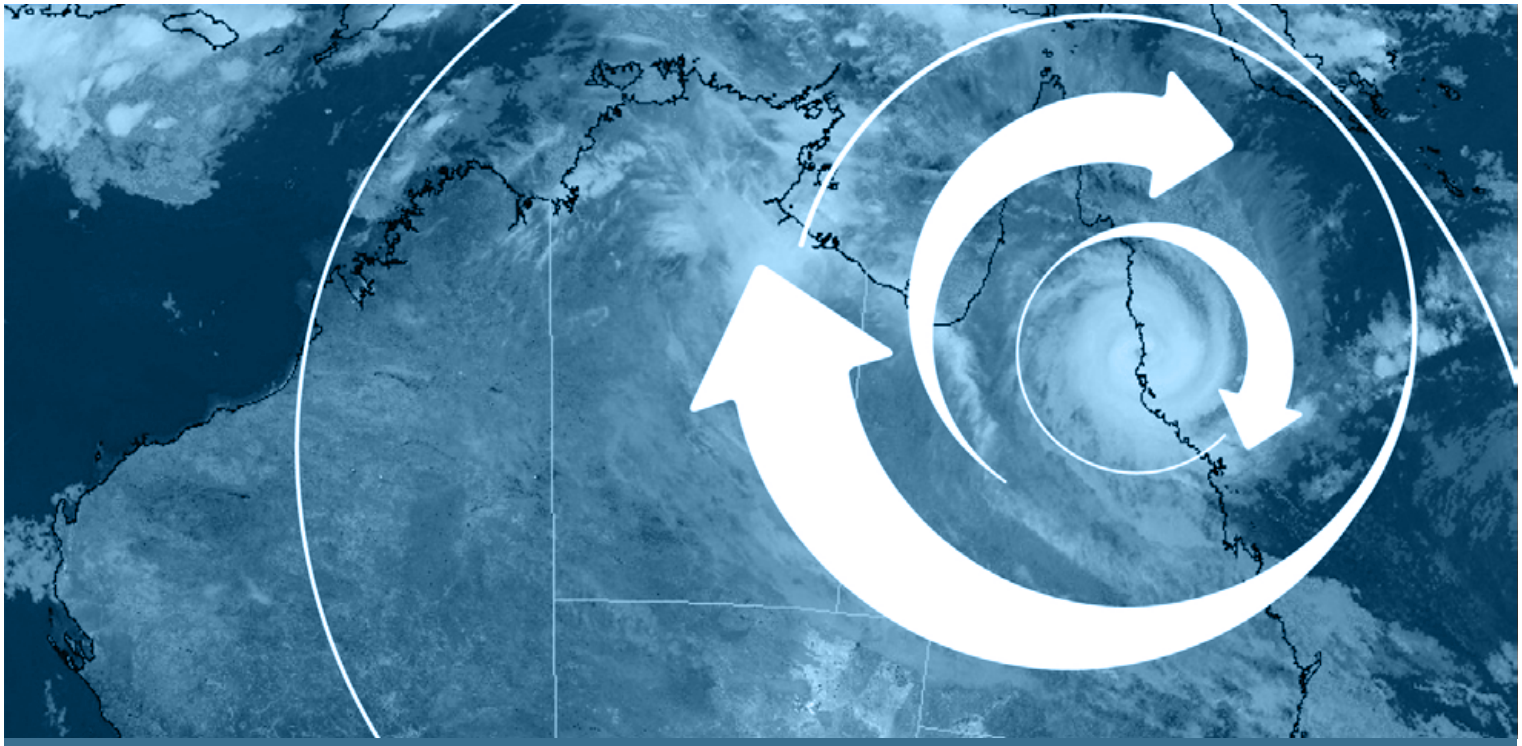

REPORT NO. TS776

Simulated Wind Driven Debris Impact Testing of Corrugated Roof Cladding

3 September 2010

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

CYCLONE TESTING STATION

JAMES COOK UNIVERSITY AUSTRALIA

Disaster Preparedness
Department of Public Works

Queensland Government

1 Introduction

In this testing program, simulated wind driven debris impact loading of corrugated roof cladding to be installed on public cyclone shelters in Queensland was performed. The cladding 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 a local supplier. 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:

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

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

$0.4 \times V_{10,000} = 34.0$ 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 roof test specimens were tested in the Cyclone Testing Station's air cannon testing facility. Two differently sized air cannons were used to fire the timber missile and the steel spheres. Both air cannons consist 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 missiles are fired through the barrels and accelerate to the required velocity.

The test specimens were mounted on a target support frame located about 1300 mm away from the exit opening of the barrels. Digital velocity meters are installed at the exit of the barrels to measure the velocity of the missiles, at their tail ends, before they impacted the target.

5 Test Specimens

The test roof specimens were set up in a 900 mm triple span arrangement, supported by 1.5 mm BMT steel z-purlins (Z151015). The cladding was screw fixed to the support at every second corrugation as per manufacturer's installation manual using 14-10 x 42 mm self-drilling metal screws fitted with *Corri-Lok* cyclone washers.

5.1 Corrugated Cladding

The corrugated steel cladding used in this test program was rolled from G550 steel sheeting with a stated Base Metal Thickness (BMT) of 0.48 mm. The total sheet width is approximately 860 mm with eleven sinusoidal corrugations per sheet which are spaced at 76 mm centres. The cover width of the cladding is 762 mm and the corrugations are approximately 16 mm high. Figure 1 is an end view that shows the sheeting profile.

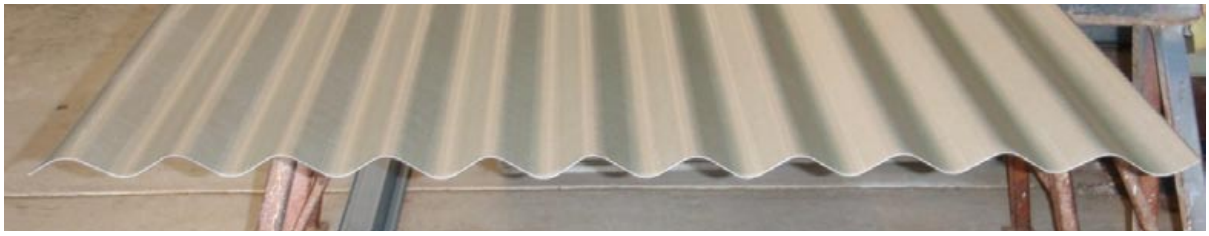

Figure 1: End view of Corrugated cladding

6 Results

A summary of the test results is presented in Table 1. Further details on the modes of deformation are provided in Appendix A.

Table 1: Impact Testing Results

Trial No.	Date Tested	Impact Location & Test Load	Impact Velocity (m/s)	Results and Observations
C1	4 Jul 2008	Various (5 impacts), Test Load B	› 34.0	**Pass.** Small indentations.
C2	12 Mar 2008	Centre of sheet, mid span of end span, Test Load A	9.1	**Pass.** Deformation across 3 corrugations.
C3	13 Mar 2008	Centre of sheet, mid span of end span, Test Load A	17.2	**Pass.** Deformation across 8 corrugations.
C4	13 Mar 2008	Centre of sheet, mid span of end span, Test Load A	25.9	**Pass.** Deformation across entire sheet width. One screw hole on end support elongated.
C5	17 Mar 2008	Side lap, mid span of end span, Test Load A	26.2	**Pass.** Deformation across 7 corrugations. Small tear (~50 mm) along internal support.
C6	17 Mar 2008	Centre of sheet, mid span of internal span, Test Load A	26.0	**Pass.** Deformation across 10 corrugations.
C7	17 Mar 2008	Centre of sheet, next to end support in end span, Test Load A	25.5	**Pass.** Deformation across 9 corrugations. 4 screw holes on end support elongated up to ~30 mm.
C8	17 Mar 2008	Side lap, mid span of internal span, Test Load A	20.9	**Pass.** Deformation across 7 corrugations.
C9	17 Mar 2008	Centre of sheet, next to internal support in end span, Test Load A	21.3	**Pass.** Deformation across 8 corrugations. Crack ~50 mm at corner of missile impact location.

7 Conclusions

A test program of simulated wind driven debris impact loading was performed on 0.48 mm BMT corrugated roof cladding.

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 roof cladding when subjected to Debris Test Loads A and B.

The roof cladding tested is deemed to satisfy the vertical trajectory 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

Appendix A – Photographs of Tested Cladding

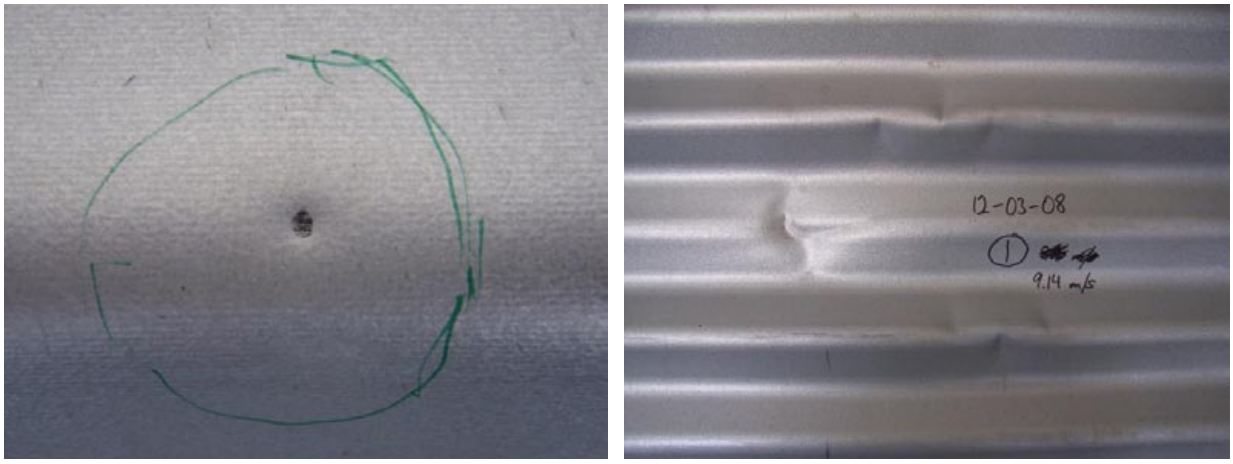

Figure 2: Cladding damage after Trials C1 (left) and C2 (right)

Figure 3: Cladding damage after Trials C3 (left) and C4 (right)

Figure 4: Cladding damage after Trials C5 (left) and C6 (right)

Figure 5: Cladding damage after Trials C7 (left) and C8 (right)

Figure 6: Cladding damage after Trial C9