Investigation of Damage:
Brisbane 27 Nov 2014 Severe Storm Event

Cyclone Testing Station, James Cook University

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Cyclone Tracy:
• Peak gust estimated 250 km/h
• Some suburbs: 90% of houses destroyed
• In comparison, engineered structures performed well
• Testing of individual screws to whole houses
• Wind tunnel tests
• Vulnerability studies
• Damage investigations
The 27 November Brisbane Thunderstorm

- Severe hail and damaging winds
- $1.3bn in damage – Mostly vehicles
- Media frequently reported wind speeds of 140 km/h
• Aims of investigation:
  – **Analysis of wind field**: what were wind speeds in affected suburbs?
  – **Damage assessment**: why did failures occur?
Analysis of Wind Field

• Based on: AWS data, Doppler Radar and field observations.

• 141km/h gust at Archerfield due to intensification of downdraft over the airport

• Wind speeds in most affected areas: 80km/h to 100km/h
  = Less than design wind speeds
Structural Damage

• Several of these buildings had been renovated – Why did they fail?
Wind Loads on Roofs

Consider the forces caused by pressures induced by wind passing over structure

Flow over and around house
Wind Loads on Roofs

Housing design standard AS4055 requires design for a dominant opening for cyclonic regions only – not Brisbane.
The Vertical Load Path – ‘Hold Down Chain’

- Cladding to battens
- Battens to trusses/rafters
- Trusses to walls
- Suction pressures on roof

The weakest link in the chain of connections = the point of failure
Loss of Cladding

Originally a tile roof, the new metal cladding was fastened to every 3\textsuperscript{rd} batten
Loss of Cladding and Battens

Again, originally a tile roof. New metal cladding fastened to every 6th batten!
Loss of Entire Roof
Due to internal pressures and inadequate rafter tie-down

+ Inadequate rafter tie-down...

= entire roof torn away.

(a new roof is currently being installed)
Debris Damage
Hail Damage

- Most windows on southern side broken
- Significant horizontal component due to wind
- New windows performed better
Summary:

The entire ‘hold-down chain’ must be considered during renovation work

- Cladding to battens
- Battens to trusses/rafters
- Trusses to walls
- To foundation
New Research – Cascading Failures

Investigating progressive failure mechanisms in roof systems using computer models
Methodology

1. Physical testing of individual connections to determine non-linear behaviour

Morrison and Kopp (2010)
Methodology

2. Computer simulation to examine progressive failures
The Applied Element Method

A new method designed for problems with separation and collision of elements

Element Contact and Collision, From Saleem et al. 2014
Thank you
Useful Resources
Light Framed Structures are Complex

– Large number of members and connections
– Load-sharing and partial composite action
– Non-linear behavior of connections to extreme loads