Improving the Resilience of Existing Housing to Severe Wind Events

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Geoscience Australia

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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

Pre-80s Houses

Post-80s Houses

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Brisbane Thunderstorm -2008

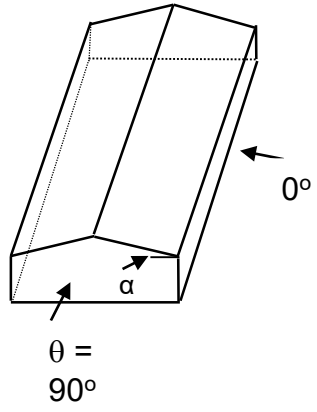
Cyclone Vance Exmouth WA -1999

House types to study the effectiveness of retrofit

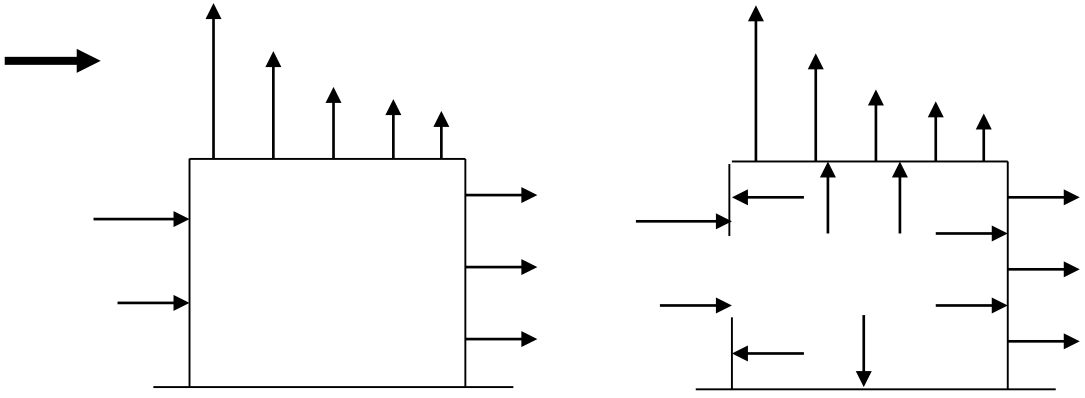
- 10 generic house types of simple geometry based on surveys from different parts of Australia, interviews and exposure databases

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, med

Wind Loads on Houses



External, Internal (and net) Pressure



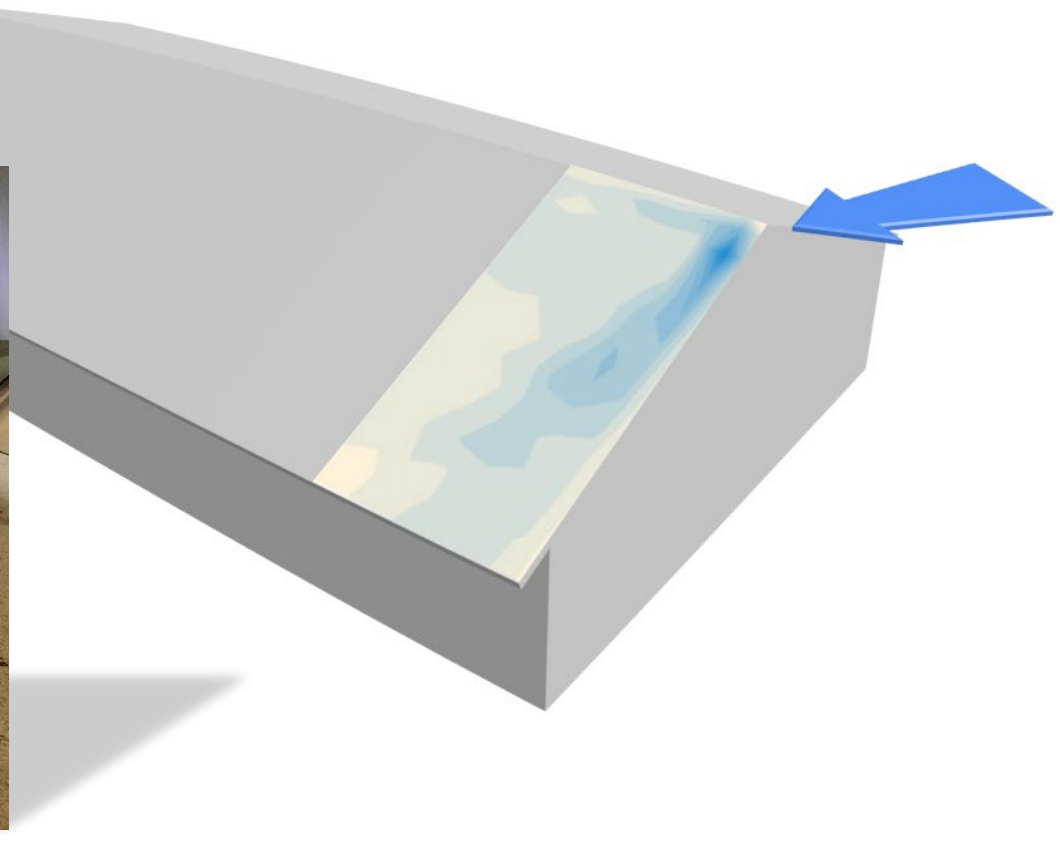
$$p, f = (0.5\,\rho_{air})\left[V_{des,\theta}\right]^2 C_{fig}\, C_{dyn}$$

Nominally Sealed

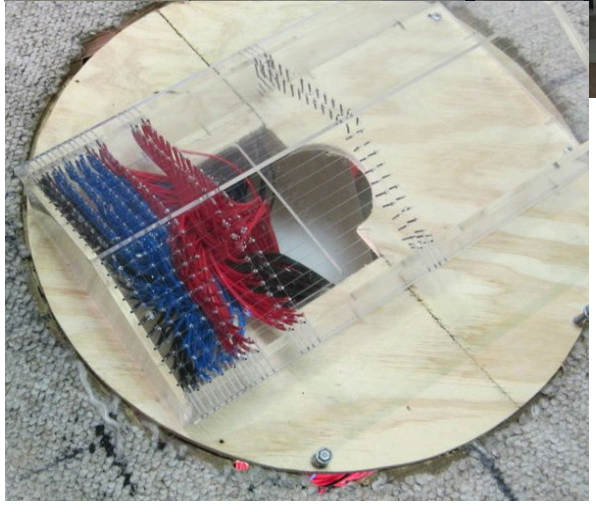
Dominant Opening

- Structural response - Probability of failure

External Pressures on a Roof



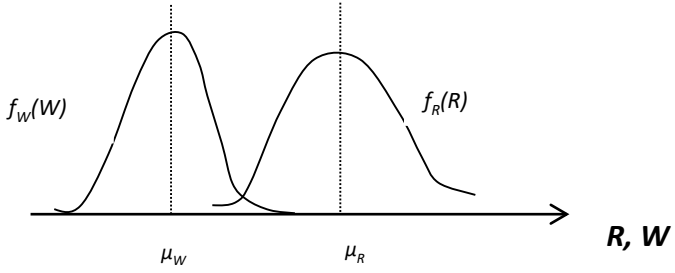
Wind Tunnel Model Tests



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

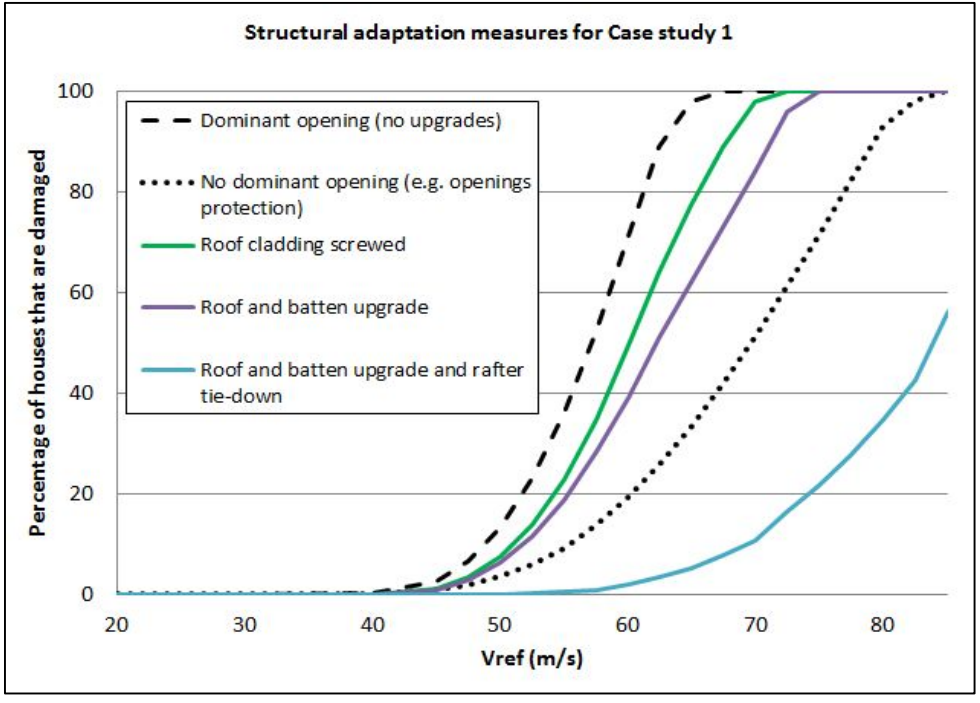
$$X = \left(\sum_{j=1}^{N} \beta_j A_j p_j\right) = \left(\sum_{j=1}^{N} \beta_j P_j\right)_{C_{pk}}$$

Loads, Resistance & Probability of failure



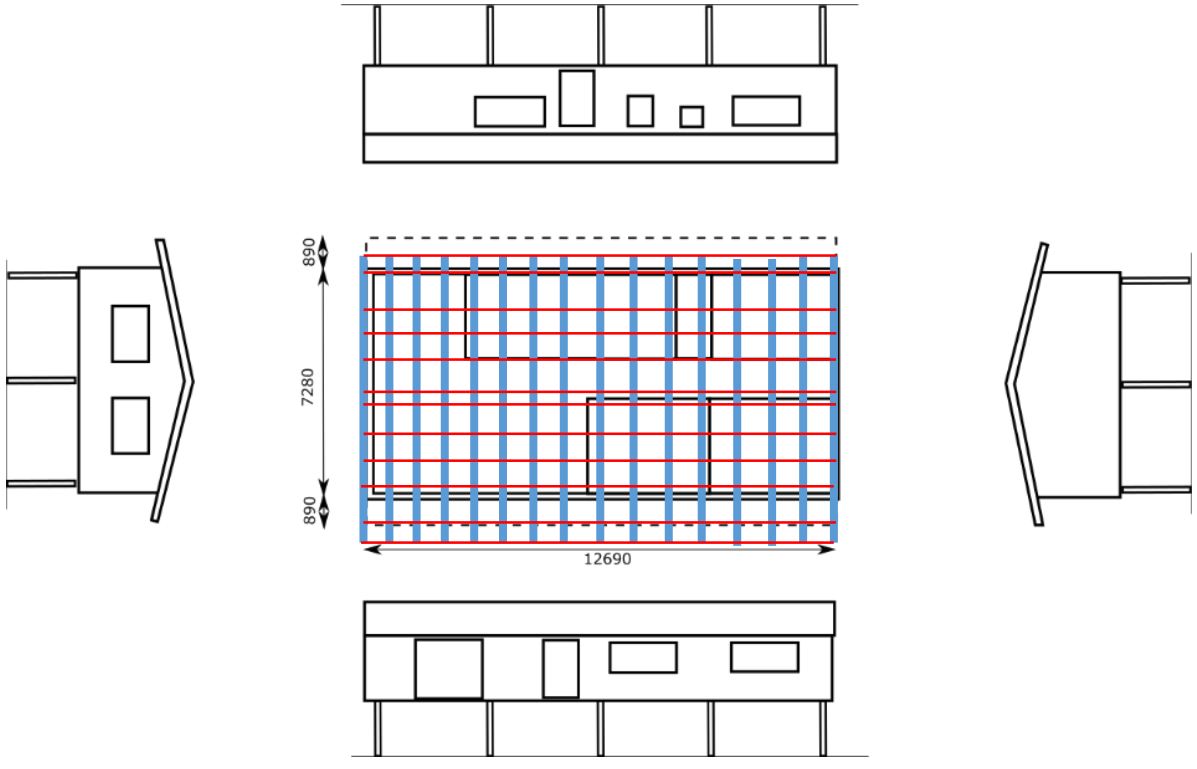
$$p_f = \int_{-\infty}^{\infty} F_R(W) f_W(W) dW$$

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



Case Study – The Group 4 House

The Group 4 House

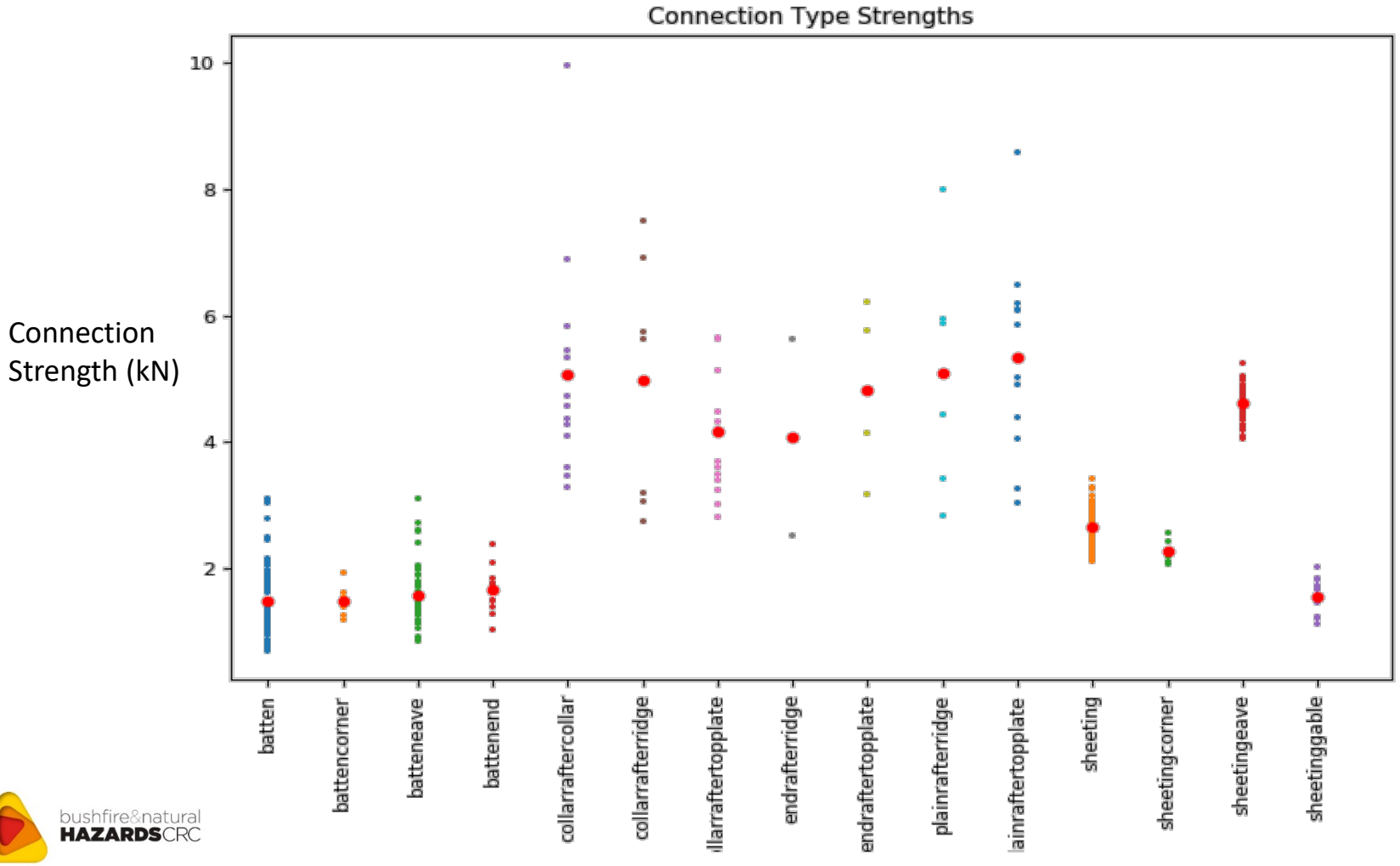


Connection Type	Strength mean (kN)	CoV
Sheeting (For approx. 4 fasteners)	2.7	0.1
Batten to Rafter Connection	1.5	0.3
Rafter to Top Plate Connection	5	0.3

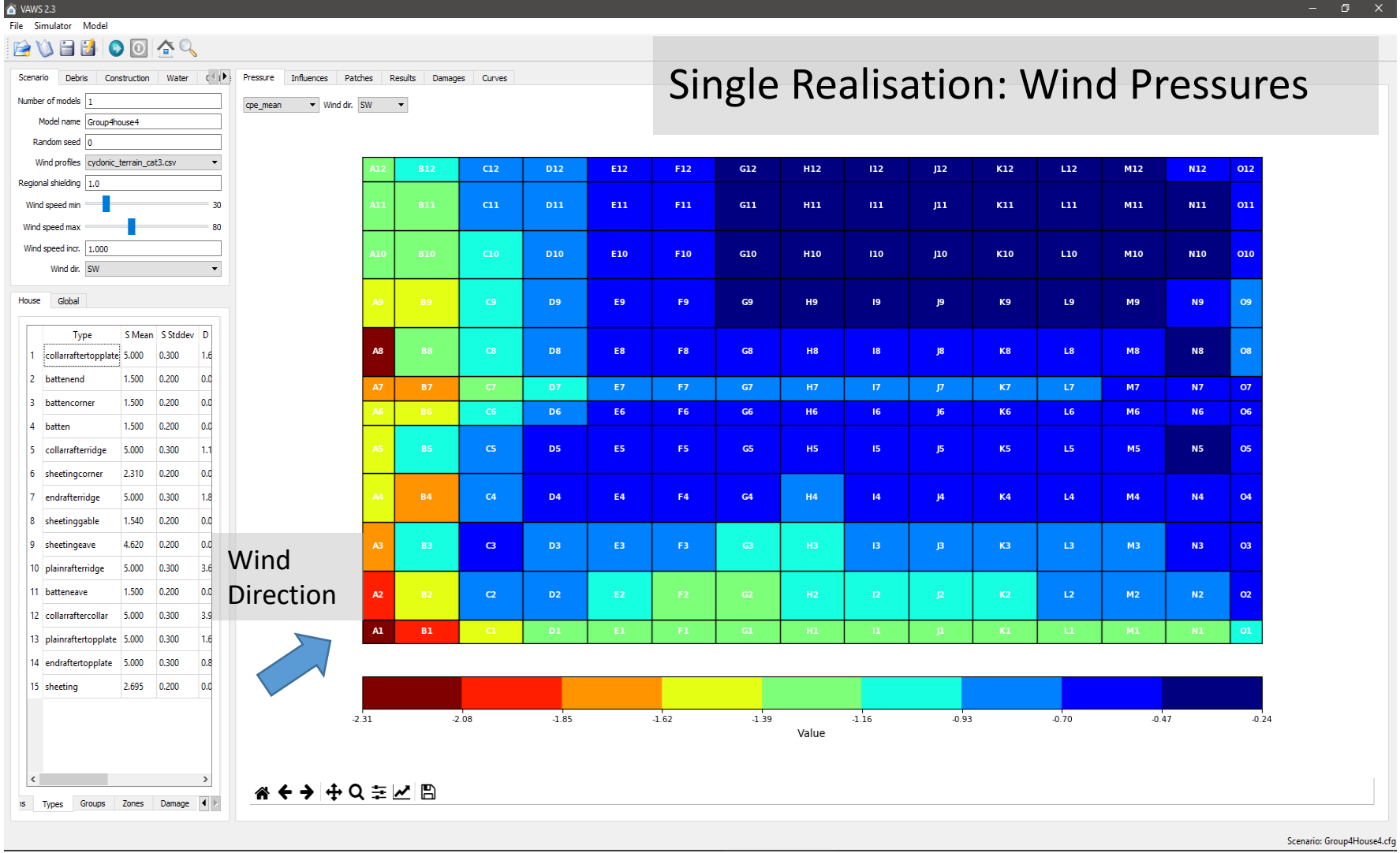
Failure when the load >strength: Failure Modes– Roof cladding: Batten-Rafter: Rafter-top plate:

Progression of failure – Load redistribution

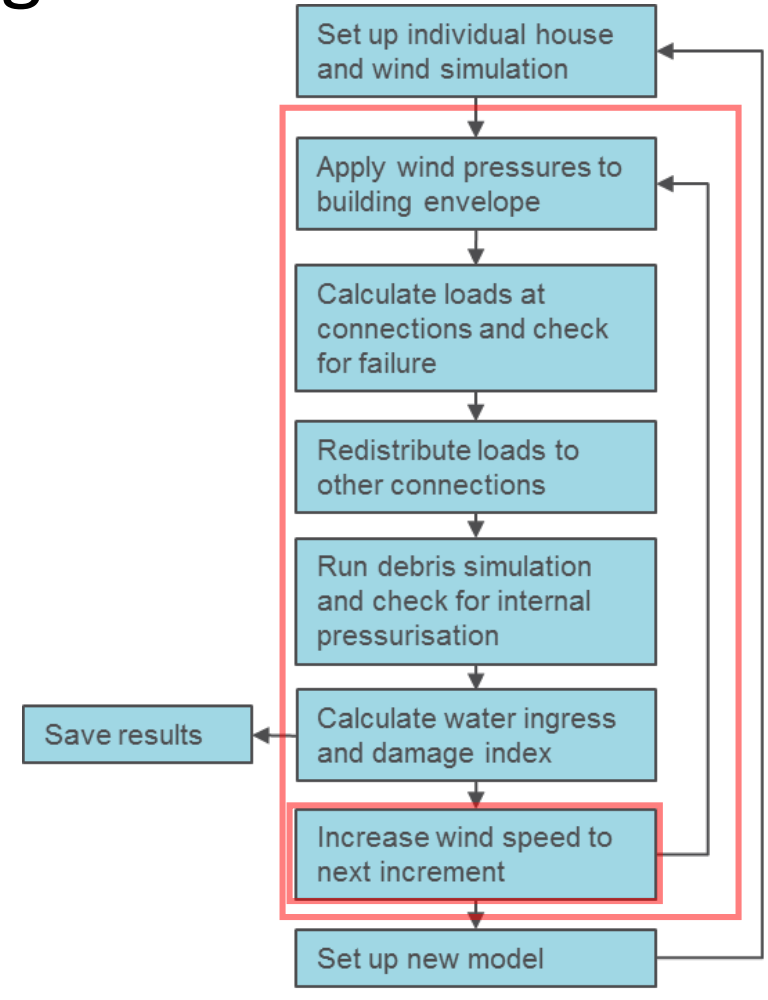
Connection Strengths



Single Realisation: Wind Pressures

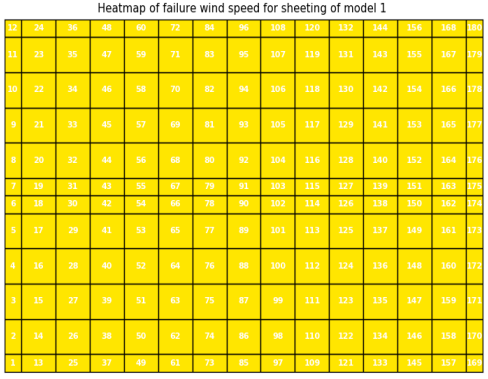


Program Logic

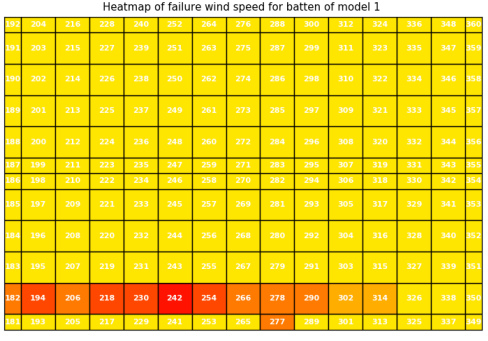


Single Realisation:

‘Heatmaps’ of Connection Failures

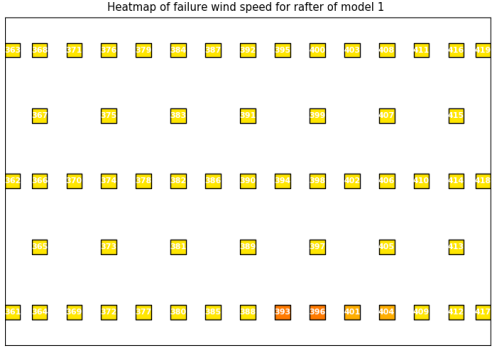


Cladding Failures

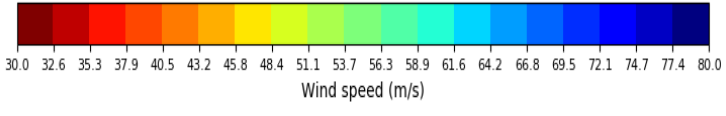


Batten to Rafter Connection Failures

Wind Direction



Roof to Wall Connections Failures



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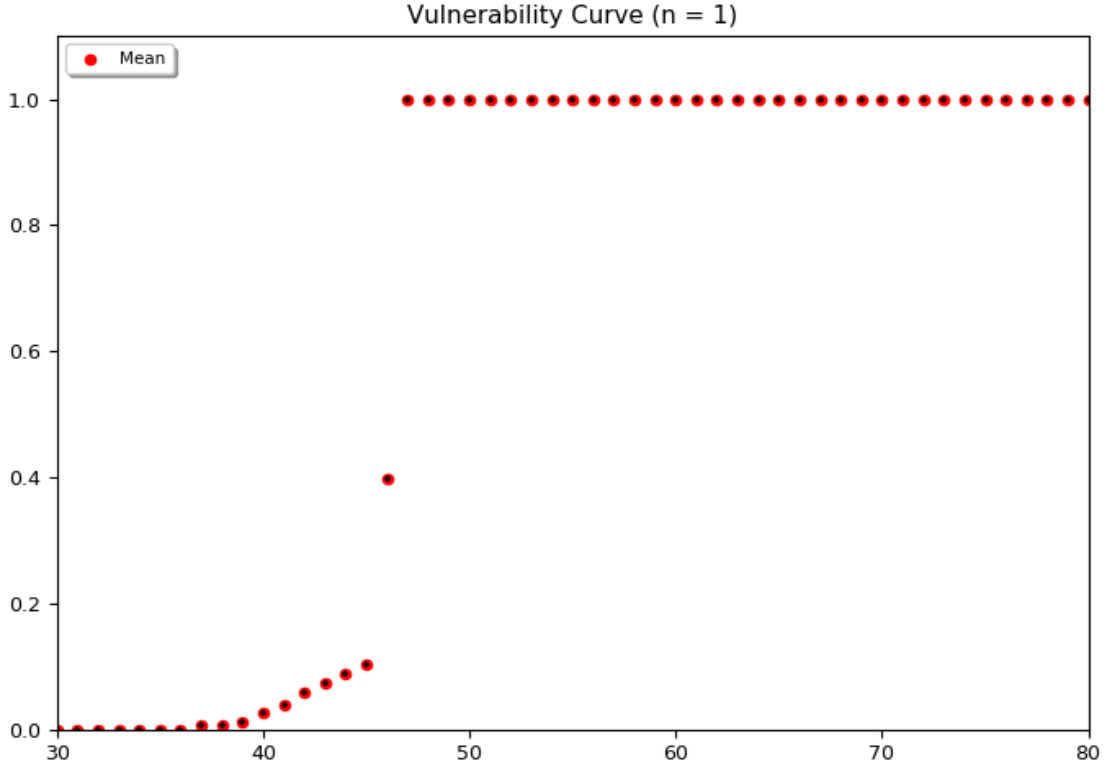
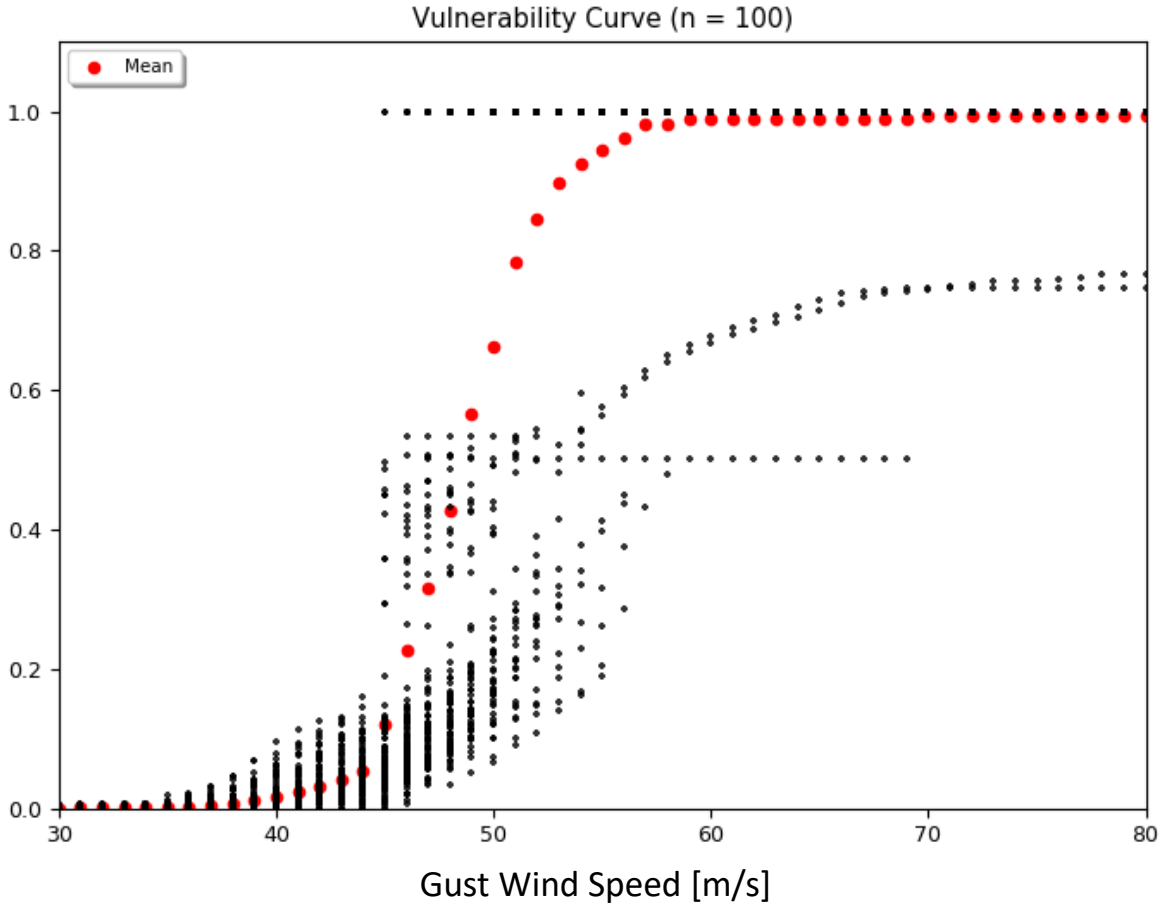
Single Realisation: Vulnerability Curve, SW Wind Direction



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

100 Realisations – SW Wind Direction



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Stakeholder Meeting – Sydney

Next Steps

- Including structural system and capacity and Wind loading data for all house types and validating VAWS
- Producing practical retrofit options and analyzing using VAWS – including for Cost Benefit
- 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)
- Investigating future opportunities