STRUCTURES TEST REPORT

ST13553-001-01

SIMPSON STRONG-TIE BOTTOM PLATE ANCHOR

CLIENT
Simpson Strong-Tie (New Zealand) Limited
52 Arrenway Drive
Rosedale
Auckland 0632

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

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FIGURES

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1. OBJECTIVE

Testing was conducted to determine the tensile and shear design capacities of Simpson Strong-Tie Titen Heavy Duty (THD) 12 x 150 mm anchor used for securing bottom plates of timber framed walls to concrete slabs, as required NZS 3604:2011 [1] Clause 7.5.12. The Clause specifies the following strength requirements for proprietary anchors spaced at a maximum of 900 mm centres where masonry header blocks are not used:

- 2 kN: horizontal loads in the plane of the wall.
- 3 kN: horizontal loads out of the plane of the wall.
- 7 kN: vertical loads in axial tension of the anchor.

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 capacities of THD 12 x 150 mm anchor were investigated for 20 Mpa and 17.5 Mpa concrete compression strengths.

2. DESCRIPTION OF SPECIMEN

2.1 Product description

The THD 12 x 150 mm screw bolt anchor samples were supplied by the Client. The minimum embedment depth and edge distance were specified as 95 mm and 48 mm, respectively. **Figure 1** shows an example of the THD 12 x 150 mm screw bolt.

Figure 1. THD 12 x 150 mm screw bolt sample.

2.2 Specimen construction

To test the anchor samples, three 210 mm thick x 600 mm wide x 2530 mm long slabs were cast. The ready-mixed concrete supplied had a specified 28-day compressive strength of 17.5 MPa. Three cylinder tests were carried out on day 8 and 9 after pouring, and three core test was carried out on day 32 after pouring, the results are shown in **Table 1**.

Table 1. Concrete compressive test results.

Days after pouring	Concrete compressive strength (MPa)
8	16.5
9	17.5
32	20

Based on the results, the following strength-time relationship was assumed (Figure 2).

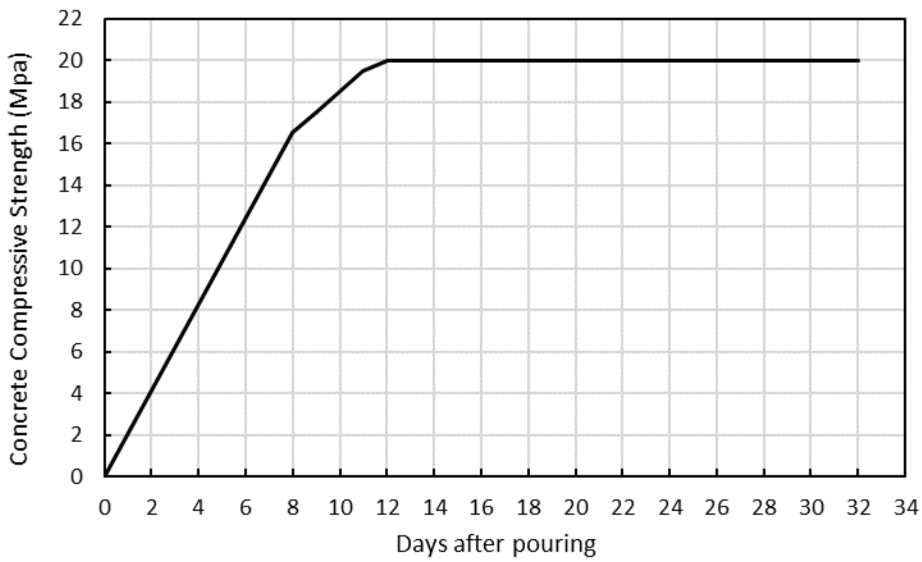

Figure 2. Concrete strengths vs time after pouring.

The anchor samples were installed in accordance with the product manual on the top surface of the concrete slabs. Each anchor was installed just prior to testing. The first anchor on each long side of a slab was installed at 300 mm from one end of the slab, and subsequently at 390 mm centres thereafter. The distance to the slab edge for all the anchors tested was 48 mm from the centre of the anchor, and the anchor embedment depth into the concrete was 95 mm. For the shear tests, each anchor was installed over a 45 x 90 mm SG8 Radiata Pine timber plate and HIANDRI packers which were inserted between the plate and concrete. The timber plate and HIANDRI packers were omitted for the tension tests but the anchors were installed to the same embedment depth (95 mm). No visible damage was observed on the concrete and timber after installation of the anchors.

Six replicate tests were undertaken for each of the horizontal loading directions, and eight tests were conducted in tension, giving a total of 20 tests.

3. DESCRIPTION OF TEST

3.1 Date and location of test

Test were carried out in February and March 2021 in the Structures Test Laboratory at BRANZ, Judgeford, New Zealand.

3.2 Test equipment and set-up

The set-up the out-of-plane shear tests, in-plane shear tests and tensile tests are shown in Figure 3, Figure 4, and Figure 5, respectively.

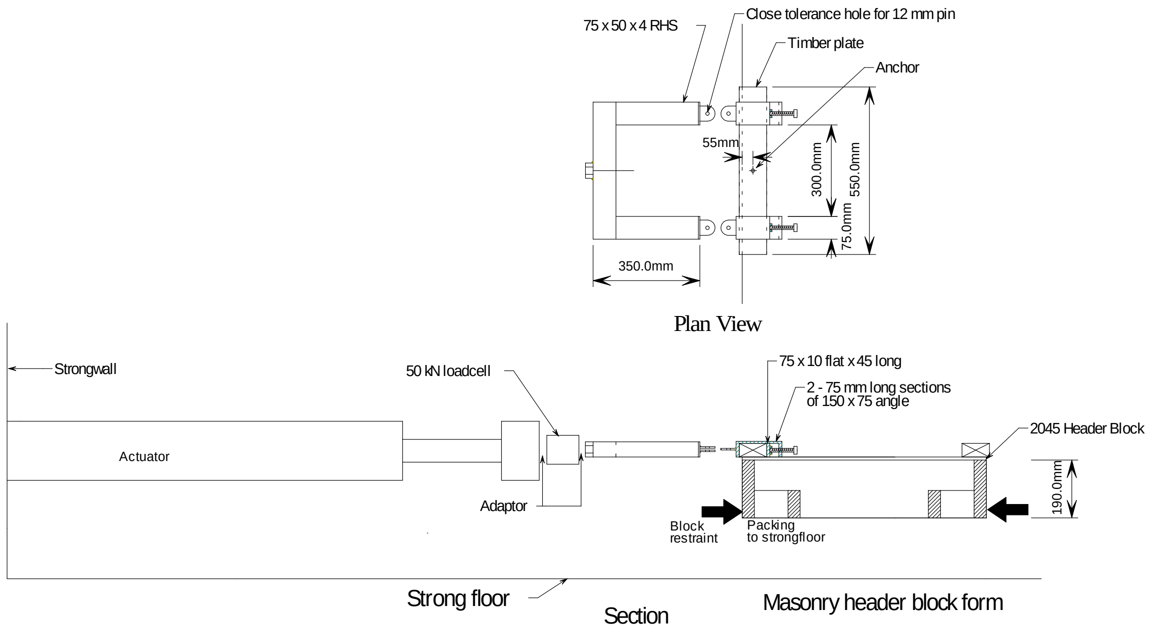

Figure 3. Out-of-plane test set-up.

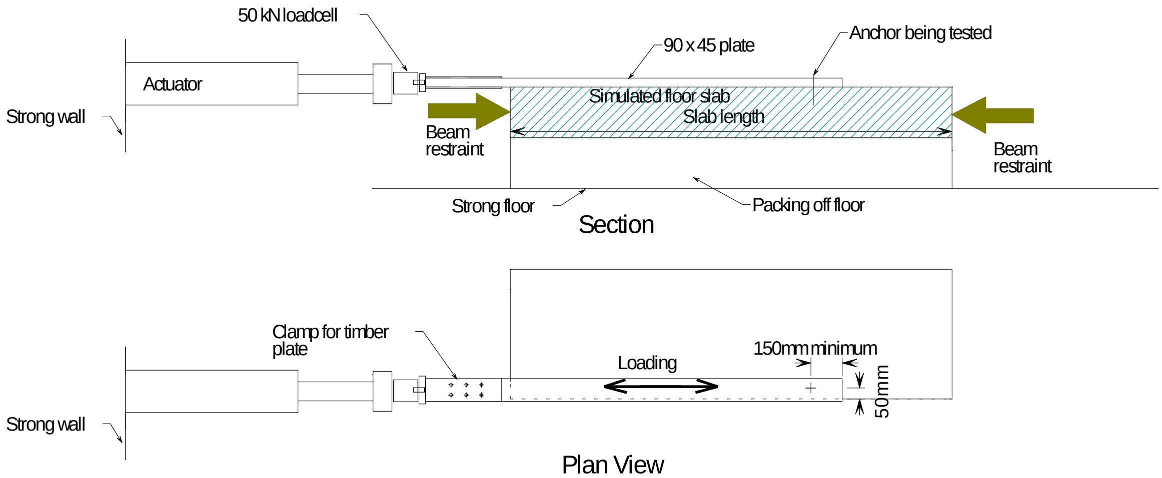

Figure 4. In-plane test set-up.

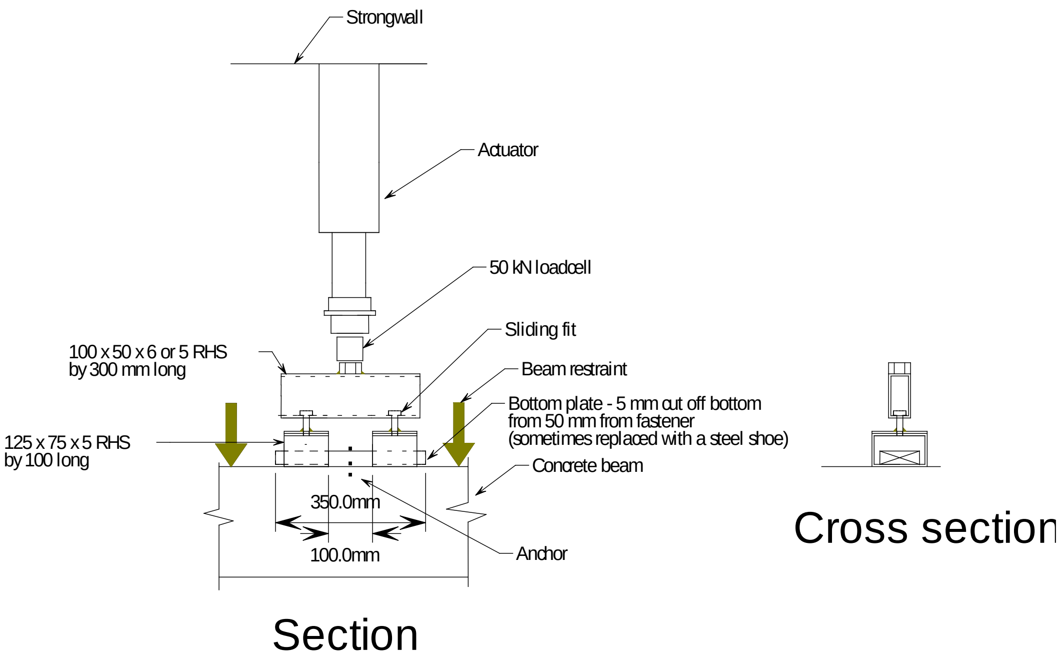

Figure 5. Tensile test set-up.

The slabs 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 2018 Grade 1 accuracy [2]. Displacements were measured with the LVDT within the actuator, reading to an accuracy of ±0.2 mm. The loads and displacements were recorded using a computer-controlled data acquisition system throughout testing.

The shear load was applied to the anchors through the 45 x 90 mm SG8 Radiata Pine timber plates as shown in Figure 3 and Figure 4. For the out-of-plane tests, the load was applied to the timber plate at points centred 188 mm on either side of the anchor. For the in-plane tests, the end distance to the anchor was a minimum of 150 mm.

For the tension tests the timber was replaced with a direct application of load on the anchors using a steel bracket and packing plate (Figure 6) to ensure that the failure related to the anchors and the embedment into the concrete, rather than the timber plates.

Figure 6. Load applicator for the tensile tests.

3.3 Test procedures

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

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. The tests were carried out at 18.5 MPa concrete compression strength (f'_c).

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 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.

Both the in-plane shear and tensions tests were carried out 20 MPa concrete compression strength.

4. OBSERVATIONS

The general failure mechanism of each loading direction is stated in

Table 2. Failure mechanisms

Test	Failure mechanism	Figure
Out-of-plane shear	Slab edge breakout	Figure 7
In-plane shear	Anchor fracture	Figure 8
Tension	Anchor withdrawal due to concrete spalling	Figure 9

Figure 7. Out-of-plane shear, typical slab edge breakout failure.

Figure 8. In-plane shear, typical anchor shear failure.

Figure 9. Tension, typical concrete breakout failure.

5. RESULTS

For the out-of-plane and tensions tests, the failure load of each test was taken as the load to which a series of three cycles was achieved immediately before the cycle in which failure occurred. For the in-plane shear tests, the failure load of each test 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 results for the out-of-plane tests are shown in **Table 3**. The anchors were tested at 18.5 MPa concrete strength, and the loads for 20 MPa and 17.5 MPa concrete were derived by multiplying the actual test results by a factor $\varphi = \sqrt{f'_{c,target\ strength}} \Big/ \sqrt{f'_{c,actual\ strength}}$ which is the square root of the ratio of the target concrete strength (20 MPa or 17.5 MPa) to the actual concrete strength (18.5 MPa) when the testing was conducted.

The anchor capacity is determined by multiplying the characteristic strength by the strength reduction factor ϕ = 0.75 which is the strength reduction factor required by NZS 3101.1:2006 [4] Clause 17.5.6.4 for anchors in concrete acting in shear.

Table 3. Out-of-plane shear test results.

	Out-of-plane shear (kN)		
	18.5 MPa concrete	**20 MPa concrete**	**17.5 MPa concrete**
Specimen 1	6.75	7.02	6.57
Specimen 2	6.00	6.24	5.61
Specimen 3	6.75	7.02	6.31
Specimen 4	6.75	7.02	6.31
Specimen 5	6.00	6.24	5.61
Specimen 6	6.00	6.24	5.61
Mean	6.38	6.63	6.01
Std dev	0.41	0.43	0.44
Variance	0.06	0.06	0.07
Characteristic (kN)	**5.45**	**5.66**	**5.03**
Phi	0.75	0.75	0.75
k	1	1	1
Capacity (kN)	**4.08**	**4.25**	**3.77**
NZS 3604 requirement for 900 mm spacing (kN)	3.0	3.0	3.0
	Pass	Pass	Pass
Maximum spacing (mm)	900	900	900

The characteristic strength of each data set was calculated using Equation (2a) of BRANZ Evaluation Method 1 [3]:

$$R_k = P_{min}\left(\frac{n}{27}\right)^v$$

Where R_k is the characteristic strength of the configuration, v is the coefficient of variation (COV) of the individual results, n is the number of tests, and P_{min} is the minimum value of the test data set.

The test results for in-plane shear and tension are provided in **Table 4** and **Table 5,** respectively. Both tests were carried out at 20 MPa concrete compression strength, so the values for 17.5 MPa concrete were scaled down from the 20 MPa concrete results using φ.

Table 4. In-plane shear test results.

	In-plane shear (kN)	
	20 MPa concrete	**17.5 MPa concrete**
Specimen 1	9.70	9.07
Specimen 2	11.26	10.53
Specimen 3	9.06	8.47
Specimen 4	10.13	9.48
Specimen 5	10.36	9.69
Specimen 6	9.69	9.06
Mean	10.03	9.39
Std dev	0.75	0.70
Variance	0.07	0.07
Characteristic (kN)	**8.10**	**7.58**
Phi	0.75	0.75
k	1	1
Capacity (kN)	**6.07**	**5.68**
NZS 3604 requirement for 900 mm spacing (kN)	2.0	2.0
	Pass	Pass
Maximum spacing (mm)	900	900

The anchor tension capacity, which was used to compare against the 7kN bottom plate anchor in tension requirement from NZS 3604:2011 [1], was calculated by ϕ = 0.65, which is the strength reduction factor for anchors in concrete acting in tension, specified by NZS 3101.1:2006 [4] Clause 17.5.6.4.

Table 5. Tension test results.

	Tension (kN)	
	20 MPa concrete	**17.5 MPa concrete**
Specimen 1	22.07	20.64
Specimen 2	21.13	19.77
Specimen 3	26.25	24.55
Specimen 4	28.14	26.32
Specimen 5	28.13	26.31
Specimen 6	25.11	23.49
Specimen 7	25.08	23.46
Specimen 8	24.16	22.60
Mean	25.01	23.39
Std dev	2.55	2.38
Variance	0.10	0.10
Characteristic (kN)	**18.67**	**17.46**
Required characteristic strength for 150 BU/m @ 900 mm crs. (kN)	15.0	15.0
	Pass	Pass
Maximum spacing (mm)	900	900
Phi	0.65	0.65
k	1	1
Capacity (kN)	**12.13**	**11.35**
NZS 3604 requirement for tension for 900 mm spacing (kN)	7.0	7.0
	Pass	Pass
Maximum spacing (mm)	900	900

6. SUMMARY

The following conclusions can be made based on the results presented above.

- The tested samples of Simpson Strong-Tie THD 12 x 150 mm anchors satisfied all the NZS 3604:2011 [1] Clause 7.5.12 strength requirements for bottom plate anchors for both 20 MPa and 17.5 MPa concrete.

- The tested samples of Simpson Strong-Tie THD 12 x 150 mm anchors satisfied the 15 kN characteristic bracing element hold-down requirement for both 20 MPa and 17.5 MPa concrete.

- The THD 12 x 150 mm anchors must be installed at a minimum edge distance of 48 mm and a minimum embedment depth of 95 mm into concrete.

7. REFERENCES

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

[2] International Organisation for Standardisation (ISO). 2018. *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 3101.1:2006. Concrete Structures Standard. Part 1 – The Design of Concrete Structures. SNZ, Wellington, New Zealand.

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