STRUCTURES TEST REPORT

ST17366-01-1

BOTTOM PLATE ANCHOR TESTING FOR ROCKCOTE RESENE

CLIENT
Rockcote Resene Limited
5 Venutre Place
Christchurch 8024

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.

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1. BACKGROUND

Rockcote Resene Limited have a system to provide concrete floor slab edge insulation. When using this system, bottom plate anchors installed adjacent to this insulation are required to achieve sufficient strength while also having sufficient concrete cover. This report investigates the strength of the specific anchor detail when using HILTI HUS4-H bonded screw anchors. Previous testing has been performed on a similar system and reported in BRANZ report ST15745-01-1.

2. OBJECTIVE

The objective of this testing is to asses HILTI HUS4-H bonded screw anchors to establish their strength capacity for out-of-plane, in-plane, and tension loading in accordance with clause 2.4.7 of NZS 3604: 2011 [1]. Strengths are then compared against the minimum capacity requirements of Clause 7.5.12.3 of NZS 3604: 2011 [1].

3. DESCRIPTION OF SPECIMEN

3.1 Product description

A detail showing the system, along with edge distances and embedment lengths is shown in Figure 1. The system uses a layer of insulation which is applied to the outside slab edge when the concrete floor slab is cast. Due to the thickness allowed for the edge insulation, the bottom plate anchor needs to be offset, within the bottom plate, to achieve a sufficient edge distance in the concrete. The critical edge distance, from the centre of the anchor to the effective edge of the structural concrete is 36 mm. From the outside face of the edge insulation this is 59 mm. The embedment depth of the anchor is 82 mm. The specified minimum concrete strength for use with the system is 25 MPa. The layout of the anchor is shown below in Figure 1.

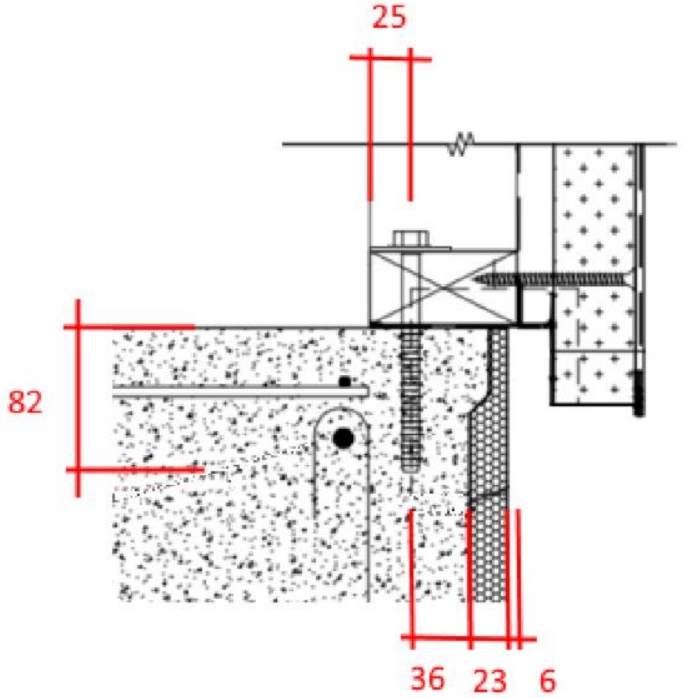

Figure 1. Detail of the bottom plate anchor system.

The bottom plate anchor is a zinc plated M10 x 130 mm HILTI HUS4-H screw anchor. This anchor screws into a 10 mm diameter hole drilled into the concrete slab using a masonry drill bit. In additional to the screw thread, the anchor also utilises an adhesive, with a HILTI HUS4-MAX capsule. This capsule is placed within the hole prior to screw installation. The installation of the screw breaks the capsule and mixes the adhesive.

An image of one of the anchors prior to installation is shown below in Figure 2. The system also uses a 50 x 50 x 3 mm square washer between the anchor head and the bottom plate.

Figure 2. HILTI M10 x 130 HUS4-H anchor and HILTI HUS4-MAX adhesive capsule.

3.2 Specimen construction

Concrete beam specimens were constructed for testing. These specimens were constructed with the edge insulation material included. The concrete beams had dimensions of 300 x 450 x 2400 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 25 MPa. At the time of casting the beams, 9 test cylinders were also cast to allow for concrete strength testing.

Lengths of the Resene Construction Systems DuraTherm gold edge insulation were cut down to remove the bottom edge and make them 150 mm high. The edge insulation was then cast into the concrete samples to create four replica concrete slab edges, per beam, for testing. Two concrete beams were cast to provide a sufficient length of slab edge for testing. 150 mm lengths were left free of edge insulation at each end of the beams to allow for clamping the samples for out-of-plane testing. An overview of the sample construction is shown in Figure 3 and Figure 4.

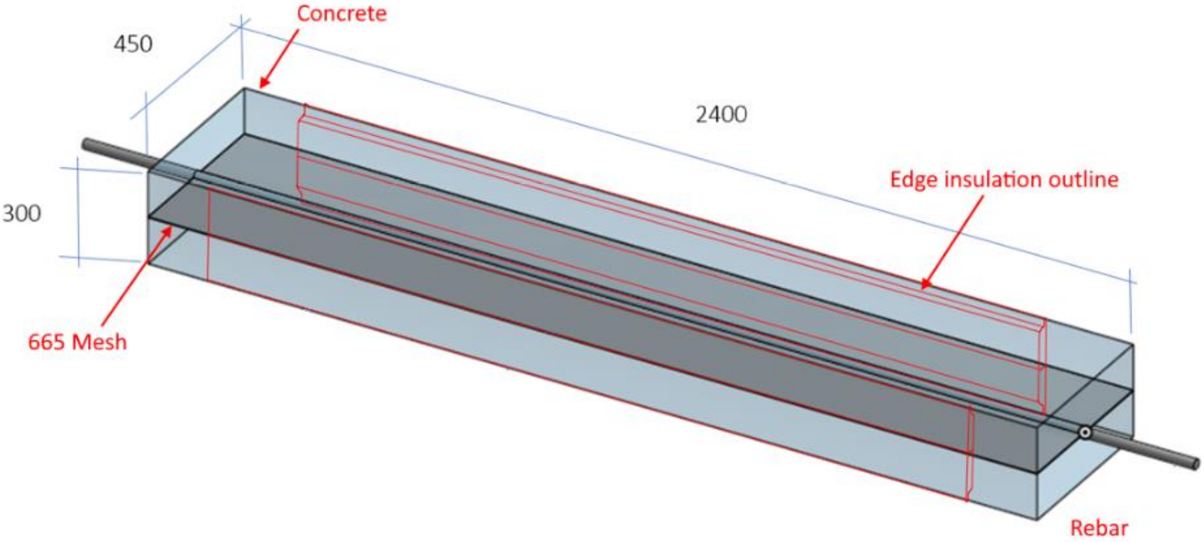

Figure 3. Test sample construction overview.

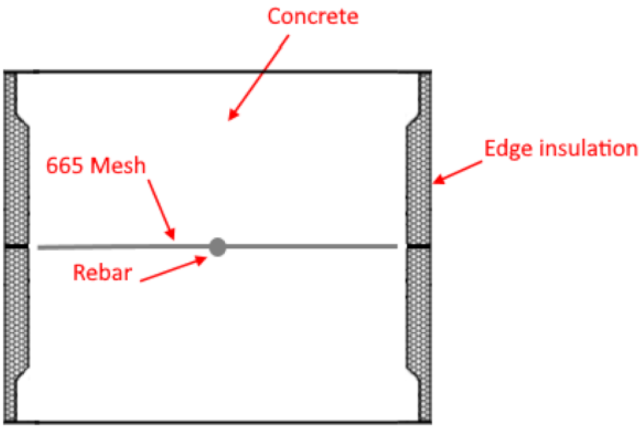

Figure 4. Cross section of concrete beam layout.

10 mm diameter holes were drilled into the concrete beams. Holes in the concrete beams were drilled to a depth of 95 mm and were thoroughly blown out before anchor installation. The HUS4-MAX adhesive capsule was inserted into the hole so it was flush with the concrete surface and the screw anchor was then installed with a total embedment depth of 82 mm. All samples were left for a minimum of 24 hours prior to testing to allow for curing of the HUS4-MAX adhesive.

4. DESCRIPTION OF TEST

4.1 Date and location of test

Tests were carried out in June 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 initially tested for each of the directions. However, due to an issue with the length of one anchor tested in the in-plane direction, and a lack of space on the beams for a repeat test, only 5 in-plane results could be used.

For all tests, the beams were rigidly clamped between reaction frames and the load was applied to the anchors with a 100 kN capacity closed loop hydraulic actuator and measured with a 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 cyclical shear in a direction at 90 degrees to the concrete edge. 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 nearest the anchor with a steel flat bar. An image of the test setup for out-of-plane testing is shown in Figure 5

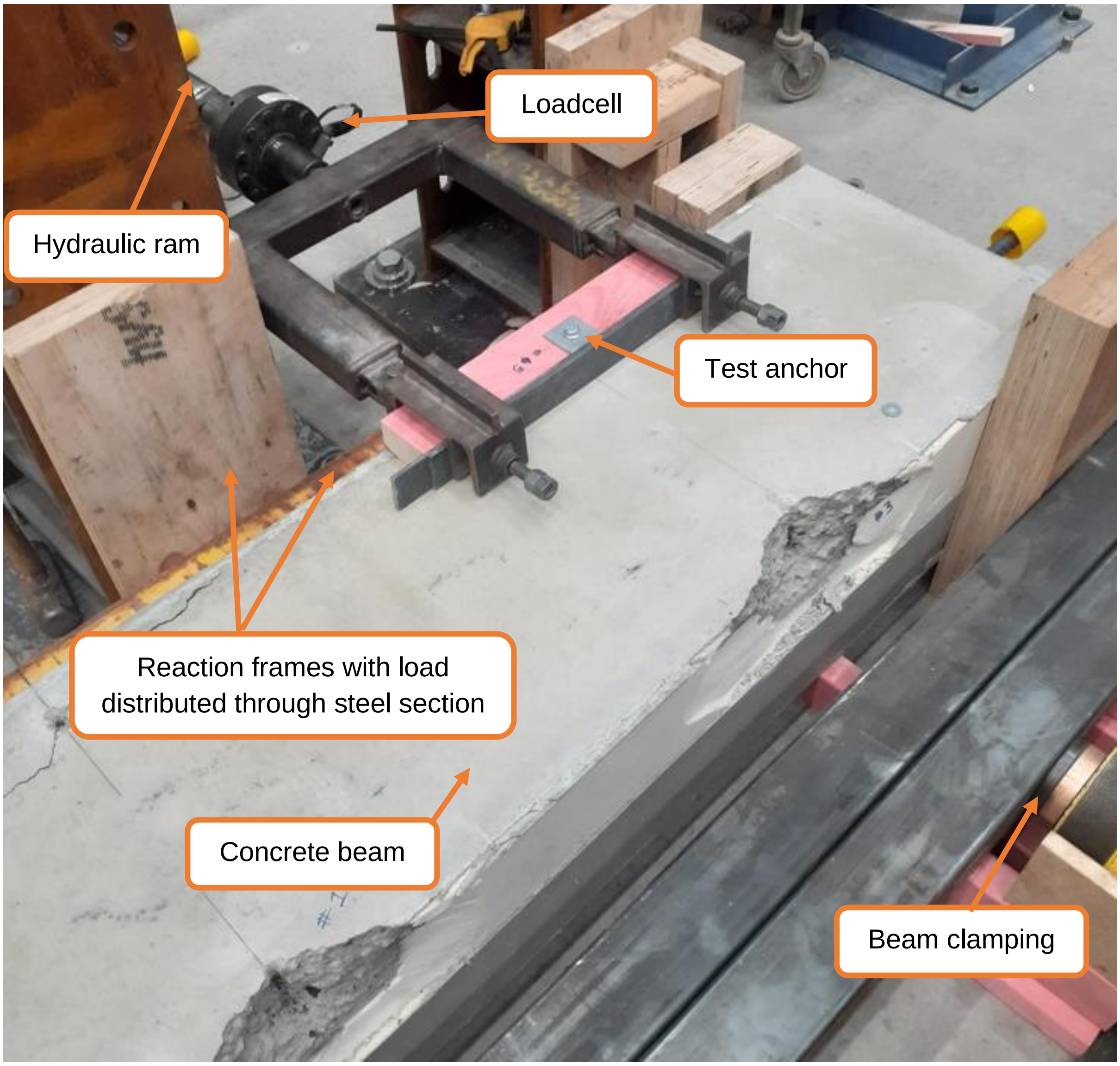

Figure 5. Test setup for out-of-plane testing.

4.2.2 In-plane

In a similar way to the out-of-plane testing, the in-plane testing subjects the anchors to cyclical shear loading. However, with in-plane loading, this shear is in a 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.

4.2.3 Tension

Tension testing refers to loading the anchors perpendicular to the horizontal top surface of the concrete slab. For tension testing the anchor was not installed through a timber bottom plate. Instead, the anchor was directly loaded by the steel testing jig. Loading in tension was cycled between the target tension load and zero load, i.e. no compression loading was tested. An image of the test setup is shown in Figure 6.

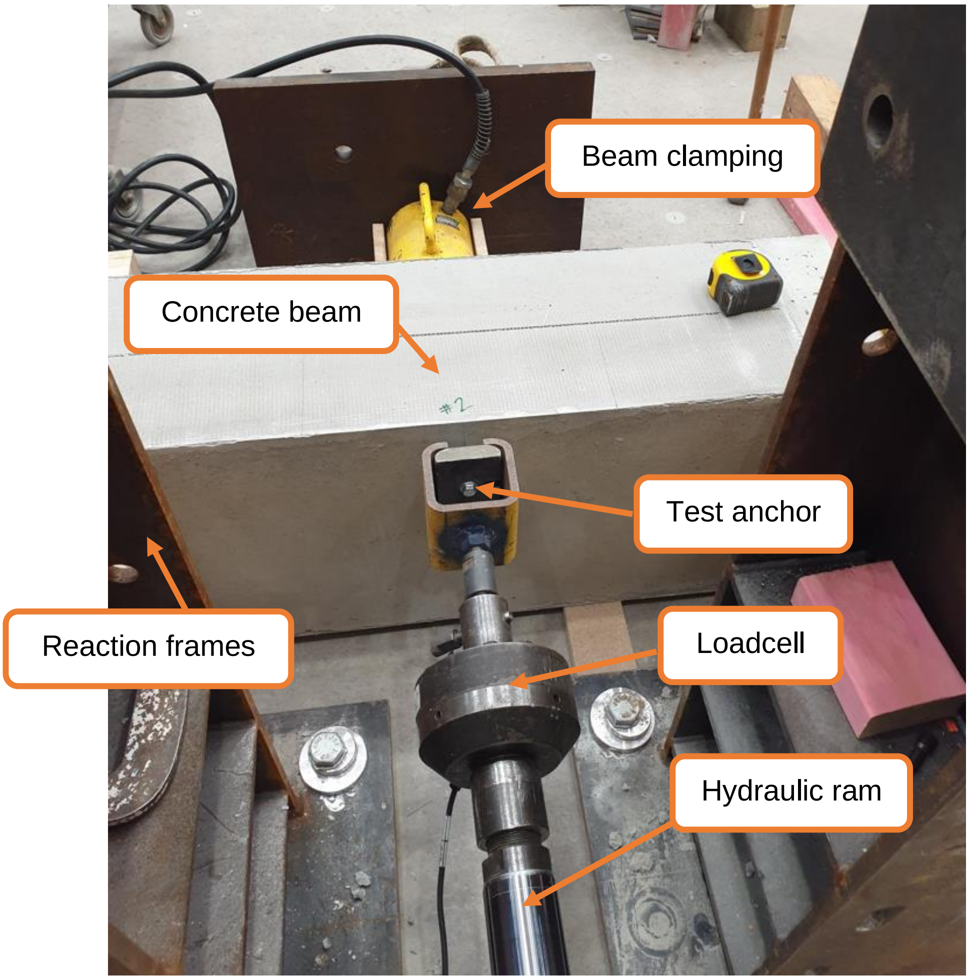

Figure 6. Tension testing setup.

4.3 Test procedure

Samples were tested following the general procedure laid out in BRANZ 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 anchors during testing was recorded throughout.

5. OBSERVATIONS

All of the out-of-plane samples failed through concrete breakout at the edge of the slab. An image of a general failure is shown below in Figure 7.

Figure 7. General failure with out-of-plane loading.

All of the in-plane failures were due to failures in the shank of the anchor at a level near the top of concrete. Prior to failure, the head of the anchor significantly 'worked' the timber of the bottom plate. An image of a typical failure, and the working in the timber bottom plate, is shown in Figure 8.

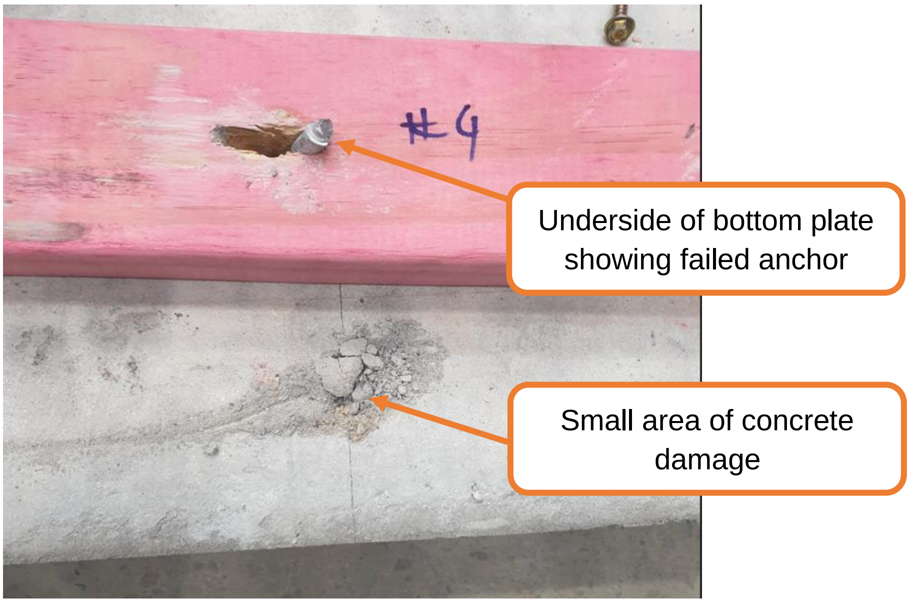

Figure 8. Failure of anchor from in-plane loading.

When loaded in tension, all of the samples broke out large concrete volumes, generally with the anchor still installed firmly in the volume. An image of a typical tension failure is shown in Figure 9.

Figure 9. General failure from tension loading.

6. RESULTS

The raw results from the testing have been adjusted, to account for the actual concrete strength at the time of testing compared to the specified design concrete strength. The concrete strength at the time of testing each individual anchor has been calculated using linear interpolation of the concrete strengths, as tested throughout the anchor testing. The progression of the concrete strength throughout testing, and the equations for interpolating strength, are shown in Figure 10.

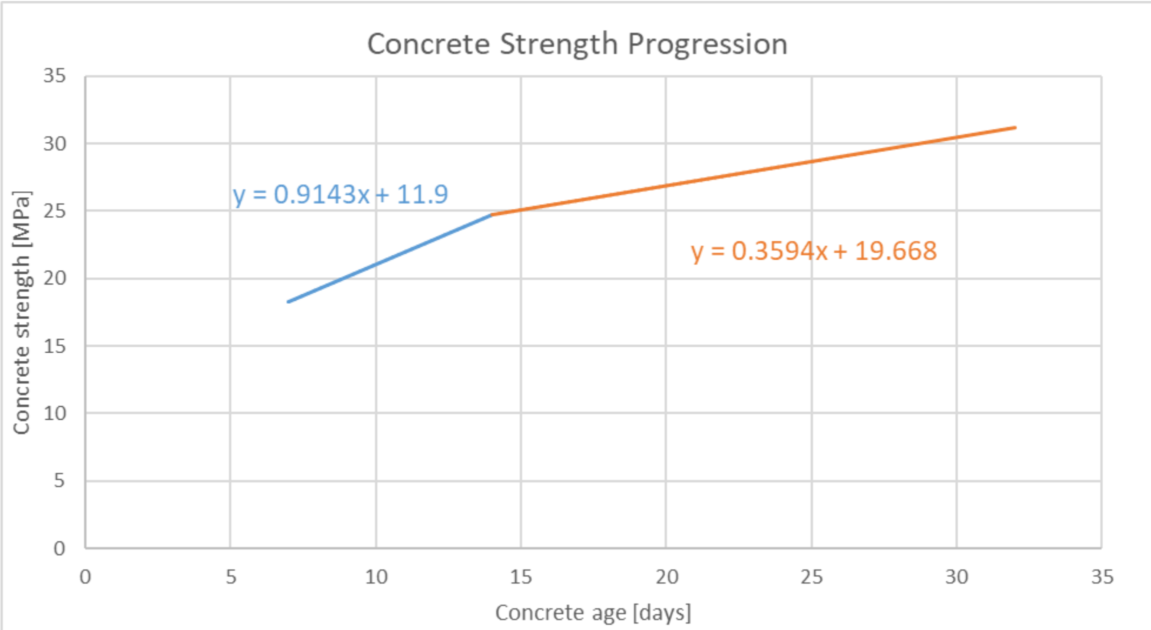

Figure 10. Plot of concrete strength against age.

The data from Figure 10 has been used to scale the test results as follows.

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

Where A is the scaling factor for concrete strength.

fc' is the specified concrete strength (25 MPa).

fcm is the measured concrete strength of cylinders, interpolated for the day of testing using the straight lines shown in Figure 10.

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 equation 2a from BRANZ EM1 [3] as required by NZS 3604:2011 [1] clause 2.4.7. Finally, a design capacity is calculated by scaling the characteristic strength by a strength reduction factor from NZS 3101.1:2006 [4] section 17. Results for the testing have been shown in Table 1.

Table 1. Results of anchor testing.

Concrete Strength	25 MPa		
Situation	Out-of-plane failure load [kN][1]	In-plane failure load [kN][1]	Tension failure load [kN][1]
Installed vertically with an edge distance of 36 mm to centre of anchor.	9.2	9.2	27.8
	8.2	9.2	23.0
	7.2	7.3	25.9
	8.9	8.3	19.6
	6.8	9.2	23.4
	7.5	-	18.6
Average [kN]	8.0	8.6	23.0
Minimum [kN]	6.8	7.3	18.6
Characteristic Strength [kN]	5.6	6.2	14.7
Strength reduction factor, ϕ	0.65	0.65	0.65
Strength Capacity	3.7	4.1	9.6
NZS 3604 Requirement	3	2	7

[1] Test results have been adjusted to account for concrete strength. Results scaled for 25 MPa concrete strength.

7. REFERENCES

[1] New Zealand Standard. NZS 3604:2011. Timber Framed Buildings.

[2] International Organisation for Standardisation (ISO). 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.

[3] Building Research Association of New Zealand. BRANZ Evaluation Method 1 (EM1) – Structural Joints – Strength and Stiffness Evaluation. 1999.

[4] New Zealand Standard. NZS 3101.1:2006. Concrete structures standard. Part 1: The design of concrete structures.