CYCLONE TESTING STATION

COLLEGE of SCIENCE and ENGINEERING

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Serviceability and Static Simulated Racking Strength Testing of Moroblock Wall System

By

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for

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NATA Accredited Laboratory Number 14937
Accredited for compliance with ISO/IEC 17025.

1 Introduction

The aim of this test programme was to perform serviceability and static simulated racking strength testing of the *Moroblock* wall system manufactured by *E-Abode Pty Ltd.* The test wall panels were loaded in accordance with the *TR440* serviceability and static strength test regimes. The test samples were manufactured by the client. The testing was performed with the use of new test materials.

The tests were conducted using the hydraulic racking testing equipment, in the Structures Laboratory, located at James Cook University. The Cyclone Testing Station is a NATA accredited testing laboratory. All trials for this testing programme were performed in accordance with NATA requirements.

2 Test Programme

A programme of racking strength testing was conducted on *Moroblock* wall system. A summary of the test programme is provided in Table 1.

Table 1: Test Programme Summary for Racking Strength Tests on *Moroblock* Wall System

Wall No.	Trial No.	Number of Tie Down Rods	Wall Length (mm)	Wall Height (mm)	Test Regime
Wall 1	S1	3	2430	2675	TR440 Serviceability Racking (Pull)
	S2				TR440 Serviceability Racking (Push)
	SS1				TR440 Static Strength Racking (Pull)
Wall 2	S3	2	1230	2670	TR440 Serviceability Racking (Pull)
	S4				TR440 Serviceability Racking (Push)
	SS2				TR440 Static Strength Racking (Pull)

3 Sample Description

The *Moroblock* samples were stated to be manufactured from 18 mm thick engineered bamboo panels. The standard size of a *Moroblock* was nominally 800 mm in length and 300 mm in height. Half-length blocks were used at the end of rows due to the staggered pattern used to build the walls. The width of the blocks was 200 mm (i.e. thickness of wall).

The blocks were described to have been assembled horizontally together with a key cut from hardwood 12 mm × 6 mm shaped into a double dovetail. The rows of blocks were fitted together at top and bottom using a tongue and groove system 6 mm × 6 mm.

Vertical wall spacers, manufactured from engineered bamboo panels, were used to join the walls faces together. The wall spacers were 400 mm centred with the end wall spacers at 200 mm from the edges of the walls. A dovetail female shape was cut on the internal faces of the walls and the wall spacers had a matching male dovetail shape to link both wall faces together.

The wall spacers for *Wall 1* were stated to have been manufactured in a way that the fibre orientation of the outer skins of the wall spacers were running horizontally in respect to the whole wall.

The wall spacers for *Wall 2* were stated to have been manufactured in a way that the fibre orientation of the outer skins of the wall spacers were running vertically in respect to the whole wall.

For both walls a 'ground plate' manufactured from engineered bamboo panels was screwed to the bottom of the wall using type 17 stainless steel, 8 gauge, 9 thread per inch, 50 mm (8-9 × 50 mm) countersunk square drive screws as seen in Figure 3.

For both walls, the top plate and wall sides were manufactured from engineered bamboo panels and assembled to the wall using a 6 mm × 6 mm tongue and groove system, glued with PVA glue and screwed using type 17 stainless steel, 8 gauge, 9 thread per inch, 50 mm (8-9 × 50 mm) countersunk square drive screws as seen in Figure 3.

The panels were stated to have been glued together using PVA glue.

Figure 1 shows *Wall 1* constructed with the *Moroblock* system and Figure 2 shows *Wall 2* constructed with the *Moroblock* system.

Figure 1: *Moroblock* Wall System Sample (Wall 1)

Figure 2: *Moroblock* Wall System Sample (Wall 2)

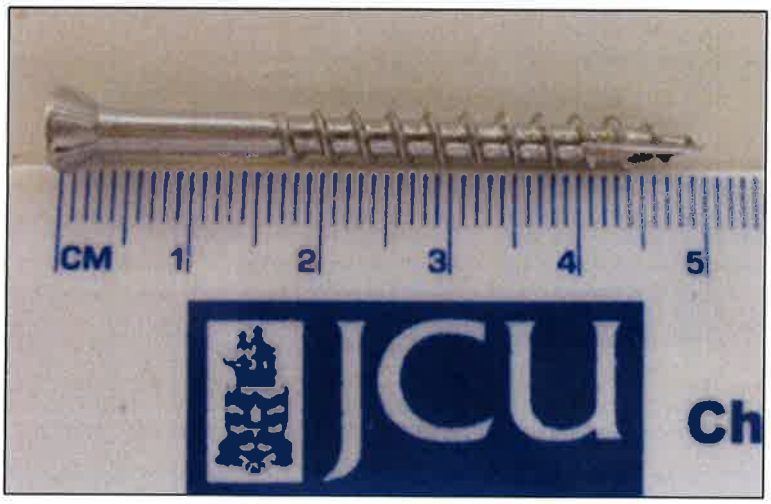

Figure 3: 8-9 × 50 mm stainless steel countersunk screw

4 Test Apparatus and Procedure for Racking Test

4.1 Racking Test Set Up

The test wall samples were installed in the racking test rig. Tie down rods were used to anchor the wall down to a steel rail which is fixed to the concrete structural floor. The tie down rods were going from the top plate to the steel rail. Two steel squares were used to further restrain the bottom plate from sliding on the rail. The hydraulic ram was mounted onto a steel post attached to the concrete structural floor and linked to the top of the walls to perform the tests. A load cell was placed between the hydraulic ram and the wall connection to monitor the load applied to the top of the walls during the tests. Two horizontal gauges (labelled D1 and D2) and two vertical gauges (labelled D3 and D4) were installed to monitor the displacements of the samples. Figure 4 shows the test setup in the racking test rig.

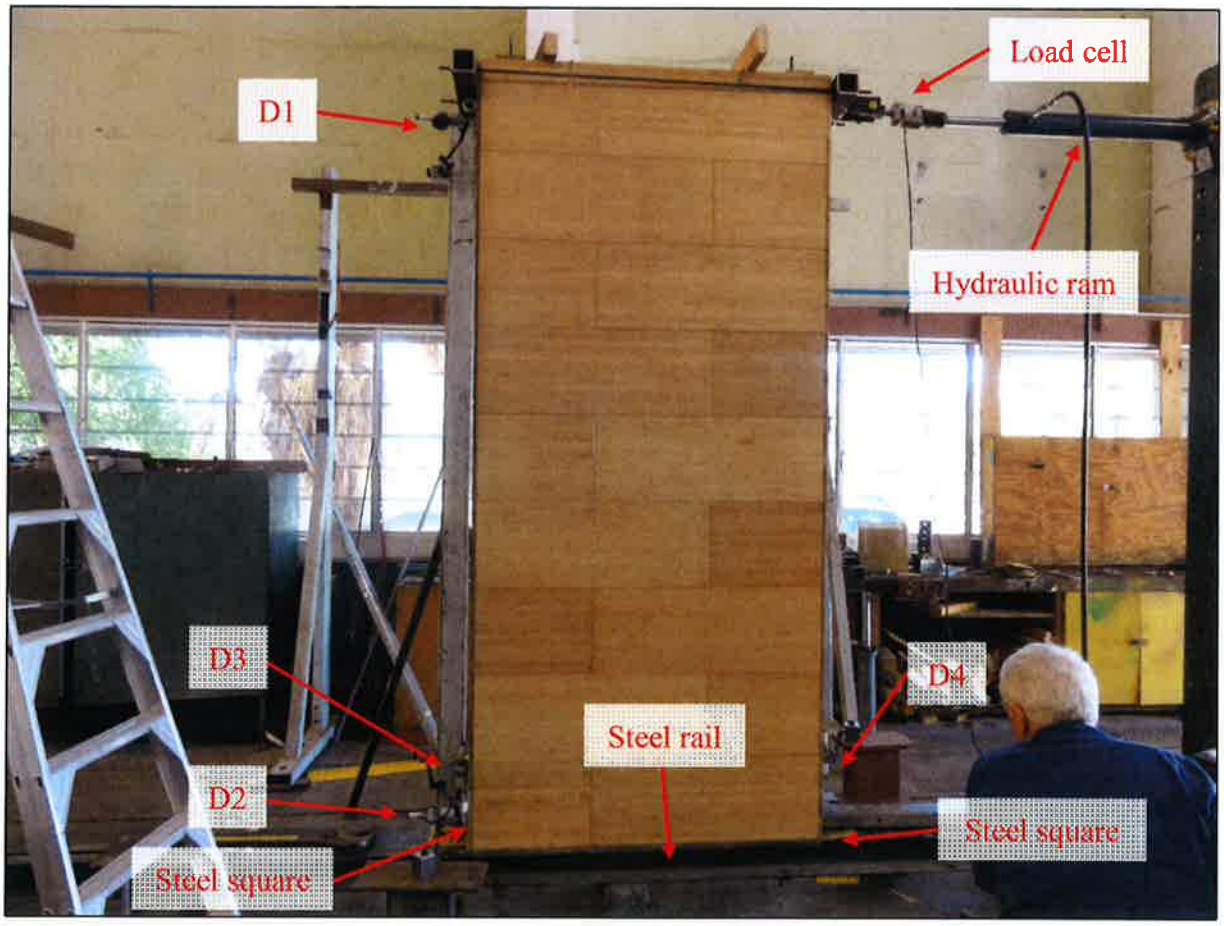

Figure 4: Sample Installed in the Testing Frame

To ensure the wall remained in vertical position, two timber rafters were fixed to the top plate and attached to a supporting frame, which was fixed to the concrete structural floor. The timber rafters were free to rotate at their attachment points with the supporting frame to minimize their effects on the test results. Figure 5 shows the location of the timber rafters.

Figure 5: Sample Maintained in Vertical Position thanks to Timber Rafters

4.2 Test Procedure for Racking Testing

The racking tests were conducted in three steps: 'pull', 'push', 'pull'. For all three steps, the load was applied to the wall sample through the hydraulic ram by the testing supervisor actuating a manual hydraulic pump. For the first pull and the push tests the loads applied were within the serviceability limits of the samples. For the last pull test, the load was slowly increased until failure of the test specimen. Failure was defined, for this test programme as maximum load able to be resisted by the test wall. For this test programme the largest total deflection (D1) was used as a comparison, however to determine classical racking displacement (D_R) from the rigid body overturning component, the following formula is commonly used:

$$D_R = D_1 - D_2 - (D_3 + D_4)\frac{H}{L}$$

Where D1 to D4 are the measured displacements at the locations 1 to 4, H is the height of D1 and L is the length between D3 and D4.

5 Results

5.1 Serviceability Racking Strength Test

A summary of the recorded racking serviceability strength test results is provided in Table 2. Raw deflection data are provided in Appendix A.

Table 2: Racking Serviceability Strength Testing Results

Wall No.	Trial No.	Date Tested	Maximum Loading Applied			Loading Removed	Observation
			Max. Force Applied (kN)	Max. Horizontal Deflection at DG1 (mm)	Force Direction	Residual Deflection at DG1 (mm)	
Wall 1	S1	7 Aug 2017	4.5	-0.74	Pull	-0.15	Test stopped after cracking was heard
	S2	7 Aug 2017	-3.5	0.59	Push	0.03	Test stopped as deflection rate increased
Wall 2	S3	8 Aug 2017	4.5	-4.63	Pull	-0.83	Test stopped as load reached same value as S1
	S4	8 Aug 2017	-3.0	2.74	Push	-0.14	Test stopped as deflection rate increased

Note: Loads applied in the "pull" direction were recorded as positive values by the load cell. Loads applied in the "push" direction were recorded as negative values by the load cell. For deflection measurements, the deflection value was recorded as positive when the measuring tip of the dial gauge was moving towards the fixed part of the dial gauge and the deflection value was recorded as negative when the measuring tip of the dial gauge was moving away from the fixed part of the dial gauge.

5.2 Static Racking Strength Test

A summary of the recorded racking static strength test results is provided in Table 3. Photographs of typical failure modes are provided in Appendix B.

Table 3: Racking Static Strength Testing Results

Wall No.	Trial No.	Date Tested	Failure (Maximum) Load supported (kN)	Comments on Failure
Wall 1	SS1	8 Aug 2017	36.09	Failure of tie down rod. From noise and slight movement during the test, the tie down rod thread may have been slipping from approximately 23 kN.
Wall 2	SS2	8 Aug 2017	14.35	Failure of tie down rod

6 Conclusions

A programme of serviceability and static strength racking testing was performed on *Moroblock* wall system manufactured by *E-Abode Pty Ltd.*

The methods of testing in accordance with *TR440* have been presented.

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Appendix A – Raw Deflection Data for Serviceability Racking Test

Table 4: Raw Deflection Data for Trial S1 and S2

Load Direction	Load (kN)	Horizontal Movements (mm)		Vertical Movements (mm)		D_R (mm)
		DG1 Top of Wall	DG2 Bottom of Wall	DG3 Left of Wall	DG4 Right of Wall	H=2505 mm L=2325 mm
Pull (S1)	0.00	0.00	0.00	0.00	0.00	0.00
	1.00	-0.14	-0.02	0.01	-0.04	-0.09
	1.50	-0.21	-0.03	0.03	-0.07	-0.14
	2.00	-0.28	-0.04	0.05	-0.09	-0.20
	2.50	-0.36	-0.06	0.07	-0.11	-0.26
	3.00	-0.44	-0.07	0.08	-0.13	-0.32
	3.50	-0.52	-0.07	0.10	-0.16	-0.39
	4.00	-0.62	-0.09	0.12	-0.18	-0.47
	4.50	-0.74	-0.10	0.14	-0.21	-0.56
	0.00	-0.15	0.00	0.02	-0.05	-0.12
Push (S2)	0.00	-0.15	0.00	0.02	-0.05	-0.12
	-1.00	0.01	0.00	0.00	-0.01	0.02
	-1.50	0.15	0.00	0.00	0.00	0.15
	-2.00	0.25	0.01	-0.02	0.03	0.23
	-2.50	0.34	0.02	-0.03	0.06	0.29
	-3.00	0.45	0.02	-0.05	0.08	0.40
	-3.50	0.59	0.04	-0.08	0.12	0.51
	0.00	0.03	0.02	-0.01	-0.03	0.05

Table 5: Raw Deflection Data for Trial S3 and S4

Load Direction	Load (kN)	Horizontal Movements (mm)		Vertical Movements (mm)		D_R (mm)
		DG1 Top of Wall	DG2 Bottom of Wall	DG3 Left of Wall	DG4 Right of Wall	H=2485 mm L=1155 mm
Pull (S3)	0.00	0.00	0.00	0.00	0.00	0
	0.50	-0.44	0.04	-0.02	-0.09	-0.24
	1.00	-0.90	0.10	-0.04	-0.20	-0.48
	1.50	-1.34	0.16	-0.06	-0.30	-0.73
	2.00	-1.78	0.23	-0.08	-0.40	-0.98
	2.50	-2.23	0.30	-0.10	-0.49	-1.26
	3.00	-2.73	0.38	-0.13	-0.60	-1.54
	3.50	-3.28	0.46	-0.15	-0.70	-1.91
	4.00	-3.95	0.63	-0.19	-0.82	-2.41
	4.50	-4.63	0.77	-0.22	-0.93	-2.93
	0.00	-0.83	0.08	-0.07	-0.27	-0.18
Push (S4)	0.00	-0.83	0.08	-0.07	-0.27	-0.18
	-0.50	-0.30	0.00	-0.05	-0.15	0.13
	-1.00	0.19	-0.06	-0.03	-0.03	0.38
	-1.50	0.69	-0.12	-0.01	0.06	0.7
	-2.00	1.25	-0.17	0.02	0.19	0.97
	-2.50	1.94	-0.22	0.06	0.38	1.21
	-3.00	2.74	-0.30	0.10	0.62	1.49
	0.00	-0.14	0.05	-0.01	-0.07	-0.02

Appendix B – Photographs of failure mode

Figure 6: Photograph of Tie-Down Rod after Failure