CYCLONE TESTING STATION

COLLEGE of SCIENCE and ENGINEERING

James Cook University

REPORT NO. TS1276

21 February 2023

Serviceability and Cyclic Simulated Wind Load Strength Testing of Mitsubishi ALPOLIC NC Wall Cladding

By

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for

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NATA Accredited Laboratory Number 14937
Accredited for compliance with ISO/IEC 17025 - Testing.

1 Introduction

The aim of this test programme was to perform serviceability and cyclic simulated wind load strength testing of Mitsubishi ALPOLIC NC cladding, supplied by *Network Architectural Pty Ltd.* The test wall panels were loaded in accordance with the *AS 4040.2/*3 serviceability and the *AS 4040.3* cyclic wind load strength test regimes. The testing was performed with the use of new test materials, supplied by the client.

The wind load tests were conducted in the airbox testing facility located in the Wind Tunnel Building at James Cook University. The Cyclone Testing Station is a NATA accredited testing laboratory. All trials for this testing programme were performed in accordance with NATA requirements.

2 Test Programme

A programme of serviceability and cyclic simulated wind load strength testing was conducted. A summary of the test programme is provided in Table 1.

Table 1: Test Programme Summary

Trial No.	Panel Number	Panel Base Metal Thickness (mm)	Nominal Panel Dimensions (mm)	Stiffener Spacing (mm)	Perimeter Fixing Spacing (mm)	Test Regime
S1	1	4.0	4,000 by 1,575	600	300	Serviceability
	2		2,700 by 800	800		
	3		1,200 by 800	600		
C1	1		4,000 by 1,575	600	300	Cyclic Wind Load Strength
	2		2,700 by 800	800		
	3		1,200 by 800	600		

3 Panels, Fastener, Support and Installation Details

3.1 *Mitsubishi ALPOLIC NC* Panels

The *Mitsubishi ALPOLIC NC* wall cladding panel was stated to have been made from two aluminium alloy outer skins of 0.5 mm thickness with a Lumiflon™ coating and 3 mm non-combustible core. The total thickness of the cladding panel was stated to be 4 mm. The panels have a flat surface and about 24 mm of the edges are folded 90° to form a tray. About 1.7 mm thick aluminium Z-sections (called Z-shaped flanges in this report) are screw fixed to the edge return using 10 gauge, 16 thread per inch, 20 mm long self-drilling stainless steel screws at 100 mm centres resulting in a nominal panel “thickness” of 30 mm. An aluminium corner extrusion was fixed to the ends of the Z-sections reinforcing the corners of the panel. Stiffeners made from square hollow section aluminium extrusions of dimensions 50 × 50× 3.5 mm are fixed on the internal face of the panel trays using adhesive tape. The stiffeners run along the panels and their ends are fixed to the panel tray returns/Z-shaped flanges using 30 mm long 40 × 40 × 3 mm angles with 10 gauge, 16 thread per inch, 20 mm long self-drilling stainless steel screws. The size of the panels supplied were nominally 4,000 × 1,575 mm, 2,700 × 800 mm and 1,200 × 800. Figure 1 is photographs that show the cladding panel, Figure 2 the stiffeners and connection detail and Figure 3 the corner reinforcement detail.

Figure 1: Photograph of *Mitsubishi ALPOLIC NC* cladding profile (note the 1,200 by 800 mm panel is displayed, larger panels have additional stiffeners)

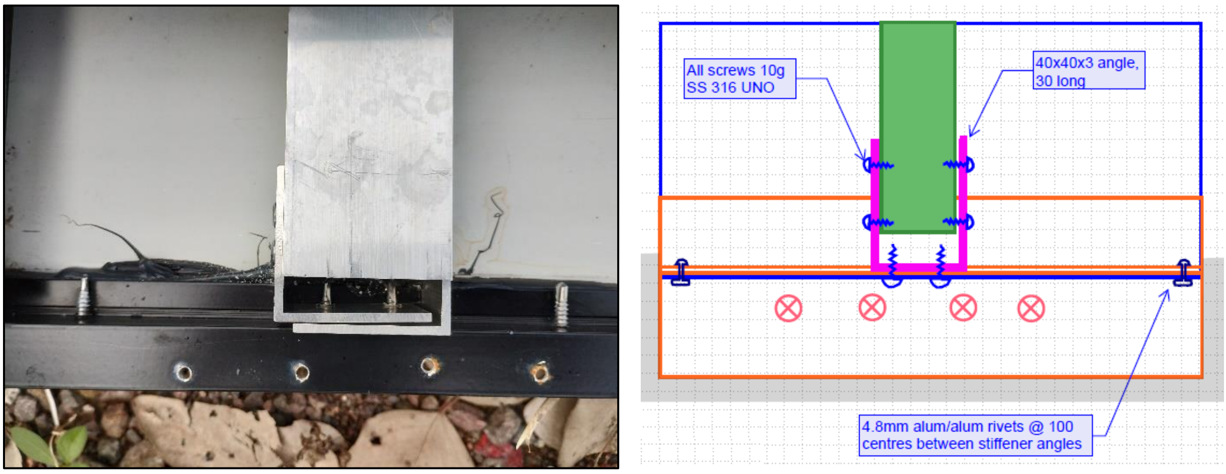

Figure 2: Photograph of panel stiffener and connection to the panel (left) and sketch, provided by the client, of the stiffener connection (right), note the rivets depicted in the sketch were replaced with screws

Figure 3: Photograph of panel corner reinforcement

3.2 Support Structure

The wall cladding panels were screw fixed to a substructure made from continuous sections of Rondo 1.15 mm Base Metal Thickness (BMT) top hat battens. The top hats were fixed to MGP12 structural timber purlins at nominally 600 mm centres. Figure 4 shows a photograph of a the top hat substructure fixed to timber purlins spaced at 600 mm.

Figure 4: Top hat substructure fixed to timber purlins for one panel

3.3 Fasteners

The Z-shaped flanges attached to the panels were screw fixed to the top hat battens using 10-gauge, 16 thread per inch self-drilling stainless steel screws with a length of 20 mm. Figure 5 shows a photograph of a typical stainless steel 10 gauge.

Figure 5: 10-16 × 20 mm self-drilling stainless steel screw used to fix the panels to the top hat batten substructure

3.4 Installation Details

The panel system was fixed to the supports using four fasteners at positions adjacent the stiffeners and two fasteners at the corners. An additional fastener was positioned midway between stiffeners. Figure 6 is a sketch, provided by the client, and photograph of the panel fixing detail.

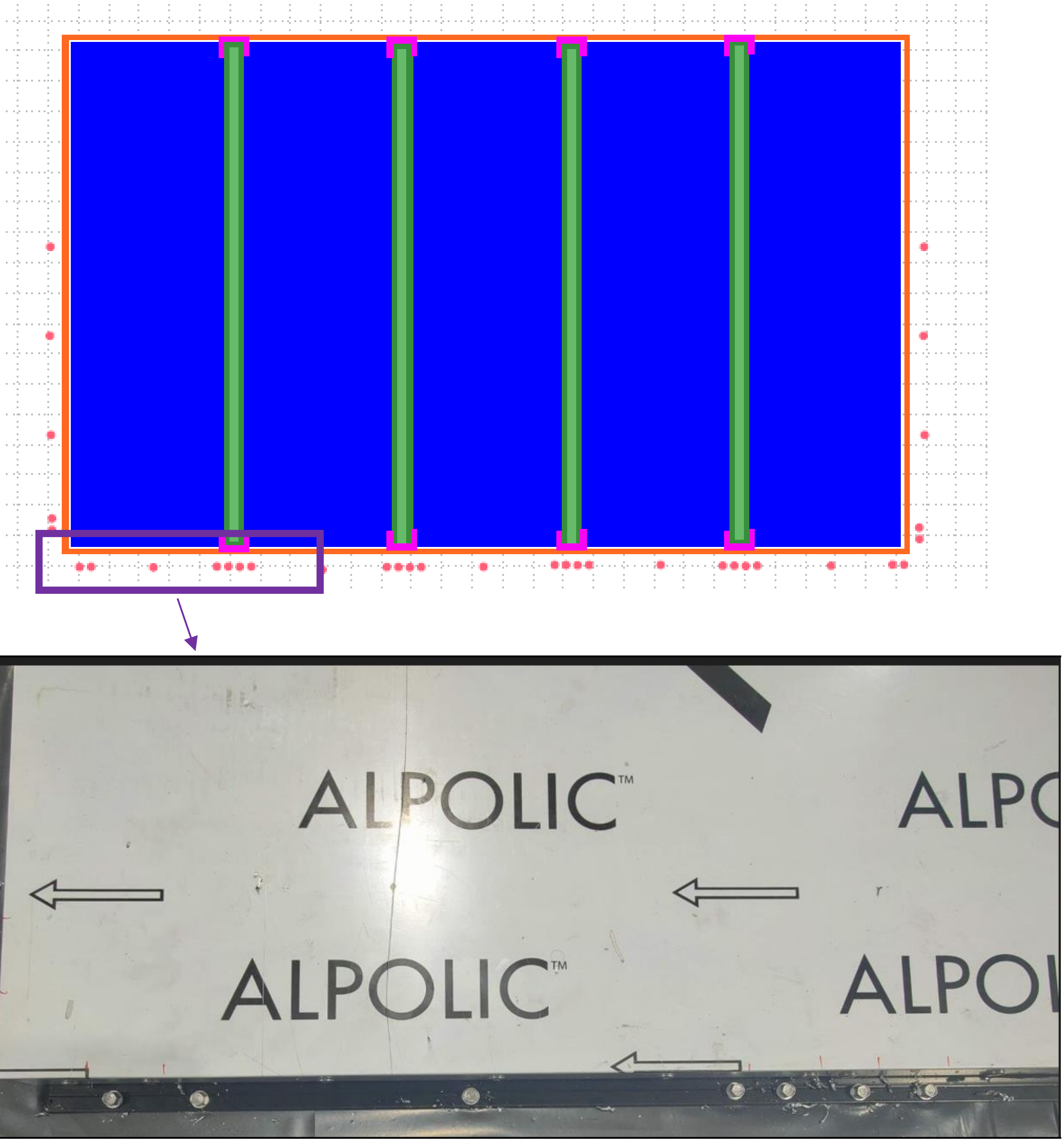

Figure 6: Sketch of perimeter fixing locations, provided by the client (upper) and detailed view of perimeter fixings (lower)

4 Test Apparatus and Procedure for Simulated Wind Load Tests

4.1 Test Set Up in Airbox Test Facility

The test specimens were installed in the Cyclone Testing Station's airbox test facility. The airbox is an open-topped pressure chamber with a maximum test width of 2,040 mm and an adjustable length of up to 10 m. For this testing programme, the top hat supports were set up to run across the width and length of the airbox.

The cladding panels were installed to become the top (horizontal) surface of the chamber. The test specimen comprised three different sized full wall cladding panels and the cladding was installed according to the manufacturer's instructions and fixed to the supports by the client's representative on site.

4.2 Simulated Wind Load Strength Testing

A uniform pressure was applied to the internal face of the cladding by one or two large centrifugal fan(s) blowing air into the airbox chamber. This pressure simulated the combined effect of both the outward pressure (suction) and the internal positive pressure acting on the cladding. A pressure transducer measured the applied load on the test roof sheeting.

4.3 Allowance for Self-Weight of Panels

The wall system is normally mounted vertically, but were tested in a horizontal position Therefore, the indicated test pressure applied was adjusted to compensate for the self-weight of the panel system (nominally 14.3 kg/m^2 ≡ 0.14 kPa). All test pressure figures stated subsequently are net pressures that allow for the self-weight of the system.

4.4 Serviceability Wind Load Testing

4.4.1 General

The serviceability testing was performed in accordance with *AS 4040.2-1992 (Incorporating Amendment No. 1), "Methods of Testing Sheet Roof and Wall Cladding, Method 2: Resistance to Wind Pressures for Non-Cyclone Regions"*. The same test method is specified in *AS 4040.3-1992, "Methods of Testing Sheet Roof and Wall Cladding, Method 3: Resistance to Wind Pressures for Cyclone Regions"*.

4.4.2 Serviceability Testing

During serviceability testing the deflections were measured by seven (7) digital dial gauges (DGs) that were arranged on the surface of two cladding panels. Two of the gauges (DG1 and DG2) were installed with their measuring shafts located on top of two (2) fixing screws on panel 1, one being at one edge and the other at the opposite edge. Similarly, DGs 3 and 6 were positioned on top two (2) fixing screws on panel 2. DGs 4 and 5 were positioned at the panel mid-height directly above a stiffener and midway between adjacent stiffeners on panel 1, respectively. Similarly, DG 26 was positioned on panel 2 midway between adjacent stiffeners.

For serviceability testing, the test wall panels were loaded by slowly increasing the air pressure inside the test chamber. At regular increments, the loading was paused to allow vertical deflection readings to be taken. The applied pressure loading was increased until the deflection limit was reached (as detailed in Section 4.4.3) or the cladding showed signs of permanent deformation.

Once the maximum deflection readings were taken, the applied pressure was reduced to zero and another two sets of readings were taken to allow residual deflections to be measured.

4.4.3 Serviceability Deflection Limits

When the Serviceability Limit State test pressure is applied during serviceability testing, Clause 5.5.1 of *AS 1562.1-2018, "Design and Installation of Sheet Roof and Wall Cladding, Part 1: Metal"* specifies that the maximum deflection of the cladding relative to the supports shall not exceed (S/120 + p/30), where "S" is the span of the cladding and "p" is the fastener spacing. The same clause also specifies that there shall be no permanent damage or unclipping of the sheeting or of the fasteners and that the residual deflections, 1 minute after the removal of the test pressure, shall not exceed (S/1000) or 1.5 mm, whichever is higher. Note 1 to Clause 5.4.2 of *AS 1562.1-2018* states that *"Limits on residual deflection have been included to preserve the appearance of the sheeting and to reduce ponding. Residual deflection is normally measured after light tapping of the sheeting to settle the sheeting to its rest position"*.

4.5 Cyclic Simulated Wind Load Strength Testing

4.5.1 General

The cyclic simulated wind load strength testing was performed in accordance with *AS 4040.3-2018, "Methods of Testing Sheet Roof and Wall Cladding, Method 3: Resistance to Wind Pressures for Cyclone Regions*". Cyclic loading was achieved by opening and closing pressure dump valves.

4.5.2 *AS 4040.3* Fatigue Loading Sequence for Wall Systems

The cyclic loading sequence used in this test programme was performed in accordance with the cyclic testing regime specified in *clause 6.3* of *AS 4040.3-2018, "Methods of Testing Sheet Roof and Wall Cladding, Method 3: Resistance to Wind Pressures for Cyclone Regions*" for wall cladding. The test pressure (P_t) for Ultimate Strength Limit State is specified as being equal to the design pressure for Ultimate Limit State divided by a material capacity reduction factor. A material capacity factor of 0.9 was adopted (as recommended by *AS 4040.3-2018)*. The loading sequence is presented in Table 2, where P_t is the test pressure.

Table 2: *AS 4040.3* Fatigue Loading Sequence

No. of Cycles	Load
8000	0 to 0.40 P_t
2000	0 to 0.50 P_t
200	0 to 0.65 P_t
1	0 to Ultimate Load

For one test sample, *AS 4040.3-2018* specifies an Ultimate Load of 1.30 P_t for the Single Load Cycle. If either two or three identical tests are performed, then the Single Load Cycle value to be applied reduces to either 1.20 Pt or 1.00 Pt, respectively, but all of the tests must support the smaller load. Note that the single load test cycle must be supported for 1 minute. For this test programme an Ultimate Load of 1.30 P_t was used for the Single Load Cycle.

4.5.3 Acceptance Criteria

The test specimen, including the cladding, its connections and immediate supporting members shall be subjected to the relevant fatigue loading sequence and must be capable of remaining in position notwithstanding any permanent distortion, fracture or damage that might occur in the sheet or fastenings, without loss of load carrying capacity.

4.5.4 Target Test Pressures

The client requested that the panels be tested for a Cyclic Strength Limit State design pressure of 5.53 kPa. Hence, the test pressure P_t was 5.53/0.9 = 6.14 kPa. As one test was performed, the ultimate load applied at the end of the loading sequences was 7.98 kPa.

5 Results

5.1 Simulated Wind Load Serviceability Testing

One wind load serviceability test was performed. The results of the serviceability tests are summarised in Table 3; all stated deflections are relative to the deflections measured on top of the screws at the supports and the deflections measured under load are stated to the nearest 0.05 mm, while the residual deflections are stated to the nearest 0.01 mm. All serviceability tests were terminated when the cladding showed first signs of permanent deformation, or the deflection limit was reached for either panel. Plots of the deflections relative to the supports are presented in Appendix A.

Table 3: Serviceability Testing Results

Trial No.	Panel No.	Date Tested	Maximum Loading Applied				Loading Removed		
			Deflection Limit (mm)	Max. Pressure Applied (kPa)	Max. Relative Deflection (mm)	DG No.	Residual Deflection Limit (mm)	Max. Relative Residual Deflection (mm)	DG No.
S1	1	18 Jan 2023	23.13	3.96	15.85	5	1.57	0.51	5
S1	2	18 Jan 2023	16.67	3.96	19.60	26	1.50	0.83	26

Note: Dial gauge numbering based on Section 4.4.2

The serviceability deflection limit was exceeded on panel 2 but not on panel 1. The applied pressure at the deflection limit for panel 2 was subsequently calculated by linear interpolation between measured data points and an estimated extrapolation for panel 1. These pressures are tabulated in Table 4.

Table 4: Serviceability Test Pressures at Deflection Limits

Trial No.	Panel	Measured Values			Calculated Values		
		Max. Relative Deflection (mm)	Max. Applied Pressure (kPa)	DG No.	Deflection Limit (mm)	Calculated Pressure at Deflection Limit (kPa)	DG No.
S1	1	15.85	3.96	5	23.13	5.93	5
S1	2	19.60	3.96	26	16.67	3.71	26

5.2 Cyclic Simulated Wind Load Strength Testing

One cyclic simulated wind load strength test was performed. A summary of the test results and observations is provided in Table 5. For photographs of damage and failure see Appendix B.

Table 5: Cyclic Simulated Wind Load Strength Testing Results

Trial No.	Date Tested	Test Pressure P_t (kPa)	Ultimate Load Applied (kPa)	Results and Observations
C1	18 Jan 2023	6.14	7.98	**Pass**. Creasing in corners of panel 1. Panel skin had separated from stiffeners (tape no longer holding).

6 Limit State Design Wind Capacities

6.1 Determination of Serviceability Limit State Design Wind Capacities

The recommended Serviceability Limit State design wind capacities for the cladding for both cyclonic and non-cyclonic regions can be determined by using an approach based on that specified in *AS 4040.2/3-1992, "Methods of Testing Sheet Roof and Wall Cladding"*. This standard specifies that the test pressure to be supported shall be equal to the Serviceability Limit State design wind pressure multiplied by the material variability factor from Table 5.1 in the Australian standard, *AS 1562.1-2018, "Design and Installation of Sheet Roof and Wall Cladding, Part 1: Metal"*. The material variability factor was dependent on the coefficient of variation of structural characteristics (V_{sc}) and the total number of units to be tested. An increase in the number of units to be tested results in a reduction of k_t and an increase in the final design capacity.

As the test was to evaluate deflection under serviceability limit state loads, a coefficient of 5% may be assumed for the wall cladding serviceability testing, as recommended in Note 1 of Table 5.1.

For this test programme, the test specimen was set up with three (3) unique cladding panels. Therefore, a total of one (1) "units to be tested" can be counted for each panel tested and the material variability factor adopted was 1.2.

6.1.1 Recommended Serviceability Limit State Design Wind Capacities

The Serviceability Limit State design wind pressure capacities can be back calculated from the test results by dividing the pressure at the deflection limit by the material variability factor. The recommended Serviceability Limit State design capacities for both cyclonic and non-cyclonic regions are summarised in Table 6. Note that these design capacities are only applicable for the cladding profile, geometry, fastener types and support details, as used in this testing programme.

6.2 Determination of Cyclonic Ultimate Limit State Design Wind Capacities

The recommended Ultimate Strength Limit State design capacity for cyclonic regions was calculated by multiplying the test pressure (P_t) by the material capacity factor of 0.9.

Table 6: Recommended Serviceability Limit State Design Wind Capacities

Triple Span Length (mm)	Recommended Serviceability Limit State Design Wind Capacity (kPa)	Recommended Cyclonic Strength Limit State Design Wind Capacity (kPa)
Panel 1	4.94	5.53
Panel 2	3.09	5.53

7 Conclusions

A programme of serviceability and cyclic simulated wind load strength testing was performed on *Mitsubishi ALPOLIC NC* cladding supplied by *Network Architectural Pty Ltd*.

The methods of testing (in accordance with *AS 1562.1 clause 5.5.1* and *AS 4040.3*) have been presented.

The serviceability simulated wind load test results can be used to determine the Serviceability Limit State design wind capacity for both cyclonic and non-cyclonic regions. Table 6 provides the recommended Serviceability Limit State design wind capacities for both cyclonic and non-cyclonic regions, for the particular arrangements tested in this test programme.

The cyclic simulated wind load strength test results can be used to determine the Ultimate Limit State design wind capacities for cyclonic regions. Table 6 provides the recommended Ultimate Limit State design wind capacities for cyclonic regions, for the particular arrangements tested in this test programme.

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Appendix A – Serviceability Deflection Plots

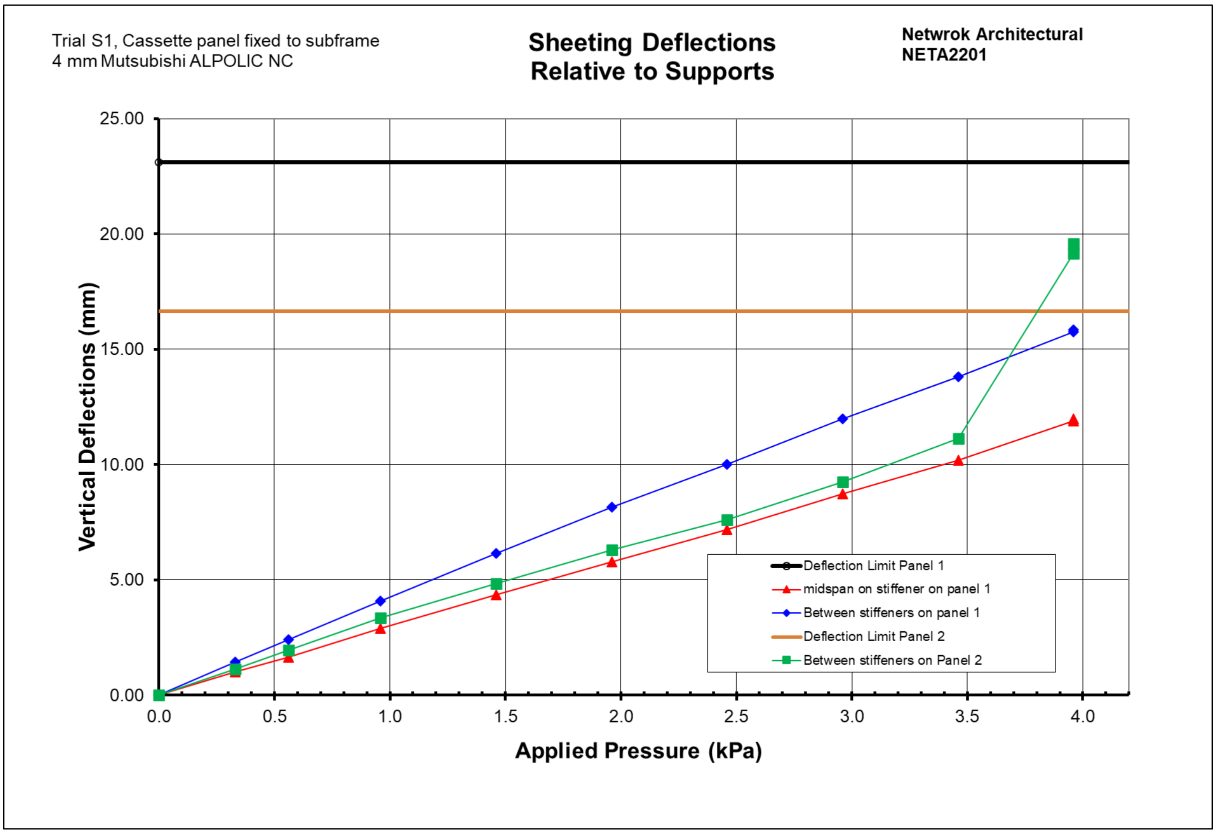

Figure 7: Plots of cladding deflections relative to supports (Trial S1)

Appendix B – Photographs of Damage after Cyclic Simulated Wind Load Strength Testing

Figure 8: Typical deformation to panel skin in corner (left) and along edges (right)

Figure 9: Typical deformation of skin viewed from underside of panel (upper) and view of detachment of stiffeners from underside of panel (lower)