TROPICAL CYCLONE SEVERE WIND RISK IN SOUTH-EAST QUEENSLAND

Trevor Jones[1], John Stehle[1], Rob Lacey[1] and Bruce Harper[2]

[1]Australian Geological Survey Organisation, GPO Box 378, Canberra, ACT, 2601. Email Trevor.Jones@agso.gov.au
[2] Systems Engineering Australia Pty Ltd, 7 Mercury Court, Bridgeman Downs, Qld 4035

We find that severe winds from tropical cyclones have the potential to cause significant economic losses to residential buildings in the South-East Queensland region. Losses are expected to be highest in areas of older construction, exposed terrain and steep topography. The risk assessment outlined in this paper was undertaken as part of a study 'Natural Hazards and the Risks they pose in South-East Queensland' (AGSO, in prep.).

Methodology

Terrain and topography factors were prepared on a property-by-property basis, according to the methods in *AS1170.2-1989* (Standards Australia, 1989). Terrain and shielding effects were accounted for by categorising properties into five groups; 'Foreshore', 'Inland', 'Town', 'Town Centre' and 'Foreshore Town', as illustrated in Figure 1. The site classes and site nomenclature were derived in part from the approach of Harper (1999a). The relevant terrain and shielding factors are given in Table 1. Although the categories are few and broad in nature, they are considered to be appropriate for risk assessment on a regional scale. Topographic effects were calculated from a Digital Elevation Model provided by local governments , along traverses with a 200 m spacing, for North, South, East and West wind directions.

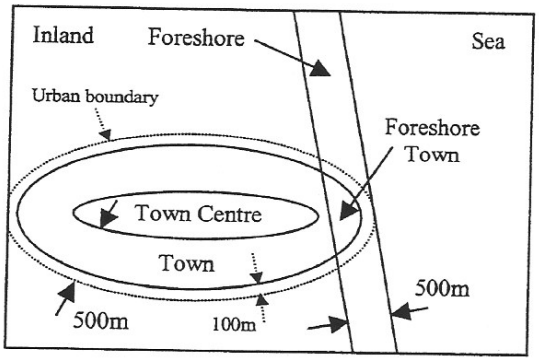

Figure 1 Classification scheme for the five terrain and shielding categories

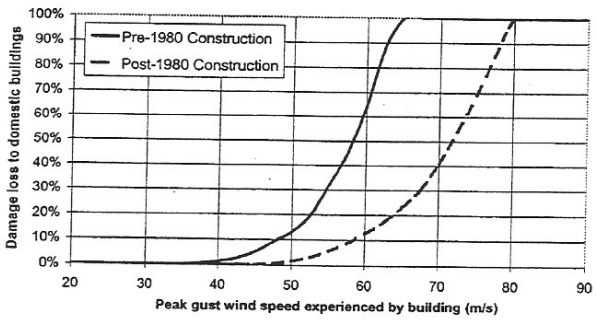

Figure 2 Damage loss curves for residential buildings (from Harper, 1999a; originally from Walker, 1994)

Table 1 Terrain and shielding multipliers

Category	AS1170.2 Terrain Category	Max. Building Height z (m)	Terrain multiplier $M_{z,cat}$	Shielding multiplier M_s
Foreshore	2.0	7	0.946	1.0
Town	2.5	7	0.864	0.85
Inland	2.5	7	0.864	1.0
Foreshore Town	2.0	7	0.946	0.85
Town Centre	3.0	7	0.782	0.85

Damage to residential buildings (flats and houses) was modelled. A building database for every developed property in South-East Queensland was assembled from the information provided by eight local governments. Two residential building age classes were established, nominally pre- and post-

1980. Damage loss curves for these two age classes were developed by Walker (1994), based on insurance industry experience in Australia, and are shown in Figure 2.

The damage loss curves clearly reflect the significance of the introduction of mandatory building standards in the 1980s. The percent damage loss values shown are relative to the nominal insured value of a single, 'typical' dwelling and associated assets, or, when aggregated, the total residential building stock.

A series of synthetic tropical cyclone scenario events, generated by the model of Harper (1999b), were supplied by author BH. The wind field data for each event consisted of maximum envelope values of peak wind gust speed and direction on a uniform grid. The wind gust speeds at one of three South-East Queensland reference sites have Average Recurrence Intervals (ARIs) of approximately 100, 200, 500, 1000, 2000 and 5000 years. For each ARI being considered, the potentially high spatial variability of the cyclonic winds (due to track, speed, size, etc.) has been approximated by taking 30 sample scenarios, each of which produces a similar peak wind speed at one reference point but not necessarily at any other point.

The damage level to houses and flats was calculated for each Census Collectors District (CCD), for each scenario event. Residential damage across the entire South-East Queensland region was also calculated for each scenario event. Cumulative loss curves for each CCD, and for the entire South-East Queensland region, were prepared by aggregating the probabilities of exceedence of various loss levels.

Results

A summary of the tropical cyclone severe wind damage losses in the South-East Queensland region is given in Table 2 and plotted in Figure 3. The losses in the figure and the table are the minimum losses expected for the probability associated with that loss. For example, there is an annual probability of 0.2% that damage losses will be 0.23% of the total insured value, or higher than 0.23% (Table 2).

A probabilistic distribution of potential tropical cyclone wind damage risk across the South-East Queensland region is shown in Figure 4. The annual risk to each CCD is shown. The risk is defined in terms of the percentage loss of the insured value of a 'typical' residence including contents or, alternatively, the percentage loss of the insured value of the residential building stock and contents (multiplied by an annual probability of one). The percentages in the legend of Figure 4 must be multiplied by 10^{-6}. All of the scenario storms were used to prepare the map.

Table 2 Residential damage losses for cyclonic winds in South-East Queensland

ARI (years)	AEP	Damage (equivalent number of houses and flats - insured value of building and contents)	Damage (% of total insured value of building and contents for houses and flats)
100	1.0%	150	0.024%
200	0.5%	500	0.078%
500	0.2%	1050	0.16%
1000	0.1%	1500	0.23%
2000	0.050%	1800	0.28%
5000	0.020%	2500	0.38%

The spatial pattern of damage losses strongly indicates areas of older construction, exposed terrain and steep topography, according to the assumptions of the analytical model. Settlements having more than one of these attributes are particularly at risk of above-average wind damage levels.

Areas of relatively old (pre-1980) settlement are expected to suffer stronger damage than newer areas (e.g., parts of Redcliffe and older suburbs in Ipswich, Logan and Brisbane). Areas of predominantly new dwellings (post-1980) are expected to fare relatively well (e.g., Redland).

The expected damage to older settlements near the coast is estimated to be almost 100 times greater than the average residential damage across the region. On the other hand, large urbanised areas offer significant shielding from severe winds, and damage in these areas is estimated to be less than the damage in areas where urbanisation is less dense. This is the case in a very large area of Brisbane (Figure 4).

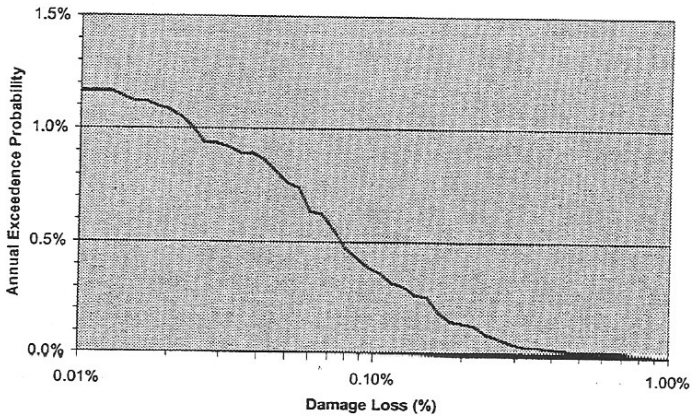

Figure 3 Cumulative tropical cyclone wind damage losses for residential buildings in South-East Queensland

Uncertainties and limitations

Very significant uncertainties are associated with the estimates of damage losses presented here. The reader should treat the estimates of damage losses as indicative only. Limits and uncertainties in the wind risk assessment include, but are not confined to:

- uncertainty in the hazard model, originating from the inherent variability of cyclonic wind fields, uncertainties due to assumptions made in the parametric hazard model, incomplete sampling of the total probability space of synthetic cyclone events, assumptions made about the probabilities of events selected from the synthetic catalogue, and from the short and incomplete historical record of cyclonic winds in South-East Queensland;
- uncertainty in the terrain model. AGSO's GIS-based terrain model was developed for a broad-scale study and it will contain inaccuracies at the individual parcel level;
- uncertainty in the building damage loss model for buildings not in tropical cyclone areas. Uuncertainties also arise from relatively few instances of severe damage, a lack of accurate wind measurements at or near building exposures, structural redundancy, variable load paths and variety of fixings, wide variations in building style and quality of construction, and second-order effects such as debris damage;
- uncertainties and incompleteness of the property inventory for information such as building age, condition, and compliance with wind loading standards; and
- limitation on the scope of the risk assessment. The analysis does not consider non-residential structures such as commercial, industrial and infrastructure facilities. Nor does it consider direct or indirect economic or social losses, or casualties, that are a consequence of building damage. Hence, significant further analysis is required to develop a more comprehensive understanding of how the community could be affected.

References

Harper, B.A. (1999a), *Tropical cyclone winds and storm tide - Mackay*, Systems Engineering Australia P/L, Brisbane.

Harper, B.A. (1999b), 'Numerical modelling of extreme tropical cyclone hazards', Journal of Wind Engineering and Industrial Aerodynamics, Vol. 83, pp. 35-47, Elsevier Science Ltd.

Standards Australia (1989), *AS 1170.2-1989*, SAA Loading Code Part 2: Wind loads, Standards Australia, Homebush.

Walker G.R. (1994), CSIRO Division of Building, Construction and Engineering, personal communication to Dr B.A. Harper, cited in Harper (1999a).

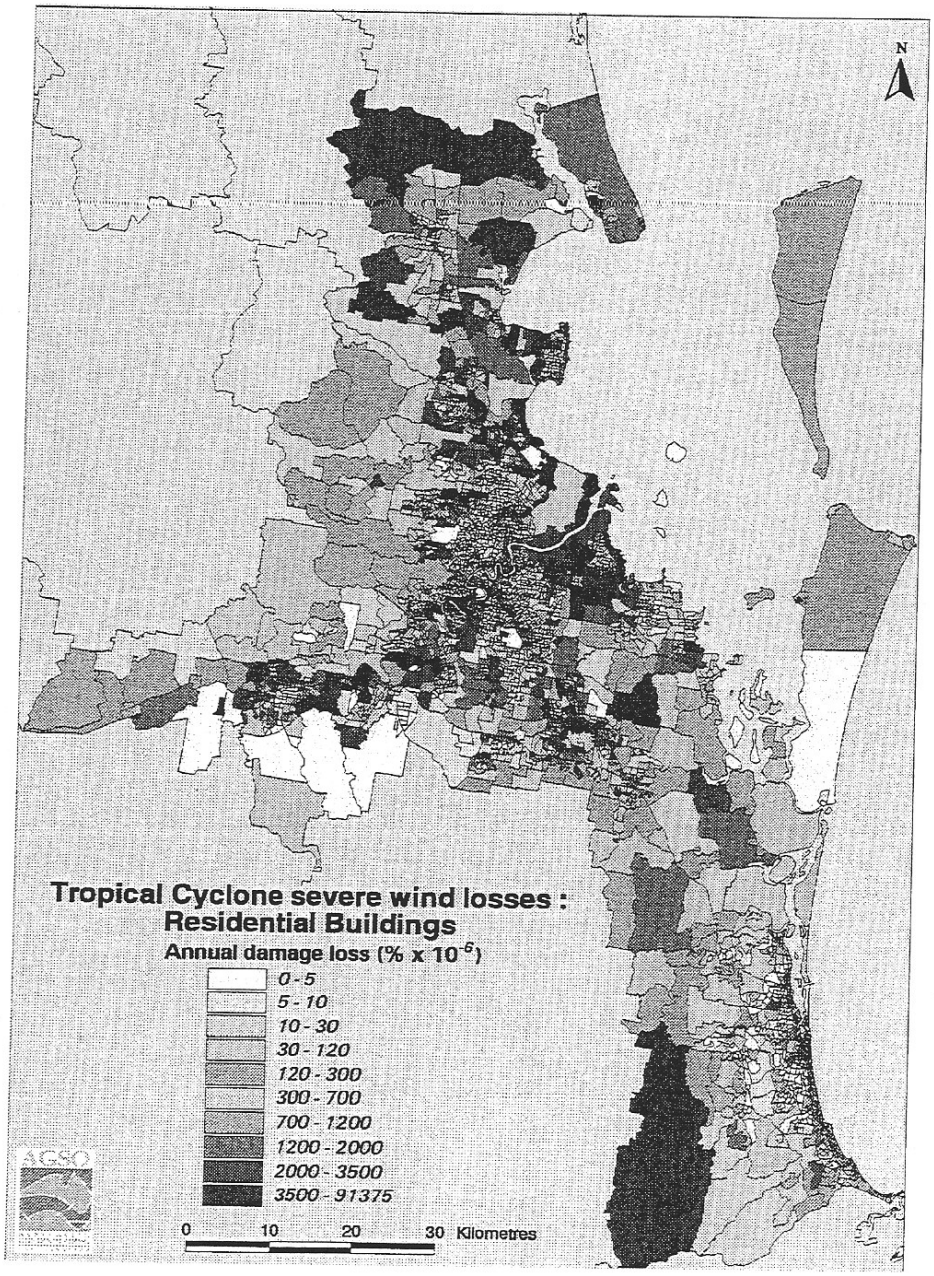

Figure 4 Annual tropical cyclone severe wind risk to residential buildings. Units are the percentage of the insured value of a 'typical' residence including contents, multiplied by 10^{-6} (see text)