STRUCTURES TEST REPORT

ST17821-03-1

BOTTOM PLATE ANCHOR TESTING FOR MAXRAFT NZ

CLIENT
MAXRaft NZ
5 Tewa Street
Queenstown 9300

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

LIMITATIONS

The results reported here relate only to the item/s tested. The sample(s) is tested as supplied.

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

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FIGURES

TABLES

1. BACKGROUND

Maxraft has an insulated concrete floor system that they want to check the capacity of bottom plate anchors in. This report tests the capacity of 2 anchor systems and compares the resulting capacities to requirements from NZS 3604:2011 [1].

2. OBJECTIVE

To determine the capacity of two anchoring systems in the following directions.

1. M10 X 140 Bowmac blue head anchors, tested in:
    a. Out-of-plane direction;
    b. In-plane direction;
    c. Tension direction.
2. 10 x 150mm HUS4 – H HILTI anchor, tested in:
    a. Out-of-plane direction;
    b. In-plane direction;
    c. Tension direction.

The capacity of the above configurations will be determined and compared to the requirements of NZS 3604:2011 [1] clause 7.5.12:

a) Horizontal out-of-plane loads – 3 kN;
b) Horizontal in-plane loads – 2 kN;
c) Vertical tension loads – 7 kN.

The Bowmac and Hilti tension results will also be compared to the industry accepted requirement of 15 kN characteristic capacity for bracing panel hold down.

3. DESCRIPTION OF SPECIMEN

3.1 Product description

Two different products were tested. These were:

1. 10 x 140 mm Bowmac blue head anchors.
2. 10 x 150 mm HUS4-H Hilti threaded anchor with tube.

A photograph of these products is shown below in Figure 1.

(a) (b)

Figure 1. (a) Bowmac Anchor (b) Hilti Anchor

3.2 Specimen construction

3.2.1 Concrete

Four concrete beams were cast to simulate a concrete floor slab. These beams were 2,400 x 500 x 400 mm with 665 mesh centrally located and a 25 mm reinforcing bar running centrally and extending out the ends to provide lifting points. Reinforcing of the samples is to provide strength while moving the samples and is not intended to replicate a standard floor slab edge. The ready-mixed concrete supplied for the beams had a specified 28-day compressive strength of 17.5 MPa. At the time of casting the beams, 9 test cylinders were also cast to allow for concrete strength testing.

Seven days after the concrete beams were cast, two cylinders were tested and the mean concrete strength was 17.5 MPa. Another Cylinder was tested at 27 days and indicated a concrete strength of 21MPa. Upon confirmation that the concrete beams had exceeded the minimum NZS 3604:2011 [1] concrete slab strength of 20 MPa, preparation for anchor installation and testing began on the 28th day after the slab was cast.

Cylinder testing was continued throughout the test program to track the strength of the concrete beams.

3.2.2 M10 x 140 mm Bowmac blue head anchors

The Bowmac anchors were installed into 10 mm holes drilled into the concrete slabs. These holes were thoroughly blown out prior to anchor installation. The anchors were installed as per the layout in Figure 2 with an effective depth of 92mm.

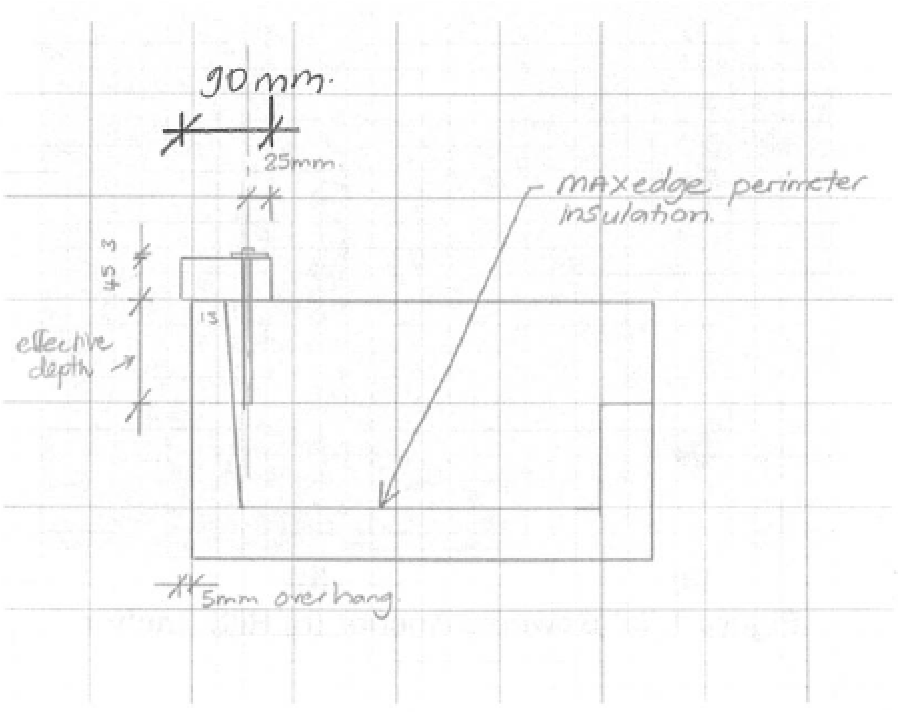

Figure 2. M10 X 140 mm Bowmac blue head anchor installation

3.2.3 10 x 150 mm HUS4-H Hilti threaded anchor

The Hilti anchors were installed into 10 mm holes drilled into the concrete slabs. Anchors were installed with HUS4-MAX capsules and allowed to set for 24 hours prior to testing. Anchors were installed as per the layout shown in Figure 3 with an effective depth of 94 mm.

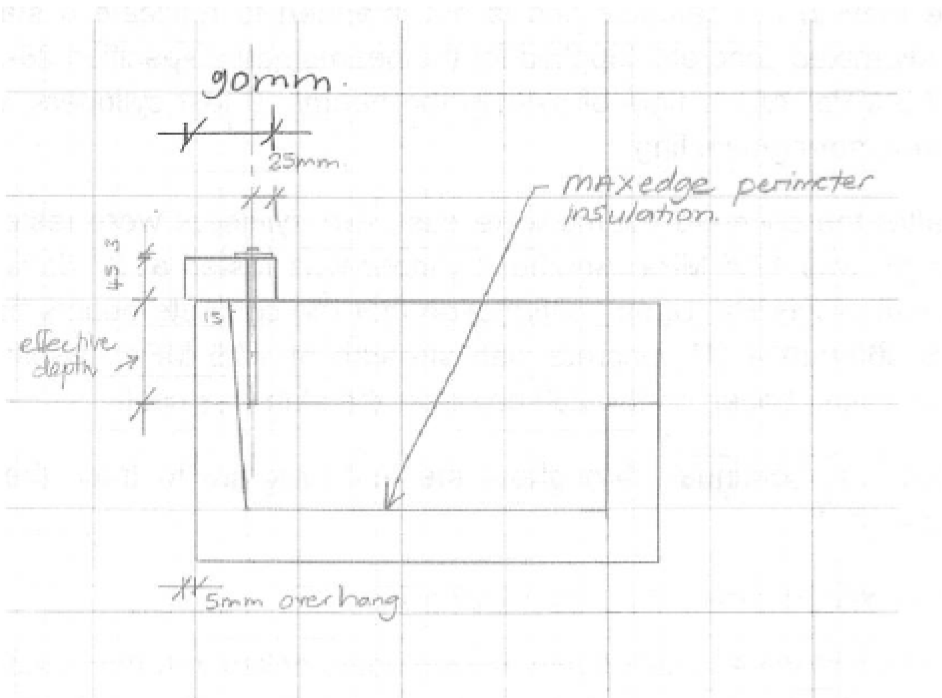

Figure 3. 10 x 150 mm HUS4-H Hilti threaded anchor installation

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4. DESCRIPTION OF TEST

4.1 Date and location of test

Tests were carried out in September, 2023 in the Structures Test Laboratory at BRANZ, Judgeford, New Zealand.

4.2 Test set-up

Testing was performed in three orthogonal directions, out-of-plane, in-plane and in tension. The setup used for each of these directions is slightly different and are given in more detail below. 6 samples were tested for each of the directions.

For all tests, the beams were rigidly fixed to the laboratory strong floor or reaction frames and the load was 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].

4.2.1 Out-of-plane

Out-of-plane testing refers to loading the anchors in horizontal shear in a direction at 90 degrees to the wall plane. For this testing, anchors were installed through a 90 x 45 mm SG8 timber bottom plate to allow for some movement of the top portion of the anchor through timber compression. To ensure that the failure was driven to the anchor/concrete, as opposed to the timber bottom plate, the bottom plate was reinforced, on the side with a steel flat bar. An image of the test setup for out-of-plane testing is shown in Figure 4.

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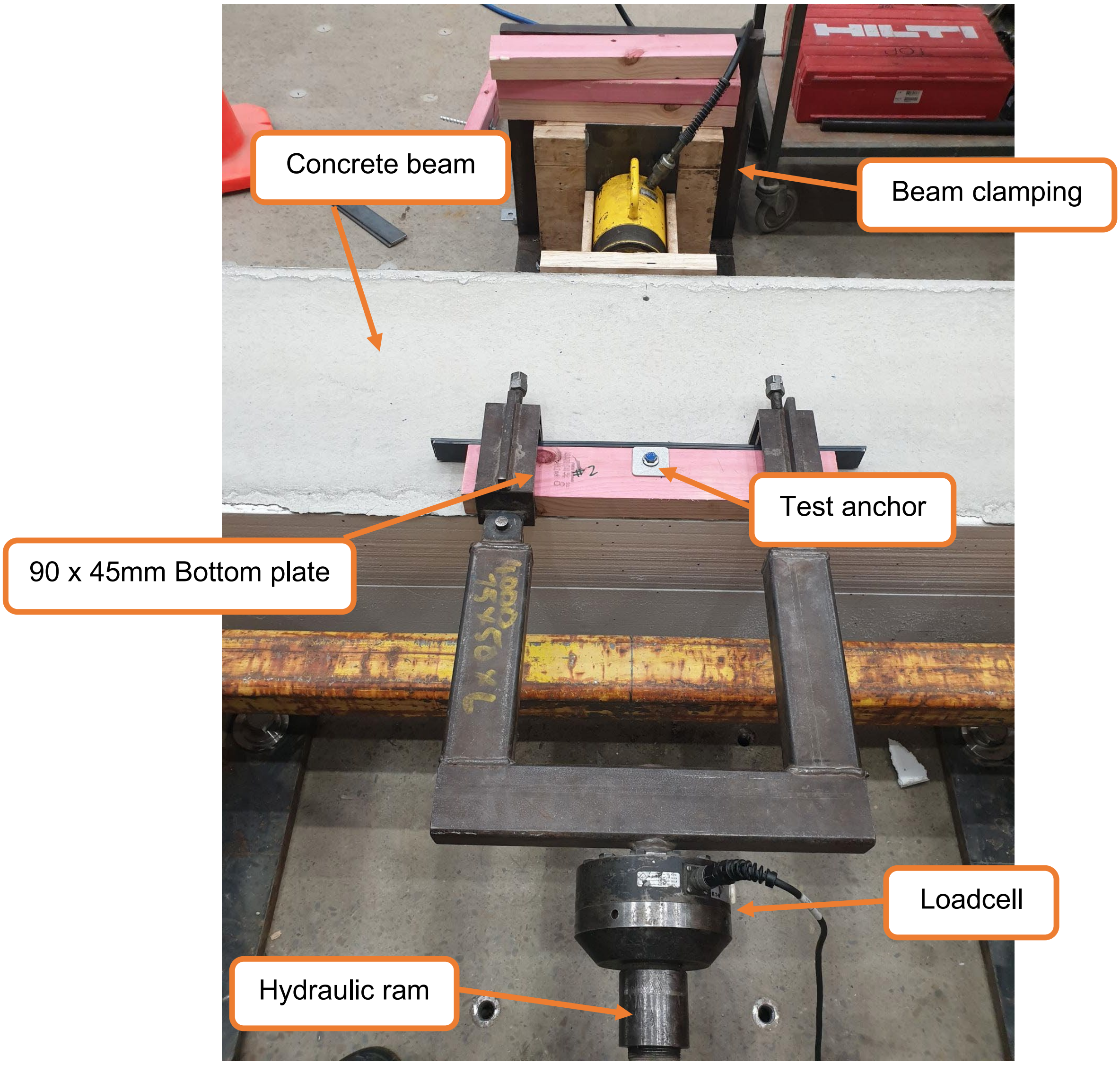
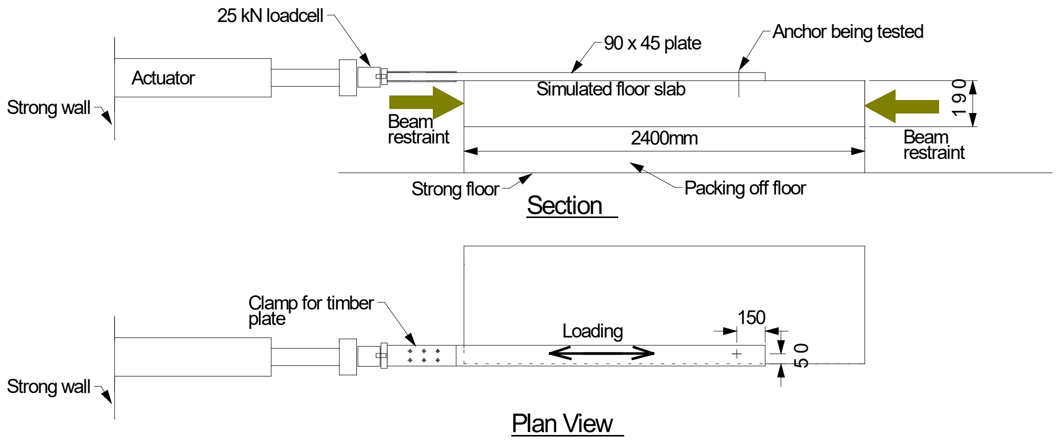


Figure 4. Out-of-plane testing setup for Bowmac Anchor

4.2.2 In-plane

In-plane testing refers to loading the anchors in horizontal shear in the direction parallel to the bottom plate. As with the out-of-plane testing, the anchor was installed through a 90 x 45 mm SG8 timber bottom plate to allow for some head movement through timber compression. An image of the test setup is shown in Figure 5.



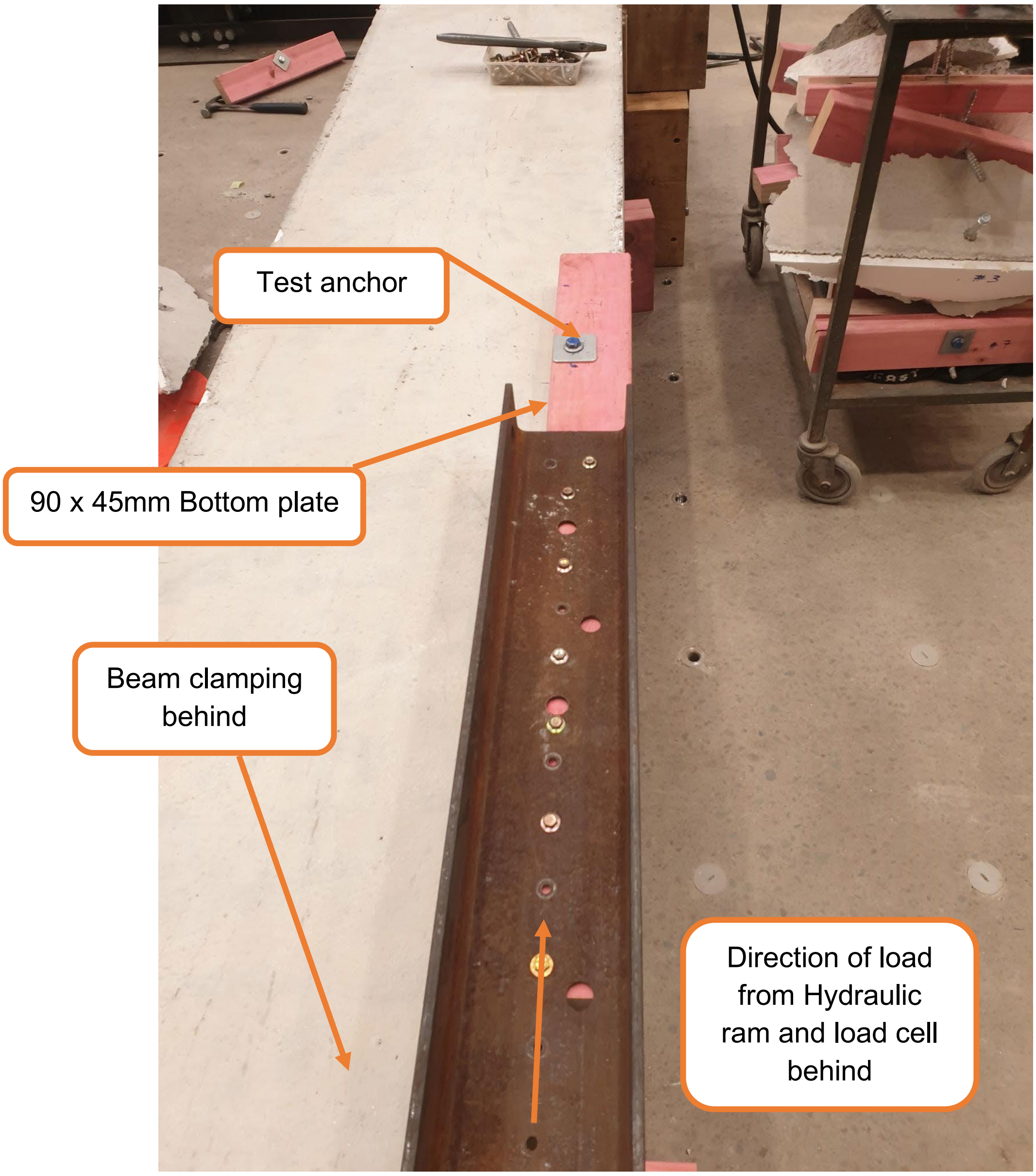


Figure 5. In-plane testing setup.

4.2.3 Tension

Tension testing refers to loading the anchors vertically. For tension testing the anchor was not installed through a timber bottom plate. Instead, a timber packer was used to get the correct embedment depth. Loading in tension was cycled between the target tension load and zero load, i.e. no compression loading was applied. An image of the test setup is shown in Figure 6.

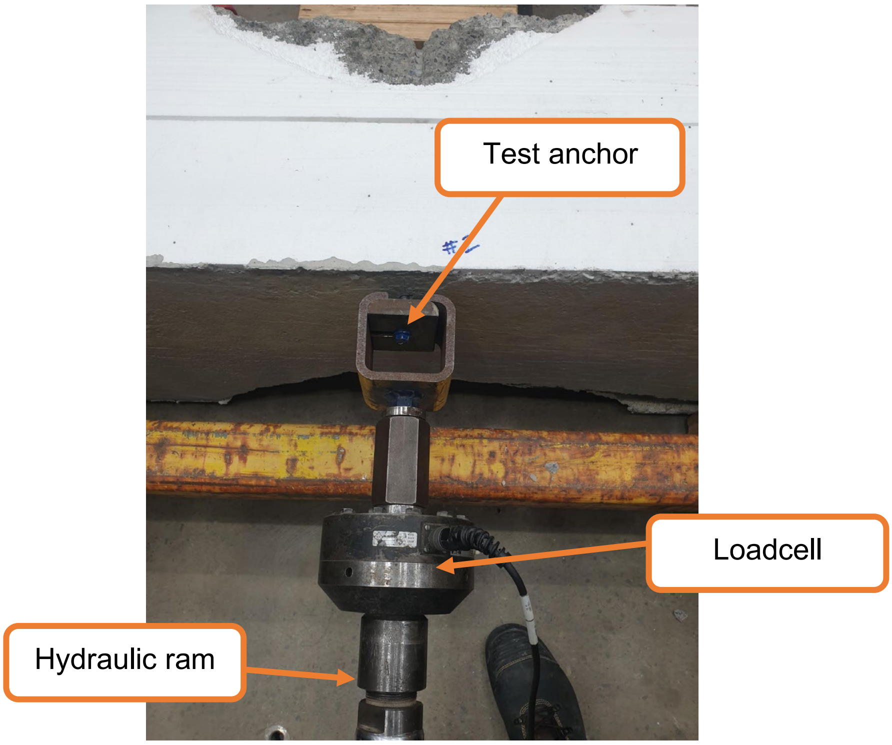


Figure 6. Tension testing setup.

4.3 Test procedure

As required by NZS 3604:2011 [1] clause 2.4.7, testing has been performed following BRANZ Evaluation Method 1 (EM1) [3]. Anchors were loaded cyclically with three full load cycles being performed at each load before the load was increased by 1 kN. The loading continued in this way until failure.

For the out-of-plane and in-plane tests, the target load was cycled between positive and negative directions, while the tension tests only cycled between the target tension load and zero load.

The load and displacement of the anchor were recorded throughout the testing.

5. OBSERVATIONS

5.1 M10 x 140mm Bowmac blue head anchors

All sample failures from testing in tension and out-of-plane were through concrete breakouts. Figure 7 and Figure 8 have been taken after testing and show the typical failure mode.

The in-plane testing typical failure mode was shearing of the steel anchor. This can often be the case for anchors tested in shear when the concrete performance is not limited by a nearby edge. Figure 9 shows an anchor that has sheared off during the in-plane testing.

Figure 7. M10 x 140 mm Bowmac Anchor after failure from tension testing.

Figure 8. M10 x 140 mm Bowmac after failure in out-of-plane testing.

Figure 9. M10 X 140mm Bowmac after failure in-plane testing.

5.2 10 x 150 mm HUS4-H Hilti threaded anchor

All of the failures from testing in tension and out-of-plane were through concrete breakouts. Figure 10 and Figure 11 have been taken after testing and show the typical failure mode.

The in-plane testing typical failure mode was shearing of the steel anchor. Figure 12 shows an anchor that has sheared off during the in-plane testing.

Figure 10.10 x 150mm HUS4-H Hilti threaded anchor after failure from out of plane testing.

Figure 11. 10 x 150mm HUS4-H Hilti threaded anchor after tension testing.

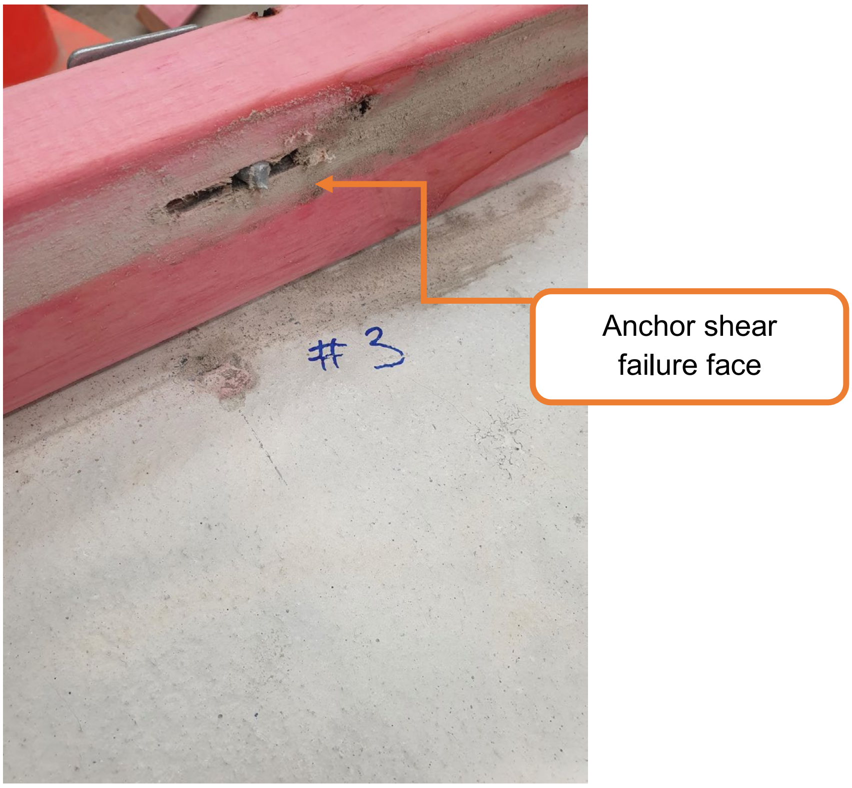


Figure 12. 10 x 150mm HUS4-H Hilti threaded anchor after in plane testing.

6. RESULTS

Concrete cylinders were tested at 7 days, 27 days, 28 days, 32 days and 34 days after the concrete was poured. A plot of the tested concrete strength over time is shown below in Figure 13. The formulas for the straight lines between the data points are also shown on the plot.

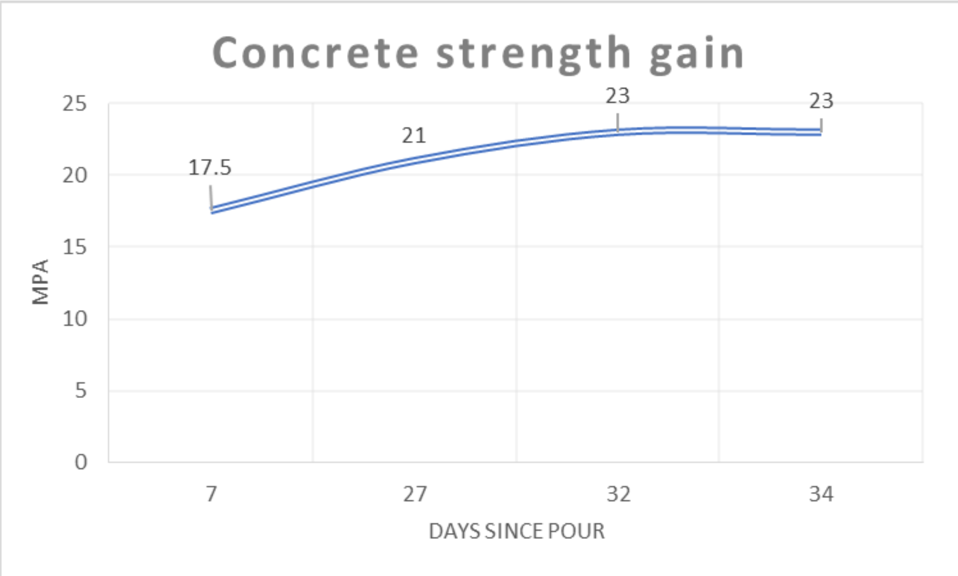


Figure 13. Concrete strength gain over time

All of the test results have been scaled to account for the fact the concrete strength, at the time of testing, is higher than the reference concrete strength of fc' = 20 MPa. The scaling factor used is:

A = sqrt(fc')/sqrt(fcm)

Where A is the scaling factor for concrete strength.

fc' is the specified concrete strength (20 MPa).

Fcm is the concrete strength of cylinders, interpolated for the day of testing using the straight lines shown in Figure 13.

This scaling is based on equations for anchor performance from NZS3101.1:2006 [4] section 17. Once the test results have been scaled by the appropriate concrete strength factor, characteristic strength values have been calculated using the method from BRANZ EM1 [3] as required by NZS 3604:2011 [1] clause 2.4.7. A design capacity is then calculated by scaling the characteristic strength by a strength reduction factor from NZS 3101.1:2006 [4] section 17.

The results of the testing performed on the M10 X 140 Bowmac blue head anchors are shown in Table 1. Cells are shaded green where the resulting capacity exceeds the requirements.

Table 1. Factored Test results for M10 X 140 Bowmac blue head anchors (20 MPa concrete)

Sample / Test	Out-of-plane[1] [kN]	In-plane [kN]	Tension [kN]
#1	7.37	16.73	22.38
#2	7.46	14.70	21.37
#3	7.35	17.49	19.68
#4	7.37	17.34	21.25
#5	7.31	17.53	23.08
#6	7.37	16.49	25.05
Average [kN]	7.37	16.71	21.97
Minimum [kN]	7.31	14.7	19.68
Variation [%]	1.0	6.0	8.0
Characteristic capacity [kN]	7.24	13.34	**17.33 (15)[3]**
Strength reduction factor, ϕ	0.65	0.65	0.65
Design Capacity [kN]	**4.7 (3)[2]**	**8.67 (2)[2]**	**11.26 (7)[2]**

[1]Tested with 12 mm bottom plate packer.
[2] NZS 3604:2011 Clause 7.5.12.3 design capacity requirements are shown brackets.
[3] Industry accepted requirements for characteristic capacity for bracing panel hold down are shown in brackets.

The results of the testing performed on the 10 x 150 HUS4-H Hilti anchors are shown in Table 2.

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Table 2. Factored test results for 10 x 150 HUS4-H Hilti Anchor (20 MPa concrete)

Sample / Test	Out-of-plane [kN]	In-plane [kN]	Tension [kN]
#1	7.5	14.82	27.91
#2	6.5	15.93	32.41
#3	7.46	12.30	27.85
#4	7.39	14.95	27.83
#5	7.40	14.21	26.95
#6	7.46	15.14	25.79
Average [kN]	7.12	14.56	28.12
Minimum [kN]	6.46	12.30	25.79
Variation [%]	7.0	9.0	8
Characteristic capacity [kN]	5.82	10.82	**22.86 (15)[2]**
Strength reduction factor, ϕ	0.65	0.65	0.65
Design Capacity [kN]	**3.78 (3)[1]**	**7.04 (2)[1]**	**14.86 (7)[1]**

[1] NZS 3604:2011 Clause 7.5.12.3 design capacity requirements are shown brackets.
[2] Industry accepted requirements for characteristic capacity for bracing panel hold down are shown in brackets.

7. CONCLUSION

M10 x 140 Bowmac bluehead anchors and 10x150 HUS4-H Hilti Anchors used as bottom plate anchors with slab edges formed by MAXRaft polystyrene edging will comply with Clause 7.5.12.2 of NZS 3604.

The same anchors will provide a 15 kN fixing for end studs of bracing wall elements.

Both conclusions depend on the anchors being accurately located with respect to the edge of the slab, and installed as per manufacturers guidelines.

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8. REFERENCES

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[2] International Organisation for Standardisation (ISO). 2018. 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] Building Research Association of New Zealand. BRANZ Evaluation Method 1 (EM1) – Structural Joints – Strength and Stiffness Evaluation. 1999.

[4] Standards New Zealand (SNZ). 2006. NZS 3101.1:2006. Concrete Structures Standard. Part 1 – The Design of Concrete Structures. SNZ, Wellington, New Zealand.