STRUCTURES TEST REPORT

ST11450-001-01

BOTTOM PLATE ANCHOR TESTING FOR BUILDING KING

CLIENT
Building King Limited
11 Rakau Road 4501
Wanganui

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.

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1. OBJECTIVE

Testing was conducted to determine the strengths of an M12 x 150 mm screw anchor, used for securing wall bottom plates to a concrete foundation with a header block edge form, in shear and tension as required by NZS 3604:2011[1] clause 7.5.12.

2. DESCRIPTION OF SPECIMENS

2.1 Product description

The nominal 12 mm diameter anchors had an average shank diameter of 11.6 mm and an average outer thread diameter of 13.6 mm. The anchors had no marking on the yellow painted head. shows a view of the 150 mm long anchor and packaging. The edge distance in all test cases was 50 mm. Figure 1 shows an example of the 150 mm long anchor and packaging. The edge distance in all test cases was 50 mm.

Figure 1. 12 mm x 150 mm Bottom Plate Anchor Screw and Packaging Provided by the Client

2.2 Specimen construction

To test the specimens, two concrete beams were cast with concrete masonry header block permanent edge forms. The beams had been cast 64 days before the tests were undertaken. The ready-mixed concrete supplied for the beams with header block edge forms had a specified 28-day compressive strength of 17.5 MPa. Each beam was nominally 600 mm wide by 190 mm thick and 2530 mm long.

The anchors were installed in accordance with common building practice in the top 600 mm wide by 2530 mm long surface of the beams. The anchors were installed just prior to testing. The first anchor was installed at 300 mm from one end and subsequently at 390 mm centres thereafter. Six replicate tests were undertaken for each of the three loading directions, giving a total of 18 tests. The distance to the edge of the beam was 50 mm from the centre of the anchor. At this distance, it is possible to place a 50 x 50 x 3 mm washer over the bolt and still not interfere with the internal lining in a conventional light timber wall frame, while also allowing for a 5 mm overhang to the outside as per NZS 3604:2011[1]. Each anchor was tightened firmly against a 90 mm by 45 mm SG8 Radiata Pine timber plate, except for the tension tests where the anchors were installed to the same depth but the timber plate was omitted. There was no visible damage to the edge of the beams after installation of the anchors. The embedment depth of the anchors in the concrete was approximately 100 mm.

3. DESCRIPTION OF TESTS

3.1 Date and location of tests

Testing was conducted during June 2019 in the BRANZ Structures Laboratory located in Judgeford, Porirua, New Zealand.

3.2 Test equipment and set-up

There was a separate test set-up for each of the three load directions. Details of these are presented in Figure 2, Figure 3 and Figure 4 for the load along the plate (in-plane loading), load across the plate (out-of-plane loading) and tension, respectively.

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 Grade 1 accuracy [2]. Displacement of the specimen was measured with the LVDT within the actuator, reading to an accuracy of ±0.2 mm.

The load cell and actuator displacement were recorded using a computer-controlled data acquisition system throughout testing.

The shear load was applied to the anchors through the 90 mm by 45 mm kiln dried SG8 grade Radiata Pine timber plate members as shown in Figure 2 and Figure 3. For the tension tests the timber was replaced with a direct application of load on the anchor using a steel “shoe” in order to ensure that the failure related to the anchor and its embedment, rather than the timber plate as shown in Figure 4.

For the out-of-plane shear tests, the load was applied to the timber plate at points centred 188 mm on either side of the anchor. For the in-plane load tests, the end distance to the anchor was a minimum of 150 mm.

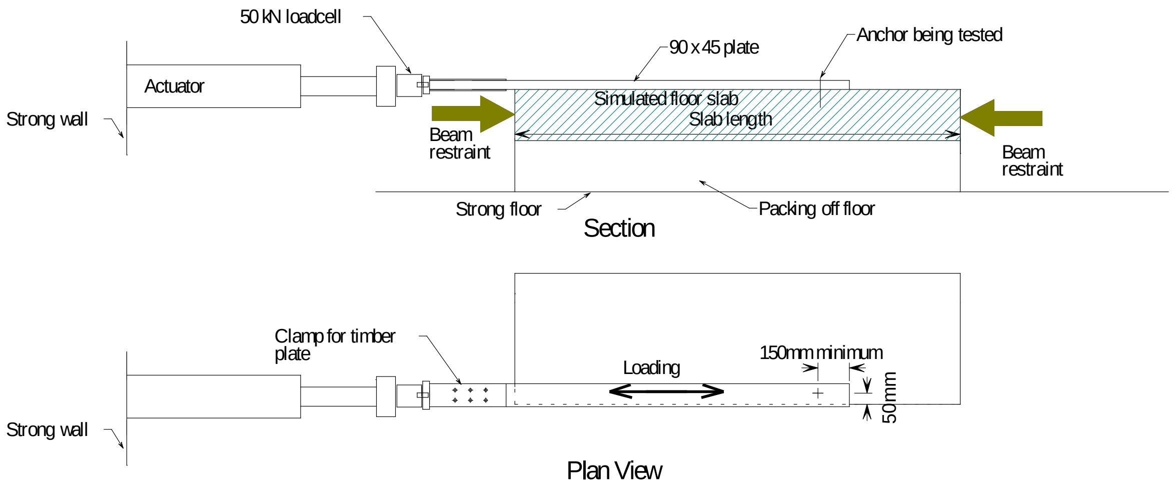

Figure 2. Test Set-up for Load Parallel to the Bottom Plate (masonry header block form)

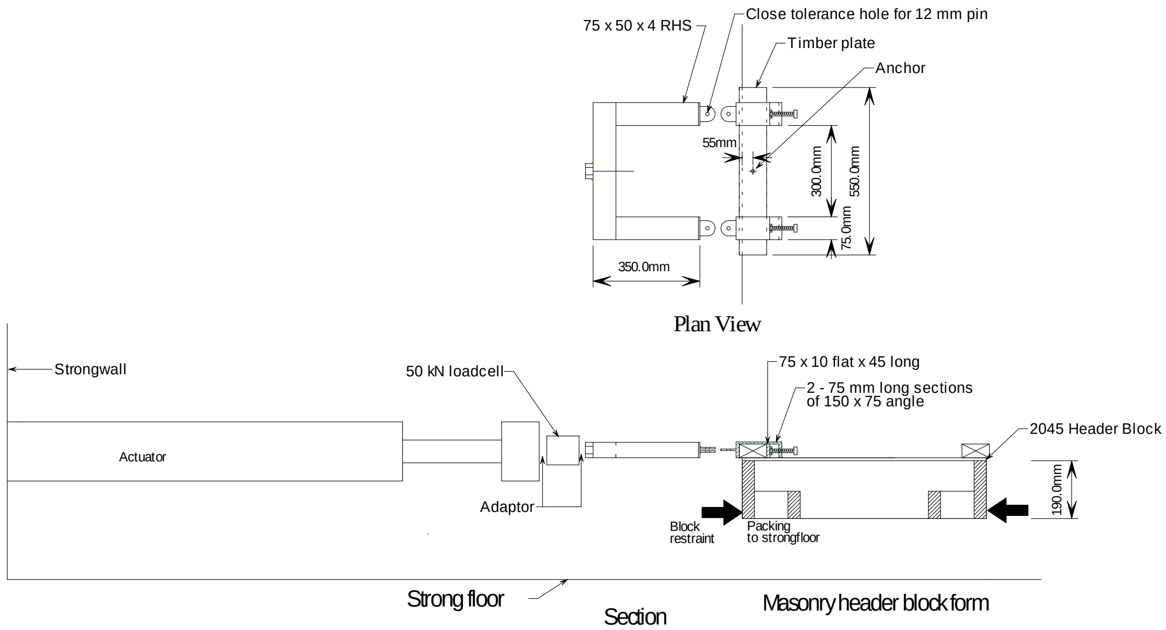

Figure 3. Test Set-up for Out-of-plane Loading

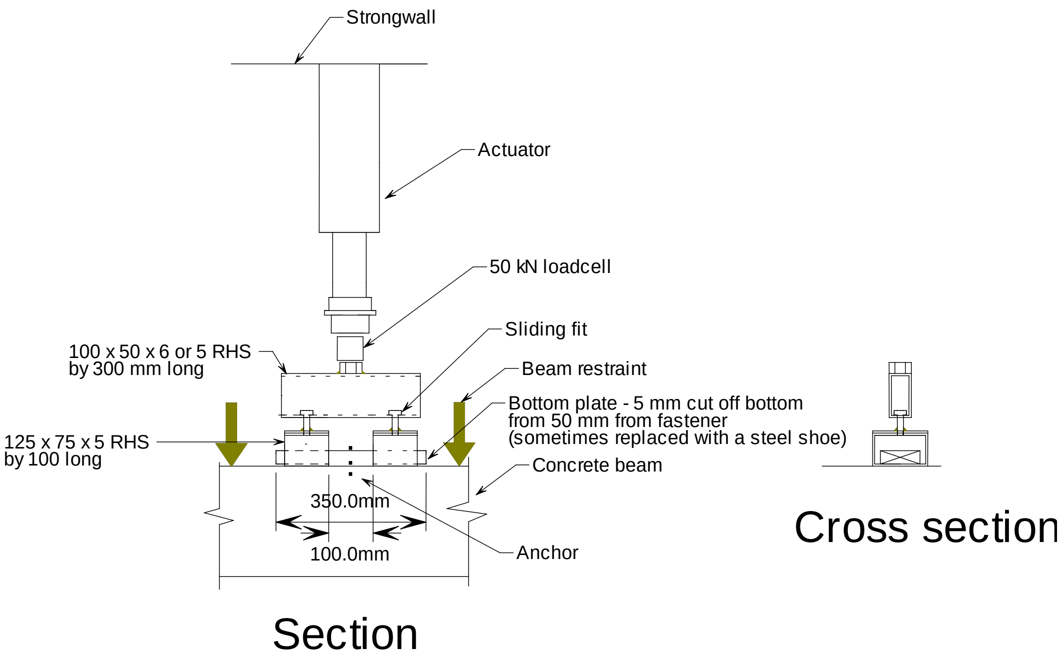

Figure 4. Test Set-up for Tension Load Testing (Note: Testing Did Not Include Section of Timber, Instead the RHS Section was Directly Connected to Head of Anchor)

3.3 Test procedures

The required capacities for proprietary bottom plate anchors from Clause 7.5.12 of NZS 3604:2011 [1] are as follows:

External walls:

Horizontal loads in the plane of the wall: 2 kN

Horizontal loads out of the plane of the wall: 3 kN

Vertical loads in axial tension of the anchor: 7 kN

NZS 3604:2011 [1] states that when the design strength of these anchors is greater than or equal to these loads, they may be spaced at 900 mm centres along the bottom plate. If the capacity derived from the tests is less, the spacing may be reduced to a fraction of the required spacing equivalent to the fraction of the derived capacity divided by the required capacity.

Further, if the anchor is to be used to hold down the ends of bracing elements with ratings of up to 150 bracing units per metre, then the characteristic tensile load is expected to be greater than or equal to 15 kN.

The loading regime was cyclic generally in accordance with BRANZ Evaluation Method EM1 [3], as required by NZS 3604:2011 [1].

For the in-plane loading tests, the first specimen was cycled three times each to load levels of ±0.4kN, ±0.8kN, ±1.2kN, ±1.6kN, ± 2kN, and so on in 0.4kN increments until failure. The subsequent specimens were cycled to multiples of the displacement recorded at a load equal to half the ultimate load achieved in the first specimen. This displacement, δy, was determined to be 4 mm. Therefore, test displacement increments were ±1 mm, ±1.5 mm, ±2 mm, ±3 mm, ± 4 mm, ±8 mm, ±16 mm, ±24 mm, ±32 mm, etc, until failure.

For the out-of-plane shear tests, the loading regime involved cycling three times to each of ±0.75 kN, ±1.5 kN, ±2.25 kN, ±3 kN, ±3.75 kN, etc, until failure.

For all tension test specimens, the loading regime involved cycling three times from zero load to each of +5 kN, +6 kN, +7 kN, and so on in +1 kN increments until failure.

4. OBSERVATIONS

The failure mechanisms are divided into loading direction and are stated as the general mode of failure.

In-plane shear

Fatigue failure in the shank of the anchor in all cases (Figure 5) just below the surface of the concrete.

Out-of-plane shear

In all cases the concrete header block face shell spalled from the beam (Figure 6).

Tension

In all cases the anchors pulled out as a result of the concrete failing at the anchor (Figure 7).

Figure 5. Typical Failure of In-Plane Shear Test Specimens

Figure 6. Typical Failure of Out-of-Plane Shear Test Specimens

Figure 7. Typical Failure of Tension Test Specimens

5. RESULTS

5.1 Concrete Compressive Strength

The average strength of three cores taken from the beams at the time of testing was 21.5 MPa.

5.2 Anchor Test Results

The individual anchor failure loads and derived capacities are presented in Table 1.

For the tension tests and the out-of-plane shear tests, the failure load was taken as the load level to which a series of three cycles was made immediately before the cycles in which failure occurred. For the in-plane shear tests, the failure strength was taken as the average of the push and pull third cycle peak loads in the series of three complete cycles just prior to failure of the anchor.

The capacity of the anchors is determined by multiplying the characteristic value by the strength reduction factor, ϕ, of 0.8. NZS 3603:1993 [4], to which NZS 3604:2011 [1] refers for the value to be used for ϕ, requires a factor of 0.8 for nails or toothed metal plate connectors in lateral loading and 0.7 for other types of fasteners.

Table 1. Individual Specimen Test Results and Derived Capacities for Building King M12 x 150 mm Screw Anchors

Anchor	Situation	In-plane failure loads (kN)$^{+}$	Out-of-plane failure load (kN)	Tension failure load (kN)
12 x 150 Screw Anchor	External wall, concrete masonry header block formwork, 50mm edge distance	17.0	10.7	20.9
		20.7	9.6	28.9
		17.1	7.7	19.9
		14.6	9.0	25.0
		18.8	9.9	28.0
		17.7	9.9	24.1
	Mean	17.6	9.5	24.5
	Characteristic**	12.2	6.5	15.9
	Capacity	9.8	5.2	12.7
	Target capacity	2.0	3.0	7.0
	Maximum spacing of anchor = 900 mm			

+ = mean of two directions

** The characteristic, R_{ek}, is determined from:

$$R_{ek} = (minimum\ result) * (n/27)^{v}$$

where n is the number of specimens and v is the coefficient of variation (standard deviation/mean)

The spacing is derived as described in Section 3.3.

6. REFERENCES

1. Standards New Zealand. NZS 3604:2011. Timber Framed Buildings. SNZ, Wellington, New Zealand.

2. International Organisation for Standardisation (ISO). 2015. *ISO 7500:2015 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, 1999. Evaluation Method No. 1 (1999). Structural joints – strength and stiffness evaluation. BRANZ Evaluation Method No 1.

4. Standards New Zealand. NZS 3603:1993. *Timber structures standard.* SNZ, Wellington, New Zealand.