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Buildings Used for Shelter during Tropical Cyclone Yasi, Places of Refuge & Public Cyclone Shelters in Queensland

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Abstract

People whose homes may be inundated by storm tide and many whose homes are old and vulnerable to wind damage seek shelter elsewhere prior to the impact of the cyclone. The majority of people shelter with friends and family in newer homes above the storm tide. Many people seek shelter in public buildings. It was reported that 10,500 people sheltered in buildings nominated as 'Evacuation Centres' during Tropical Cyclone Yasi.

This paper presents a brief overview of the buildings in which people sheltered during the TC Yasi and the programs instigated by the Queensland Government since to provide the best level of safety to people sheltering in public buildings during severe tropical cyclones.

Introduction

The Building Code of Australia (BCA) defines a building's Importance Level which, based on probability, defines the design wind speed. Table 1 shows the wind speed relative to the cyclone category for each of the Importance Levels. Also shown in the table is the design wind speed for Public Cyclone Shelters constructed in Queensland.

Importance level	Building	Gust wind km/hr	Cyclone category
1	Farm sheds	220	Low 4
2	Houses and small buildings	248	Mid 4
3	Larger buildings	266	Mid to high 4
4	Post- disaster structures (Designated emergency shelters)	277	High 4
	Queensland Public Cyclone Shelters	306	Low 5

Table 1: Building standards and cyclone categories

Table 1 shows that, with the exception of isolated buildings such as farm sheds, failure of the buildings constructed to current building standards should be minimal in tropical cyclones with wind speeds up to 250 km/hr. That is, mid range of wind speed of Category 4 cyclones.

JCU-CTS report concluded that the maximum gust wind speeds of 225 km/hr were experienced in Tully Heads and Mission Beach and 200 km/hr in the townships of Tully and Cardwell. Very high levels of damage occurred in Tully and Cardwell due to the large proportion of the buildings having been constructed pre-1980. In 1982 it was mandated that houses in Queensland's cyclone region be constructed to comply with cyclone resistant building standards.

The BCA requires buildings that are essential to post-disaster recovery to be designed for wind speeds consistent with the maximum speeds experienced in a Category 4 cyclone. The Guide to the BCA nominates 'Designed emergency shelters' as Importance Level 4 buildings.

While current building standards require buildings to be constructed to resist wind loads they do not require buildings to be constructed to resist wind borne debris.

Buildings used for shelter during TC Yasi

Evacuation of potential storm tide inundation areas of Townsville, Cairns and coastal communities between occurred prior to the cyclone. In the Tully area these included South Mission Beach, Tully Heads, Hull Heads, Cardwell and Port Hinchinbrook. Many people evacuated took shelter in homes of friends and family. Others sought shelter during the cyclone in community buildings nominated as 'Evacuation Centres'

In the week following the cyclone the writer, as part of the JCU-CTS team, and with the support of the Queensland Government, Department of Public Works, undertook an inspection of buildings used to shelter people from the severe winds and wind borne debris.

Two purpose built cyclone shelters were inspected as well as a selection of buildings nominated by authorities as evacuation centres between Cairns and Ingham. A detailed damage survey of houses was undertaken by the JCU-CTS team.

Figure 1. Public cyclone shelter, Multipurpose centre, Redlynch State College.

Very high levels of damage occurred to housing constructed prior to 1980's while housing constructed post 1980's experienced low levels of damage.

Figure 2. Old houses in Tully, damaged by cyclone Yasi.

Figure 3. New houses in Tully & Port Hinchinbrook undamaged by Yasi

People sheltering in houses should shelter in houses constructed post 1982 which should be built to cyclone building standards.

Houses are not constructed to resist wind borne debris. The vulnerability of people sheltering in their homes would be reduced should a cyclone shelter room be constructed in homes. This room would be designed and constructed to protect the residents, family and friends from wind borne debris.

The Public Cyclone shelters in Redlynch and Innisfail State Colleges constructed to resist low Category 5 wind gusts and wind borne debris provided an appropriate level of safety for the 1,400 people who sheltered in these buildings.

Figure 4. Public Cyclone Shelter, Performing Arts, Innisfail State College

The other buildings nominated as 'Evacuation Centres' inspected at Smithfield, Earlville, Babinda, Innisfail, Tully and Ingham appeared to have been constructed to building standards equivalent to or less than the current BCA Importance Level 3. Most of the buildings had extensive areas of unprotected glazing. Some buildings had large roller doors without or with inadequate wind locks.

The Senior Citizens Hall in Tully was listed as an Evacuation Centre on the day prior to TC Yasi. Fortunately, local residents intervened late on the afternoon before the cyclone and relocated people sheltering in the building to the Tully Red Cross building. The Senior Citizens Hall, an old building, was demolished during the night by the cyclone. The Tully Red Cross building suffered some damage due to wind borne debris and roller door failure.

Figure 5. Tully Senior Citizens hall.

All of the 10,500 people sheltering in the evacuation centres were reported as safe on the morning following the cyclone.

Public cyclone shelter project

Design guidelines for the construction of public cyclone shelters in Queensland have been developed and were endorsed by the State Disaster Management Group in September 2006. Public cyclone shelters have been constructed in Innisfail, Cairns, Kowanyama and Cooktown.

The guidelines require the shelter to be:

- Sited on land: above the 1:10,000 storm tide evacuation zone; above the Q500 flood level; not exposed to other hazards such as land slip or hazardous facilities; and adjoining an area accessible by helicopter.
- Constructed to resist a 1:10,000 wind event and associated wind borne debris.
- Constructed with amenities, emergency lighting, and adequate ventilation for life safety and acceptable comfort.

The guidelines are based upon the majority of people being seated in the shelter with an average floor area allowance of $1.2m^2$ per person.

In May 2011 funding of $60 million was announced for the construction of 10 cyclone shelters which will be used as multipurpose facilities in North Queensland. The project is jointly funded by the emirate of Abu Dhabi and the Queensland Government.

Figure 6. Proposed Public Cyclone Shelter, Generic Design

Figure 7. Shelter during lock down

The shelters are fitted with emergency generators to provide power to the building when mains power is shut off. The shelter is also fitted with battery back-up to provide light within the shelter should the generator fail. Toilets and showers are provided along with a small kitchen, first aid room and shelter office. Chairs are stored in the building for use during lock-down. The chair stores along with the sports laboratory are included with the sports hall as the shelter area. The foyer is to be used as the shelter registration area and spill-out area as it adjoins the small kitchen and the staff room which will be used as the shelter office and communications room.

The shelter is to be "locked down" when the gust wind speed reaches 100km/hr. During the lock down period the shelter is to be naturally ventilated, with the ventilation being manually operated with mechanical louvers.

Figure 8. Proposed public cyclone shelter, Floor plan

The buildings are constructed as indoor sports facilities. All of the shelter buildings incorporate an indoor basketball court, except the Edmonton building which will incorporate two basketball courts.

Figure 9. Shelter normal use, Indoor sports facility

JCU-CTS were engaged to provide design advice on building geometry to reduce wind loads on the building. The building design developed incorporated: chamfered (45 degree) corners on the lower level walls and roof; porous sunshades and porous vertical wing walls on the corners of the upper walls; vented overhanging corners of the upper level roof.

Wind tunnel tests were undertaken on the generic building design to determine wind pressures for roof sheeting, framing, and windows and to establish external pressures for natural ventilation design. The building was modelled at a length scale of 1/100, and tested in turbulent atmosphere boundary layer flow in the boundary layer wind tunnel at JCU-CTS. The modelled approach terrain was representative of open country. Wind pressures on the building were measured using pressure taps installed on the roof and the walls. The wind load mitigation devices were fitted to one end of the model only with instrumentation at both ends for comparison.

The venting at the corner of the roof overhangs were found to be very effective in reducing the negative local pressures in that region by about 30%. Reductions in the negative pressures near the corners of the walls were achieved, as a result of the porous corner features and the chamfering.

The ventilation performance of the building was assessed using the mean directional pressure coefficients measured at ventilation inlets and outlets on the walls. A lock-down 10-minute mean wind speed of 19.4 m/s was used to determine the mean pressures for ventilation flow rates in shelter mode.

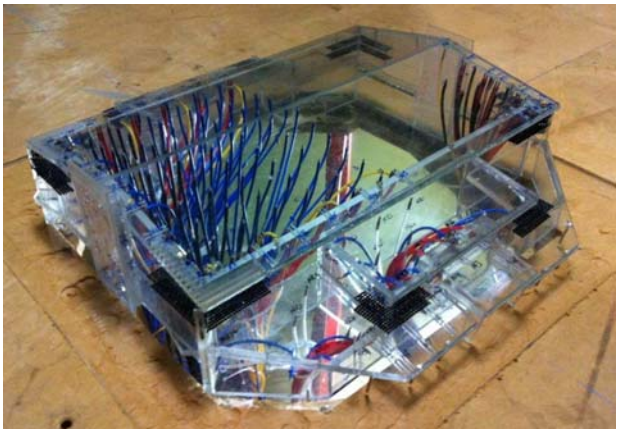

Figure 10. General view of model in the wind tunnel

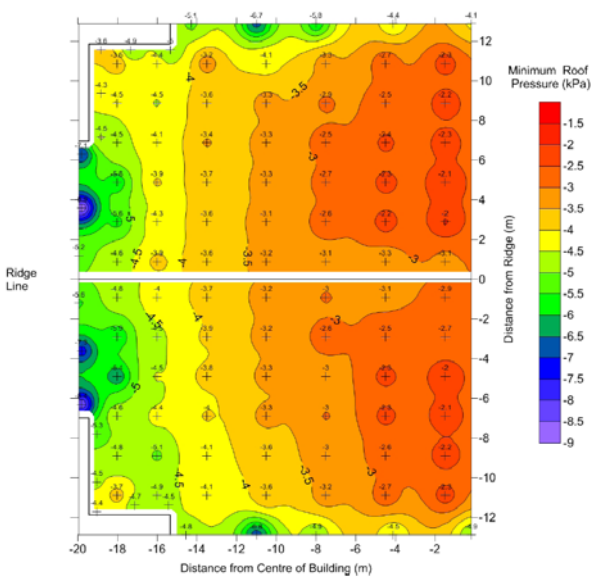

Figure 11. Upper roof with vented corners, External suction (worst for any wind direction)

In January 2012 the Queensland Department of Public Works awarded contracts for the construction of cyclone shelters at schools in Port Douglas, Tully, Ingham, Townsville, Bowen, Proserpine and Yeppoon. Further contracts for construction of shelters at Weipa, Cairns and Mackay should be awarded early 2012. The shelter in Cairns, to be constructed by the Cairns Regional Council, is being incorporated into the council's new sports facility at Edmonton.

Collectively these building will provide shelter for 8,700 people.

Figure 12. People sheltering in the Redlynch Public Cyclone Shelter during Yasi Photograph by news.com.au

Places of refuge project

Prior to the development of an infrastructure of public cyclone shelters to meet a community's need, it is essential that people with no other shelter option are accommodated in the best available buildings in the community. These buildings are not purpose built public cyclone shelters but rather the most suitable existing buildings in which people may shelter during a tropical cyclone.

A Place of Refuge is a building not specifically designed as a public cyclone shelter, but one which can be used to provide a level of protection from the effects of a cyclone as it passes.

In 1998-1999, the Queensland Department of Public Works surveyed 384 buildings nominated by local authorities along Queensland's cyclonic region. The buildings were inspected by an experienced structural engineer. None of the buildings surveyed complied with the BCA Importance Level 4.

Figure 13. People sheltering in Stockland's Earlville Shopping Centre, Cairns during TC Yasi. Photograph by Courier Mail

In 2011, the Queensland Department of Public Works has again requested local authorities to nominate buildings which may be suitable as Places of Refuge.

Buildings with large empty open spaces (or areas with fixed seating) and minimal glass windows are most suited for use as Places of Refuge.

To be nominated as a Place of Refuge a building should be:

- On high ground above a 1:1,000 AEP storm tide evacuation zone and 0.5m above the Q100 river or creek flood level.
- Near to the evacuating community and directly accessible from a public road.
- Away from potential hazards such as tall trees and structures or fuel stores
- Constructed after 1982.
- Externally clad with materials with a moderate degree of resistance to wind borne debris. Fibre cement sheeting is not acceptable.
- Built with a screw fixed metal roof. Tiled and clear sheet roofs are not acceptable.

Roller doors are not acceptable unless certified by a Registered Professional Engineer of Queensland.

Following a desktop review a list of buildings to be inspected by an experienced structural engineer is developed. Reports are then prepared for each building inspected. Reports classify the building and provide details to permit temporary protection of glazing on the day prior to the cyclone.

A substantial number of buildings have been inspected in preparation for this cyclone season.

Conclusion

People should shelter in their homes provide they were constructed after 1982 and located above the storm tide evacuation zones.

People evacuating their homes should shelter with friends or family in houses constructed after 1982.

People with no other shelter options should seek shelter in a Public Cyclone Shelter or Place of Refuge.

The Public Cyclone Shelter and Places of Refuge projects initiated since Tropical Cyclone Yasi will reduce the vulnerability of Queensland communities to cyclones.

The development a cyclone shelter room in houses would reduce the vulnerability of people sheltering in their home with friends and family.

Acknowledgments

The Public Cyclone Shelter and Places of Refuge projects have been an initiative of the Queensland Government, Department of Public Works.

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