CYCLONE TESTING STATION

SCHOOL of ENGINEERING and PHYSICAL SCIENCES

James Cook University

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Serviceability and Cyclic Strength Wind Load Testing of ALPOLIC/fr 4 mm Wall Cladding

By

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for

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1 Introduction

The aim of this test program was to perform serviceability and cyclic strength simulated wind load testing of *ALPOLIC/fr* wall cladding, manufactured by *Mitsubishi Plastics*. The test wall panels were loaded in accordance with the *AS4040.2/*3 serviceability and the *AS4040.3* cyclic 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 program were performed in accordance with NATA requirements.

2 Test Program

One serviceability and three cyclic strength wind load tests were conducted. A summary of the test program is provided in Table 1.

Table 1: Test Program Summary

Trial No.	Cladding Thickness (mm)	Span Length (mm)	Span Type	Test Regime
1	4.0	1542	Single	Cyclic Strength Wind Load
2				Serviceability & Cyclic Strength Wind Load
3				Cyclic Strength Wind Load

3 Cladding, Fastener, Support and Installation Details

3.1 ALPOLIC/fr 4 mm Cladding

The ALPOLIC/fr wall cladding was stated to have been made from two aluminium alloy 3105-H14 outer skins of 0.5 mm thickness with a 3 mm thick core made from non-combustible minerals. The total thickness of the cladding is therefore 4 mm. The panels have a flat surface and 30 mm of the edges are folded 90° to form a tray. 1.5 mm thick aluminium Z-sections (called Z-shaped flanges from here on) are riveted to the edge return using 4 mm aluminium rivets. Stiffeners made from rectangular hollow section aluminium extrusions of dimensions 50 x 25 x 2 mm are fixed on the internal face of the panel trays using 3M VHB tape 4941; the stiffeners run along the panels and their ends are fixed to the panel via C-channel aluminium brackets through the Z-shaped flanges and the panel tray returns with 4 mm aluminium rivets. The size of panels supplied was 1950 x 1524 mm. Figure 1 is a photograph of an internal view of a panel with marked components. Detail drawings of the panels and test assemblies (provided by the client) are included in Appendix A.

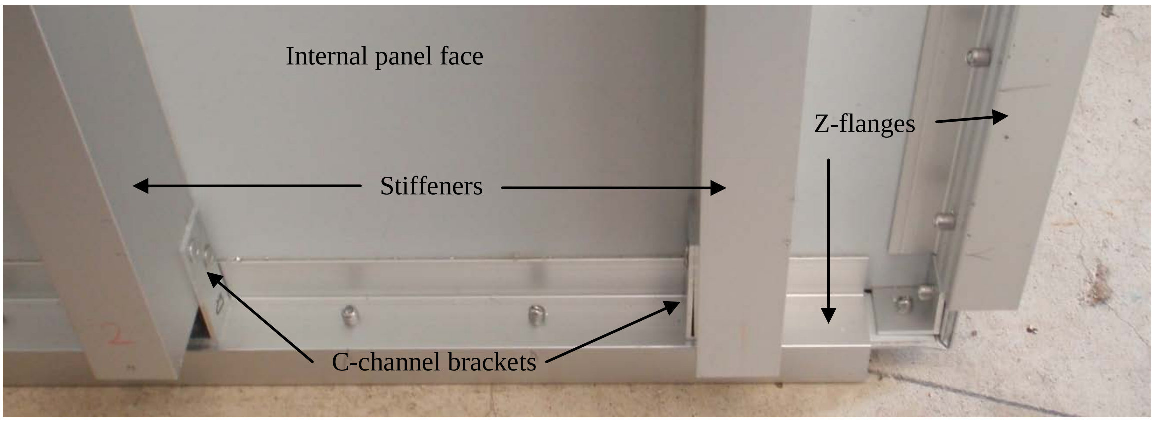

Figure 1: Internal view of panel assembly

3.2 Sub-Structure and Brackets

The wall cladding panels were screw fixed to a sub-structure made from continuous 40 x 40 x 3 mm aluminium (A6063, T5) angle. The sub-structure was fixed to 50 x 50 x 4 mm aluminium (A6063, T5) brackets of 100 mm length which were installed at 300 mm spacings. The fixing details are included in Appendix A. Note that the sub-structure and brackets were part of the test, but the strength of the connections between the brackets and the building structure were not being tested.

3.3 Fasteners

The Z-shaped flanges attached to the panels were screw fixed to the sub-structure using self-tapping #10 x ¾” stainless steel 304 pan head screws at 65 mm centres. The sub-structure was fixed to the brackets with M6 x 25 mm stainless steel 304 bolts with nylon lock nuts. Figure 2 shows a photograph of a typical screw, a bolt and nut.

Figure 2: #10 x ¾” screw (left), M6 x 25 mm bolt (centre) and nylon lock nut (right)

3.4 Installation

For detail drawings of the installation of the cladding system into the test rig, see Appendix A.

4 Test Apparatus and Procedure for Wind Load Tests

4.1 Test Set Up in Airbox Test Facility

The test wall panels 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 2050 mm and an adjustable length of up to 10 m. For this testing program, the sub-structure was set up to run across the width of the airbox.

The cladding was installed to become the top (horizontal) surface of the chamber. The test wall panels comprised two panels and were installed according to the manufacturer's instructions.

4.2 Wind Load Testing

A uniform pressure was applied to the internal face of the cladding by a large centrifugal fan 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 wall panels.

4.2.1 Allowance for Panel Self-Weight

The wall panel cladding is normally mounted vertically but was tested in a horizontal position. Therefore, the actual test pressures applied were determined by adding the self-weight of the panel assembly (nominally 13.8 kg/m^2 ≡ 0.14 kPa). All test pressure figures stated subsequently are net pressures that allow for the self-weight of the cladding.

4.3 Serviceability Wind Load Testing

4.3.1 General

The serviceability testing was performed in accordance with *AS 4040.2-1992, "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*".

4.3.2 Serviceability Testing

During serviceability testing the deflections were measured by four (4) digital dial gauges (DGs) that were arranged on the surface of a panel. Two of the gauges (DG1 and DG2) were installed with their measuring shafts located on top of two (2) fixing screws, one being at an end support and the other at an internal support. DGs 3 and 4 were positioned at midspan of the panel on top of the external cladding surface, with DG3 located directly above a stiffener and DG4 positioned midway between stiffeners. Refer to Figure 3 (Appendix A) for a graphical illustration of dial gauge locations.

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 a pressure of about 80% of the cyclic strength test pressure was reached. 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.

4.3.3 Serviceability Deflection Limits

When the Serviceability Limit State test pressure is applied during serviceability testing, Clause 5.5.1 of *AS 1562.1-1992, "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). Note 1 to Clause 5.4.2 of *AS 1562.1-1992* states that *"Techniques performed to improve the reliability of the measurement, such as light tapping of* *the sheeting, are permissible provided it can be demonstrated that such techniques serve only to settle the sheeting to its rest position".*

4.4 Cyclic Wind Load Strength Testing

4.4.1 General

The cyclic strength testing was performed in accordance with *AS 4040.3-1992, "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.

4.4.2 Cyclic Testing Procedure

The cyclic testing involved strength testing, in accordance with the *AS 4040.3* testing regime, to determine if the wall panel cladding could support the fatigue loading sequence for the strength limit state design pressures nominated by the client, for the particular configuration being tested.

During the course of the tests, the test wall panel was visually inspected. The test method is for ultimate limit state design strength criteria, therefore the test specimen can show signs of distortion or permanent deformation and still be considered a successful outcome.

4.4.3 AS 4040.3 Fatigue Loading Sequence

The cyclic loading sequence used in this test program was performed in accordance with the cyclic testing regime specified in the *AS 4040.3-1992, "Methods of Testing Sheet Roof and Wall Cladding, Method 3: Resistance to Wind Pressures for Cyclone Regions*". The test pressure (P_t) for strength limit state is specified as being equal to the design pressure for strength limit state divided by a material capacity reduction factor. A material capacity factor of 0.9 was adopted (as recommended by *AS 4040.3-1992*). 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 4040.3-1992* 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 program an Ultimate Load of 1.00 P_t was used for the Single Load Cycles.

4.4.4 Test Pressure

The client requested that the panel be tested for a Strength Limit State design pressure of 6.30 kPa. Hence, the test pressure P_t was 6.30/0.9 = 7.00 kPa. As three identical tests were performed, the ultimate load applied at the end of the loading sequences was 7.00 kPa.

5 Results

5.1 Wind Load Serviceability Testing

One wind load serviceability tests was performed. The results of the serviceability test 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. Plots of the deflections relative to the supports are presented in Appendix B.

Table 3: Serviceability Testing Results

Trial 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.
2	16 Feb 2011	15.02	5.49	10.50	3	1.54	0.21	3

Note: Dial gauge numbering based on Section 4.3.2 and Figure 1.

5.2 Wind Load Cyclic Strength Testing

A summary of the test results and observations is provided in Table 4.

Table 4: Wind Load Cyclic Strength Testing Results

Trial No.	Date Tested	Test Pressure P_t (kPa)	Results and Observations
1	15 & 16 Feb 2011	7.00	**Pass**. No visible damage.
2	16 & 17 Feb 2011	7.00	**Pass**. No visible damage.
3	18 Feb 2011	7.00	**Pass**. No visible damage.

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 4040-1992, "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 1562.1-1992, "Design and Installation of Sheet Roof and Wall Cladding, Part 1: Metal"*. No more than three serviceability wind load test were conducted, and therefore the material variability factor adopted was 1.2.

6.1.1 Recommended Serviceability Limit State Design Wind Capacity

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 5. Note that these design capacities are only applicable for the cladding profile, geometry, fastener types and support details, as used in this testing program.

6.1.2 Recommended Strength Limit State Design Wind Capacity for Cyclonic Regions

A target design capacity of the tested ALPOLIC/fr wall cladding system was nominated by the client. As the three cyclic strength tests were successful, this design pressure can be adopted and it is summarised in Table 5.

6.1.3 Summary of Recommended Limit State Design Wind Capacities

The recommended limit state design wind capacities of the ALPOLIC/fr wall cladding system are summarised in Table 5. Note that these design capacities are only applicable for the wall cladding panels, geometry, fastener types and support details, as used in this testing program.

Table 5: Recommended Limit State Design Wind Capacities

Single Span Length (mm)	Recommended Serviceability Limit State Design Wind Capacity (kPa)	Recommended Cyclonic Strength Limit State Design Wind Capacity (kPa)
1542	4.58	6.30

7 Conclusions

A program of serviceability and cyclic strength simulated wind load testing was performed on *ALPOLIC/fr* 4 mm wall cladding manufactured by *Mitsubishi Plastics*.

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

The serviceability wind load test results can be used to determine the Serviceability Limit State design wind capacity for both cyclonic and non-cyclonic regions. Table 5 provides the recommended Serviceability Limit State design wind capacities for both cyclonic and non-cyclonic regions, for the particular arrangements tested in this test program.

The cyclic strength wind load test results can be used to determine the Ultimate Strength Limit State design wind capacities for cyclonic regions. Table 5 provides the recommended Ultimate Strength Limit State design wind capacities for cyclonic regions, for the particular arrangements tested in this test program.

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Appendix A – Installation Details

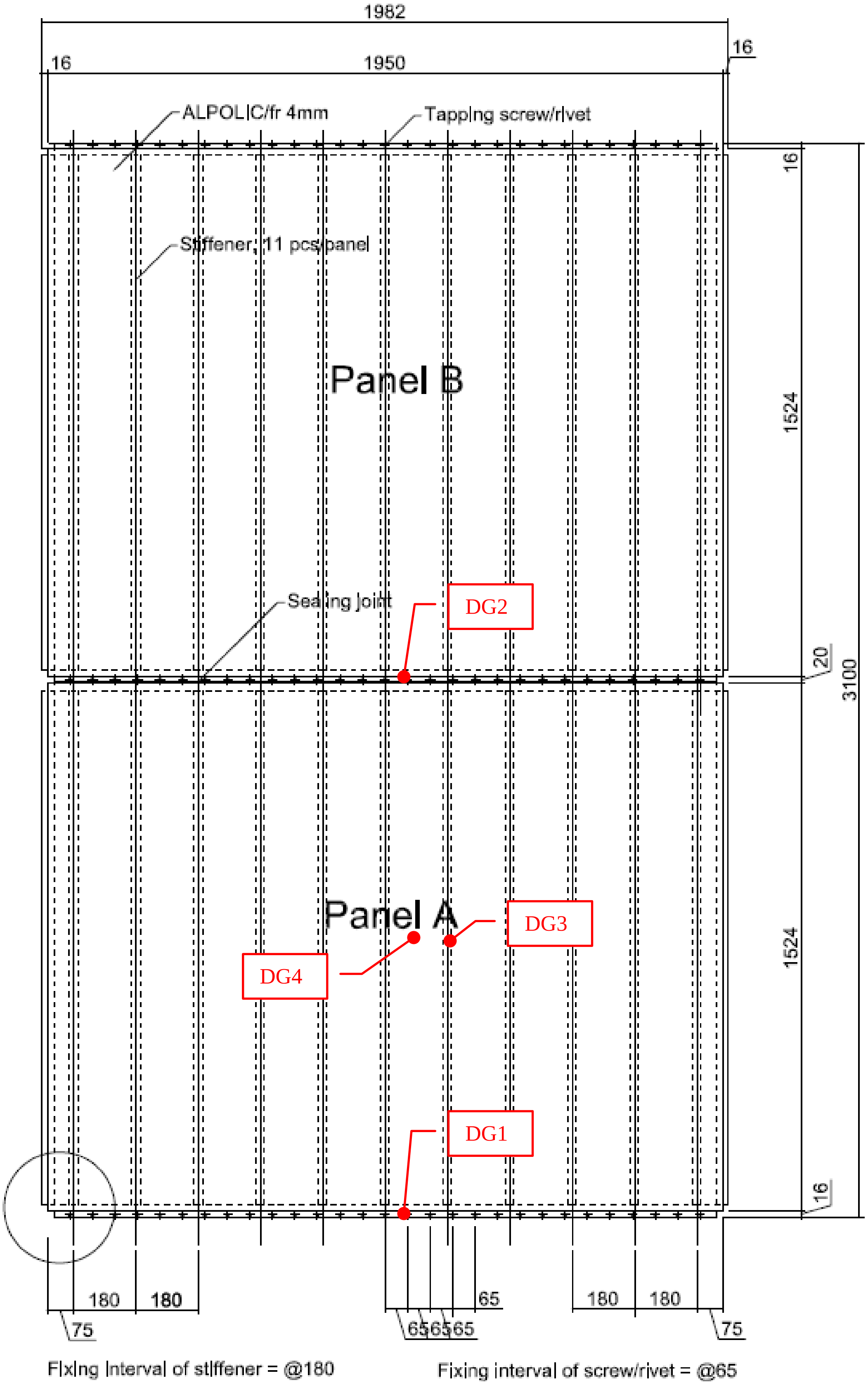

Figure 3: Plan view of installed panels

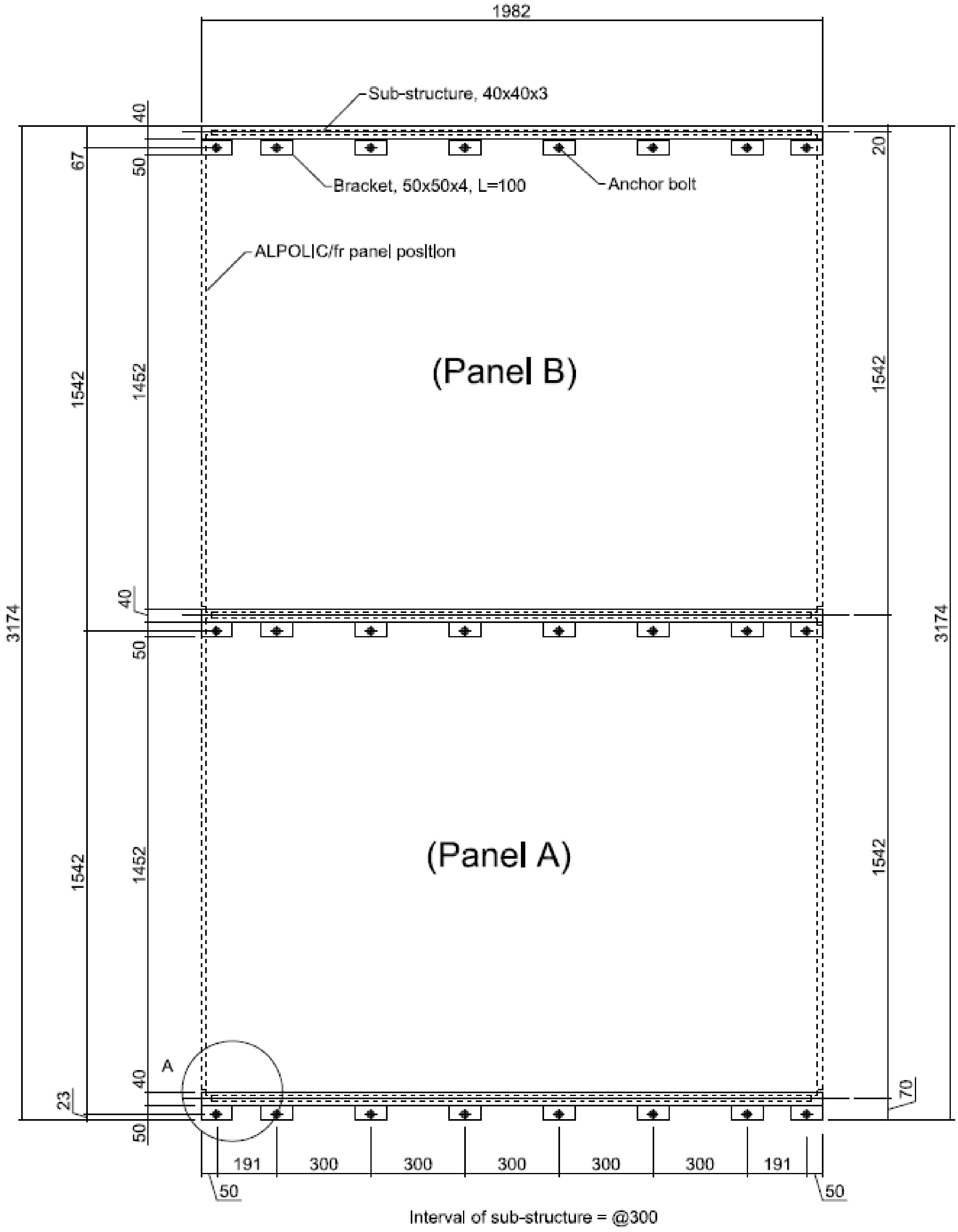

Figure 4: Plan view of installed sub-structure and brackets

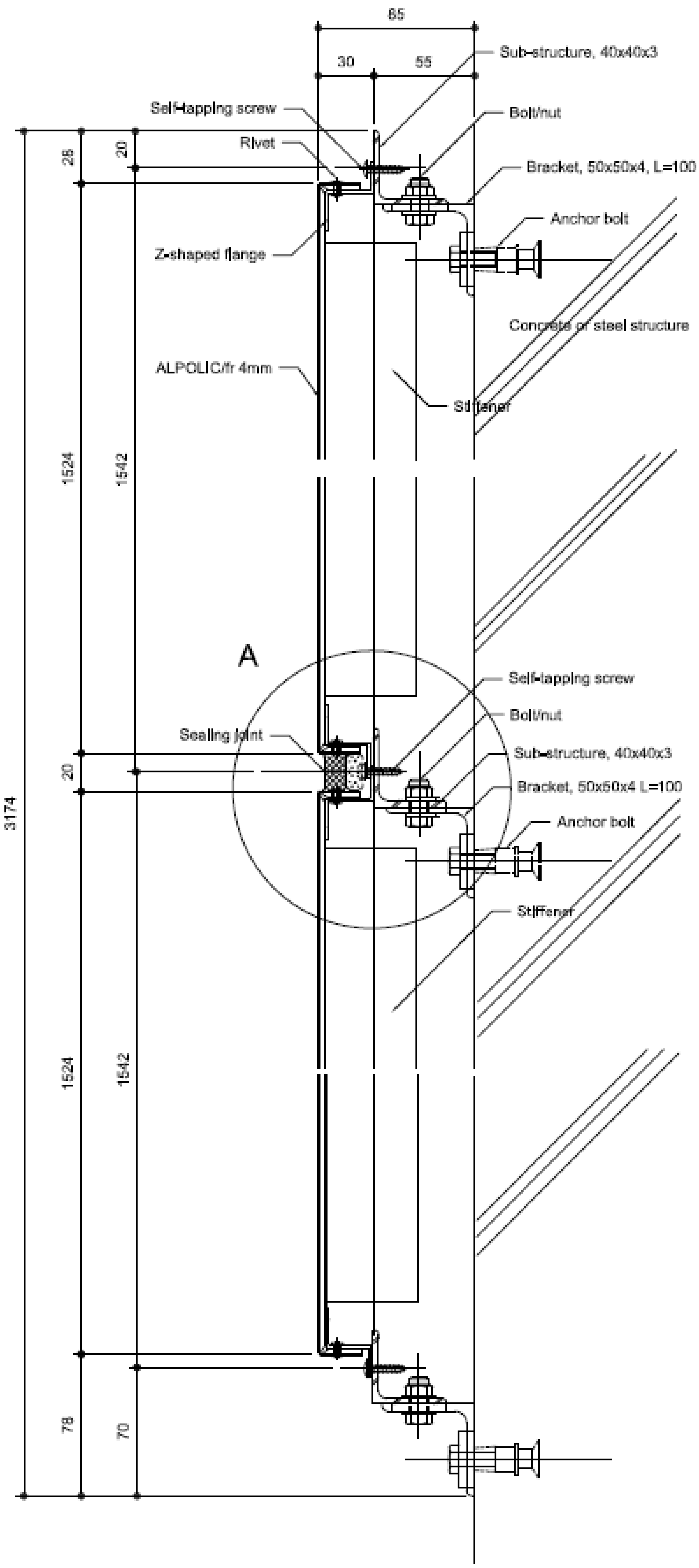

Figure 5: Vertical section view of installed panels

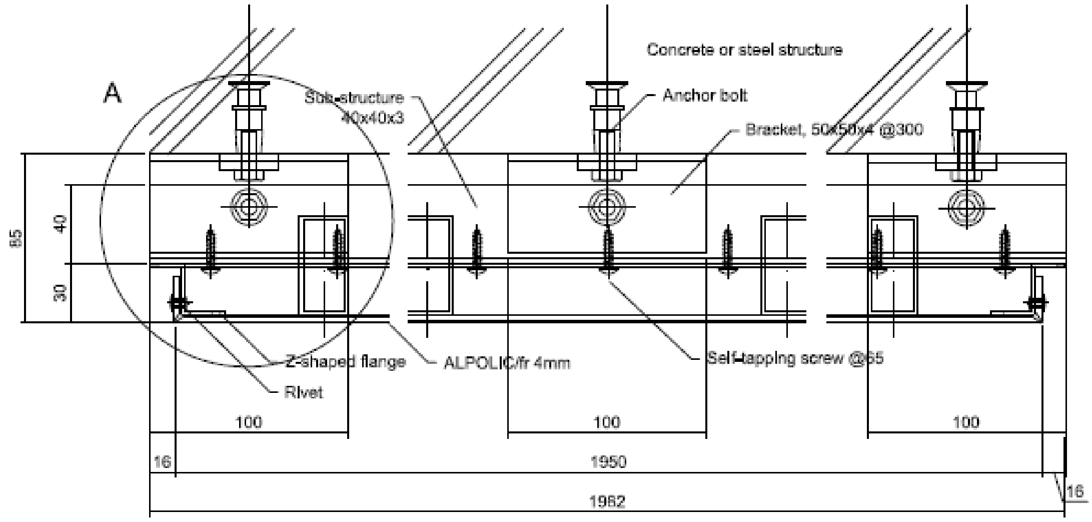

Figure 6: Horizontal section view of installed panels

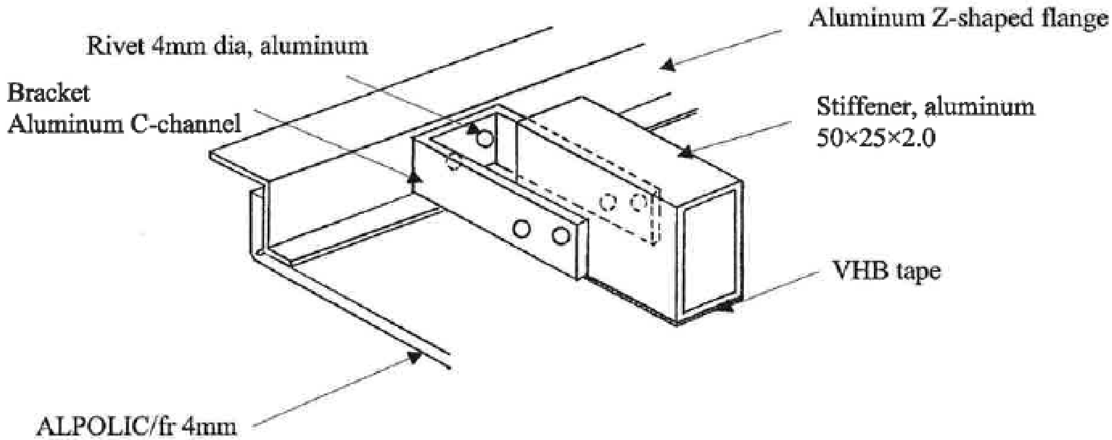

Figure 7: Stiffener connection detail

Appendix B – Serviceability Deflection Plot

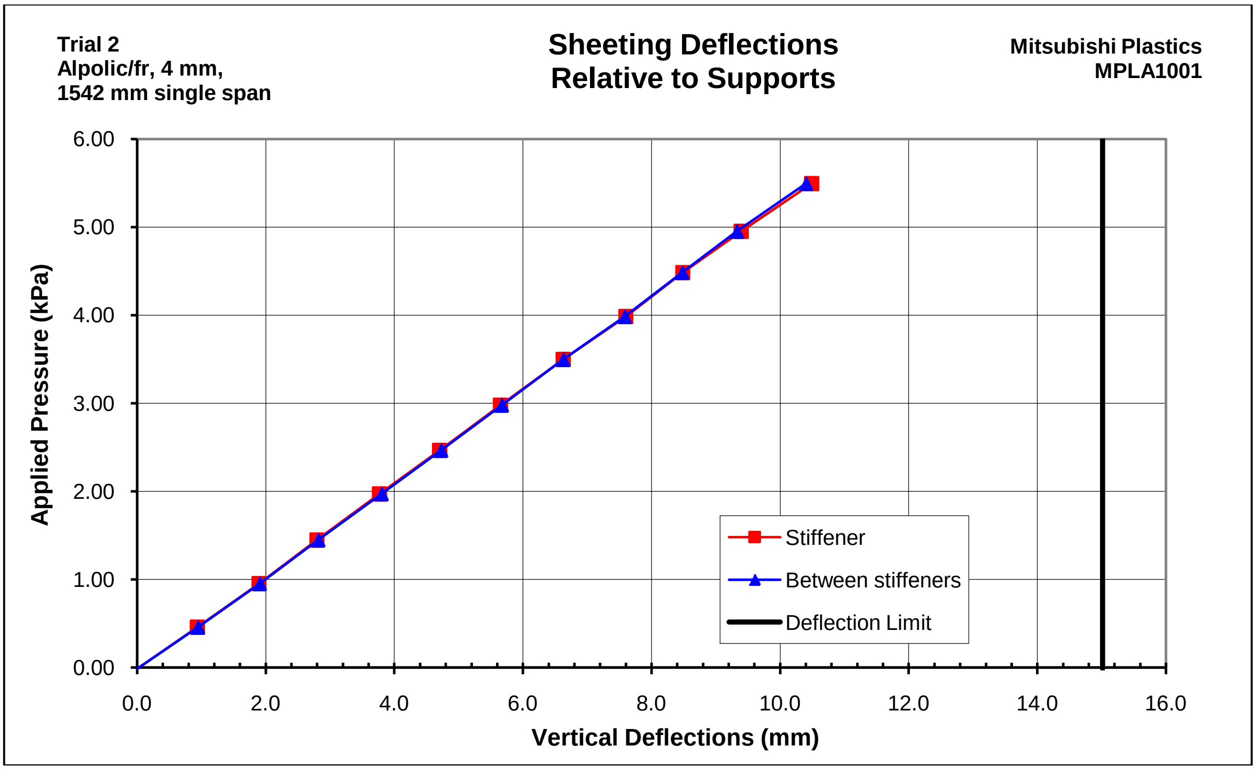

Figure 8: Plots of cladding deflections relative to supports (Trial 2)