Swinburne University of Technology

Centre for Sustainable Infrastructure

ICCONS Screwbolt testing

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EXECUTIVE SUMMARY

Swinburne University of Technology was commissioned by ICCONS to carry out testing of Screwbolt Hex 8×140mm white head (Part No. SXB08140G WHITE) for bottom plate applications in accordance with NZS 3604:2011. The purpose of the tests was to assess tension, in-plane shear, and out-of-plane shear capacities of the specified anchor in close to edge applications. The concrete blocks used for the test were precast with a target characteristic compressive strength (f'_c) of 20MPa. For the test program the average concrete strength was found to be 22.8 MPa. This report summarises the results of the tests conducted.

The testing methods are in accordance with BRANZ Report No. 125 (2004) and the evaluation of the results are in accordance with BRANZ Evaluation Method EM1 (1999). The results for the tests conducted are summarised in Table 1.

Table 1: Summary of results for Screwbolt Hex 8x140mm anchors and concrete strength

Type of test	No. of samples	Coefficient of variation	Mean ultimate strength (kN)	Characteristic strength (kN)
Tension	5	14.4%	16.4	11.9
In-plane shear	6	12.6%	11.5	8.2
Out-of-plane shear	4	10.2%	5.7	4.0

Note: peak load measured on 3rd cycle for shear tests

Contents

1 INTRODUCTION

Swinburne University of Technology was commissioned by ICCONS to carry out testing of Screwbolt Hex 8x140mm anchors (refer Figure 1) for bottom plate applications in accordance with NZS 3604:2011. The purpose of the tests was to assess tension, in-plane shear, and out-of-plane shear capacities of the specified anchor in concrete with target characteristic compressive strength (f'_c) of 20MPa at 28 days in close to edge applications. The testing methods are in accordance with BRANZ Report No. 125 (2004) and the evaluation of the results are in accordance with BRANZ Evaluation Method EM1 (1999).

The scope of work included: (i) casting of test blocks measuring 2.0m × 2.0m × 0.4m with concrete having a target characteristic compressive strength of 20MPa at 28 days; (ii) design and fabrication of test rigs which accommodate testing of the anchors in tension, in-plane shear, and out-of-plane shear, (iii) conduct testing on anchors and concrete cylinder compression tests, and (vi) provide a report on the work completed.

The work was undertaken at the Smart Structures Laboratory, Swinburne University of Technology (SUT) in Hawthorn, Victoria.

Figure 1: Screwbolt Hex 8x140mm anchor as provided by ICCONS

2 CONCRETE TEST BLOCK AND ANCHORS

Concrete was cast by Hollow Core Concrete. The concrete blocks were delivered to Smart Structures Laboratory, Swinburne University of Technology, after 28 days. Standard cylinders were also cast to confirm the compressive strength by testing.

All anchors for testing were supplied by ICCONS.

3 INSTALLATION OF ANCHORS

After 28 days of casting, the holes for the anchors were drilled to a depth of 105mm with a hammer drill and a brand new 8mm carbide tipped drill bit. The drill bit was checked after every 10 drills to ensure the diameter of the hard metal bit is within the tolerance specified in ETAG001. The drilled holes were cleaned as per instructions provided by ICCONS.

For all anchors, the bottom plate was 90 × 45mm MGP10 structural pine. A piece of bituminous damp-proof course (DPC) was placed between the bottom plate and concrete surface for all shear tests. The bottom plate overhang was 10mm as per information supplied by ICCONS as shown in Figure 2. A 50×50mm washer was utilised in all tests. The anchors were installed to an embedment depth of 95mm with 50mm edge distance as per installation instructions provided by ICCONS. A torque of 40Nm was applied to the anchors with a calibrated torque wrench.

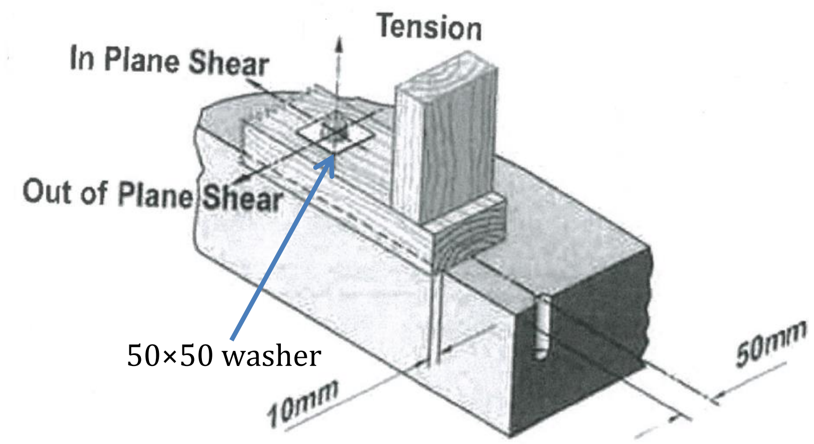


Figure 2: Installation of anchors

4 TEST SETUP

A plan view schematic of the location of the anchors for the various test types is provided in Figure 3.

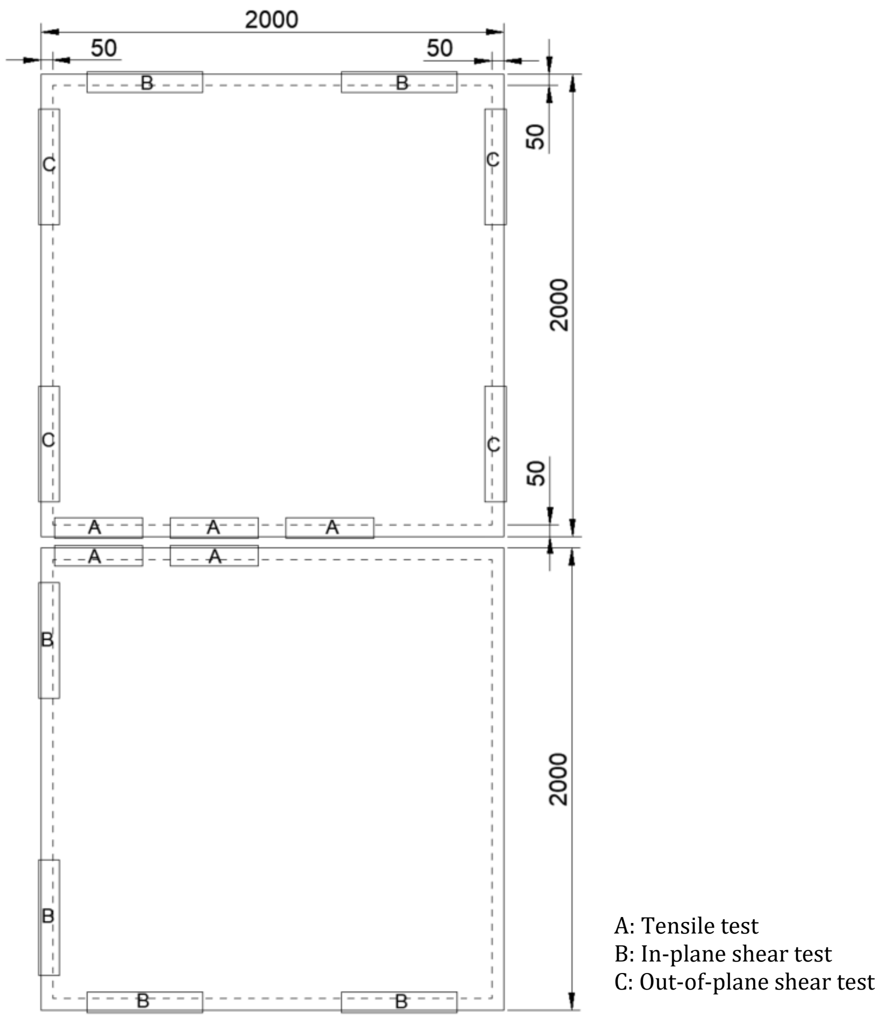


Figure 3: Plan view schematic showing the location of anchors for various test types

4.1 Tension test

Concrete blocks were laid side by side on the laboratory strong floor. The tension load was applied to the anchor under displacement control with a 500kN capacity closed loop hydraulic actuator with a self-reacting frame. Displacement of the specimen was measured by a displacement transducer within the actuator. In addition, a calibrated displacement transducer was positioned on top of the anchor to measure the displacement of the anchor. Refer to Figure 4 to Figure 6 for tension test setup. The measurements from the displacement transducers and the load applied from the actuator were digitally recorded during the loading of each anchor. Tests were conducted by a qualified test engineer.

Loading regime for all tension tests was conducted as per BRANZ Report No. 125 (2004) supplied by ICCONS. The loading regime involved cycling three times to each of +0.25, +0.375, +0.5, +1.0, +2.0 etc. multiplied by the target load specified in NZS 3604.

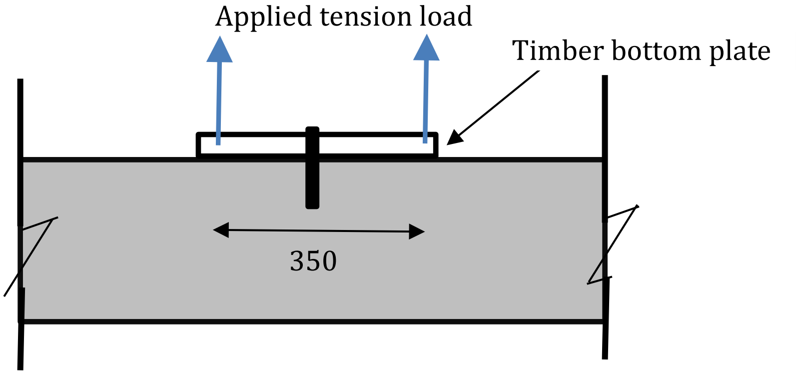


Figure 4: Schematic tension test setup

Figure 5: Test setup and instrumentations for tension test

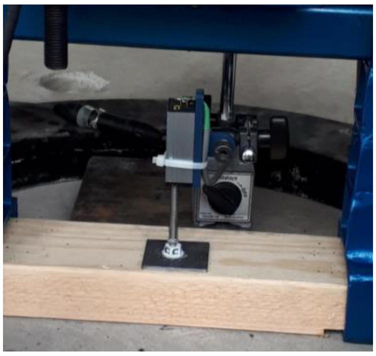


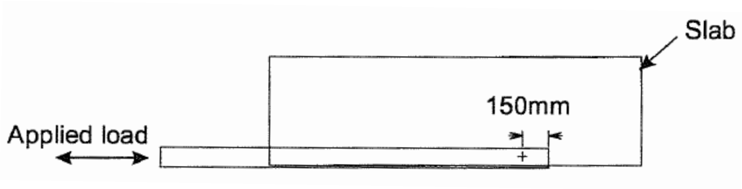
Figure 6: Close up view of test setup

4.2 Shear test

The load was applied to the anchor under displacement control with a 100kN capacity closed loop hydraulic actuator. Displacement of the specimen was measured by a displacement transducer within the actuator. In addition, calibrated displacement transducers are positioned to measure the displacement of the timber and the anchor for monitoring purposes. Refer to Figure 7 to Figure 9 for in-plane shear test setup and Figure 10 to Figure 12 for out-of-plane shear test setup. The measurements from the displacement transducers and the load applied from the actuator were digitally recorded during the loading of each anchor. Tests were conducted by a qualified test engineer.

For the shear tests, the loading regime is conducted as per BRANZ Report No. 125 (2004) supplied by ICCONS. The first series for each configuration was cycled three times to each of +0.25, +0.375, +0.5, +1.0, +2.0 etc. multiplied by the target load specified in NZS 3604. The remaining specimens in the series are then cycled to multiples of the displacement recorded at half the ultimate load achieved in the first specimen, as detailed in BRANZ Evaluation Method EM1 (1999).

(a)



(b)

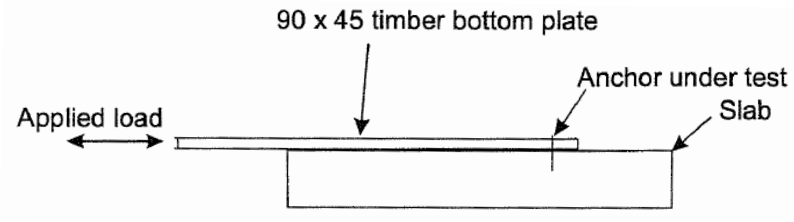


Figure 7: Schematic in plane shear test setup as per BRANZ Study Report No. 125, (a) plan view, (b) side view

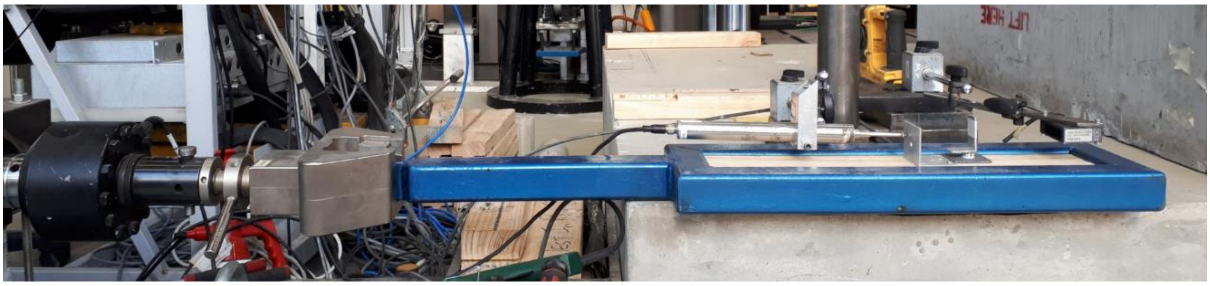


Figure 8: In-plane shear test setup

Figure 9: Close up view of the in-plane shear test setup

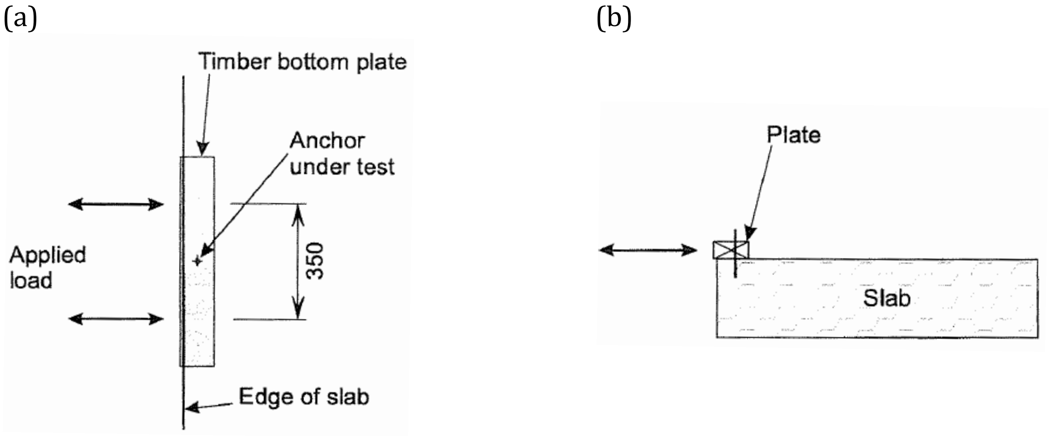


Figure 10: Schematic out of plane shear test setup as per BRANZ Study Report No. 125, (a) plan view, (b) side view

Figure 11: Out-of-plane shear test setup

Figure 12: Close up view of the out-of-plane shear test setup

5 TEST RESULTS

5.1 Tension test results

Results from basic tension tests are summarised in Table 2.

Table 2: Tension test results for Screwbolt Hex 8x140mm anchors

Test	Failure mode	Peak load from 3rd cycle (kN)	Maximum ultimate load (kN)
1	Timber	14.0	15.8
2	Timber	14.0	15.2
3	Timber	14.0	15.2
4	Timber	14.0	20.6
5	Timber	14.0	15.2
		Average ultimate load	**16.4**

Note: average maximum screwbolt displacement was 0.17mm

Standard deviation = 2.4
Coefficient of variation = 14.4 %
Number of specimens = 5
Minimum value of peak load of the individual test = 15.2 kN
Characteristic strength = 11.9 kN

The failure mode for all specimens was due to timber failure. Figure 13 shows the photo of bottom plate timber failure from the test. Load-displacement curves for the six specimens is provided in Appendix A.

Figure 13: Bottom plate timber failure

5.2 In-plane shear test results

Results from in-plane shear tests are summarised in Table 3.

Table 3: In-plane shear test results for Screwbolt Hex 8x140mm anchors

Test	Failure mode	Peak load at 3rd cycle (+ve) (kN)	Peak load at 3rd cycle (-ve) (kN)	Avg. peak load from 3rd cycle (kN)
1	Anchor in shear	14.0	14.0	14.0
2	Anchor in shear	11.9	11.5	11.7
3	Anchor in shear	9.4	10.3	9.9
4	Anchor in shear	11.0	12.7	11.8
5	Anchor in shear	9.5	12.8	9.5
6	Anchor in shear	9.9	10.8	10.3
		Average 3rd cycle peak load		**11.5**

Standard deviation = 1.45
Coefficient of variation = 12.6%
Number of specimens = 6
Minimum value of peak load of the individual test = 9.9kN
Characteristic strength = 8.2kN

Figure 14 shows examples of anchor failure in shear of the specimens. Load displacement curves from the tests can be found in Appendix B.

Figure 14: Anchor in shear failure

5.3 Out-of-plane shear test results

Results from out of plane shear tests are summarised in Table 4.

Table 4: Out-of-plane shear test results for Screwbolt Hex 8x140mm anchors

Test	Failure mode	Peak load at 3rd cycle (+ve) (kN)	Peak load at 3rd cycle (-ve) (kN)	Avg. peak load from 3rd cycle (kN)
1	Concrete	6.0	6.0	6.0
2	Concrete	4.5	5.2	4.9
3	Concrete	4.2	7.9	6.0
4	Concrete	4.7	7.4	6.0
			Average 3rd cycle peak load	**5.7**

Standard deviation = 0.59
Coefficient of variation = 10.2%
Number of specimens = 4
Minimum value of peak load of the individual test = 4.9kN
Characteristic strength = 4.0kN

Figure 15 shows an example of typical concrete failure of the specimens. Load displacement curves from the tests can be found in Appendix C.

Figure 15: Concrete failure

6 CONCLUSIONS

Experimental test setups were developed to test Screwbolt Hex 8x140mm anchors in tension, in-plane shear, and out-of-plane shear. The anchors were installed in drilled holes of 8mm in diameter and hole depths of 105mm with embedment depths of 95mm, at 50mm to concrete edge with 90×45 MGP10 structural pine as bottom plate. The screwbolt anchors were tightened with a torque of 40Nm. Installation of anchors was done in accordance to instructions provided by ICCONS. Table 5 summarises the results for the Screwbolt Hex 8x140mm anchors.

Table 5: Summary of results for Screwbolt Hex 8x140mm anchors

Type of test	No. of samples	Coefficient of variation	Mean ultimate strength (kN)	Characteristic strength (kN)
Tension	5	14.4 %	16.4	11.9
In-plane shear	6	12.6%	11.5	8.2
Out-of-plane shear	4	10.2%	5.7	4.0

Note: peak load measured on 3rd cycle for shear tests

7 REFERENCES

BRANZ (1999). Structural joints - strength and stiffness evaluation. BRANZ Evaluation Method EM1. BRANZ Ltd, Judgeford, New Zealand.

Shelton, R. H. (2004). Bottom plate anchors under NZS 3604:1994. BRANZ Study Report No. SR 125 (2004). Judgeford, Porirua, New Zealand, Building Research Association of New Zealand.

Standards New Zealand (SNZ) (2011). Timber framed buildings, NZS 3604. Standard NZ, Wellington.

APPENDIX A – LOAD DISPLACEMENT CURVES FOR TENSION TESTS

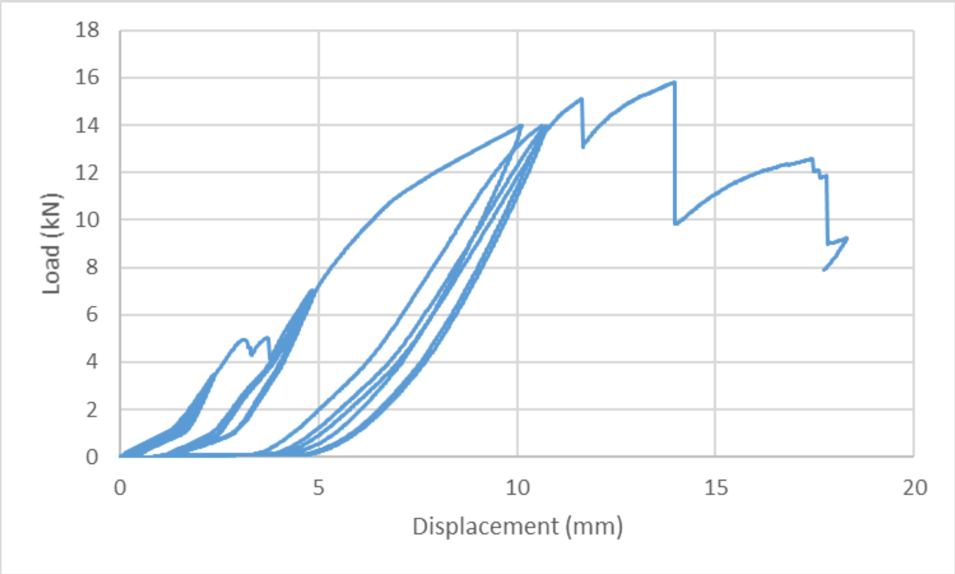


Figure 16: Load displacement curve for tension test #1

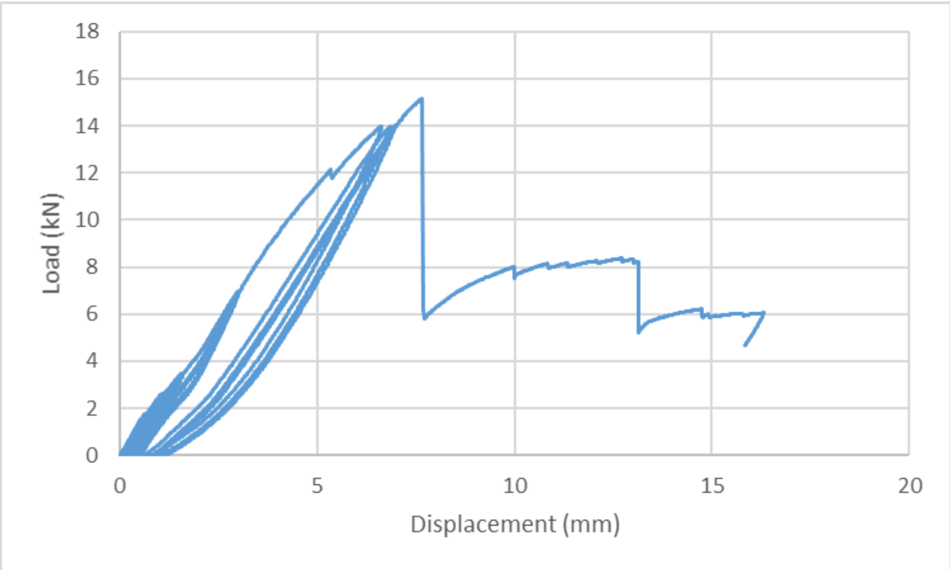


Figure 17: Load displacement curve for tension test #2

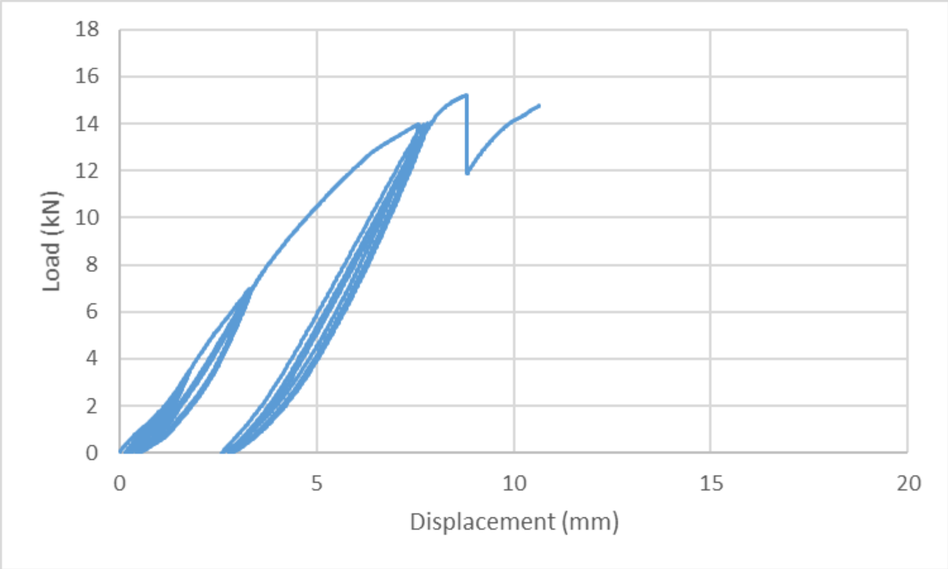


Figure 18: Load displacement curve for tension test #3

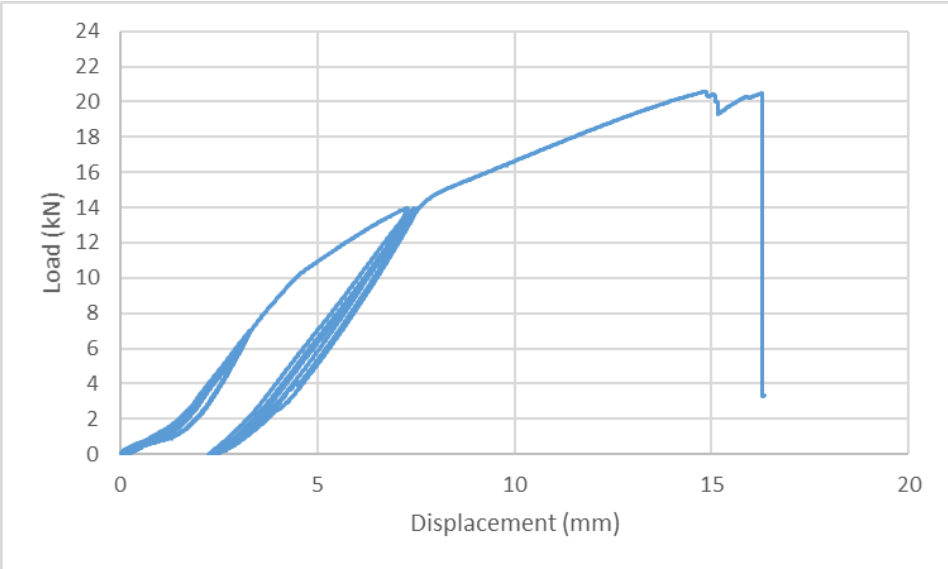


Figure 19: Load displacement curve for tension test #4

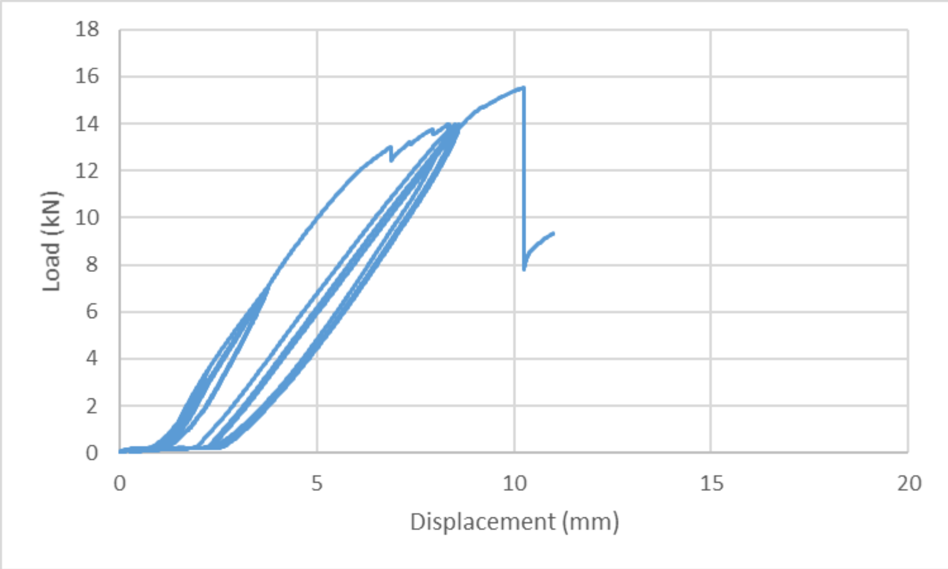


Figure 20: Load displacement curve for tension test #5

APPENDIX B – LOAD DISPLACEMENT CURVES FOR IN-PLANE SHEAR TESTS

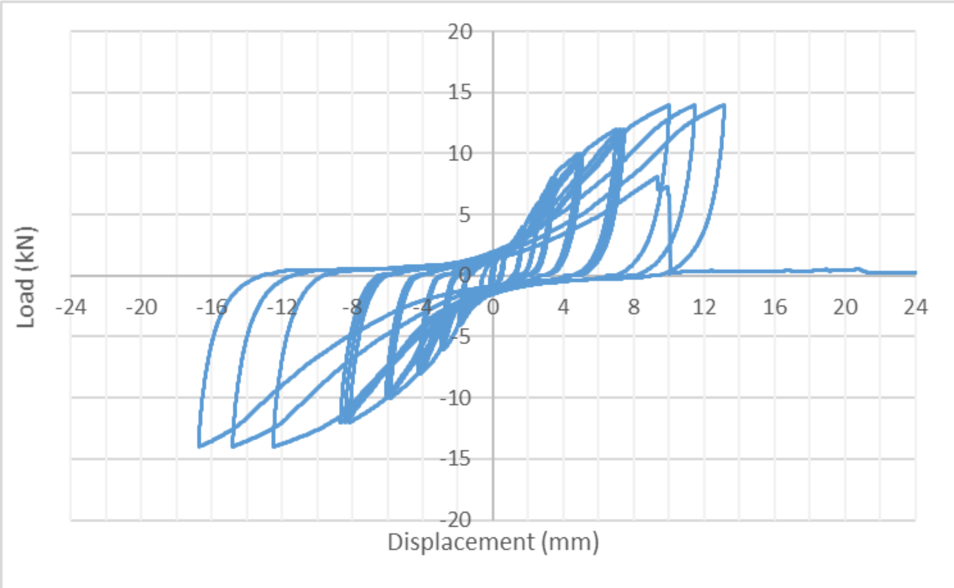


Figure 21: Load displacement curve for in-plane shear test #1

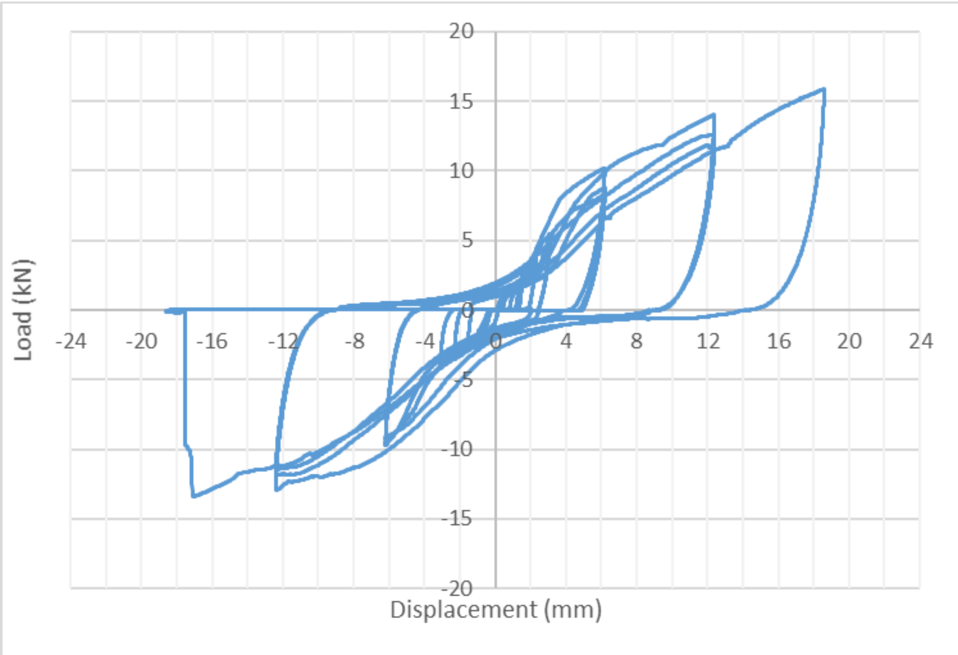


Figure 22: Load displacement curve for in-plane shear test #2

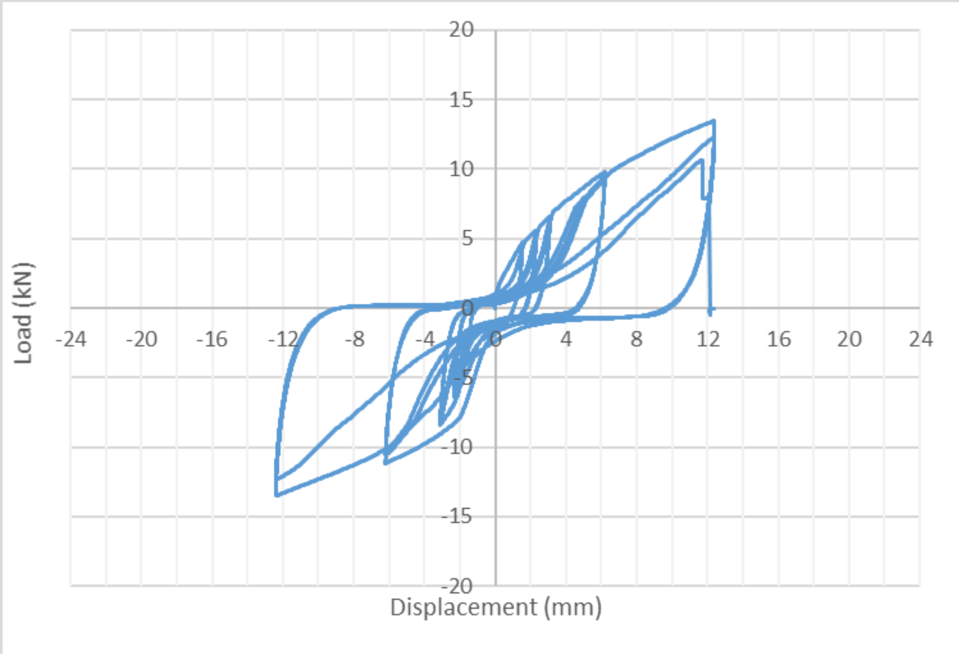


Figure 23: Load displacement curve for in-plane shear test #3

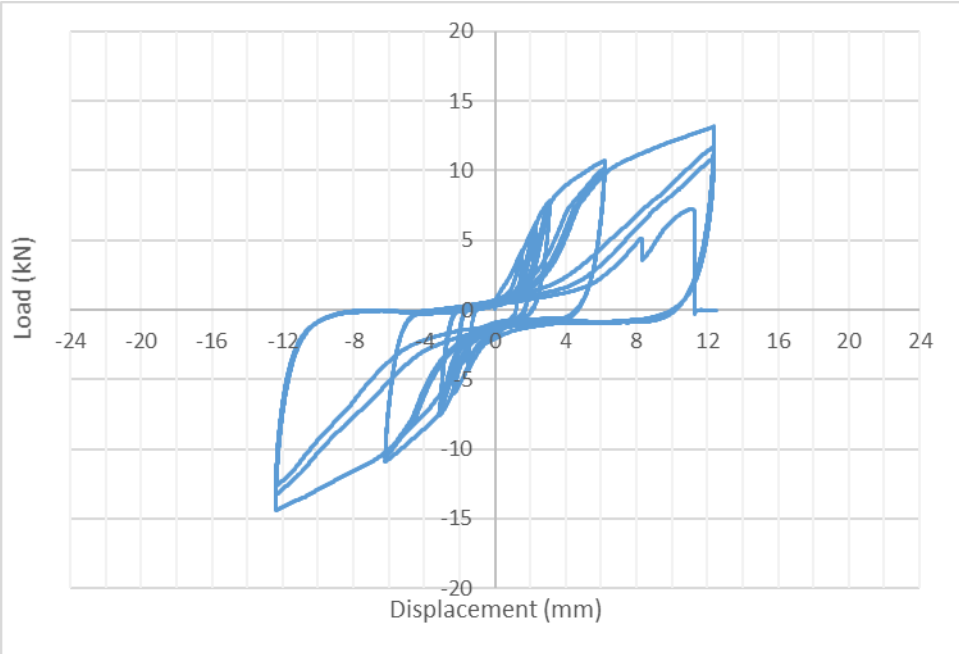


Figure 24: Load displacement curve for in-plane shear test #4

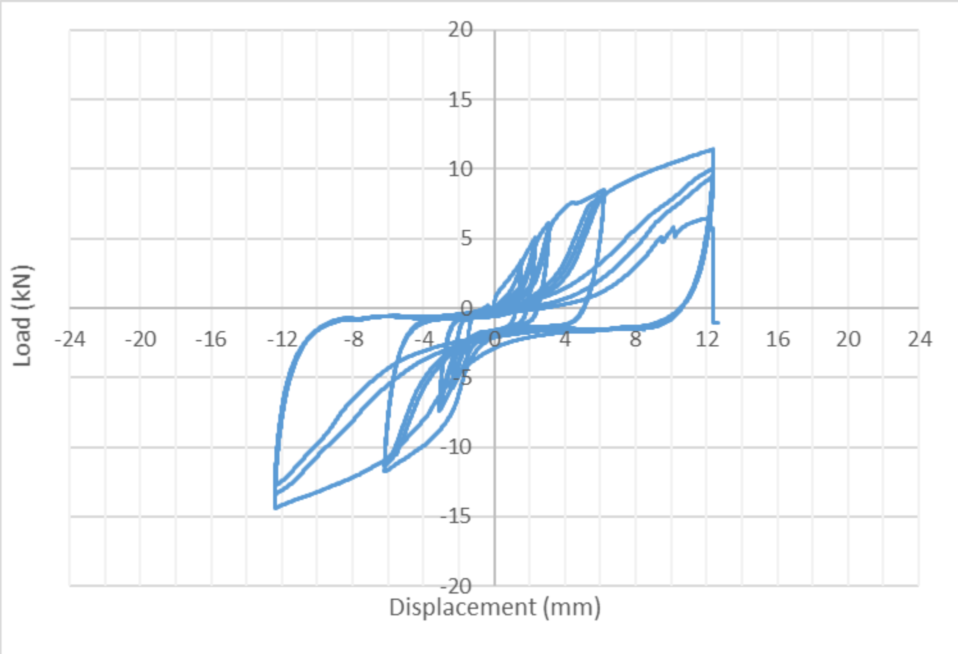


Figure 25: Load displacement curve for in-plane shear test #5

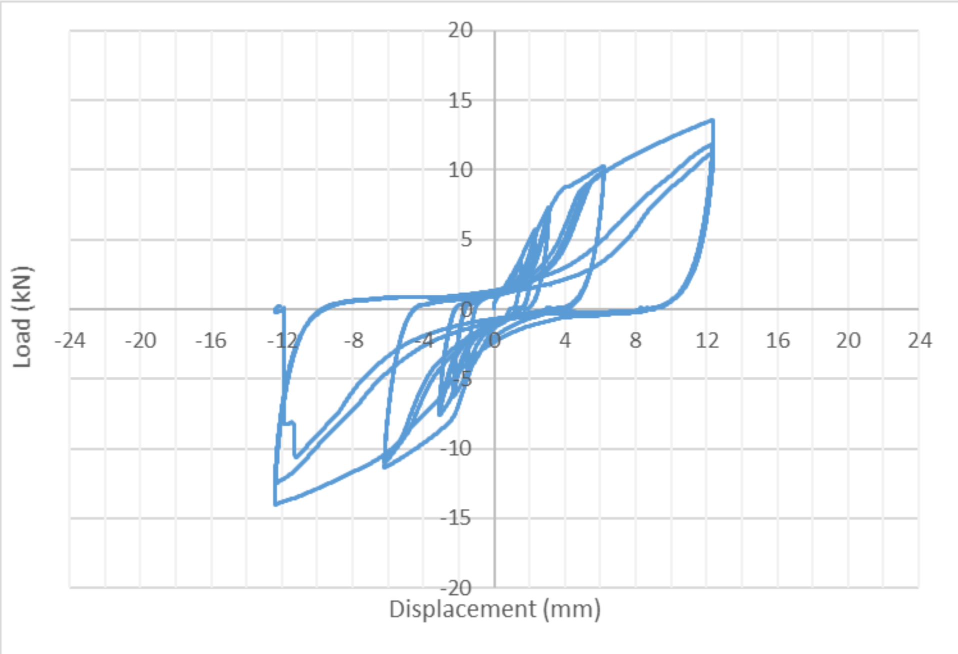


Figure 26: Load displacement curve for in-plane shear test #6

APPENDIX C – LOAD DISPLACEMENT CURVES FOR OUT-OF-PLANE SHEAR TESTS

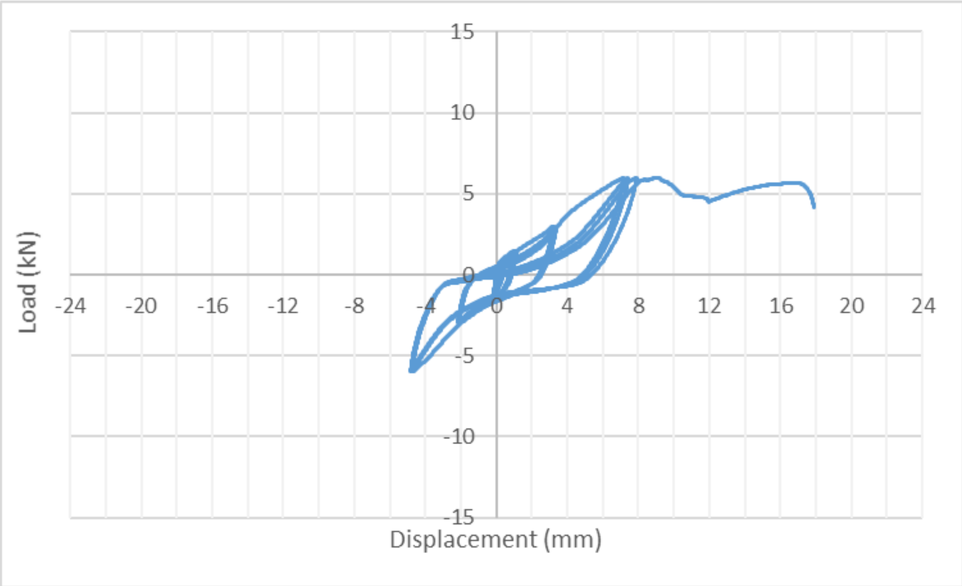


Figure 27: Load displacement curve for out-of-plane shear test #1 for

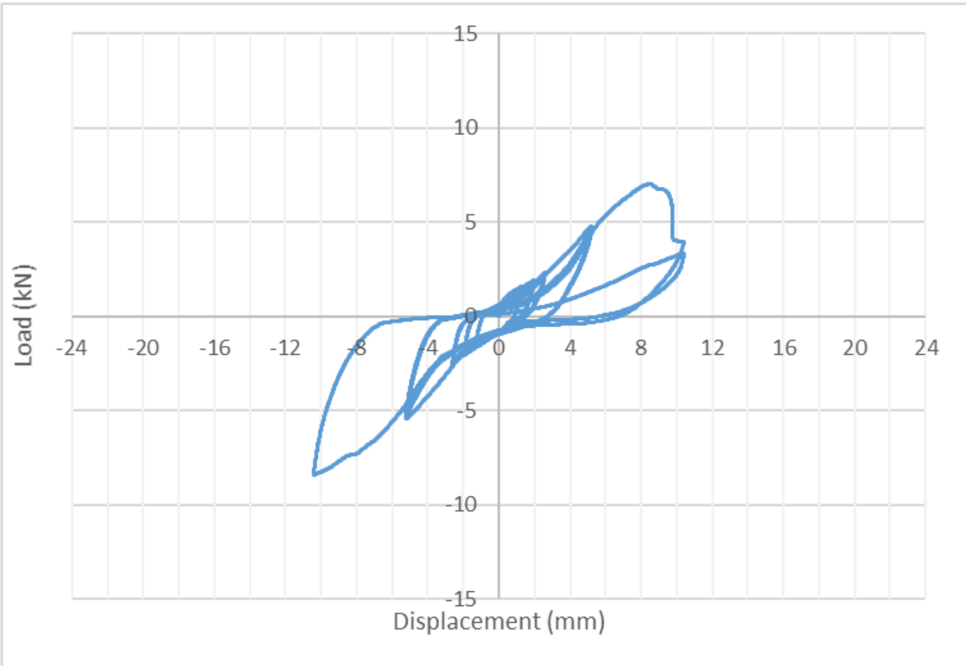


Figure 28: Load displacement curve for out-of-plane shear test #2

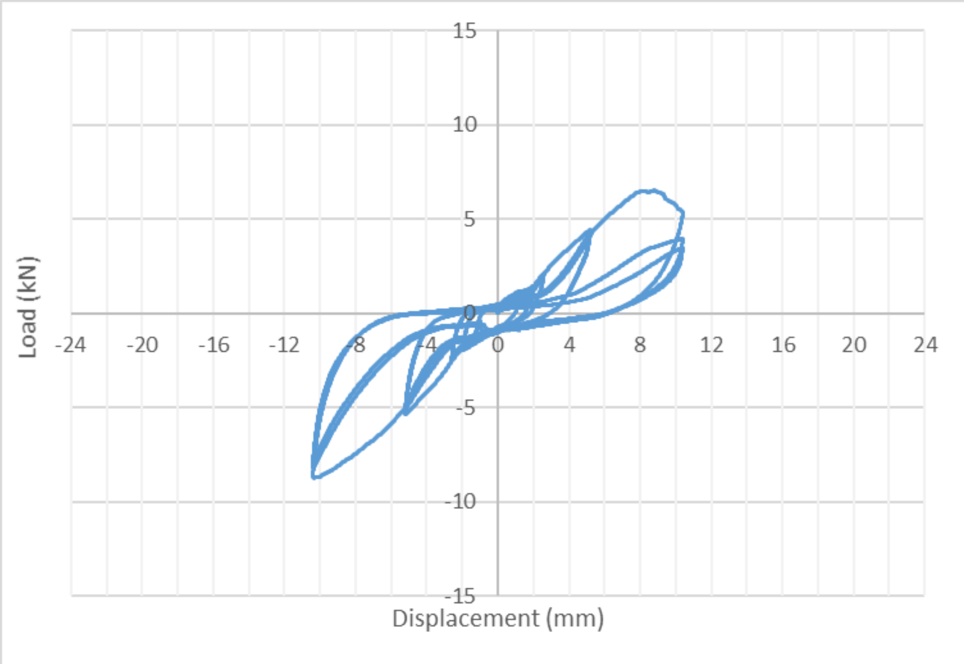


Figure 29: Load displacement curve for out-of-plane shear test #3

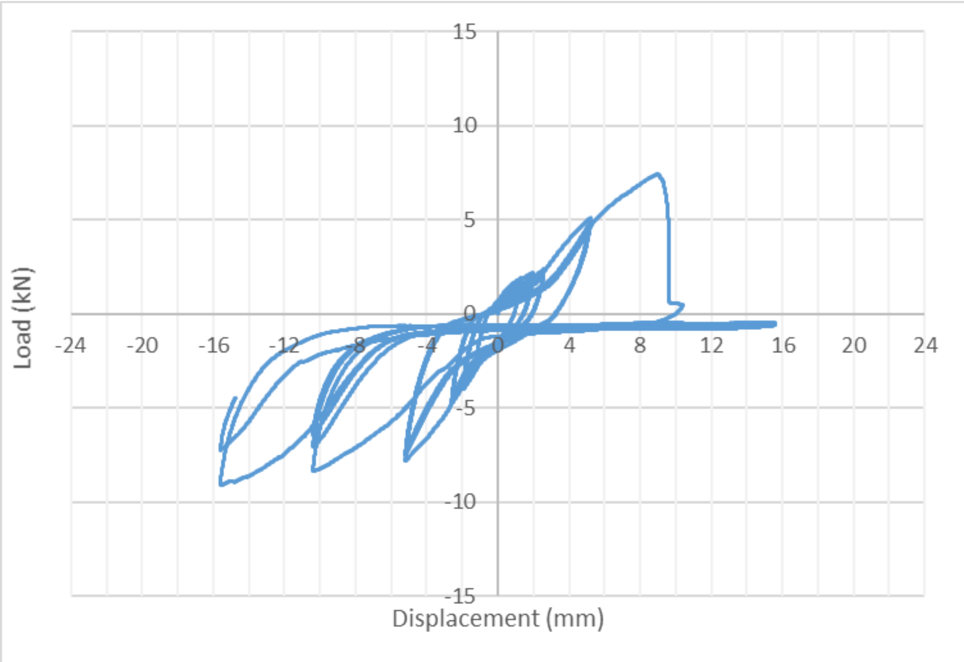


Figure 30: Load displacement curve for out-of-plane shear test #4