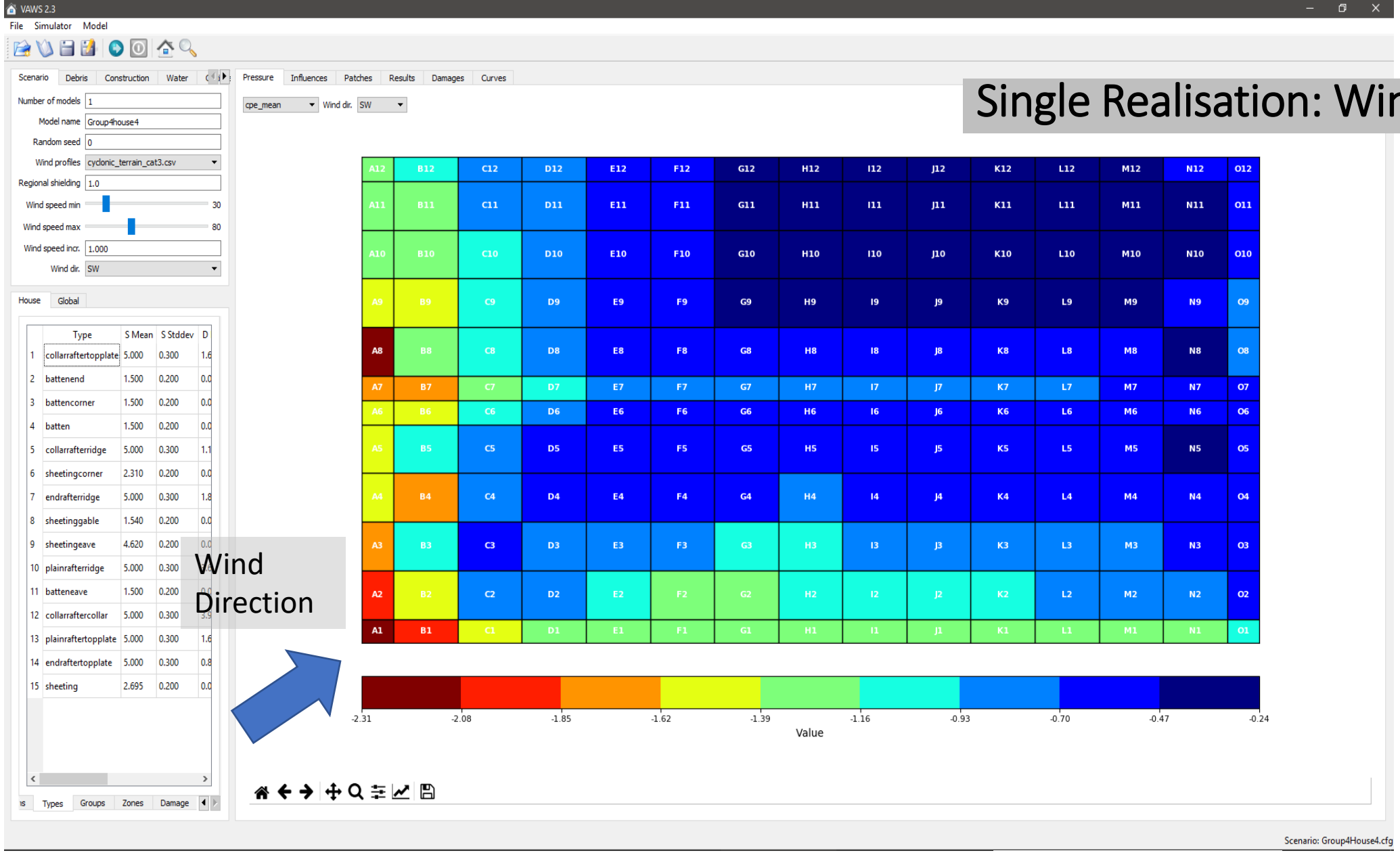
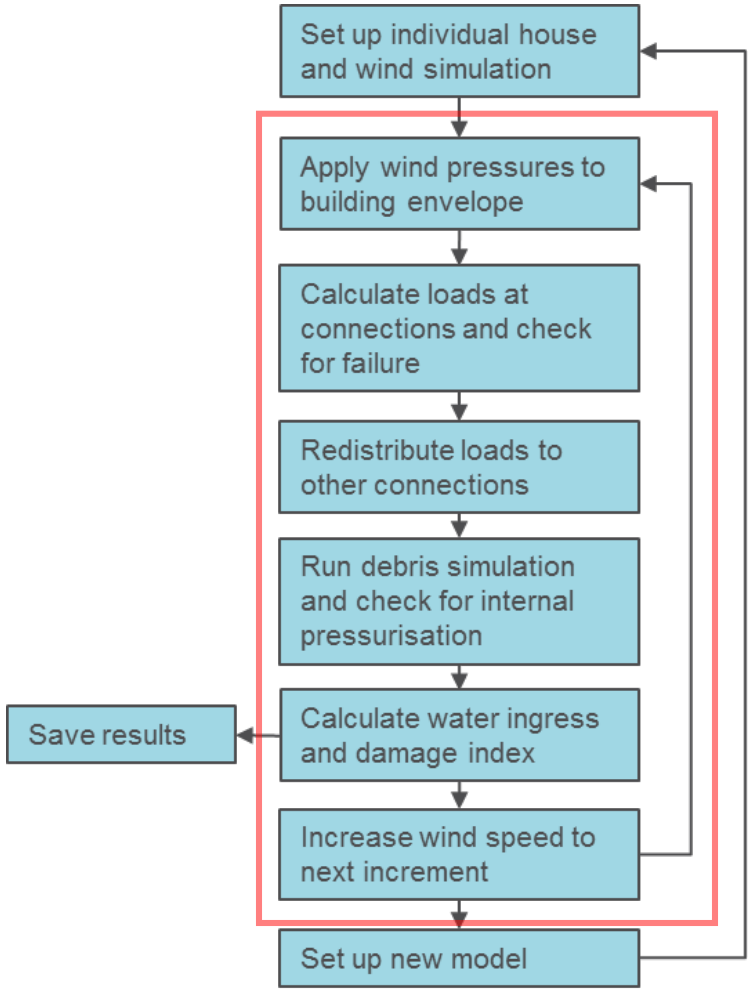
Single Realisation: Wind Pressures

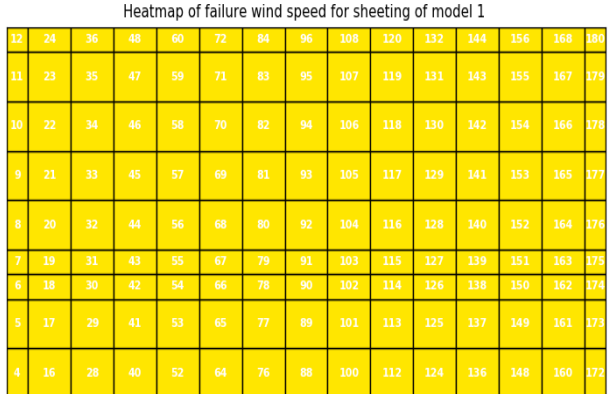


Program Logic

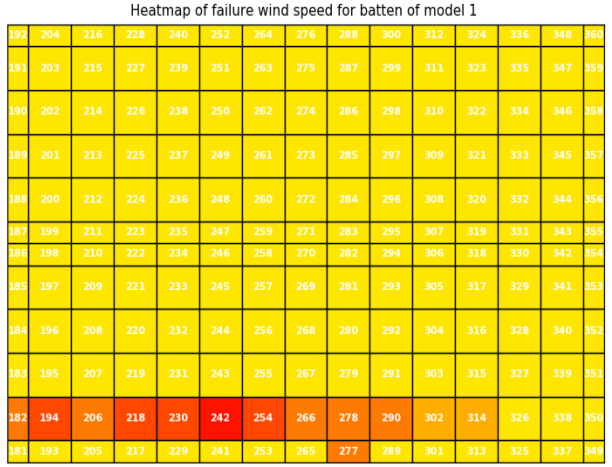


Single Realisation:

‘Heatmaps’ of Connection Failures

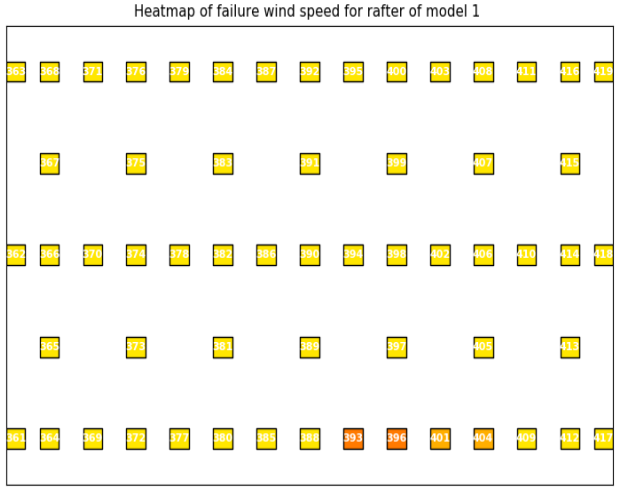


Cladding Failures

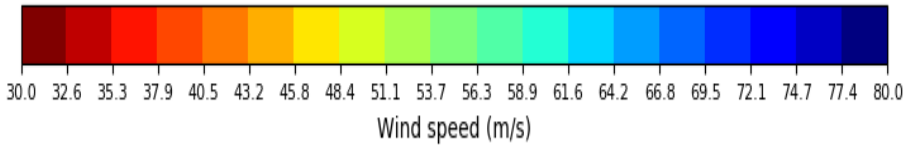


Batten to Rafter Connection Failures

Wind Direction



Roof to Wall Connections Failures



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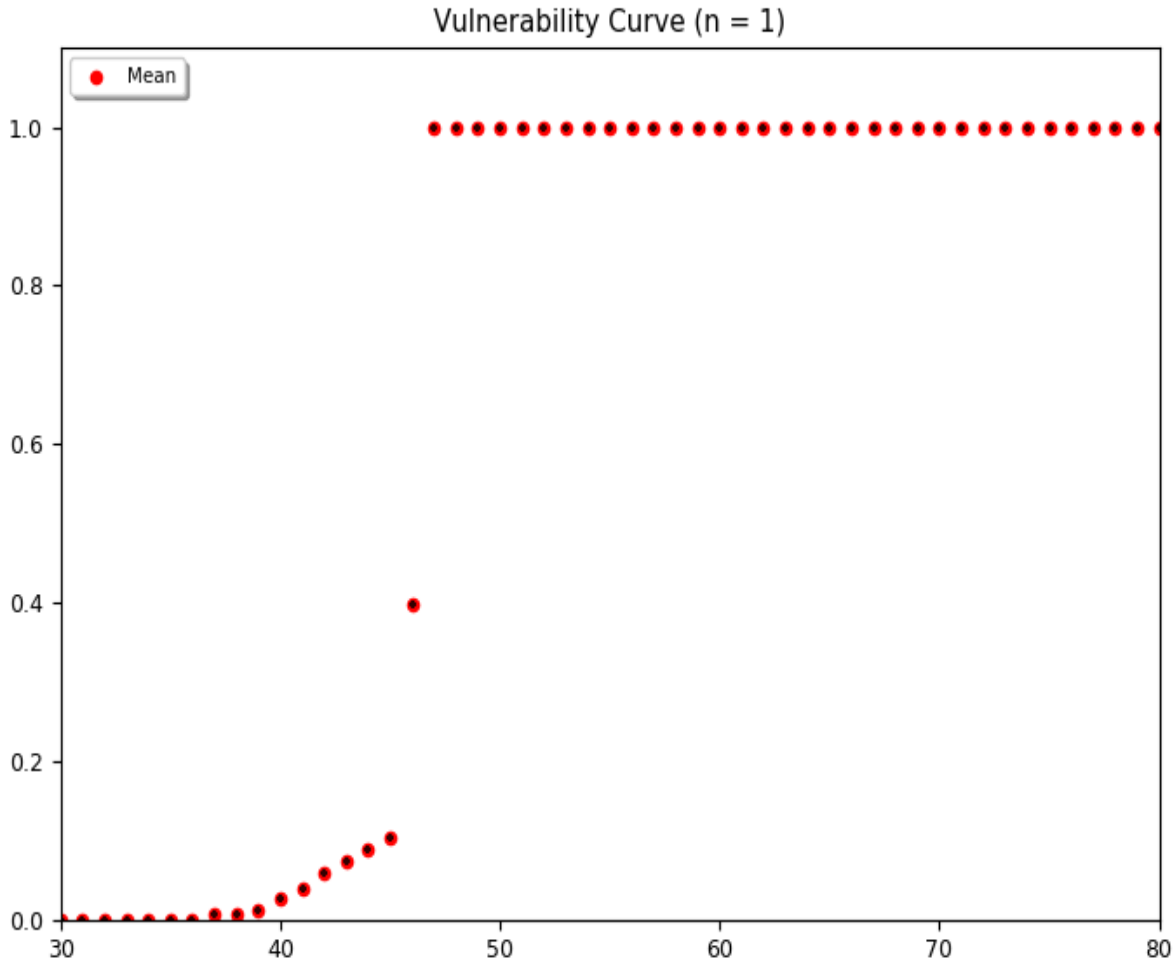
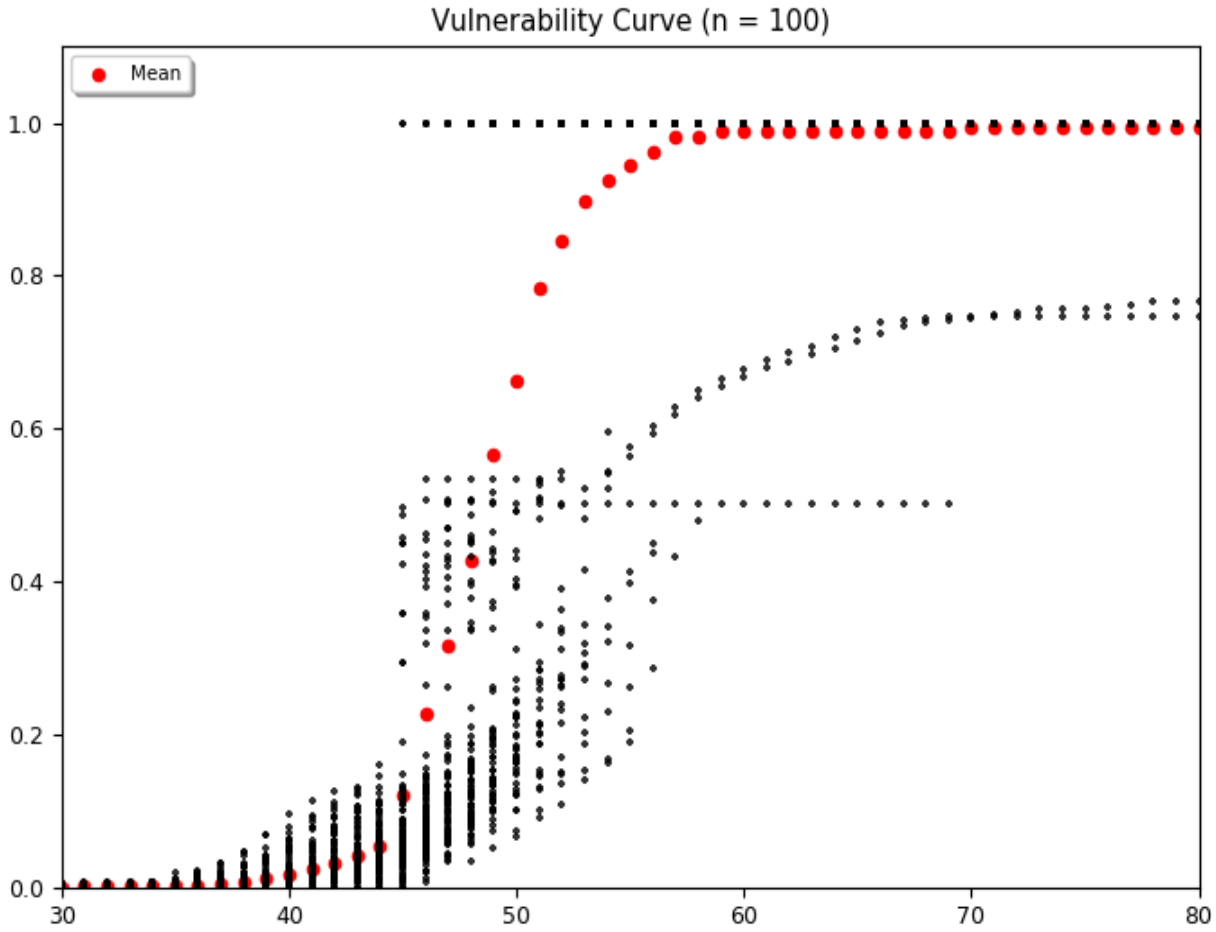
Single Realisation: Vulnerability Curve, SW Wind Direction



- Debris Impact on
- Window/door blow in
- Damage index of roof only

100 Realisations – SW Wind Direction

Damage Index



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Stakeholder Meeting – Sydney (3rd June 2019)

Participation 30+ from both Australia and New Zealand:-

- Insurers
- Brokers
- CatLoss modellers
- Engineering consultants
- Building industry organisations
- Government science agencies
- State government
- Academic researchers
- BNHCRC

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Stakeholder Meeting – Sydney

Overall

- Value of the software as a research tool endorsed.
- Necessity and usefulness of the information produced validated.
- Future development to produce information in forms useable to wider group.

Specifically:-

- Range of software refinements proposed.
- Need for more user friendlier version with improved graphics.
- Recommendation for further effort to calibrate and validate the tool against actual damage.
- Request to include tiled roof cladding.
- Functionality to examine the effects of water ingress and debris damage independently.
- Expansion of the building types beyond non-residential

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Next Steps

- Including structural system and capacity and wind loading data for all 10 generic house types and validating VAWS.
- Producing practical retrofit options and analysing using VAWS – including for Cost Benefit including broader metrics than avoided damage. Comparison with actual retrofit costs from Qld Government Household Resilience Program for validation.
- Presenting outcomes at the next Stakeholder Workshop in late 2019 / early 2020. This workshop is planned for presenting intermediate results for gaining feedback from Stakeholders (building, regulatory, insurance industries).
- Disseminating project outcomes.

Thank You

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