Test Report for Lateral Load Capacity of Pacific Homes SmartWall® System

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1. INTRODUCTION

Pacific Homes' SmartWall® System is a prefabricated 2 x 6 wall system which minimizes thermal bridging by reducing the amount of wood that can act as a thermal bridge. This is achieved by using 2 x 6 framing members as top plates, bottom plates as well as end studs of the wall. Framing members of 2 x 4, spaced at 16 in. (406 mm) on center, are used as intermediate studs. With this arrangement, the 2 x 4 intermediate studs only contact the exterior wall face, thus providing thermal break between exterior and interior surface. In conventional wall framing, all the framing members are in contact with both the exterior and interior wall face.

Figure 1 shows a configuration of a Pacific SmartWall®. On the interior side of the wall, 2 x 3 horizontal purlins spaced at 24 in. (610 mm) on center were installed to provide the backing for interior gypsum wallboard. As the horizontal purlins are connected to intermediate and end studs, it is believed that they also contribute to the lateral load resistance of the wall. This means that a Pacific SmartWall® would have higher lateral load resistance than a conventional wall having the same panel sheathing, framing members, nail size and spacing. At the request of Pacific Homes, a test program was developed to assess the lateral load resistance and stiffness of the Pacific SmartWall® System. For comparison, conventional walls with the same panel sheathing, framing members, nail size and spacing were also tested.

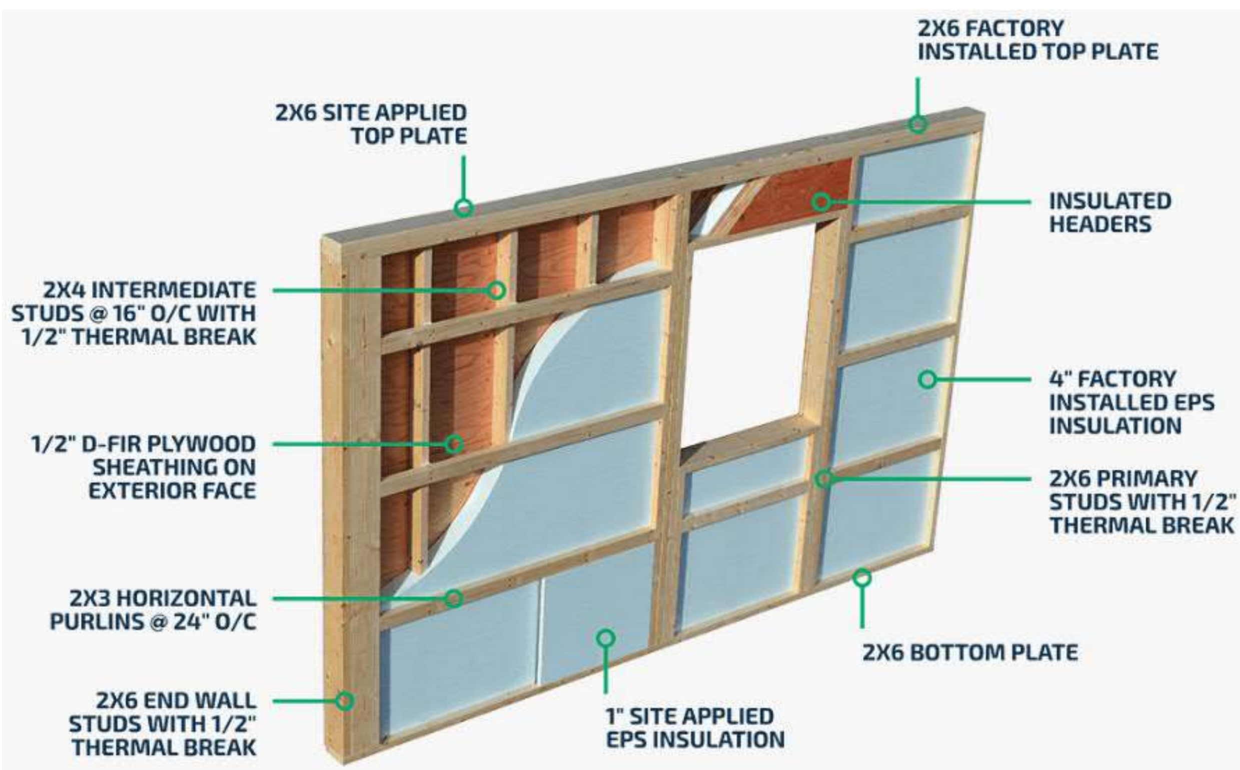


Figure 1 Pacific SmartWall® configuration

2. OBJECTIVES

The objectives of the test program are to

- Evaluate the stiffness, strength, and deformation capacity of the Pacific SmartWall® under monotonic and reversed cyclic load
- Compare the performance of Pacific SmartWall® and comparable conventional wall

3. MATERIALS

Three 2x6 Pacific SmartWall® and three conventional 2x6 walls were built by Pacific Homes and tested by the Advanced Building Systems Department of FPInnovations in Vancouver. The wall specimens were received on November 15, 2016.

Both the Pacific SmartWall® and conventional walls were 8 feet (2.4 m) in height and 8 feet in length (2.4m). No. 2 and better grade of Spruce-Pine-Fir was used for studs and plates. A single 2 x 6 (38 mm x 140 mm) bottom plate and a double 2 x 6 (38 mm x 140 mm) top plate were used for both Pacific SmartWall® and conventional walls. Exterior plywood of 12 mm (½ in.) was attached horizontally to the studs. Spiral nails of 2.5 in. were used to attach the plywood to the studs and plates. The nail spacing was at 150 mm (6 in.) on center at supported panel edges of the plywood and 300 mm (12 in.) on center at intermediate studs. Neither the Pacific SmartWall® nor the conventional wall used blocking along the horizontal joint between the two pieces of plywood. Both walls used a single 2 x 6 (38 mm x 140 mm) end stud that was anchored to the bottom plate using a Simpson Strong-Tie HTT5 Hold-Down. The conventional walls were constructed using 2 x 6 (38 mm x 140 mm) interior studs spaced at 400mm (16in.) intervals, see Figure 2a, while the Pacific SmartWall® used 2 x 4 (38 mm x 89 mm) interior studs spaced at 400mm (16 in.) intervals. The Pacific SmartWall® had 100 mm (4 in.) thick EPS that was held in position with three 2 x 3 (38 mm x 63 mm) purlins running horizontally at the 610 mm, 1220 mm, and 1830 mm level, see Figure 2b. The purling was attached to the studs with two 3” nails.

(a) Conventional wall (b) Pacific SmartWall® (insulation side)

Figure 2 Photos of a Pacific SmartWall® and conventional wall specimen

4. TEST METHODS

The walls were tested following ASTM E564 (ASTM 2012) and ASTM E2126 (ASTM 2011). The wall specimen was bolted between a fixed base support and a loading beam at the top. The walls were bolted to the test frame along the centre line of the base support and loading beam at 406 mm (16 in.) intervals with 12.7 mm (1/2 in.) anchor bolts. Hold-downs, see Figure 3, were attached to the end of the walls and bolted to the base support. The shear load was applied through an actuator that was pinned to the end of the loading beam. The loading beam had rollers along the edges to prevent the wall from moving out of plane, see Figure 4. Figure 5 shows the shear wall test setup with a test wall in it.

Figure 3 Hold down

Figure 4 Rollers and Top Load Beam

Figure 5 Test setup

Figure 6 shows the location of instrumentations which were used to measure the loads and deflections during the test. The load (ch.0) was measured using a load cell that was located between the actuator and the loading beam. The horizontal displacement was measured from the top plate (ch.2) as well as the actuator (ch.1). The slip was also measured at the base from the outside stud relative to the base (ch.5). The vertical uplift was measured from the end stud relative to the base at each end of the wall (ch.3 and ch.4).

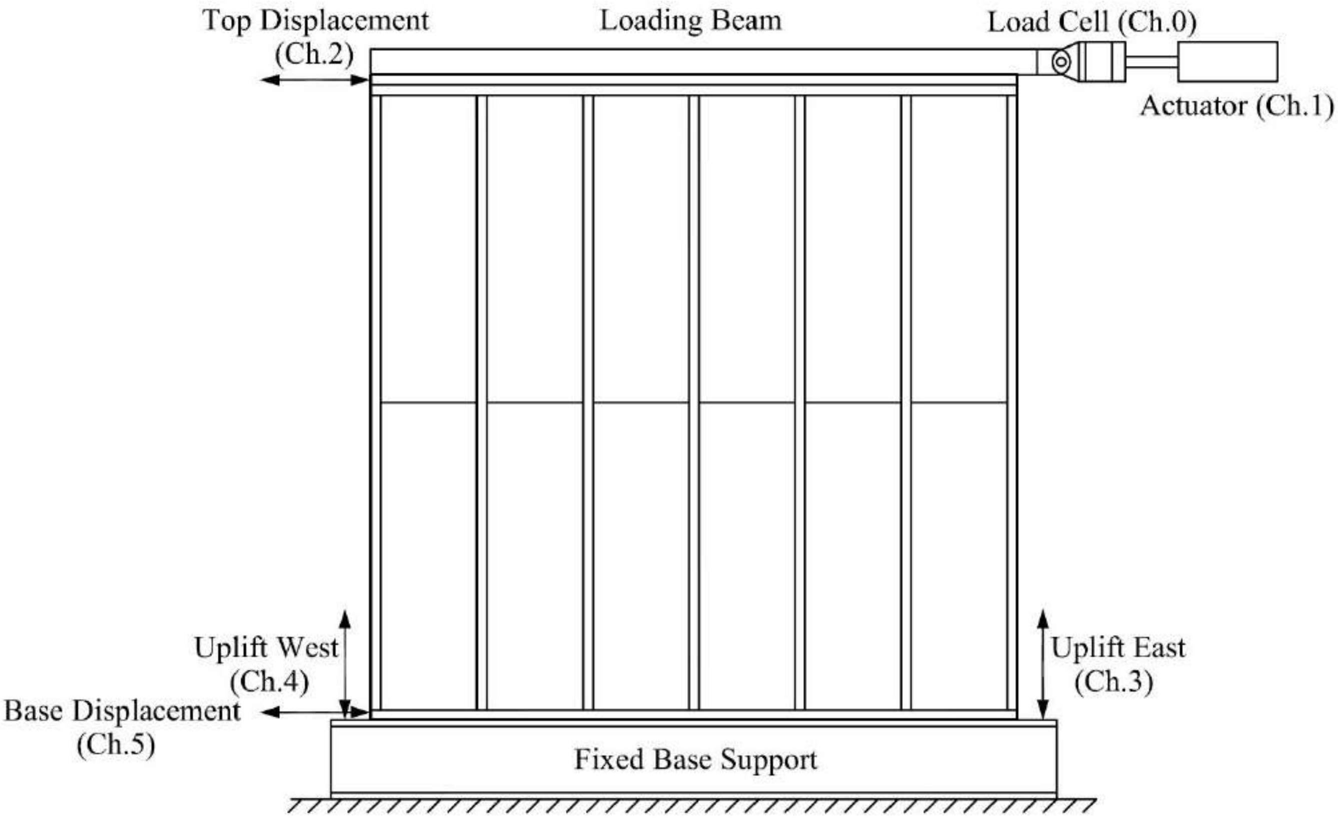


Figure 6 Test setup with instrumentation location

One Pacific SmartWall® and one conventional wall were tested in static (monotonic) according to ASTM E564. The load rate was 0.3 in./min. The maximum load and the displacement at 80% past the maximum load were recorded. Two Pacific SmartWall® and two conventional walls were tested under reverses cyclic loading according to ASTM E2126 Section 8.4 using the ISO 16670 protocol. The average displacement, from the two static tests, at 80% past the maximum load was used as the 100% displacement for the cyclic loading. Figure 7 shows the loading protocol used.

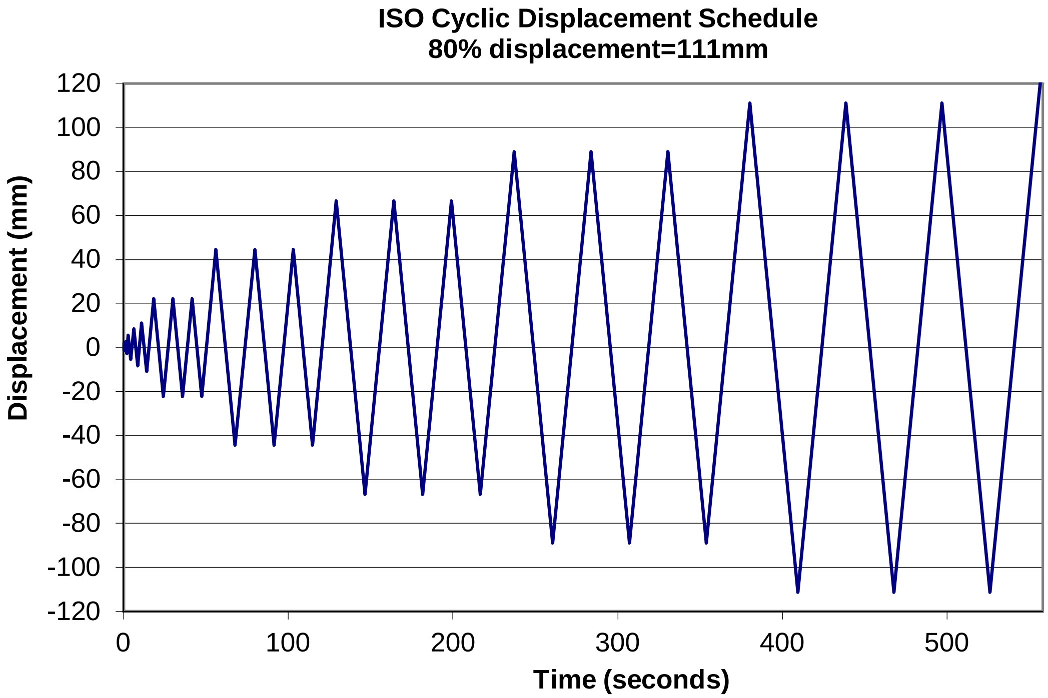


Figure 7 ISO loading protocol

5. RESULTS

The load-displacement curves of the tested walls under static and reversed cyclic loading are provided in Figures 8 to 12, respectively.

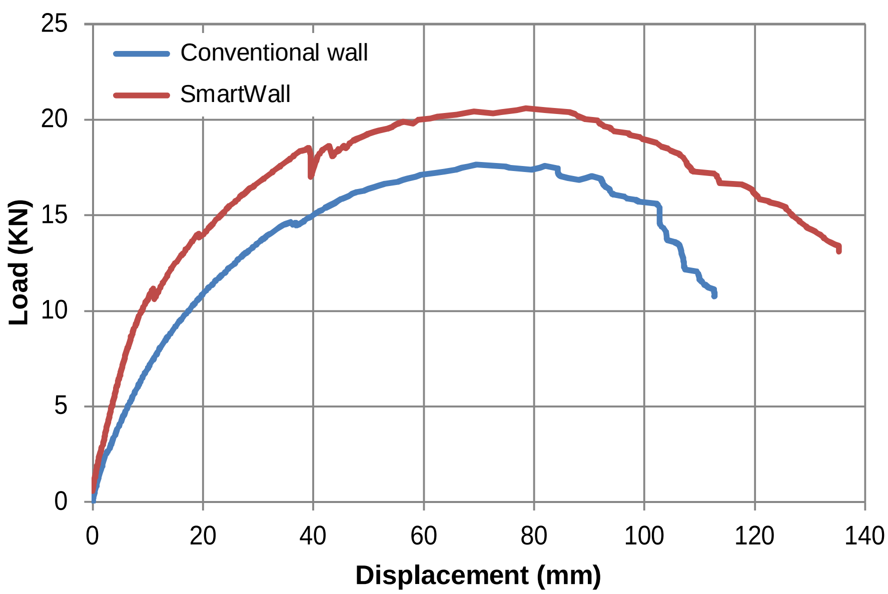


Figure 8 Load-displacement curve under static loading

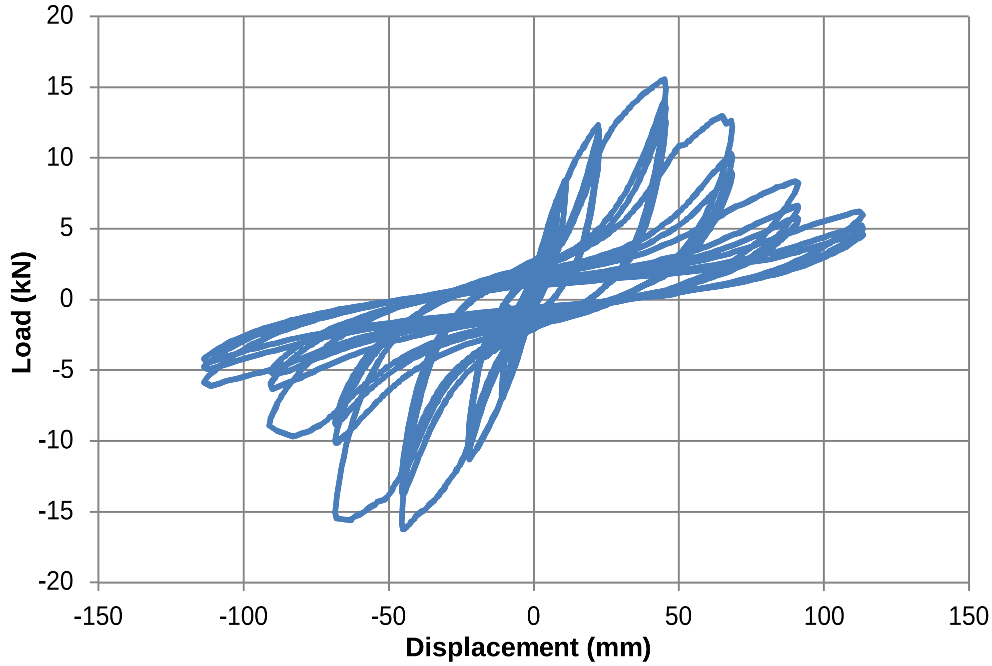


Figure 9 Load-displacement curve of conventional wall 2 under reversed cyclic loading

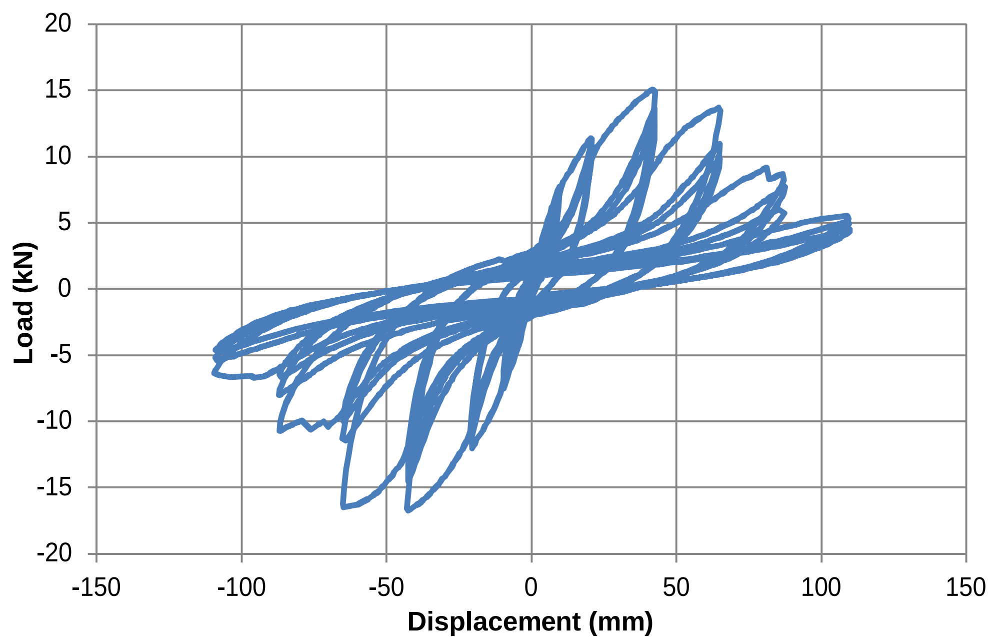


Figure 10 Load-displacement curve of conventional wall 3 under reversed cyclic loading

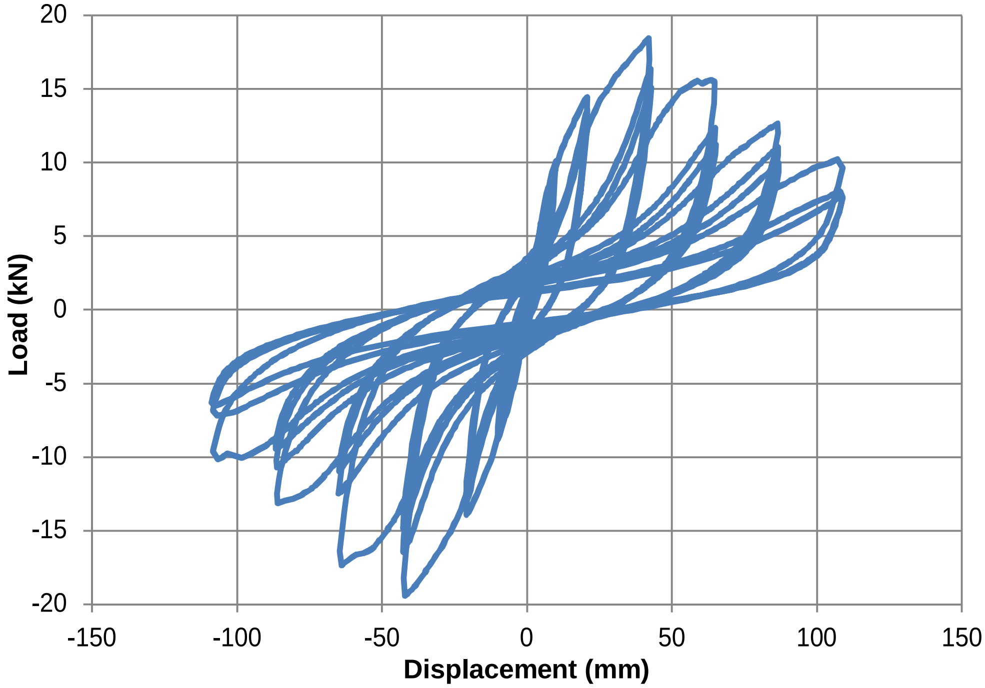


Figure 11 Load-displacement curve of Pacific SmartWall® specimen 2 under reversed cyclic loading

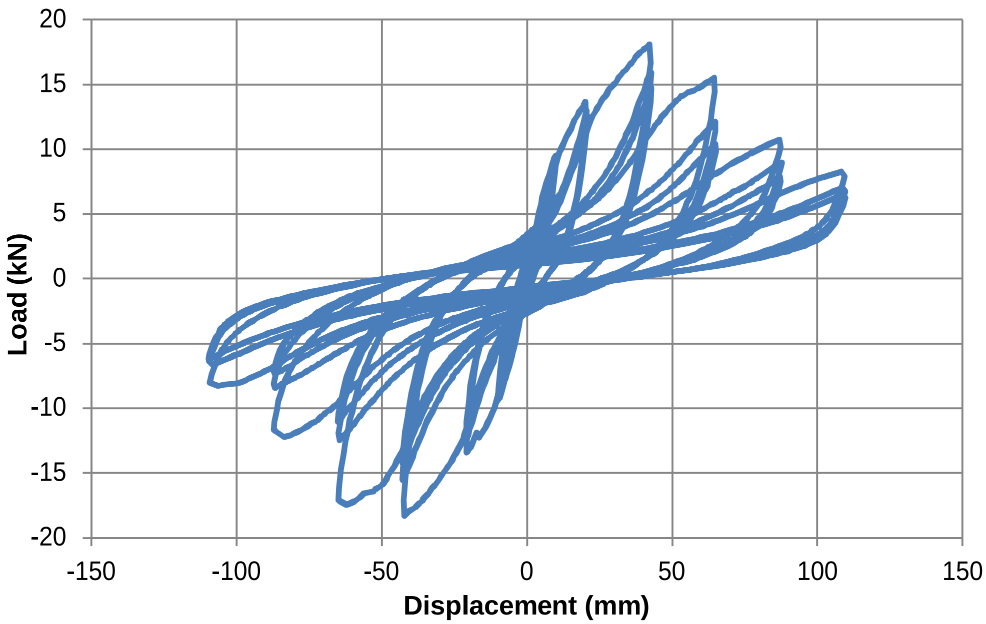


Figure 12 Load-displacement curve of Pacific SmartWall® specimen 3 under reversed cyclic loading

The maximum loads, ultimate displacements and secant stiffness of the Pacific SmartWall® and the conventional walls under static and reversed cyclic loading are summarised in Tables 1 and 2, respectively. The ultimate displacement is defined as the displacement at 80% of maximum load on the descending portion of the load-displacement curve, see Figure 13. The secant stiffness is calculated between zero and 40% of the maximum load, see Figure 13.

Table 1. Summary of test results under static loading

Specimen	Maximum load (kN)	Ultimate displacement (mm)	Secant stiffness (kN/mm)
Conventional wall specimen 1	17.7	103.9	0.71
Pacific SmartWall® specimen 1	20.6	118.4	1.23
Pacific SmartWall® / Conventional wall	1.16	1.14	1.73

Table 2. Summary of test results under reversed cyclic loading

Specimen	Maximum load (kN)			Ultimate displacement (mm)			Secant stiffness (kN/mm)		
Table text	+	-	AVG	+	-	AVG	+	-	AVG
Conventional wall									
Specimen 2	15.5	16.2	15.9	68.5	72.0	70.3	0.99	0.65	0.82
Specimen 3	15.3	16.7	15.9	70.1	76.1	73.1	0.86	0.80	0.83
Average	15.4	16.4	15.9	69.3	74.1	71.7	0.93	0.73	0.83
Pacific SmartWall®									
Specimen 2	18.4	19.4	18.9	71.2	73.1	72.2	1.23	0.93	1.08
Specimen 3	18.1	18.3	18.2	74.3	73.2	73.8	1.14	1.07	1.10
Average	18.2	18.8	18.6	72.8	73.2	73.0	1.18	1.00	1.09
Conventional /Pacific SmartWall®			1.17			1.02			1.31

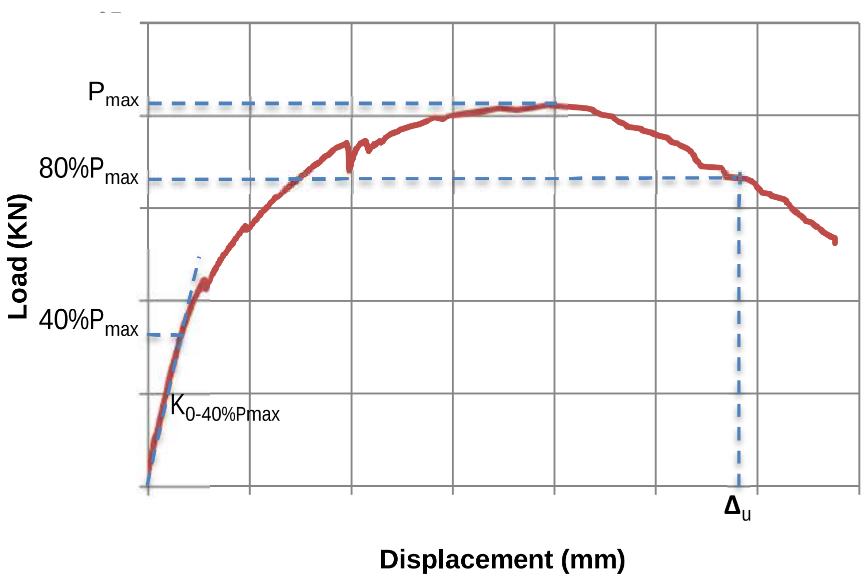


Figure 13 Schematic diagram for determination of stiffness and ultimate displacement

Results in Tables 1 and 2 show that the PacificSmartWall® possessed higher resistance, stiffness and deformation capacity under either static or reversed cyclic loading. The results clearly indicate that the horizontal purlins in the Pacific SmartWall® improve the lateral load resistance and stiffness of the wall. The results also show that the Pacific SmartWall® has greater ductility than the conventional wall.

Both the Pacific SmartWall® and the conventional walls failed in a similar way under static and reversed cyclic loading. Figures 14 and 15 show the deformed shape of the conventional wall and Pacific SmartWall® specimens. For both the conventional wall and Pacific SmartWall®, only the nail joints along the horizontal joint reached their capacities. The nail joints along the horizontal joint either withdrew from the studs or pulled through the panels. Details of failure modes for each specimen are provided in Appendix I.

Figure 14 Conventional wall failure

Figure 15 Pacific SmartWall® specimen failure

6. CONCLUSIONS

A total of six wall specimens (three Pacific SmartWall® and three conventional walls) were tested under static or reversed cyclic loading by Advanced Building System Department of FPInnovations in Vancouver.

The results show that:

- Pacific SmartWall® had higher lateral load resistance, stiffness and ultimate deformation than a comparable conventional wall;
- Both the Pacific SmartWall® and the conventional walls failed in a similar way under static and reversed cyclic loading.

The test results clearly indicate that the horizontal purlins in the Pacific SmartWall® improve the lateral load resistance and stiffness of the wall. For all the tests, the plywood was oriented in the horizontal direction without blocking which leaved a horizontal gap between the top and bottom plywood panel. The lateral load resistance and stiffness can be further increased if all the panel edges of plywood are supported by framing members with nail spacing at 150 mm on center. This can be achieved by using blocking at the horizontal gap or placing the plywood in the vertical direction.

7. REFERENCES

[1] ASTM E564-06, Standard Practice for Satic Load Test for Shear Resistance of Framed Walls for Buildings, 2012

[2] ASTM E2126-11, Standard Test Methods for Cyclic (Reversed) Load Test for Shear Resistance of Vertical Elements of the Lateral Force Resisting Systems for Buildings, 2011.

[3] ISO 21581 Timber Timber Structures- Static and Cyclic later Load Test Methods for Shear Walls, 2010

APPENDIX I DETAILED FAILURE MODES OF WALL SPECIMENS

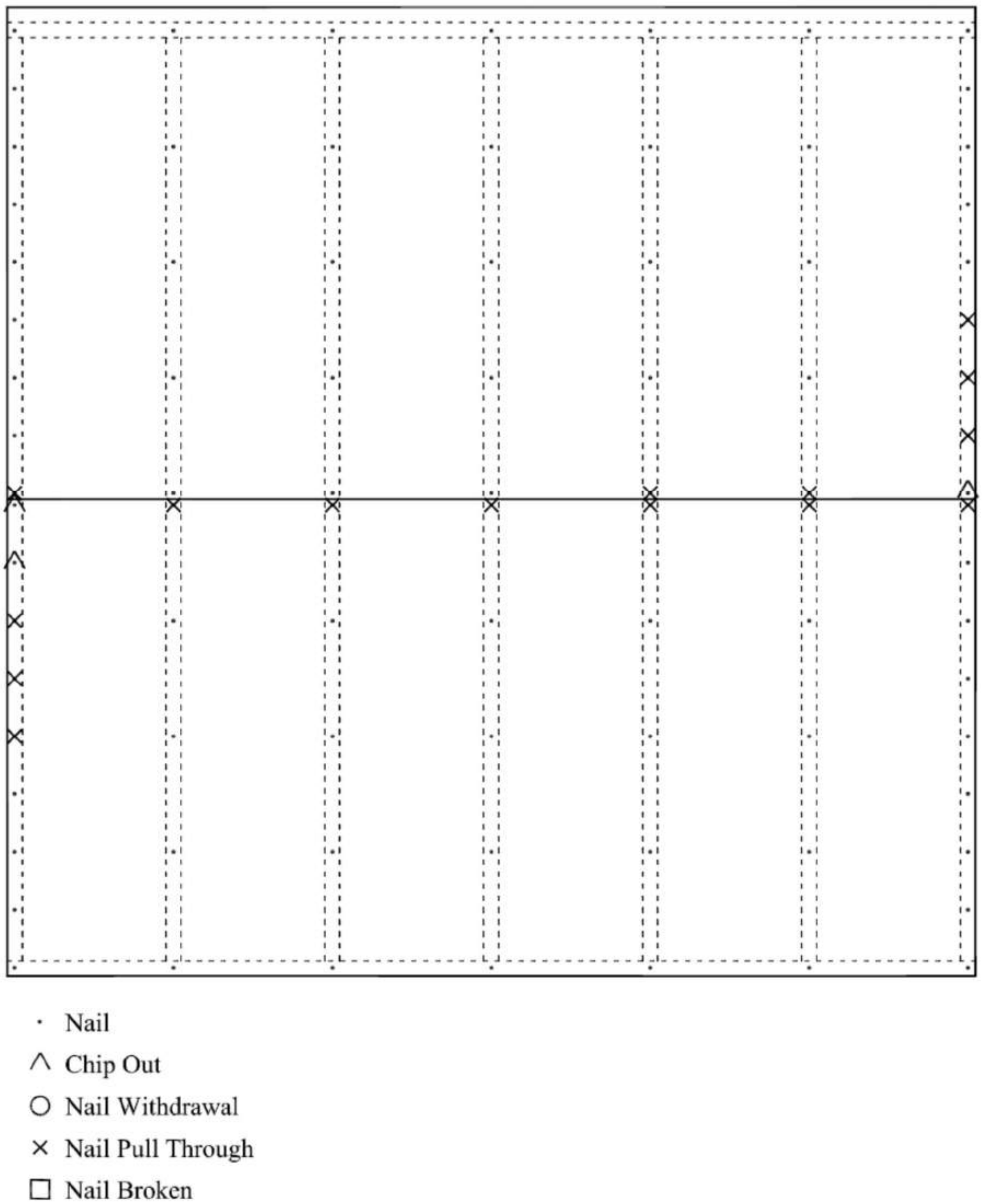
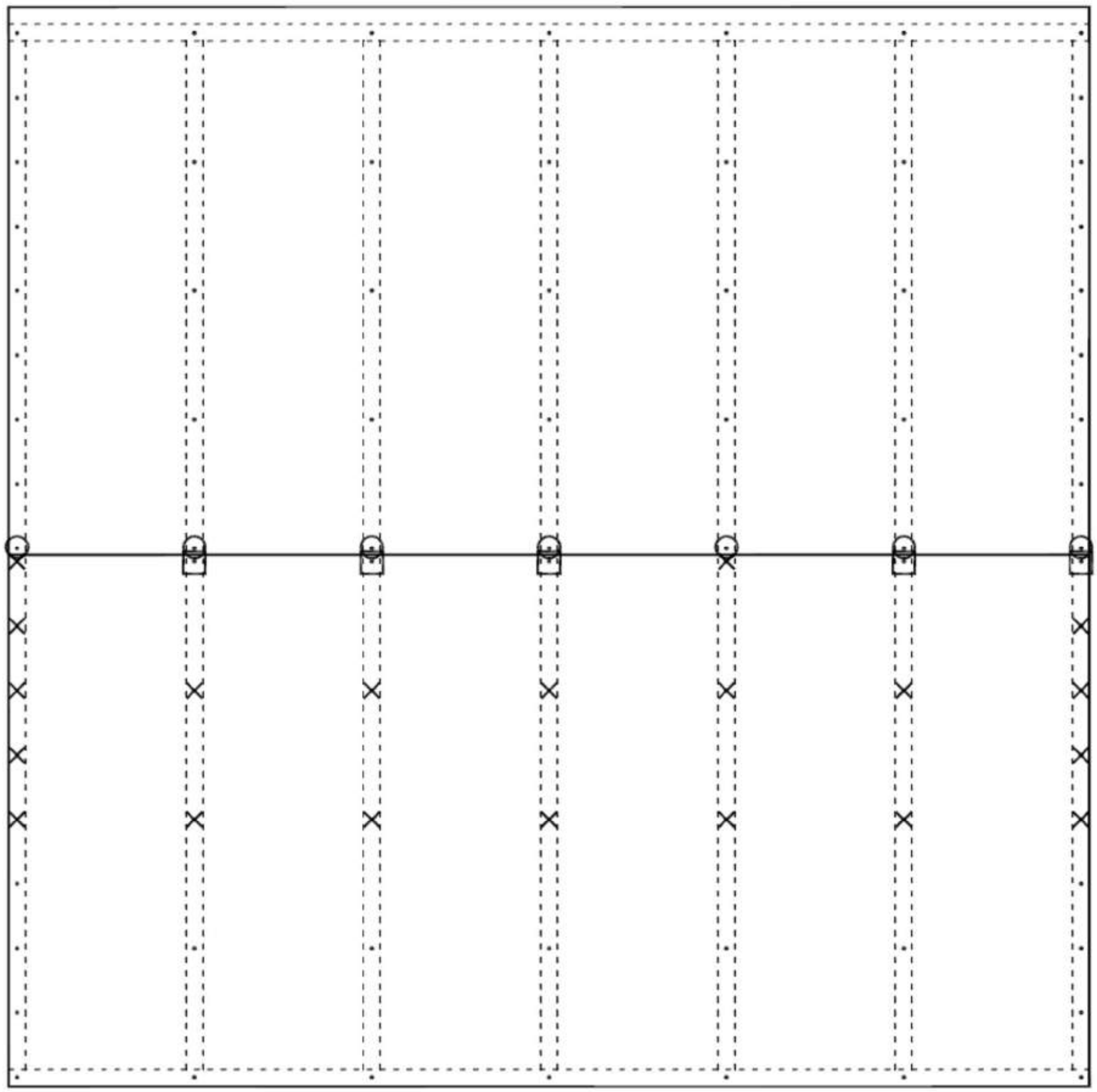


Figure 16 Conventional wall 1



· Nail
∧ Chip Out
○ Nail Withdrawal
× Nail Pull Through
□ Nail Broken

Figure 17 Conventional wall 2

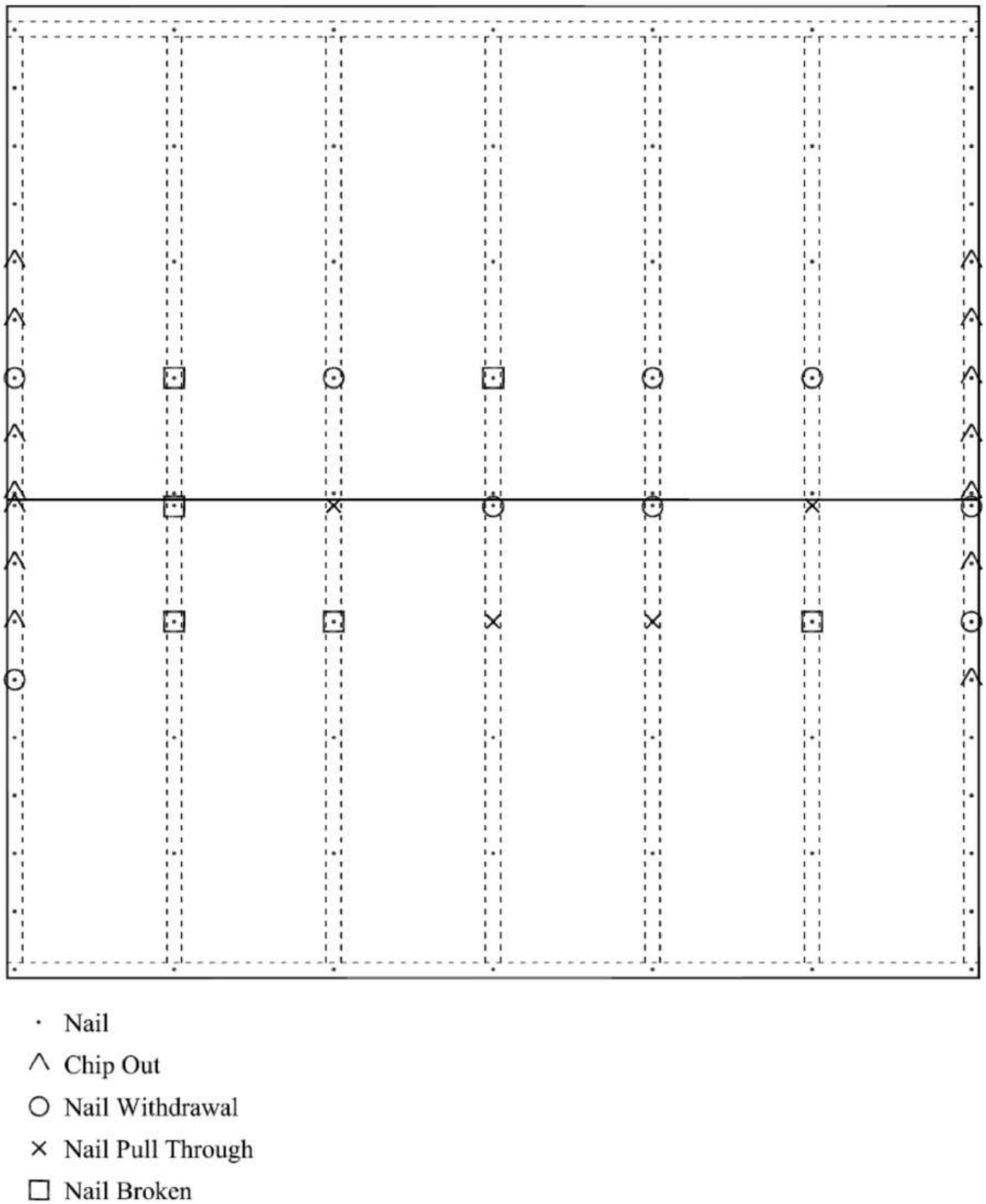


Figure 18 Conventional wall 3

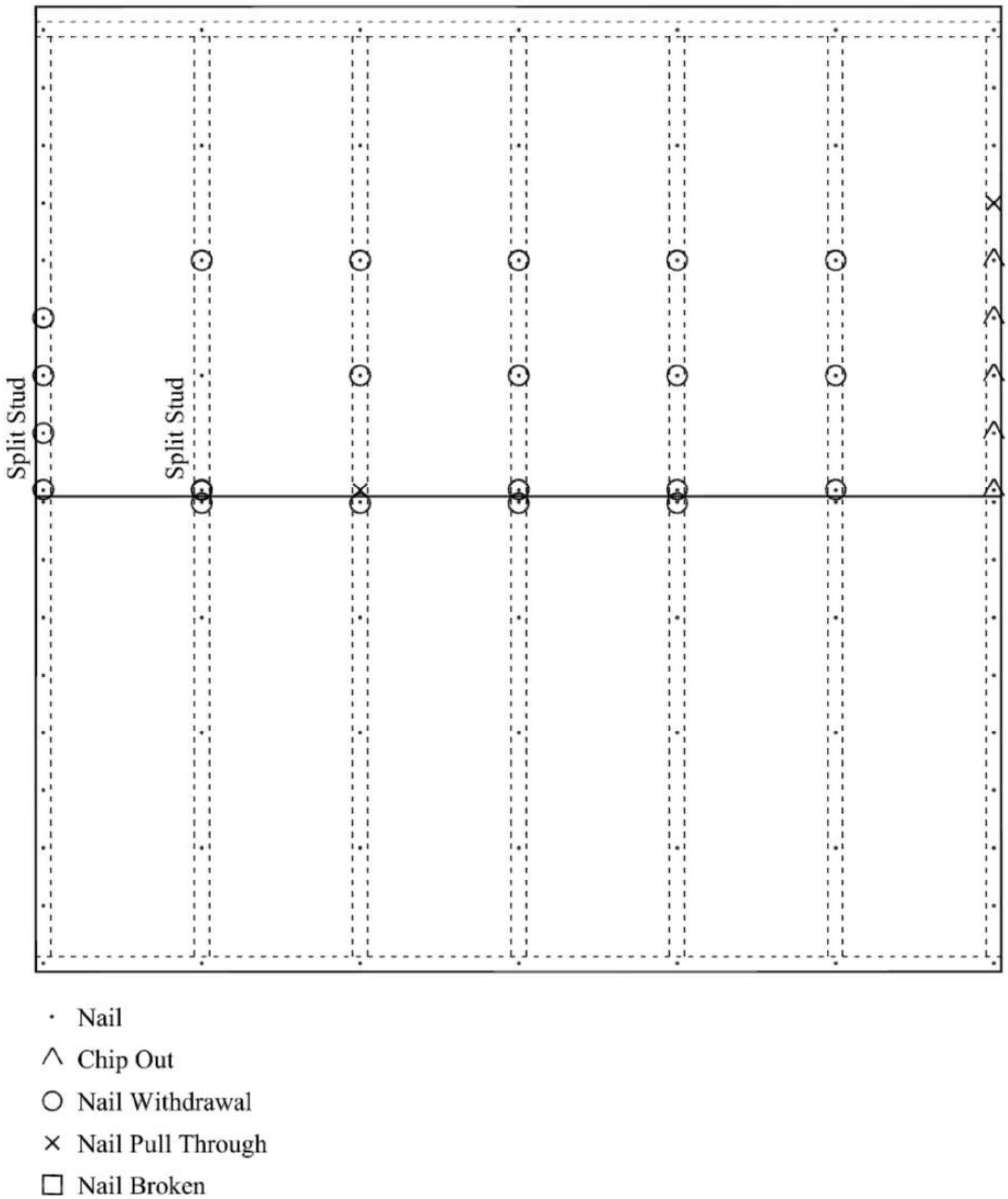


Figure 19 Pacific SmartWall® specimen 1

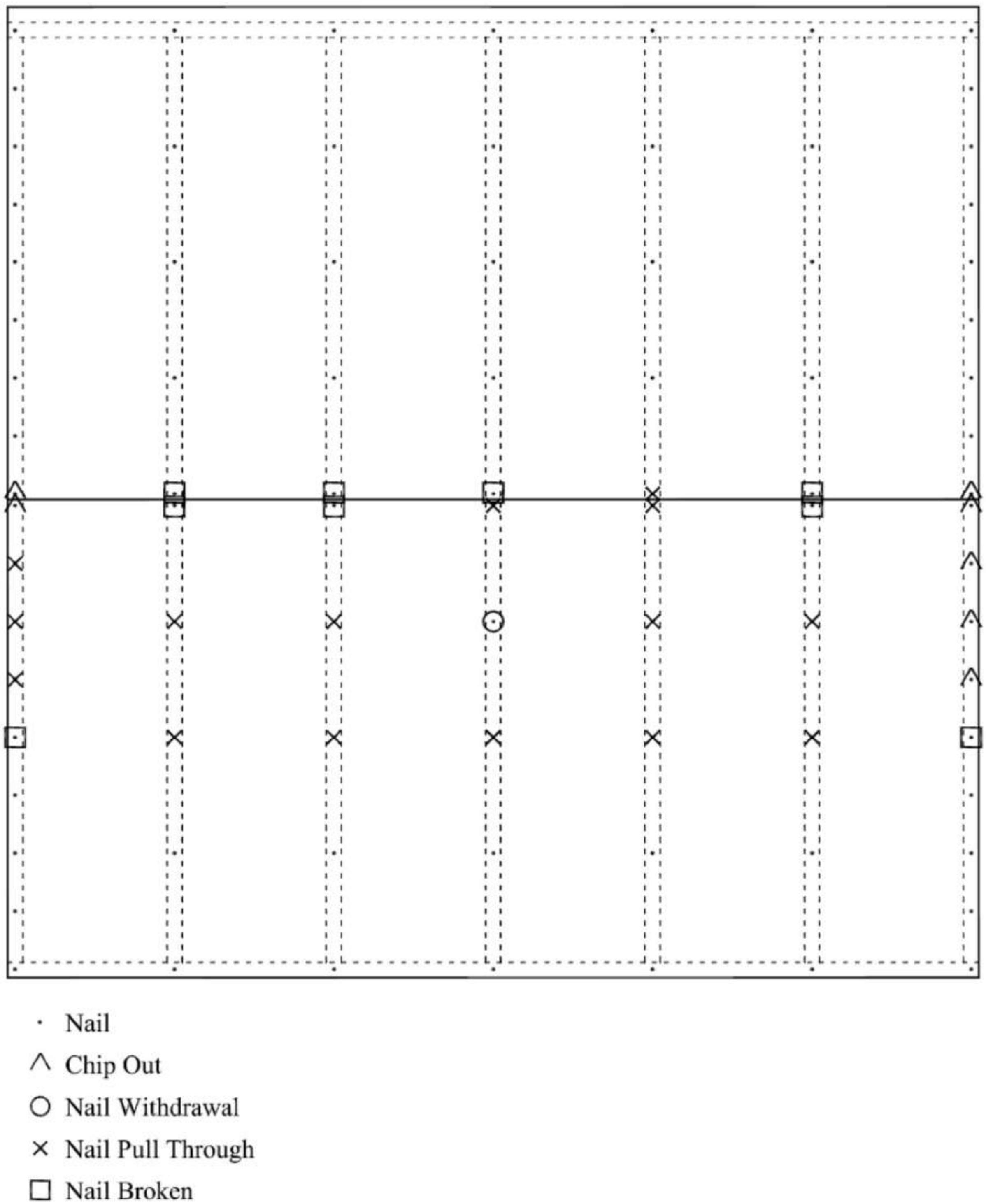


Figure 20 Pacific SmartWall® specimen 2

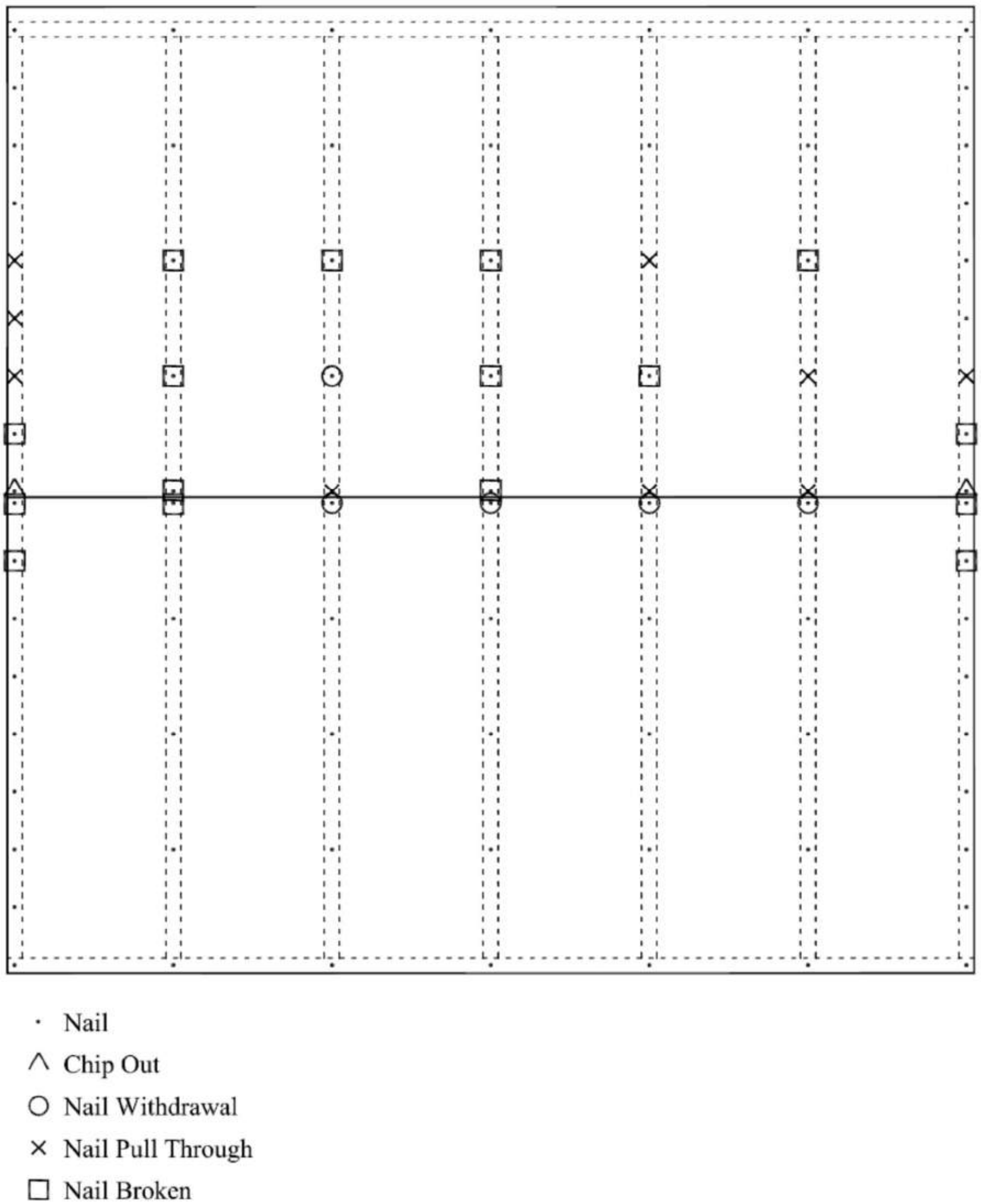


Figure 21 Pacific SmartWall® specimen 3

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