

REPORT NO. TS783

Simulated Wind Driven Debris Impact Testing of Laminated Glass Window

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By Ulrich Frye

Cyclone Testing Station
School of Engineering and Physical Sciences
James Cook University

for Queensland Government
Department of Public Works
GPO Box 2457, Brisbane, QLD 4001



Disaster Preparedness
Department of Public Works



1 Introduction

In this testing program, simulated wind driven debris impact loading of a laminated glass window to be installed on public cyclone shelters in Queensland was performed. The window was loaded in accordance with the *Design Guidelines for Queensland Public Cyclone Shelters, Sep 2006*. The testing was performed with the use of new test materials, purchased from *G.James Glass & Aluminium*. All tests were conducted in the air cannon testing facility located at James Cook University.

2 Design Guidelines for Debris Loads

The structural design guidelines for debris loads state that 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 and 8 mm diameter impacting at $0.4 \times V_{10,000}$ for horizontal trajectories and $0.3 \times V_{10,000}$ for vertical trajectories.
- b) A 100 mm x 50 mm piece of timber of 4 kg mass impacting end-on at $0.4 \times V_{10,000}$ for horizontal trajectories and $0.1 \times V_{10,000}$ for vertical trajectories.

In Queensland's tropical cyclone region (Region C) $V_{10,000} = 85$ m/s. Thus, the required impact speeds are:

$$0.1 \times V_{10,000} = 8.5 \text{ m/s}$$

$$0.3 \times V_{10,000} = 25.5 \text{ m/s}$$

$$0.4 \times V_{10,000} = 34.0 \text{ m/s}$$

3 Test Criteria and Procedures

3.1 Test Loads

For Cyclonic Regions C the debris test loads for the external fabric of public cyclone shelters are specified as follows:

- Test Load A: End-on impact of timber 4 kg in mass, with cross-section dimensions of 100 mm x 50 mm, impacting at the speed specified for the trajectory.
- Test Load B: Series of five steel balls of 2 grams mass and 8 mm diameter, successively impacting at the speed specified for the trajectory.

3.2 Test Sequence

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

Test load A shall impact the most critical location(s). The testing authority shall determine the most critical location(s) by test. Test load B shall successively impact at various random locations on the test specimen.

3.3 Acceptance Criteria

A test specimen shall:

- a) Prevent a debris missile from penetrating through
- b) If perforated, have a maximum perforation width of less than 8 mm.

4 Test Apparatus and Procedure

The window test specimen was tested in the Cyclone Testing Station's air cannon testing facility; the air cannon was used to fire the series of steel spheres. The air cannon consists of a cylinder, which is pressurised by an air compressor. Once the required air pressure is reached a solenoid valve is triggered to instantaneously release the air and the missile is fired through the barrel and accelerates to the required velocity.

The test specimen was mounted on a target support frame located about 2200 mm away from the exit opening of the barrel. A digital velocity meter is installed at the exit of the barrel to measure the velocity of the missile, at its tail end, before it impacted the target.

5 Test Specimen

The glass panel size of the tested window was 1238 x 1238 mm to fit into an opening of 1487 x 1463 mm. The test specimen was supplied in aluminium extrusion frames, which was mounted in a 200 x 100 x 4 mm RHS frame using M8 bolts at 400 mm centres around the perimeter.

5.1 Window Assemblies

The overall thickness of the laminated glass panel was 13.52 mm (subsequently labelled W1.1) The edge cover provided to the glass by the aluminium extrusion frames was 19 mm. A detail drawing of the aluminium extrusion frame assembly is provided in Appendix A.

6 Results

A summary of the test results is presented in Table 1. Photographs of damage are provided in Appendix B.

Table 1: Impact Testing Results

Trial No.	Date Tested	Impact Location & Test Load	Impact Velocity (m/s)	Results and Observations
W1.1	26 May 2010	Various, Test Load B	>34.0	Pass. Outer glass layer spalled at all impact locations, inner glass layer undamaged.

7 Conclusions

A test program of simulated wind driven debris impact loading was successfully performed on a laminated glass window.

The method and criteria of testing (in accordance with the *Design Guidelines for Queensland Public Cyclone Shelters, Sep 2006 including amendment 1*) has been presented. The results demonstrate the performance of the window when subjected to Debris Test Loads B.

The laminated glass window is deemed to satisfy the Debris Test Load B impact load performance requirements detailed in the *Design Guidelines for Queensland Public Cyclone Shelters, Sep 2006*.

Prepared by

Mr. U. Frye
Senior Engineer
Cyclone Testing Station
James Cook University

Checked

Mr. C. J. Leitch
Manager
Cyclone Testing Station
James Cook University

Prof Y. He
Head of School
School of Engineering and Physical Sciences
James Cook University

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Appendix A – Drawings of Window Frame Assembly

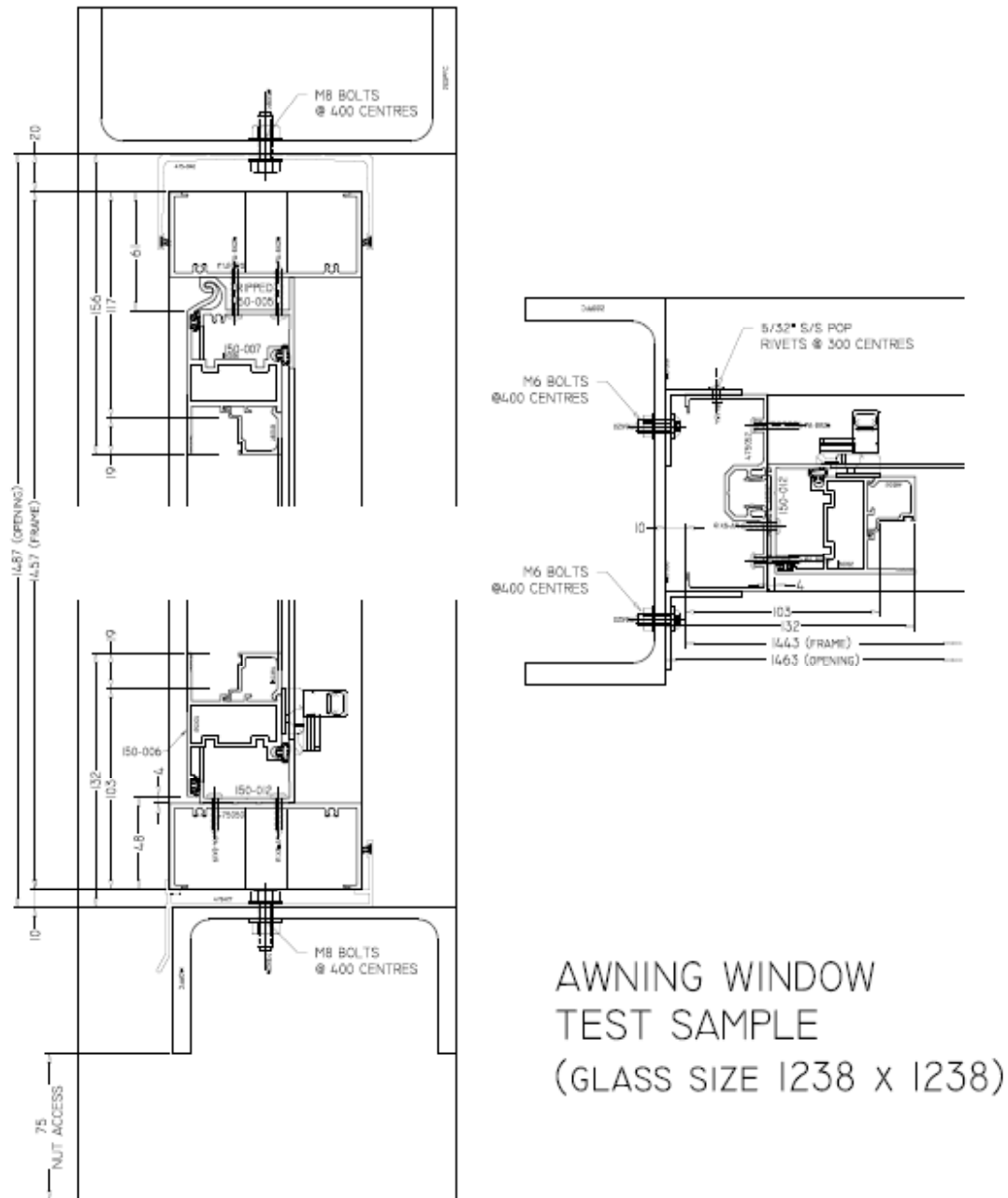


Figure 1: Detail drawing of window aluminium extrusion frame assembly

Appendix B – Photographs of Damage



Figure 3: Outside (left) and inside (right) views of typical damage after Trial W1.1