STRUCTURES TEST REPORT

ST17842-01-03

BOTTOM PLATE ANCHOR TESTING FOR HILTI FASTENING SYSTEMS

CLIENT
HILTI

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

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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.

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CONTENTS

1. OBJECTIVE

There were two objectives for this project:

- To determine the strength of M8 X 150 HUS4-H Hilti Screw Anchors used for securing the bottom plates of timber framed walls to concrete slabs incorporating three profiles of edge insulation product, Firth Hotedge, Maxraft, Quickedge and a slab with no insulation. Testing was carried out to requirements in NZS 3604 clause 7.5.12 [1].

- To determine the characteristic strength in axial tension of M8 X 150 HUS4-H Hilti Screw Anchors used for hold-down anchors for bracing elements installed in concrete slabs with all insulation options.

Test	Insulation Type	Load Directions	Packer Installed	Edge Distance	Embedment Depth
1	No Insulation	Tension/Out of Plane	No Packer	34mm	102mm
2	Maxraft	Tension/Out of Plane	No Packer	34mm	102mm
3	Firth Hotedge	Tension/Out of Plane	Hiandri 12mm	34mm	90mm
4	Quickedge	Tension/Out of Plane	Hiandri 12mm	34mm	90mm

Table 1 Testing Plan

In plane testing has been excluded from the scope of this report as previous results have shown that out of plane and tension are the governing load directions with screw in concrete 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. Anchors were supplied with a 50mmx50mmx3mm square washer.

Figure 1 Anchor as tested.

The screw length under the head was 150 mm, the shank diameter was 8mm. The anchor is mechanically galvanised and had a hex head with square washer. The client also supplied 12mm Hiandri packers as shown in Figure 2 however, only the firth & quick edge testing was carried out with a packer in place.

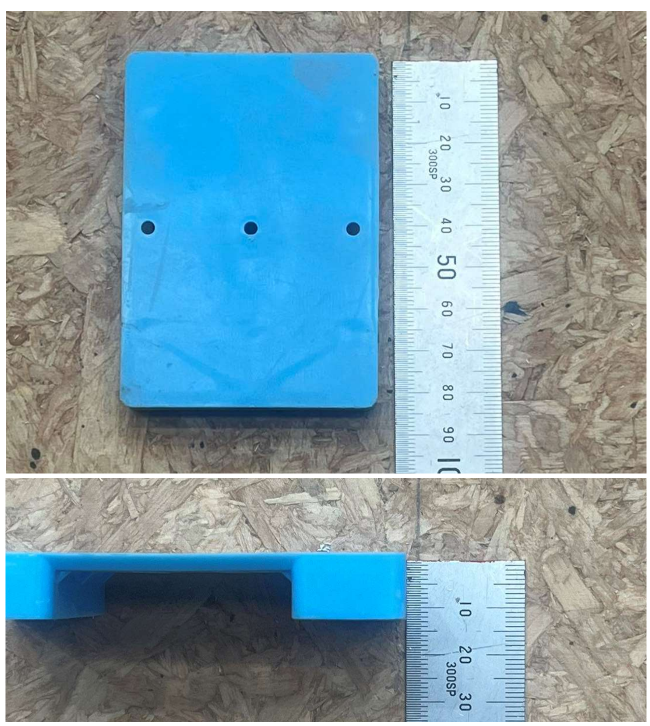

Figure 2 Hiandri Packer

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.

Four slabs were poured using 20 MPa 19mm aggregate concrete, one slab for each edge insulation type and a fourth with no edge insulation.

Test cylinders were made and tested before testing began, and at specified dates during testing.

In total concrete was poured on two dates on 9/05/2024 three slabs were poured to cover the no insulation, Maxraft and Firth Hot edge testing. On 30/05/2024 a second slab was poured for quick edge testing.

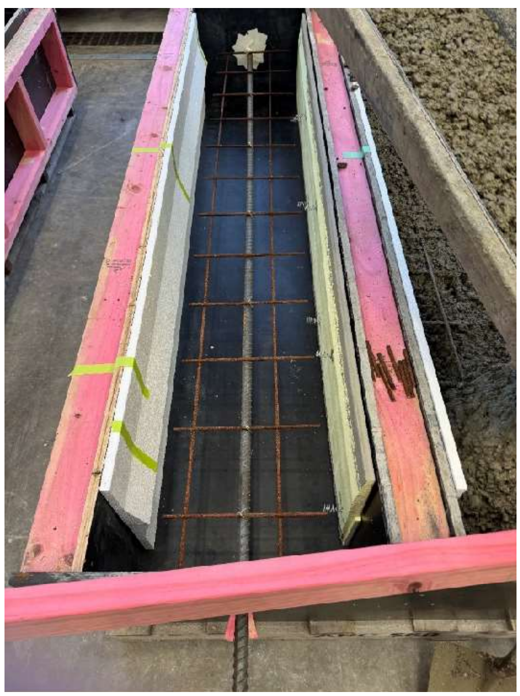

Figure 3 Cast in insulation in concrete slabs.

Each anchor was installed just prior to testing holes with 102mm embedment following client instructions. For anchors that were intended to be installed with the 12mm Hiandri Packer to be positioned under the timber bottom plate the embedment would be reduced by 12mm. The anchor was positioned relative to the slab edge to provide a 6mm overhang with a 90mm timber bottom plate. For the slab installed with no insulation to simulate a generic insulation the anchor was installed at 34mm from the concrete edge. Anchors were installed with the provided 50x50x3mm square washer.

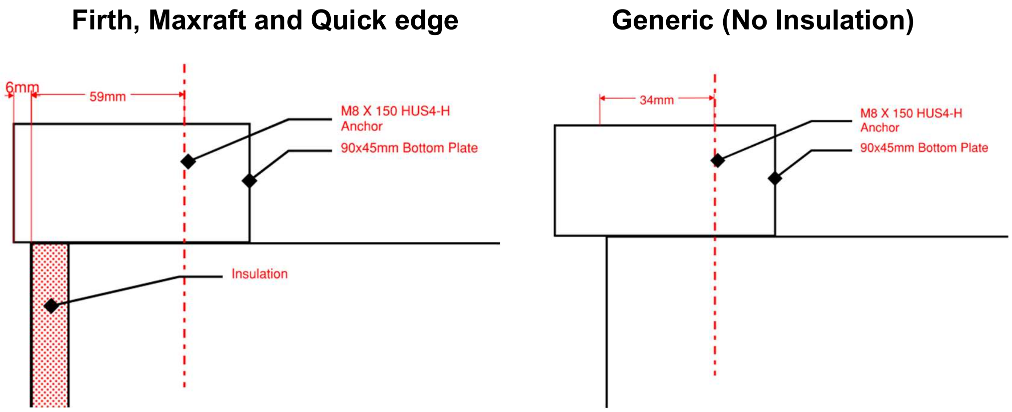

Figure 4 Anchor installation and slab edge dimensions.

3. DESCRIPTION OF TESTS

3.1 Date and location

Tests were carried out between May & June 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. The test setup for out-of-plane testing is shown in Figure 5

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Figure 5 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. Embedment was reduced by 12mm for samples that were intended to be used with Hiandri packers.

An illustration of the test setup is shown below in Figure 6.

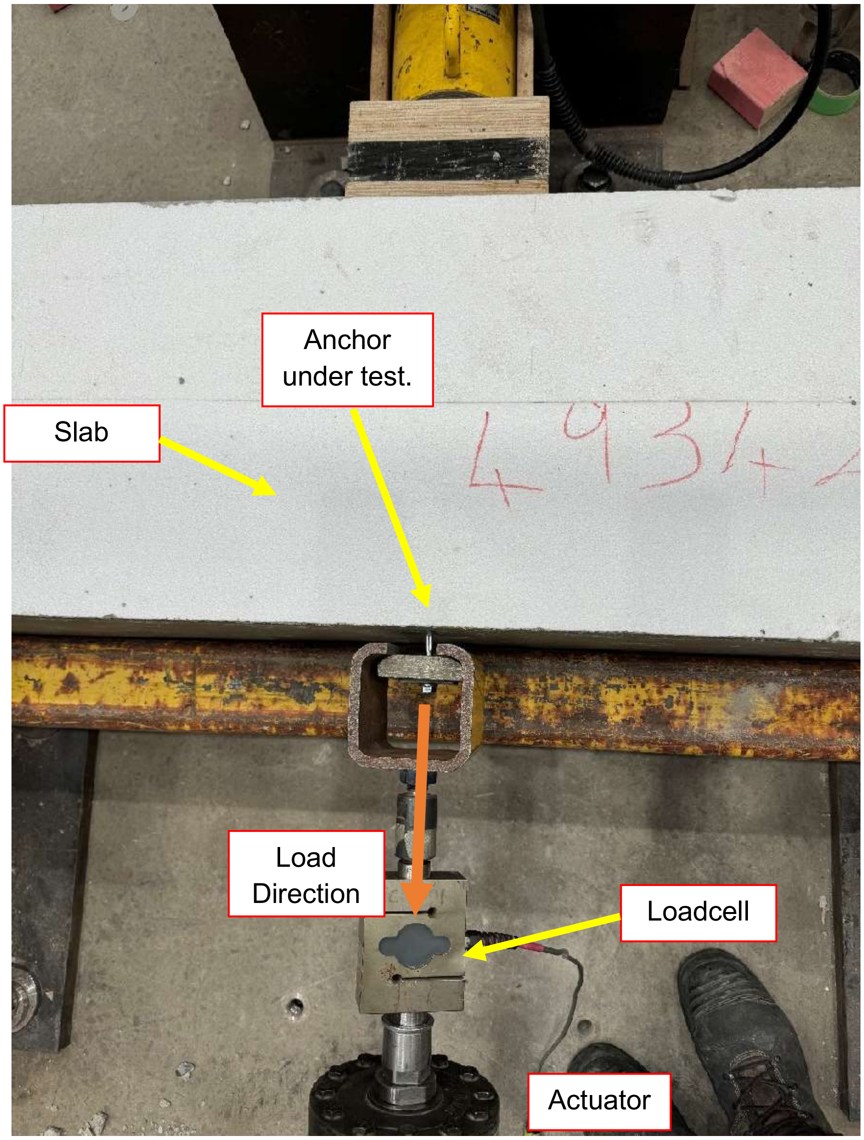

Figure 6 Set up for Tension/Uplift testing.

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 most samples of each insulation type tested the anchors failed from concrete breaking and consequent anchor withdrawal as seen in Figure 7. There were some instances of timber failure that occurred, but this generally occurred close to the failure load of the anchor.

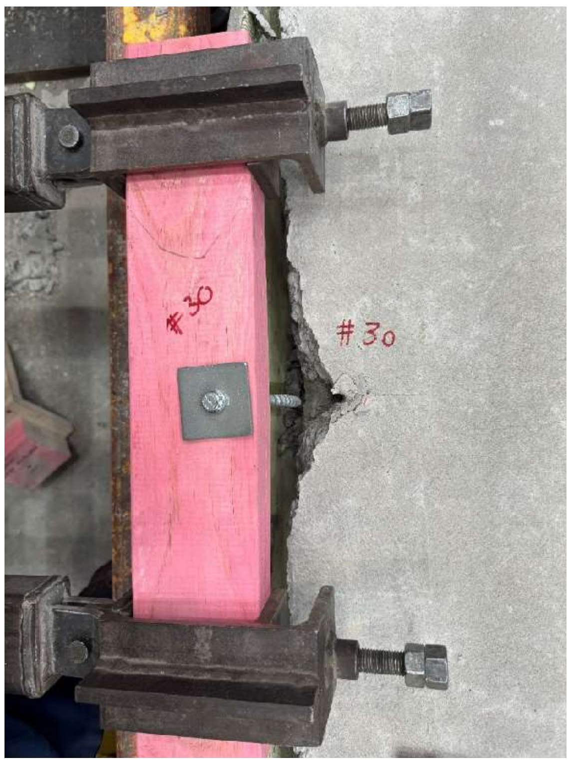

Figure 7 Concrete break out from Out of Plane testing

4.2 Tension test

Failure in tension was exclusively by concrete edge breakout and consequent anchor withdrawal (see Figure 8. Failure by concrete edge breakout during tension test). No screw anchor failure was observed during the direct tension loading.

Figure 8. Failure by concrete edge breakout during tension testing.

5. RESULTS

Representative plots of load against displacement are presented in Figure 9, and 8 for sample 4 in the generic insulation tests. Failure in each plot is indicated by the sudden drop off in the load.

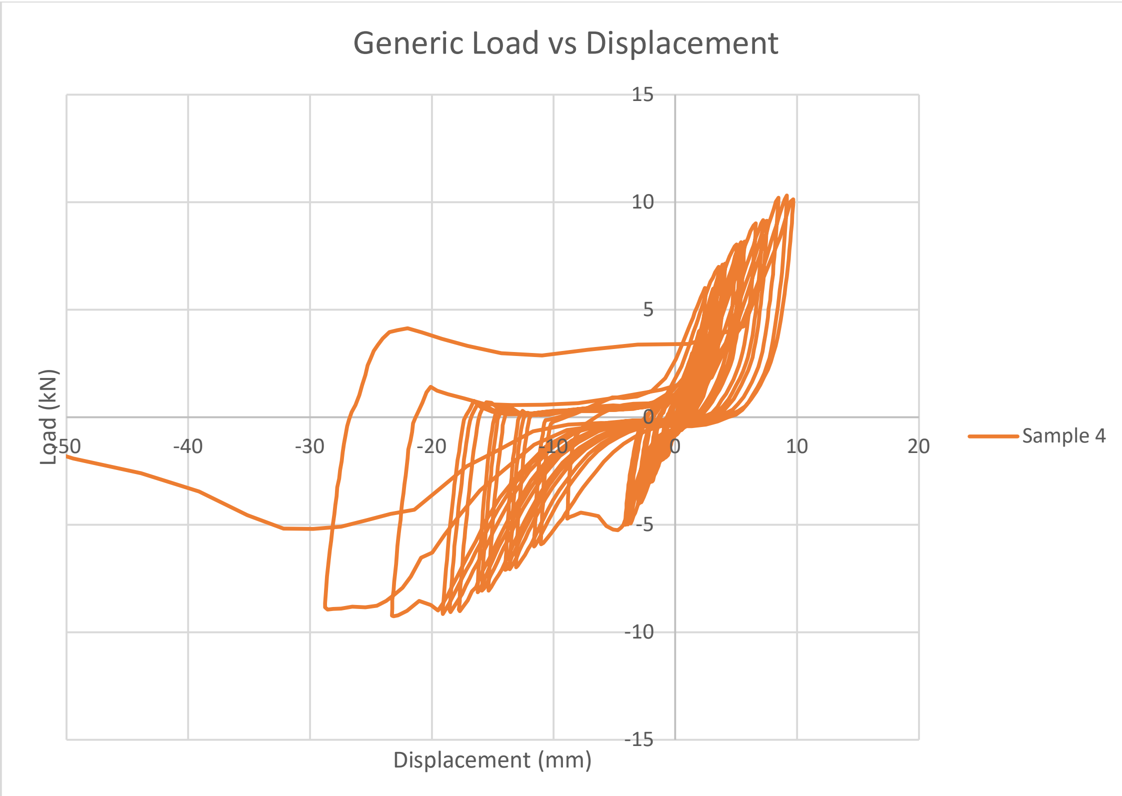

Figure 9. Representative plot of load v displacement for an out-of-plane test

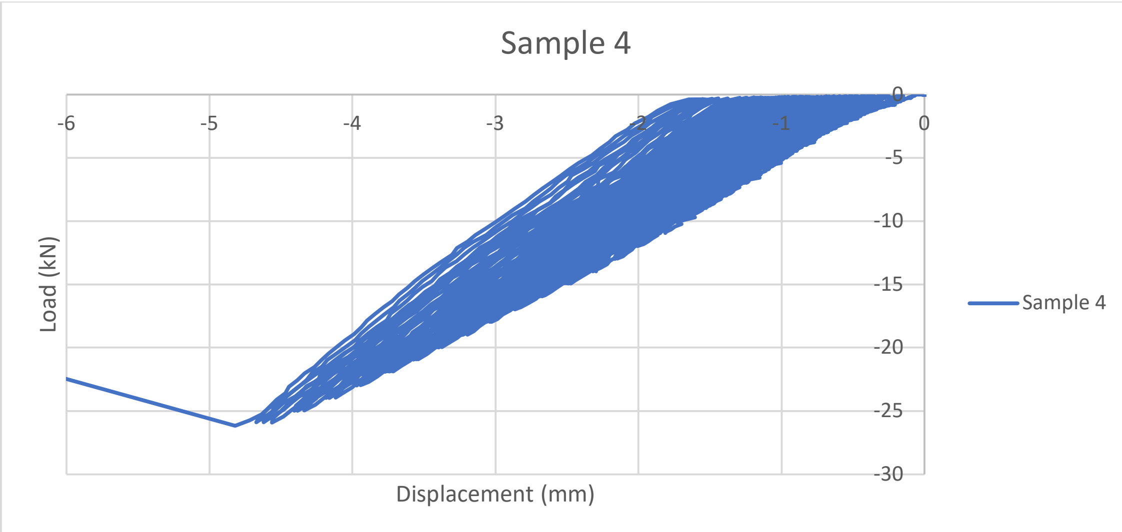

Figure 10. Representative plot of load v displacement for a tension test

5.1 Testing to NZS 3604 performance criteria

The individual test results quoted in Table 4-Table 6 include the characteristic strength (to BRANZ EM1). and the design capacity (Using factors outlined in NZS 3101:2006[4].).

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 20MPa 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. Factors are included in Table 2 & Table 3.

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, Characteristic capacity has then been determined using EM1 (BRANZ, 1999) section 2.1

The design capacities have been calculated by multiplying the determined characteristic value by the appropriate strength reduction factor as given in clause 17.5.6.4 NZS 3101:2006[4].

As requested by Hilti and agreed by BRANZ Tension testing results for each of the data sets were combined for Analysis. This was agreed on the basis that both sets of samples had the same edge distances with only slight differences caused by the different insulation profiles. Both sets of samples had the same embedment depths, and the failure modes were all concrete breakout forming truncated cones.

		Concrete Compressive Strength		
Date	Day	MPa Tested	MPa interpolated	Factor
17/05/2024	9	21.5		0.96
18/05/2024	10		22.23	0.95
19/05/2024	11		22.96	0.93
20/05/2024	12	23.5		0.92
21/05/2024	13		24.29	0.91
22/05/2024	14	25		0.89
23/05/2024	15		25.44	0.89
24/05/2024	16		25.94	0.88
25/05/2024	17		26.40	0.87
26/05/2024	18		26.82	0.86
27/05/2024	19		27.19	0.86
28/05/2024	20	27.5		0.85

Table 2 Concrete strength factors by testing date slab 1

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		Concrete Compressive Strength		
Date	Day	MPa Tested	MPa interpolated	Factor
6/06/2024	7	23.5	-	0.92
7/06/2024	8	24.5	-	0.90
10/06/2024	11	28.5	-	0.84

Table 3 Concrete strength factors by testing date slab 2

Out of plane – No slab edge insulation			
Sample	Out of plane test Capacity (kN)	Out of plane Capacity with Factor for concrete strength applied kN	Date
1	7.93	7.32	20/05/2024
2	8.89	8.20	20/05/2024
3	10.22	9.43	20/05/2024
4	9.1	8.40	20/05/2024
5	8.44	7.79	20/05/2024
Std Dev	0.79		
Mean	8.23		
Characteristic Capacity	6.22	kN (Brace Element Hold Down Only)	
Co-eff Variation	0.10		
Design capacity	4.04	kN (Φ 0.65)	

Table 4 Results summary No edge Insulation

Out of Plane– Maxraft Slab edge insulation			
Sample	Out of plane test Capacity (kN)	Out of plane Capacity with Factor for concrete strength applied kN	Test Date
1	7.88	7.27	20/05/2024
2	7.79	7.07	21/05/2024
3	10.38	9.28	22/05/2024
4	11.04	9.87	22/05/2024
5	10.94	9.79	22/05/2024
Std Dev	1.38		
Mean	8.66		
Characteristic Capacity	5.4	kN (Brace Element Hold Down Only)	
Co-eff Variation	0.16		
kt	1.50		
Design capacity	3.51	kN (Φ 0.65)	

Table 5 Results summary Maxraft insulation

Out of Plane - Firth Slab edge insulation			
Sample	Out of plane test Capacity (kN)	Out of plane Capacity with Factor for concrete strength applied kN	Test Date
1	6.99	5.99	27/05/2024
2	6.04	5.15	28/05/2024
3	7.08	6.04	28/05/2024
4	7.04	6.00	28/05/2024
5	6.82	5.82	28/05/2024
Std Dev	0.37		
Mean	5.80		
Characteristic Capacity	4.62	kN (Brace Element Hold Down Only)	
Co-eff Variation	0.06		
kt	1.17		
Design capacity	3.00	kN (Φ 0.65)	

Table 6 Results summary Firth Insulation

Out of Plane – Quickset Slab edge insulation			
Sample	Out of plane test Capacity (kN)	Out of plane Capacity with Factor for concrete strength applied kN	Test Date
1	6.95	6.41	6/06/2024
2	5.85	5.40	6/06/2024
3	6.73	6.08	7/06/2024
4	6.83	6.17	7/06/2024
Std Dev	0.44		
Mean	6.01		
Characteristic Capacity	4.70	kN (Brace Element Hold Down Only)	
Co-eff Variation	0.07		
kt	1.20		
Design capacity	3.05	kN (Φ 0.65)	

Table 7 Results summary Quickset edge Insulation

Tension			
Sample	result (kN)	Results With factors	Date
Generic 1	25.78	23.39	21/05/2024
2	24.86	22.56	21/05/2024
3	19.79	17.96	21/05/2024
4	25.63	23.26	21/05/2024
5	27.6	25.04	21/05/2024
Maxraft 1	25.98	23.04	23/05/2024
2	24.9	22.08	23/05/2024
3	19.88	17.63	23/05/2024
4	25.89	22.96	23/05/2024
5	27.99	24.82	23/05/2024
Std Dev	2.53		
Mean	22.27		
Characteristic Capacity	16.34	kN (Brace Element Hold Down Only)	
Co-eff Variation	0.11		
kt	1.33		
Design capacity	10.62	kN (0.65 phi)	

Table 8 Results summary tension Generic/Maxraft

Tension				
Sample		result (kN)	Results With factors	Date
Firth	1	21.94	19.26	21/05/2024
	2	23.81	20.91	21/05/2024
	3	19.94	17.10	21/05/2024
	4	25.88	22.19	21/05/2024
	5	26.86	23.04	21/05/2024
Quickedge	1	21.83	20.14	6/06/2024
	2	21.84	20.15	6/06/2024
	3	26.87	24.28	7/06/2024
	4	27.84	25.15	7/06/2024
Std Dev		2.55		
Mean		21.36		
Characteristic Capacity		15.00	kN (Brace Element Hold Down Only)	
Co-eff Variation		0.12		
kt		1.35		
Design capacity		9.75	kN (0.65 phi)	

Table 9 Results summary tension Firth/Quickedge

6. SUMMARY

It is concluded that in the opinion of Branz the design capacity of the tested M8 X 150 HUS4-H Hilti Screw anchors with the use of the various slab edge insulation profiles as specified in this report exceeded the requirements of 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 for firth hot edge and Quickedge were conducted with a 12mm Hiandri packer. It can also be concluded that removal of the packer would increase the embedment by 12mm which would improve the design capacity and meet compliance with NZS3604 clause 7.5.12.

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.