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INVESTIGATION OF DAMAGE: BRISBANE 27 NOVEMBER 2014 SEVERE STORM EVENT

Research proceedings from the Bushfire and Natural Hazards CRC & AFAC conference
Adelaide, 1-3 September 2015

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Version	Release history	Date
1.0	Initial release of document	03/09/2015

Australian Government
Department of Industry and Science

Business
Cooperative Research
Centres Programme

Publisher:
Bushfire and Natural Hazards CRC

September 2015

INTRODUCTION

The city of Brisbane and other Australian cities are often subject to thunderstorms that can cause significant damage to houses by hail and strong winds. The severe thunderstorm of 27 November 2014 was an example of such an event. Two adjoining storm cells moving in a northerly direction (Figure 1) subjected Brisbane and neighbouring suburbs to severe hail, damaging winds and localized flooding.

Damage estimates for the event exceeded $1.3bn AUD (Insurance Council of Australia, 2015). The high cost of the event was mainly due to hail damage to motor vehicles and windows of buildings. Information from the Insurance Council of Australia suggests that up to 70% of claims were from hail damage to vehicles alone (Insurance Council of Australia, 2014).

Several cases of severe structural damage did occur due to wind loading. In response, the Cyclone Testing Station (CTS) conducted street and house surveys between the 28th of November and the 5th of December to estimate wind speeds in affected suburbs. Additionally, where structural damage was observed, the nature and likely causes of failure were determined. It was found that failures that occurred were due to defective construction details, degraded timbers and poor renovation and repair work.

It was frequently reported in the media that the storm brought winds of 140km/h. However it is believed that this gust was only an isolated occurrence due to the intensification of the storm's rear flank downdraft over Archerfield airport. From field surveys and analysis of Doppler radar it is estimated that high winds were up to 100 km/h in open terrain and 80km/h in suburban terrain within the affected areas.

This article will present an analysis of the wind field during the event and a summary of the damage investigation that was conducted. Further details can be found in Cyclone Testing Station's Technical Report 60 (Parackal et al., 2015).

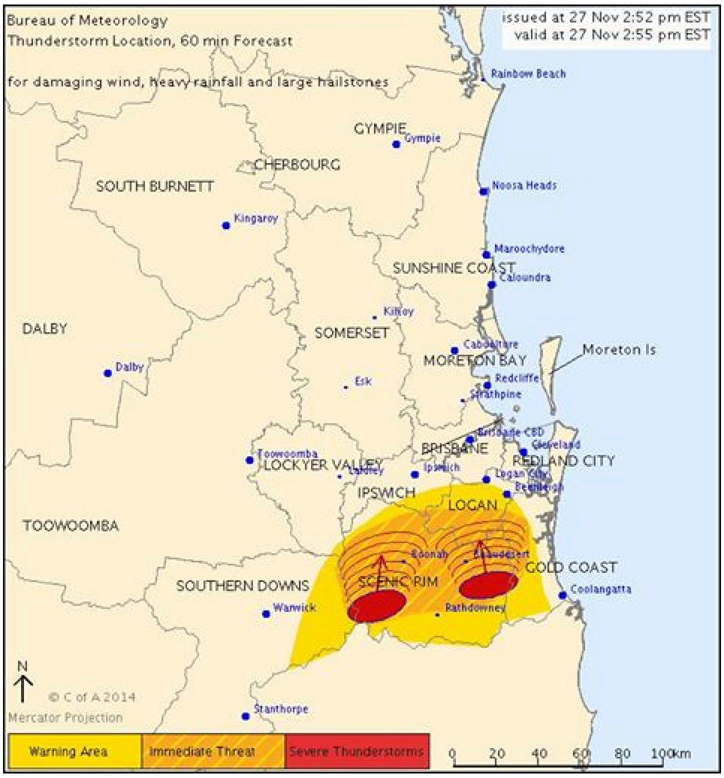

Figure 1: estimated storm track source*: bureau of meteorology*

ESTIMATED WIND SPEEDS

Based on field observations it is believed that the maximum surface wind speeds in most affected areas were below the 141km/h gust measured at Archerfield Airport. Indicators used were damage to street signs, buildings and defoliation of trees. It was found that in areas where complete roof failures occurred there was still considerable leaf cover including flowers and seedpods as well as relatively undamaged palm fronds. Unlike the widespread hail damage to windows, severe roof failures were localised, affecting individual houses with neighbouring houses relatively undamaged.

In addition to these damage indicators, a full surface wind field assessment was made using a combination of Bureau of Meteorology (BoM) 1-minute automatic weather station (AWS) measurements, radar scans (Mt Stapylton rain and Doppler winds), and amateur weather station information from the website WeatherUnderground.com. Figure 2 shows the broad area affected by winds greater than 90 km/h (at scan level), as observed by the Doppler radar. The majority of strong winds appear to have come from the southeast through southwest quadrant. Damage observations also suggest a strong southerly component to winds throughout this entire region.

The strongest winds for this event are believed to have occurred within the storm's rear flank downdraft (RFD). More specifically, they occurred during what appears to have been a re-intensification of the existing downdraft that occurred over Archerfield Airport as a result of intense rainfall and hail. Observations of damage to trees, buildings and road signs around the airport show evidence of diverging winds, suggesting downdraft impingement occurred near to the area. Given there was no intensification of wind speeds as the storm moved north of this point (as per Doppler imagery), and that winds would have been influenced by the rough suburban terrain, it is expected that lesser wind speeds would have been experienced throughout the suburbs north of the airport.

Considering these data it is believed that the storm's maximum wind speeds would have occurred in the vicinity of the Archerfield Airport AWS, and are unlikely to have been significantly higher than the 141 km/h recorded at that site. Given an observed gust of 84 km/h at the Brisbane AWS and similar, but less reliable, amateur weather station observations at Bardon, Ashgrove and Fig Tree Pocket, it is believed that wind gusts felt throughout much of the 'high wind region' (Figure 2) were up to 100 km/h in open terrain and 80km/h in suburban. These winds speeds are less than design wind speeds specified in the Australian wind-loading Standard AS/NZS1170.2. For a house in Brisbane this would be approximately 170km/h in suburban terrain (Standards Australia, 2011).

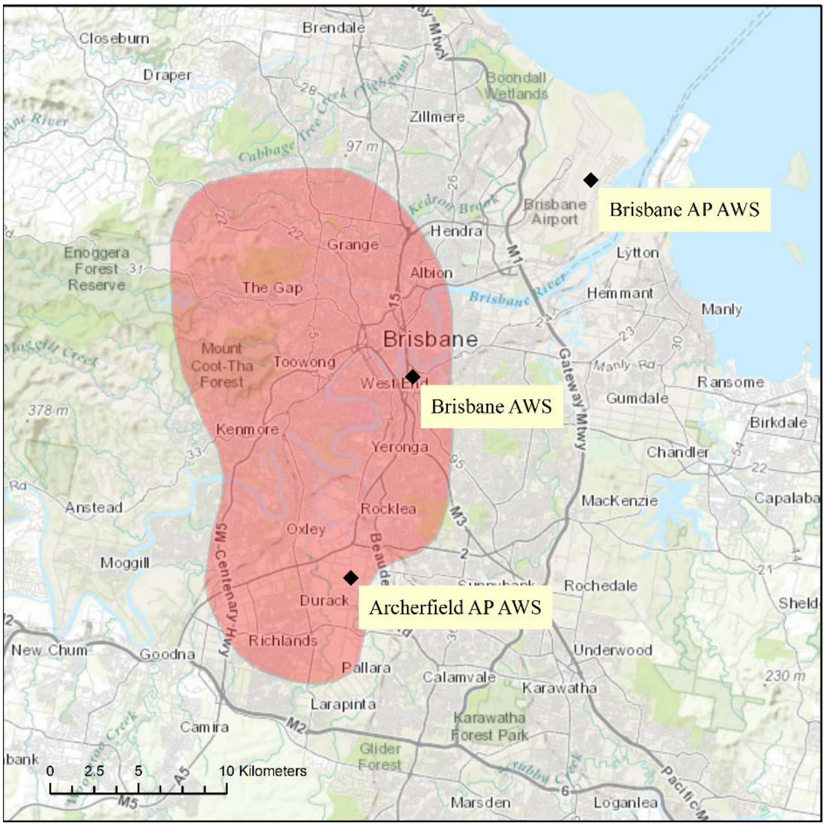

Figure 2: Envelope of areas with Doppler recorded wind speeds greater than 90 km/h.

Base image source: ESRI

Table 1: Maximum wind gusts measured by BOM weather stations as the storm moved in a northerly direction

Location	Maximum Gust (km/h)
Archerfield AP AWS	141
Brisbane AWS	84
Brisbane AP AWS	37

DAMAGE ASSESSMENT

As the storm moved in a northerly direction some impacted suburbs included: Archerfield, Moorooka, Annerley, West End, Brisbane CBD, Spring Hill and Herston. Locations of damaged properties were provided by the Queensland Fire and Emergency Services (QFES) through their Rapid Damage assessment (RDA) conducted within hours of the event occurring.

The RDA also provided an indication of the overall severity of damage from the storm. More than 2800 damaged properties were recorded with approximately 80% of these being houses. Of the damaged properties, approximately 92% of these were considered ‘minor’ damage, 7% ‘moderate’ and 1% ‘severe’. During this event most ‘minor’ damage was from broken windows due to hail, ‘moderate’ and ‘severe’ damage from debris or tree impact and in a few cases roof failure due to wind load.

Based on this information, teams from the CTS conducted street and house inspections between the 28th of November and the 5th of December to determine typical damage levels to the general building stock and causes of failure in the case of significant structural damage. Key observations from this survey include:

- The majority of damage to housing was window breakage due to hail, subsequently resulting in damage due to water ingress.
- There was a noticeable difference in performance of new vs. old window glass in this event.
- Structural damage due to wind was observed in several locations. Roof damage was observed mostly on older housing, on some occasions with complete roof loss. Often these were due to incorrect detailing after renovation works e.g. replacement of roof cladding.
- Generally little tile damage due to hail was observed, as most records of hail were smaller than the threshold for tile damage (50mm diameter) (Risk Management Solutions, 2009).

STRUCTURAL DAMAGE

Despite estimated winds being less than design wind speeds, several cases of significant roof failures were observed. These were typically older structures including houses, units and churches. Very often neighbouring houses had little or no roof damage at all, indicating that the area experienced low wind speeds.

Several failures of new roofs installed on old structures were observed. This was often the case for tile roof buildings that were replaced with newer metal cladding (Figure 3) Generally original battens were retained but the new cladding only fastened to a few battens. In one case this was to every 3rd batten and in another every 6th batten. This resulted in the overloading of batten to truss connections or cladding fasteners during the storm, causing the failure of large sections of the roof. In some cases, when metal clad roofs were replaced with new cladding, the older battens were not checked for rot or degradation. In one case this resulted in the loss cladding of the entire roof (Figure 4)

There were cases of complete roof loss of top floor units of some double brick apartments with timber roofs. For one site that was surveyed this had occurred due to window damage by hail, and a subsequent dramatic increase in internal pressure. The timber rafters of this apartment was observed to have insufficient tie down and resulted in the loss of the entire roof structure (Figure 5). Most cases were roof failures occurred resulted in debris damage to neighbouring properties otherwise undamaged by wind loading.

Damage from this event highlights the importance of reconstruction and repairs being carried out in accordance with relevant Standards and the regular inspection of structural elements within the roof space, to look for signs of deterioration such as corrosion and rot. For the rebuilding or upgrading of older housing, the complete load path from roofing to foundations must be considered, this is especially relevant when changing from a tile roof to metal roof cladding. Reference should be made to documents for the upgrading of older housing such as HB132.1 or AS1684 User guide no 3 (FWPRDC, 2002, Standards Australia, 1999).

Figure 3: Loss of metal cladding and battens of a church. Originally a tile roof, the new metal roof was only secured to every 6th timber batten.

Figure 4: Loss of cladding and battens of an older home. New cladding had been installed onto the original battens.

Figure 5: An example of complete roof loss of the top storey unit of a 3-storey apartment building (new roofing currently being installed). Original timber rafters had inadequate tie down to withstand internal pressure due to the breakage of a large southern facing window. The unit was also located on top of an escarpment (outlook shown in the lower photograph) and may have experienced slightly higher wind speeds.

HAIL DAMAGE AND WATER INGRESS

The level of damage to houses was especially high due to window breakage from hail and subsequent water ingress. The latter could be observed by damaged furniture and goods that were placed outside of homes for collection (Figure 6). Apart from the widespread damage to cars from hail, it is likely that water ingress would be a large contributor to insurance claims from this event.

Estimates of hail intensity and size reported by the media varied greatly. The BoM reported that 40mm diameter hail (golf ball size) was observed in most locations and the CBD experienced up to 70-80mm diameter hail. Based on damage observed it is believed that the hail impacting buildings in the areas studied was indeed up to 40mm in diameter. Common hail damage to roofs observed during this event included, dented roof vents, broken skylights and damaged air conditioning units.

The strong winds created a significant horizontal component in the trajectory of the hail. Many streets were surveyed that had the majority of windows on the southern side broken, even those that were protected by awnings, while windows on other sides were undamaged (Figure 7).

It was observed that newer windows showed a better resistance than older thinner window glass. There were several examples of new homes or recently renovated homes with new windows experiencing little to no hail damage compared to older houses nearby (Figure 8). Thus, anecdotally, the installation of the new windows can reduce the vulnerability to water ingress and potential structural damage from internal pressures.

Figure 6: Broken windows on the southern facing wall as well as water damaged goods placed at the front for collection was commonly observed.

Figure 7: Hail damage to windows and vinyl cladding of an older house. The proximity of the neighbouring house on the right and the size of the window shades suggest hail being driven at a sharp angle by the wind.

Figure 8: A new apartment building in a storm-affected neighbourhood. All windows on the exposed southern side were undamaged, indicating the improved performance of new window glass.

CONCLUSIONS

The Brisbane thunderstorm of 27 November 2014 caused significant damage to properties as well as motor vehicles due to strong winds and wind driven hail. From field observations and the analysis of meteorological data, it is believed that wind speeds in most affected suburbs were significantly less than the 141km/h gust at Archerfield airport. It is estimated that winds of up to 100 km/h in open terrain and 80km/h in suburban terrain would have been felt in the affected suburbs.

Wind-driven hail extensively damaged windows (predominantly on older housing) leading to damage to building interiors from water ingress. There was a noted difference in the performance of new window glass compared with older windows.

Despite wind speeds being less than design level, several roof failures did occur. These were often caused by the deterioration of old connections or inadequate detailing of connections during renovations. This was especially the case when changing roof cladding from tiles to metal sheet. Such damage highlights the importance of repair and renovations being performed according to contemporary building Standards and the inspection of older structures for signs rot and corrosion.

ACKNOWLEDGEMENTS

The CTS appreciates the support and assistance of the Queensland Fire and Emergency Services, Bureau of Meteorology, Brisbane City Council and the Bushfire and Natural Hazards CRC (BNHCRC). Additionally, we are very grateful to the residents who generously assisted this survey by volunteering information, answering questions and on occasions inviting the authors into their houses to inspect damage.

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