STRUCTURES TEST REPORT

ST1234-001-02

FACE LOAD TESTING OF NU-WALL CLADDING USING ALUMINIUM BATTENS

CLIENT
Aluminium Product Brands New Zealand Limited
750B Great South Road
Penrose
Auckland 1061

All tests and procedures reported herein, unless indicated, have been performed in accordance with the BRANZ ISO9001 Certification

LIMITATION

The results reported here relate only to the items tested.

TERMS AND CONDITIONS

This report is issued in accordance with the Terms and Conditions as detailed and agreed in the BRANZ Services Agreement for this work.

SIGNATORIES

Author

David Carradine
Structural Engineer
BRANZ

Reviewer

Roger Shelton
Senior Structural Engineer
BRANZ

DOCUMENT REVISION STATUS

ISSUE NO.	DATE ISSUED	DESCRIPTION
02	12/12/2018	Final Issue – Revised as requested by client for accuracy

CONTENTS

FIGURES

TABLES

1. BACKGROUND AND OBJECTIVE

At the request of the client, Aluminium Product Brands New Zealand Limited (APBNZ), face load testing was conducted on five specimens to determine the design level of differential pressure able to be resisted by cladding systems incorporating aluminium battens and Nu-Wall cladding.

This report ST1234-001-02 supersedes BRANZ Report ST1234-001-01 and has been altered to more accurately reflect the materials used in the cladding system.

2. DESCRIPTION OF SPECIMENS

2.1 Product description

All materials used for test specimens were provided by the client. Horizontal lengths of aluminium battens as shown in Figure 1 were screwed to SG8 timber framing using 10g x 50 mm stainless steel screws. Nu-Wall Mono200 cladding was vertically installed onto the battens using Nu-Wall NC232F locator brackets and Nu-Wall NC203 fixing brackets, both fixed using 10g x 16 mm galvanised TEK screws.

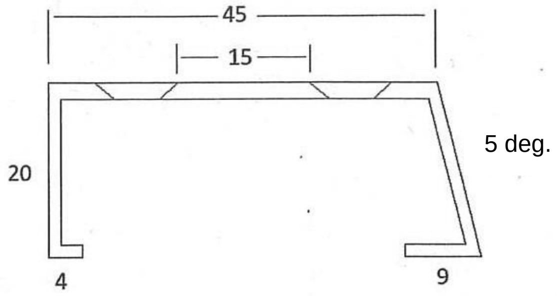

Figure 1. Cross-section of APBNZ aluminium battens used for testing (Note: dimensions in mm, 45 mm wide face 2.25 mm thick and remaining sections 1.5 mm thick)

2.2 Specimen construction

A total of five face load specimens were constructed and tested for this project, and all were fabricated by the client. All specimens covered a nominal area of 2.4 m x 2.4 m, a size selected to fit within the opening of the laboratory pressure chamber at BRANZ. All specimens were constructed to be in accordance with standard installation specifications issued by Nu-Wall for their range of cladding products.

The first 3 test specimens were replicates and were delivered by the client fully assembled and ready to test. The timber frames were constructed using 90 mm x 45 mm SG8 timber and included studs on 600 mm centres, top and bottom plates, and horizontal dwangs on 800 mm centres. For transporting purposes, diagonal steel straps were included in the frames, but these were not seen as having any effect on the face load performance of the specimens and left in place during testing. Aluminium battens (see Figure 1) were screwed to the timber framing at each stud crossing using two 10g x 50 mm stainless steel screws with countersunk heads to match the pre-drilled holes in the aluminium battens. Battens were run at 600 mm centres up the height of each specimen.

Specimen cladding consisted of 2400 mm long Nu-Wall Mono200 aluminium cladding boards running vertically that covered the entire specimen front. The first board was located using Nu-Wall NC232F locator brackets on 600 mm centres. These brackets were secured to the horizontally run aluminium battens with a single 10g x 16 mm galvanised self-drilling TEK screw through the bracket into each batten. The first board was clipped into the locator brackets on one side then secured on the other side using Nu-Wall NC203E universal fixing brackets on 600 mm centres with a single 10g x 16 mm galvanised self-drilling TEK screw through the bracket into the battens. The remaining boards clipped into the previously secured board and were similarly fixed to battens using Nu-Wall NC203E universal fixing brackets on 600 mm centres with a single 10g x 16 mm galvanised self-drilling TEK screw through the bracket into the battens. The final board had to be ripped down to fill the remaining space and therefore was clipped to the previous board but had to be screwed through the face using NC203E universal fixing brackets on 600 mm centres with a single 10g x 16 mm galvanised self-drilling TEK screw through the bracket into the battens. This final board was a Nu-Wall E200 profile which had a 20 mm wide negative detail which allowed fixing using the same length screws as the remaining boards.

The fourth specimen was similar to the first three specimens with the exception of the timber framing and the method of securing the first board. The timber frame was constructed using 140 mm x 45 mm SG8 timber and included doubled studs on 600 mm centres, top and bottom plates, and horizontal dwangs on 1200 mm centres. The studs were doubled to increase the strength of the frame against premature bending failure and were not used to increase the batten fixings. The bare frame was constructed by a Nu-Wall agent and delivered to BRANZ, where the client installed the battens and cladding. The first board was located using a 2400 length of Nu-Wall NC101 starter strip as seen in Figure 2, fixed with pairs of 10g x 16 mm galvanised self-drilling TEK screws to the battens on 600 mm centres. The remainder of the fourth specimen construction was identical to the first three replicate specimens.

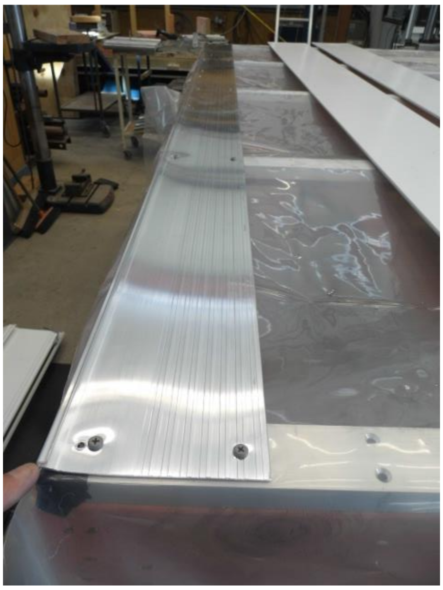

Figure 2. Installation of Nu-Wall NC101 Starter Strip for first board attachment for the fourth and fifth specimens

The fifth specimen was tested using the same timber framing as the fourth specimen with the battens and cladding installed on the previously untested side. The only other difference between the fourth and fifth specimens was that the fifth specimen included additional battens such that the batten spacing was 300 mm on centre up the height of the specimen. This resulted in additional fixings for the Nu-Wall Mono200 aluminium, which for this specimen were attached using Nu-Wall NC232F locator brackets on 300 mm centres using the same screws as all other specimens.

All specimens had a loose-fitting sheet of 250 µm plastic installed between the inside face of the aluminium cladding panels and the aluminium battens to maintain air tightness without affecting specimen strength. This plastic sheeting was included as part of the specimen construction done by the client.

3. DESCRIPTION OF TESTS

3.1 Date and location of test

Testing was conducted during March and April 2018 in the BRANZ Structures Laboratory located in Judgeford, New Zealand.

3.2 Test set-up

All specimens were secured in an upright position within the front opening of an airtight pressure chamber with the NuWall exterior cladding positioned on the inside of the pressure box, as shown in Figure 3. The top and bottom plates were securely fixed to the perimeter of the chamber with Tek screws with additional dummy studs sharing the load at the top of the specimen. The sides of the specimens were not fixed to the chamber but were sealed all around using the polythene sheet and adhesive tape to create a seal and allow the specimens to be pressurised uniformly.

Figure 3. Initial test set up of first three tested specimens shown in pressure box

Strong-backs were included at bottom plate and at three locations to strengthen the frame. These strong-backs were horizontally orientated 90 mm x 45 mm SG8 timber members that were screwed to the plates and studs as shown in Figure 3 for the first three specimens.

Initially these strong-backs did not extend past the width of the specimens so that the specimens could deflect inward during testing. Because the timber frames failed prematurely starting with the first specimen tested, additional timber was added to the frames and the strong-backs were extended to restrain the specimens from excessive deflections as shown in Figure 4. Similar reinforcing was used for the first three specimens tested. Because the fourth and fifth specimens included doubled studs and 140 mm deep framing, it was not necessary to reinforce the frame, but the same strong-back configuration was used. These modifications were not considered to prejudice the conclusions reached in this report as the tests were intended to test the cladding and cladding fixings and not the framing.

Figure 4. Augmented test set up of first three tested specimens with additional timber and extended strong-backs

3.3 Test procedure

Negative pressure (suction) was applied to the pressure box chamber using a centrifugal air pump. The fan speed was manually controlled during testing to create the target pressure as required by the cyclic loading regime. The test pressure was monitored with two manometers and all test pressures and deflections of the centre of the specimen were recorded manually throughout testing.

The test procedure used for face load testing is based on AS 4040.2:1992 [1]. The specimens were tested under negative pressure applied to the chamber shown in Figure 3 and Figure 4, corresponding to wind “suction” on a wall. The pressure was applied to the first three specimens with an initial level of 2.0 kPa and then in increasing steps of 0.2 kPa. The pressure was applied to the fourth and fifth specimens with an initial level of 3.0 kPa and then in increasing steps of 0.2 kPa. Each pressure step was held for one minute then released back to zero for 15 seconds before the next level of pressure was applied to the specimen. The maximum pressure resisted by the specimen was the greatest pressure that could be resisted for one minute.

4. OBSERVATIONS

The first three face load specimens behaved in a similar manner to one another. Because the framing was only 90 mm deep and included significantly sized knots there were premature failures of the framing. At the lower pressure levels these framing failures did not create perforations in the cladding and therefore the testing was continued once the frames were reinforced and strong-backs extended as described in Section 3.2 of this report. Final failures of the first three specimens were primarily due to peeling away of the aluminium cladding starting with the first board that was located using the Nu-Wall NC232F locator brackets as seen in Figure 5. Failures of the framing leading up to the cladding failures made it difficult to determine the exact initiation of failures but it was assumed there was some contribution from the first board cladding fixings and the framing failures.

Figure 5. Typical failure of first three specimens starting with first board

The fourth specimen was intended to be a replicate of the first three specimens with the exception of the more robust fixing of the first board as previously described, which was considered to be more realistic in terms of how the system is installed. The fourth specimen was taken up to 7.0 kPa, which was the maximum capacity of the pressure box, but local failures of the Nu-Wall NC203 fixing brackets were observed during cycles to 4.6 kPa, 6.0 kPa and 6.6 kPa. None of these bracket failures resulted in global failure of the specimen, but the application of the results was considered to be limited.

The fifth specimen was able to resist 7.0 kPa with only a single area of local failure observed and this was due to a missing screw rather than a failure of part of the cladding system. This minor local failure was not considered a global specimen failure and therefore 7.0 kPa was considered to the maximum pressure resisted by this specimen.

None of the specimens showed any failure of the aluminium batten connections to the framing.

5. RESULTS AND ANALYSIS

The maximum pressures resisted by the first three specimens for a full minute were 5.6 kPa, 5.4 kPa and 5.2 kPa for Specimen 1, Specimen 2 and Specimen 3, respectively. Specimen 4 was not included in this evaluation because it was constructed slightly differently than the first three specimen. The maximum pressure resisted by Specimen 5 for a full minute was 7.0 kPa.

The Ultimate Limit State (ULS) design differential pressure was derived from the test data using the k_t values described in Appendix B of AS/NZS1170.0 [2] for 5% coefficient of variability for testing of three specimens. This variability was assumed to be for the parent population from which the specimens were obtained based on the results of the face load testing and the failures that were observed. This resulted in a k_t value of 1.15 which was used for both the first specimens and the fifth specimen.

The design capacity is the value of lowest single test result divided by the appropriate factor for variability (k_t). The ULS design differential pressure, p_d, is therefore given by $p_d = 5.2/1.15 = 4.52$ kPa for specimens having battens spaced at 600 mm on centre. The ULS design differential pressure $p_d = 7.0/1.15 = 6.09$ kPa for specimens having battens spaced at 300 mm on centre.

6. DESIGN WIND SPEEDS

The analysis given below is only applicable to the exterior walls of buildings which fall within the scope of NZS 3604 [3], AS1684.2 [4] and AS 1684.4[5]. These standards assume:

- The interior of walls are fully lined and consequently wall cavity internal pressures are taken as zero in this analysis.
- The framing is separately designed to resist the design wind speeds calculated below.

The wind loadings are based on AS/NZS 1170.2:2011[6]. The design wind pressure, p, is given by Equation 2.4(1) of AS/NZS 1170.2 as:

$$p = 0.6V_{des}^2 \times C_{fig} \times C_{dyn} \quad \text{(Pa)},$$

where:

V_{des} is the design wind speed applicable to the relevant wind zone.

C_{fig} is the aerodynamic shape factor

C_{dyn} is the dynamic response factor = 1.0 for walls of a building within the scope of application described above.

The aerodynamic shape factor from Equation 5.2 of AS/NZS 1170.2 is given by:

$C_{fig} = C_{pe}K_aK_cK_LK_p$ for external pressures and $C_{fig} = C_{pi}K_aK_c$ for internal pressures.

For houses within the scope on NZS 3604 and AS 1684 the maximum $C_{pe} = -0.65$ suction, $K_a = 1.0$, $K_L = 2.0$ within 0.5a of a corner and 1.5 within 1.0a of a corner, (where 'a' = minimum of

0.2 times the length or width of the house and apex height), $K_c = 1$ for a single wall and generally $K_p = 1.0$.

Generally the width of New Zealand and Australian houses does not exceed 12 m. Hence, 'a' is taken as 0.2 x 12 = 2.4 m. Thus, within 1.2 m of a corner this report has used $K_L = 2.0$ and elsewhere it has used $K_L = 1.5$. For areas beyond 2.4 m from the corner this is a slightly conservative assumption.

Substituting these values gives the external pressure, p_e, on a wall as:

$p_e = 0.6V_{des}^2 \times 0.65 \times 1 \times 1 \times 2 \times 1 = 0.78V_{des}^2$ within 1200 mm of a corner; and

$p_e = 0.6V_{des}^2 \times 0.65 \times 1 \times 1 \times 1.5 \times 1 = 0.585V_{des}^2$ at more than 1200 mm from a corner.

As discussed in the assumptions above, the internal pressure coefficient, C_{pi}, has been taken to be zero and thus the internal pressure, p_i, on a wall = 0.

Thus, the demand differential pressure, p_z, to be resisted by cladding within a specified wind zone is given by:

$p_z = (p_i + p_e) = (0 + p_e) = p_e = 0.78V_{des}^2$ within 1200 mm of a corner and;

$p_z = (p_i + p_e) = (0 + p_e) = p_e = 0.585V_{des}^2$ at more than 1200 mm from a corner.

The demand differential pressures which are listed in Table 1 were derived using these equations.

Table 1. Demand Differential Pressures across a Wall Cladding on Lined Buildings Complying with the Scope of NZS 3604 and AS 1684.2

NZS 3604 or AS4055 wind zone	Wind speed m/s	Basic pressure (kPa)	Differential pressure Cpe = -0.65 (kPa)	
			KL=1.5	KL=2.0
L	32	0.614	0.599	0.799
N1	34	0.694	0.676	0.902
M	37	0.821	0.801	1.068
N2	40	0.960	0.936	1.248
H	44	1.162	1.133	1.510
VH or N3	50	1.500	1.463	1.950
EH	55	1.815	1.770	2.360
N4	61	2.233	2.177	2.902

From data in Table 1 and the determined design differential pressures of 4.52 kPa and 6.09 kPa it can be seen that the tested Nu-Wall cladding system is suitable for wind zones up to EH and N4 when studs are on 600 mm centres, either within 1200 mm of a corner as well as at more than 1200 mm from a corner and when using aluminium battens at 300 mm or 600 mm centres. These results also indicate that the tested systems using studs at 600 mm centres have the ability to resist design differential pressures up to 4.52 kPa and 6.09 kPa for specifically designed structures where battens are installed at 600 mm or 300 mm centres, respectively.

7. REFERENCES

[1]. Standards Australia. AS 4040.2 – 1992. Method of testing roof and wall cladding. Method 2: Resistance to wind pressures for non-cyclone regions. SA, Sydney, Australia.

[2]. Standards New Zealand. AS/NZS 1170.0:2011. Structural design actions. Part 0: General Principles. SNZ, Wellington, New Zealand.

[3]. Standards New Zealand. NZS 3604:2011. Timber Framed Buildings. SNZ, Wellington, New Zealand.

[4]. Standards Australia. AS 1684.2 – 2010. Residential timber-framed construction – Non-cyclonic areas. SA, Sydney, Australia.

[5]. Standards Australia. AS 1684.4 – 2010. Residential timber-framed construction – Simplified - Non-cyclonic areas. SA, Sydney, Australia.

[6]. Standards New Zealand. AS/NZS 1170.2:2011. Structural design actions. Part 2: Wind actions. SNZ, Wellington, New Zealand.