STRUCTURES TEST REPORT

ST18050-01-02

BOTTOM PLATE ANCHOR TESTING FOR ECKO FASTENING SYSTEMS

CLIENT
Fletcher Concrete and Infrastructure, trading as Firth Industries

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.

DOCUMENT REVISION STATUS

ISSUE NO.	DATE ISSUED	DESCRIPTION
01	14/02/2024	Draft Issue to client
02	05/03/2024	Final issue for client

branz.nz | 1222 Moonshine Rd, RD1, Porirua 5381, Private Bag 50 908, Porirua 5240, New Zealand | Phone +64 4237 1170 | branz@branz.co.nz

SIGNATORIES

Author

Lucy Brosnan
Structural Testing Engineer
Authorised to author this report.

Reviewed by

David Carradine
Senior Structural Engineer
Authorised to review this report.

CONTENTS

1. OBJECTIVE

There were two objectives for this project:

- To determine the strength of M10 X 155 Ecko Screw Anchors used for securing the bottom plates of timber framed walls to concrete slabs incorporating Firth HotEdge slab edge insulation, as required by NZS 3604 clause 7.5.12 [1].

- To determine the characteristic strength in axial tension of M10 X 155 Ecko screw anchors used for hold-down anchors for bracing elements installed in concrete slabs with Firth HotEdge slab edge insulation.

Both objectives were explored using the 12mm thick Ecko packer and using Firth HotEdge slab insulation meaning reduced edge distances to the anchors.

2. DESCRIPTION OF SPECIMENS

2.1 Product description

The anchors tested and the packers were supplied by the client and are shown in Figure 1.

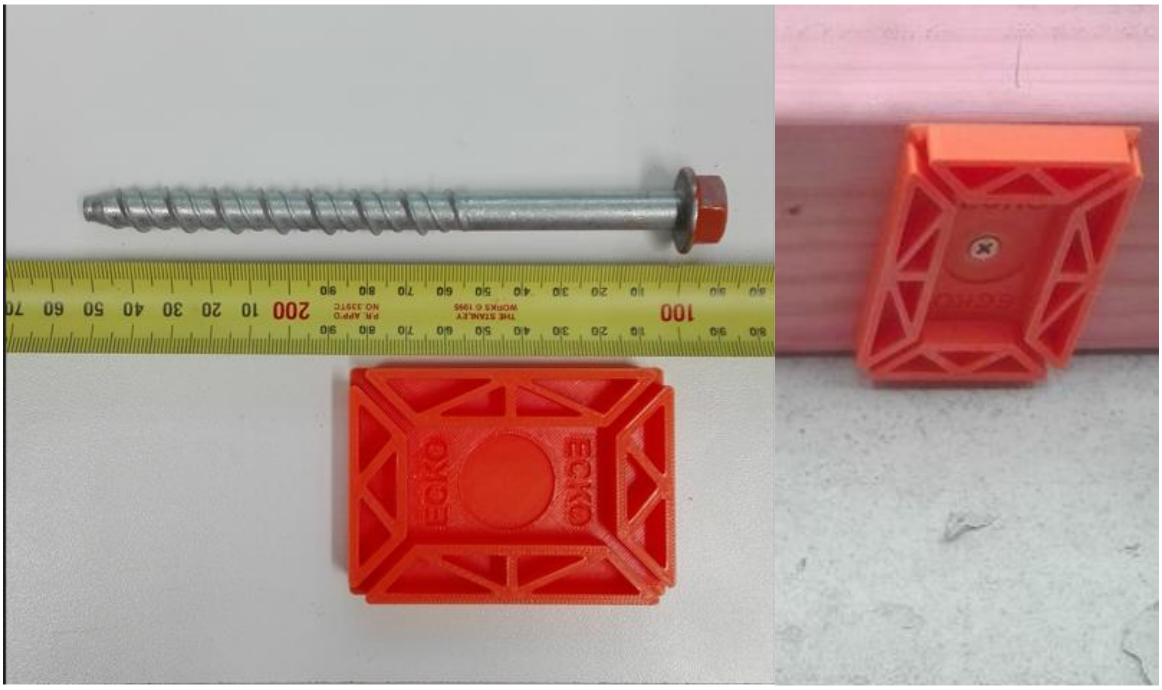

Figure 1 Anchor and Packer as tested.

The screw length under the head was 155 mm, the shank diameter was 10mm. The anchor is mechanically galvanised and had a hex head with attached washer. The client also supplied 12mm Ecko packers as shown in Figure 1. The anchor was able to be tested with an allowance for use with the 12mm packer in practice.

2.2 Specimen construction

To test the anchor specimens, 2,400 x 450 x 250mm thick concrete slabs were cast. They were reinforced with 665 mesh centrally located and a 20mm reinforcing bar running centrally and extending out the ends to provide lifting points. Reinforcing of the slabs was to provide strength for handling and was not intended to replicate a standard floor slab edge.

All slabs were poured with Firth HotEdge insulation as seen in Figure 2. Firth HotEdge slab insulation was provided by the client and is 25mm thick tapered to 15mm thick. HotEdge system with Tornado wire screw connectors were included in the form work. Concrete was supplied ready-mixed by Firth with a specified strength of 20 MPa. Test cylinders were made and tested before testing began, and at specified dates during testing.

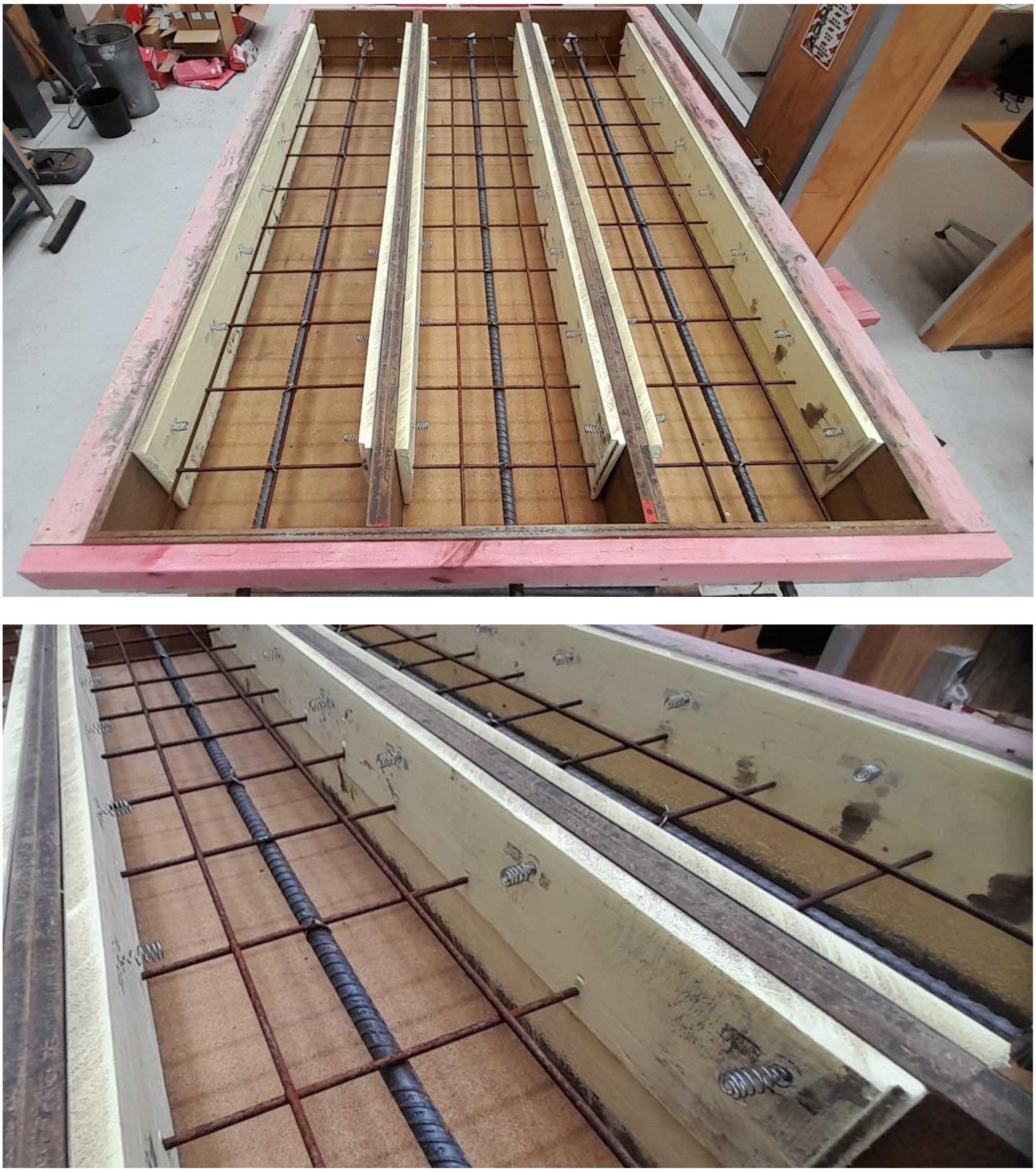

Figure 2 Cast in insulation in concrete slabs.

Each anchor was installed just prior to testing holes with 110mm embedment following client instructions. Anchors were installed to allow for the 12mm Ecko Packer to be positioned under the timber bottom plate. The anchor was positioned relative to the slab edge as shown in Figure 3.

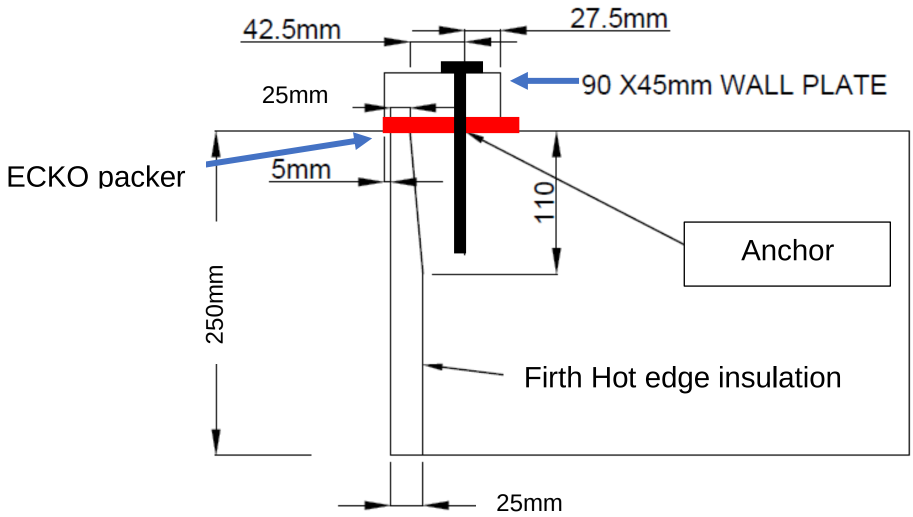

Figure 3 Anchor installation and slab edge dimensions.

3. DESCRIPTION OF TESTS

3.1 Date and location

Tests were carried out in January 2024 in the Structures Test Laboratory at BRANZ, Judgeford, New Zealand.

3.2 Test set-up

A separate test set-up was used for Axial tension uplift and Shear out of plane. Testing of the anchor for in plane shear has not been carried out as requested by the client.

3.2.1 Out-of-plane

Anchors were installed through a 90 x 45mm SG8 Radiata Pine timber bottom plate to allow for some movement of the top portion of the anchor through timber embedment. To ensure consistent loading, a 50 x 6mm steel flat bar was added to the bottom plate on the edge closest to the fixing. The test setup for out-of-plane testing is shown in Figure 4

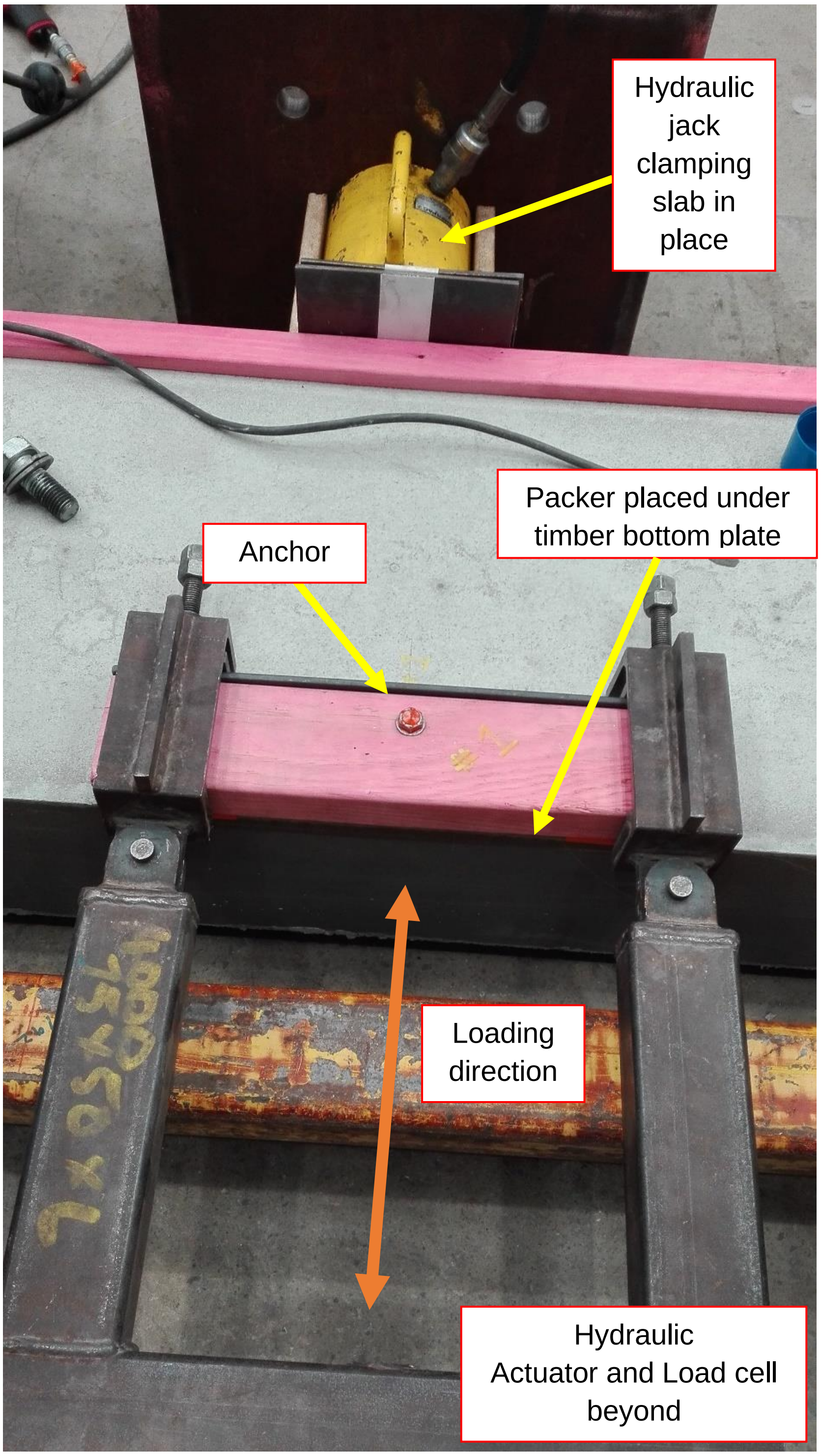

Figure 4 Out of plane shear testing set up

3.2.2 Tension/uplift

For tension testing the anchor was directly loaded by the steel testing jig to avoid potential breakage of the bottom plate. Note that the load was applied in a direction perpendicular to the slab surface.

An illustration of the test setup is shown below in Figure 5.

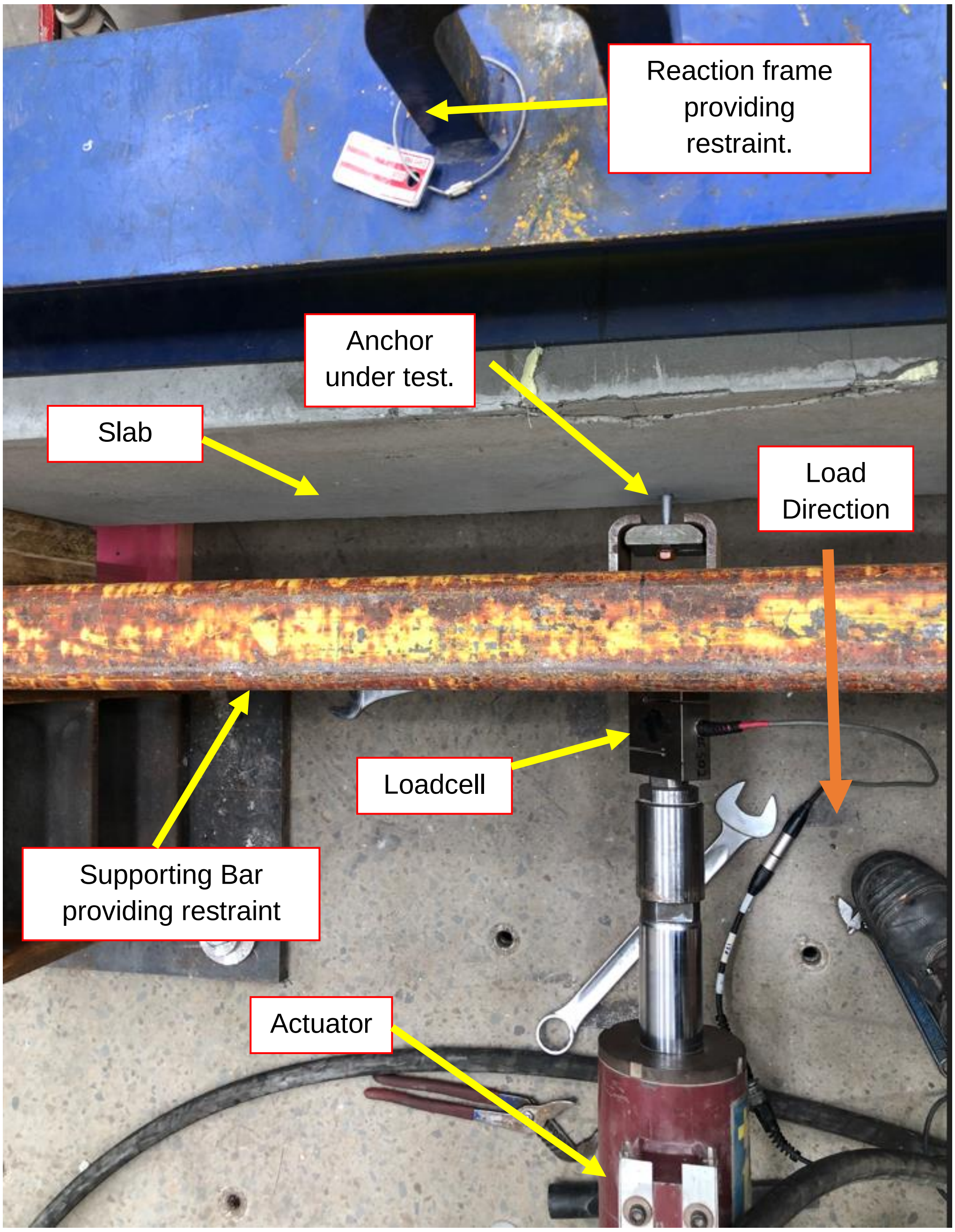

Figure 5 Set up for Tension/Uplift testing

branz.nz | 1222 Moonshine Rd, RD1, Porirua 5381, Private Bag 50 908, Porirua 5240, New Zealand | Phone +64 4237 1170 | branz@branz.co.nz

All test slabs were rigidly fixed to the laboratory strong floor (or reaction frame in the case of tension tests) and wedged in place with a hand pumped hydraulic jack.

The loads were applied to the anchors with a 100 kN capacity closed loop hydraulic actuator and measured with a 50 kN load cell. The load cell used was within International Standard EN ISO 7500-1 2015 Class 1 accuracy [2]. Displacement of the specimens was measured with the LVDT within the actuator, reading to an accuracy of ±1.0 mm.

The test load and displacement measurements were recorded using a PC running a software program to record the data.

3.3 Test procedure

The Design capacities for proprietary bottom plate anchors as specified by clause 7.5.12 of NZS 3604:2011 [1] are as follows:

External walls:

Horizontal loads out of the plane of the wall	3 kN
Vertical loads in axial tension of the anchor	7 kN

For the anchor to be used to hold down bracing elements of up to 150 bracing units per metre, industry standard is for the characteristic load to be greater than or equal to 15 kN. This figure is based on the findings from the following Study Reports:

- J.T. Gerlich (1987) BRANZ SR2 The end restraint of timber framed panels in wall bracing tests.
- R.H. Shelton (2004) BRANZ SR125 Bottom plate anchors under NZS 3604:1999.

For all tests, the loading regime was cyclic in accordance with BRANZ Evaluation Method No 1(1999) [3], as required by NZS 3604:2011. This method included three cycles at each “level”, starting at a control load of 1kN +/- cycle with increment increases of 1kN.

For the out-of-plane tests the specimens were cycled between positive and negative directions, and for the tension tests, between zero and the upwards direction.

4. OBSERVATIONS

4.1 Out-of-plane tests

In all six samples tested the anchors failed from concrete breaking and consequent anchor withdrawal as seen in Figure 6.

Figure 6 Concrete break out from Out of Plane testing

4.2 Tension test

Failure was mainly by concrete edge breakout and consequent anchor withdrawal (see Figure 7. Failure by concrete edge breakout during tension test). No screw failed during the direct tension loading.

Figure 7. Failure by concrete edge breakout during tension testing.

5. RESULTS

Representative plots of load against displacement are presented in Figure 8, and 8. Failure in each plot is indicated by the sudden drop off in the load.

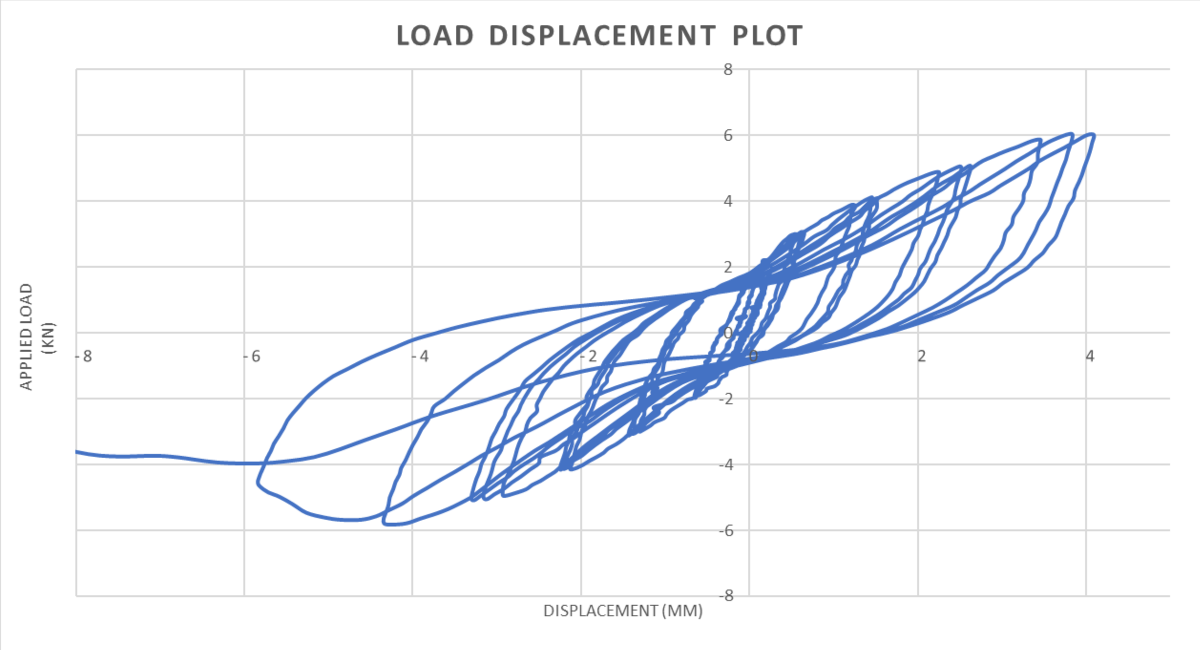

Figure 8. Representative plot of load v displacement for an out-of-plane test

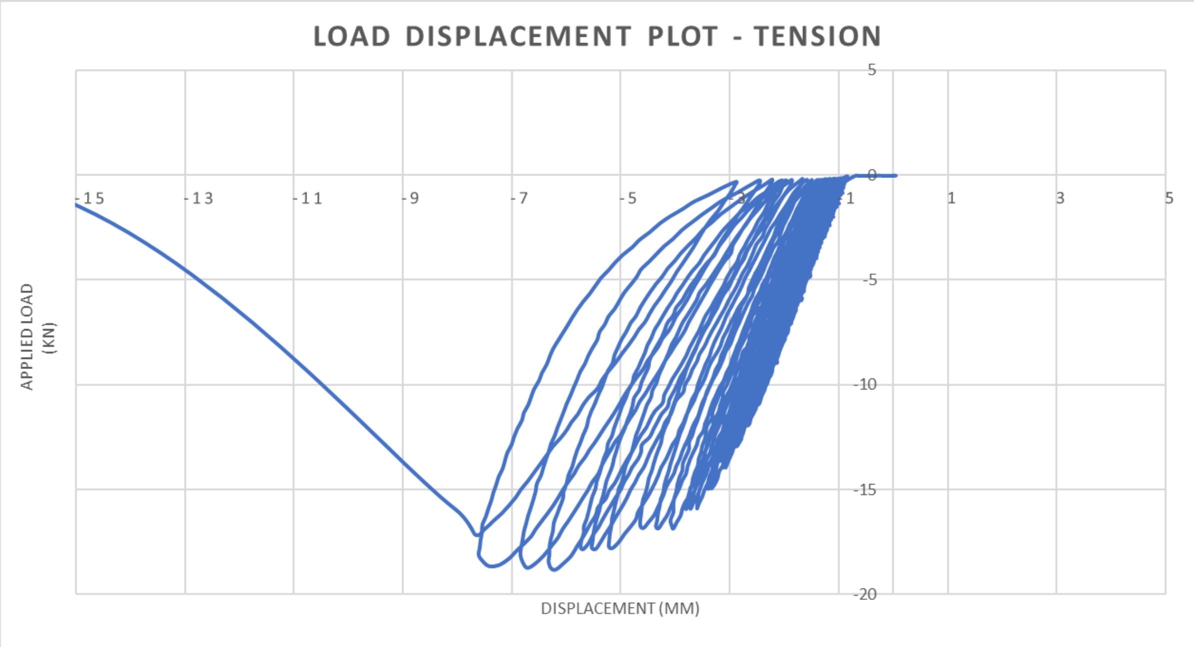

Figure 9. Representative plot of load v displacement for a tension test

5.1 Testing to NZS 3604 performance criteria

A summary of the test results is given below in Table 1.

The individual test results quoted in Table 1 are the peak loads recorded after three complete displacement cycles without failure.

The recorded loads have been adjusted by a factor to account for the actual concrete strength at the time of testing compared to the client specified design concrete strength of 20 MPa. The estimated concrete strength at the time of testing each individual anchor has been interpolated from concrete strengths tested before and during testing. The factor used is given by:

Factor = $\sqrt{\left({}^{20}/_{fc}\right)}$, where 20 is the specified strength, and fc is the interpolated strength at the time of testing. This scaling is based on the equation for anchor performance from NZS3101.1:2006[4] section 17. In the case of the tension tests, the estimated concrete strength at the time of testing was 24 MPa, so the adjustment factor used was 0.91. In the case of the out of plane tests the estimated concrete strength was 29.5MPa, so the adjustment factor used was 0.82.

NZS 3604 normally requires the use of BRANZ EM1 to analyse connection test results, but because the failure mode in the tests was concrete edge breakout, rather than timber failure, analysis of these results was carried out using the methodology of AS/NZS 1170.0 Appendix B [4], using the equation:

Design capacity = ${}^{minimum\ result}/_{k_t}$, where k_t is a factor depending on number of test results and their variability. The values chosen were interpolated from Table B1 of AS/NZS 1170.0.

Table 1 Results summary for NZS 3604 criteria

NZS 3604 criteria		
	Load direction (kN)	
Specimen number	Out-of-plane	Tension
1	4.58	15.49
2	5.32	16.44
3	5.33	15.99
4	6.17	16.40
5	5.67	15.48
6	5.15	15.48
Means (kN)	5.37	15.88
Std dev'n (kN)	0.53	0.46
Coef. Variation (%)	10%	3%
Number (n)	6	6
Minimum (kN)	4.58	15.48
Variability factor kt	1.26	1.12
Design Capacity (kN)	3.63	13.82
NZS 3604 criteria (kN)	**3.0**	**7.0**

5.2 Testing for bracing element hold-down

For use as hold-down anchors of bracing elements, the NZ industry standard is to quote characteristic strengths under uplift loading. After adjusting for concrete strengths as above, the characteristic strengths were determined using the standard statistical equation:

Characteristic strength = Mean strength – 1.65 x standard deviation of test results. [3]

A summary of the results and analysis is shown in Table 2.

Table 2. Results summary for brace element hold-downs

Brace element hold down criterion	
	Uplift loading
Specimen number	Peak Load (kN)
1	15.49
2	16.44
3	15.99
4	16.40
5	15.48
6	15.48
Means (kN)	15.88
Std dev'n (kN)	0.46
Characteristic value (kN)	15.12
Industry Standard (kN)	15

6. SUMMARY

It is concluded that in the opinion of Branz the design capacity of the tested M10 X 155 Ecko Screw anchors in association with the tapered Firth HotEdge Extra exceeded the actions required by NZS3604 (clause 7.5.12.3) and hence testing has demonstrated compliance with NZS3604 clause 7.5.12 for proprietary anchors placed at 900mm centres.

The tests were conducted with a 12mm packer. If this packer was not used the bolts would be embedded a further 12mm into the concrete and similar or better capacity is expected.

The same anchor will provide a 15kN fixing for end studs of bracing wall elements with or without the 12mm Ecko packer.

Both conclusions depend on the anchors being accurately installed with respect to the edge of the slab and minimum embedment and installed as per manufacturer guidelines.

7. REFERENCES

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

[2] International Organisation for Standardisation (ISO). 2018. EN ISO 7500:2018 Metallic Materials – Verification of Static Uniaxial Testing Machines, Part 1: Tension/Compression Testing Machines – Verification and Calibration of the Force-Measuring System. ISO, Geneva, Switzerland.

[3] BRANZ Evaluation method EM1 (1999). Structural joints – Strength and stiffness evaluation, Judgeford, Wellington, New Zealand.

[4] Standards Australia. AS/NZS 1170.0:2002. Structural design actions. Part 0: General principles. Standards Australia, Sydney, Australia.