

Design Guidelines for Queensland Public Cyclone Shelters

LIMITATIONS OF THE REPORT

The Department of Public Works, Mullins Consulting and others listed herein have taken all reasonable steps and due care to ensure the information contained herein is correct at the time of publication. The Department of Public Works and Mullins Consulting expressly excludes all liability for errors or omissions whether made negligently or otherwise for loss, damage or other consequences that may result from this report

Prepared by Mullins Consulting Pty Ltd for Queensland Government

© The State of Queensland, Department of Public Works 2006

Table of Contents

1	Introduction	5
2	Objective	5
3	Design Guidelines.....	5
3.1	Shelter Location	6
(a)	Access.....	6
(b)	Storm Tide.....	7
(c)	Flood	7
(d)	Land Slip	8
(e)	Other	8
3.2	Structure.....	8
(a)	Wind Loads.....	8
(b)	Debris Loads.....	8
(c)	Earthquake Loads.....	9
(d)	Permanent and Imposed Loads	9
(e)	Wave and Flood Flow Loads.....	10
3.3	Human Factors	10
(a)	Area per Occupant	10
(b)	Occupancy Duration.....	10
(c)	Lighting.....	10
(d)	Safe Movement and Access	11
(e)	Access for People with Disabilities.....	11
(f)	Ventilation	11
(g)	Amenities	13
(h)	Communications	13
(i)	Emergency Power.....	13
(j)	Emergency Provisions.....	14
(k)	Waterproofing and Weatherproofing.....	14
3.4	Other Factors	14
(a)	Fire Direction and Emergency Warning	14
(b)	Lightning Protection	15
3.5	Other Factors	15
(a)	Shelter Operational Plan	15
(b)	Shelter Maintenance Plan.....	16
(c)	Signage	16
4.	CONCLUSION.....	17

APPENDIX I: Specifications and Guidelines	18
External fabric of Public Cyclone Shelters – Specification of test criteria and procedures.	19
Debris resistant screens for Public Cyclone Shelter Specifications	20
Detailed Mechanical Guidelines - Minimum Requirements	21
Detailed Mechanical Guidelines - Desirable Requirements	22
Guidelines for an alternative building solution	23
APPENDIX II: Reference Documents	26
REFERENCE DOCUMENTS – Cited	27
REFERENCE DOCUMENTS - Not Cited	28
REFERENCE DOCUMENTS - Draft Documents.....	28

1 Introduction

These guidelines are based upon the “Design Guidelines for Australian Public Cyclone Shelters’ and incorporate the recommendations of the Queensland Tropical Cyclone Coordination Committee (QTCCC).

The Queensland Government, Department of Public Works prepared the ‘Design Guidelines for Australian Public Cyclone Shelters’ for Emergency Management Australia (EMA) in 2002. The document was reviewed by and incorporated input from stakeholders in Western Australia, the Northern Territory and Queensland.

In 2006 the QTCCC requested the Department of Public Works to convene and facilitate a group to review the document and make recommendations for the design of public cyclone shelters in Queensland.

The review group chaired by the Department of Public Works included representatives from Queensland Government Departments of Local Government and Planning, Sport and Recreation, Emergency Management Queensland, Environmental Protection Agency, Natural Resources, Mines and Water; Commonwealth Government agencies of Bureau of Meteorology, Geoscience Australia, Emergency Management Australia, Australian Building Codes Board, and James Cook University Cyclone Testing Station and Standards Australia.

The QTCCC recommendations for the design of Public Cyclone Shelters in Queensland were endorsed by the State Disaster Management Group (SDMG) in September 2006.

The document is dated September 2006 to reflect the date of endorsement by the SDMG. The title is amended to reflect the jurisdiction of the SDMG. The following sections included in the August 2002 document have not been reproduced in this document: Acknowledgements, Background and Appendix III - Stakeholder distribution list.

2 Objective

The objective of this document is to provide guidelines for design requirements of public cyclone shelters in Queensland. Guidelines are included for site selection, for the design of new buildings and for the assessment and upgrading of existing buildings, including management and operational aspects.

Public cyclone shelters are buildings that provide shelter during a severe tropical cyclone. The requirements of shelters occupied after the cyclonic event (recovery centres) differ from the requirements for shelters occupied during the event (public cyclone shelters). This document only addresses design guidelines for public cyclone shelters (occupied during a severe tropical cyclone) and does not address the requirements of recovery centres (occupied after the event). Issues such as the number of shelter spaces required within a community, and the acquisition and activation of buildings are beyond the scope of this document.

3 Design Guidelines

Design guidelines primarily address the safety of people in the shelter. The shelter is not intended for the purpose of storage of property. It is intended that people enter the shelter with minimal personal effects (e.g. waterproof satchel containing personal papers and valuables such as insurance papers and passports; special medicines and baby needs; battery radio, torch and spare batteries; light snacks and drinks).

Guidelines contained in this document relating to the strength of the shelter building are consistent with and additional to the Building Code of Australia (References 16, 17) requirements for designated emergency shelters in the cyclonic regions of Australia (refer Section 3.2). While designated emergency shelters are constructed to resist a more severe cyclone than normal buildings within the community, it is possible but not likely that a cyclone with even greater severity could occur and may result in failure of the shelter building.

These guidelines provide a method of assessment to ensure the shelter is “fit-for-purpose”. They address the temporary use of a building, or a portion of a building, with basic amenities to provide safe shelter for a large number of people during severe tropical cyclones.

In addition to location and structure of the building, basic human factors to be incorporated into the building such as lighting, ventilation, amenities and others are addressed.

Although the shelter will be used for the assembly of persons, the normal use of the building may not necessarily be for assembly purposes. The Building Code of Australia classifies buildings according to their usage, and most State Building Legislation considers an occupation other than in accordance with the design classification to be an offence. However, under special circumstances, relevant State Legislation (e.g. Disaster Management Act (Reference 34) and the Standard Building Regulation – Regulation 96 (Reference 36)) provide a legislative framework so that a building can be used for a purpose other than that which it is classified, provided the building is fit for the purpose.

Note:

It is suggested that a formal risk management assessment (including disaster risks) is undertaken for each shelter in accordance with AS/NZS 4360.

It is suggested that a formal risk management assessment (including disaster risks) is undertaken for each shelter in accordance with AS/NZS 4360.

The guidelines for design of public cyclone shelters are categorised in the following sections as:

- Shelter Location – Factors affecting the location of the shelter including storm tide heights, river or creek flood levels, access and the location of existing significant hazards.
- Structure – Loads that the building structure and external fabric, including windows and doors, are to resist during the cyclone are defined.
- Human Factors – Human factors encompassing both comfort and life safety issues including floor area per occupant, duration of occupation, lighting, ventilation, communications, amenities and emergency provisions along with safe movement and access, emergency power, waterproofing and weatherproofing.
- Other Factors - Fire safety issues including fire detection and emergency warning and lightning protection.

Notes are informative. They do not form part of the guidelines but provide explanation and comment on the guidelines.

3.1 Shelter Location

The shelter shall be located so that: access to the shelter is maintained; the shelter is not inundated by storm tide or flooded by river or creek flow; the shelter is not at risk from landslip or other significant hazards.

(a) Access

The shelter shall be located so that access to the shelter is maintained prior to and after the cyclonic event. An area suitable for bus set-down shall be located near the shelter entrance.

(b) Storm Tide

The shelter floor should be above the maximum storm tide level for a cyclone with an annual probability of exceedence of 1 in 10,000 ($V_{10,000} = 306\text{km/hr}$) Probability based criterion: The shelter floor level shall be above the evacuation zone for a storm tide with an annual probability of exceedence of 1 in 10,000

Note: The QTCCC review group proposed these two criteria and recommended that a specialist group be convened to determine an appropriate criterion. In the interim either of these criteria may be adopted.

Buildings, which have the lower levels inundated, but upper levels above the design storm tide height are considered not suitable, unless there is an access route to the building that is above design storm tide height and the building and foundations are assessed as structurally adequate to resist the wind and water loads.

Notes: It is estimated that buildings constructed to resist a 1 in 2,000 year cyclonic wind load (Section 3.2(a)) would, when material capacity reduction factors are considered, have a probability of failure of 1 in 10,000. Loads associated with wave action are greater than loads associated with wind. A building not designed to resist wave loads is likely to fail when subjected to wave loads. The return period for storm tide height is based upon the premise that the building would fail should it be subjected to wave loads. Estimates of 1 in 10,000 year storm tide height have been published (Reference 27).

Definitions:

Storm surge is a rise above normal water level of the ocean due to the combined effects of surface wind and reduced atmospheric pressure associated with a tropical cyclone.

Storm tide is the combined action of storm surge, astronomical tide and wave setup.

Wave setup is a quasi-steady super-elevation of the water surface due to the onshore mass transport of water caused entirely by the action of breaking waves.

Wave runup is the vertical height above still-water level (wave setup level) to which the rush of water reaches when a wave breaks against a structure or beach.

(c) Flood

The shelter floor level is to be above the river or creek flood with an annual probability of exceedence of 1 in 500. The backwater effect on flood levels due to the design storm tide shall be considered in determining the design river or creek flood heights.

Where the hydrology of the area is such that flooding with high water velocities may occur concurrently with the cyclonic winds the criteria defined for storm tide shall apply to floods.

Stormwater drainage shall be provided in the form of piped systems, overland flow or levies to ensure that the floor level of a shelter located below ground level is substantially dry during the design rainfall intensity. Provisions shall be made to ensure that the water level does not exceed 1m depth within the shelter should the piped system become blocked or levies overtopped or breached by the design events.

Where the proposed shelter site has the potential to be flooded an assessment shall be made of the scour potential of the predicted inundation depths and flow velocities. This assessment shall be made by a competent geotechnical professional and shall take into consideration flow depth, flow conditions, soil characteristics and foundation type.

Note: While flooding may be associated with cyclonic activity, a river or creek flood may not necessarily occur at the same time as the destructive phase of cyclonic winds. Depending upon the hydrology of the area a flood may occur at a similar time or some days later.

(d) Land Slip

Where a local authority zones the site for a cyclone shelter as prone to landslide hazard, acceptable landslide risk levels under the design cyclonic event shall be:

- “low” or “very low” for property (ref Appendix G of AGS, 2000)
- 1E-6pa for loss of life.

The geotechnical assessment of the shelter design shall demonstrate that the acceptable risk levels are not exceeded for all viable scenarios. The methods of AGS (2000) shall be used for the landslide risk assessment. The assessment may include the implementation of measures to reduce risk through reduction of the likelihood of slope instability and/or the mitigation of the impacts on the facility should a landslide occur. The landslide risk assessment for the site shall be conducted by a geotechnical practitioner of chartered professional status, with landslide risk management as a core competency.

Reference:

Australian Geomechanics Society (2000) “Landslide Risk Management Concepts and Guidelines”, AGS Landslide Risk Management Sub-Committee, Australian Geomechanics Vol 35 No 1, March 2000 – also reprinted in Vol 37, No 2, May 2002.

(e) Other

The shelter shall not be located near significant hazards such as: hazardous materials (e.g. fuel or chemical storage), physical hazards (e.g. other building or heavy falling debris), high voltage overhead power lines etc. The safe separation distance between the hazard and the shelter shall be assessed for each shelter and is dependent upon the nature and magnitude of the hazard.

3.2 Structure

The building structure and external fabric, including windows and doors, shall be capable of resisting the following loads.

(a) Wind Loads

The annual probability of exceedance of the design wind event for ultimate limit states to be 1 in 10,000. Determine the gust wind speed in accordance with AS/NZS1170.2.

Note: In Queensland’s tropical cyclone region (Region C) $V_{10,000} = 306$ km/hr (85 m/s).

The internal pressure shall be determined on the basis that a dominant opening exists on one wall.

Note: The internal pressure is determined on the basis that localised failure of a cladding element may occur due to a load larger than the design debris load or that use of the natural ventilation system may result in full internal pressure.

(b) Debris Loads

The external fabric of public cyclone shelters is to be at least capable of resisting wind debris defined as:

(a) five spherical steel balls of 2 grams mass {8mm diameter} impacting at $0.4 \times V_{10,000}$ for horizontal trajectories and $0.3 \times V_{10,000}$ for vertical trajectories;

(b) a 100mm x 50mm piece of timber of 4 kg impacting end-on at $0.4 \times V_{10,000}$ for horizontal trajectories and $0.1 \times V_{10,000}$ for vertical trajectories.

Note:

1. In Region C: the impact speeds are:
- | | |
|--|------------------------|
| $0.1 \times V_{10,000} = 8.5\text{m/s}$ | (30.6 km/hr) |
| $0.3 \times V_{10,000} = 25.5\text{m/s}$ | (91.8 km/hr) |
| $0.4 \times V_{10,000} = 34\text{m/s}$ | (122 km/hr) |

2. The Wind code defines a wind borne debris load in a clause relating to determination of debris to create a potential dominant opening on a windward wall. The criteria developed for shelter buildings are more severe.

The debris potential of a shelter site shall be assessed during the maintenance inspection and where possible the debris potential shall be reduced by removal of objects not adequately fixed in position.

The external building fabric (debris screens, cladding, windows and doors) shall resist the debris load associated with the windward wall positive pressures and the cyclic wind loads associated with the leeward negative pressures (Refer Appendix I – Specification of Test Criteria and Procedures).

The shelter should be located away from taller structures (Section 3.1(e)) defined by a plane that is 1 vertical to 1 (minimum) horizontal. If a shelter is located within this zone then the shelter structure and external fabric exposed to the falling debris shall be capable of resisting the dynamic load associated with the heaviest building material identified as potential falling debris from the taller structure.

Note: Falling debris can have considerable mass and fall from taller structures located a short distance away.

(c) Earthquake Loads

The building is to be designed to resist earthquake loads for a building of importance level 3 as defined by the BCA and AS1170.4.

Note: The occurrence of earthquakes and cyclones are not correlated. It is proposed that the shelter design earthquake load be based upon the buildings normal function. It is noted that wind loads are applied to the exterior of the building while earthquake loads are applied to all elements including internal walls, with the load related to the mass of the element.

(d) Permanent and Imposed Loads

The structure is to be capable of supporting permanent and imposed loads as defined by AS/NZS 1170.1 for a building used for public assembly.

The minimum uniformly distributed imposed roof load for structural elements and cladding shall be 1.8 kPa.

The flexure of windows including louvres shall be limited to ensure they remain supported by their frames when subjected to the ultimate design loads.

Notes:

1. Occupants in buildings clad in metal wall sheeting capable of resisting the debris load may experience excessive noise levels during the cyclonic event. Walls constructed of reinforced masonry or concrete are preferred.
2. Doors fixed at three points (two hinges and a single lock) are unlikely to satisfy these loading criteria. Additional fixings to required exit doors may compromise the need to maintain egress. It is possible to devise an Alternative Building Solution to address additional restraint requirements necessary to resist loads during times of the cyclone event. Such an Alternative Solution would be dependent upon management protocols during both the normal use of the building, and its use during a cyclonic event. Refer to 'Design Guidelines for Australian Public Cyclone Shelters - Appendix I' for an Alternative Building Solution to achieve additional restraint where the doorway is a required exit.

•

(e) Wave and Flood Flow Loads

Design the structure and building fabric to resist wave and flood flows where the shelter building is located in the storm tide inundation area.

3.3 Human Factors

Human factors encompassing both comfort and life safety issues include:

(a) Area per Occupant

The shelter design density is a minimum floor area of 1m² per person.

Note:

1. The concept of shelter density is that the density be similar to the seating capacity of a movie theatre. It is not intended to allow for people to sleep in a supine position.
2. This is consistent with the Building Code of Australia, which nominates 1m² per person as an appropriate density for uses involving public assembly and gathering: for example, restaurants, theatres, churches, school multi-purpose halls and spectator stands.
3. Some disabled people may require greater area.
4. In comparison FEMA recommends a minimum of 5 ft² (0.45m²) per person for tornado shelters and 10 ft² (0.9m²) for hurricane shelters.

(b) Occupancy Duration

The shelter shall be designed for two periods of occupancy. These periods are the total occupancy period and the lock-down period. The design total occupancy period is 36hrs and includes: a period prior to the wind reaching a gust wind speed of 100km/hr, the period of lock-down of the shelter when the winds are greater, and a period after the winds have abated but prior to people departing the shelter. The design lock-down period when windows and doors are closed to provide protection from winds greater than a gust wind speed of 100km/hr is a maximum of 18hrs.

Note:

1. The 100km/h wind speed is the 3 sec wind gusts and is deemed to be the speed beyond which it is unsafe to be outdoors. This speed is used in the Queensland Storm Surge Warning system as the threshold speed before which all evacuations should be completed. The warnings aim to give predictions of expected surge 12-24 hours before wind gusts of 100km/h are expected in the impact area.
2. The Bureau of Meteorology has advised that during a tropical cyclone the period of time during which wind gusts are greater than 100 km/hr at any one location varies, but suggests that the period would not typically extend beyond 15hrs. Logistically, it is preferable if people enter and leave the shelter during daylight. The period between nightfall and sunrise during the cyclone season varies from about 10hrs to 13hrs depending on location.
3. The shelter will be locked-down when local conditions and circumstances permit.
4. The gust wind speed of 100 km/hr nominated as the design lock-down wind speed is an assessment of the likely wind speed at which the shelter will be locked-down.
5. Caution should be exercised against premature lock-down where mechanical ventilation systems are not operating.
6. Caution should also be exercised when winds abate to avoid prematurely opening-up the shelter. The eye of a tropical cyclone may pass over a cyclone shelter. At this time the winds will drop dramatically (well below 100km/hr) and can also rise very quickly as the eye passes over. The shelter should remain locked-down during this period.

(c) Lighting

The minimum desirable lighting level is 40 lux with supplementary task lighting to provide 400 lux in areas for first aid treatment, tea rooms and for recreation areas where occupants may want to read or write. Emergency lighting shall comply with the BCA for a class 9b building. Emergency lighting shall be battery powered with a minimum life of 24hrs. The minimum emergency lighting level shall be 1 lux generally and 15 lux in task areas. External lighting is

required at the shelter entry. The shelter management plan shall allow for the provision of torchlights and batteries (Sections 3.4(a); 3.5(a)).

Notes:

1. Lighting within the shelter is necessary to calm shelter occupants during the cyclone and to permit safe movement within the shelter.
2. The minimum desirable level is consistent with AS1680.2 recommendations for indoor car park lighting.
3. Torch lights and batteries would be used should electrical supply fail and the duration of the failure exceed the life of the emergency lighting system.

(d) Safe Movement and Access

Safe movement and access provisions including handrails, balustrades and barriers, human impact on glazing and signage shall comply with the BCA requirements for the normal usage of the building.

In shelters where it is probable that the floors may be wet during the cyclonic event, then either the floor coverings shall be slip resistant when wet, or strategies (Section 3.3(k)) are developed as part of the shelter operations plan (Section 3.5(a)) to maintain dry floor surfaces during the shelter occupancy period.

Notes:

1. The shelter will include a relatively large number of people in an unfamiliar space.
2. It is expected that the normal use of the building will have addressed normal safe access and movement issues for such a large number of people.
3. In addition to these normal use matters, it is possible that during the cyclonic event the floors may be wet and the slip resistance of floor surfaces may be affected by moisture.

(e) Access for People with Disabilities

Access for people with disabilities to the shelter areas must be assessed for compliance with current building regulations. An accessible path of travel must be provided between the shelter area and any amenities, either existing within the building, or provided as temporary measures during the shelter occupancy.

Notes:

1. The Disability Discrimination Act and the Anti-Discrimination Act require non-discriminatory access to all buildings.
2. Current Building Regulations include prescriptive requirements to ensure access for people with mobility or sensory impairments. These requirements may affect the access-way to the shelter and provision of amenities.
3. The normal use of the building will require portions of the building to be accessible. It is possible that not all of the building would be required to be, or will be, accessible. It is also possible that those portions that are accessible for normal use may not be the most suitable portions for functioning as a cyclone shelter.

(f) Ventilation

Sufficient ventilation shall be provided so that the shelter complies with the performance requirement of the Building Code of Australia, which requires the shelter to be *ventilated with outside air to maintain air quality*.

The ventilation system shall ensure that people of varying ages including children, the aged and handicapped are safely accommodated in the shelter.

The preferred ventilation design concept is that the shelter be conventionally (mechanical &/or natural) ventilated when the wind speed is less than the “lock-down” condition (Section 3.3(b)) and naturally ventilated when wind speeds are above that condition. The natural ventilation

system is to be specifically designed and fitted with dampers with manual override to enable adjustment of the level of ventilation during the event.

The system shall be protected from damage by debris and the design shall consider the potential for blockage of the inlet to the ventilation system by debris. Natural ventilation openings are to be located to maximize cross flow ventilation, particularly for large shelters.

Design criteria regarding maximum carbon dioxide (CO₂) levels, maximum temperature rise and minimum fresh air levels shall comply with the Detailed Mechanical Guidelines contained in 'Design Guidelines for Australian Public Cyclone Shelters - Appendix I'. If the volume of internal space per person is low (less than 6m³ per person) the fresh air quantity shall be specifically selected in order to meet the design criteria. The potential that people occupying the shelter may be in wet clothes and that water may be entering the shelter during the event should be a consideration in the design of the natural ventilation system. These criteria are based upon the assumption that no smoking, cooking or heating are permitted in the shelter.

Use of the shelter facility under these emergency "lock-down" conditions should be minimized (Section 3.3(b) Notes 4 & 5). Ventilation rates are to be restored to the Building Code of Australia deemed to comply provisions after the lock-down period. Management of the ventilation system, including restrictions on smoking, cooking and heating, is to be documented in the shelter operations plan (Section 3.5(a)). The plan shall address the evacuation of the shelter after "lock-down" (i.e. "opening-up") should natural ventilation not be adequate at wind speeds below the design "lock-down" speed and mechanical ventilation is not available due to damage or loss of power supply.

Car park shelters built under buildings should contain mechanical ventilation and exhaust systems. Where emergency power is available, these systems should provide ventilation to the shelter area. Natural ventilation should be provided to supplement these systems.

Where the construction of basement car parks does not allow access for the cutting of natural ventilation openings, mechanical ventilation may be required necessitating the connection of permanent emergency power.

Toilet exhaust systems will preferably be connected to mains supply and emergency power. Where emergency power is not available, special provisions will be required to be made to include exhaust via natural ventilation e.g. venturi systems.

All mechanical ventilation exhaust systems, manual and motorized fresh air natural ventilation systems shall be performance tested in accordance with the shelter maintenance plan (Section 3.5 (b)).

Notes:

1. The need for enclosure of the shelter to provide protection from wind and wind borne debris and the desire to waterproof the shelter tend to be contrary to the provision of ventilation.
2. The current deemed to comply requirements contained in the Australian Standard - AS 1668.2 (Reference 9) - do not provide design criteria for emergency situations and are in excess of criteria deemed acceptable thirty years ago. Ventilation performance criteria based upon minimum CO₂ levels, maximum air movement velocities, odour control and acceptable temperature rise suitable for people of varying ages in a mostly at rest, although stressed state, are suggested as being more appropriate for the design of the shelter ventilation system during lock-down or emergency conditions when wind velocities are high.
3. External wind pressures associated with cyclonic winds can render mechanical ventilation equipment ineffectual during the cyclonic event. Mains power supply is likely to fail during the event and be unavailable for a period

after the event. Hence a ventilation system based upon natural ventilation during the lock-down period of the shelter is the preferred ventilation system.

4. Car park shelters require special attention, as these enclosures tend to be much larger in area and capable of housing higher volumes of people.

(g) Amenities

Amenities are to be provided in the shelter. At least 1 toilet is to be provided for every 40 people in the shelter. The amenities may be existing and/or temporary facilities and shall include facilities for people with disabilities. Where provision of temporary amenities is required then the number, type and location of the amenities is to be defined in the shelter operations plan (Section 3.5(a)).

Where temporary facilities are provided, consideration shall be given to:

- a. Adequate screening for privacy purposes
- b. Provision of separate facilities for males and females
- c. Provision for hand washing
- d. Provision for disposal of sanitary napkins

Where access to existing building amenities is not available, temporary facilities providing amenities for all persons including persons with disabilities are to be provided. Where temporary facilities for persons with disabilities are provided (in addition to the above considerations) they shall further provide a privacy screened enclosure of sufficient size to permit manoeuvring of a wheelchair, including the possibility of transfer between wheelchairs and commode chairs (or such other solution as adopted for temporary facilities), and room for presence and actions of assistants/personal attendants.

(h) Communications

The Consideration is to be given to provision of communication systems within the shelter and external to the shelter. A battery powered hand held megaphone and a battery-powered radio receiver or television are considered the minimum provisions for internal and external communications. It is desirable that an effective communication system is provided between the shelter and the designated disaster coordination centre.

(i) Emergency Power

It is desirable for shelters designed to accommodate large numbers of people to be provided with emergency generators. Provision should be made in all shelters for an external generator inlet socket, connected to a manual change over switch on the shelter switchboard, to allow for connection of an emergency generator. Where the generators are external to the shelter the generators and fuel tanks shall be protected from the effects of wind, rain and wind borne debris. The generator exhaust shall be located away from shelter air intakes so that exhaust fumes do not enter the shelter ventilation system. Fuel tanks shall be located and fuel shut-off systems installed so that the shelter is not at risk from a fire associated with the generator fuel storage. Where the generator is to be located within the shelter, ventilation, noise and fire safety issues are to be addressed. Provision of battery-powered torchlights is a minimum requirement (Section 3.3(c)).

Emergency lighting shall be battery powered with a minimum life of 24hrs

Note: It is assumed that there is a high risk of power supply failure to the shelter during a cyclone.

(j) Emergency Provisions

Provision of essential sustenance items including drinking water and food shall be part of the shelter operations plan (Section 3.5(a)). Preference should be given to light snacks and hot drinks which do not require any significant level of preparation or cooking inside the shelter.

Community evacuation plans should incorporate a desire for those seeking shelter to bring items of food (snacks), particularly those who have special diets or needs. Provision of first aid medical supplies shall also be included in the plan.

(k) Waterproofing and Weatherproofing

The consequences of water penetration into the shelter, due to cyclonic winds, shall be considered, particularly in relation to: safe movement and access as wet floors may present a potential hazard; and to ventilation and thermal comfort conditions as wet clothes for a prolonged period may cause discomfort and health issues.

Attention should be paid to matters of safety such as ensuring that floors, particularly principal traffic areas, are provided with non-slip flooring material such as non-slip matting and/or that procedures are documented in the shelter operations plan (Section 3.5(a)) to ensure frequent and routine removal of water through methods such as using brooms, mops, squeegees etc.

Notes:

1. The Building Code of Australia currently expects a building used for assembly purposes to be both waterproof and weatherproof. This expectation would apply to the normal use of the building.
2. Cyclonic winds may cause water penetration into the building, particularly buildings which have high-level ventilation louvres.

The exterior building fabric shall be resistant to water penetration. The fabric shall not permit penetration of uncontrolled water when tested in accordance with AS2047 under a water penetration resistance test pressure of 630 Pa.

Note: The water penetration resistance test pressure is consistent with AS2047 Windows in Buildings for a 10m high commercial building in terrain category 2, region C.

3.4 Other Factors

(a) Fire Direction and Emergency Warning

The shelter operations plan (Section 3.5(a)) shall provide for suitable management of fire risk on the basis that there is no electrical power supply, mains water supply may not be available, and that the fire brigade could not provide assistance, during the shelter lock down period. The plan should include:

- Limiting fire ignition through the prohibition of smoking and other naked flames (such as candles, gas lights etc);
- Eliminating fuel sources by prohibiting gas cylinders in the shelter, removal of cars, vehicles and stored fuel from the shelter prior to occupation;
- Constant surveillance by persons appointed as shelter supervisors;
- Advice to shelter occupants of the limitation of sources of ignition, combustibles, surveillance techniques, and a warning system to be employed in case of an emergency.
- Provision of one (1) tri-class (2A: 20B: (E) minimum) fire extinguisher for each specific risk location, for each shelter management personnel, and for each 1,000 shelter occupants.
- Provision of two (2) 9-litre water extinguishers at each Fire Hose Reel location.

Fire extinguishers shall be tested in accordance with the shelter maintenance plan (Section 3.5 (b)).

Notes:

1. The building may not normally include sleeping accommodation but while it is occupied as a cyclone shelter it may be inhabited by occupants who are asleep or in unfamiliar surroundings. Early fire warning is required so that the shelter occupants have time to take preventative action.
2. A real contingency that must be planned for is the loss of electrical power during a cyclonic event. In such cases many of the fire detection, warning and suppression devices provided for the normal use of a building will be rendered ineffective. Some systems will have battery powered back-up, however this is usually only for a limited period and it is likely that failure of electrical supply during a cyclonic event will exceed the capacity of such battery back-up.
3. It is unlikely that the Fire Brigade could provide assistance during the shelter lock-down period. It is also possible that mains water pressure may not be available

(b) Lightning Protection

Lightning protection shall be provided to protect the shelter structure and to also provide protection from lightning induced surges in power and telecommunications cables entering the shelter.

Note: The shelter may have to provide protection from severe electrical storms and must be provided with adequate lightning protection.

3.5 Other Factors

Management issues such as the number of shelter spaces required within a community, and the acquisition and activation of buildings are not considered in this document. The authority for activation of any designated shelter building and its management, including development and updating of shelter operations and maintenance plans, would be as delegated by the respective Local, District, State Disaster Management Groups.

This section of the document addresses shelter operations, maintenance and signage issues, which relate to the guidelines contained in the previous sections.

(a) Shelter Operational Plan

A shelter operations plan should include clauses regarding: aim; objectives; authority of the plan; management committee; activation of plan; financial aspects; concept of operations; roles and responsibilities; staffing; blankets; sanitation; fire detection; first aid facility; registration; counselling; sustenance; shelter preparation; communications; pets.

The plan should address training of personnel to manage the shelter. A register of trained personnel, contact details and availability is to be compiled/updated annually, prior to the commencement of the cyclone season. A copy of the register is to be provided to the Disaster District Coordinator.

The plan should maintain a register of the location of any items needed for the operation and management of the shelter accommodation and necessary contact details. This register should be reviewed annually for completeness and modified accordingly.

The shelter operations plan is to address the shelter management process including: manning levels and expertise; provision of food and drinking water (Section 3.3(j)); provision of basic medical supplies (Section 3.3(j)); provision of amenities (Section 3.3(g)); management including registration of people entering, accommodated within and leaving the shelter (Sections 3.3(a)(b)); strategies for redirection of people to alternative accommodation should the shelter reach capacity (Section 3.3(a)); provision and management of communications within and external to the shelter (Section 3.3(h)); management of public safety issues (e.g. limiting combustibles, fire detection, ventilation, safe walking areas) (Sections 3.3(c)(d)(e)(f)(i)(k) 3.4(a)(b)); and enforcement of the operations plan.

The plan should be tested by a training exercise.

No special allowance has been made in the performance criteria for accommodation of pets.

Note:

1. Design Guidelines for Australian Public Cyclone Shelters document is a minimum standard that primarily addresses the safety of people.
2. Accommodation of pets within the shelter may reduce the number of people able to be accommodated and has implications regarding ventilation and sanitation.
3. While some pets may be reasonably accommodated within the shelter others should not be accommodated as they could affect the health and safety of people. Alternative accommodation could be identified for pets, where such a need is identified.

The potential occupation period is extensive and the shelter operations plan should consider the needs of people. People in the shelter should be able to move around and involve themselves in different activities: e.g. reading, talking and resting etc. The shelter operation plan should ensure this opportunity is available to all persons resorting to the shelter, including those with a disability. This may require additional consideration in respect of persons with disabilities including:

- Having mobility aids available for those persons who have been evacuated to the shelter without their own personal mobility aids, or
- Making arrangements with search and rescue personnel effecting evacuations to ensure mobility aids for persons with disabilities are evacuated with the person,
- Providing additional lighting in certain areas for persons with sight impairments (e.g. primary circulation routes and amenities areas).

(b) Shelter Maintenance Plan

The shelter maintenance plan should include: scheduled regular maintenance works in accordance with the buildings approved maintenance plan; a scheduled maintenance inspection prior to each cyclone season and immediately prior to an impending event; a check list of the emergency supplies which are permanently located within the shelter; an updated list of sources of provisions not permanently located within the shelter; a list of items to be inspected/checked (e.g. emergency generators, doors, locks, signage, drainage, debris screens, lighting etc); and person(s) responsible for the inspection.

The annual inspection shall include a fitness-for purpose assessment of the shelter. This would include assessment of changed circumstances including any modifications that may have occurred to the shelter or the surrounding area. Where the changes are detrimental to the shelter, action shall be taken to ensure the shelter is fit for purpose prior to the commencement of the cyclone season.

The maintenance inspection plan shall include building inspection (e.g. roof fixing; debris screens; operability of windows/louvers etc) and site inspection (e.g. maintenance of slope stability; potential debris etc).

The plan shall ensure that the building is maintained in an appropriate condition to ensure the shelter is fit-for-purpose.

(c) Signage

The location of the shelter, limitations within the shelter, maximum occupancy of the shelter and emergency exits should be clearly signed.

Note: It is suggested that a sign be erected near the entry to the shelter that states condition of entry.

4. CONCLUSION

This document presents criteria for the design of public cyclone shelters. It provides the basis for development of national guidelines and forms a standard by which Government and Disaster Managers can determine the provision of an appropriate level of safety to address their duty of care to the community.

APPENDIX I: Specifications and Guidelines

- Specification of Test Criteria and Procedure External Fabric of Public Cyclone Shelters
- Specification – Debris Resistant Screens for Public Cyclone Shelters
- Detailed Mechanical Guidelines
 - Minimum Requirements
 - Debris Requirements
- Guidelines for an Alternative Building Solution
 - Example: Additional Restraint to Required Exit Doors

External fabric of Public Cyclone Shelters – Specification of test criteria and procedures.

The external fabric including debris screens, cladding, windows and doors shall comply with the following test criteria:

1. TEST LOADS

Cyclonic Region C

(a) Debris Test Load:

Test Load A:

End-on impact of a piece of timber 4 kilograms in mass, with cross-section dimensions of 100mm by 50mm, impacting at the speed specified for the trajectory.

Test Load B:

Series of five steel balls of 2 gram mass (8mm diameter) impacting at the speed specified for the trajectory, successively.

(b) Wind Test Load:

Fatigue loading as defined in the BCA Specification B1.2 Table 1.

In the case of debris screens to be located on walls, the magnitude of the load may be reduced due to the porosity of the screen by the factor K_p determined in accordance with AS 1170.2-1989 clause 3.4.13.

2.0 TEST SEQUENCE:

Cladding or Debris Screens:

A test specimen shall be subject to successive test loads applied in the following order:

1. Debris test load A
2. Debris test load B
3. Wind test load

Test load A shall impact the most critical location(s). The testing authority shall determine the most critical location(s) (e.g. Debris Screens: centre of screen; centre of frame; fixing location – Cladding: centre of span; fixing location) by test. Test load B shall successively impact at various random locations on the screen.

3.0 ACCEPTANCE CRITERIA:

A test specimen shall:

- (a) prevent a debris missile from penetrating through the screen/cladding;
- (b) if perforated, have a maximum perforation width of less than 8mm;
- (c) in the case of a debris screen, not deflect more than 0.8 times the clear distance between the screen and the glazing, at any stage of the test.
- (d) be capable of resisting the specified wind load.

Debris resistant screens for Public Cyclone Shelter Specifications

1.0 STRENGTH

The screens shall be capable of resisting the design debris load and wind load as defined in the “Shelter Buildings (Cyclone) Criteria for Debris Screens and Cladding”.

2.0 GEOMETRY

- (a) The largest aperture in the screen shall be 8mm or less.
- (b) To ensure the glazing is not fractured due to screen deflection under impact, the screen shall be located at a distance at least equal to 1.25 times the maximum displacement of the screen under the impact load.
- (c) The screen shall envelope the glazed panel by either:
 - 1. Returning to the wall to completely envelope the opening; or
 - 2. Overlapping the opening by a distance measured in a plane parallel to the wall, by at least two times the distance the edge of the screen is from the wall where the maximum distance from the edge of the screen to the wall is 300mm
or
 - 3. A combination of 1 and 2.

3.0 CERTIFICATION

The screen shall be designed based upon calculation and test data from a NATA registered testing laboratory approved to undertake the specified cyclone debris test. The screen shall be certified, by a Registered Professional Engineer with expertise in the design and testing of debris screens to the specified criteria.

Detailed Mechanical Guidelines - Minimum Requirements

The design lockdown condition shall correspond to a minimum average external wind speed of 70km/hr (refer Sections 3.3(a), (b), (f), (i)).

Notes:

1. Average wind speed is averaged over 10 minutes.
 2. Gust wind speeds are higher than average wind speeds.
- Where external wind velocities are below lockdown conditions:
 - fresh air volumes per person be maintained in accordance with the deemed to comply provisions of the BCA.
 - all mechanical ventilation and exhaust systems be operated on mains power.
 - provide emergency power and or natural ventilation.
 - Where external wind velocity exceeds lockdown conditions:
 - carbon dioxide levels shall not exceed 800 ppm or 0.5% by volume.
 - minimum ventilation rates be maintained at 1.4 l/s at a space allocation of 6 cubic metres per person. Minimum ventilation rates to be increased on a pro rata basis as space allocation volumes decrease.

NOTE: Minimum occupancy allocation of 2.4 cubic metres per person.

 - temperature rise with in the enclosure to be limited to 6 degrees C above outside ambient.

Note: The 6 degree rise includes an allowance for the drop in the external ambient temperature during the cyclone of 3 degrees.
 - Where toilet exhaust systems are installed these be capable of being activated
 - That provision for natural ventilation be provided by way of debris protected grilled openings to exterior walls and/or doors fitted with adjustable manual dampers to adjust air volumes and be accessible from within the shelter.

Minimum area of natural ventilation damper openings

Shelter Volume	Opening Size
< 100m ³	2 @ 0.1 m ² or 4 @ 0.05m ²
100 to 200m ³	4 @ 0.1 m ² or 8 @ 0.05m ²
200 to 1000m ³	Multiple Openings 1m ² in total
> 1000m ³	Multiple Openings 1m ² in total for each 1000m ³ volume

NOTE: Compare minimum areas with the requirements of the ICC/NSSA Standard on the Design and Construction of Storm Shelters.

NOTES:

1. All openings to be located on a minimum of two external faces of the shelter - walls or roof. Openings to be evenly distributed over the area of the shelter as far as the structure allows.
2. The final position and size of ventilation openings may be determined by computer modelling, testing of models, or on site testing during periods of high wind velocity.

Detailed Mechanical Guidelines - Desirable Requirements

- Where external wind velocities are below lockdown conditions:
 - All installed air conditioning and mechanical ventilation and exhaust systems be operated.

Note: Where air conditioning systems are installed, provision be included to operate the system on 100% fresh air without recirculation of air.

- Where external wind velocity exceeds lockdown conditions:
 - fresh air volumes per person be maintained in accordance with the BCA.
 - ventilation openings be provided in excess of minimum area of natural ventilation damper openings nominated in Detailed Mechanical Guidelines and in accordance with "Free area of damper openings" as shown.
- Where smoke and toilet exhaust systems are installed these be capable of being activated and connected to emergency power
- Improved natural ventilation be provided by way of wind scoop or venturi grilled openings to exterior walls and doors fitted with adjustable manual dampers to adjust air volumes and be accessible from within the shelter.

Free area of damper openings

It is recommended that the number and size of ventilation openings be increased above those nominated in the minimum requirements schedule. It is further recommended that openings be evenly distributed across all faces and the roof of the structure to maximise natural ventilation.

Guidelines for an alternative building solution – Example: additional restraint to required exit doors

1.0 GENERAL

Additional restraint is often required to doors to achieve compliance with shelter building criteria for resistance to wind and debris loads. To achieve adequate restraint an alternative building solution may be required. The following presents an alternative building solution for acceptance of additional restraint to Required EXIT doors in public cyclone shelters.

2.0 ALTERNATIVE BUILDING SOLUTION

- (a) Provide pad bolts to the doors, in positions as required to optimise the distribution of the wind loadings to the door.
- (b) The pad bolts to be locked in the open position by padlocks at all times the building is not serving a function as a cyclone shelter.
- (c) Padlocks to have a keying system independent of any master keying system related to the normal use of the building, and the key to be a registered and restricted profile requiring the authorisation of the cyclone shelter management for reproduction.
- (d) During use as a cyclone shelter, the pad bolts are only to be driven home during the “lock-down” phase of the cyclone period. The design lock-down period is the period when average external wind speeds exceed 70 km/hr.
- (e) When the pad bolts are in use, the padlocks are to be totally removed from the vicinity, or they may be locked into a deactivated position adjacent to the pad bolts, but not so that they lock the pad bolt in the closed position.
- (f) During the time of occupation as a Cyclone Shelter, procedures are to be in place to ensure that a suitably trained and capable person is to be available to withdraw the pad bolts at or near each door in the event the door must be used as an emergency exit.
- (g) The key to operate the padlocks is to be retained by the person responsible for the management of the cyclone shelter function – it is not to be retained by the operator/owner/manager/occupier of the building for its normal function.
- (h) A sign is to be placed on or adjacent to any door so fitted to the effect “Pad bolts are for use during cyclone shelter function only”, or similar words.
- (i) The operator/owner/manager/occupier of the building at time other than Cyclone shelter function are to be advised of these conditions and reasons for provision of the pad bolts and padlocks, and are to be advised that it is an offence under the Building Act and the Fire and Rescue Services Act to lock the fire exit under any condition – except when the building is in use as a Cyclone Shelter.

The above solution could be accepted as an alternate solution under the Building Code of Australia having consideration to the following:

1. Deemed-to-Satisfy provision not satisfied BCA clause D2.21
2. Relevant Performance Criteria – DP2(b) ‘So that people can move safely to and within a building, it must have any doors installed to avoid the risk to occupants having their egress impeded or being trapped in the building’.
3. Method of assessment relied upon – Comparison with the DTS provisions.
4. Evidence relied upon to support the proposal:
 - (a) Under normal use of the building the pad bolts are locked in the closed position, the door will function as though the pad bolts were not there, and the exit door can function as required under BCA clause D2.21;

- (b) The normal building owner/occupier etc of the building does not have access to the key in order to activate the pad bolts;
 - (c) The key is a restricted and registered profile and cannot be reproduced without authority of the cyclone shelter manager;
 - (d) The normal building owner/occupant etc is advised through management procedures and signage at the door of:
 - i. The reasons the pad bolts are provided.
 - ii. The function the pad bolts serve.
 - iii. That it is an offence to activate the pad bolts at any time other than during use as a Cyclone Shelter.
 - (e) During use as a cyclone shelter, the management of the shelter incorporates a mechanism to ensure that a suitable instructed and physically capable person is available at or near each affected door to deactivate the pad bolts should the door be required to function as an exit.
 - (f) During use as a cyclone shelter the padlocks are either removed or deactivated thus preventing their use to lock the pad bolts in position
5. Continuing maintenance-in-use consequences of this solution:
- (a) The Cyclone Shelter management procedures are to include instructions to the effect:
 - i. Functioning of pad bolts and padlocks are to be included in an annual maintenance check prior to the commencement of the cyclone season. This will consist of at least opening and closing each pad bolt and padlock and ensuring the explanatory sign is in place and legible.
 - ii. Upon alert that the Cyclone Shelter may be required, functioning of the pad bolts and padlocks is to be checked;
 - iii. Upon occupation of the Cyclone Shelter, the persons responsible for the Cyclone Shelter management shall:
 - 1. Unlock the padlocks in order to prepare the pad bolts for use;
 - 2. Shall either lock the padlocks into a deactivated position at or near the door, or shall remove the padlocks completely from the vicinity of the door;
 - 3. Shall ensure the key to operate the pad bolts is not available to any persons other than those bearing responsibility for management of the shelter;
 - 4. Nominate a particular person or persons to remain near to each exit door including suitable relief and replacement arrangements, at all times the pad bolts are in the home position. Those persons shall be instructed in the correct operation of the pad bolts, and shall have the physical capacity to operate the pad bolts;
 - 5. Until the pad bolts are driven into the home position, shall regularly check the pad bolts to ensure that other persons or occupants have not driven the pad bolts into the home position prematurely.
 - iv. The pad bolts shall not be driven into the home position for restraint purposes prior to shelter lock-down.
 - v. After the cyclone event and the shelter is opened-up the pad bolts are to be withdrawn from the home position. Regular checking to ensure that the pad bolts have not been mistakenly driven back into the home position is recommended.
 - vi. Upon completion of the cyclone event, and removal of the occupants, the management shall resecure the padlocks to lock the pad bolts in the disengaged position.

- (b) The normal occupants, owners and users of the building shall be advised, via the Cyclone Shelter Management committee, of the following:
- i. Doors fitted with additional restraint pad bolts are not to be regarded differently to any other door serving as a required exit. That is, the presence of pad bolts and padlocks on the door does not mean the users/occupants can provide additional similar security arrangements for their own purposes.
 - ii. A full explanation of the purpose and function of the additional pad bolt and padlock restraint system, and the operating conditions that are in place during a cyclone event.
 - iii. Specifically advised that in accordance with the Building Act and Fire and Rescue Services Act, it is an offence to obstruct free passage through a nominated exit door.
 - iv. The necessity to maintain the information sign posted at any door provided with additional restraint pad bolts.
 - v. The need to advise the Cyclone Shelter Management committee should the information signage damaged or removed.

APPENDIX II: Reference Documents

- Reference Documents – Cited
- Reference Documents – Not Cited
- Reference Documents – Draft



REFERENCE DOCUMENTS – Cited

- 1) AS/NZS1170.0 *Structural design actions Part 0: General principles*, Standard Australia, 2002.
- 2) AS/NZS1170.1 *Structural design actions Part 1: Permanent, imposed and other actions*, Standard Australia, 2002.
- 3) AS/NZS1170.2 *Structural design actions Part 2: Wind loads*, Standards Australia, 2002.
- 4) AS1170.4 *Earthquake loads*, Standards Australia, 1993.
- 5) AS1288 *Glass in buildings – selection and installation*, Standards Australia, 1994.
- 6) AS1428.1 *Design for access and mobility – general requirements for access – new building work*, Standards Australia, 2001.
- 7) AS1428.1 *Design for access and mobility – tactile ground surface indicators for the orientation of people with vision impairment*, Standards Australia, 1992.
- 8) AS1668.1 *Fire and Smoke Control*, 1998.
- 9) AS1668.2 *Mechanical ventilation for acceptable indoor air quality*, 1991.
- 10) AS1680 *Interior lighting for safe movement*, 1998.
- 11) AS1720.1 *Timber Structures - Design methods*, Standards Australia, 1997.
- 12) AS3600 *Concrete Structures*, Standards Australia, 2001.
- 13) AS3700 *Masonry Structures*, Standards Australia, 2001.
- 14) AS4100 *Steel Structures*, Standards Australia, 1990.
- 15) AS4586 *Slip resistance classification of new pedestrian surface materials*, Standards Australia, 1999.
- 16) Australian Building Codes Board, *BCA96 Building Code of Australia*, Canberra, 1996.
- 17) Australian Building Codes Board, *BCA96 Guide to the BCA*, Canberra, 1996.
- 18) Darwin Reconstruction Commission, *Darwin Area Building Manual* (1976).
- 19) Department of Emergency Services, *State Planning Policy on Land Planning for Natural Disaster Mitigation and Development Assessment – Discussion Paper*, Queensland Government, Brisbane, September 2001.
- 20) Department of Public Works, *Shelter Buildings (Cyclone) Nomination and Investigation Program Report on Stage 1*”, Queensland Government, Brisbane, July 1998, (3 Volumes).
- 21) Department of Public Works, *Shelter Building (Cyclone) Nomination and Investigation Program Report on Stage 2*, Queensland Government, Brisbane June 1999, (2 Volumes)
- 22) Department of Public Works, *Shelter Building (Cyclone) Nomination, Investigation and Upgrade Programs - Report on Shelter Buildings Programs*, Queensland Government, Brisbane, September 2000, (1 Volume).
- 23) FEMA, *National Performance Criteria for Tornado Shelters*, Federal Emergency Management Agency, Mitigation Directorate, Washington D.C, 1st Ed., May 1999.
- 24) FEMA, *Design and Construction Guidance for Community Shelters*, Federal Emergency Management Agency, Mitigation Directorate, FEMA361, 1st Ed., July 2000
- 25) Granger, K., “Managing the Risks to Urban Communities Posed by Environmental Hazards”, Australian Geological Survey Organisation, Cities Project, GPO Box 762, Brisbane, Qld. 4001
- 26) Granger, K.J. & Smith, D.I., “Storm Tide Impact and Consequence Modeling: Some Preliminary Observations”, *Mathl. Comput. Modeling* Vol. 21, No. 9, pp15-21, Elsevier Science Ltd. 1995
- 27) Harper, B., “Storm tide threat in Queensland: History, prediction and relative risks”, Conservation Technical Report No.10, Queensland Government, Department of Environment and Heritage, August 1998.
- 28) Holmes, J.D., “Debris Damage Criteria for Cyclone Shelter Buildings in Queensland”, Report JDH 99/1, JDH Consulting, April 1999.





- 29) Holmes J.D., Mullins P.J., *The Mechanics of Flying Debris in Severe Wind Storms*, Proceedings of the Australian Wind Engineering Society, Workshop, Perth, March 2000.
- 30) Holmes J.D., Mullins P.J., *The Mechanics of Flying debris and test criteria*, Proceedings Fifth Asia-Pacific Conference on Wind Engineering, Kyoto, Japan October 2001.
- 31) Mullins P.J., Rossiter J. and Mollee F., *Shelter Buildings – Cyclone*, Proceedings disaster management, crisis and opportunity: hazard management and disaster preparedness in Australia and the Pacific Region, Conference, Cairns, November 1998.
- 32) Mullins P.J., Holmes J.D., *Flying Debris Test Criteria for Post Disaster Function Buildings in Cyclonic Areas*, Proceedings of the Australian Wind Engineering Society, Workshop, Perth, March 2000
- 33) Northern Territory Emergency Services, *Cyclone Protection in the Northern Territory, What Are Your Options?* Darwin, Ed 2, November 1995.
- 34) Disaster Management Act, Goprint, Queensland, 2003.
- 35) Smith, D.I. & Greenaway, M.A., “Tropical Storm Surge, Damage Assessment and Emergency Planning – A pilot study for Mackay, Queensland” Resource and Environmental Studies Number 8, Centre for Resource and Environmental Studies, The Australian National University, March 1994.
- 36) Standard Building Regulation, Goprint, Queensland, 1993.
- 37) State Counter-Disaster Organisation and the Bureau of Meteorology, “Storm Tide Warning – Response System”, Third edition-July 1997
- 38) Department of Public Works, *Design Guidelines for Australian Public Cyclone Shelters*, Queensland Government and Emergency Management Australia, August 2002.

REFERENCE DOCUMENTS - Not Cited

- 39) Carter, R.R., *Wind Generated Missile Impact on Composite Wall Systems*, MS Thesis. Department of Civil Engineering, Texas Tech University. Lubbock, TX. May 1998.
- 40) FEMA, *Interim Guidelines for Building Occupant Protection from Tornadoes and Extreme Winds*, Federal Emergency Management Agency, TR-83A, September 1980
- 41) Pietras. B. K., *Analysis of Angular Wind Borne Debris Impact Loads*, Senior Independent Study Report, Department of Civil Engineering, Clemson University, Clemson, SC May 1997
- 42) Sciaudore, J.C., *Analysis of Wind Borne Debris Impact Loads*, MS Thesis, Department of Civil Engineering, Clemson University, Clemson, SC, August 1996.
- 43) Texas Tech University Wind Engineering Research Centre, *Design of Residential Shelters from Extreme Winds*, Texas Tech University, Lubbock, TX, July 1998.

REFERENCE DOCUMENTS - Draft Documents

- 44) Department of Public Works, *Selection Criteria for Public Shelters*, Queensland Government, Brisbane, (3 pages), 1998
- 45) Department of Public Works, *Compliance Criteria for Public Cyclone Shelters*,
- 46) Queensland Government, Brisbane, (1 page), 1998
- 47) Department of Public Works, *Specification for Debris Resistant Screens for Public Cyclone Shelters*, Queensland Government, Brisbane, (1 page), 1999
- 48) Department of Public Works, *Test Criteria and Procedure for Debris Screens and Cladding for Public Cyclone Shelters*, Queensland Government, Brisbane, (1 page), 1999.
- 49) Department of Public Works, *Shelter Building Upgrade Work – Mechanical Ventilation – Guidelines for Compliance Criteria*, Queensland Government, Brisbane, (5 pages), 1999.

