

Experimental Testing of Hold Down Devices for Timber Frame Shear Walls

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Abstract

Källsner and Girhammar [1] have presented a new plastic design method for wood-framed shear walls at ultimate limit state. This method allows the designer to calculate the load-carrying capacity of partially anchored shear walls, where the leading stud is not anchored against uplift.

The anchorage system of shear walls is provided by anchor bolts in the bottom rail and hold downs at the leading stud. Anchor bolts provide horizontal shear continuity between the bottom rail and the foundation. Hold downs are directly connecting the vertical leading stud to the foundation. Sometimes hold downs are not provided and only the bottom rail is anchored to the substrate. In this case the bottom row of nails transmits the vertical forces in the sheathing to the bottom rail (instead of the stud) where the anchor bolts will further transmit the forces into the foundation.

In this report hold downs have been experimentally studied with respect to the strength and stiffness of the connection.

Four different types of hold downs have been tested.

The specimen was subjected to tension load applied to the stud.

Four tests series are presented. Each series was divided into different sets according to the type of fastener used with the hold down device.

The results show that the failure load is higher when hold downs with anchor bolts are used, up to ten times higher than the anchorage that uses only screws or nails. The failure mode vary with the type of hold down and the type of fasteners used. The tests showed three primary failure modes: failure of the stud when a bolt is used as the fastener between hold down device and stud, failure due to pull-out of the screws or nails from the rail and failure due to failure or pull-out of screws or nails from stud. Also, failure of the stud itself occurred in some tests caused by some defect of the timber

Key words: timber shear walls, partially anchored, hold downs, rail-to-stud joint, tie downs.

Acknowledgements

The experiments of this report were carried out at Umeå University, Sweden, from February to April 2011.

Bo Källsner and Ulf Arne Girhammar have initiated this study as part of their research work on a plastic design method for partially anchored light-frame shear walls. Giuseppe Caprolu has performed the experiment and written the report.

I would like to thanks Bo Källsner and Ulf Arne Girhammar for reviewed the report and Helena Johnsson for reading and commenting the manuscript.

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Introduction

Background

Light frame timber shear walls are vertical structural elements designed to carry the dead and lateral load, received from horizontal roof and floor diaphragms, and to transfer them to the foundation.

There are different methods to design the timber shear walls. In EC5 two methods are given: method A, where the shear wall is fully anchored, and method B, where the shear wall is partially anchored, where the leading stud is free to move and the bottom rail is anchored to the substrate.

EN 594 gives the test method to be used in determining the racking resistance.

This research is part of a new plastic design method of wood-framed shear walls at ultimate limit state presented by Källsner and Girhammar [1]. This method allows the designer to calculate the load-carrying capacity of partially anchored shear walls.

The anchorage system of shear walls is provided by anchor bolts in the bottom rail, hold downs at the leading stud and transverse walls. Anchor bolts provide horizontal shear continuity between the bottom rail and the foundation. Hold downs provide a vertical anchorage device between the vertical end studs and the foundation. In partially anchored shear walls hold downs are not necessarily provided and the bottom row of nails transmit the vertical forces in the sheathing-to-framing joint in the bottom rail (instead of the vertical stud) where the anchor bolts will further transmit the forces into the foundation.

The aim of these tests was to evaluate the strength and the stiffness of the hold downs, in order to determine the magnitude of the load carried by hold downs.

Aim and Scope

The aim of this report is to present results of laboratory tests of hold downs and to evaluate their strength and the stiffness.

The scope of the experiment program was as follow:

a total of 120 specimens were tested. The tests were divided in four different series with respect to the type of hold downs device and each series was divided into several sets with respect to the use and arrangements of screws and nails. For each set, 12 tests were conducted.

The experimental work was conducted at Umeå University from February to April 2011.

Test setup and material

Test specimen

The specimens tested were built with two timber pieces of different lengths joined by four different connectors. The horizontal part of the specimen is the bottom rail of a shear wall whilst the vertical part is the stud. The length of the bottom rail was 300 mm for each series whilst the length of the stud was 400 mm for series 1, 2 and 3 and 900 mm for series 4 (*see figure 1*).

The cross section of the original timber was 45x145 mm but the cross section of the board for the specimen had to be 45x120 mm. Therefore 12.5 mm were cut from each side for each board.

The length of the rails was originally of 6000 mm and in September 2010, when they arrived to the lab of Umeå University, they were cut in pieces of 900 mm and were kept enclosed in a plastic cover until testing (*see Appendix B for a chronological summary of the conduction of the tests*). The temperature in the lab was about 20° C.

All specimens were assembled manually.

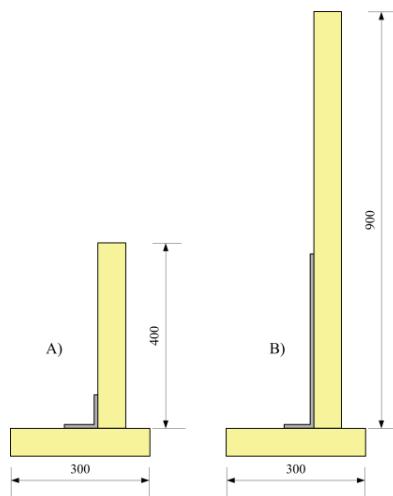


Figure 1: A) dimensions of the specimen of series 1, 2 and 3; B) dimensions of the specimen of series 4.

Test program

A total of 120 specimens were tested. The tests were divided in four different series with respect to the type of hold down device and each series was divided into several sets with respect to the use and arrangement of screws and nails. For each set, 12 tests were conducted.

Table 1: Test program

Series	Set	Type of fastening of the connector	Connector	Number of tests
1	1	Stud: Bolt M8	AB 55365	12
		Rail: 8 wooden screws 5x40		12
	2	Stud: 8 wooden screws 5x40		12
		Rail: 8 wooden screws 5x40		12
2	1	Stud: Bolt M10 + 10 wooden screws 5x40	ABR 9020	12
		Rail: 10 wooden screws 5x40		12
	2	Stud: Bolt M10 + 10 annular ringed shank nail 4x40		12
		Rail: 10 annular ringed shank nail 4x40		12
	3	Stud: 10 wooden screws 5x40		12
		Rail: 10 wooden screws 5x40		12
	4	Stud: 10 wooden screws 5x40		12
		Rail: 6 wooden screws 5x40		12
3	1	Stud: 14 wooden screws 5x40	AKR 135	12
		Rail: Bolt M12		12
	2	Stud: 14 annular ringed shank nail 4x40		12
		Rail: Bolt M12		12
4	1	Stud: 18 wooden screws 5x40	HTT4 ⁽¹⁾	12
		Rail: Bolt M16		12
	2	Stud: 18 annular ringed shank nail 4x40		12
		Rail: Bolt M16		12

⁽¹⁾ The hole of the screws of this connector in series 4 – set 1 were enlarged from 4.7 mm to 5 mm

Material properties

The following materials were used for the specimens:

- Rail and stud: Spruce (*Picea Abies*), C24, 45x145 mm;
- Connectors: Simpson strong-tie AB 55365, Simpson strong-tie ABR 9020, Simpson strong-tie AKR 135 and Simpson strong-tie HTT4 (*see Appendix C for the dimensions and characteristics of the connectors*);
- Anchor bolts: M8 8.8, M10 8.8, M12 8.8 and M16 8.8;
- Screws: Simpson strong-tie wooden screws CSA 5.0x40 mm, Service Class 2 (EC5);
- Nails: Simpson strong-tie annular ringed shank nails CNA 4.0x40 mm, Service Class (EC5).

Moisture content and density

After each test, material samples were taken from the test specimen. The samples were cut from the rail if the failure was on the rail and from the stud if the failure was on the stud. The moisture

content and density of the timber were determined according to the recommendations of ISO 3130:1975 and ISO 3131:1975 respectively.

The moisture content (ω) was calculated according to the following formula (ISO 3130):

$$\omega = \frac{m_1 - m_0}{m_0} \cdot 100 [\%]$$

where:

- m_1 is the mass of the test piece before the drying [g];
- m_0 is the mass of the test piece after the drying [g].

The density (ρ) was calculated according to the following formula (ISO 3131):

$$\rho = \frac{m_0}{V_w} \left[\frac{kg}{m^3} \right]$$

where:

- m_0 is the mass of the test piece after the drying [g];
- V_w is the volume of the test piece before the drying [m^3 , cm^3].

The moisture content and density were measured the same day of the test. Sometime due different problems this was not possible and they were measured some day later (*see Appendix B for a chronological summary of the conduction of the tests*).

Test setup

Two different anchorage systems were used during the test. Series 1 and 2 had an anchorage system composed by two clamps in order to fix the specimen to the I steel beams simulating the foundation which in turn was welded to a steel structure (*see figures 2, 3 and 4*). In series 3 and 4 two different types of connectors were used: M12 bolt for series 3 and M16 bolt for series 4 which were tightened to a steel plate simulating the foundation which in turn was welded to a steel structure (*see figures 2, 5, 6, 7, 8, 9 and 10*).

A tensile load with a rate of 2 mm/min was applied by a hydraulic piston (static load capacity 100 kN). The connection between the hydraulic piston and the stud was made by steel bars and bolt M16.

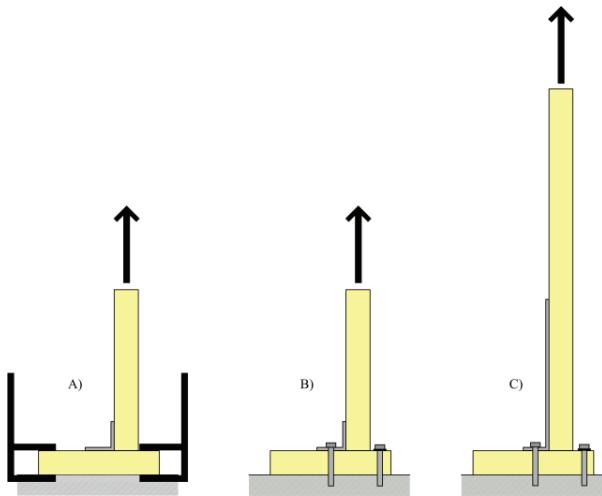


Figure 2: A) test setup for series 1 and 2; B) test setup for series 3; C) test setup for series 4.



Figure 3: setup for series 1 and 2.



Figure 4: setup for series 1 and 2.



Figure 5: steel plate for series 3 and 4.



Figure 6: steel plate for series 3 and 4.



Figure 7: setup for series 3.



Figure 8: setup for series 3.



Figure 9: setup for series 4.



Figure 10: setup for series 4.

During the testing the displacement was recorded using a Linear Voltage Displacement Transducer (LVDT). For series 1 – set 2 from specimen 55365-1B to 55365-9B only one LVDT was used and it was positioned on the upper surface of the angle connector in the part of the rail. However this displacement was not good because during the deformation of the connector the LVDT moved and did not measure the displacement at the same point (*see figures 11 and 12*). The stud was not guided and it was free to move in horizontal direction due to the eccentricity.



Figure 11: position of LVDT before to start the test.



Figure 12: movement of LVDT during the test.

Therefore, in order to resolve this problem, another displacement was measured. The displacement measured was the distance between the end of the stud and the upper surface of the rail. Two LVDT were fixed on both edge of the rail, at the same distance from the edge, in order to see the possible influence of eccentricity (see figures 13, 14 and 15).



Figure 13: position of the two LVDT.



Figure 14: position of the two LVDT.



Figure 15: displacements measured.

Test results

Load vs. time and load vs. displacement curves for each test are displayed in Appendix A. Moreover other data and test result, as well as figures for each test, are displayed.

- Type of failure;
- Failure load;
- Displacement 1 and displacement 2 at failure;
- Mean displacement;
- Moisture;
- Density.

Failure modes

Different failure modes were found during the tests. They were dependant on the connector used and on the type of fastening of the connector. In total three primary failure modes were observed.

- **Failure mode 1:** failure of the stud when a bolt is used as the connector between connector and stud (*see figure 16*);

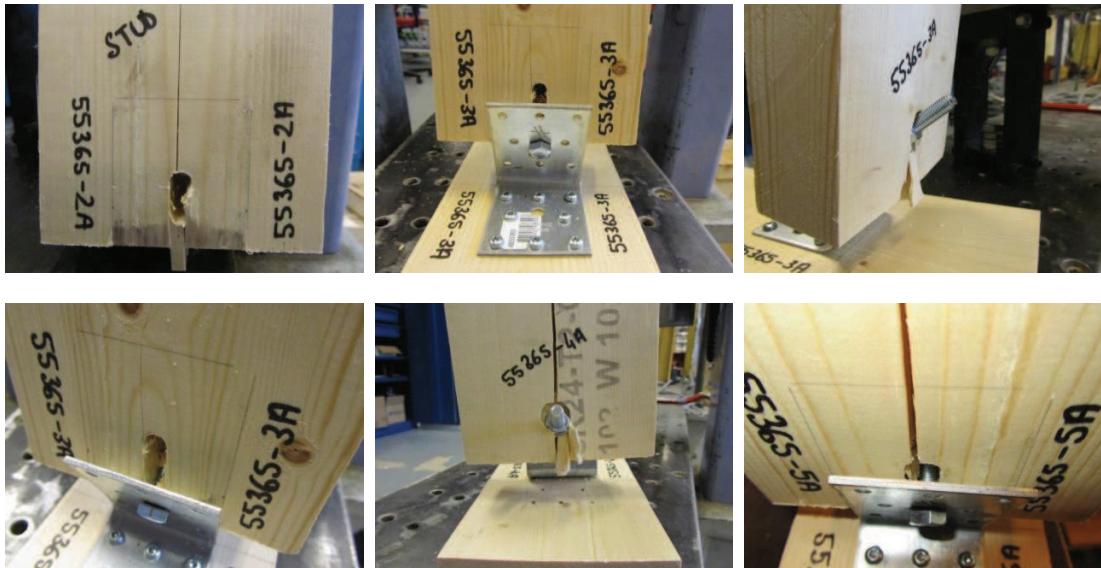


Figure 16: failure mode 1, failure of the stud

- **Failure mode 2:** failure due to pull-out of the screws or nails from the rail (*see figure 17*);



Figure 17: failure mode 2, pull-out of the screws or nails from the rail

- **Failure mode 3a:** failure due to failure or pull-out of screws or nails from stud (see figure 18);



Figure 18: failure mode 3a, failure or pull-out of screws or nails

- **Failure mode 3b:** failure of the stud caused by some defect of the timber (see figure 19);

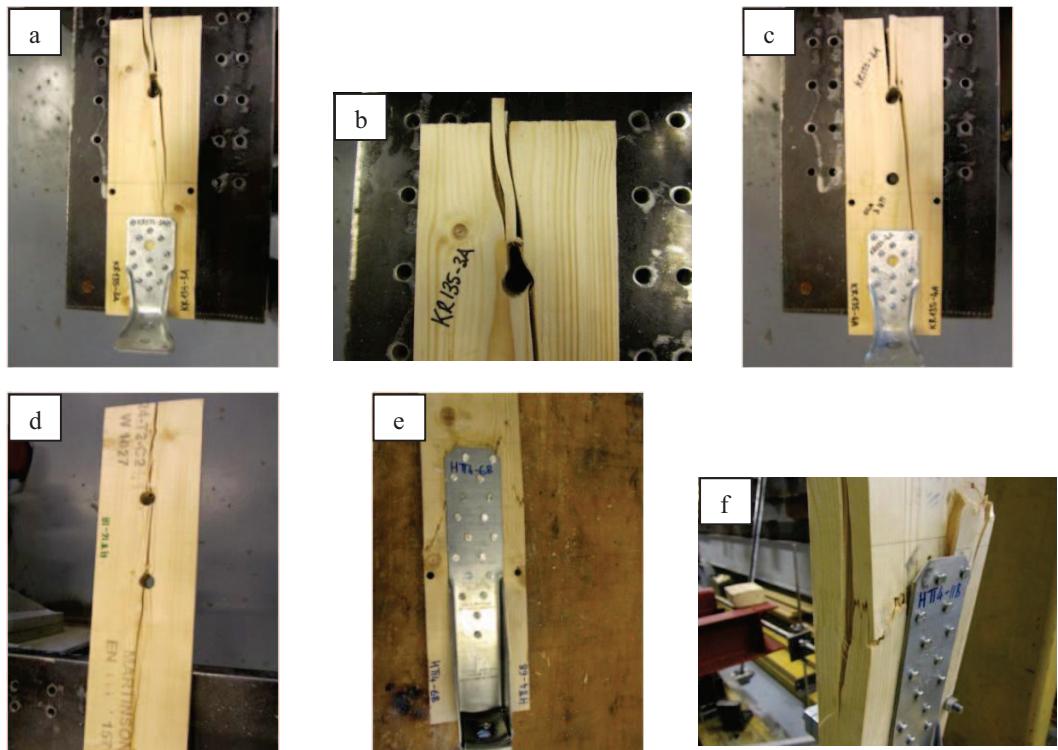


Figure 19: failure mode 3b, failure of the stud due to different defect. a), b), c) and d) four different failure of the stud due defects of the timber in the connection between stud and steel bars of the hydraulic piston. e) and f) failure of the stud due defects of the timber, in this case in the position of the finger joint

Load vs. time and load vs. displacement curves

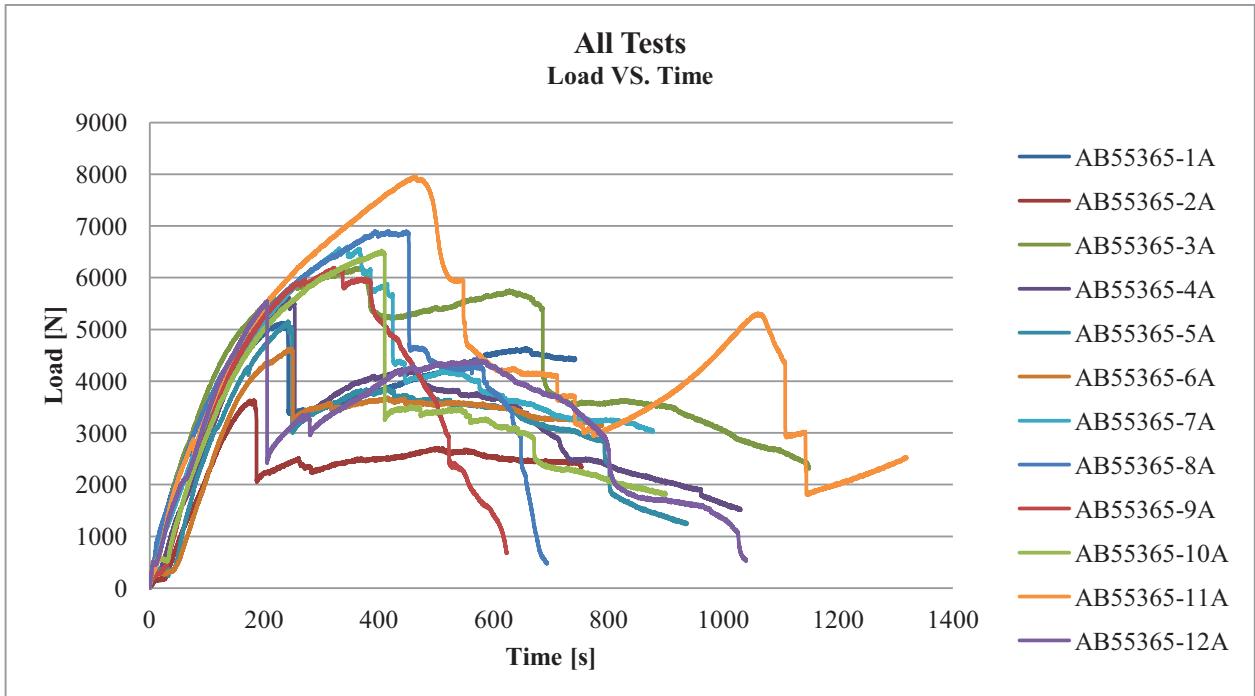


Figure 20: Load vs. time curves for angle connector AB 55365 of Series 1 – Set 1.

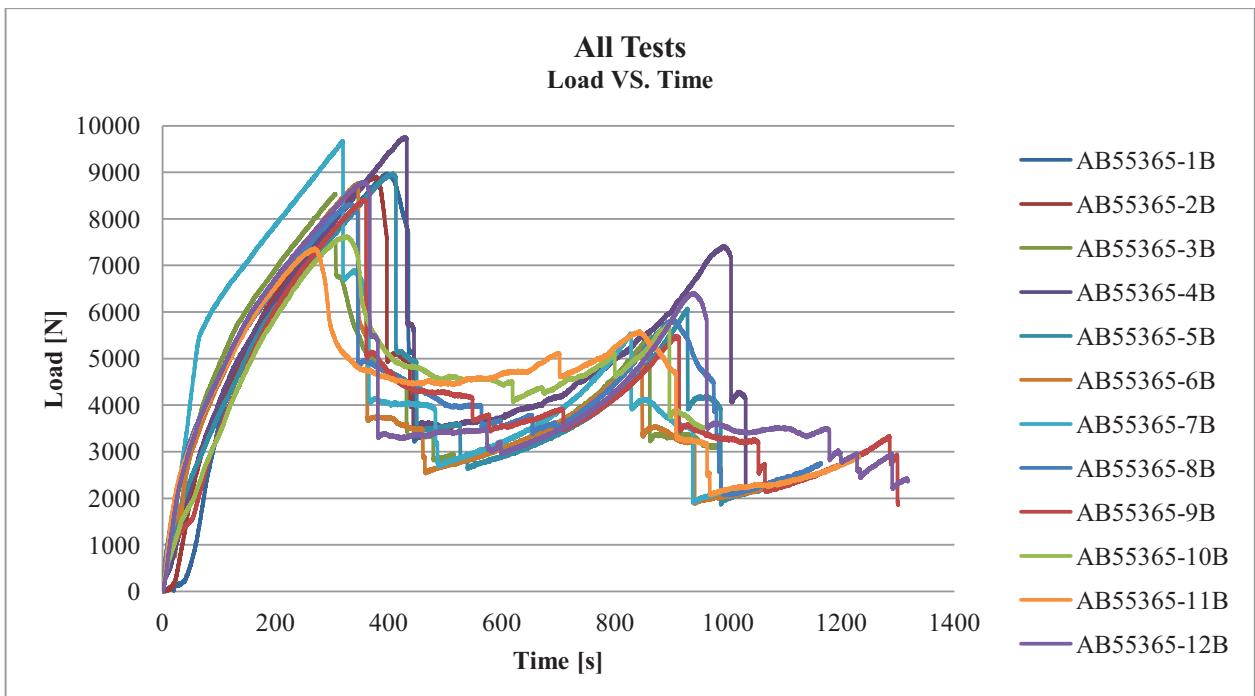


Figure 21: Load vs. time curves for angle connector AB 55365 of Series 1 – Set 2.

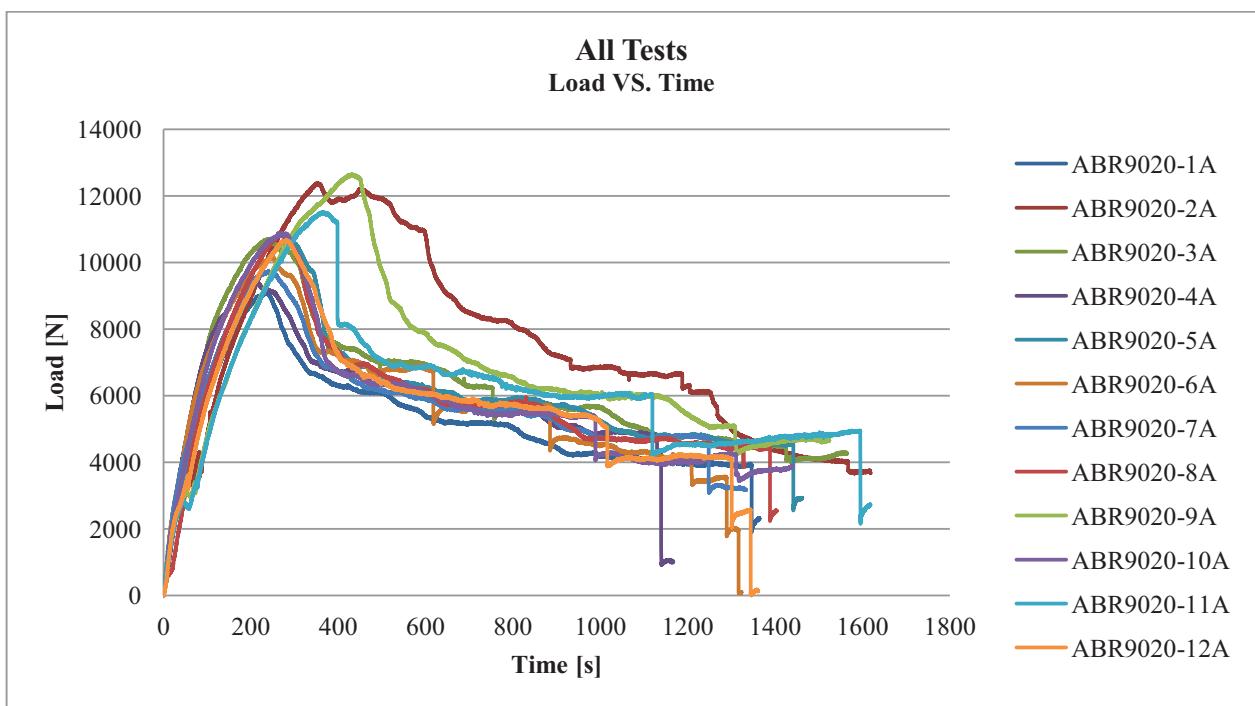


Figure 22: Load vs. time curves for angle connector ABR 9020 of Series 2 – Set 1.

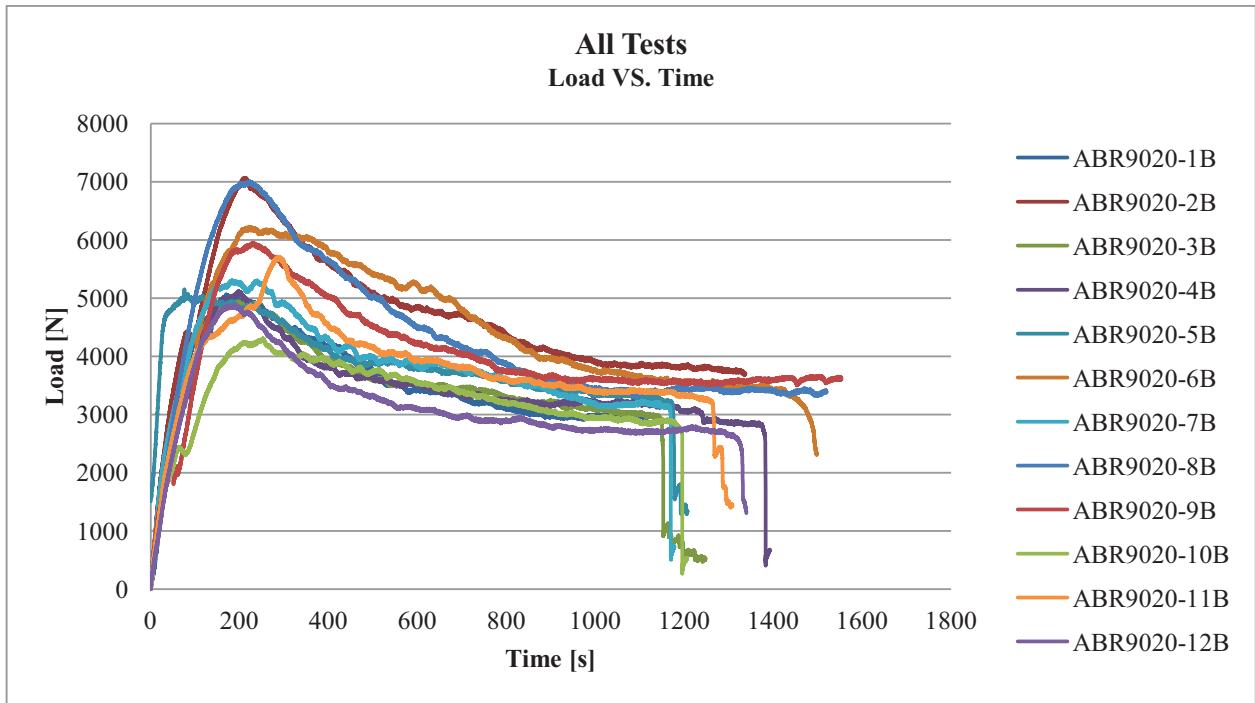


Figure 23: Load vs. time for angle connector ABR 9020 of Series 2 – Set 2.

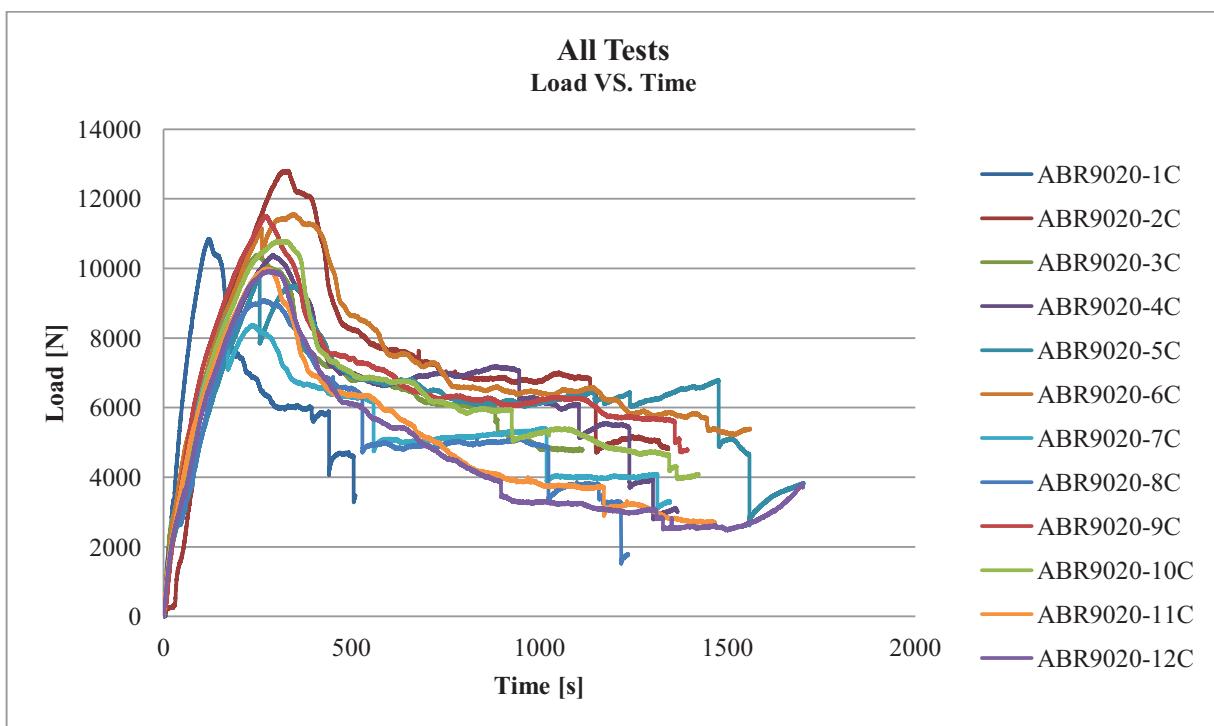


Figure 24: Load vs. time curves for angle connector ABR 9020 of Series 2 – Set 3.

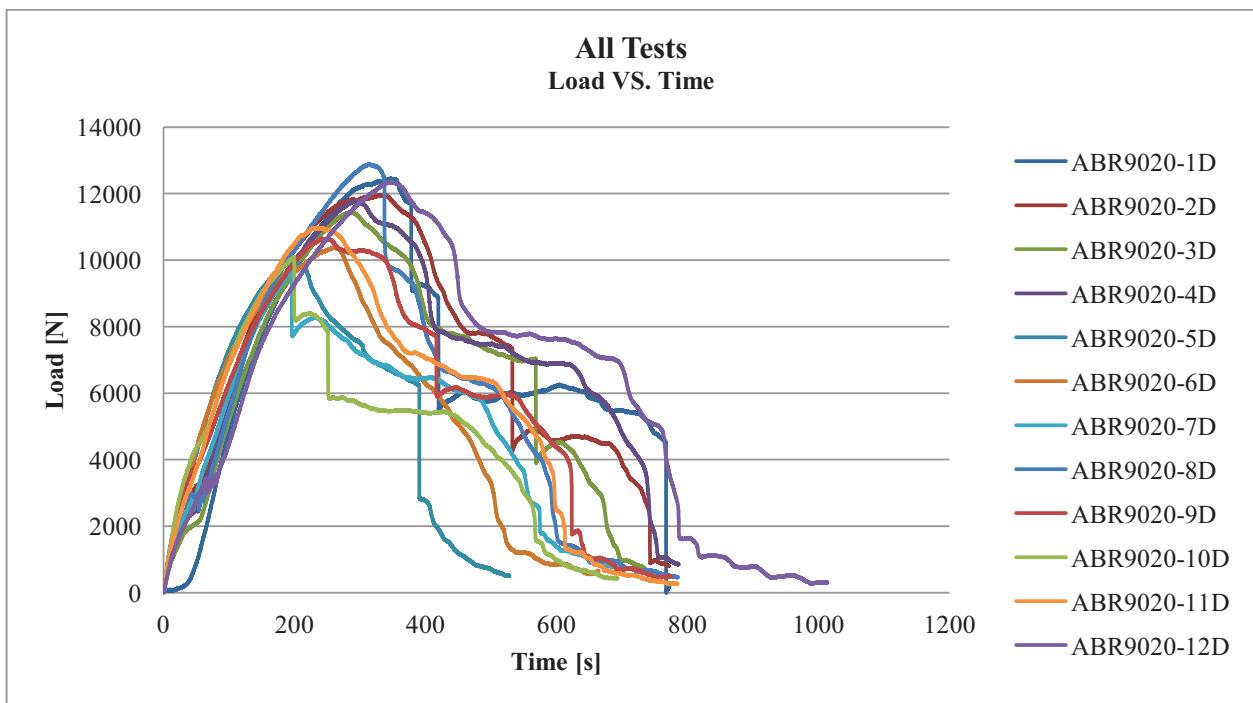


Figure 25: Load vs. time curves for angle connector ABR 9020 of Series 2 – Set 4.

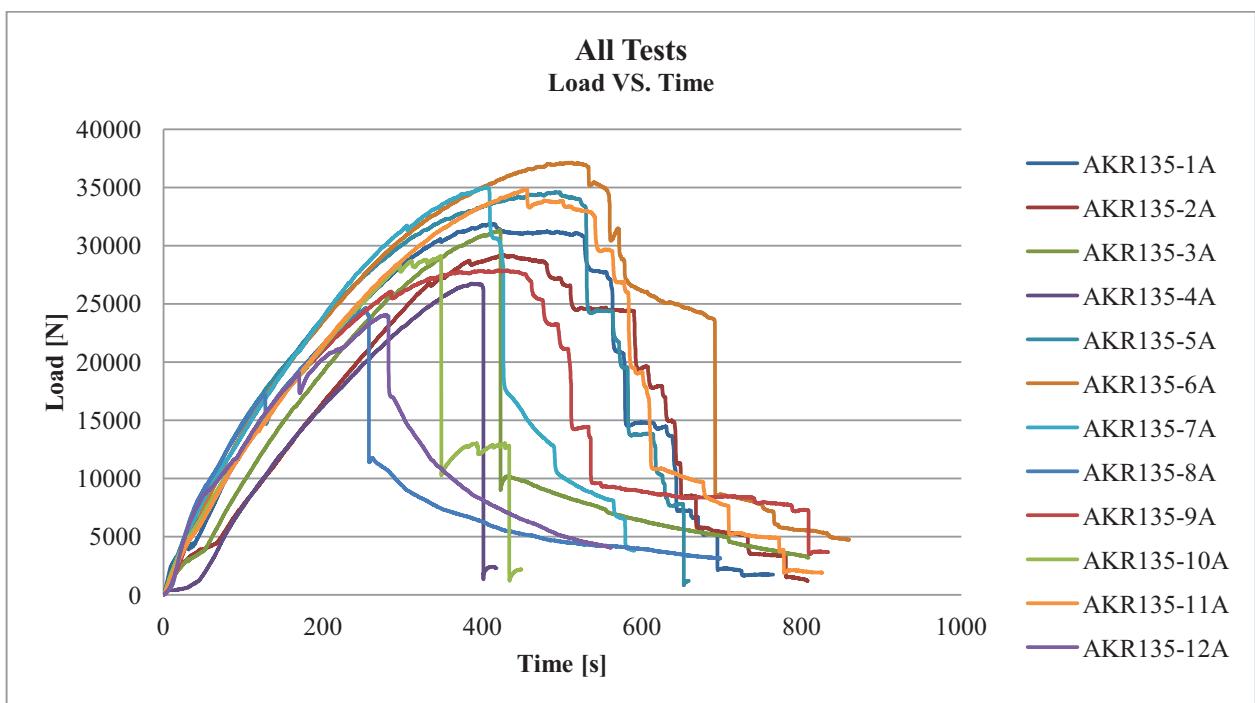


Figure 26: Load vs. time curves of connector AKR 135 of Series 3 – Set 1.

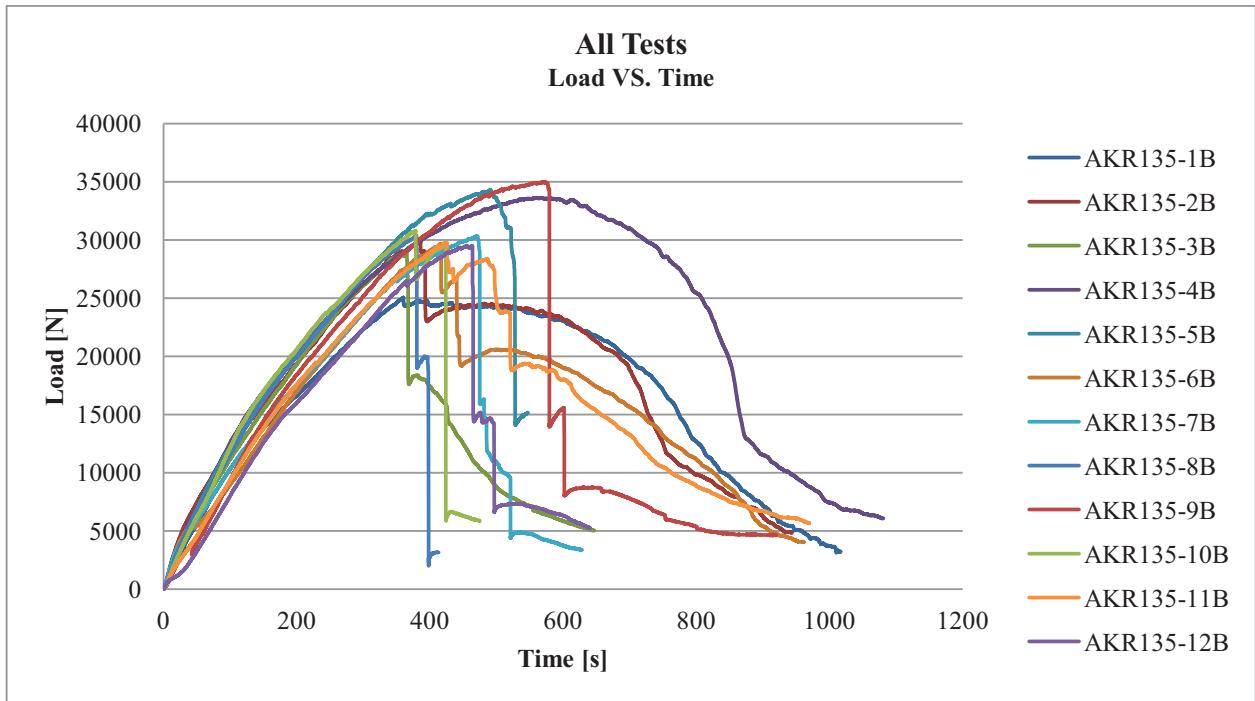


Figure 27: Load vs. time curves for angle connector AKR 135 of Series 3 – Set 2.

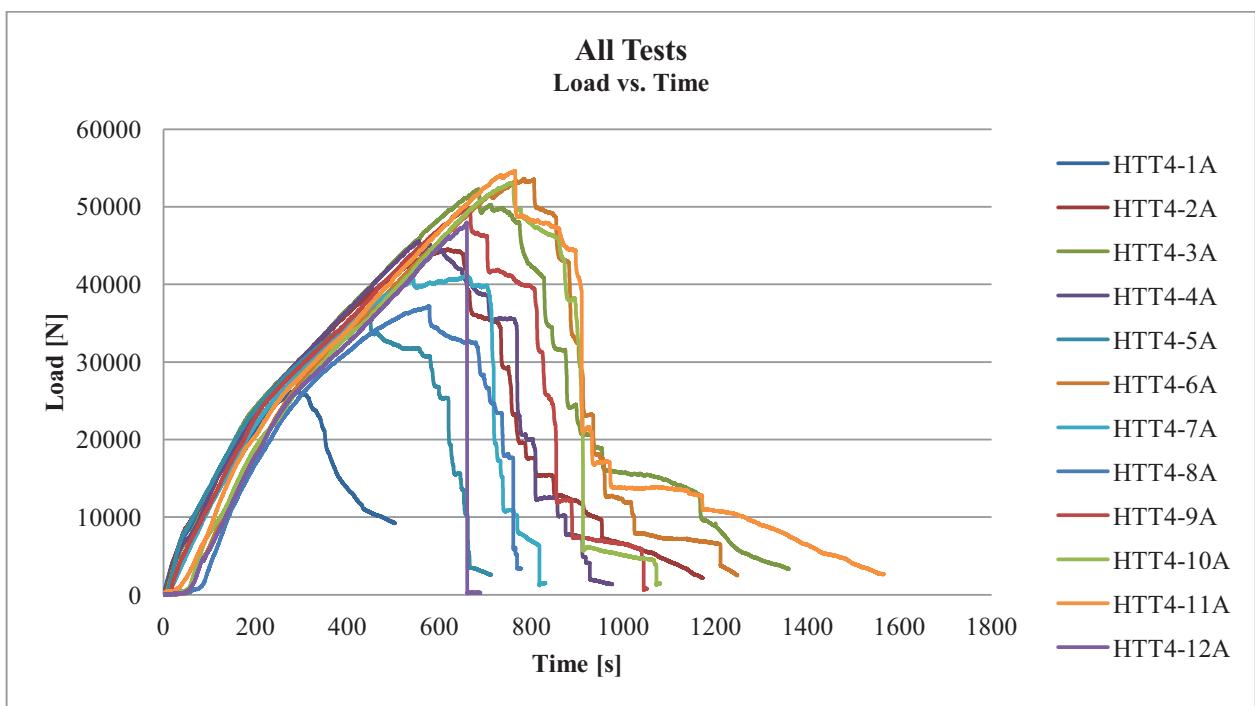


Figure 28: Load vs. time curves for tension tie HTT4 of Series 4 – Set 1.

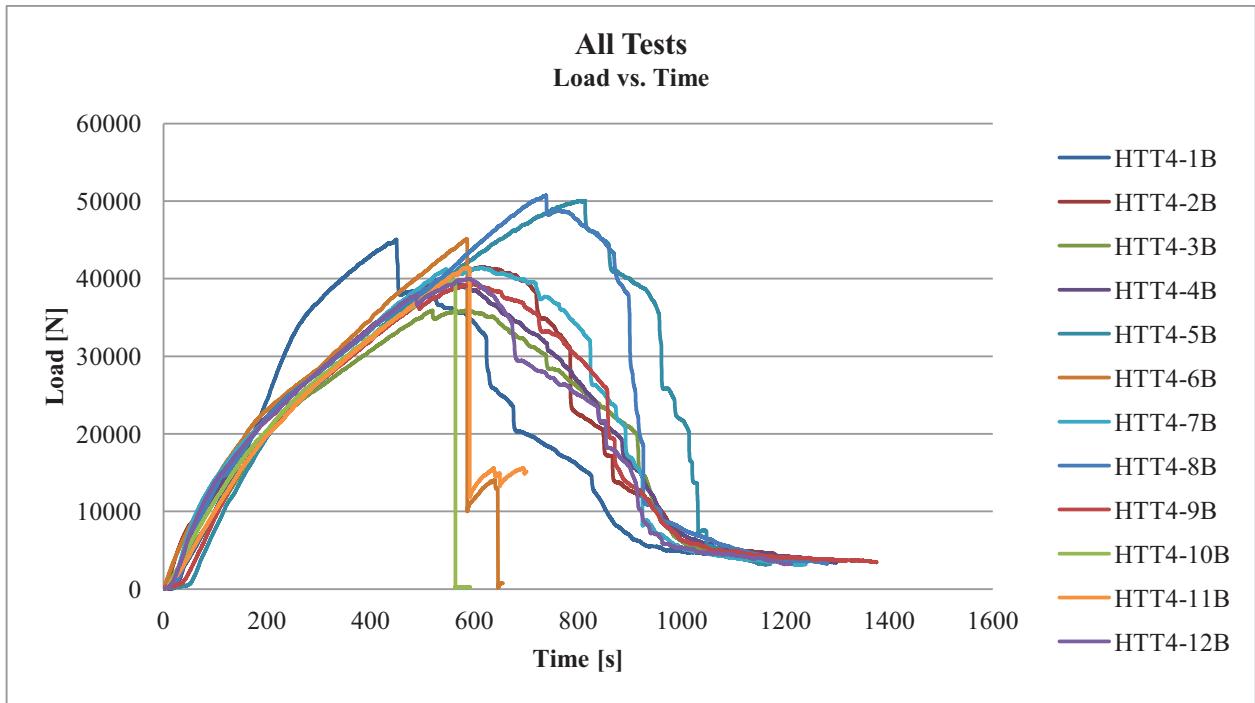


Figure 29: Load vs. time curves for tension tie HTT4 of Series 4 – Set 2.

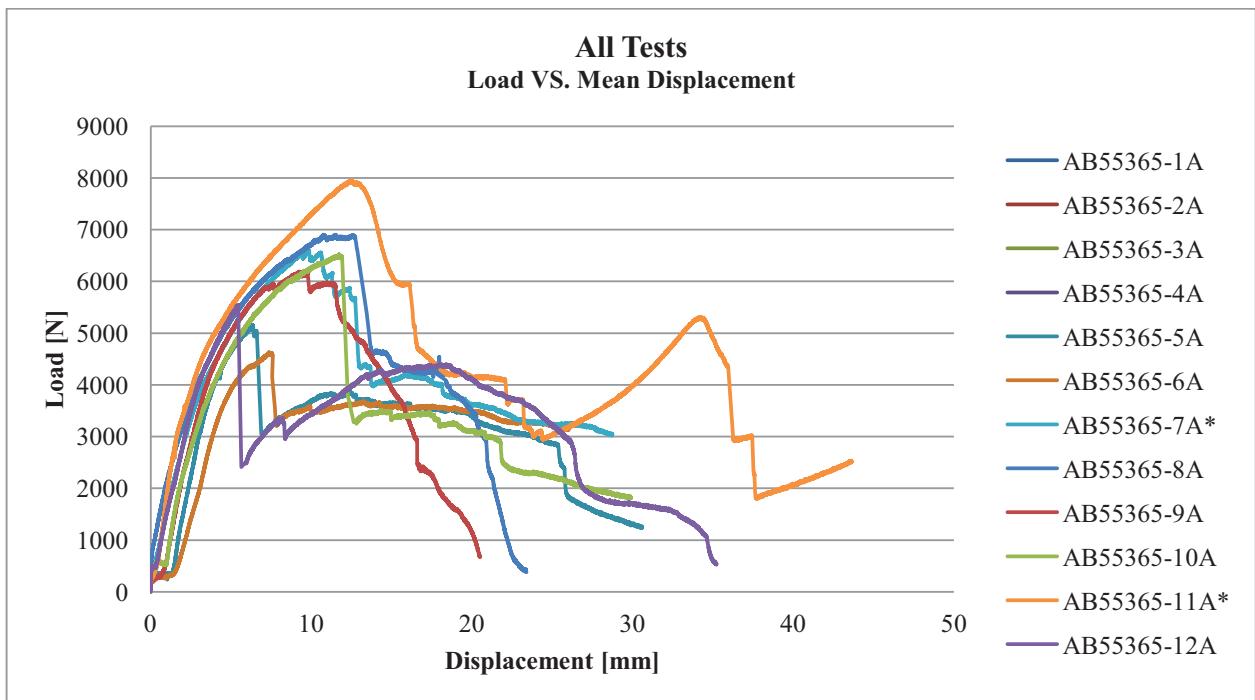


Figure 30: *mean displacement not available, only one displacement is used. Load vs. mean displacement curves for angle connector AB 55365 of Series 1 – Set 1.

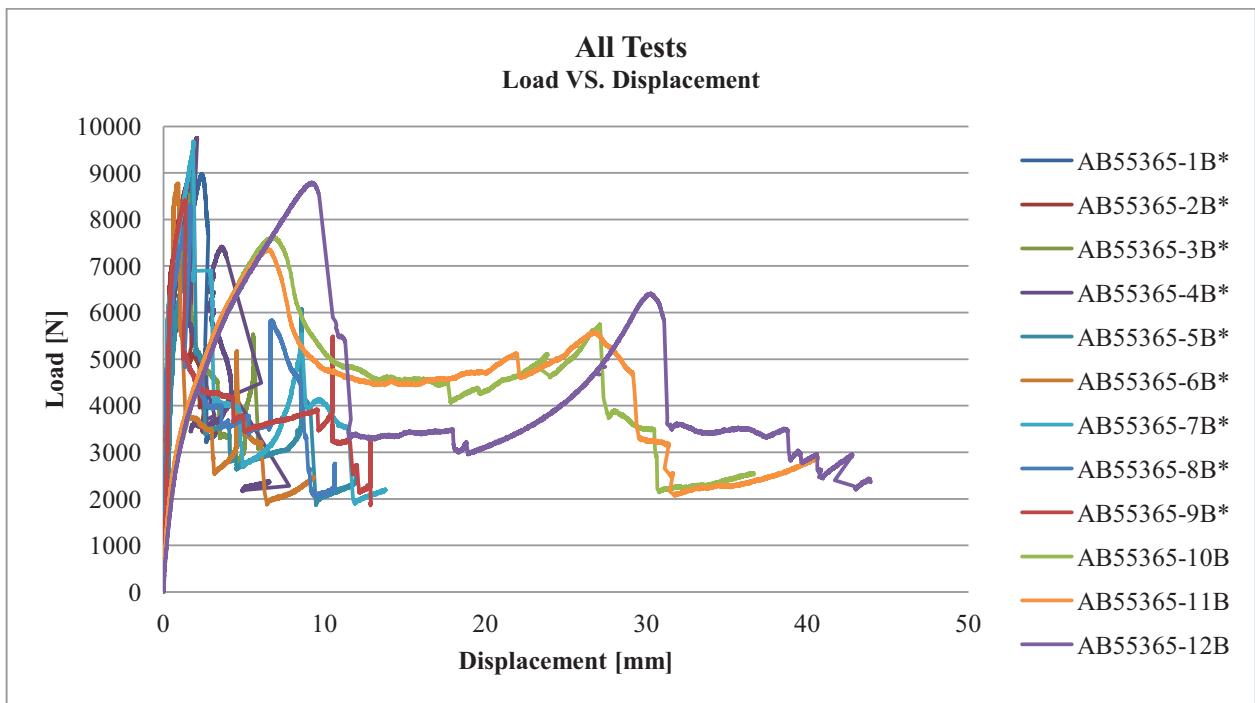


Figure 31: *mean displacement not available, only one displacement is used. Load vs. mean displacement curves for angle connector AB 55365 of Series 1 – Set 2.

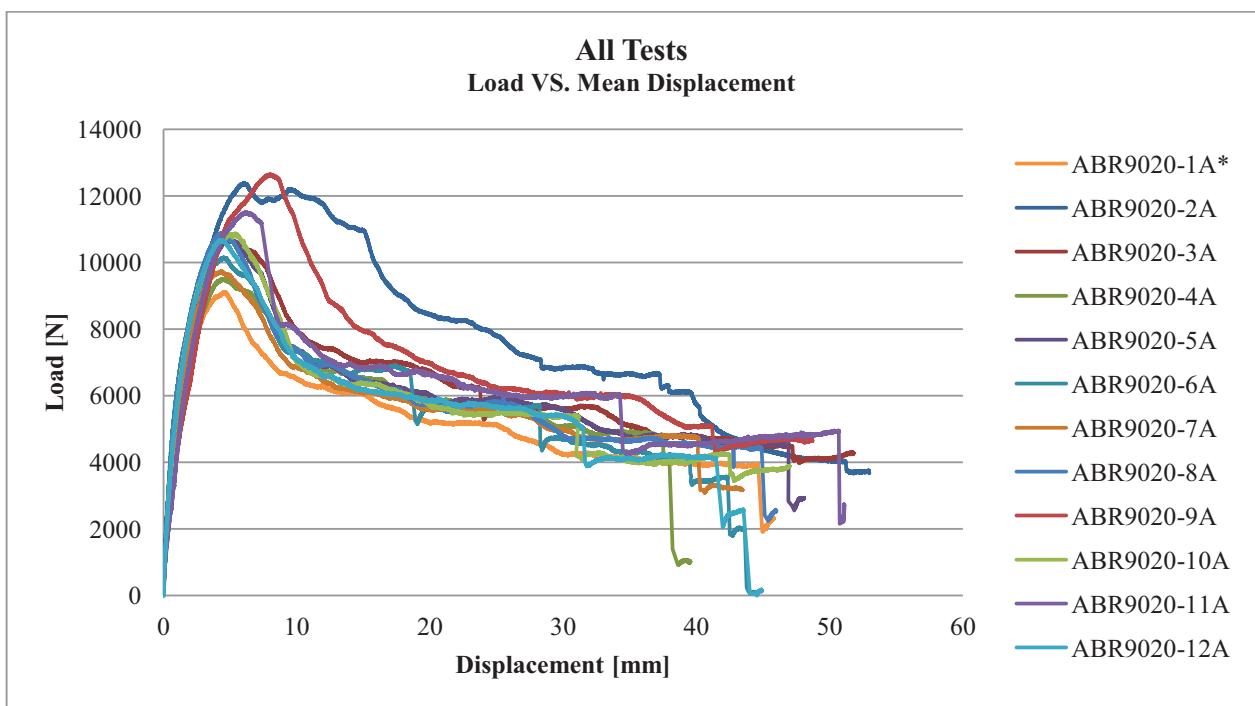


Figure 32: *mean displacement not available, only one displacement is used. Load vs. mean displacement curves for angle connector ABR 9020 of Series 2 – Set 1.

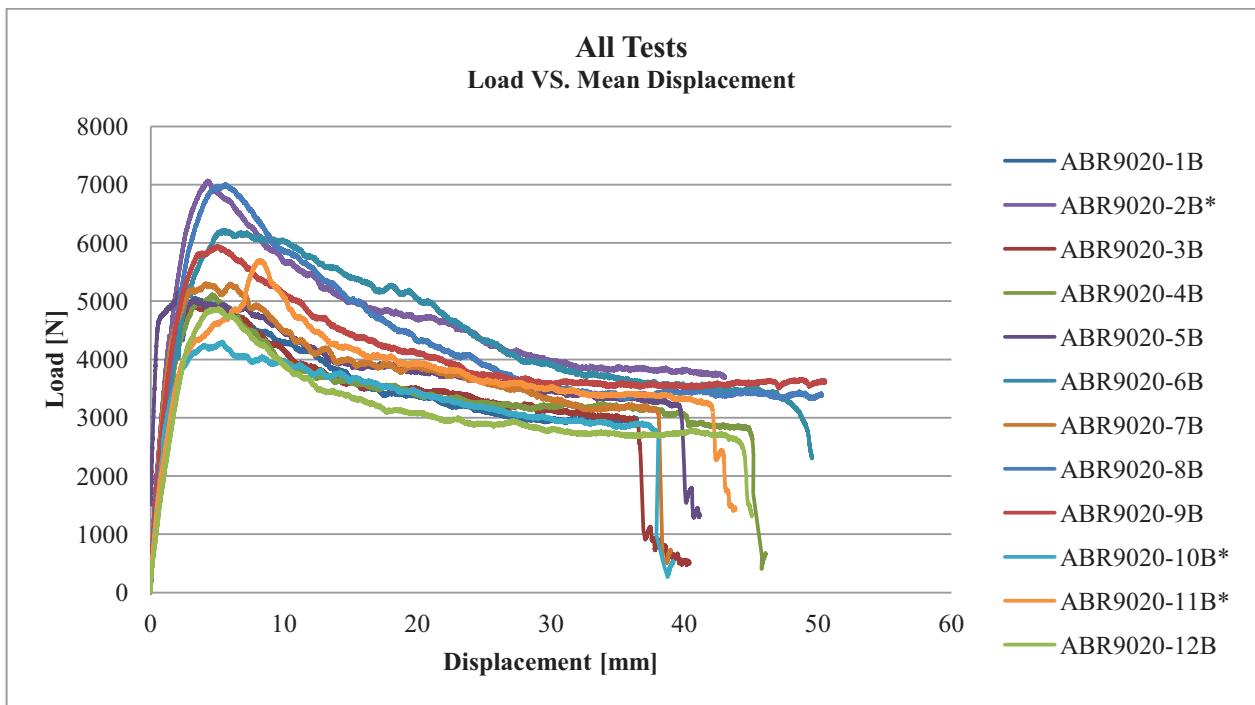


Figure 33: *mean displacement not available, only one displacement is used. Load vs. mean displacement curves for angle connector ABR 9020 of Series 2 – Set 2.

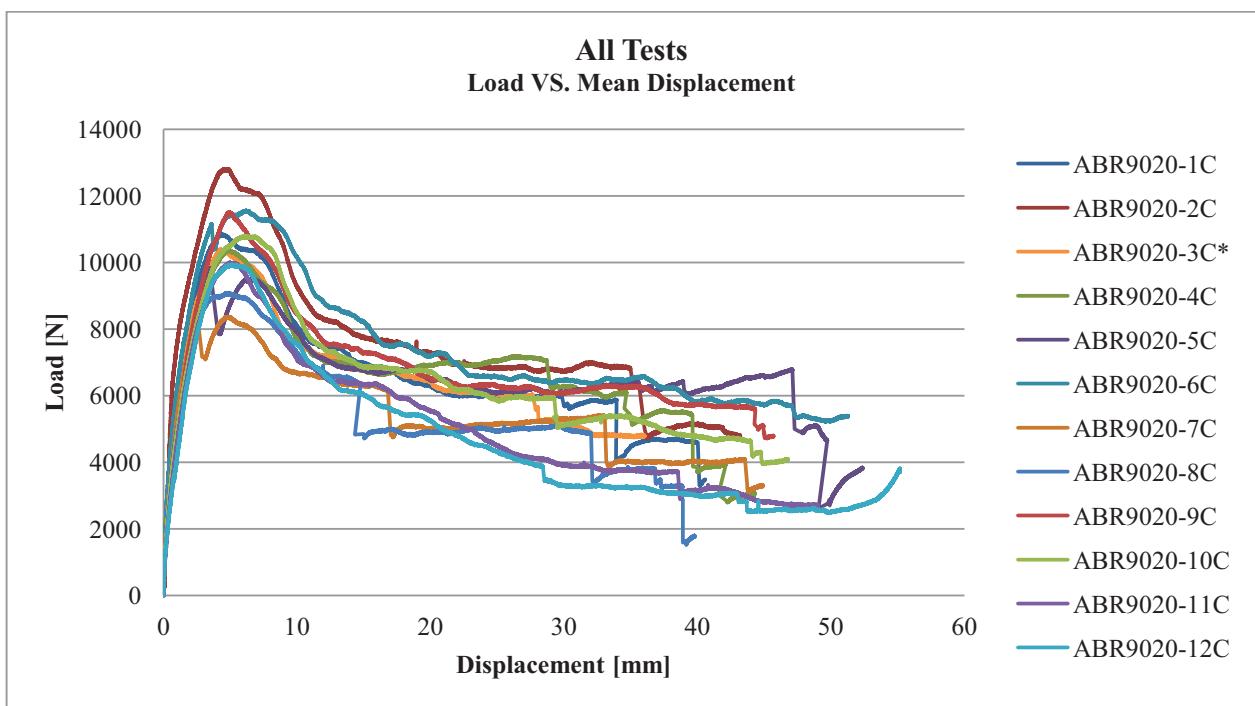


Figure 34: *mean displacement not available, only one displacement is used. Load vs. mean displacement curves for angle connector ABR 9020 of Series 2 – Set 3.

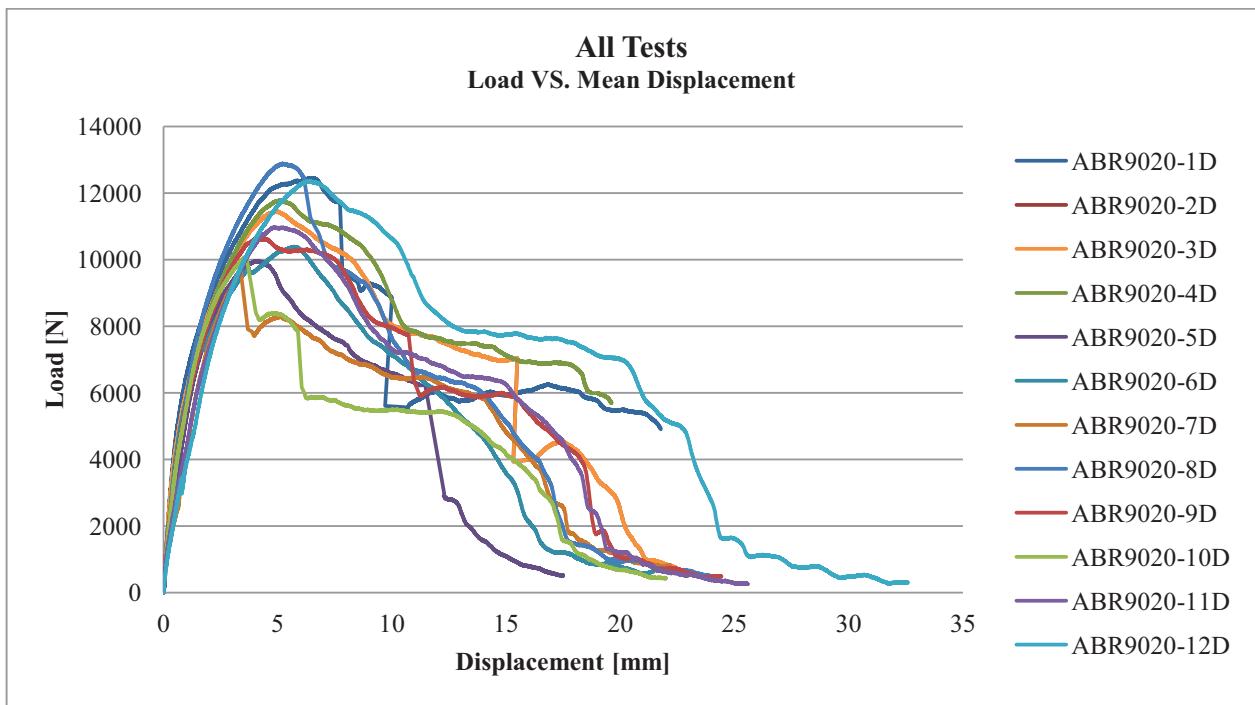


Figure 35: Load vs. mean displacement curves for angle connector ABR 9020 of Series 2 – Set 4.

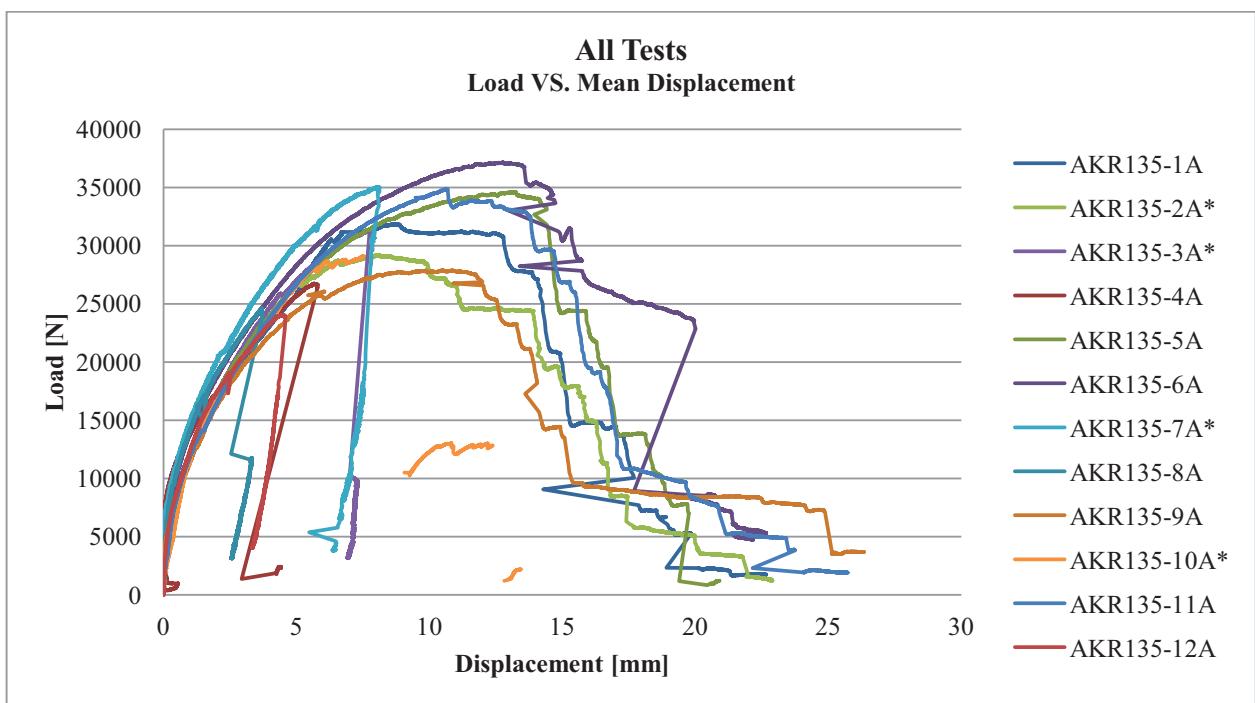


Figure 36: *mean displacement not available, only one displacement is used. Load vs. mean displacement for angle connector AKR 135 of Series 3 – Set 1.

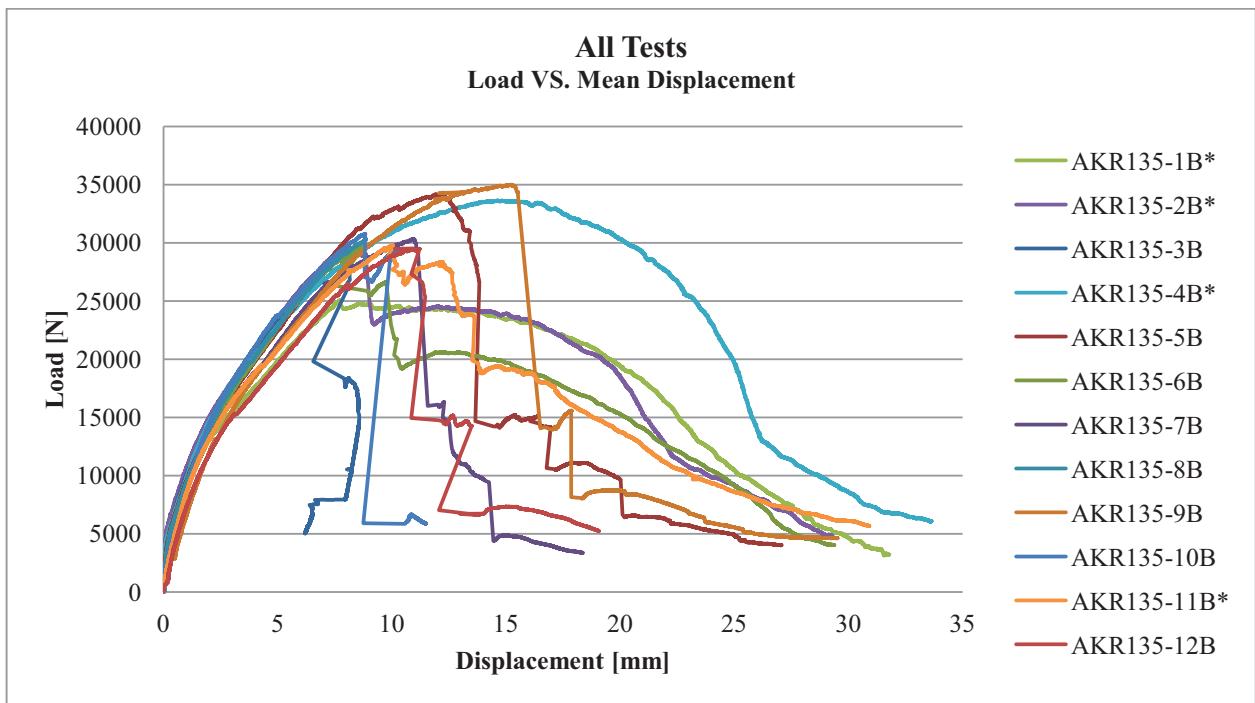


Figure 37: *mean displacement not available, only one displacement is used. Load vs. mean displacement curves of angle connector AKR 135 of Series 3 – Set 2.

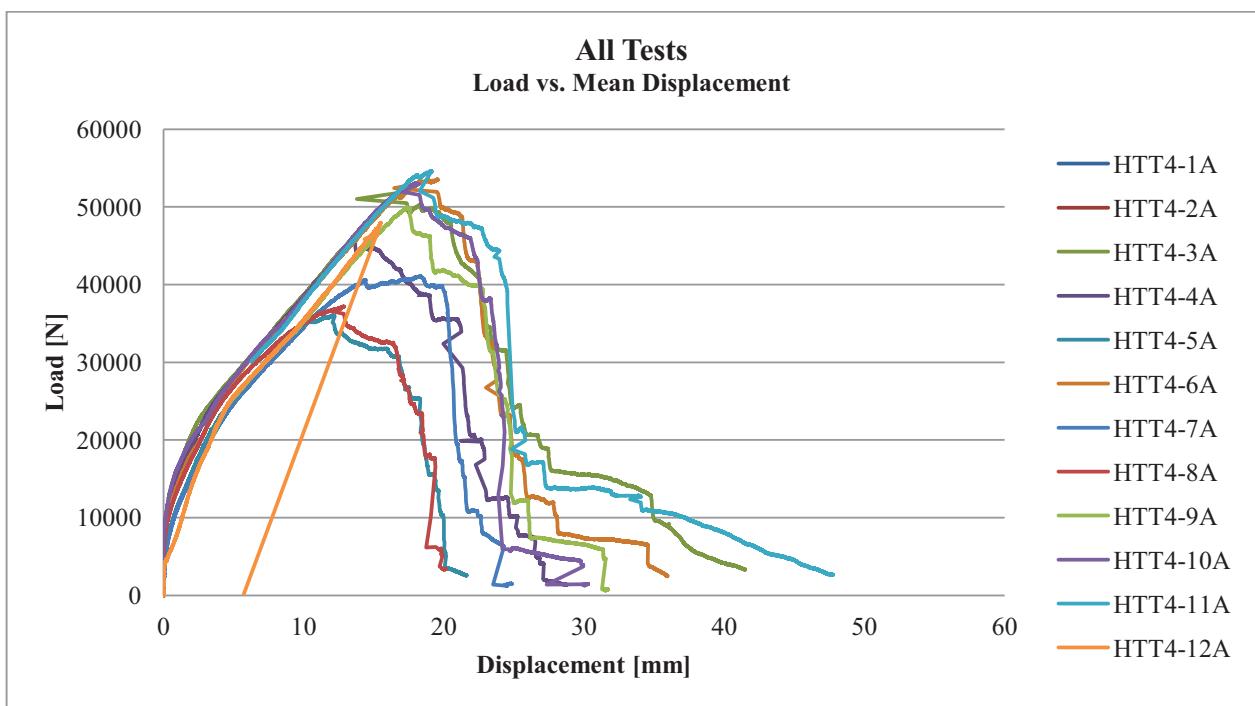


Figure 38: Load vs. mean displacement curves for tension tie HTT4 of Series 4 – Set 1.

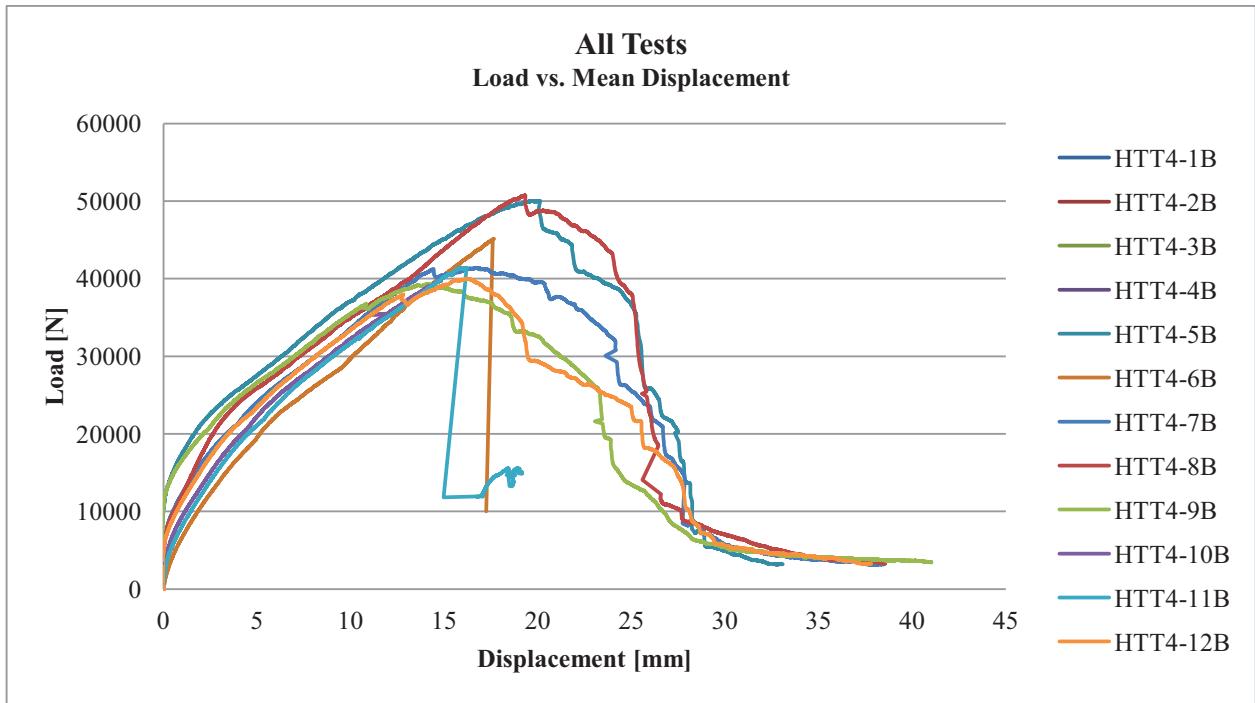


Figure 39: Load vs. mean displacement curves for tension tie HTT4 of Series 4 – Set 2.

Summary of test results

Series 1 – Angle connector AB 55365

Set 1 – 1 bolt M8 on the stud and 8 wooden screws 5x40 on the rail

12 tests

Table 2: Summary of test results for Series 1 – Set 1

	Failure load [kN]	Min. and max. failure load [kN]	Density [kg/m ³]	Moisture [%]	Displ. 1 [mm]	Displ. 2 [mm]	Mean displacement [mm]
Average	5.84	3.63 ÷ 7.96	372.6	8.30	8.49	7.95 ⁽¹⁾	8.04 ⁽¹⁾
St. Dev.	1.14	-	37.9	0.58	2.75	2.38	2.47
Coeff. of Var. [%]	19.6	-	10.2	6.97	32.3	30.0	30.7
Char. Value 0.05	3.51	-	295.4	7.12	2.89	3.02	2.93

⁽¹⁾ data available for eleven tests

Set 2 – 8 wooden screws 5x40 on the stud and 8 wooden screws 5x40 on the rail

12 tests

Table 3: Summary of test results for Series 1 – Set 2

	Failure load [kN]	Min. and max. failure load [kN]	Density [kg/m ³]	Moisture [%]	Displ. 1 [mm]	Displ. 2 [mm]	Mean displacement [mm]
Average	8.68	7.37 ÷ 9.76	432.7	7.57	3.17	7.40 ⁽¹⁾	7.53 ⁽¹⁾
St. Dev.	0.70	-	33.8	0.87	2.80	1.53	1.47
Coeff. of Var. [%]	8.12	-	7.80	11.5	88.3	20.6	19.6
Char. Value 0.05	7.24	-	393.9	5.79	-2.54	2.53	2.83

⁽¹⁾ data available for three tests

Series 2 – Angle connector ABR 9020

Set 1 – 10 wooden screws 5x40 on the stud and 10 wooden screws 5x40 on the rail

12 tests

Table 4: Summary of test results for Series 2 – Set 1

	Failure load [kN]	Min. and max. failure load [kN]	Density [kg/m ³]	Moisture [%]	Displ. 1 [mm]	Displ. 2 [mm]	Mean displacement [mm]
Average	10.7	9.12 ÷ 12.4	407.4	9.45	5.33 ⁽¹⁾	5.01	5.19 ⁽¹⁾
St. Dev.	1.07	-	25.5	1.00	1.28	1.08	1.15
Coeff. of Var. [%]	9.92	-	6.26	10.6	24.0	21.6	22.2
Char. Value 0.05	8.56	-	355.4	7.40	2.68	2.80	2.81

⁽¹⁾ data available for eleven tests

Set 2 – 1 bolt M 10 and 10 annular ringed shank nails 4x40 on the stud and 10 annular ringed shank nail 4x40 on the rail

12 tests

Table 5: Summary of test results for Series 2 – Set 2

	Failure load [kN]	Min. and max. failure load [kN]	Density [kg/m ³]	Moisture [%]	Displ. 1 [mm]	Displ. 2 [mm]	Mean displacement [mm]
Average	5.56	4.31 ÷ 7.07	428.3	9.60	4.24 ⁽¹⁾	4.77 ⁽²⁾	4.29 ⁽³⁾
St. Dev.	0.86	-	33.2	0.92	1.10	1.60	1.20
Coeff. of Var. [%]	15.4	-	7.76	9.62	25.9	33.5	28.0
Char. Value 0.05	3.81	-	360.5	7.72	1.94	1.46	1.72

⁽¹⁾ data available for ten tests; ⁽²⁾ data available for eleven tests; ⁽³⁾ data available for nine tests

Set 3 – 10 wooden screws 5x40 on the stud and 10 wooden screws 5x40 on the rail

12 tests

Table 6: Summary of test results for Series 2 – Set 3

	Failure load [kN]	Min. and max. failure load [kN]	Density [kg/m ³]	Moisture [%]	Displ. 1 [mm]	Displ. 2 [mm]	Mean displacement [mm]
Average	10.5	8.64 ÷ 12.8	410.6	9.05	4.60 ⁽¹⁾	4.90	4.78 ⁽¹⁾
St. Dev.	1.13	-	37.4	0.56	1.19	1.15	1.14
Coeff. of Var. [%]	10.8	-	9.11	6.20	25.9	23.5	23.9
Char. Value 0.05	8.17	-	334.3	7.91	2.14	2.55	2.42

⁽¹⁾ data available for eleven tests

Set 4 – 10 wooden screws 5x40 on the stud and 6 wooden screws 5x40 on the rail

12 tests

Table 7: Summary of test results for Series 2 – Set 4

	Failure load [kN]	Min. and max. failure load [kN]	Density [kg/m ³]	Moisture [%]	Displ. 1 [mm]	Displ. 2 [mm]	Mean displacement [mm]
Average	11.2	9.65 ÷ 12.9	444.9	9.02	4.50 ⁽¹⁾	5.48	4.90 ⁽¹⁾
St. Dev.	1.08	-	37.6	1.07	1.02	1.20	1.02
Coeff. of Var. [%]	9.67	-	8.46	11.9	22.7	21.9	20.9
Char. Value 0.05	9.00	-	368.2	6.84	2.39	3.04	2.79

⁽¹⁾ data available for eleven tests

Series 3 – Angle connector AKR 135

Set 1 – 14 wooden screws 5x40 on the stud and 1 bolt M12 on the rail

12 tests

Table 8: Summary of test results for Series 3 – Set 1

	Failure load [kN]	Min. and max. failure load [kN]	Density [kg/m ³]	Moisture [%]	Displ. 1 [mm]	Displ. 2 [mm]	Mean displacement [mm]
Average	30.5	24.0 ÷ 37.1	395.6	9.86 ⁽¹⁾	8.87 ⁽²⁾	8.17	8.56 ⁽²⁾
St. Dev.	4.30	-	36.2	0.60	3.50	3.05	3.51
Coeff. of Var. [%]	14.1	-	9.16	6.07	39.4	37.4	41.0
Char. Value 0.05	21.7	-	321.7	8.62	1.39	1.94	1.05

⁽¹⁾ data available for eleven tests; ⁽²⁾ data available for nine tests

Set 2 – 14 annular ringed shank nails 4x40 on the stud and 1 bolt M12 on the rail

12 tests

Table 9: Summary of test results for Series 3 – Set 2

	Failure load [kN]	Min. and max. failure load [kN]	Density [kg/m ³]	Moisture [%]	Displ. 1 [mm]	Displ. 2 [mm]	Mean displacement [mm]
Average	30.6	25.0 ÷ 35.0	412.9	10.0	10.7 ⁽¹⁾	10.3	10.5 ⁽¹⁾
St. Dev.	2.69	-	55.5	1.48	2.25	2.49	2.23
Coeff. of Var. [%]	8.79	-	13.5	14.7	21.0	24.3	21.3
Char. Value 0.05	25.1	-	299.6	7.02	5.89	5.17	5.69

⁽¹⁾ data available for nine tests

Series 4 – Tension tie HTT4

Set 1 – 18 wooden screws 5x40 on the stud and 1 bolt M16 on the rail

12 tests

Table 10: Summary of test results for Series 4 – Set 1

	Failure load [kN]	Min. and max. failure load [kN]	Density [kg/m ³]	Moisture [%]	Displ. 1 [mm]	Displ. 2 [mm]	Mean displacement [mm]
Average	45.2	26.2 ÷ 54.6	399.9	8.61	14.8	16.0	15.4
St. Dev.	8.66	-	49.9	0.81	3.97	3.73	3.85
Coeff. of Var. [%]	19.2	-	12.5	9.39	26.8	23.4	25.0
Char. Value _{0.05}	27.5	-	298.1	6.96	6.74	8.34	7.55

Set 2 – 18 annular ringed shank nails 4x40 on the stud and 1 bolt M16

12 tests

Table 11: Summary of test results for Series 4 – Set 2

	Failure load [kN]	Min. and max. failure load [kN]	Density [kg/m ³]	Moisture [%]	Displ. 1 [mm]	Displ. 2 [mm]	Mean displacement [mm]
Average	42.5	35.9 ÷ 50.7	393.1	8.54	15.4	16.4	15.9
St. Dev.	4.42	-	31.2	0.50	2.32	2.34	2.33
Coeff. of Var. [%]	10.4	-	7.94	5.90	15.1	14.3	14.7
Char. Value _{0.05}	33.5	-	329.4	7.52	10.7	11.6	11.1

Conclusions

The test results show different failure load and different failure modes. The failure load is higher when hold downs with anchor bolts compared to screws or nails. Anchor bolts can be up ten times stronger than screws or nails.

Connector HTT4 was the one with the highest strength whilst connector 90 m/Rippe with nails was the one with the lowest strength.

Connector	Type of fastening of the connector	Average Strength [kN]
AB 55365	Stud: Bolt M8	5.84
	Rail: 8 wooden screws 4x40	
	Stud: 8 wooden screws 4x40	8.68
	Rail: 8 wooden screws 4x40	
ABR 9020	Stud: Bolt M10 + 10 wooden screws 4x40	10.7
	Rail: 10 wooden screws 4x40	
	Stud: Bolt M10 + 10 annular ringed shank nail 4x40	5.56
	Rail: 10 annular ringed shank nail 4x40	
	Stud: 10 wooden screws 4x40	10.5
	Rail: 10 wooden screws 4x40	
	Stud: 10 wooden screws 4x40	11.2
	Rail: 6 wooden screws 4x40	
AKR 135	Stud: 14 wooden screws 4x40	30.5
	Rail: Bolt M12	
	Stud: 14 annular ringed shank nail 4x40	30.6
	Rail: Bolt M12	
HTT4	Stud: 18 wooden screws 4x40	45.2
	Rail: Bolt M16	
	Stud: 18 annular ringed shank nail 4x40	42.5
	Rail: Bolt M16	

It was found that the strength of the connection is dependent not only on the type of connector but also on the fastener used in the connection. Nails have the lowest strength and they pull-out easily. Screws have a higher strength compared with nails but the highest strength is reached when bolts are used.

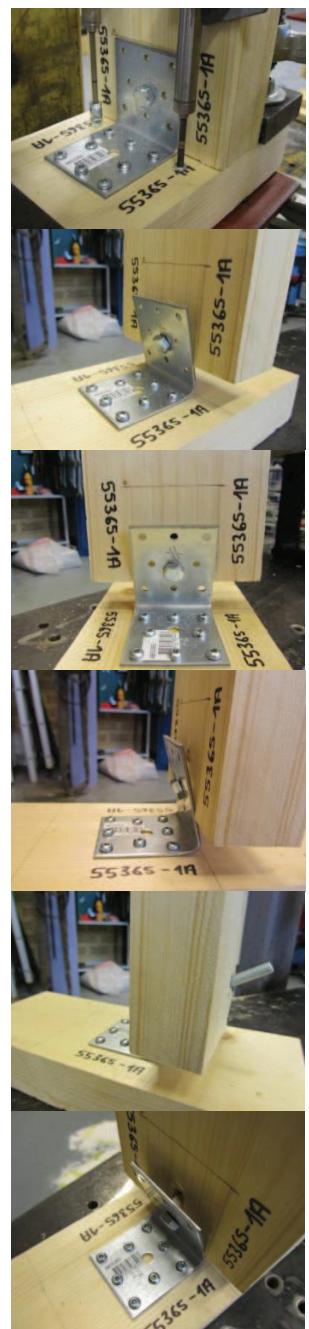
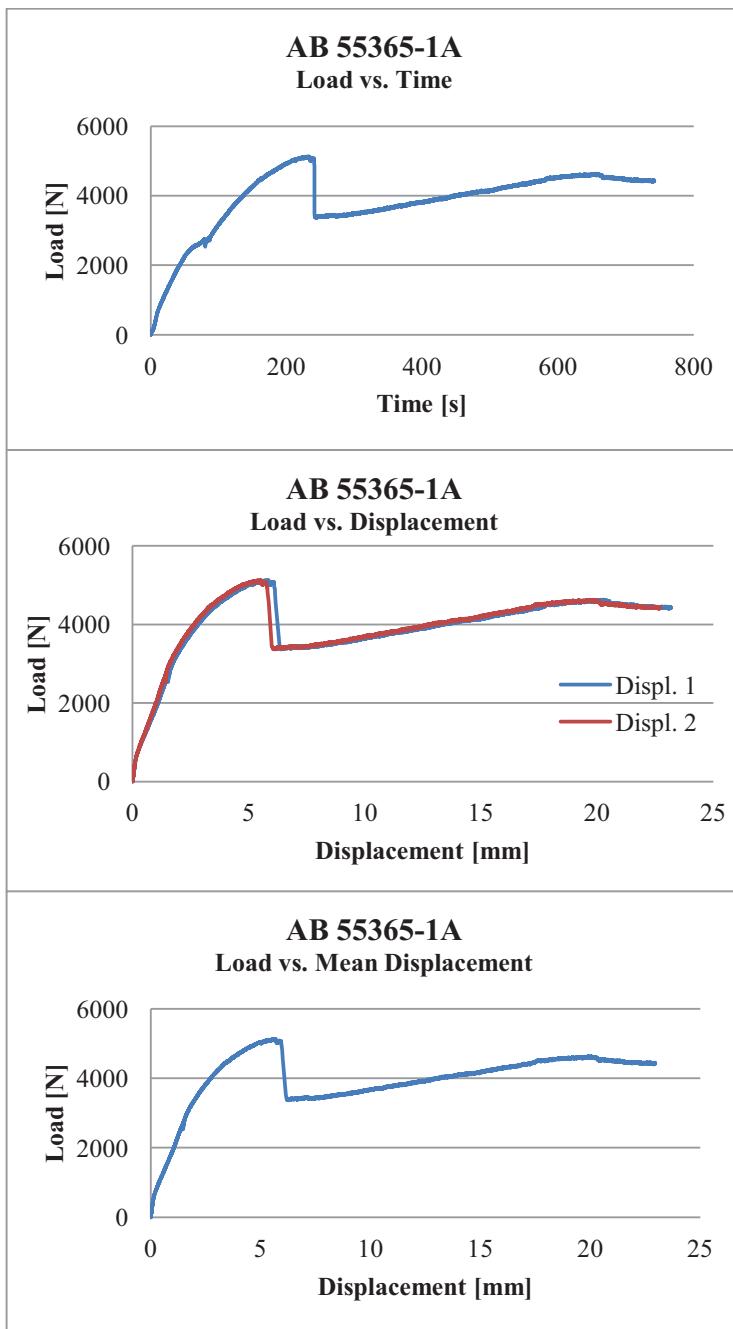
The failure modes vary with type of connector. The tests showed three primary failure modes:

- failure mode 1: failure of the stud when a bolt is used as the connector between connector and stud;
- failure mode 2: failure due to pull-out of the screws or nails from the rail;
- failure mode 3a: failure due to failure or pull-out of screws or nails from stud;
- failure 3b: failure of the stud caused by some defect of the timber.

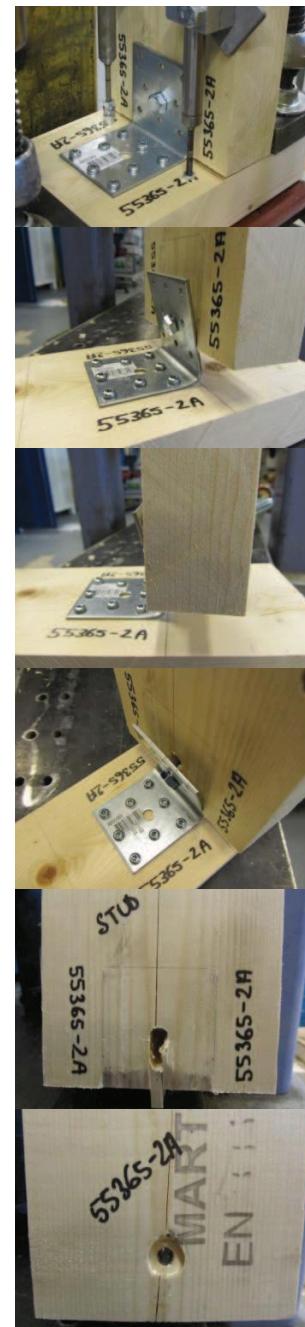
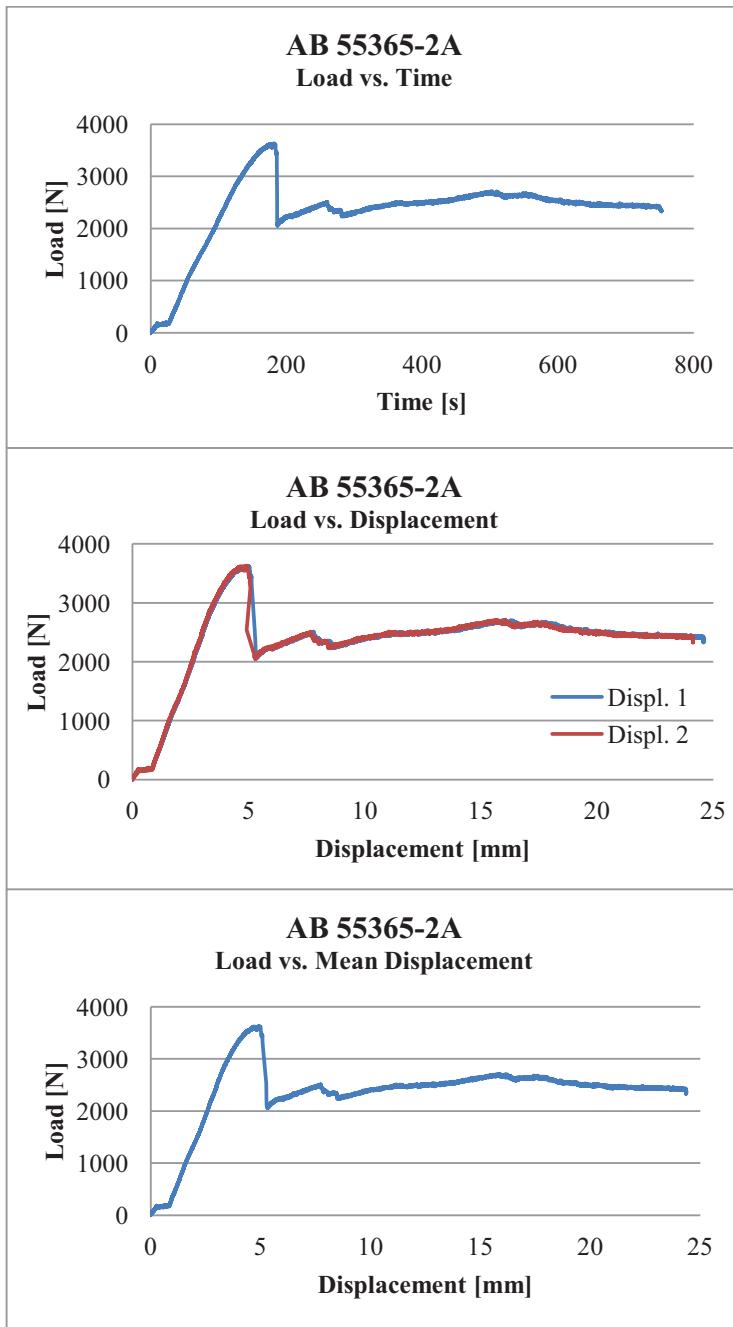
Appendix A

Series 1 – Angle connector AB 55365

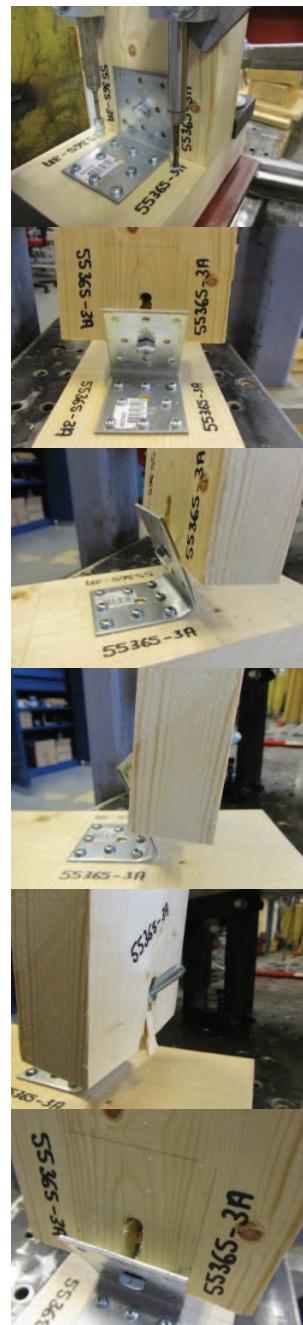
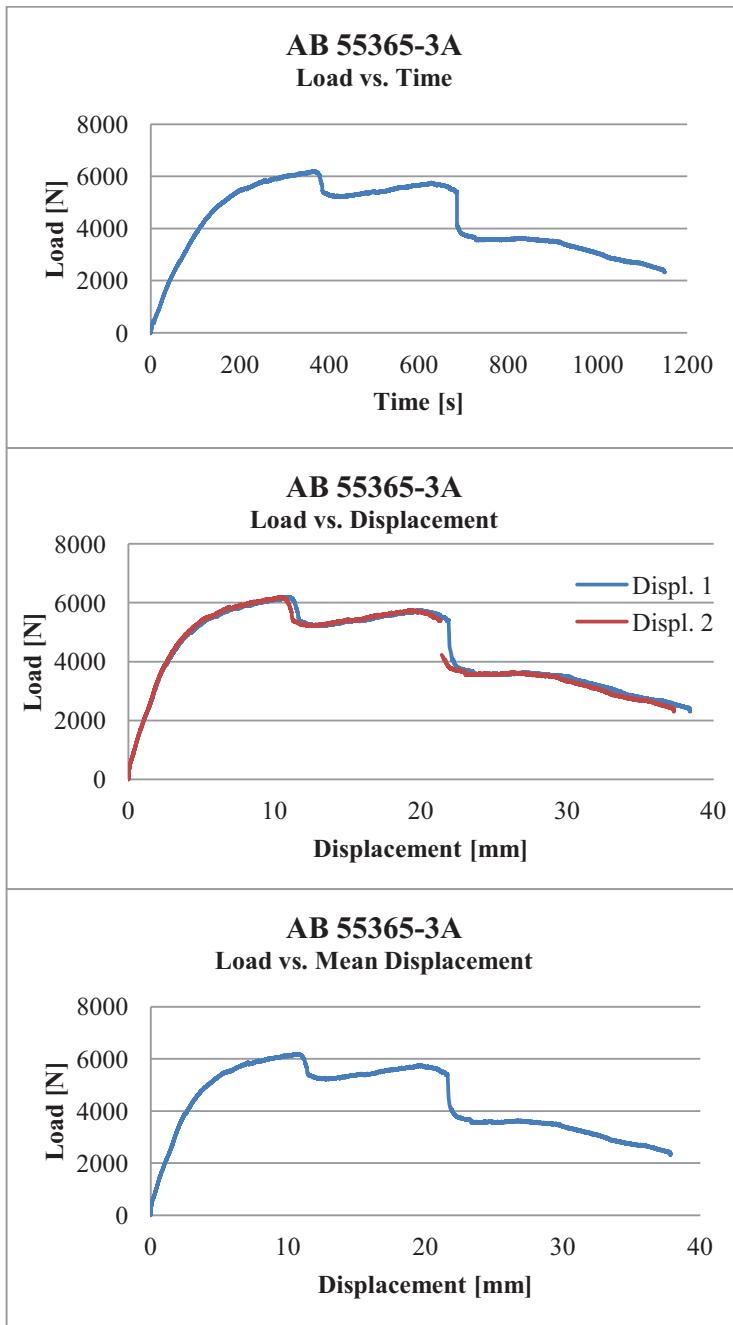
Set 1 – 1 bolt M8 on the stud and 8 wooden screws 5x40 on the rail



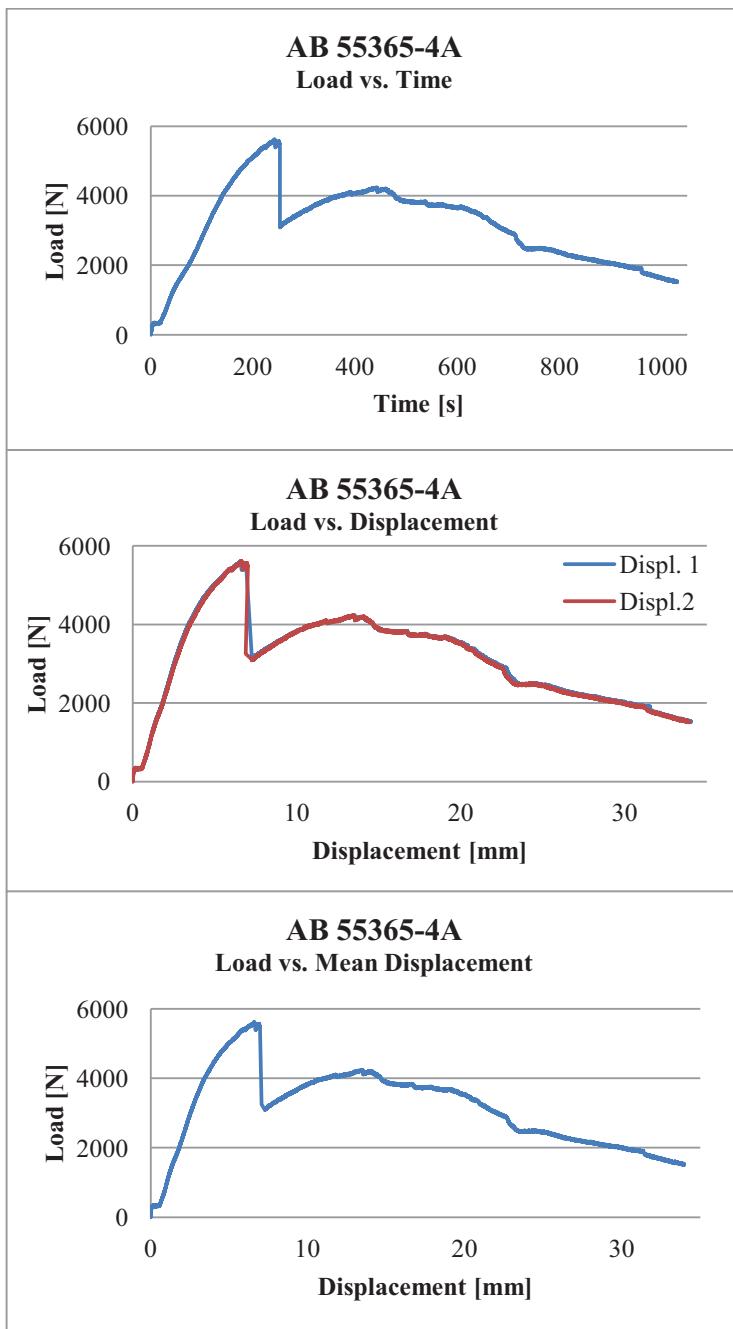
Failure	1
Failure load [N]	5127
Displacement 1 [mm]	5.72
Displacement 2 [mm]	5.40
Mean Displacement [mm]	5.56
Moisture [%]	8.95
Density [kg/m ³]	327



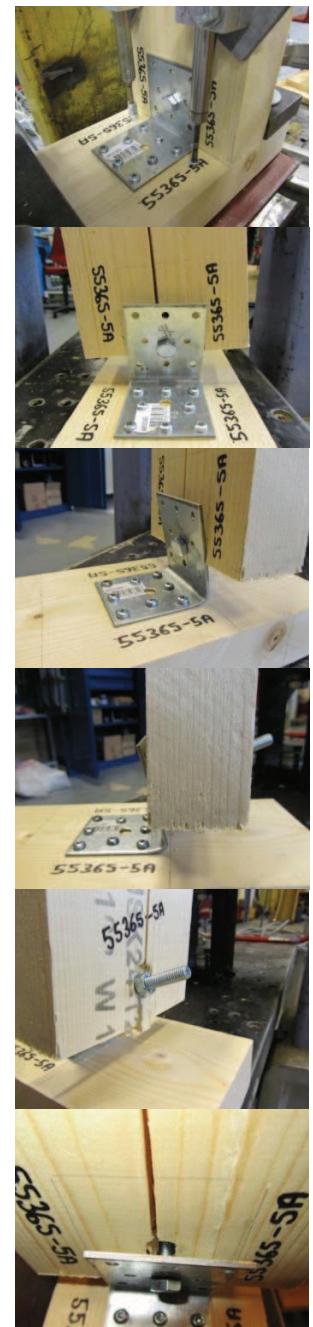
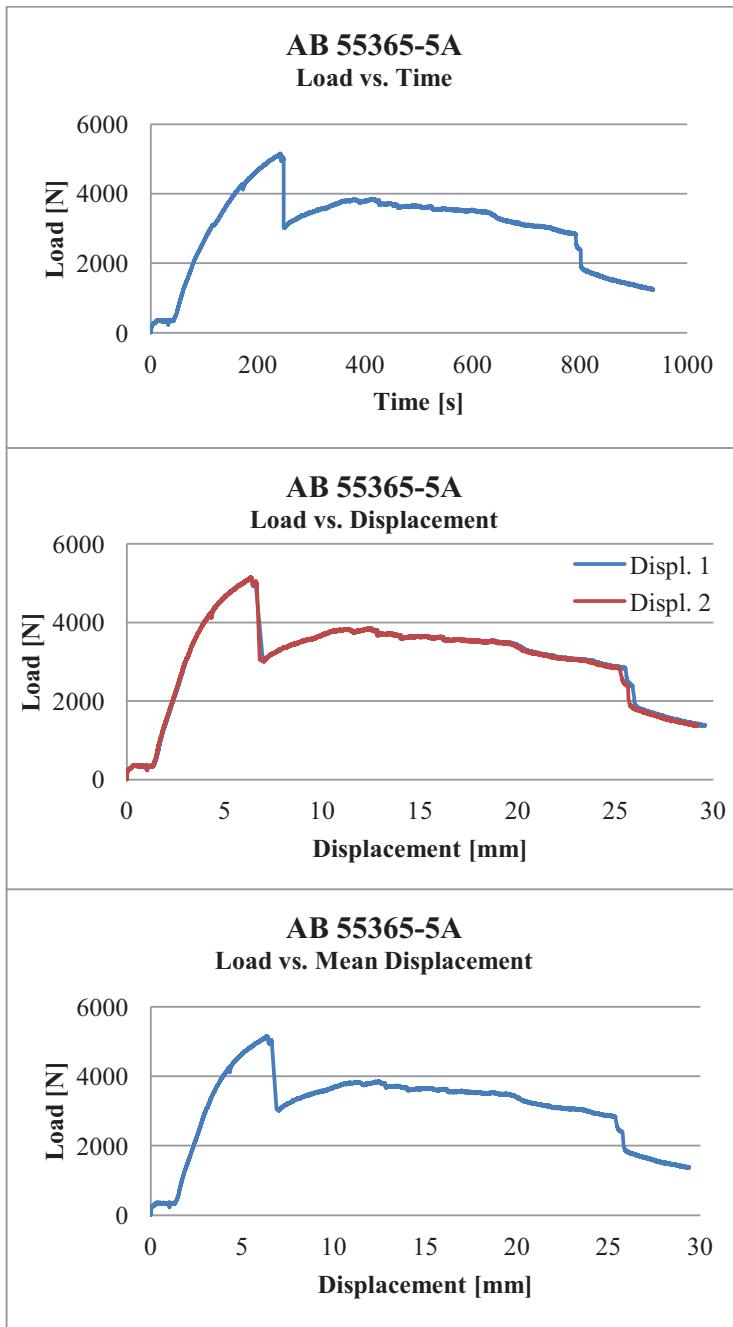
Failure	1
Failure load [N]	3630
Displacement 1 [mm]	4.96
Displacement 2 [mm]	4.87
Mean Displacement [mm]	4.91
Moisture [%]	8.85
Density [kg/m ³]	298



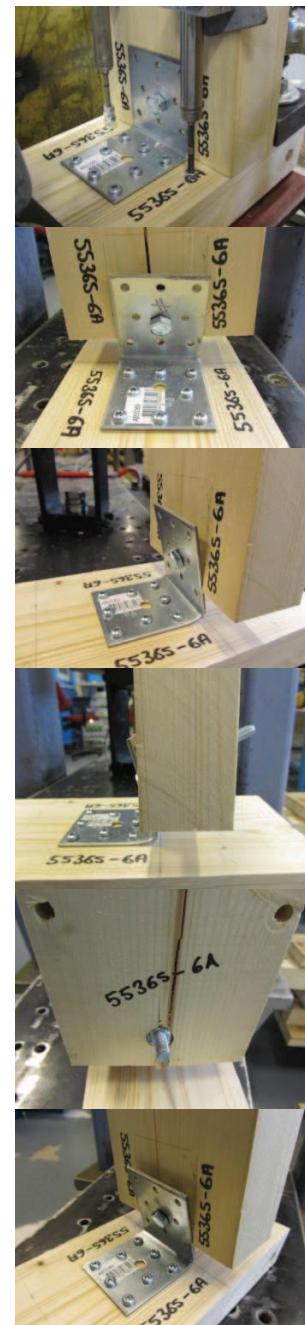
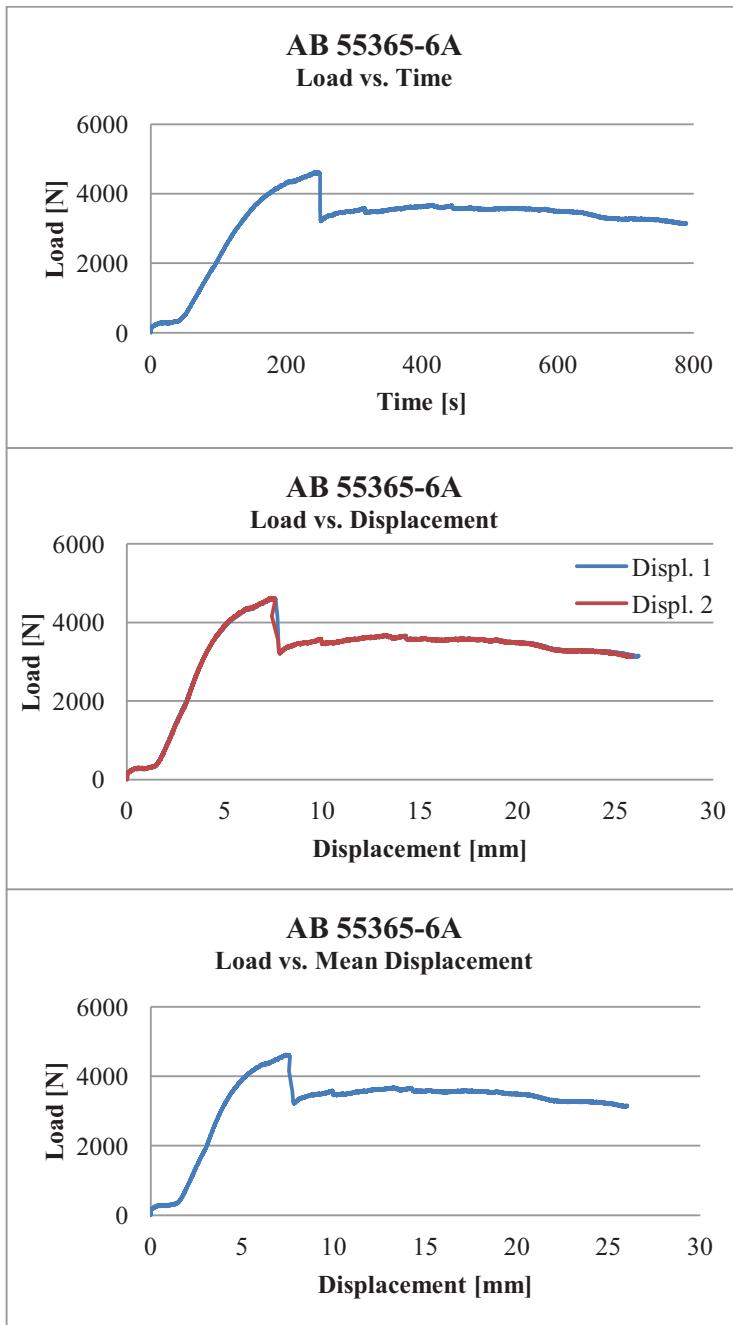
Failure	1
Failure load [N]	6191
Displacement 1 [mm]	11.1
Displacement 2 [mm]	10.6
Mean Displacement [mm]	10.9
Moisture [%]	8.38
Density [kg/m ³]	337



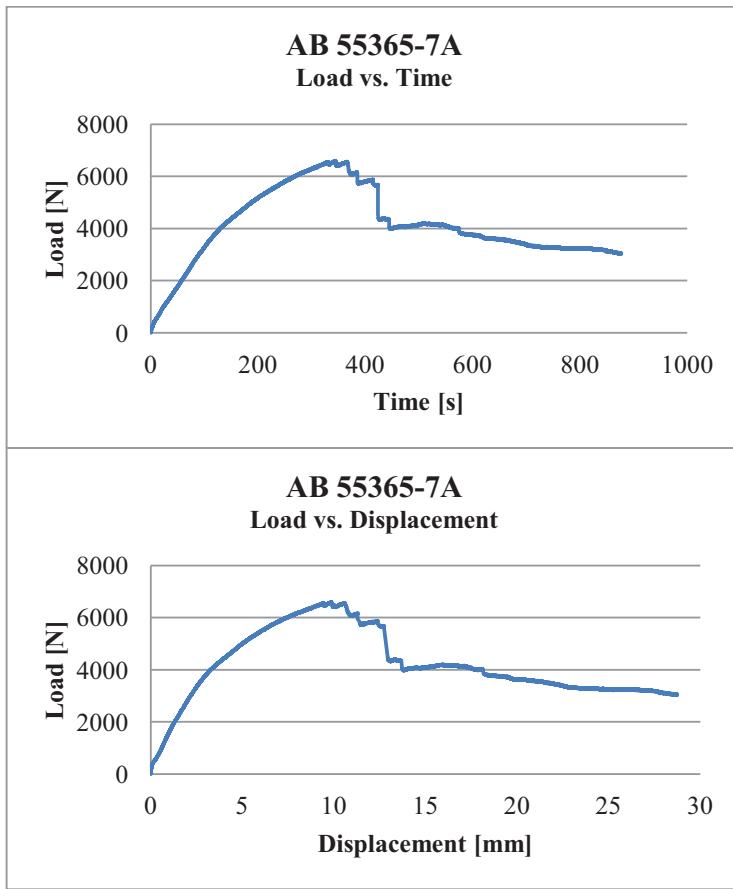
Failure	1
Failure load [N]	5618
Displacement 1 [mm]	6.58
Displacement 2 [mm]	6.62
Mean Displacement [mm]	6.60
Moisture [%]	7.31
Density [kg/m ³]	376



Failure	1
Failure load [N]	5152
Displacement 1 [mm]	6.33
Displacement 2 [mm]	6.34
Mean Displacement [mm]	6.34
Moisture [%]	8.92
Density [kg/m ³]	375

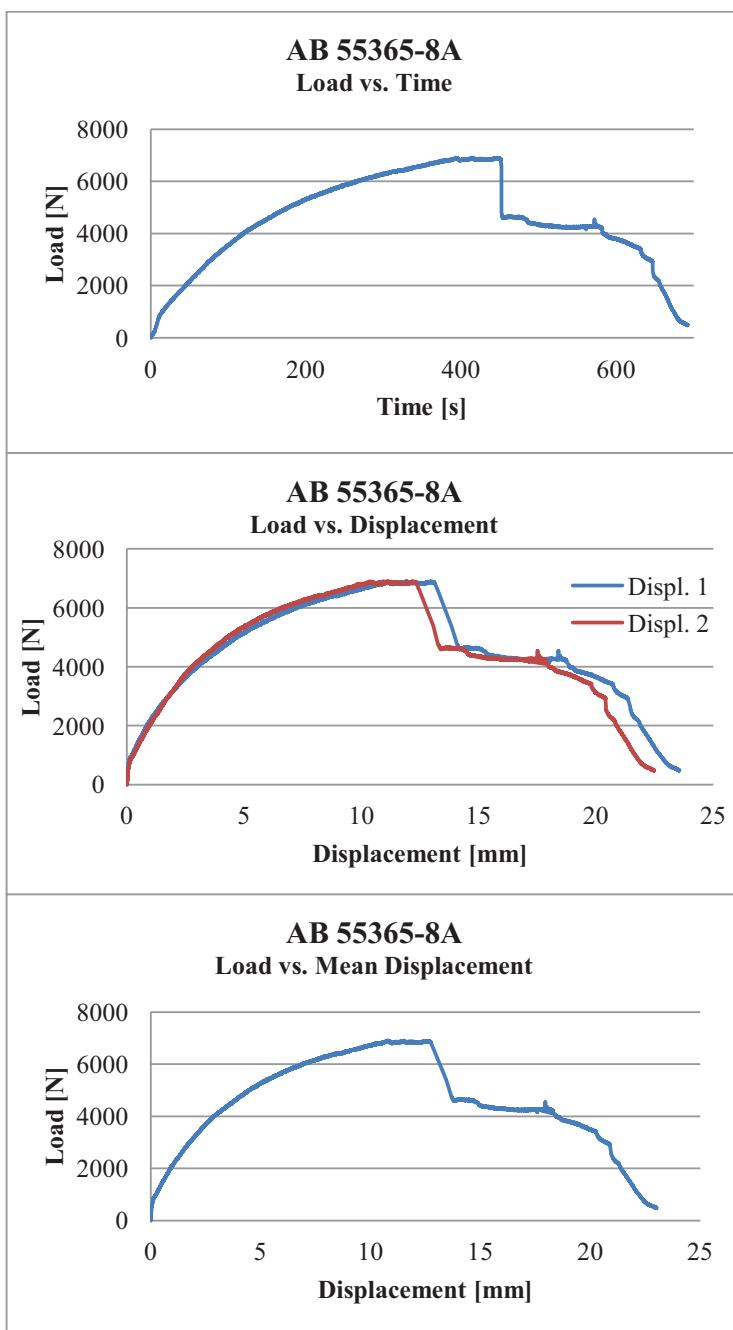


Failure	1
Failure load [N]	4268
Displacement 1 [mm]	7.41
Displacement 2 [mm]	7.34
Mean Displacement [mm]	7.38
Moisture [%]	8.23
Density [kg/m ³]	373

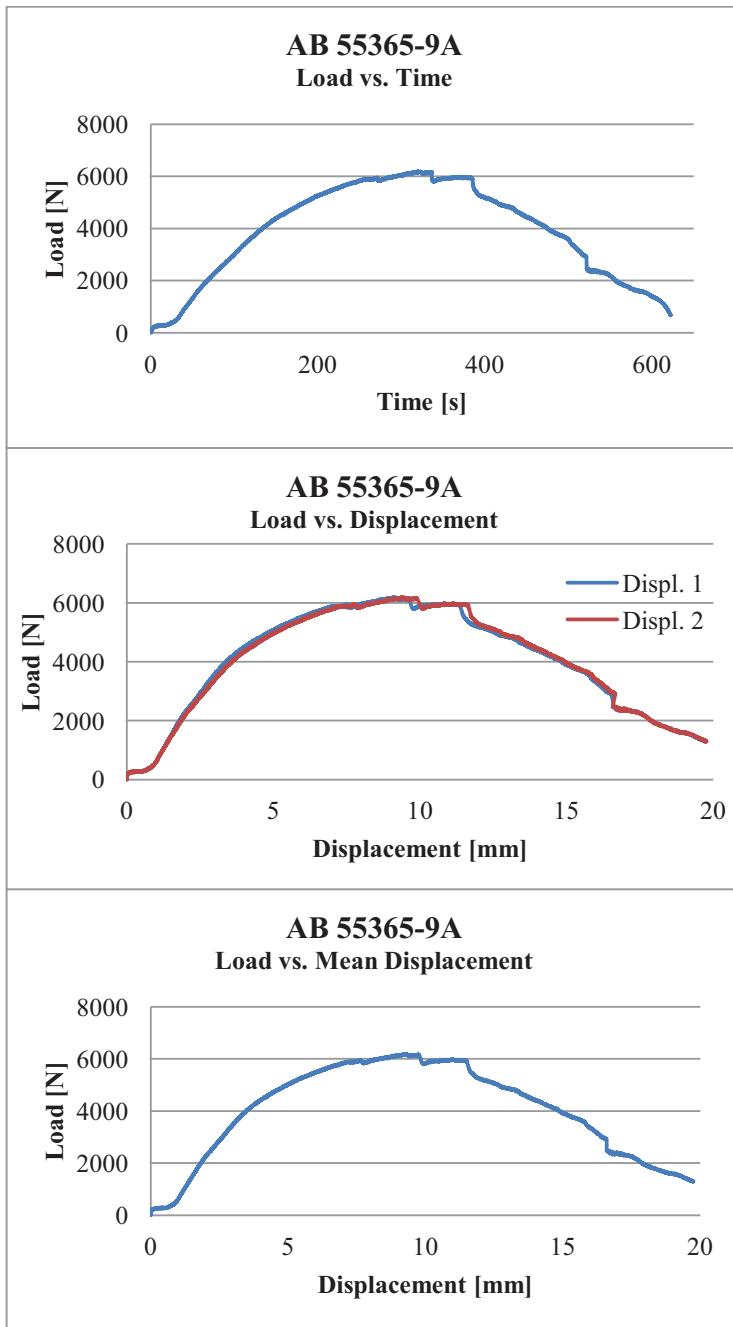


Failure	1
Failure load [N]	6603
Displacement 1 [mm]	9.87
Displacement 2 [mm]	-
Mean Displacement [mm]	-
Moisture [%]	8.32
Density [kg/m ³]	372

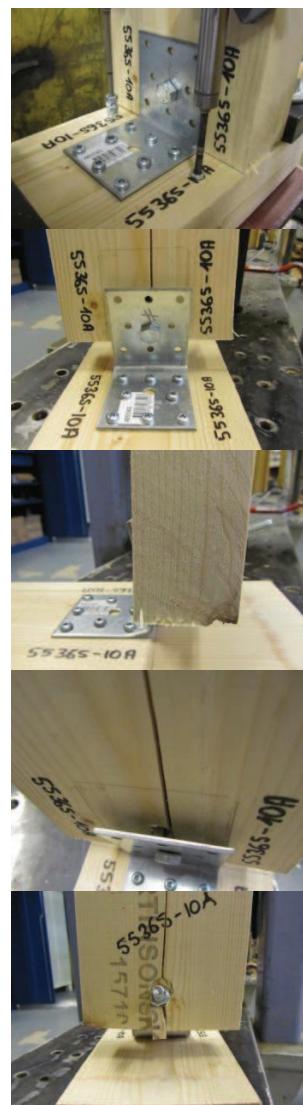
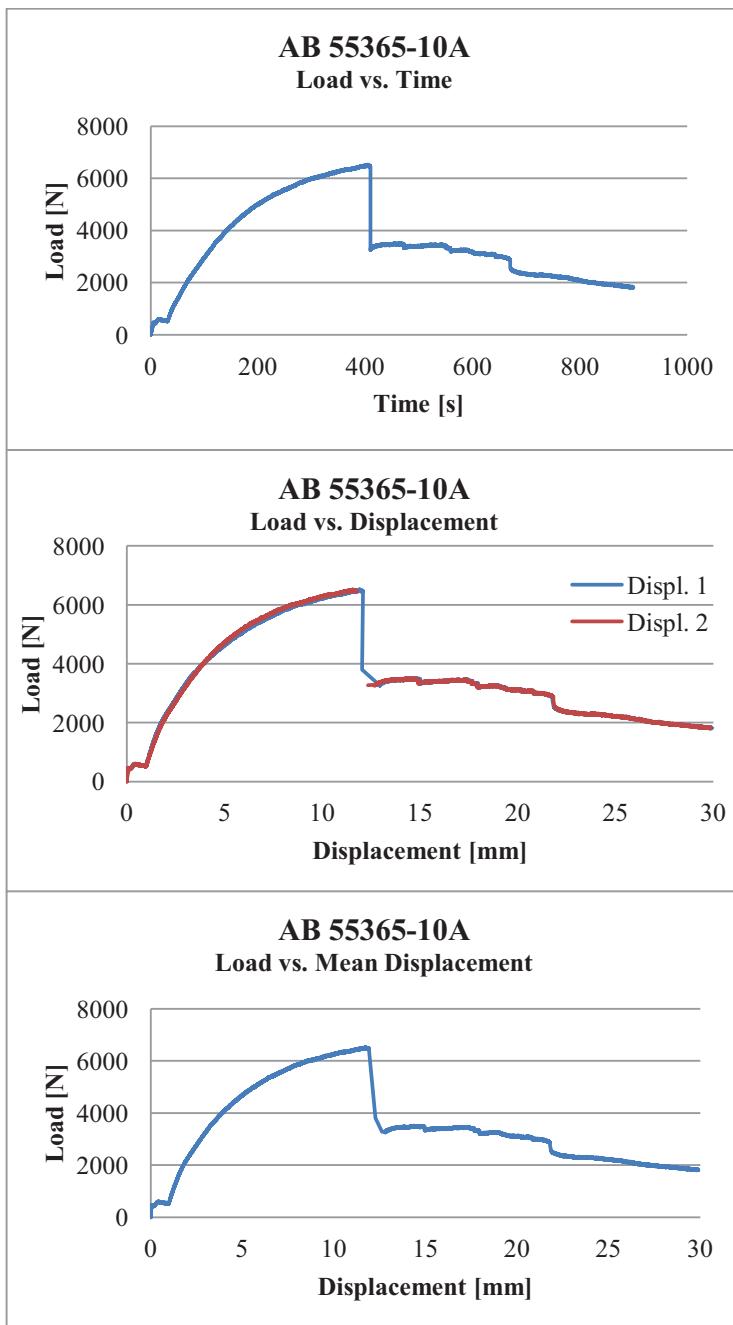
The LVDT number 2 did not work.



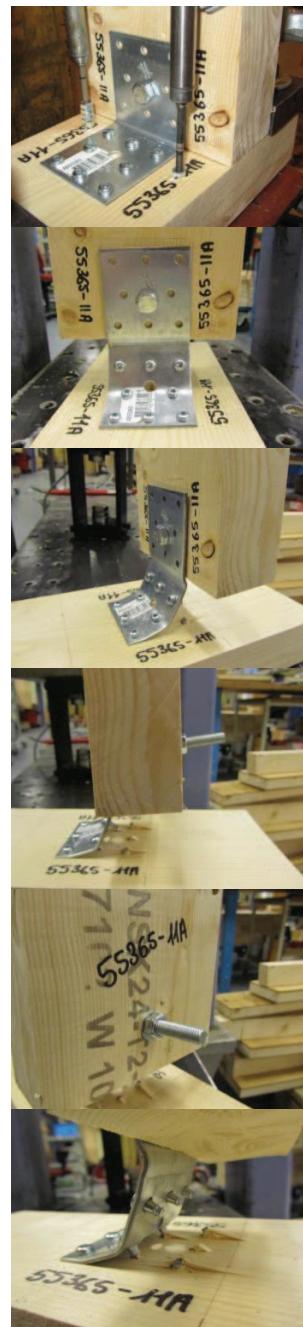
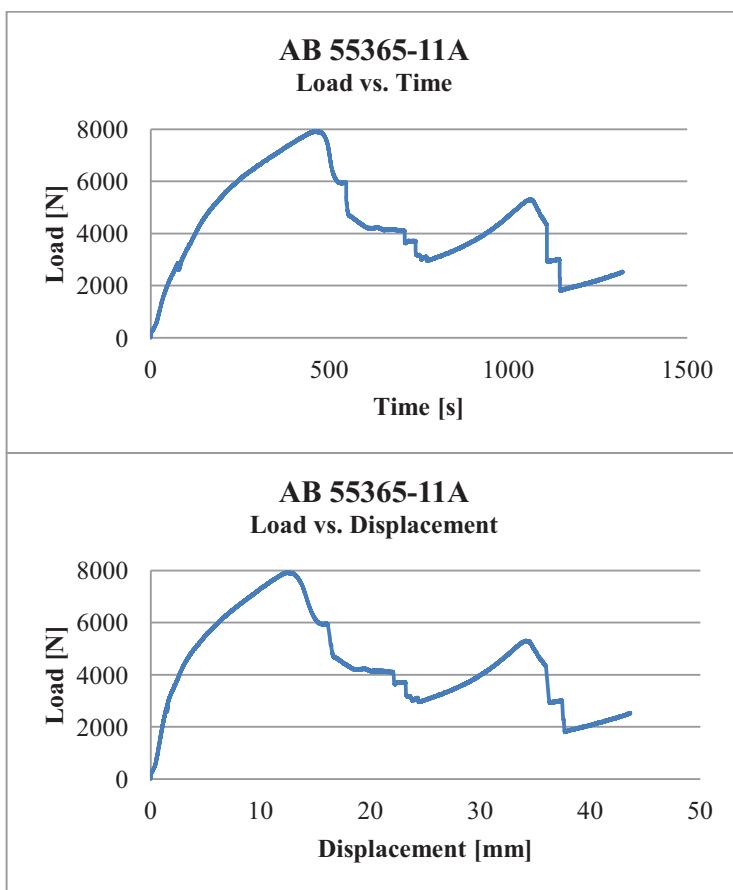
Failure	1
Failure load [N]	6904
Displacement 1 [mm]	11.1
Displacement 2 [mm]	10.4
Mean Displacement [mm]	10.8
Moisture [%]	8.34
Density [kg/m ³]	385



Failure	1
Failure load [N]	6188
Displacement 1 [mm]	9.07
Displacement 2 [mm]	9.36
Mean Displacement [mm]	9.22
Moisture [%]	8.24
Density [kg/m ³]	426

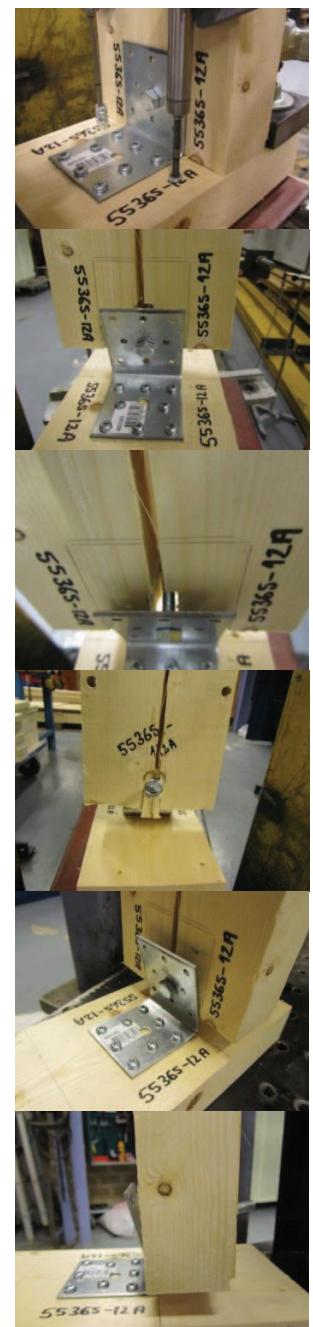
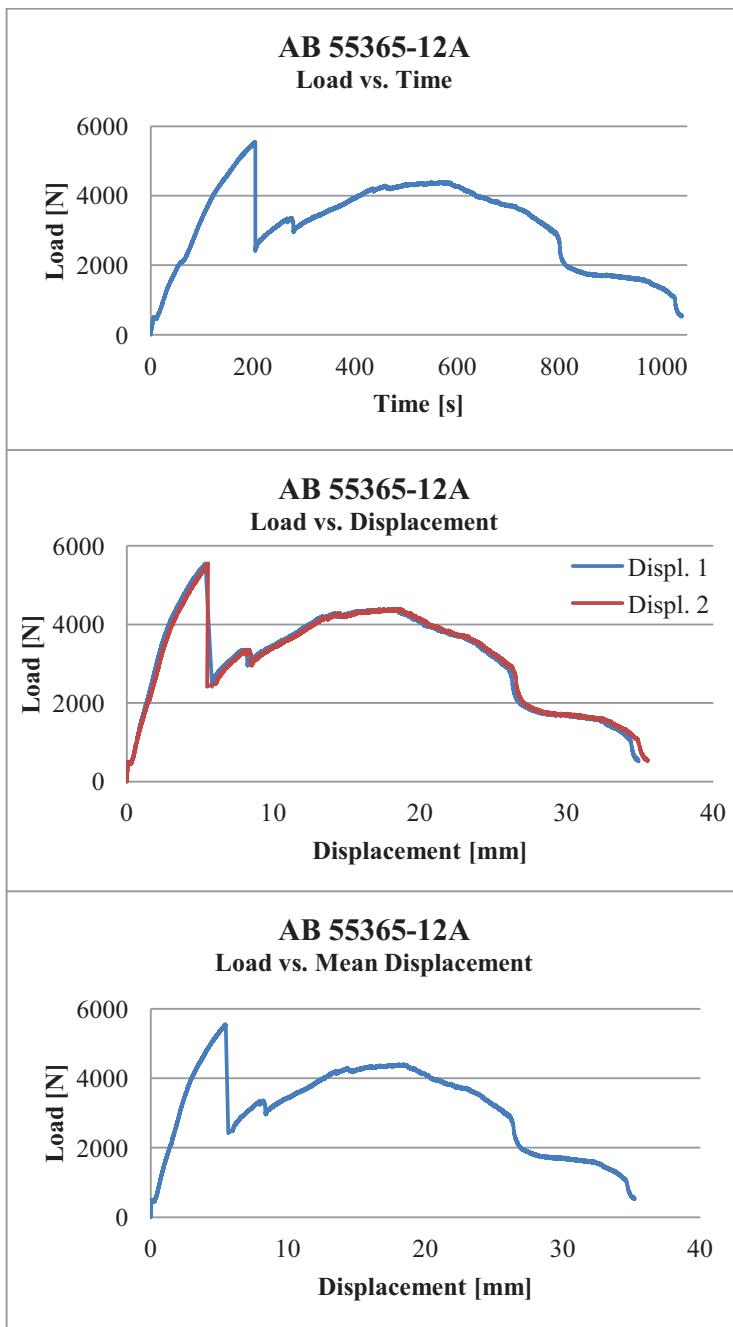


Failure	1
Failure load [N]	6523
Displacement 1 [mm]	11.9
Displacement 2 [mm]	11.6
Mean Displacement [mm]	11.7
Moisture [%]	8.72
Density [kg/m ³]	375



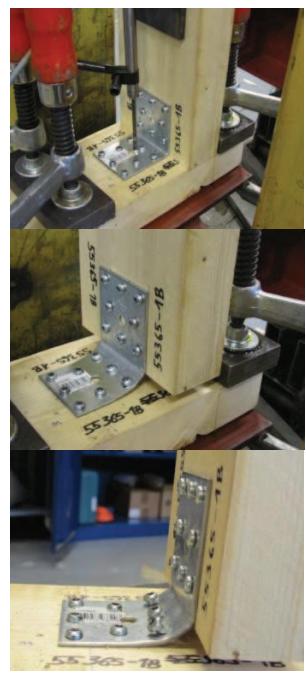
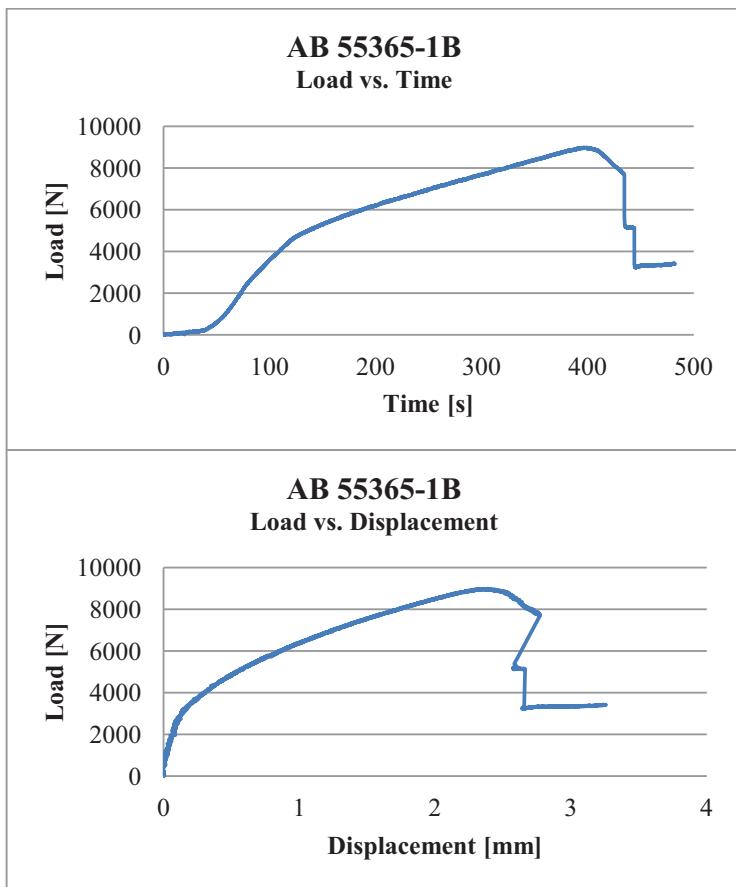
Failure	2
Failure load [N]	7956
Displacement 1 [mm]	12.5
Displacement 2 [mm]	-
Mean Displacement [mm]	-
Moisture [%]	8.21
Density [kg/m ³]	427

The LVDT number 2 did not work.



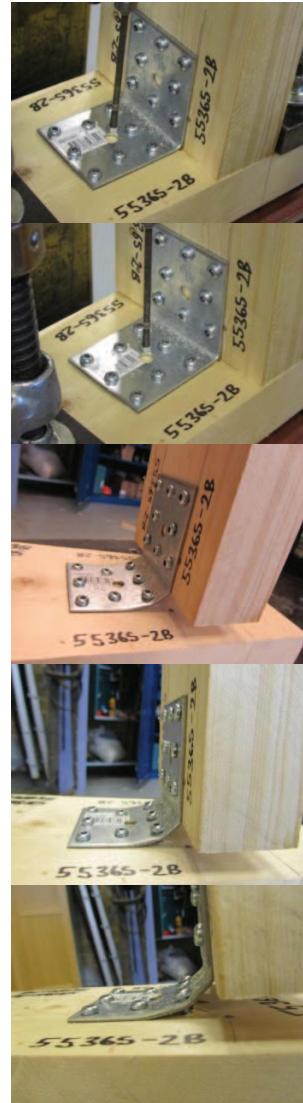
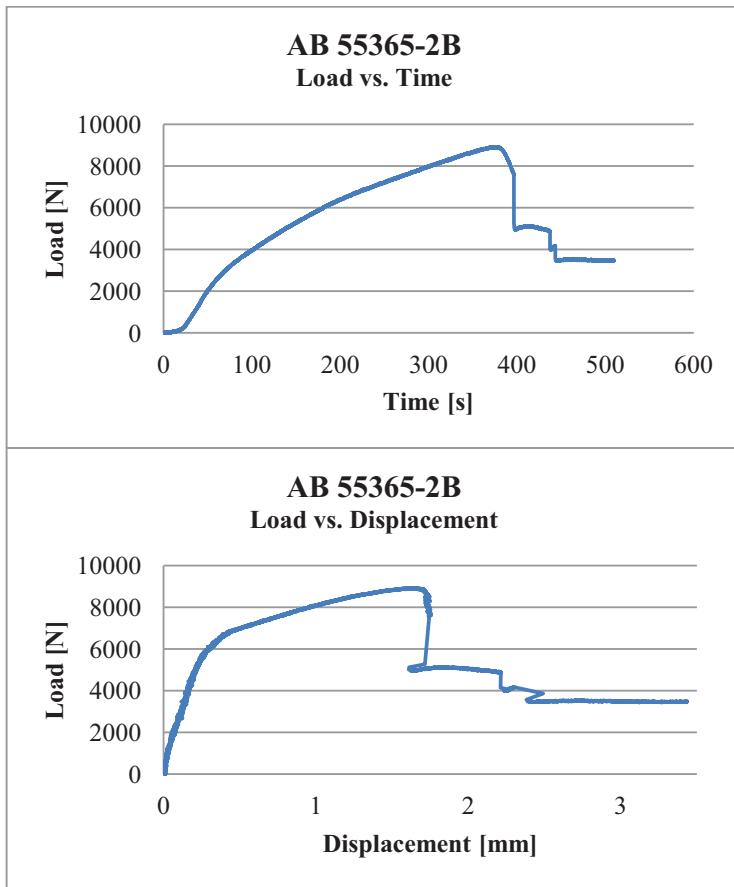
Failure	1
Failure load [N]	5547
Displacement 1 [mm]	5.36
Displacement 2 [mm]	5.53
Mean Displacement [mm]	5.45
Moisture [%]	7.12
Density [kg/m ³]	402

Set 2 – 8 wooden screws 5x40 on the stud and 8 wooden screws 5x40 on the rail



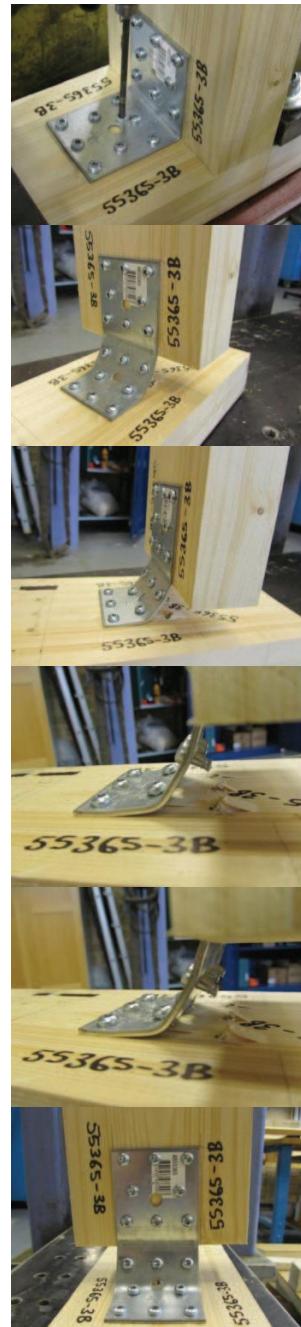
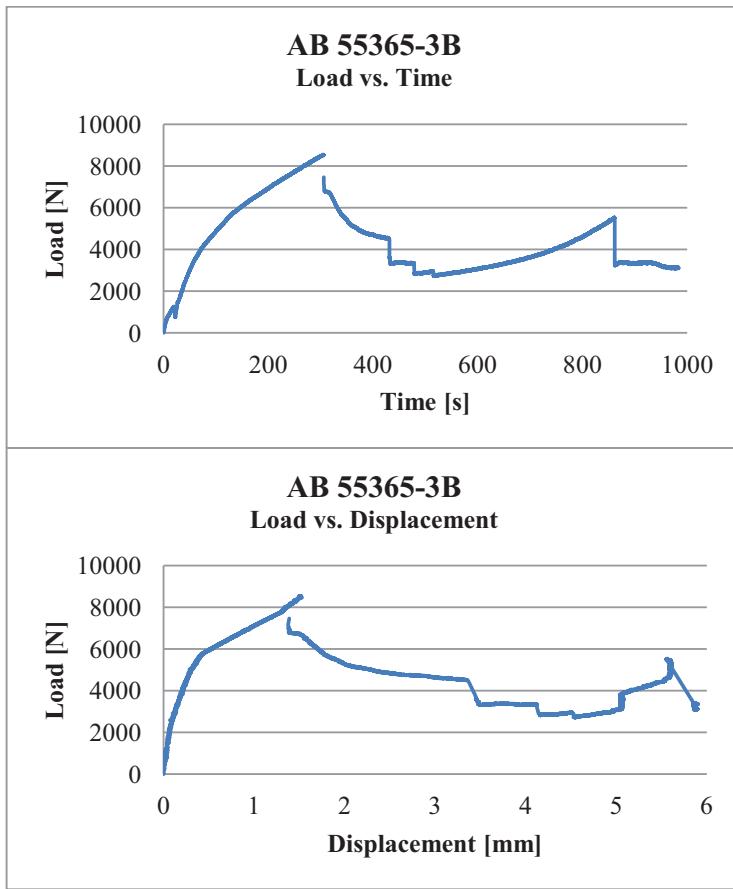
Failure	2
Failure load [N]	8975
Displacement 1 [mm]	2.35
Displacement 2 [mm]	-
Mean Displacement [mm]	-
Moisture [%]	7.99
Density [kg/m ³]	470

In this test only one displacement was recorded.



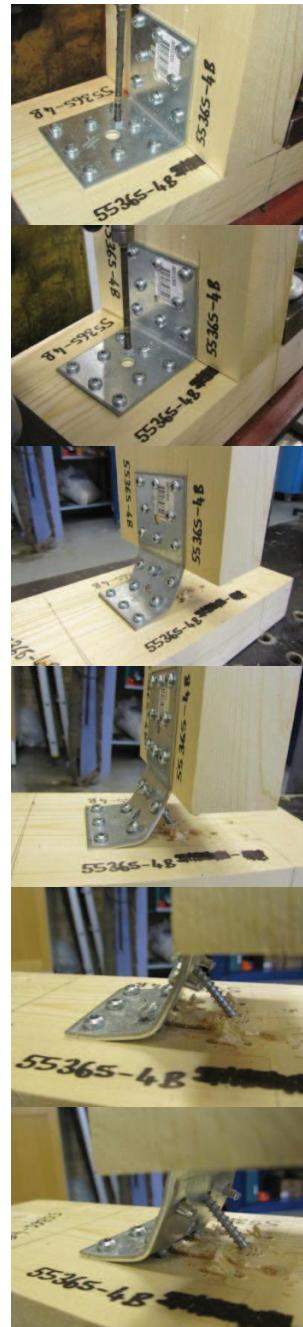
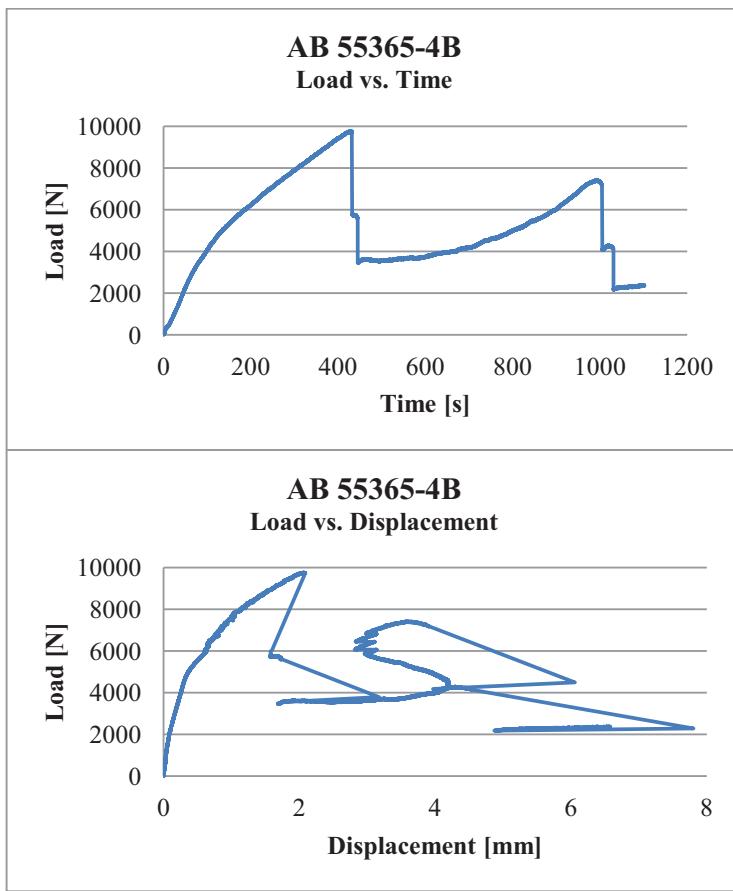
Failure	2
Failure load [N]	8910
Displacement 1 [mm]	1.64
Displacement 2 [mm]	-
Mean Displacement [mm]	-
Moisture [%]	7.89
Density [kg/m ³]	419

In this test only one displacement was recorded.



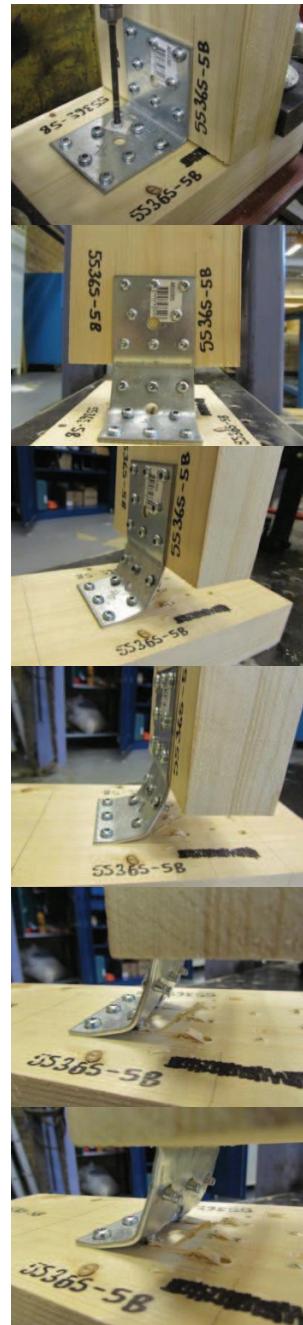
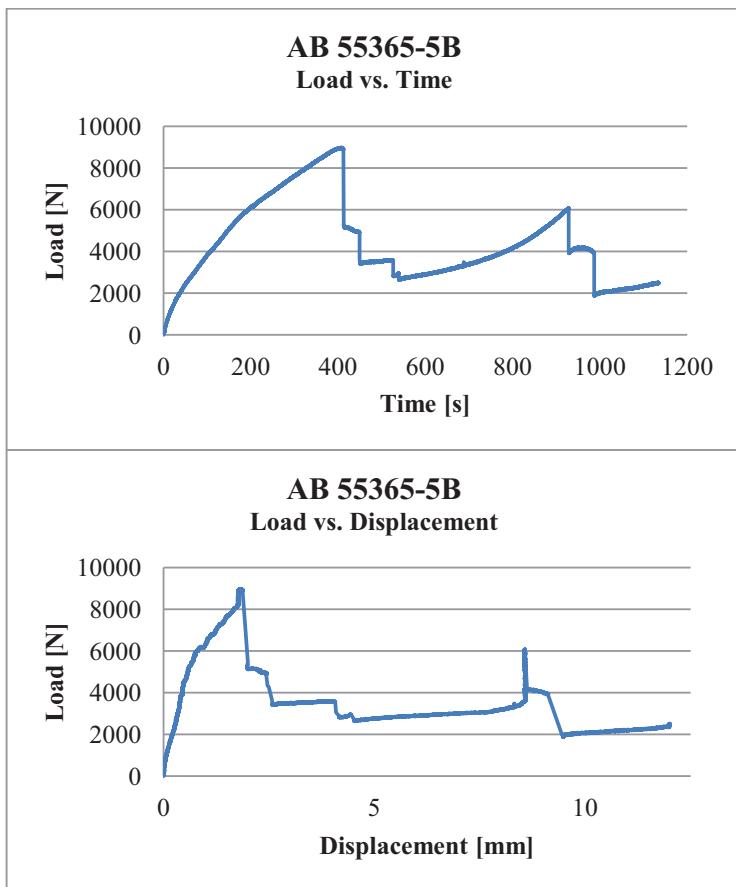
Failure	2
Failure load [N]	8541
Displacement 1 [mm]	1.51
Displacement 2 [mm]	-
Mean Displacement [mm]	-
Moisture [%]	6.43
Density [kg/m ³]	420

In this test only one displacement was recorded.



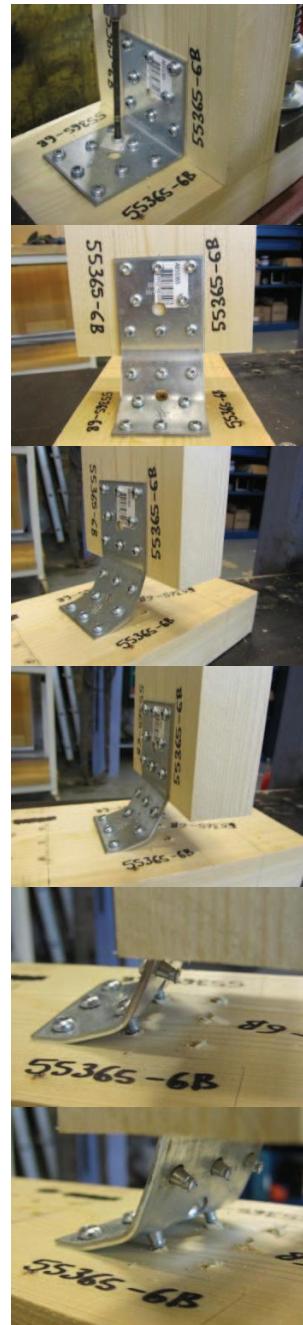
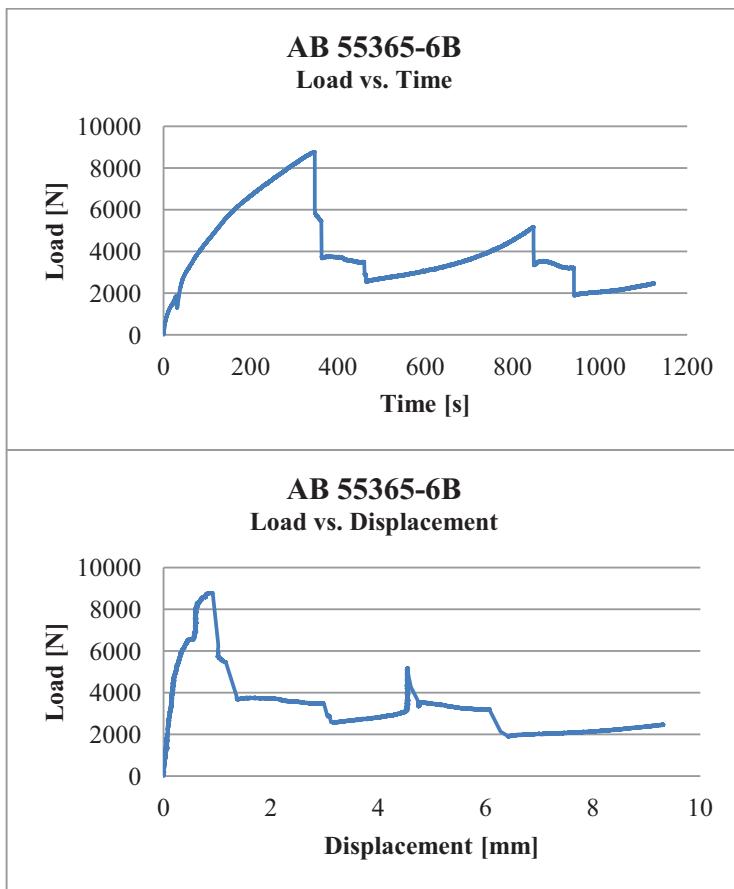
Failure	2
Failure load [N]	9755
Displacement 1 [mm]	2.06
Displacement 2 [mm]	-
Mean Displacement [mm]	-
Moisture [%]	7.17
Density [kg/m ³]	437

In this test only one displacement was recorded.



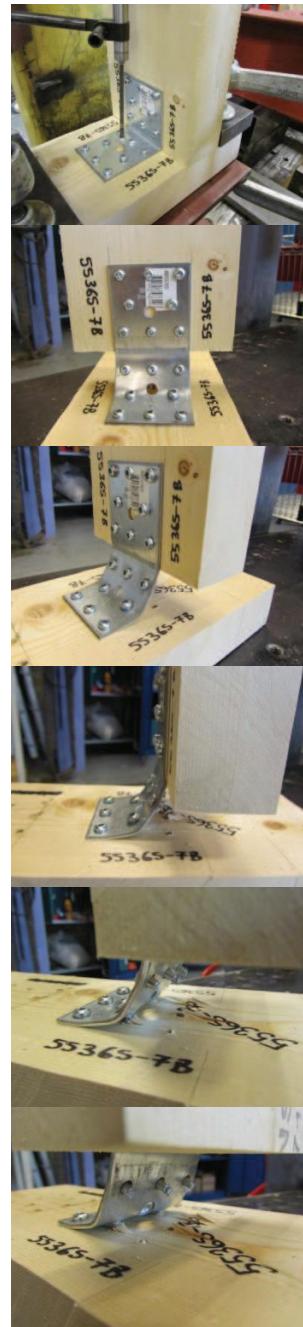
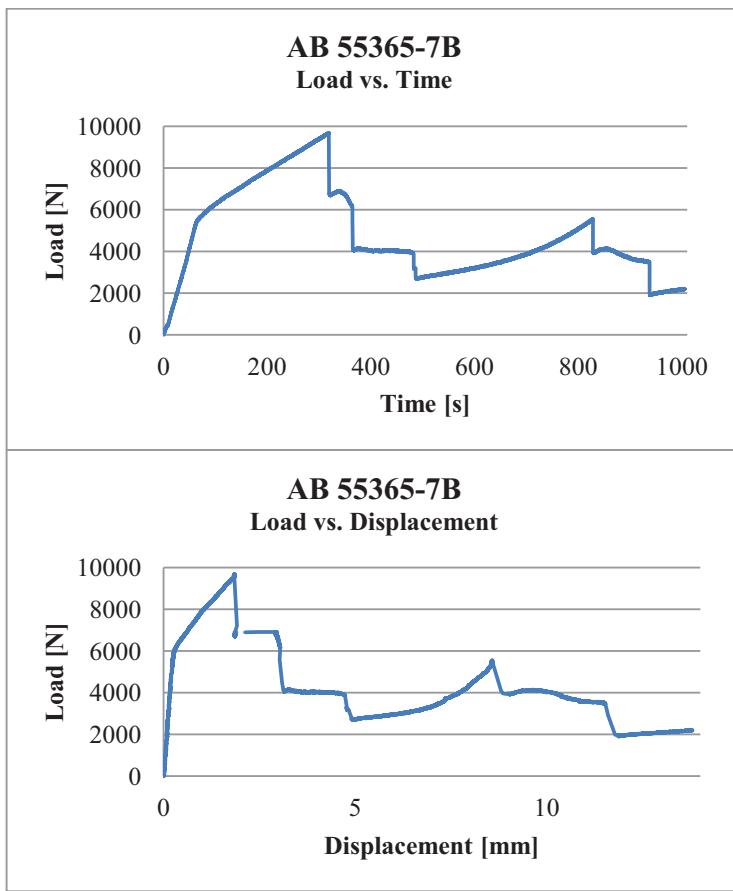
Failure	2
Failure load [N]	8981
Displacement 1 [mm]	1.83
Displacement 2 [mm]	-
Mean Displacement [mm]	-
Moisture [%]	7.20
Density [kg/m ³]	506

In this test only one displacement was recorded.



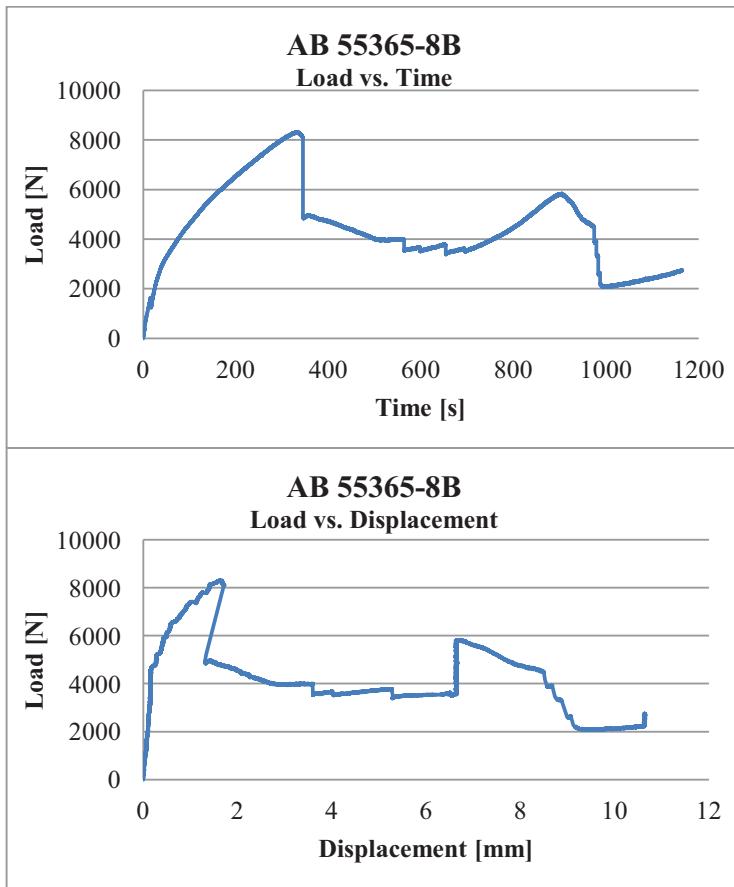
Failure	2
Failure load [N]	8774
Displacement 1 [mm]	0.87
Displacement 2 [mm]	-
Mean Displacement [mm]	-
Moisture [%]	9.33
Density [kg/m ³]	421

In this test only one displacement was recorded.



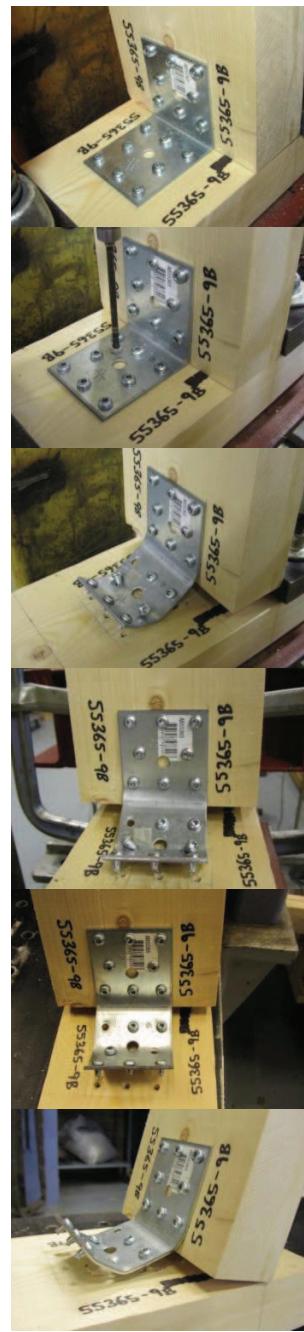
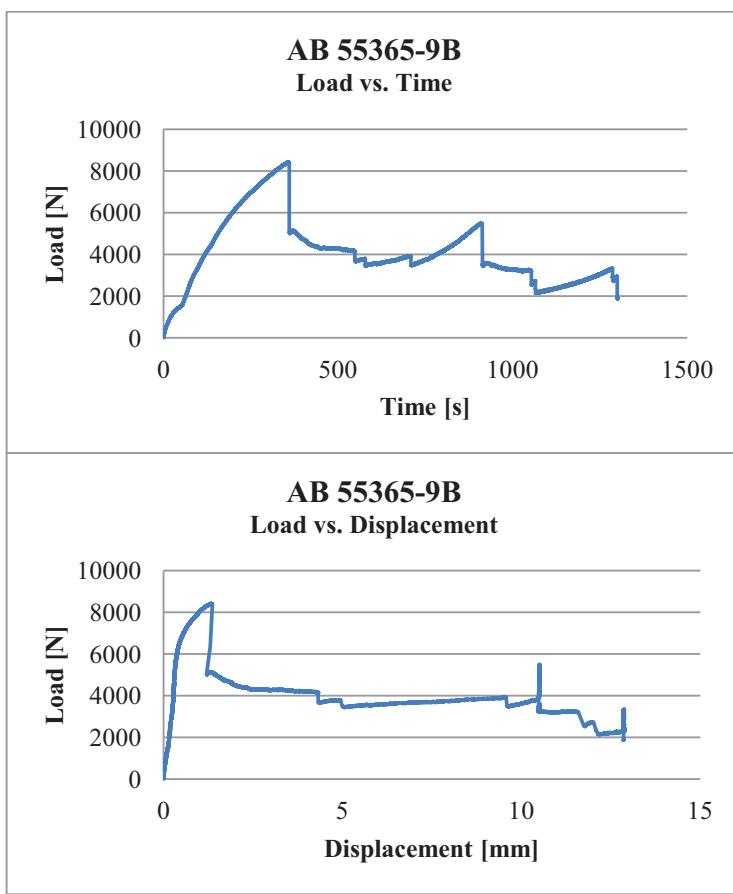
Failure	2
Failure load [N]	9676
Displacement 1 [mm]	1.85
Displacement 2 [mm]	-
Mean Displacement [mm]	-
Moisture [%]	8.49
Density [kg/m ³]	459

In this test only one displacement was recorded. Under 5 kN the LVDT did not work.



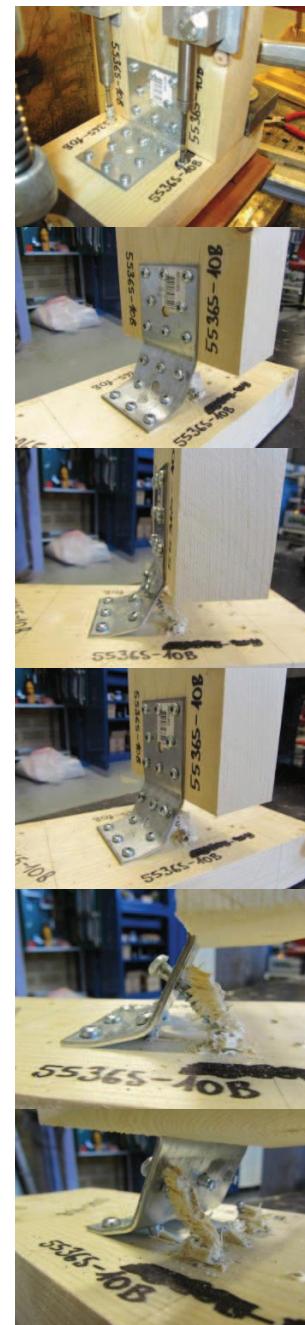
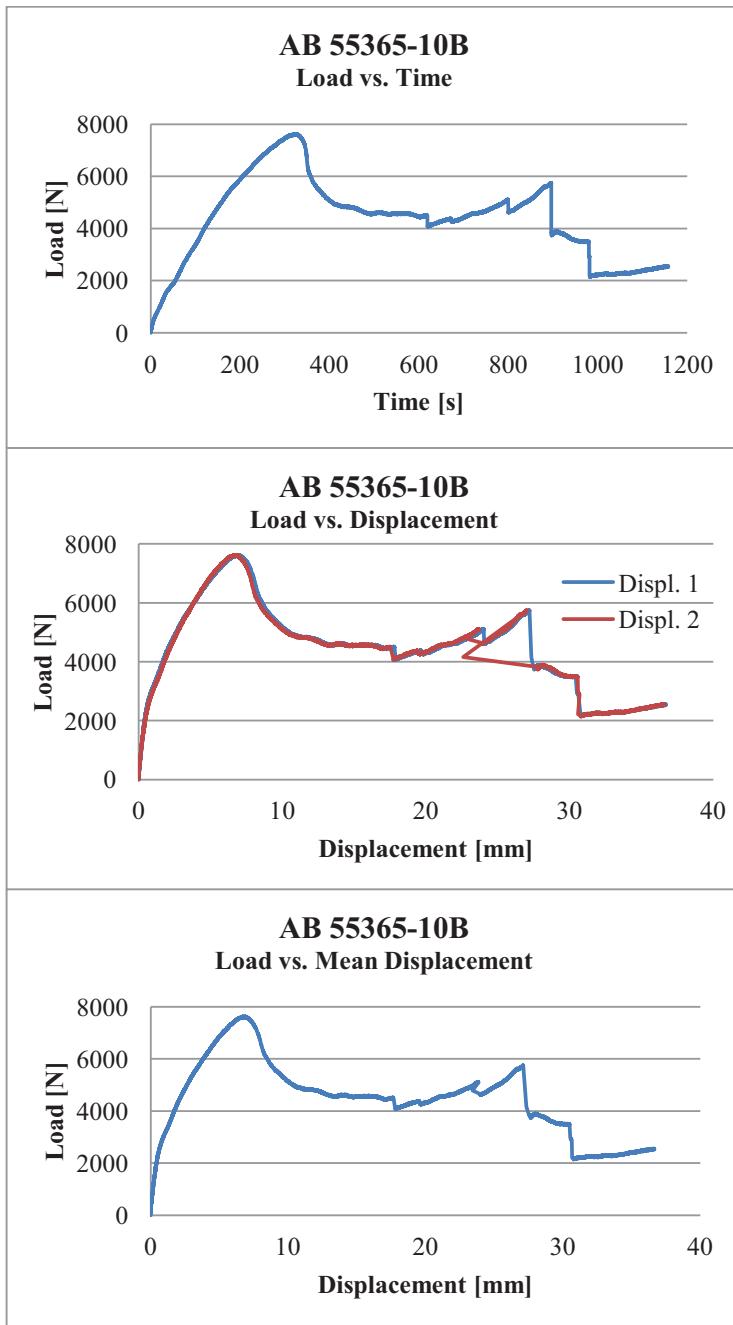
Failure	2
Failure load [N]	8315
Displacement 1 [mm]	1.63
Displacement 2 [mm]	-
Mean Displacement [mm]	-
Moisture [%]	6.32
Density [kg/m ³]	416

In this test only one displacement was recorded.

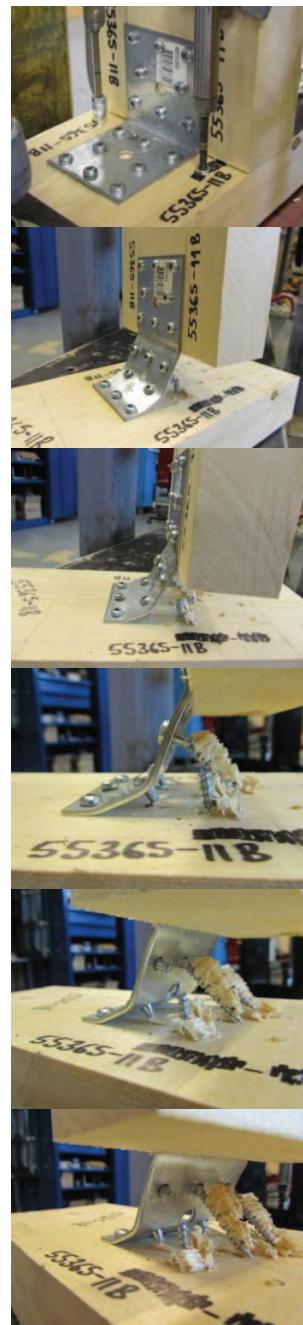
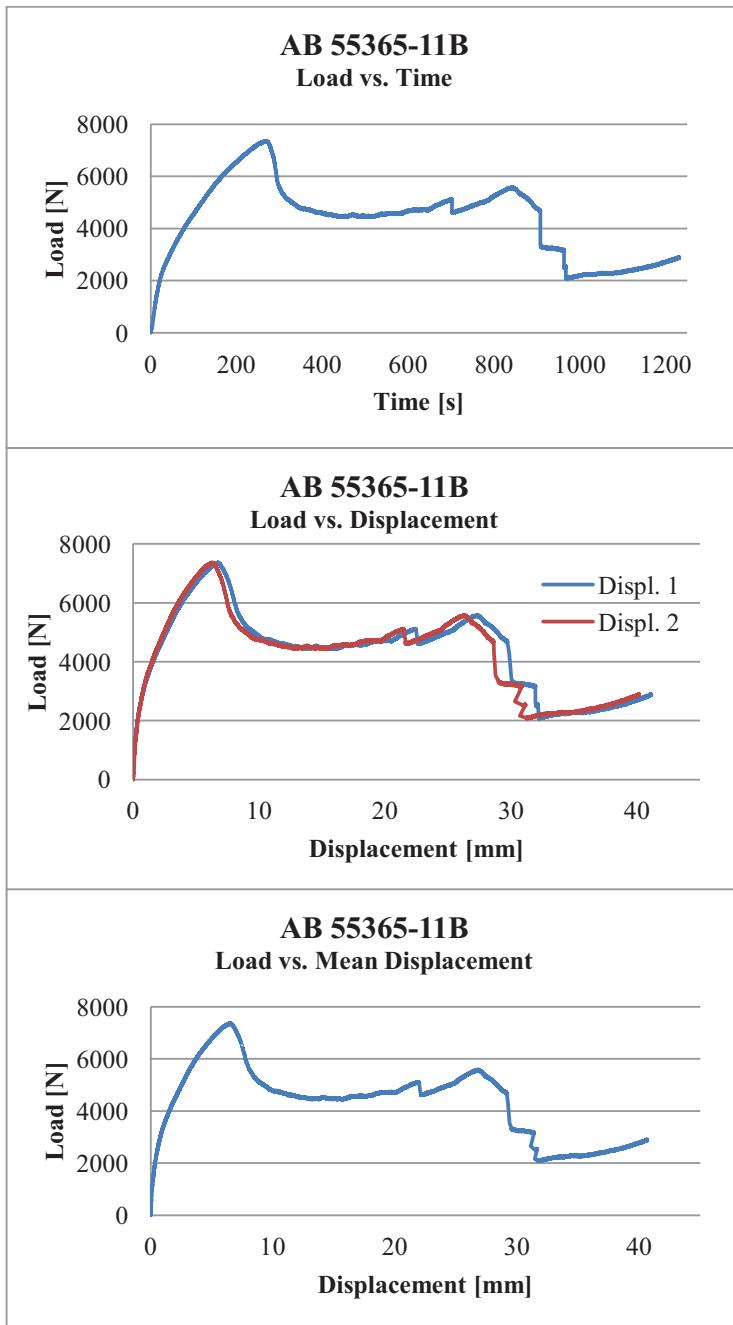


Failure	2
Failure load [N]	8415
Displacement 1 [mm]	1.33
Displacement 2 [mm]	-
Mean Displacement [mm]	-
Moisture [%]	7.83
Density [kg/m ³]	451

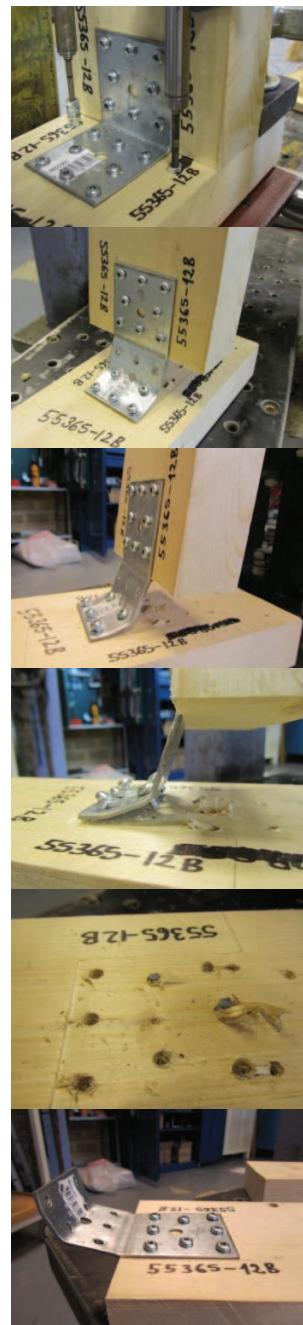
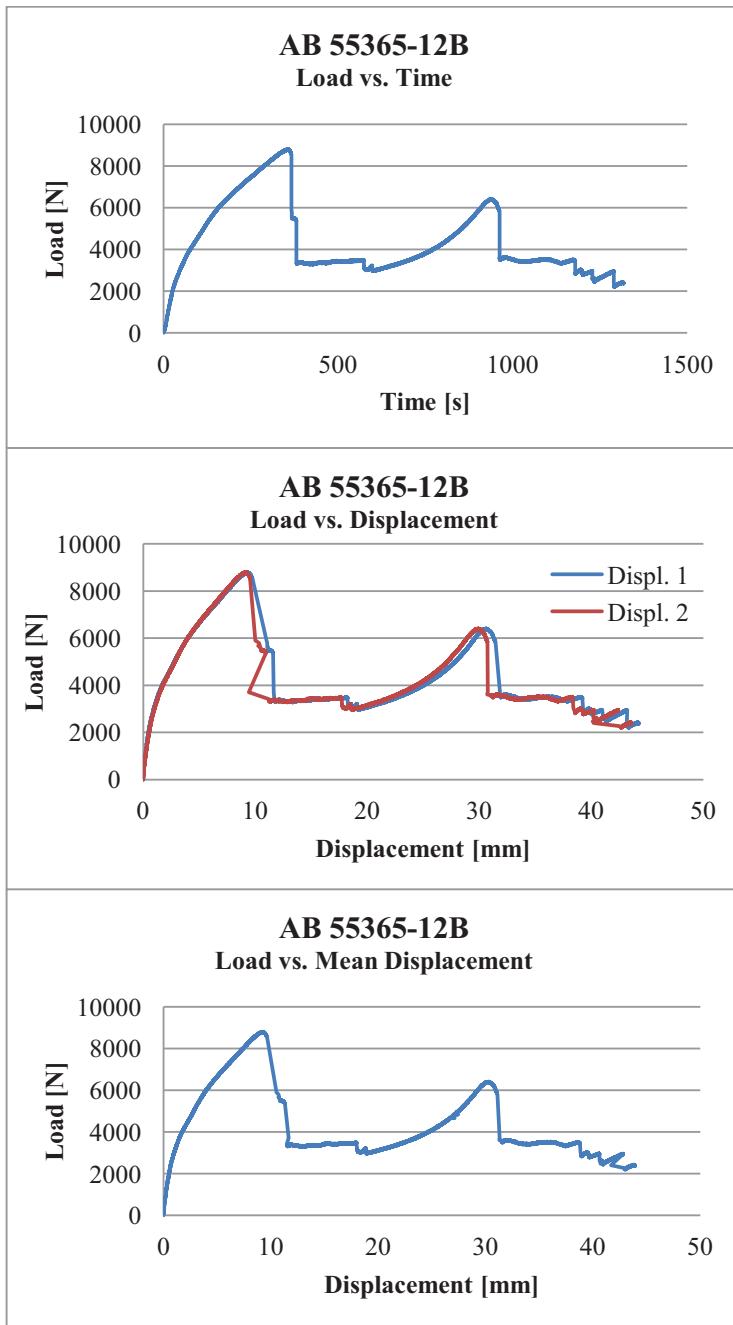
In this test only one displacement was recorded.



Failure	2
Failure load [N]	7624
Displacement 1 [mm]	6.94
Displacement 2 [mm]	6.75
Mean Displacement [mm]	6.85
Moisture [%]	6.87
Density [kg/m ³]	386



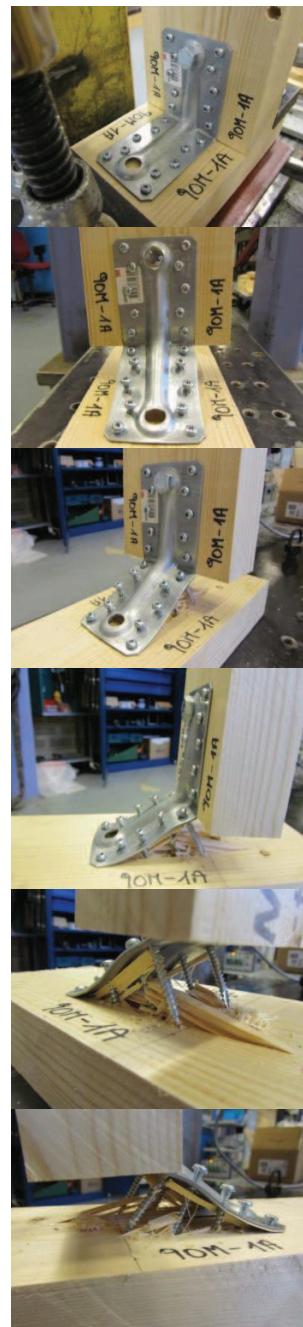
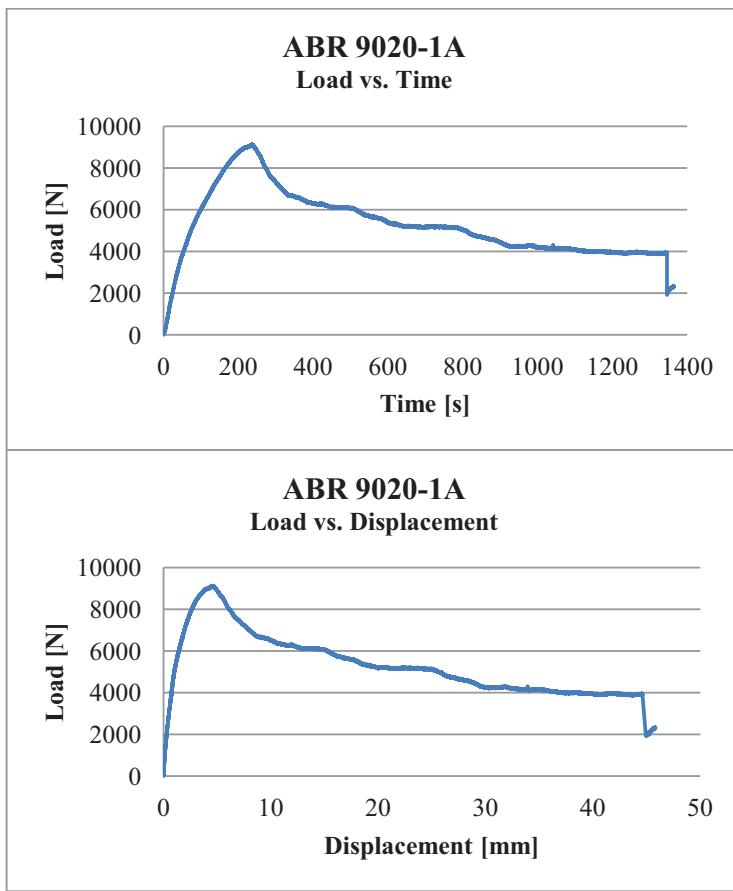
Failure	2
Failure load [N]	7367
Displacement 1 [mm]	6.74
Displacement 2 [mm]	6.30
Mean Displacement [mm]	6.52
Moisture [%]	7.18
Density [kg/m ³]	393



Failure	2
Failure load [N]	8796
Displacement 1 [mm]	9.30
Displacement 2 [mm]	9.14
Mean Displacement [mm]	9.22
Moisture [%]	8.13
Density [kg/m ³]	415

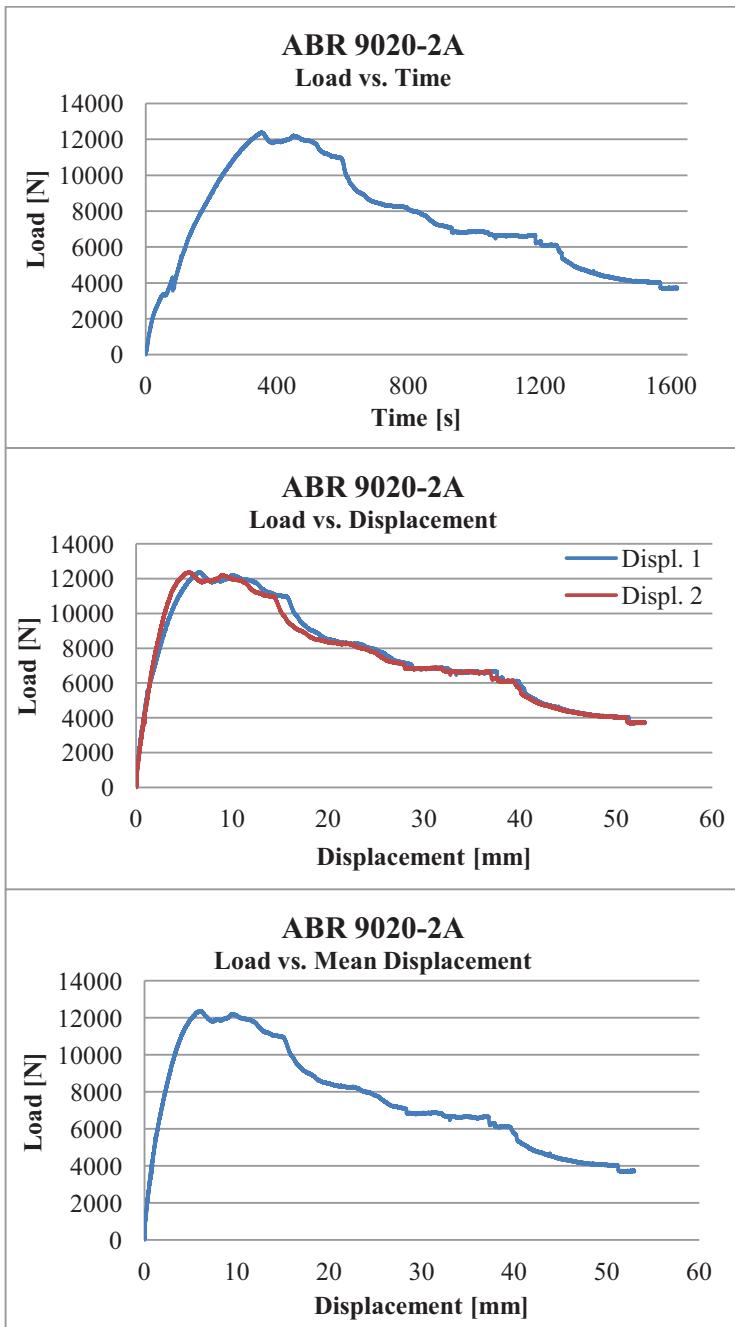
Series 2 – Angle connector ABR 9020

Set 1 – 10 wooden screws 5x40 on the stud and 10 wooden screws 5x40 on the rail

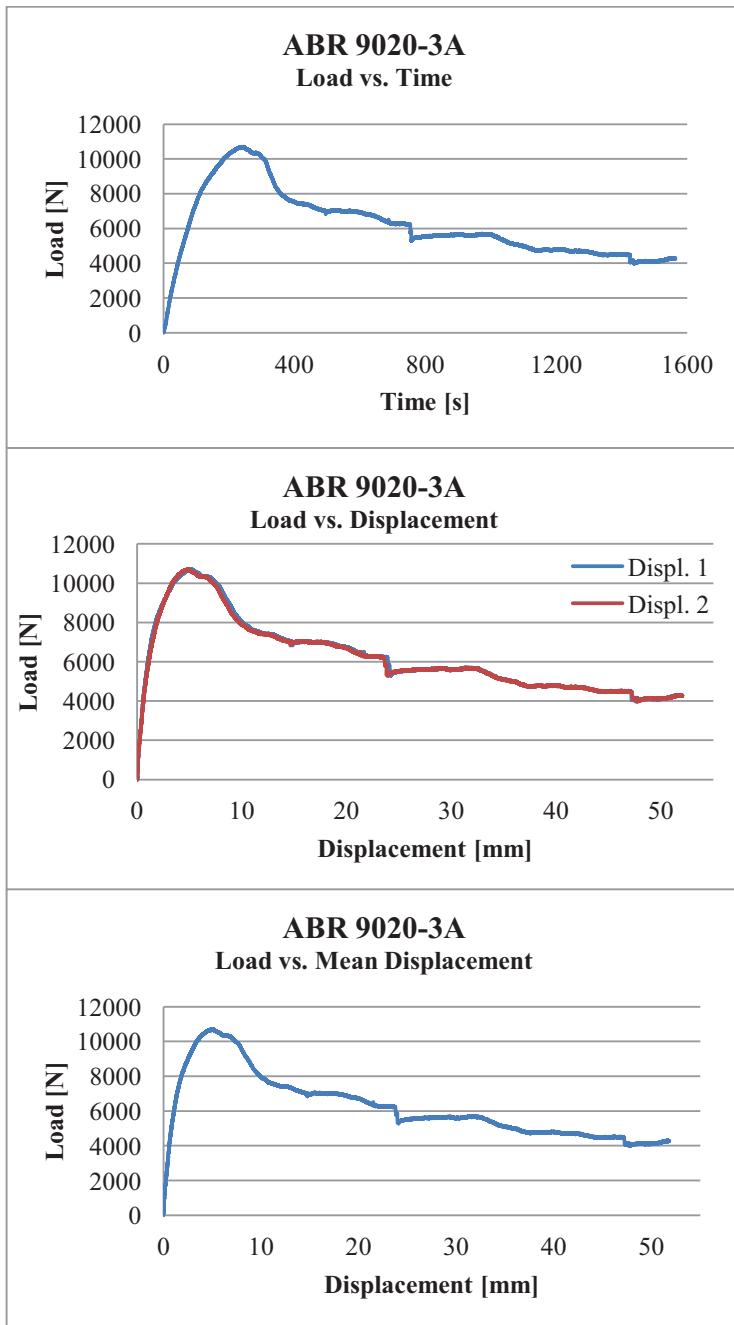


Failure	2
Failure load [N]	9120
Displacement 1 [mm]	-
Displacement 2 [mm]	4.55
Mean Displacement [mm]	-
Moisture [%]	9.75
Density [kg/m ³]	392

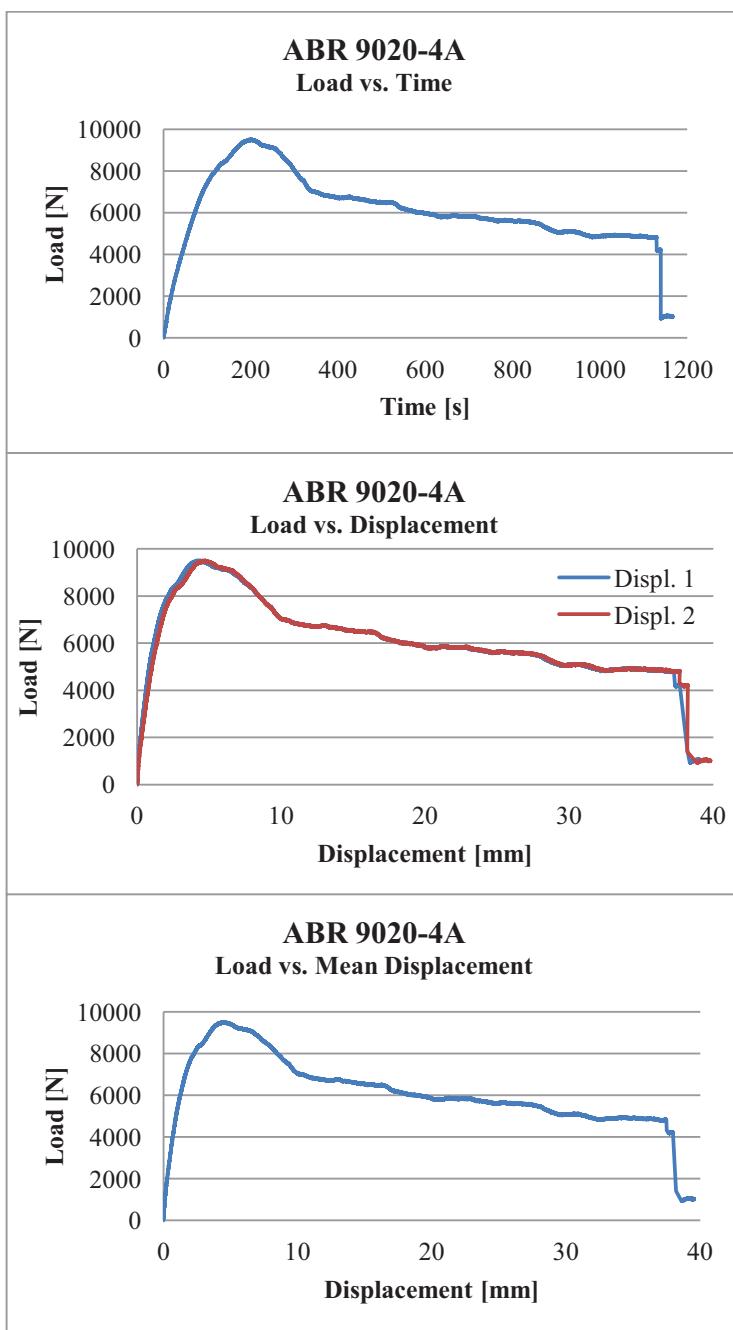
The LVDT number 1 did not work.



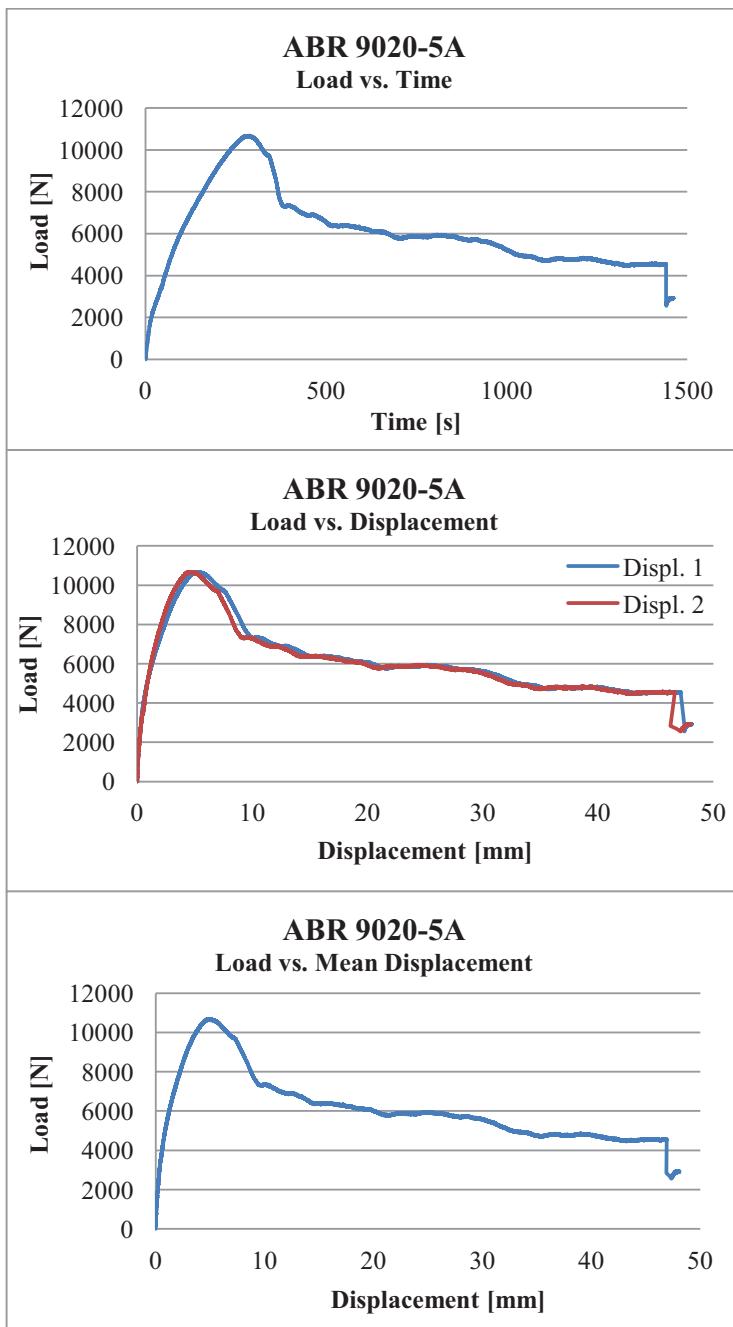
Failure	2
Failure load [N]	12378
Displacement 1 [mm]	6.59
Displacement 2 [mm]	5.53
Mean Displacement [mm]	6.06
Moisture [%]	9.97
Density [kg/m ³]	459



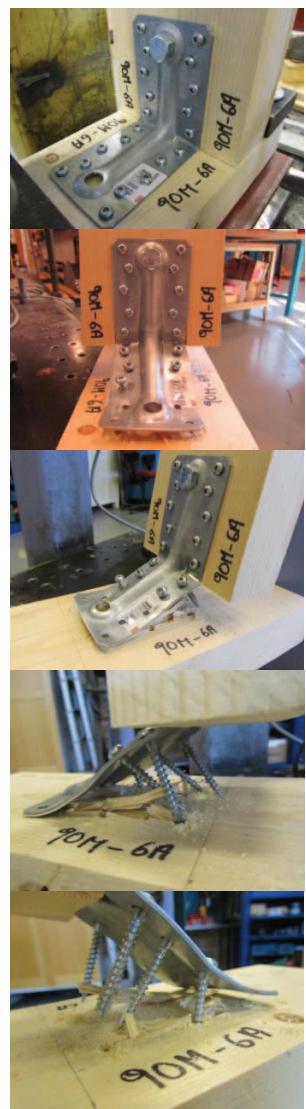
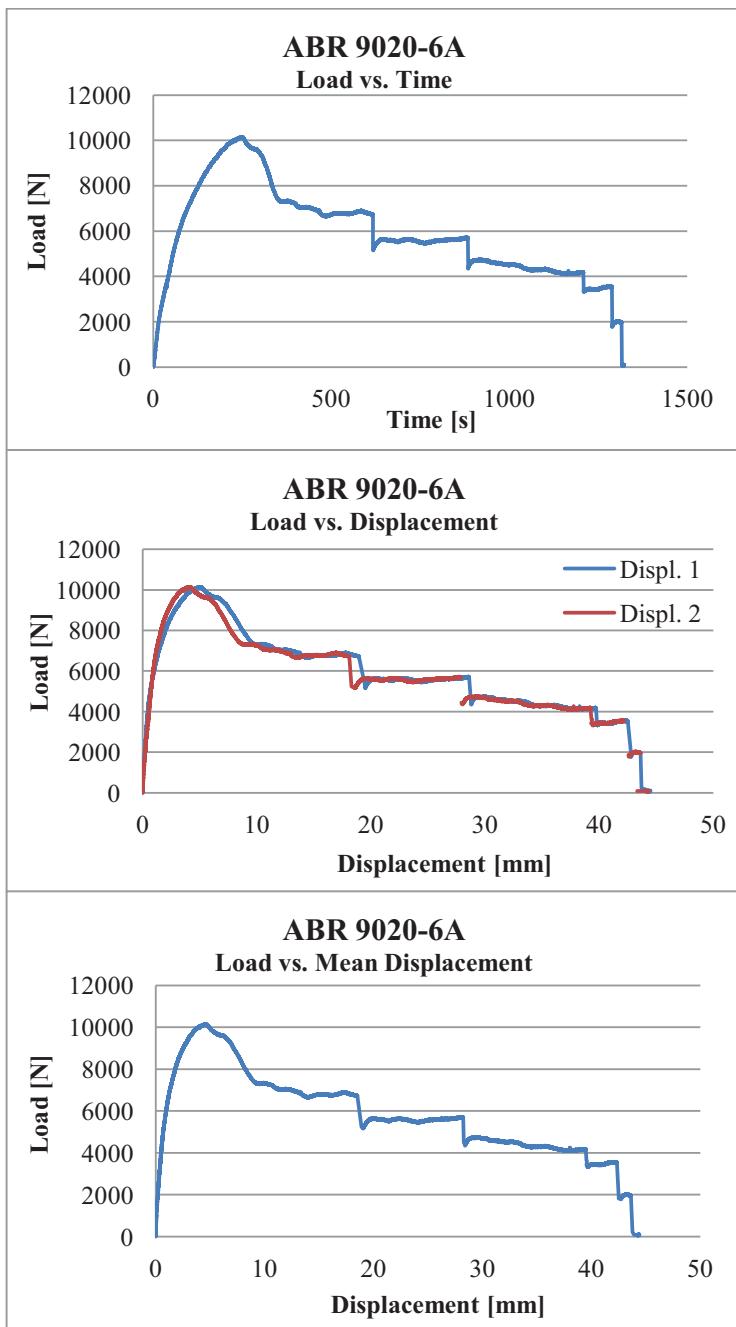
Failure	2
Failure load [N]	10709
Displacement 1 [mm]	5.11
Displacement 2 [mm]	4.78
Mean Displacement [mm]	4.94
Moisture [%]	10.4
Density [kg/m ³]	402



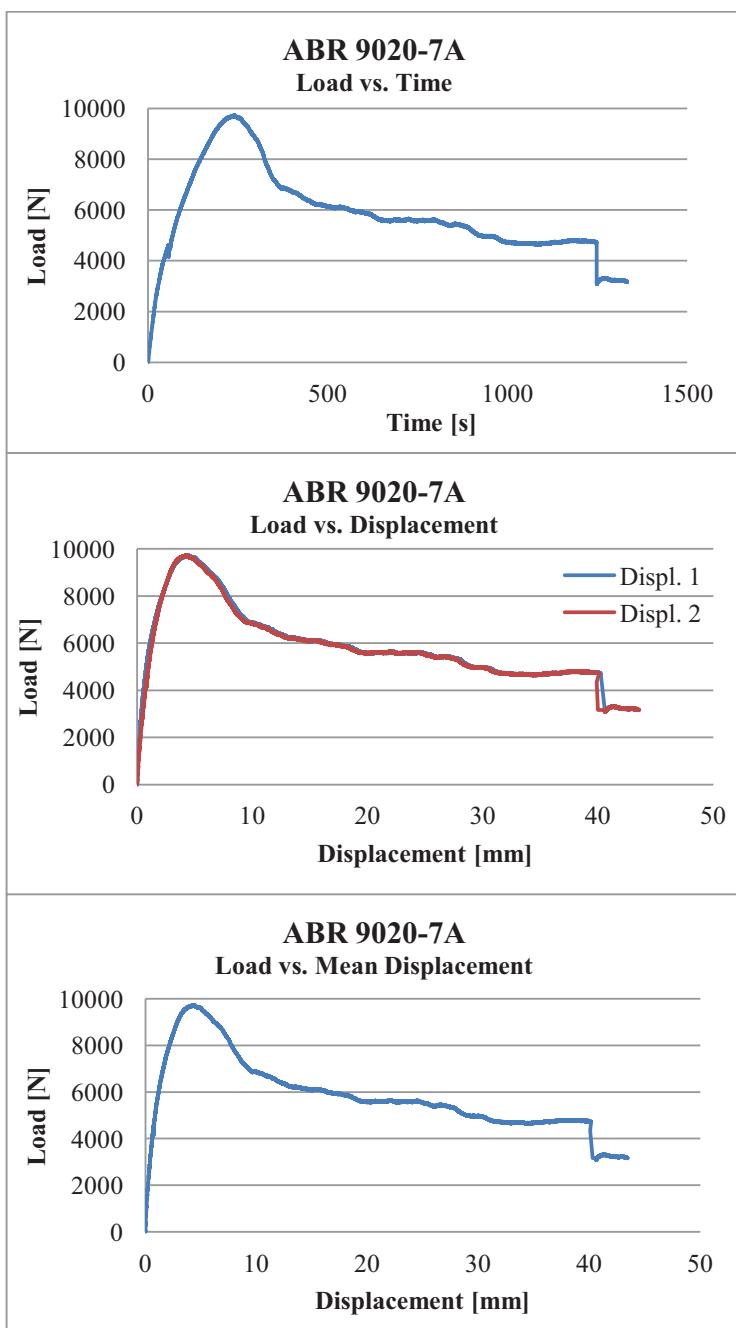
Failure	2
Failure load [N]	9503
Displacement 1 [mm]	4.29
Displacement 2 [mm]	4.66
Mean Displacement [mm]	4.48
Moisture [%]	10.3
Density [kg/m ³]	387



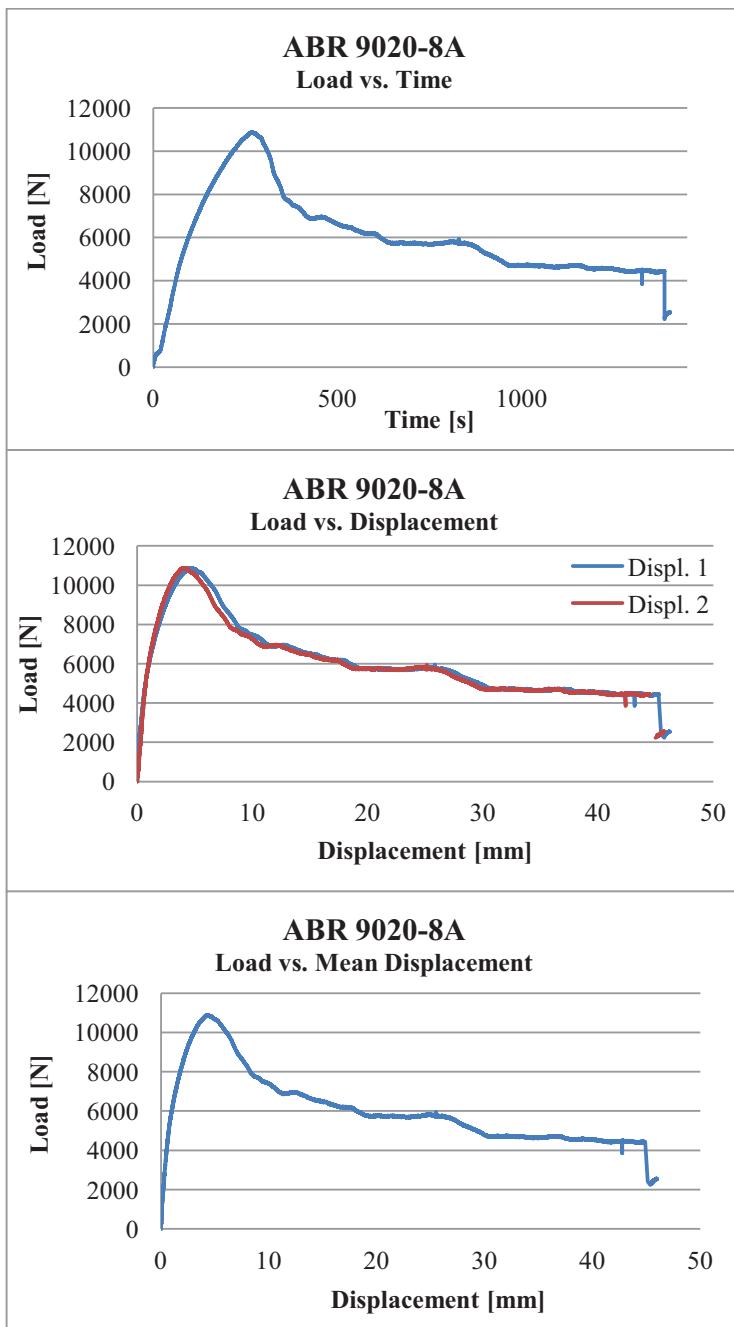
Failure	2
Failure load [N]	10676
Displacement 1 [mm]	5.39
Displacement 2 [mm]	4.80
Mean Displacement [mm]	5.09
Moisture [%]	9.39
Density [kg/m ³]	418



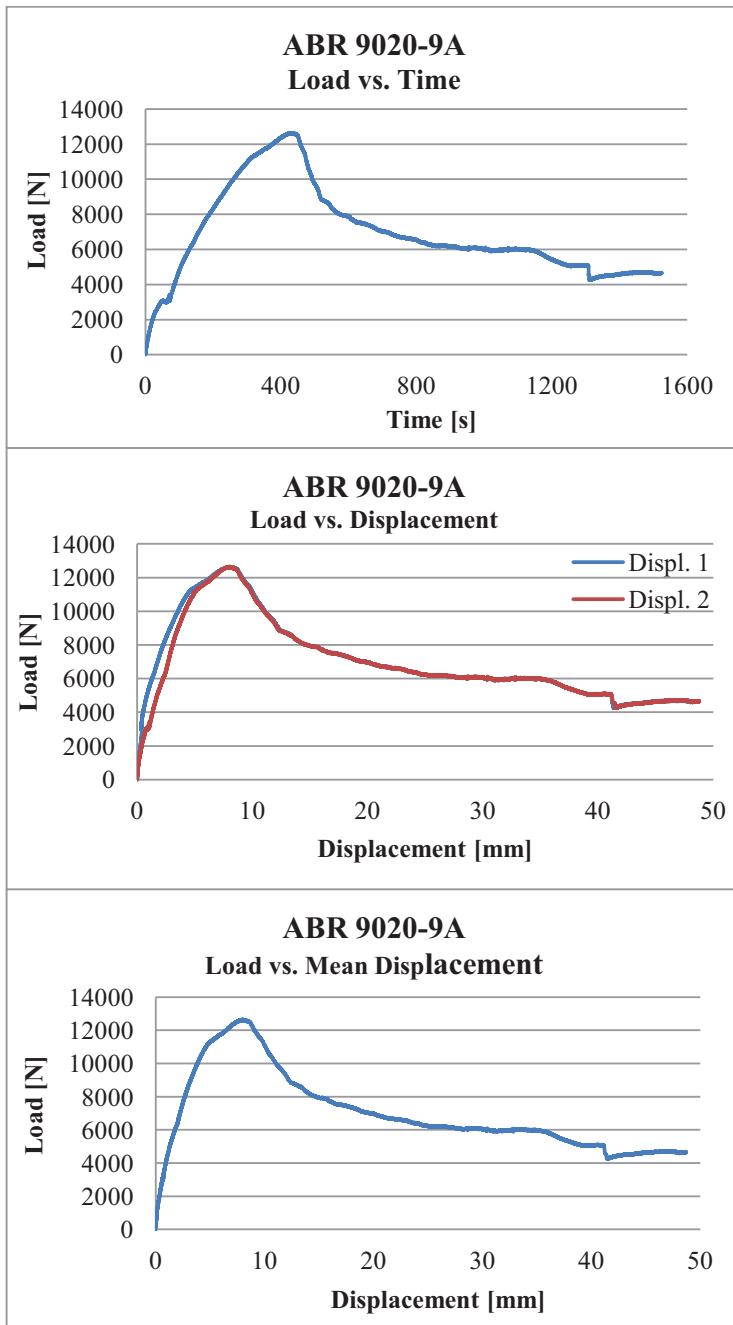
Failure	2
Failure load [N]	10145
Displacement 1 [mm]	4.92
Displacement 2 [mm]	4.00
Mean Displacement [mm]	4.46
Moisture [%]	11.0
Density [kg/m ³]	373



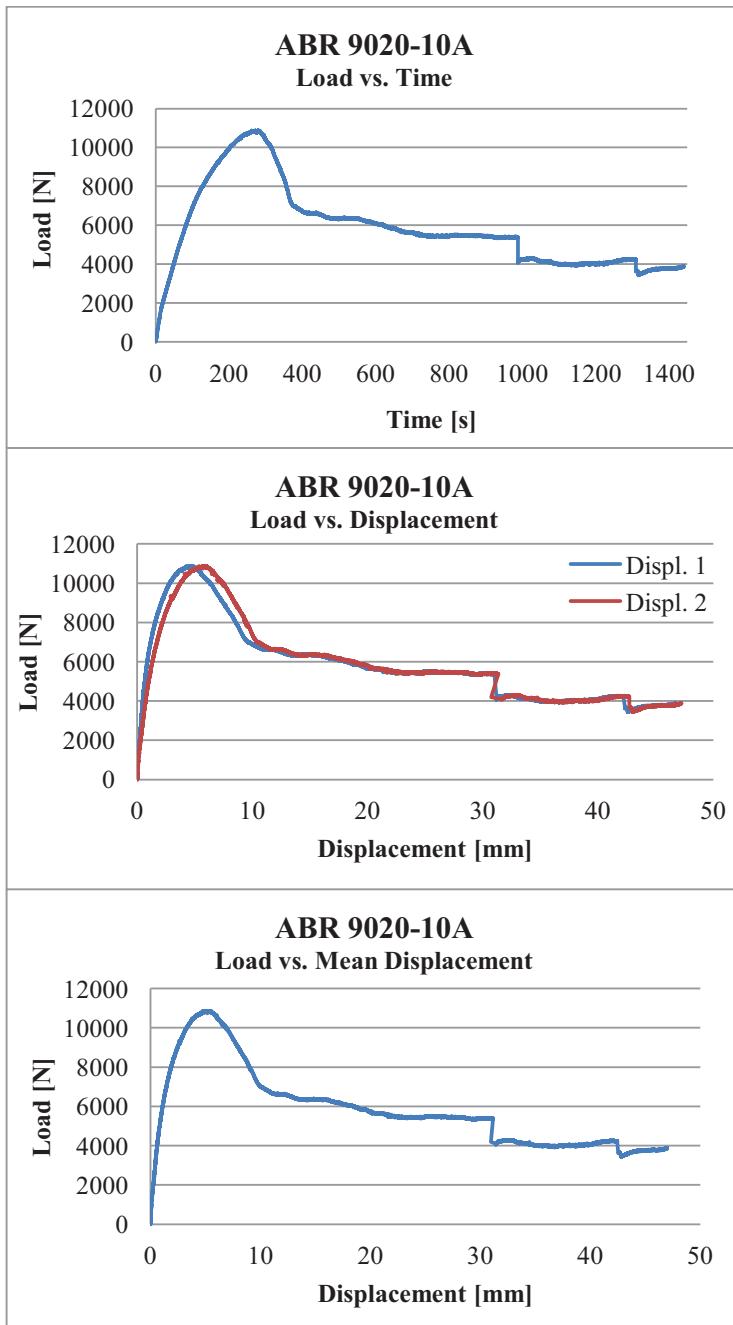
Failure	2
Failure load [N]	9732
Displacement 1 [mm]	4.45
Displacement 2 [mm]	4.25
Mean Displacement [mm]	4.35
Moisture [%]	8.98
Density [kg/m ³]	397



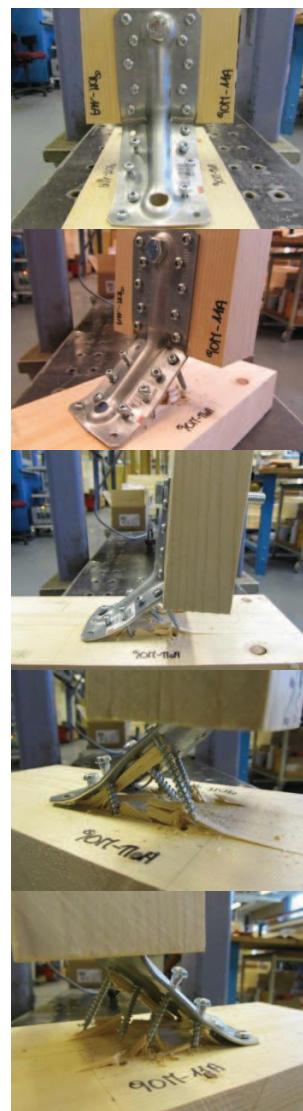
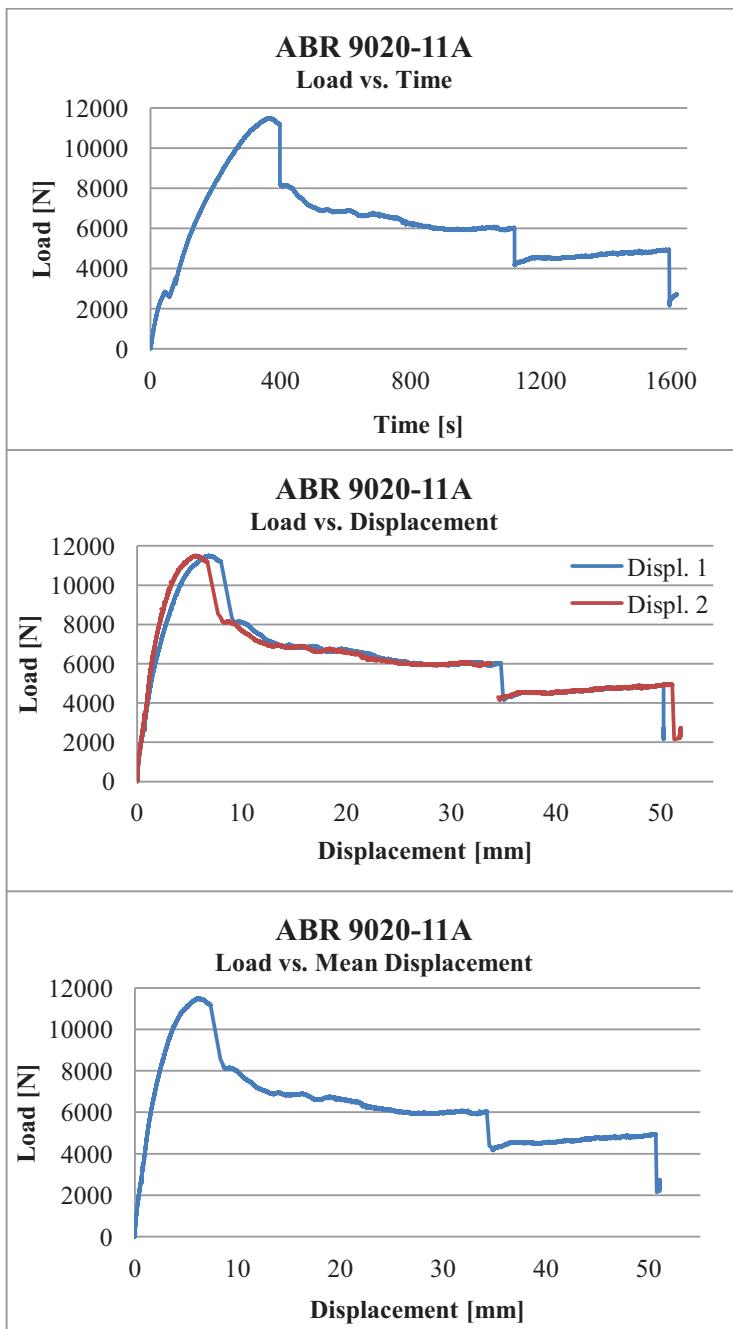
Failure	2
Failure load [N]	10872
Displacement 1 [mm]	4.55
Displacement 2 [mm]	3.95
Mean Displacement [mm]	4.25
Moisture [%]	8.53
Density [kg/m ³]	416



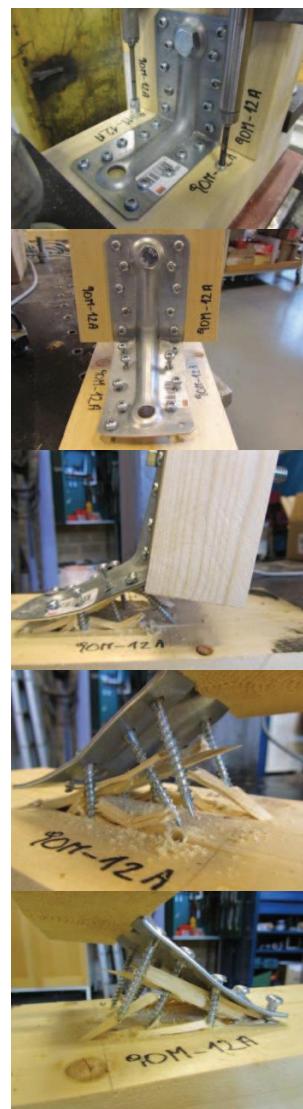
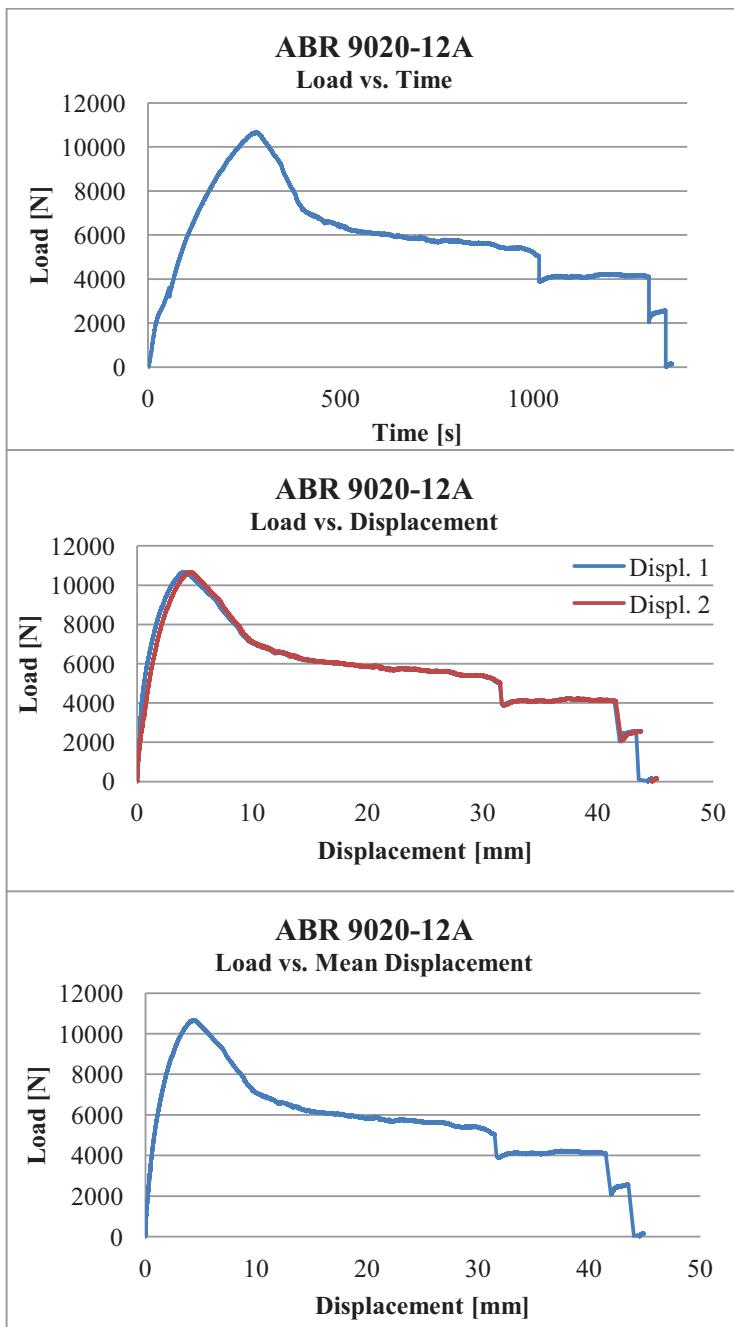
Failure	2
Failure load [N]	12649
Displacement 1 [mm]	8.04
Displacement 2 [mm]	8.00
Mean Displacement [mm]	8.02
Moisture [%]	8.52
Density [kg/m ³]	422



Failure	2
Failure load [N]	10870
Displacement 1 [mm]	4.28
Displacement 2 [mm]	5.37
Mean Displacement [mm]	4.83
Moisture [%]	7.36
Density [kg/m ³]	391

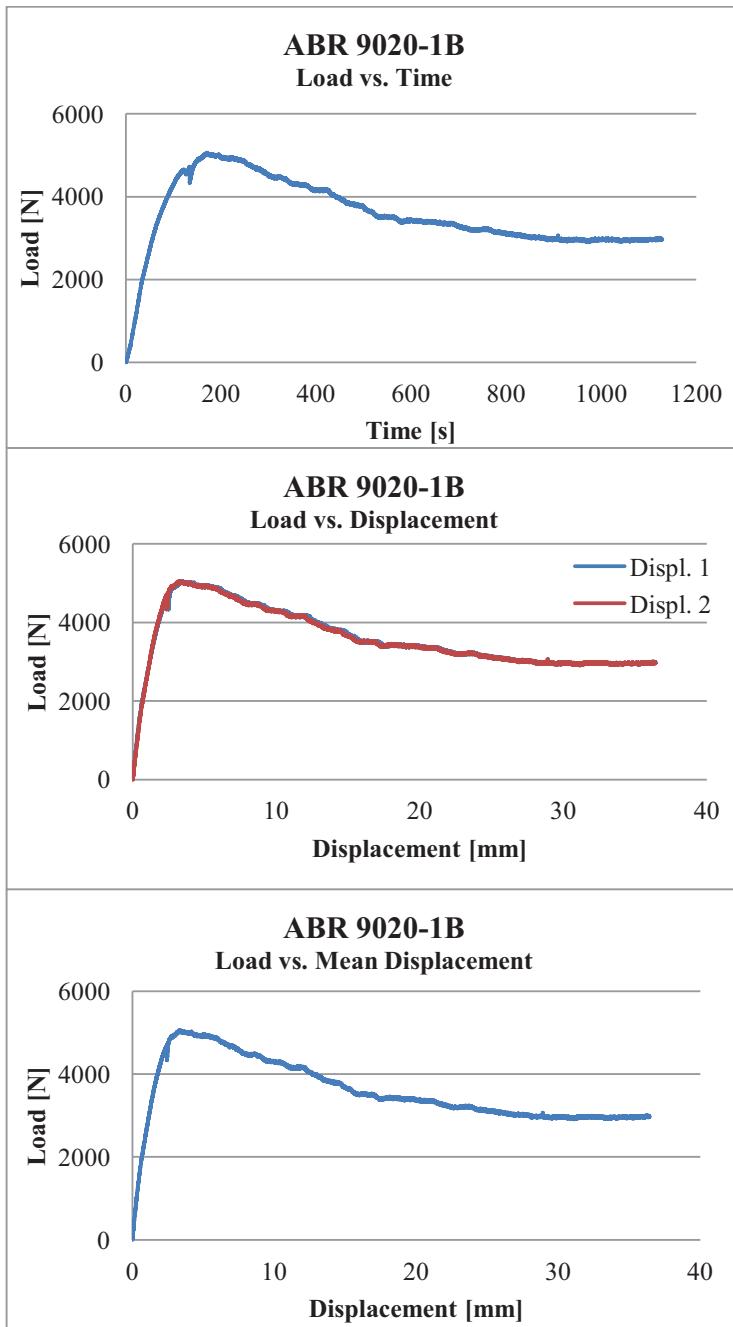


Failure	2
Failure load [N]	11506
Displacement 1 [mm]	6.84
Displacement 2 [mm]	5.59
Mean Displacement [mm]	6.21
Moisture [%]	9.24
Density [kg/m ³]	445

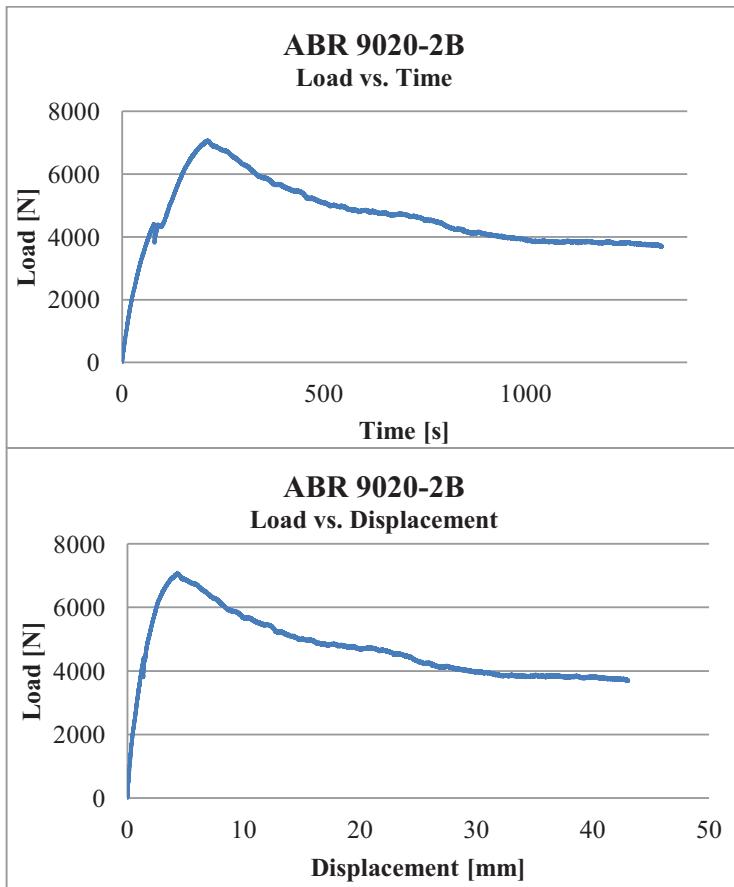


Failure	2
Failure load [N]	10670
Displacement 1 [mm]	4.16
Displacement 2 [mm]	4.68
Mean Displacement [mm]	4.42
Moisture [%]	9.86
Density [kg/m ³]	387

Set 2 – 1 bolt M 10 and 10 annular ringed shank nails 4x40 on the stud and 10 annular ringed shank nail 4x40 on the rail

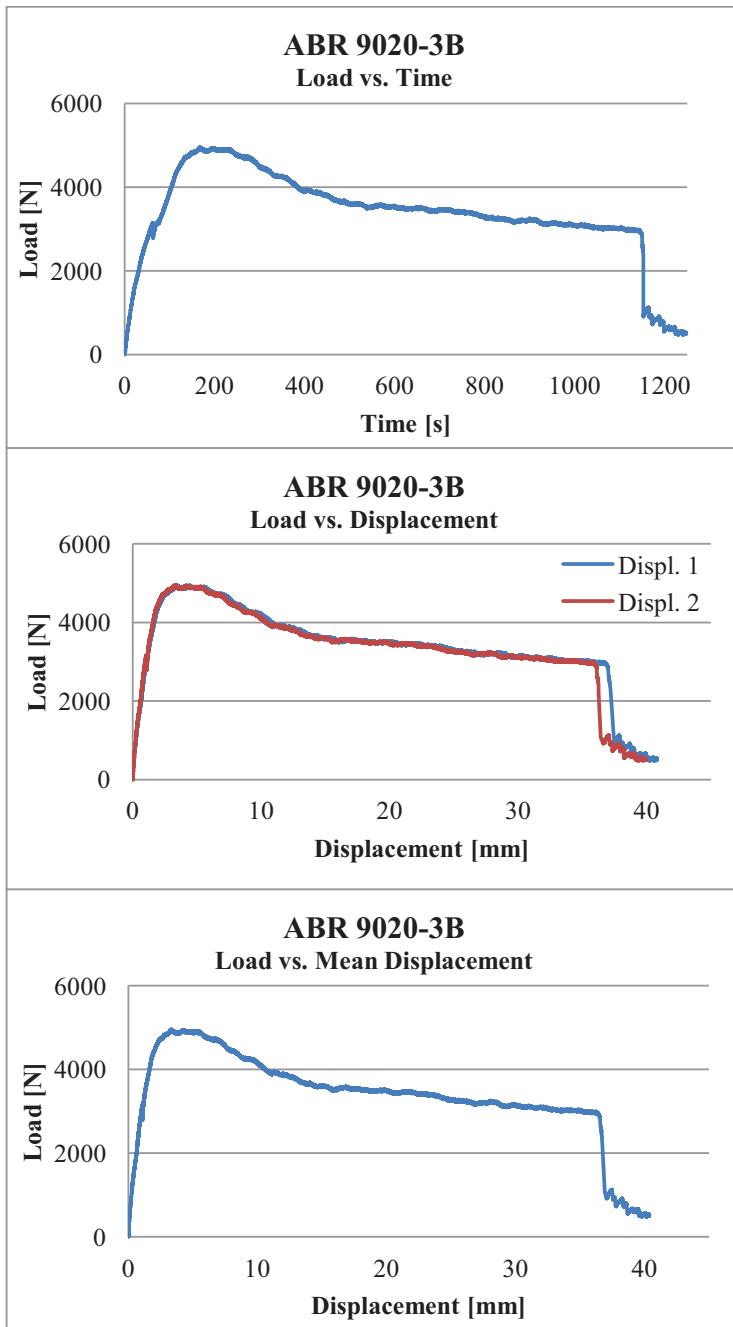


Failure	2
Failure load [N]	5061
Displacement 1 [mm]	3.41
Displacement 2 [mm]	3.25
Mean Displacement [mm]	3.33
Moisture [%]	9.71
Density [kg/m ³]	402

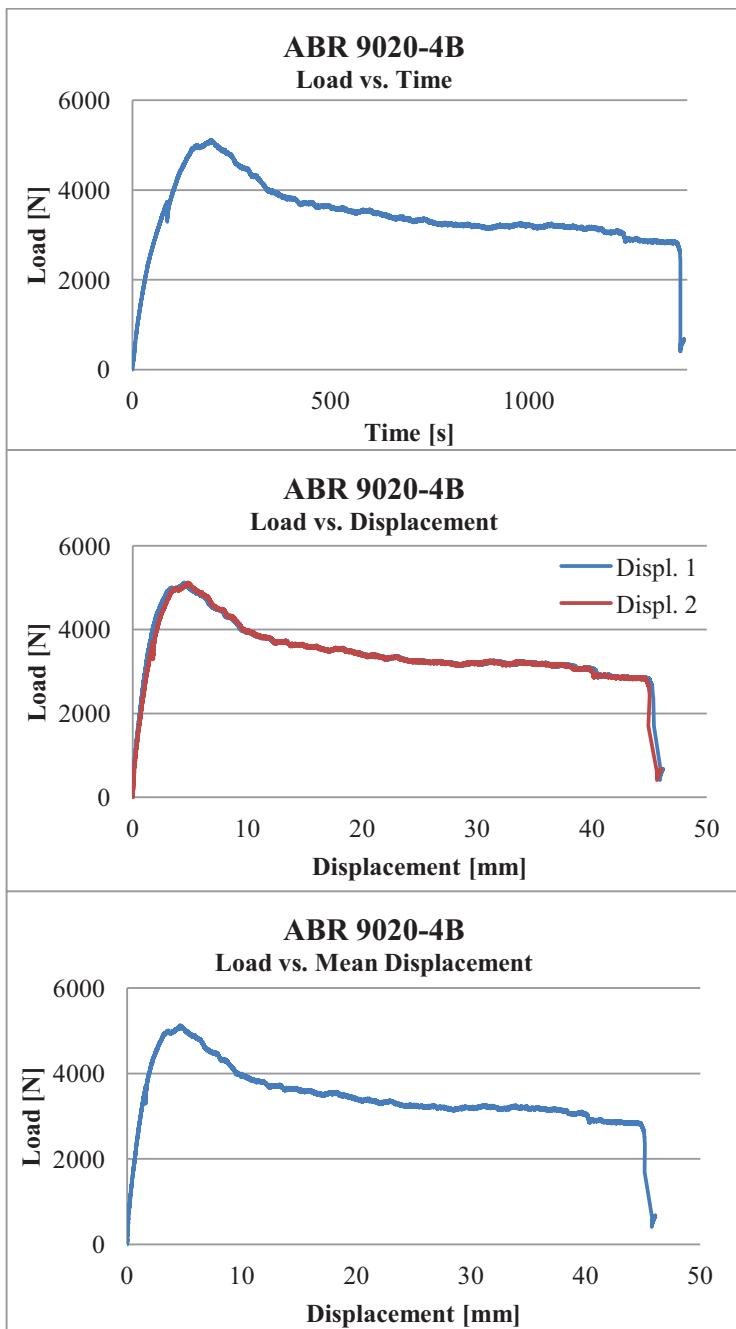


Failure	2
Failure load [N]	7069
Displacement 1 [mm]	4.25
Displacement 2 [mm]	-
Mean Displacement [mm]	-
Moisture [%]	8.29
Density [kg/m ³]	484

The LVDT number 2 did not work.



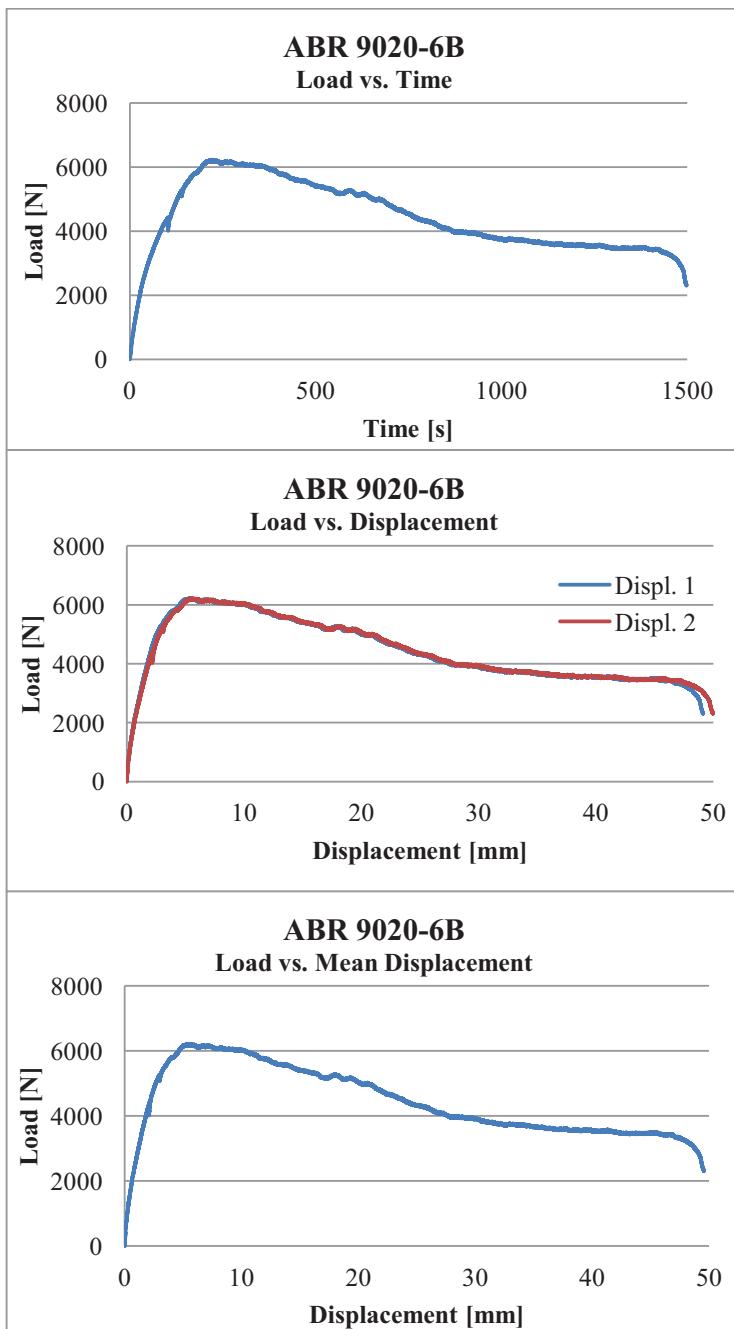
Failure	2
Failure load [N]	4956
Displacement 1 [mm]	3.41
Displacement 2 [mm]	3.23
Mean Displacement [mm]	3.32
Moisture [%]	9.15
Density [kg/m ³]	421



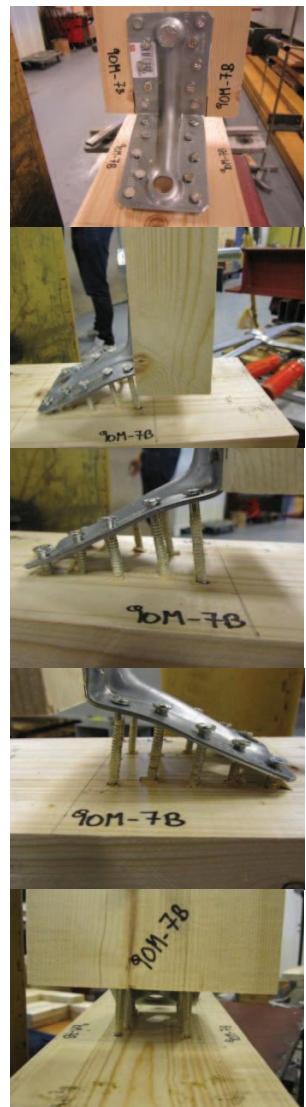
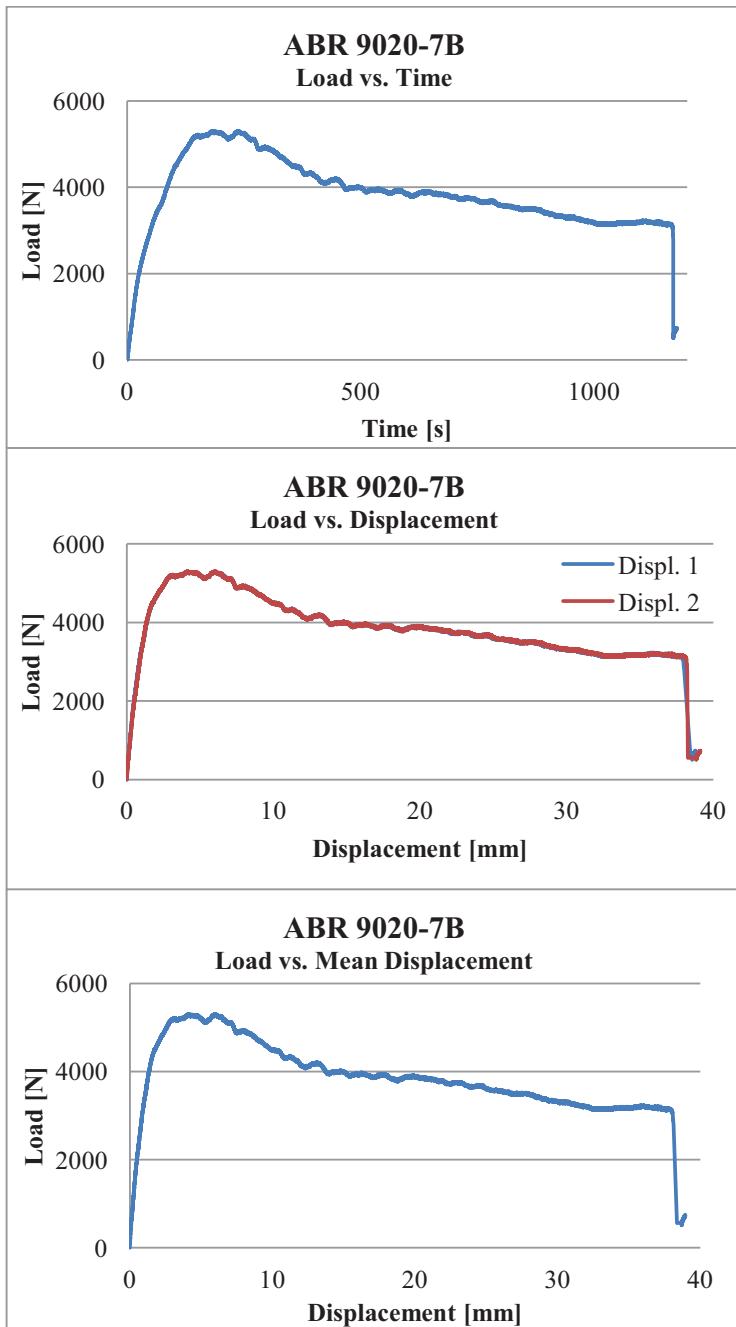
Failure	2
Failure load [N]	5122
Displacement 1 [mm]	4.47
Displacement 2 [mm]	4.80
Mean Displacement [mm]	4.63
Moisture [%]	11.2
Density [kg/m ³]	395



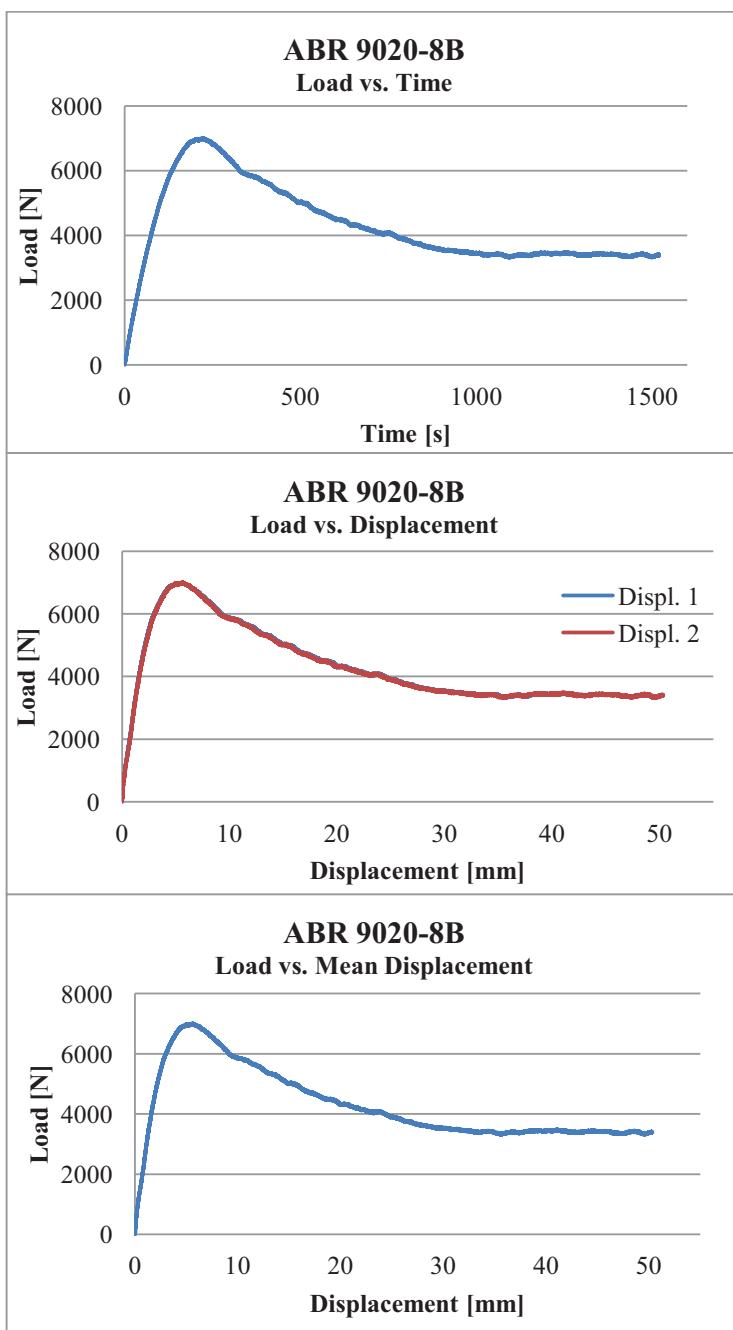
Failure	2
Failure load [N]	5148
Displacement 1 [mm]	1.92
Displacement 2 [mm]	2.07
Mean Displacement [mm]	2.00
Moisture [%]	8.81
Density [kg/m ³]	476



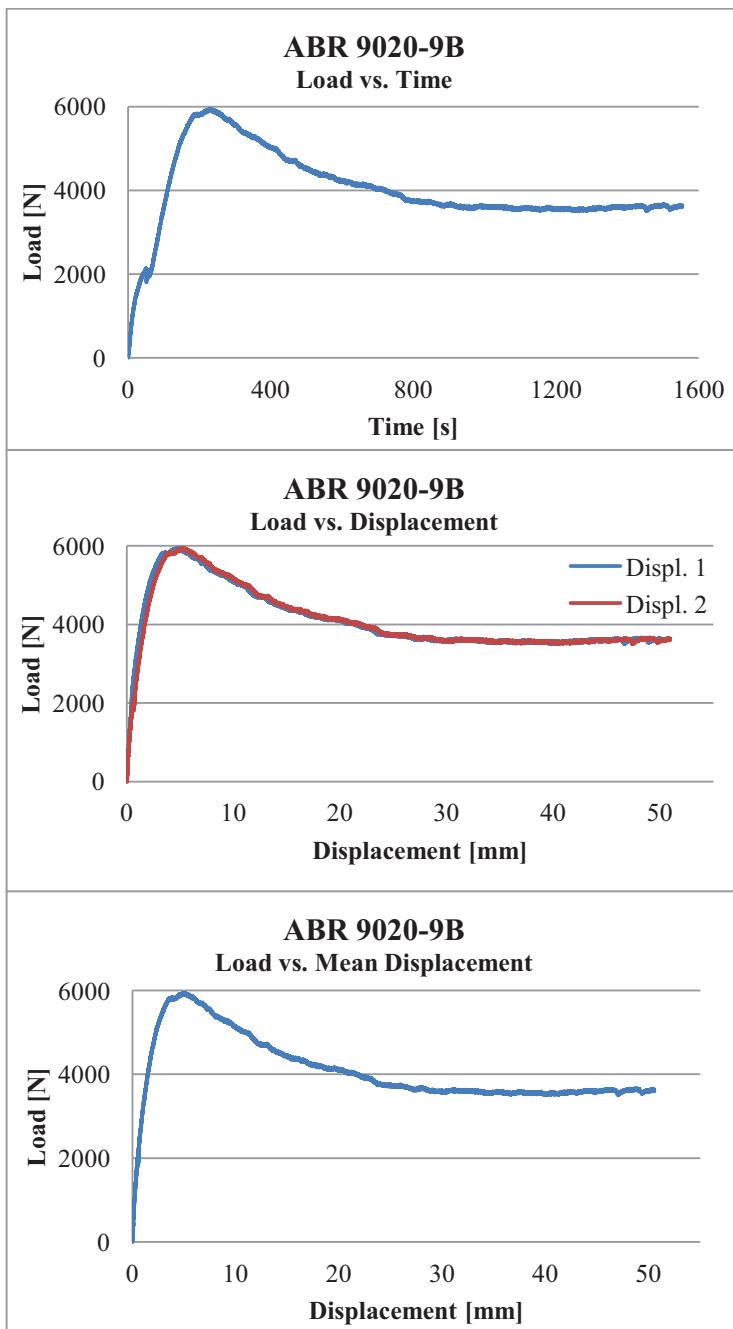
Failure	2
Failure load [N]	6226
Displacement 1 [mm]	5.30
Displacement 2 [mm]	5.55
Mean Displacement [mm]	5.43
Moisture [%]	10.2
Density [kg/m ³]	457



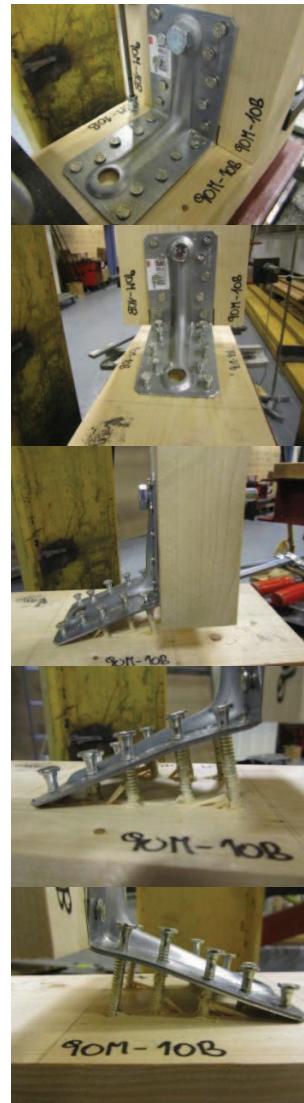
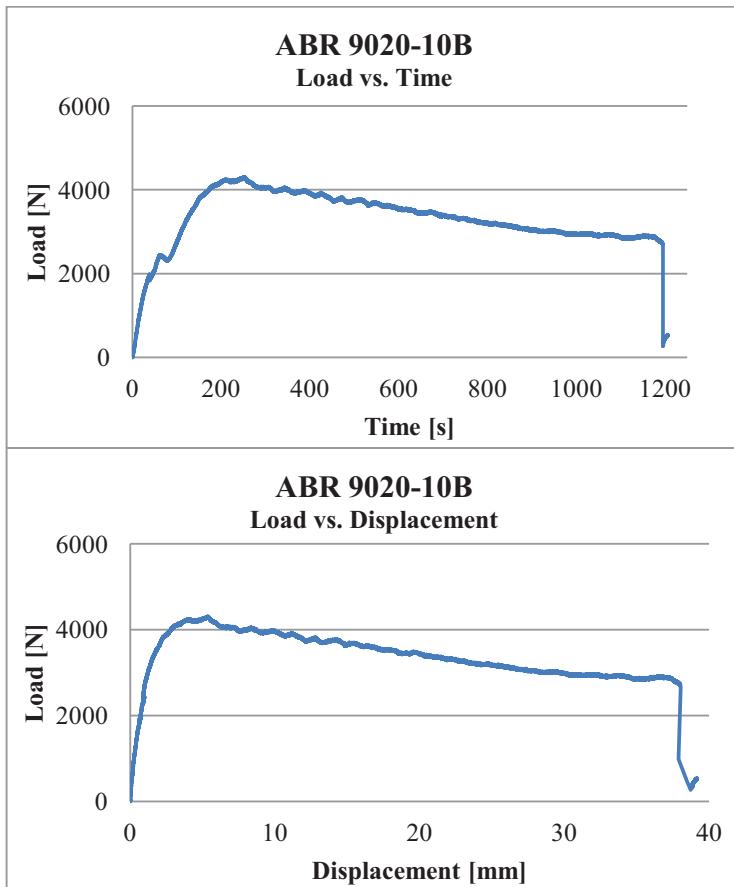
Failure	2
Failure load [N]	5306
Displacement 1 [mm]	4.14
Displacement 2 [mm]	4.13
Mean Displacement [mm]	4.14
Moisture [%]	9.32
Density [kg/m ³]	391



Failure	2
Failure load [N]	7010
Displacement 1 [mm]	5.61
Displacement 2 [mm]	5.63
Mean Displacement [mm]	5.62
Moisture [%]	9.67
Density [kg/m ³]	442

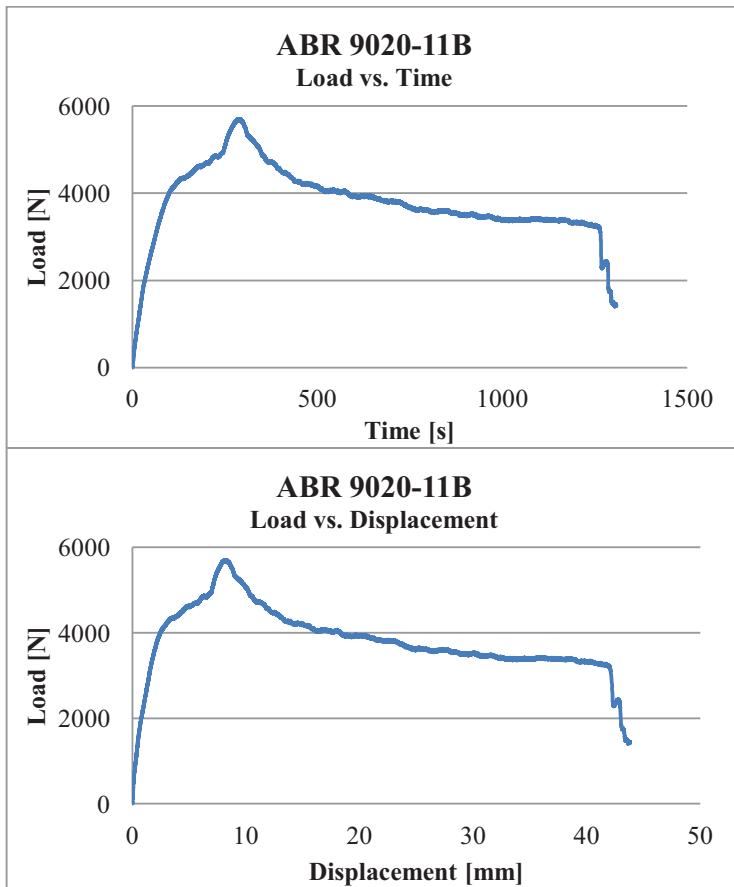


Failure	2
Failure load [N]	5945
Displacement 1 [mm]	4.75
Displacement 2 [mm]	5.23
Mean Displacement [mm]	4.99
Moisture [%]	10.6
Density [kg/m ³]	408



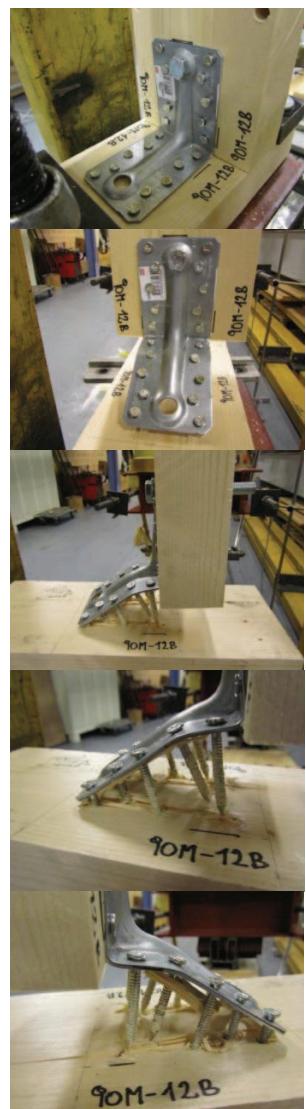
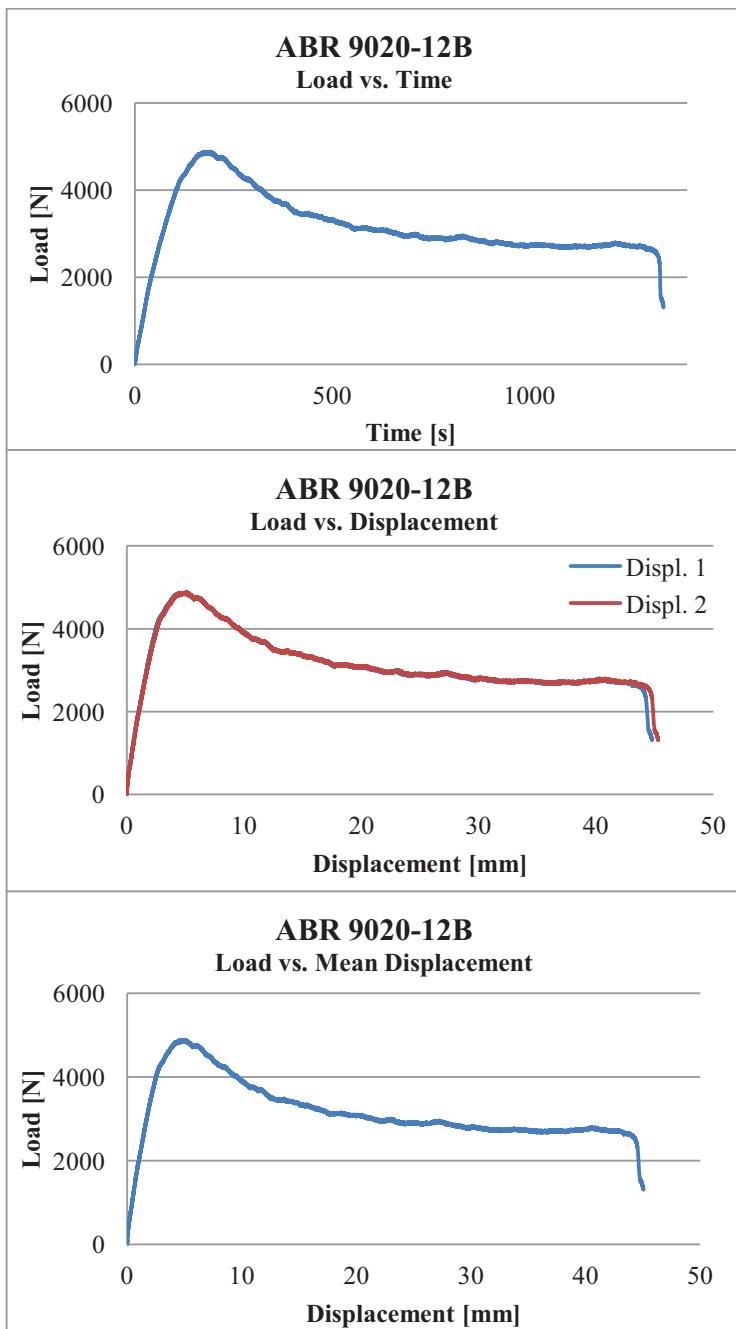
Failure	2
Failure load [N]	4308
Displacement 1 [mm]	-
Displacement 2 [mm]	5.34
Mean Displacement [mm]	-
Moisture [%]	10.8
Density [kg/m ³]	436

The LVDT number 1 did not work.



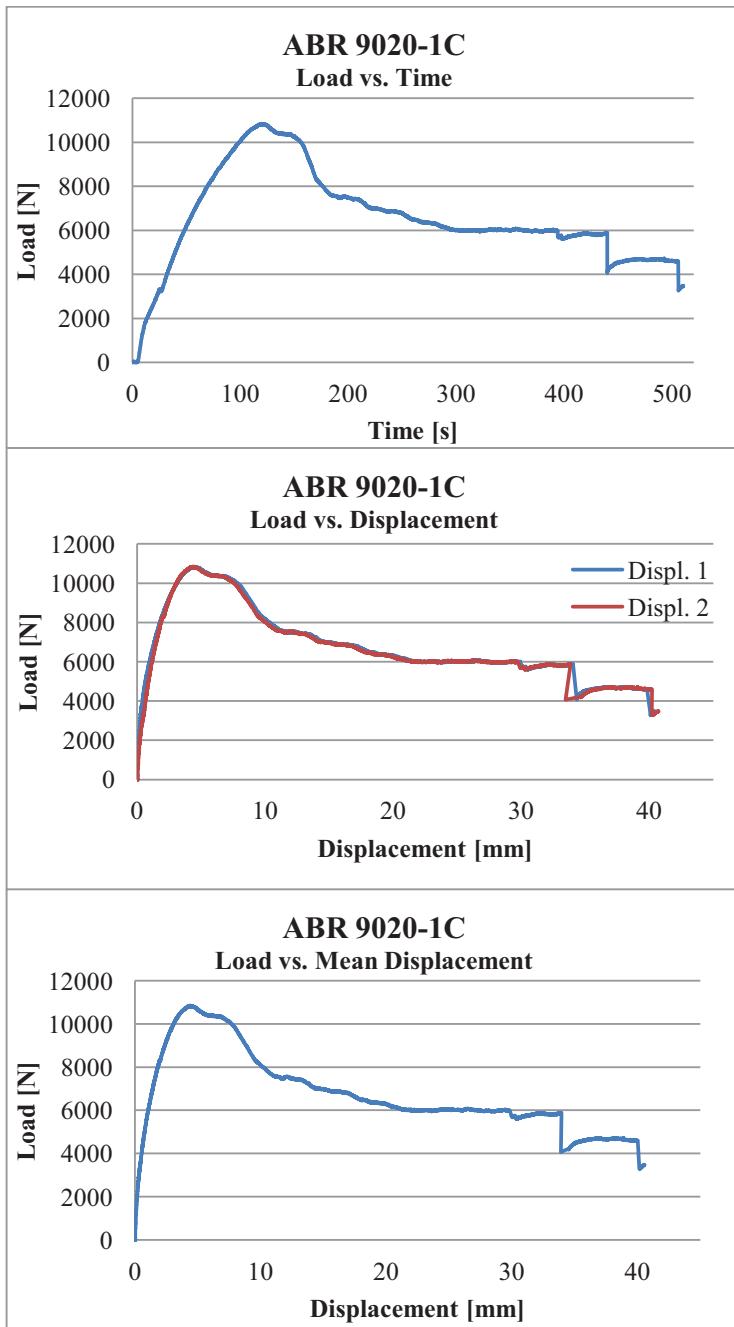
Failure	2
Failure load [N]	4308
Displacement 1 [mm]	-
Displacement 2 [mm]	5.34
Mean Displacement [mm]	-
Moisture [%]	10.8
Density [kg/m ³]	436

The LVDT number 1 did not work.



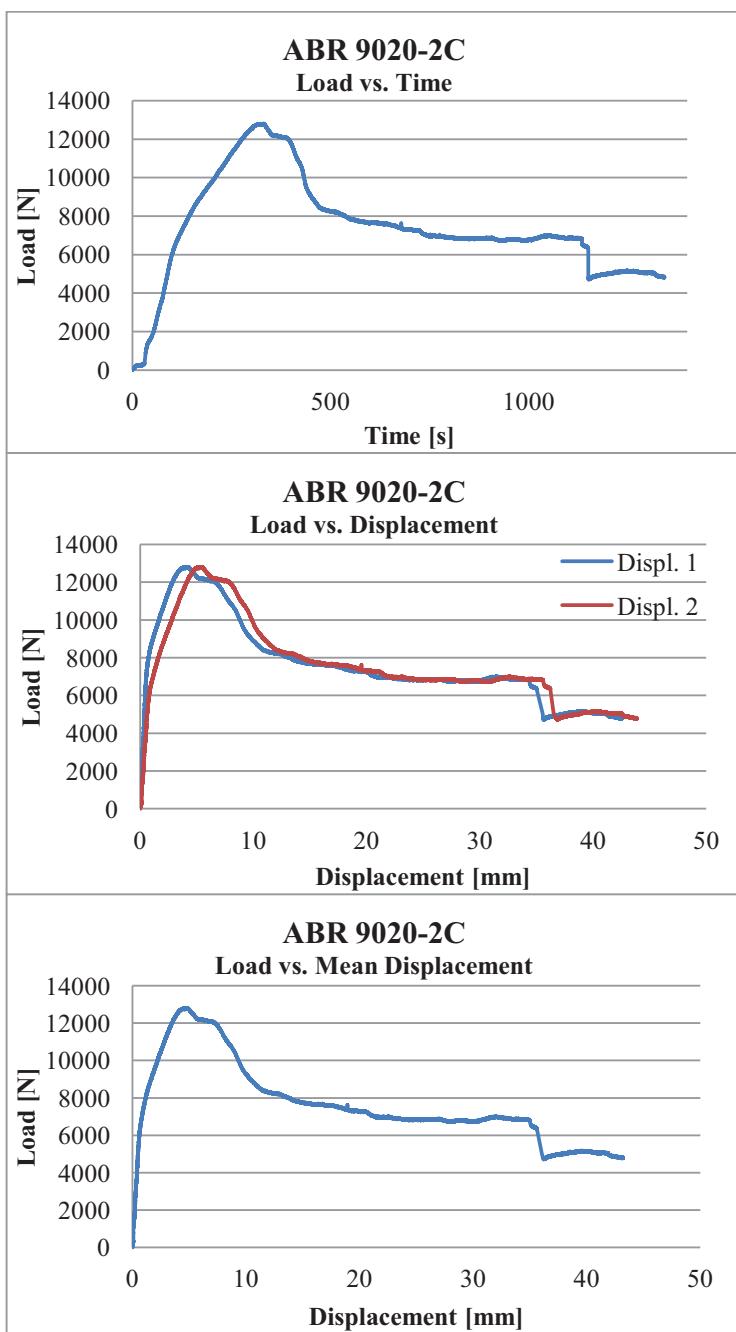
Failure	2
Failure load [N]	4881
Displacement 1 [mm]	5.09
Displacement 2 [mm]	5.16
Mean Displacement [mm]	5.12
Moisture [%]	8.85
Density [kg/m ³]	386

Set 3 – 10 wooden screws 5x40 on the stud and 10 wooden screws 5x40 on the rail

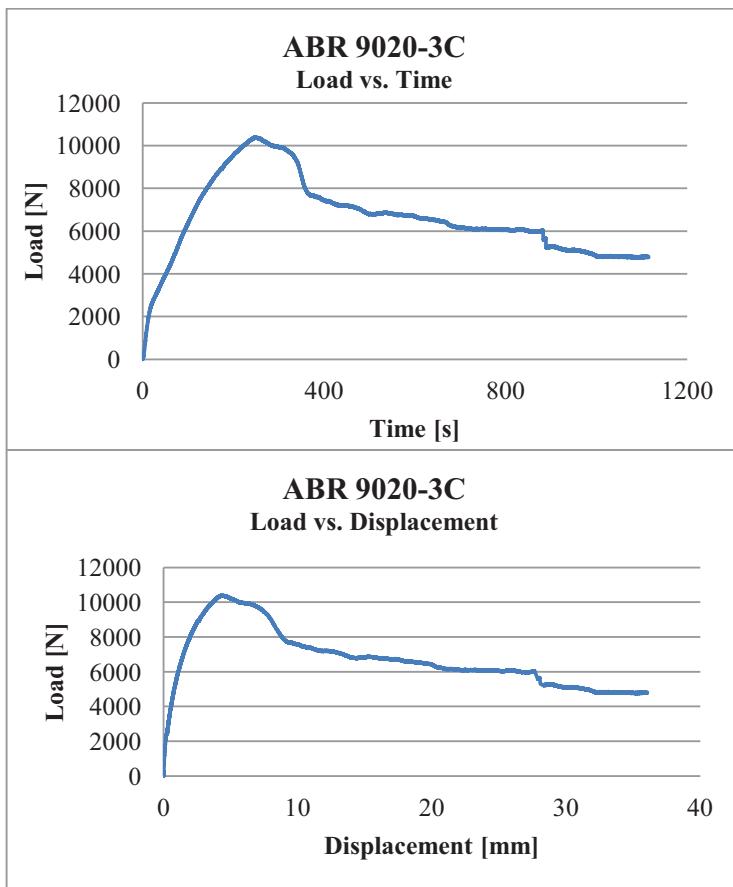


Failure	2
Failure load [N]	10845
Displacement 1 [mm]	4.44
Displacement 2 [mm]	4.33
Mean Displacement [mm]	4.39
Moisture [%]	9.24
Density [kg/m ³]	400

By mistake the rate of this test was 5 mm/min instead 2 mm/min.

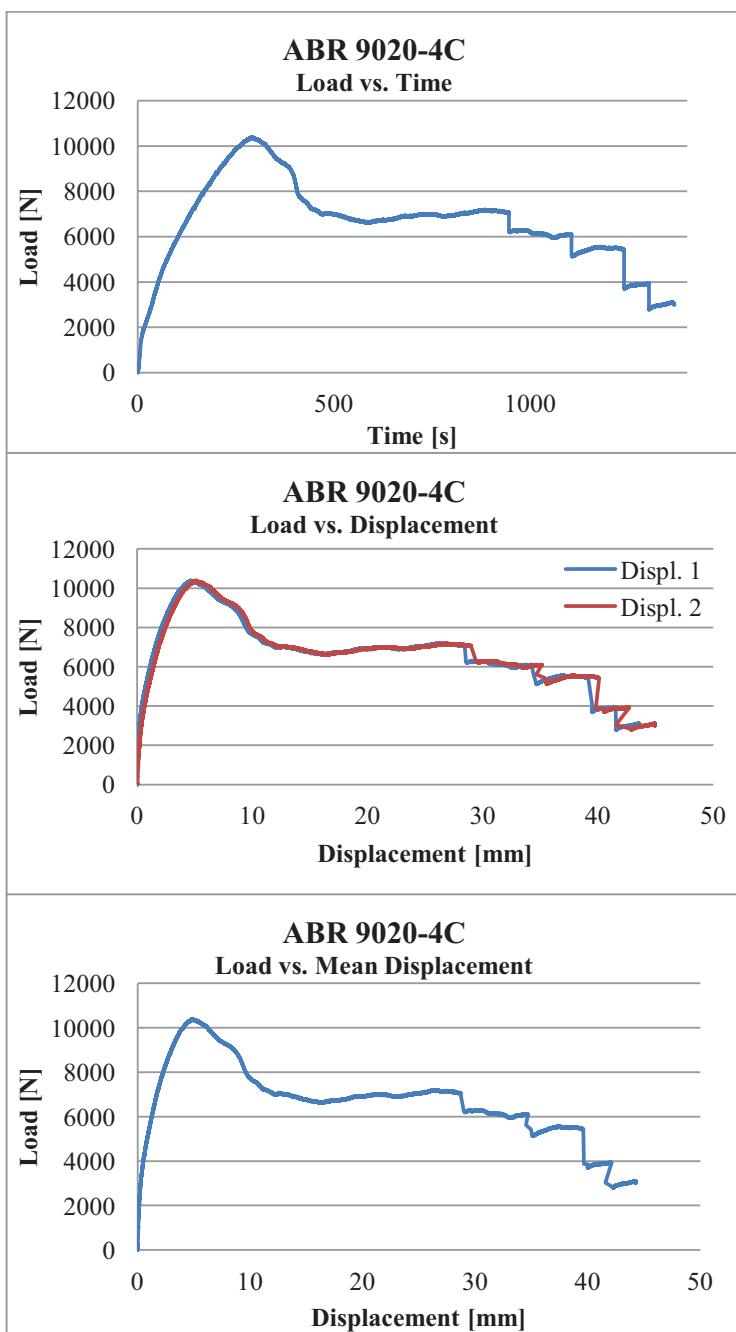


Failure	2
Failure load [N]	12804
Displacement 1 [mm]	4.17
Displacement 2 [mm]	5.37
Mean Displacement [mm]	4.77
Moisture [%]	8.23
Density [kg/m ³]	441

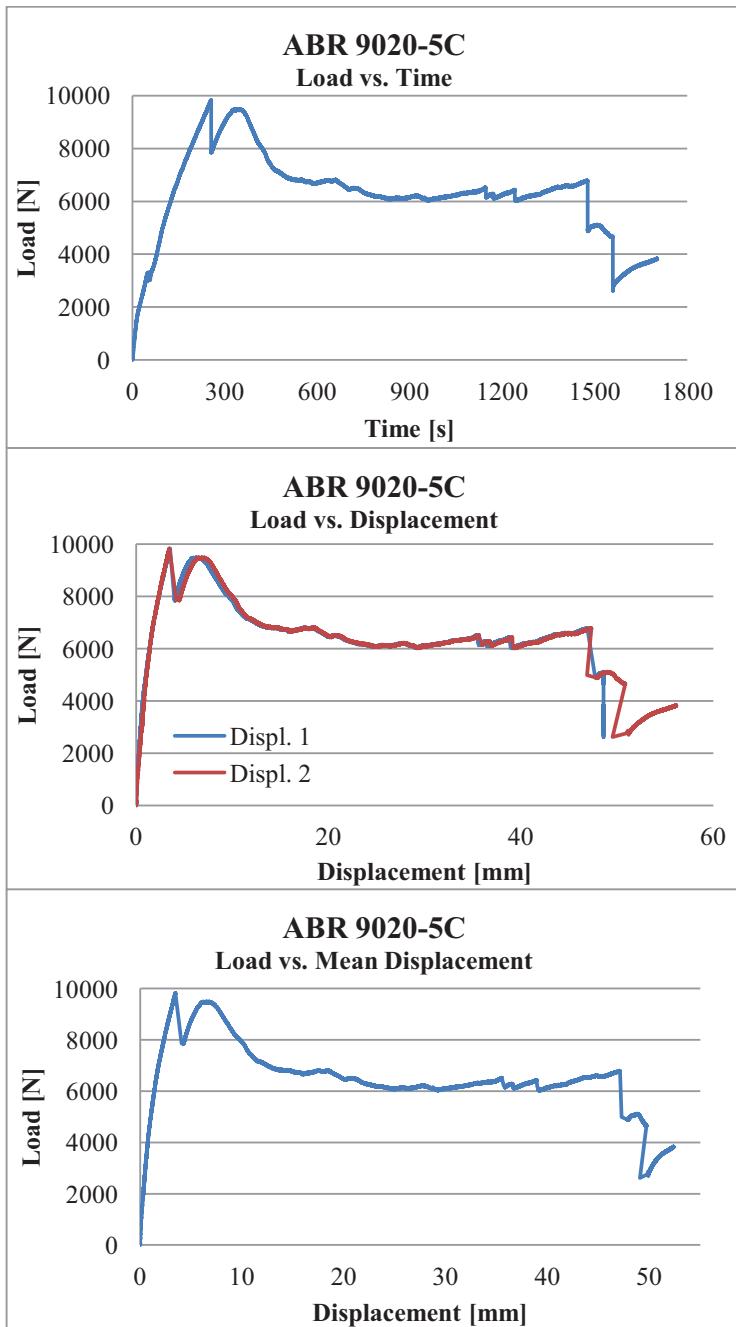


Failure	2
Failure load [N]	10397
Displacement 1 [mm]	-
Displacement 2 [mm]	4.30
Mean Displacement [mm]	-
Moisture [%]	8.94
Density [kg/m ³]	377

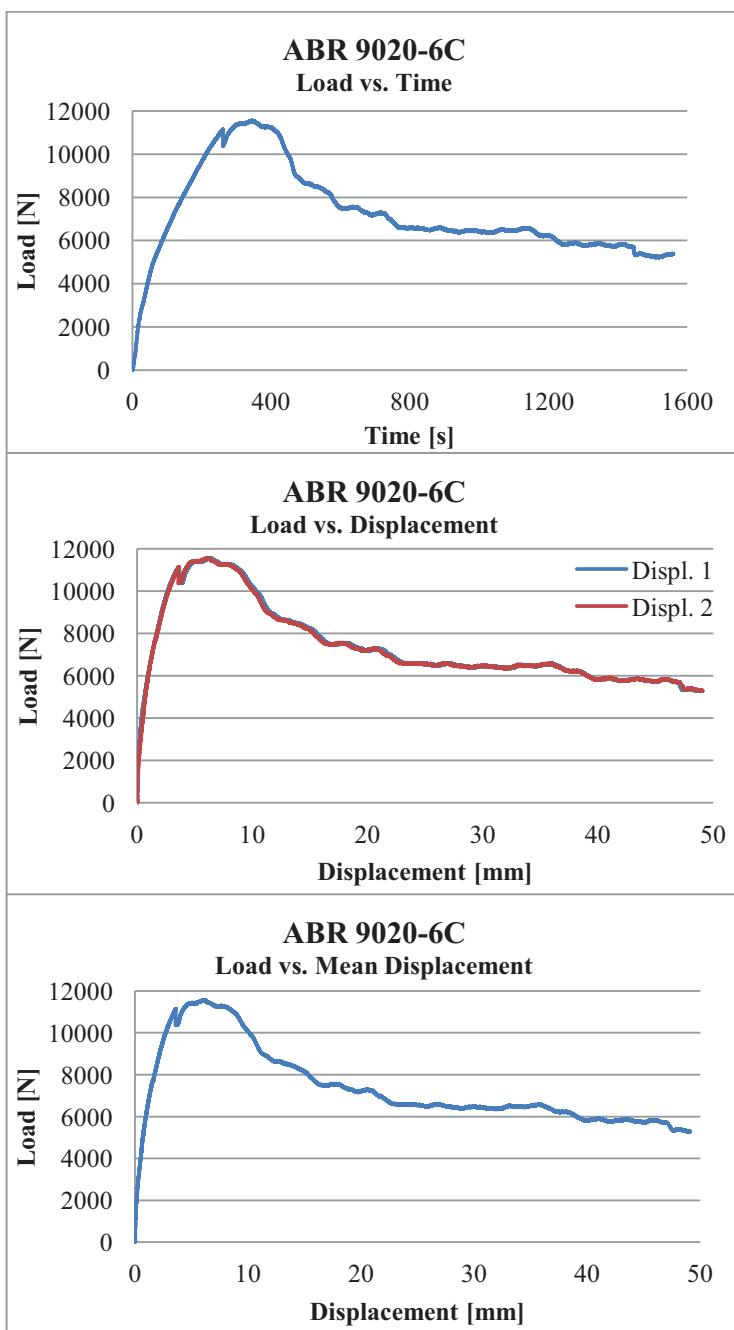
The LVDT number 1 did not work.



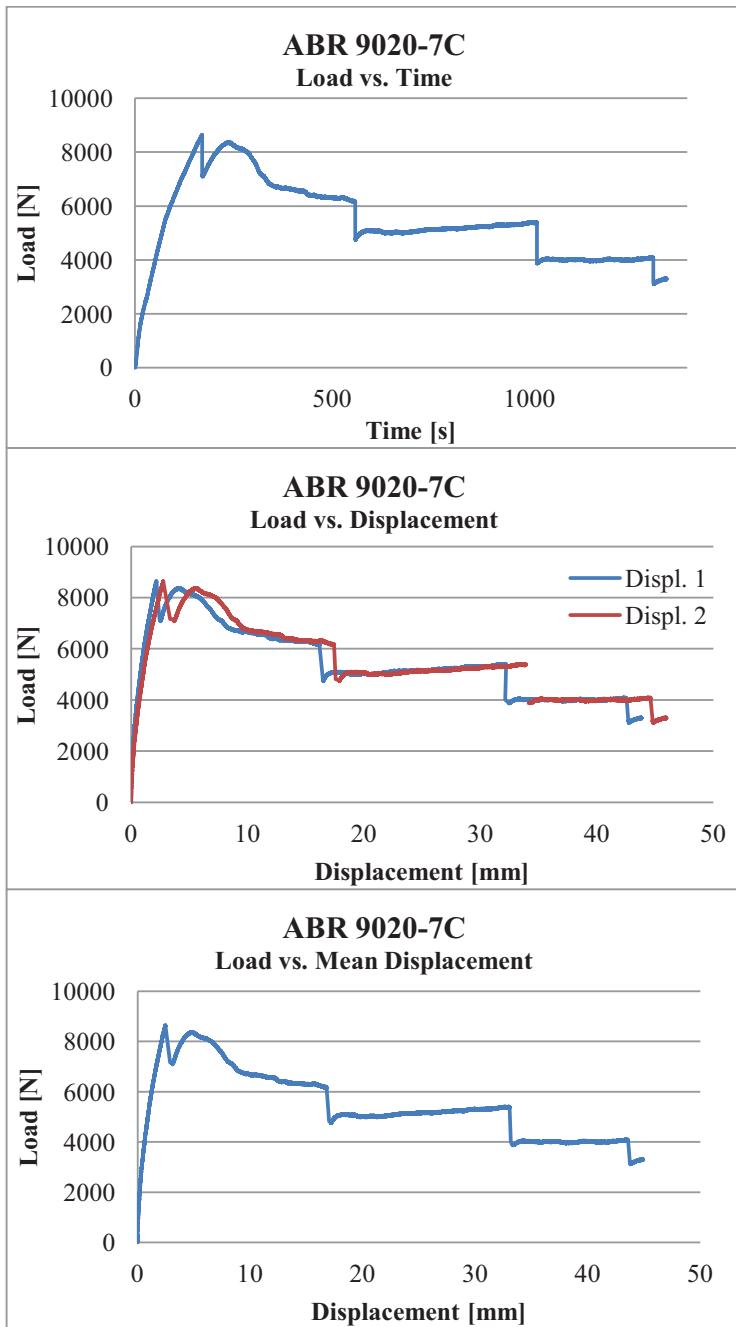
Failure	2
Failure load [N]	10396
Displacement 1 [mm]	4.67
Displacement 2 [mm]	5.09
Mean Displacement [mm]	4.88
Moisture [%]	8.41
Density [kg/m ³]	3.74



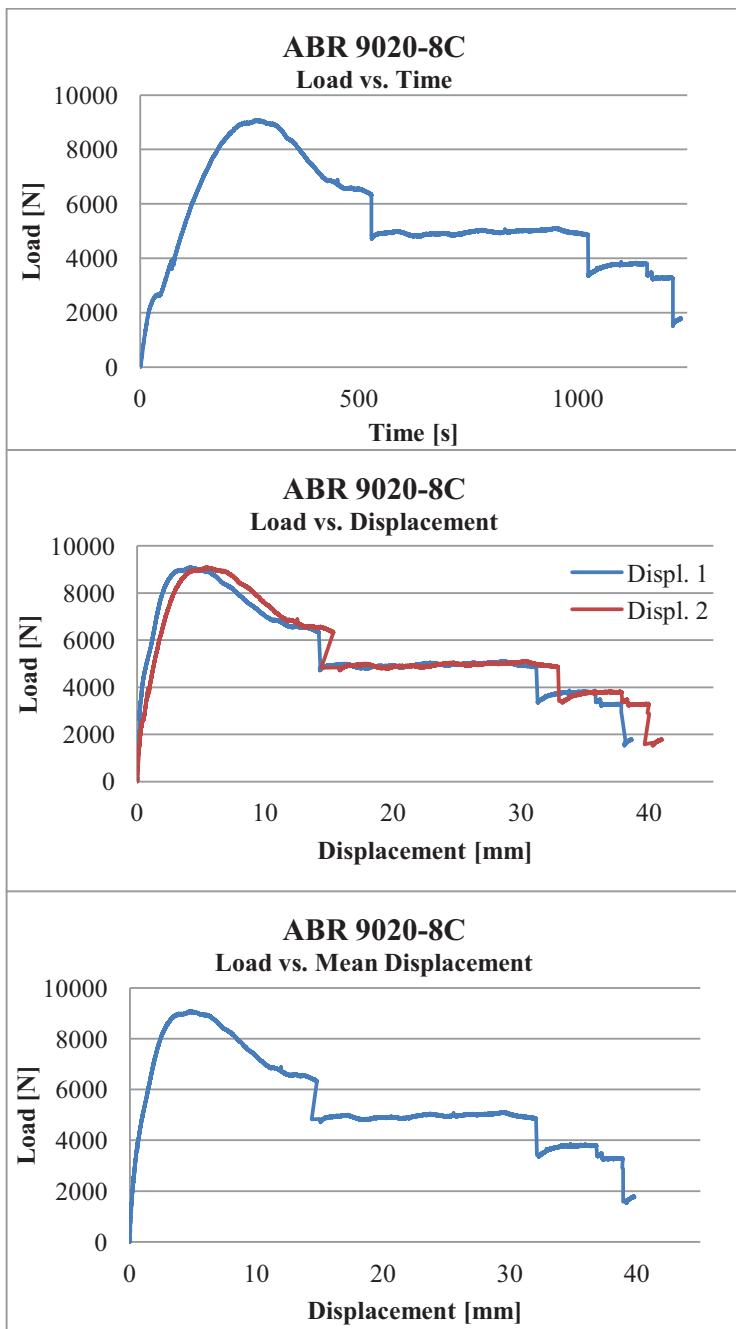
Failure	2
Failure load [N]	9834
Displacement 1 [mm]	3.50
Displacement 2 [mm]	3.44
Mean Displacement [mm]	3.47
Moisture [%]	8.97
Density [kg/m ³]	398



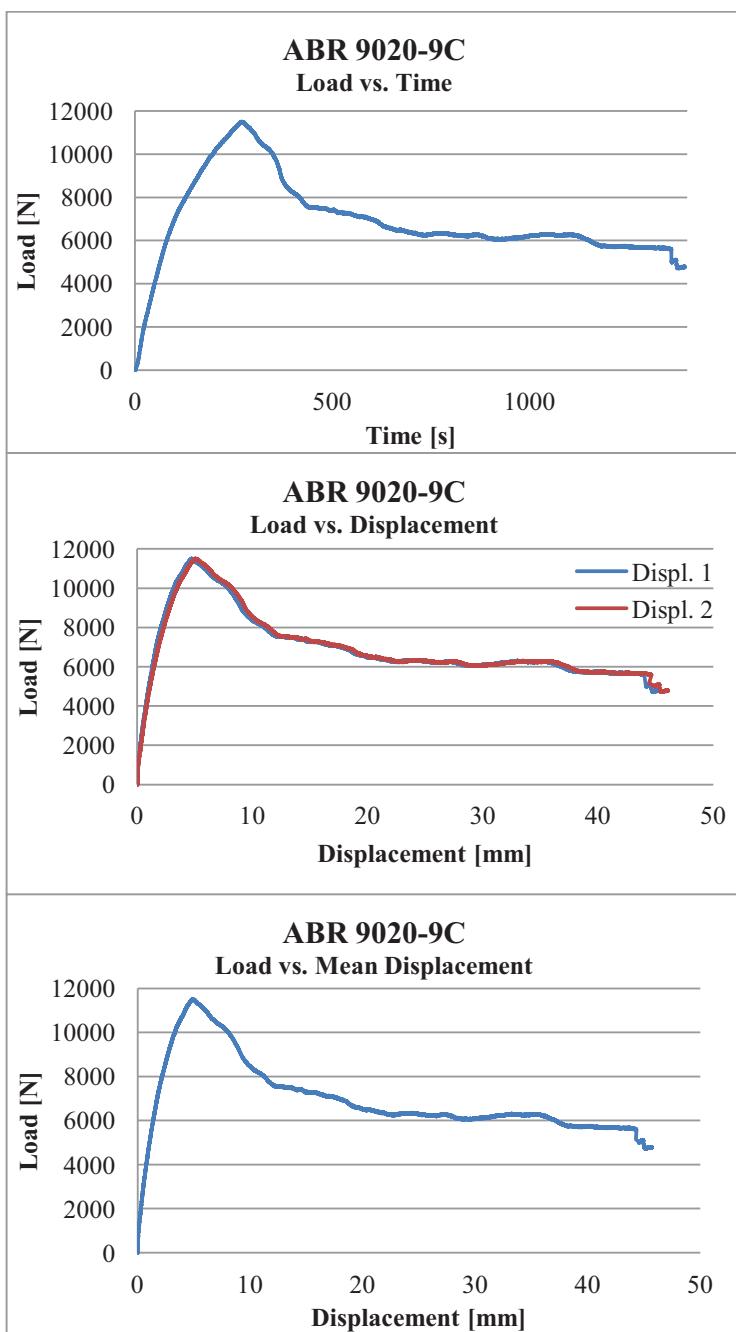
Failure	2
Failure load [N]	11560
Displacement 1 [mm]	6.29
Displacement 2 [mm]	6.05
Mean Displacement [mm]	6.17
Moisture [%]	8.60
Density [kg/m ³]	481



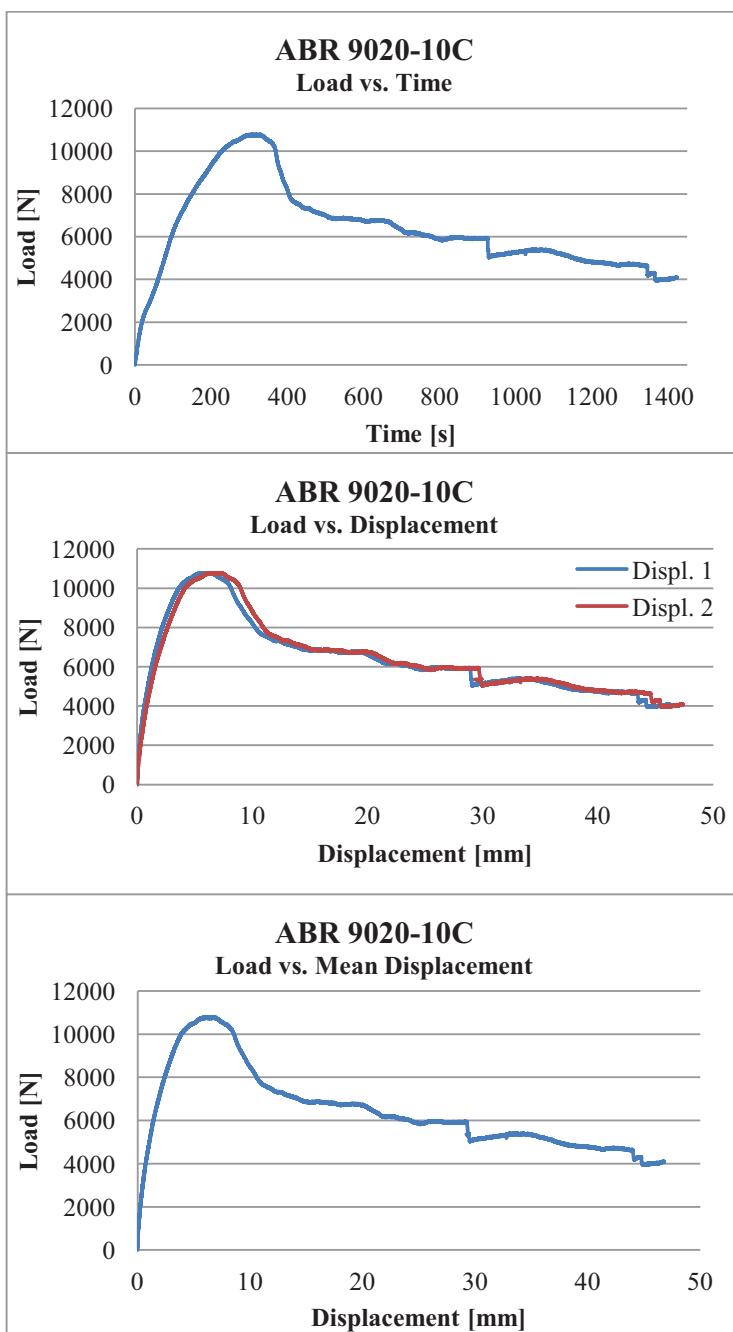
Failure	2
Failure load [N]	8643
Displacement 1 [mm]	2.17
Displacement 2 [mm]	2.76
Mean Displacement [mm]	2.47
Moisture [%]	8.80
Density [kg/m ³]	367



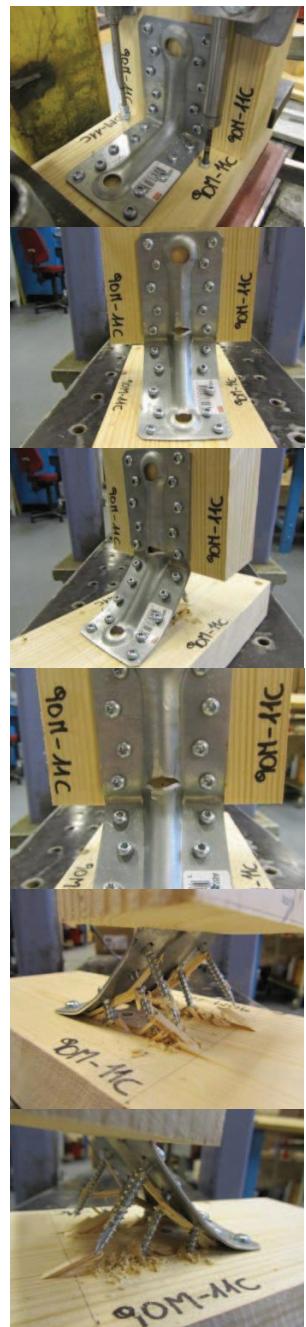
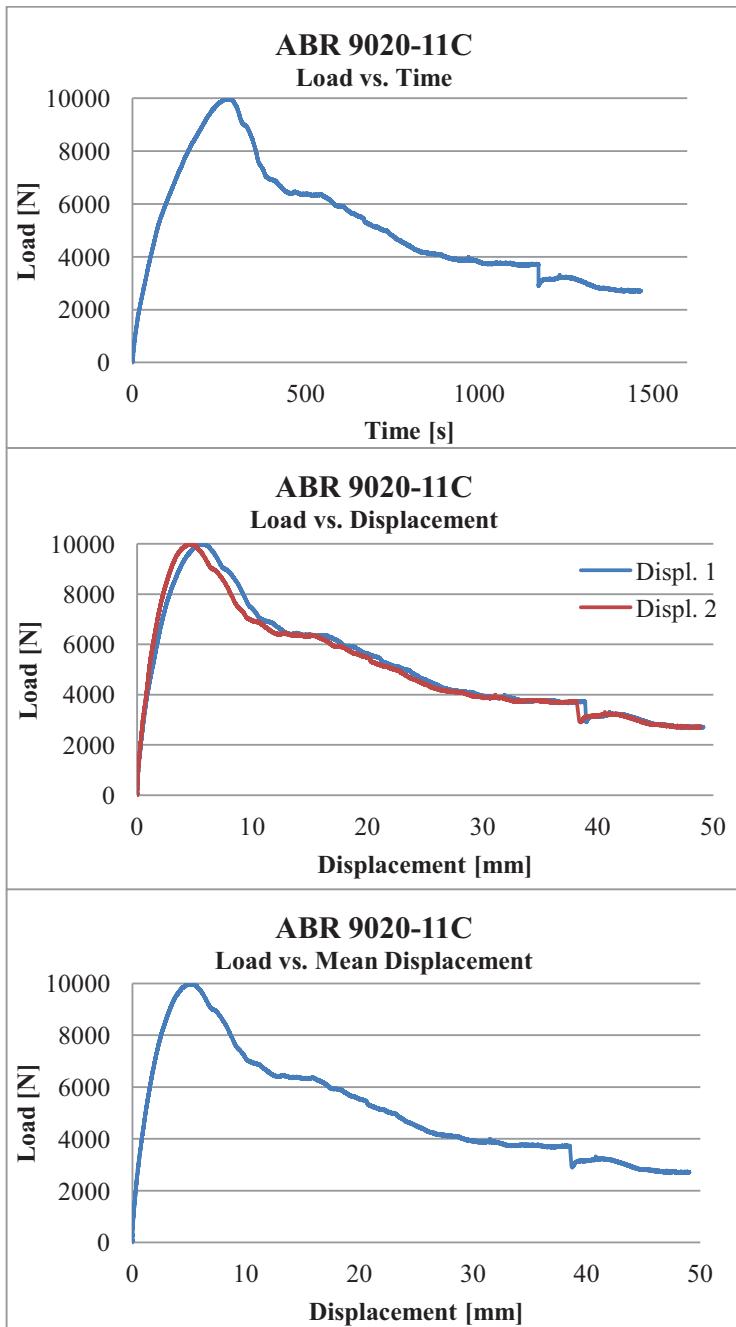
Failure	2
Failure load [N]	9088
Displacement 1 [mm]	4.09
Displacement 2 [mm]	5.36
Mean Displacement [mm]	4.73
Moisture [%]	9.51
Density [kg/m ³]	372



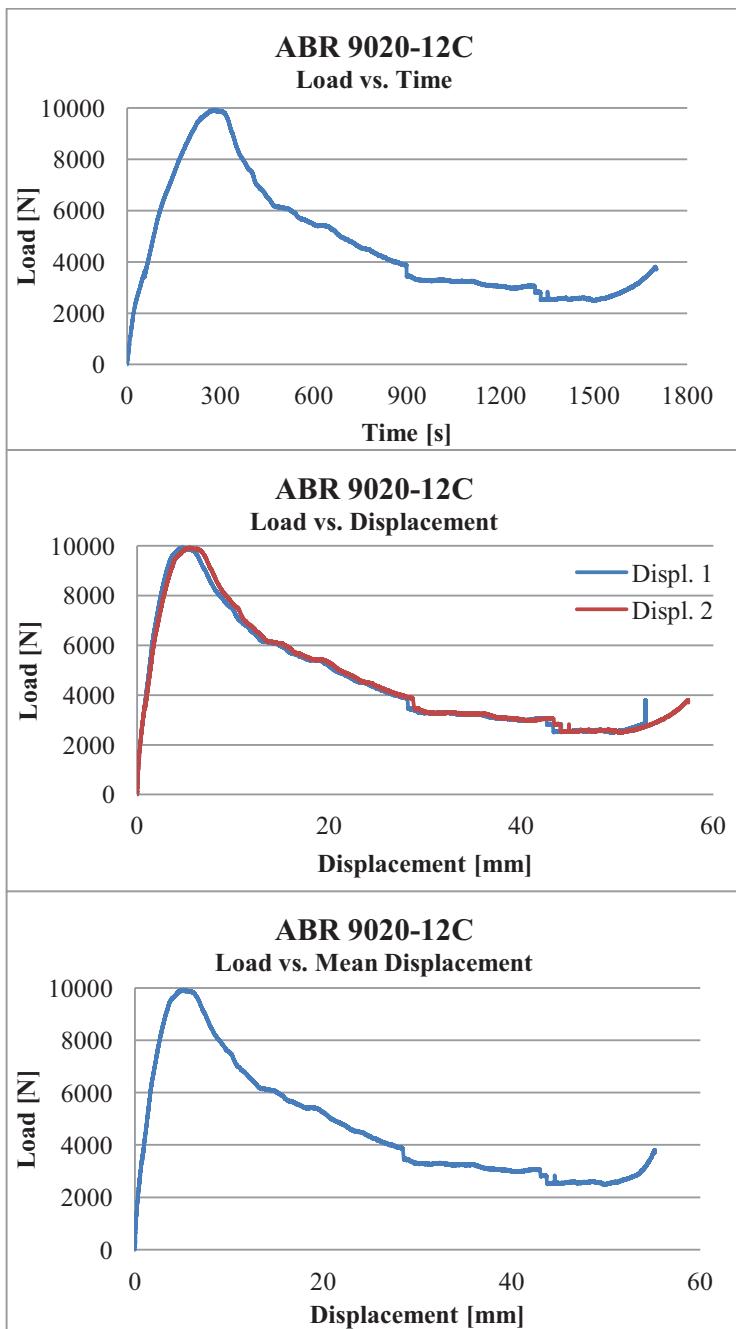
Failure	2
Failure load [N]	11508
Displacement 1 [mm]	4.72
Displacement 2 [mm]	5.03
Mean Displacement [mm]	4.88
Moisture [%]	10.2
Density [kg/m ³]	467



Failure	2
Failure load [N]	10781
Displacement 1 [mm]	6.27
Displacement 2 [mm]	7.11
Mean Displacement [mm]	6.69
Moisture [%]	9.29
Density [kg/m ³]	427

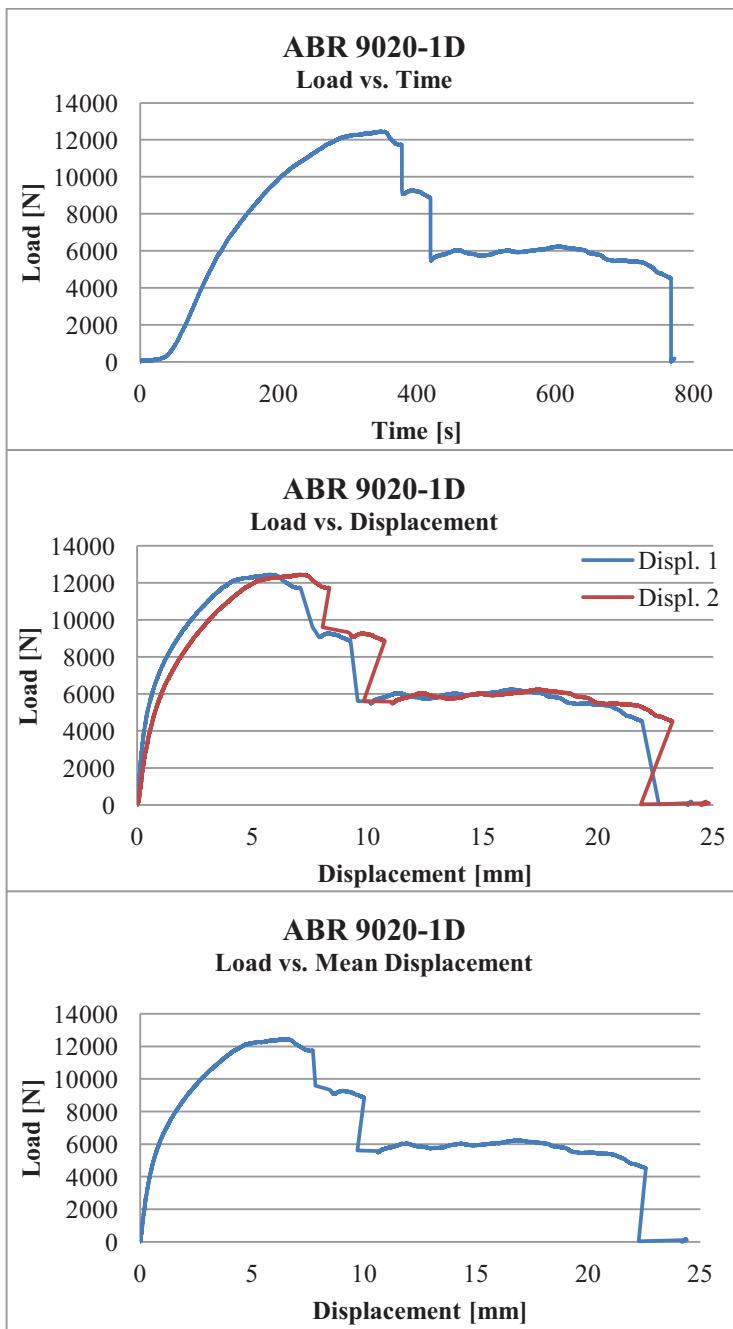


Failure	2
Failure load [N]	9994
Displacement 1 [mm]	5.55
Displacement 2 [mm]	4.48
Mean Displacement [mm]	5.01
Moisture [%]	8.77
Density [kg/m ³]	410

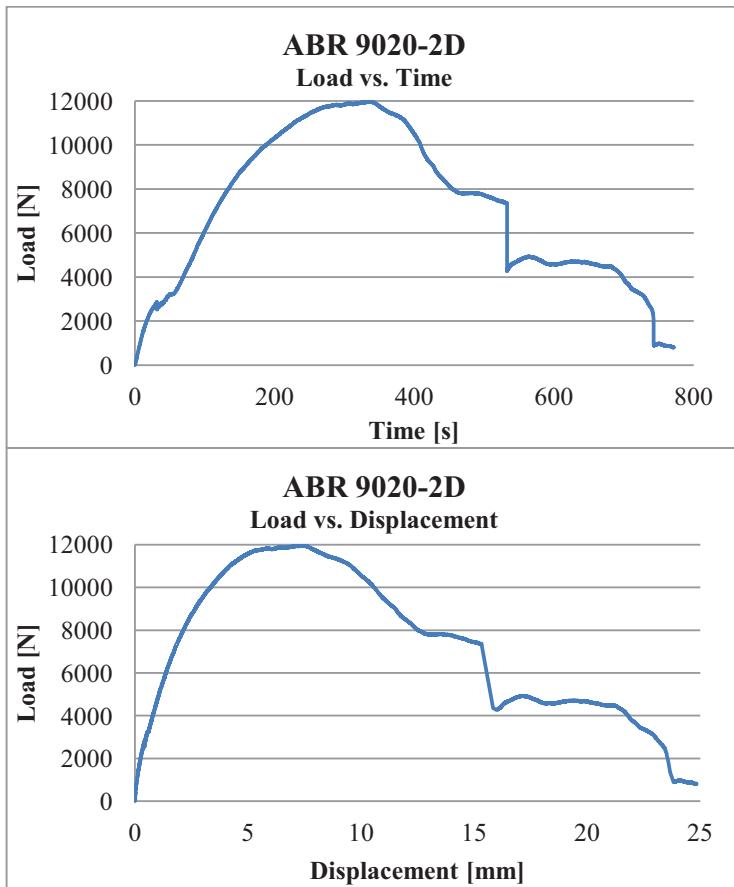


Failure	2
Failure load [N]	9938
Displacement 1 [mm]	4.77
Displacement 2 [mm]	5.49
Mean Displacement [mm]	5.13
Moisture [%]	9.67
Density [kg/m ³]	413

Set 4 – 10 wooden screws 5x40 on the stud and 6 wooden screws 5x40 on the rail

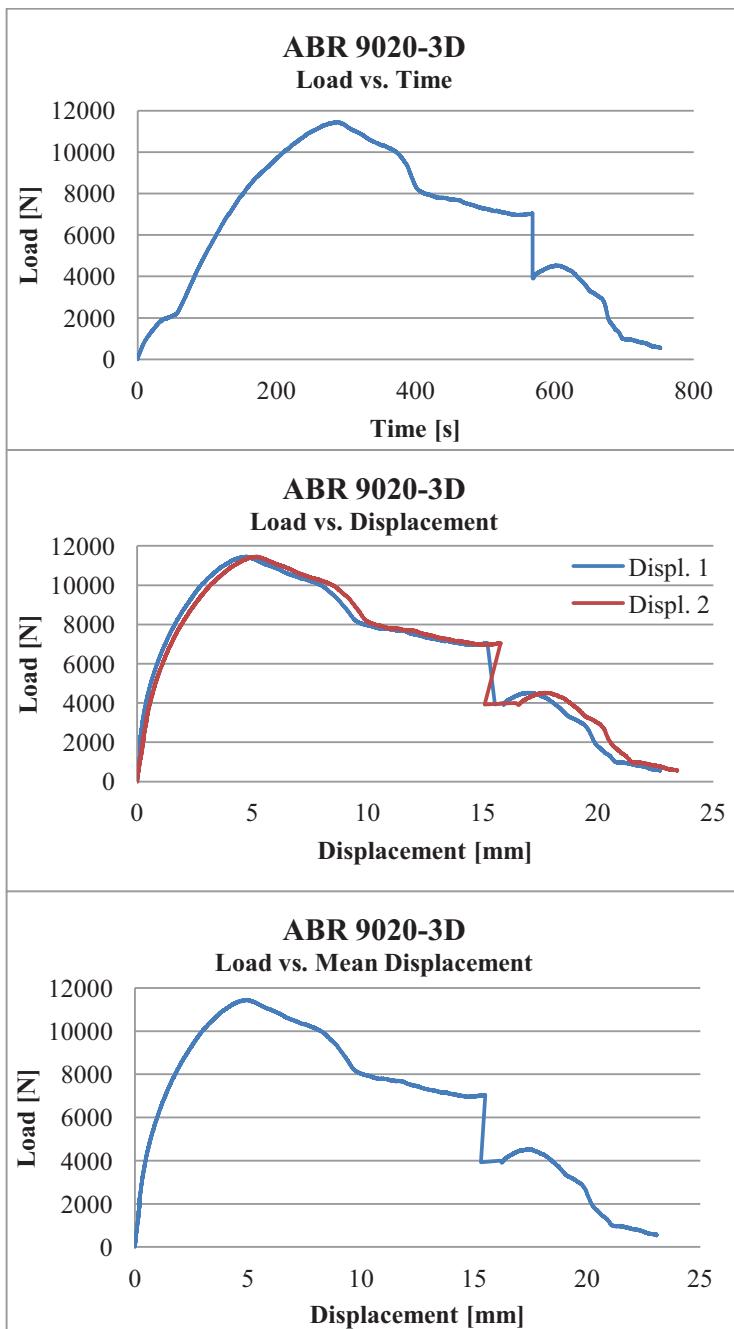


Failure	2
Failure load [N]	12458
Displacement 1 [mm]	5.74
Displacement 2 [mm]	7.07
Mean Displacement [mm]	6.41
Moisture [%]	10.6
Density [kg/m ³]	480

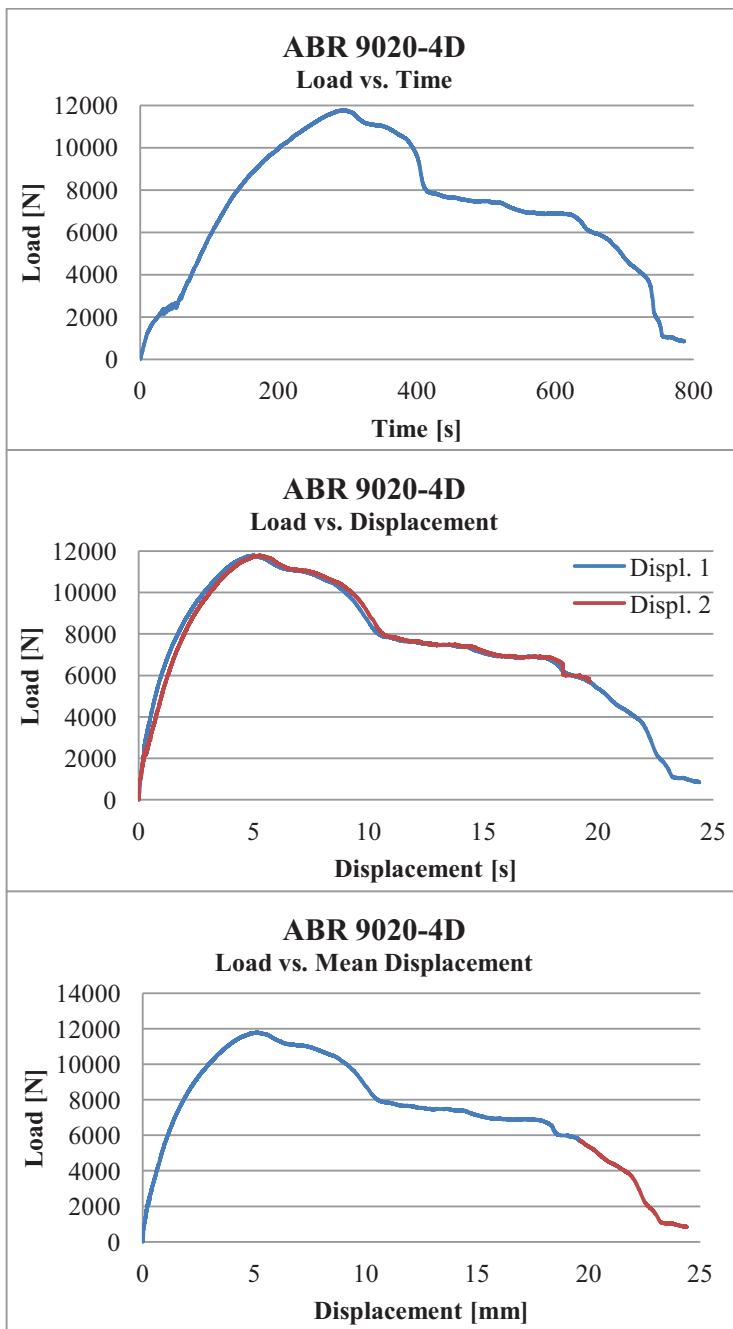


Failure	2
Failure load [N]	11958
Displacement 1 [mm]	-
Displacement 2 [mm]	7.51
Mean Displacement [mm]	-
Moisture [%]	9.36
Density [kg/m ³]	466

The LVDT number 1 did not work.

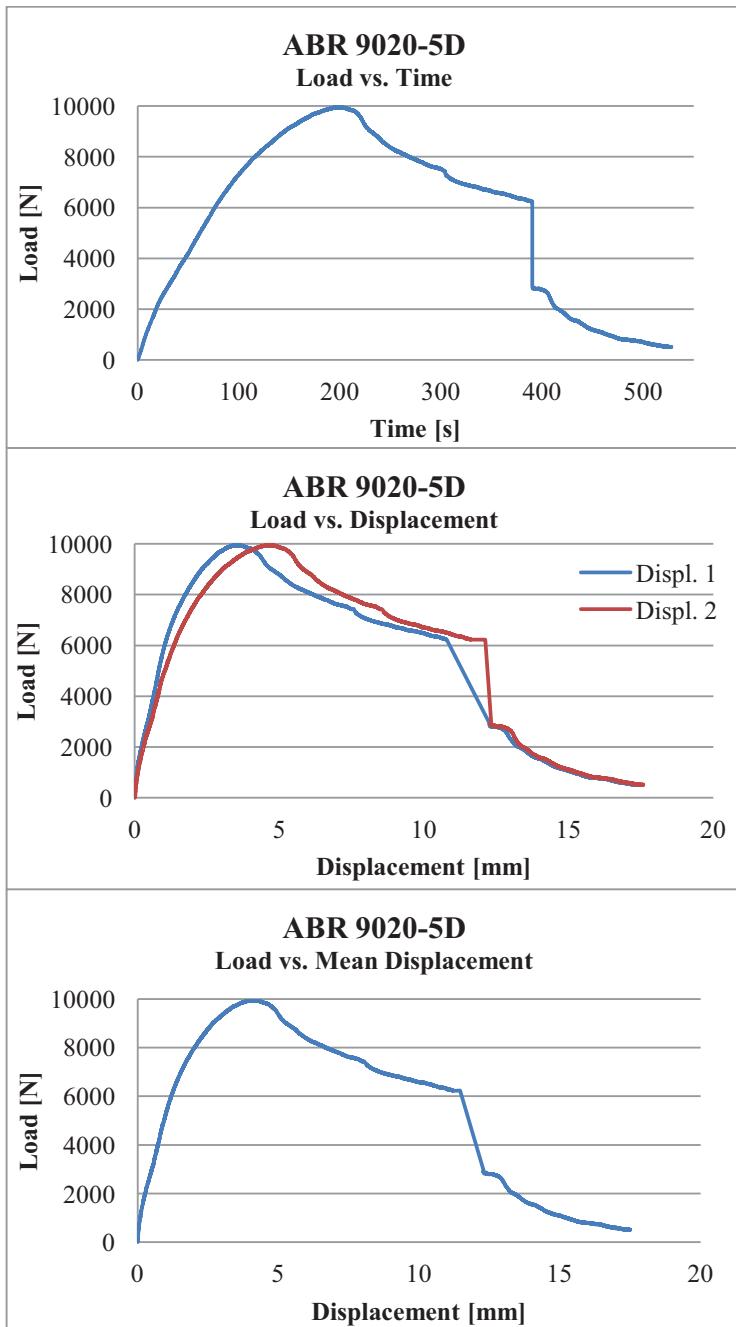


Failure	2
Failure load [N]	11453
Displacement 1 [mm]	4.75
Displacement 2 [mm]	5.20
Mean Displacement [mm]	4.97
Moisture [%]	9.36
Density [kg/m ³]	477

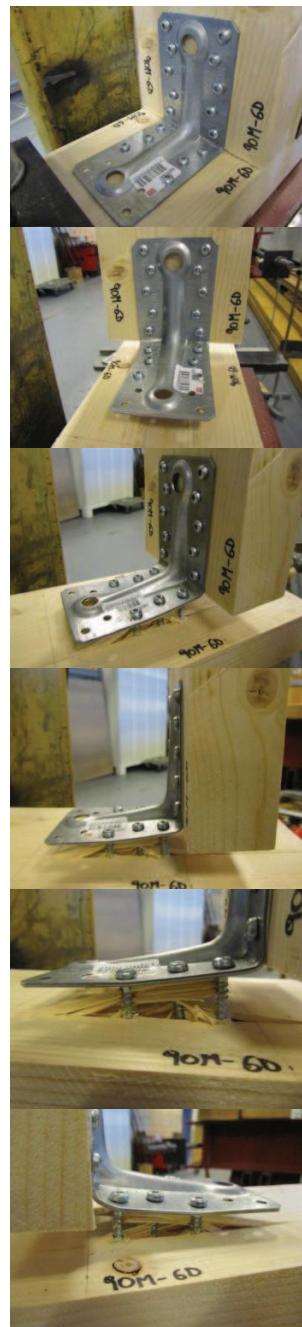
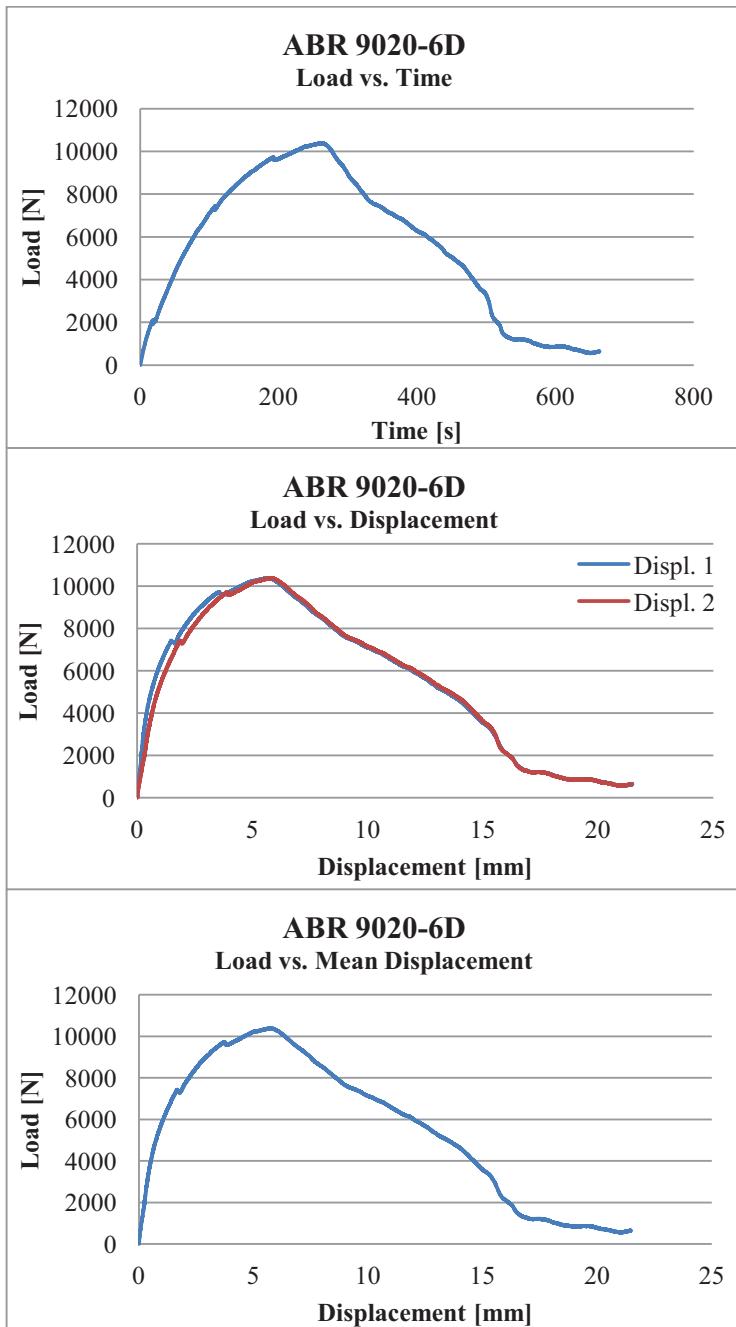


Failure	2
Failure load [N]	11787
Displacement 1 [mm]	4.98
Displacement 2 [mm]	5.26
Mean Displacement [mm]	5.12
Moisture [%]	8.34
Density [kg/m ³]	492

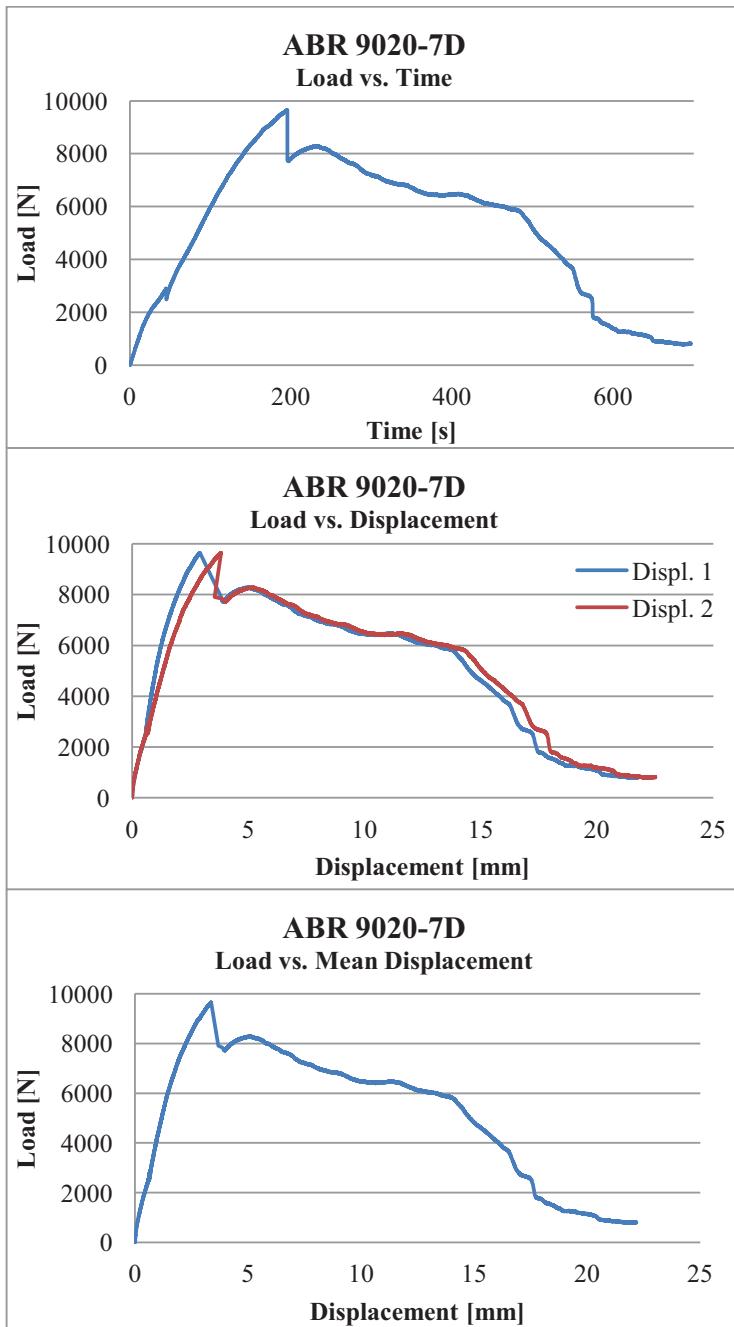
The LVDT number 2 did not work until the end of the test.



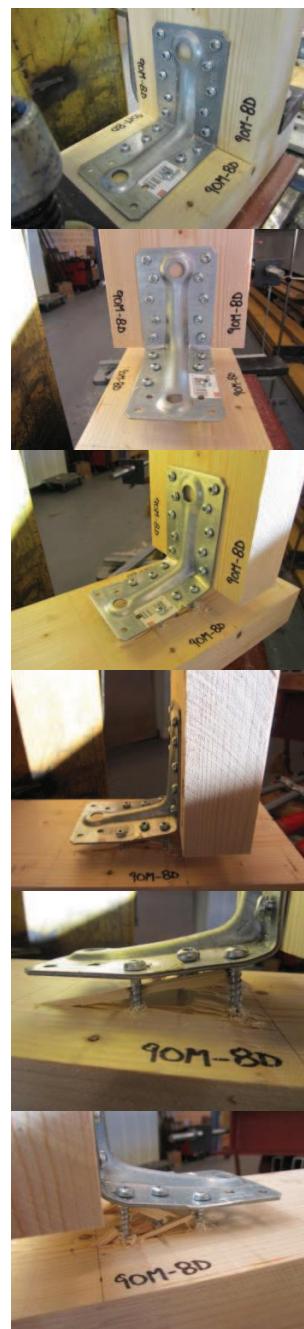
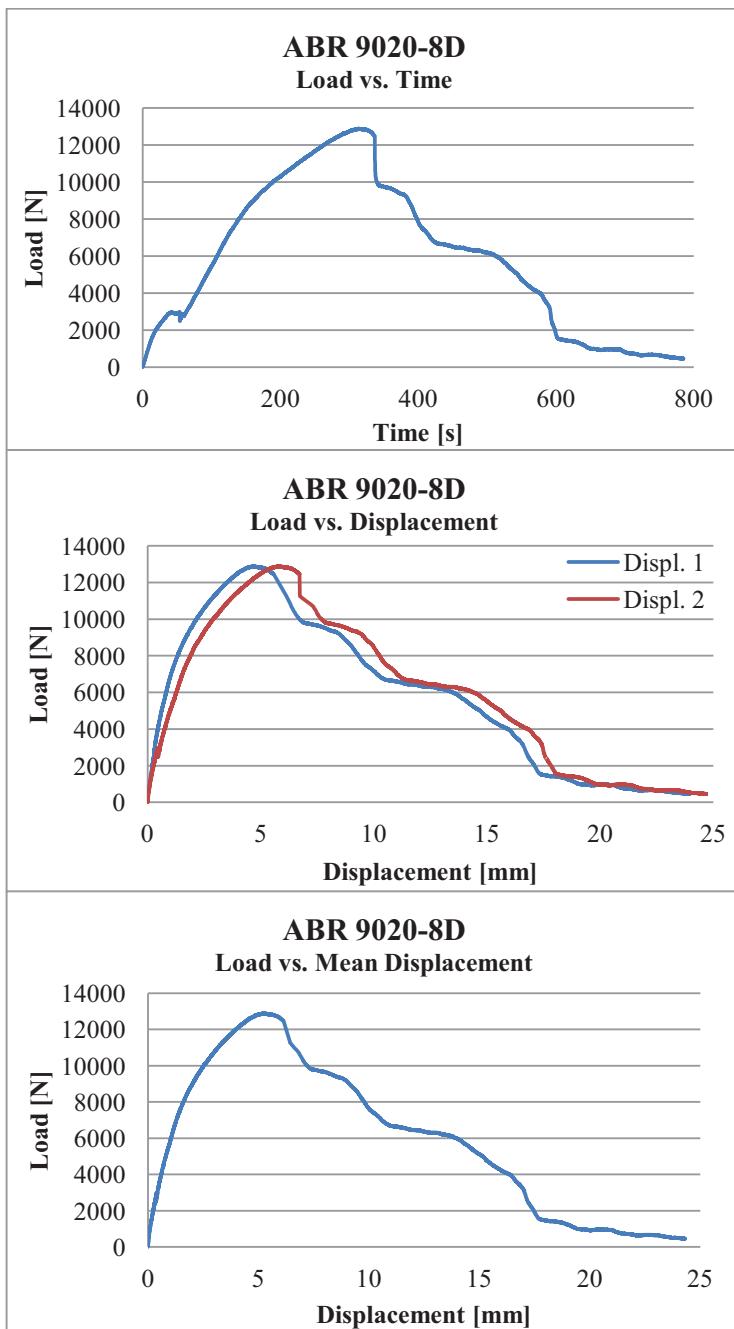
Failure	2
Failure load [N]	9955
Displacement 1 [mm]	3.60
Displacement 2 [mm]	4.73
Mean Displacement [mm]	4.17
Moisture [%]	7.64
Density [kg/m ³]	413



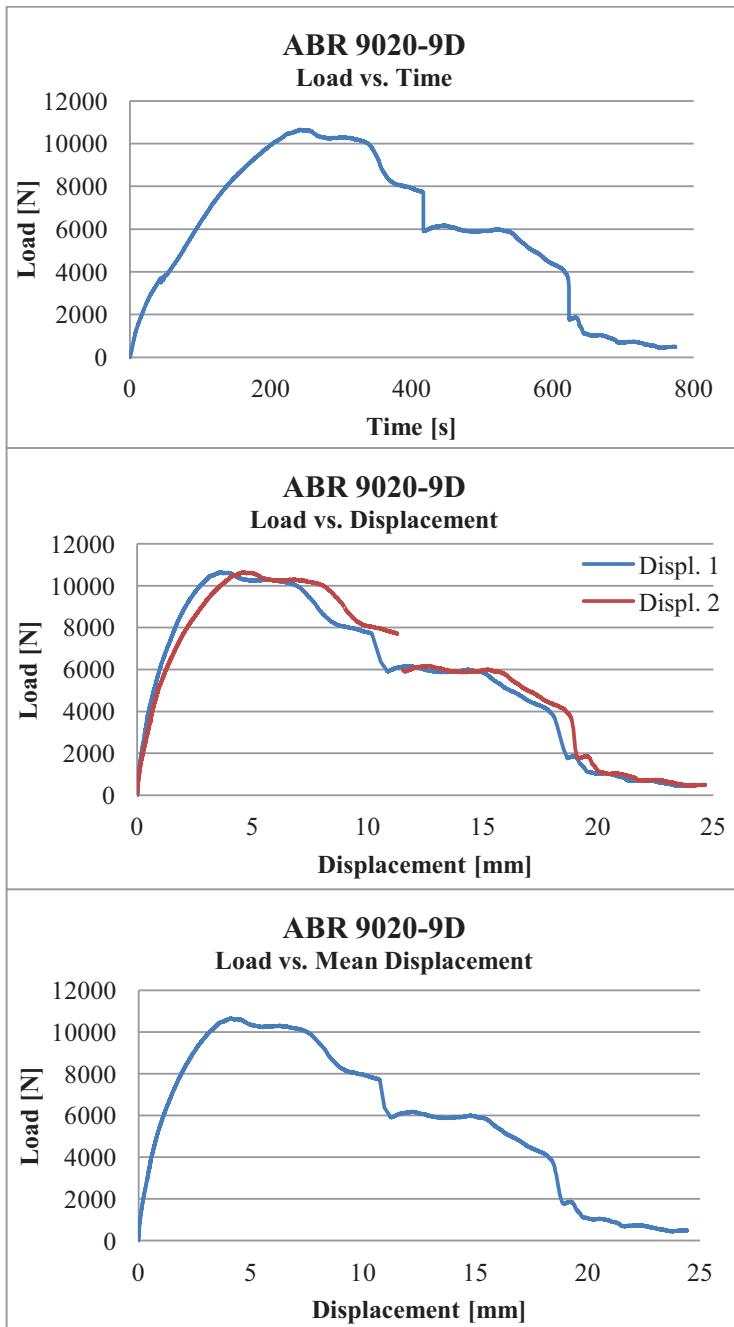
Failure	2
Failure load [N]	10388
Displacement 1 [mm]	5.65
Displacement 2 [mm]	5.77
Mean Displacement [mm]	5.71
Moisture [%]	11.0
Density [kg/m ³]	407



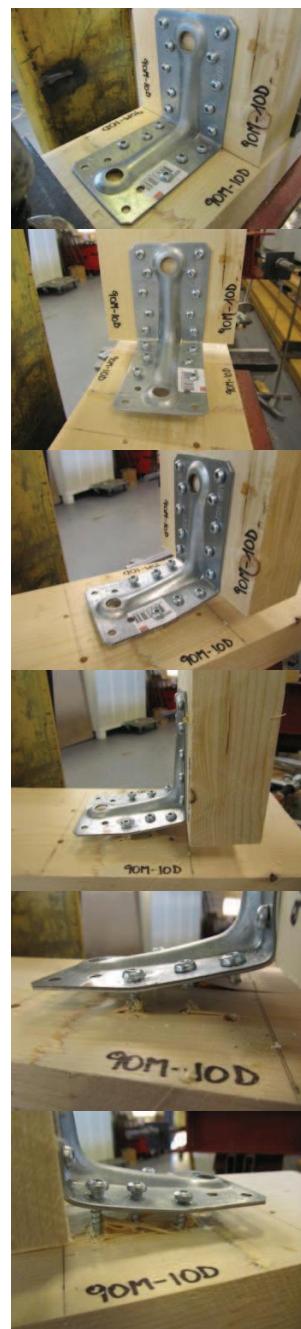
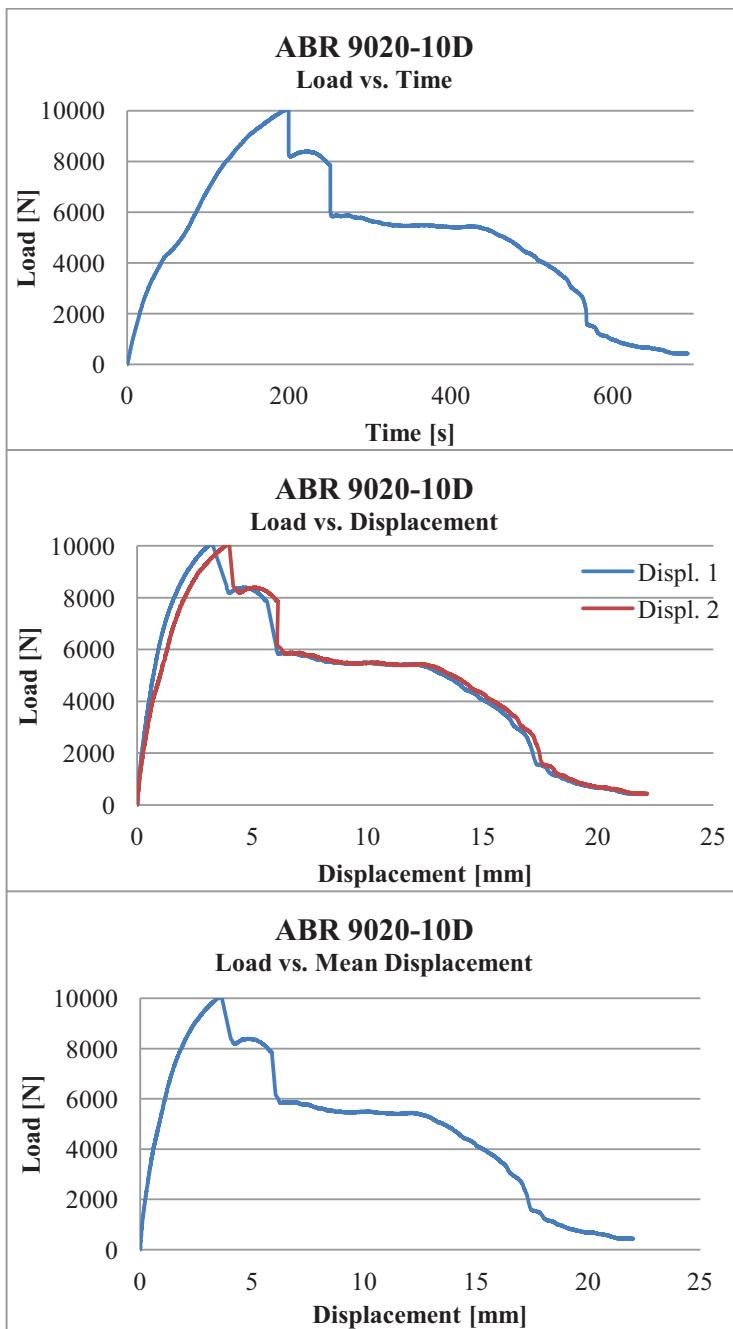
Failure	2
Failure load [N]	9650
Displacement 1 [mm]	2.92
Displacement 2 [mm]	3.83
Mean Displacement [mm]	3.37
Moisture [%]	7.54
Density [kg/m ³]	402



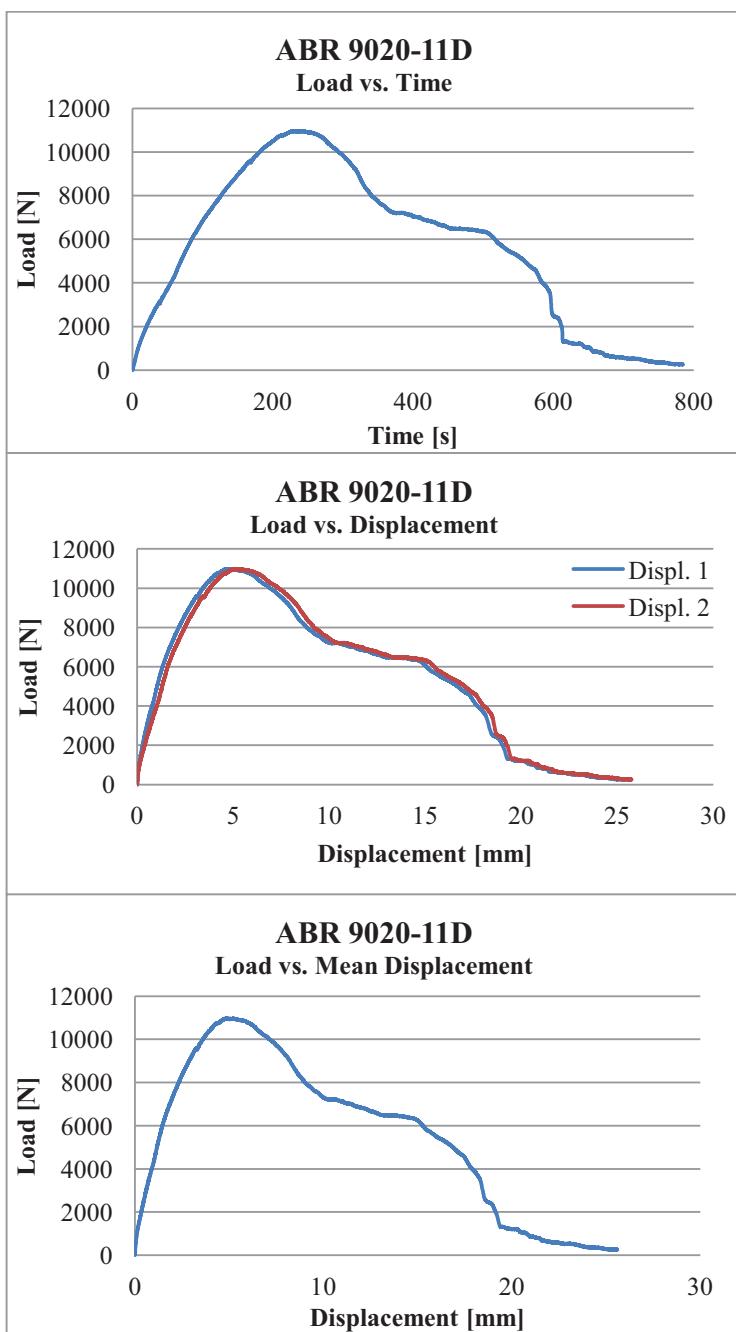
Failure	2
Failure load [N]	12886
Displacement 1 [mm]	4.66
Displacement 2 [mm]	5.79
Mean Displacement [mm]	5.23
Moisture [%]	8.11
Density [kg/m ³]	404



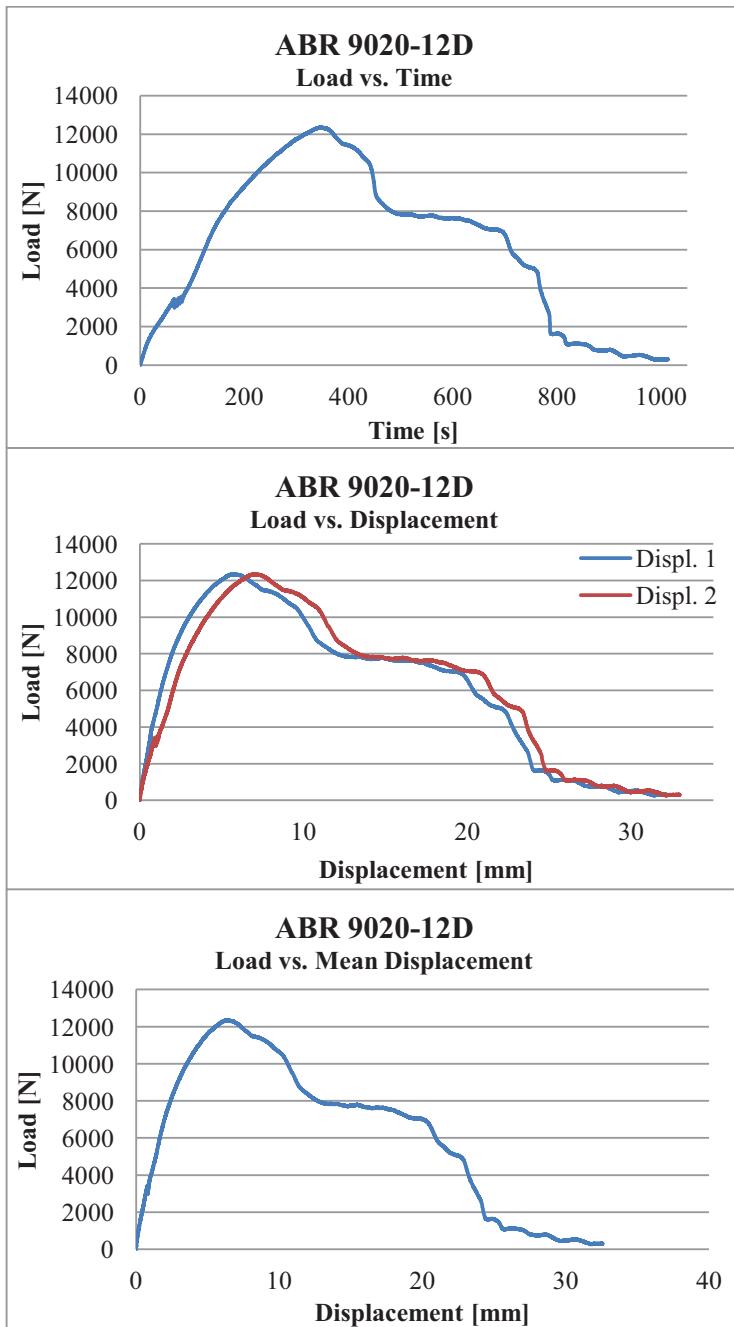
Failure	2
Failure load [N]	10650
Displacement 1 [mm]	3.58
Displacement 2 [mm]	4.58
Mean Displacement [mm]	4.08
Moisture [%]	8.97
Density [kg/m ³]	465



Failure	2
Failure load [N]	10096
Displacement 1 [mm]	3.25
Displacement 2 [mm]	4.00
Mean Displacement [mm]	3.62
Moisture [%]	9.08
Density [kg/m ³]	406



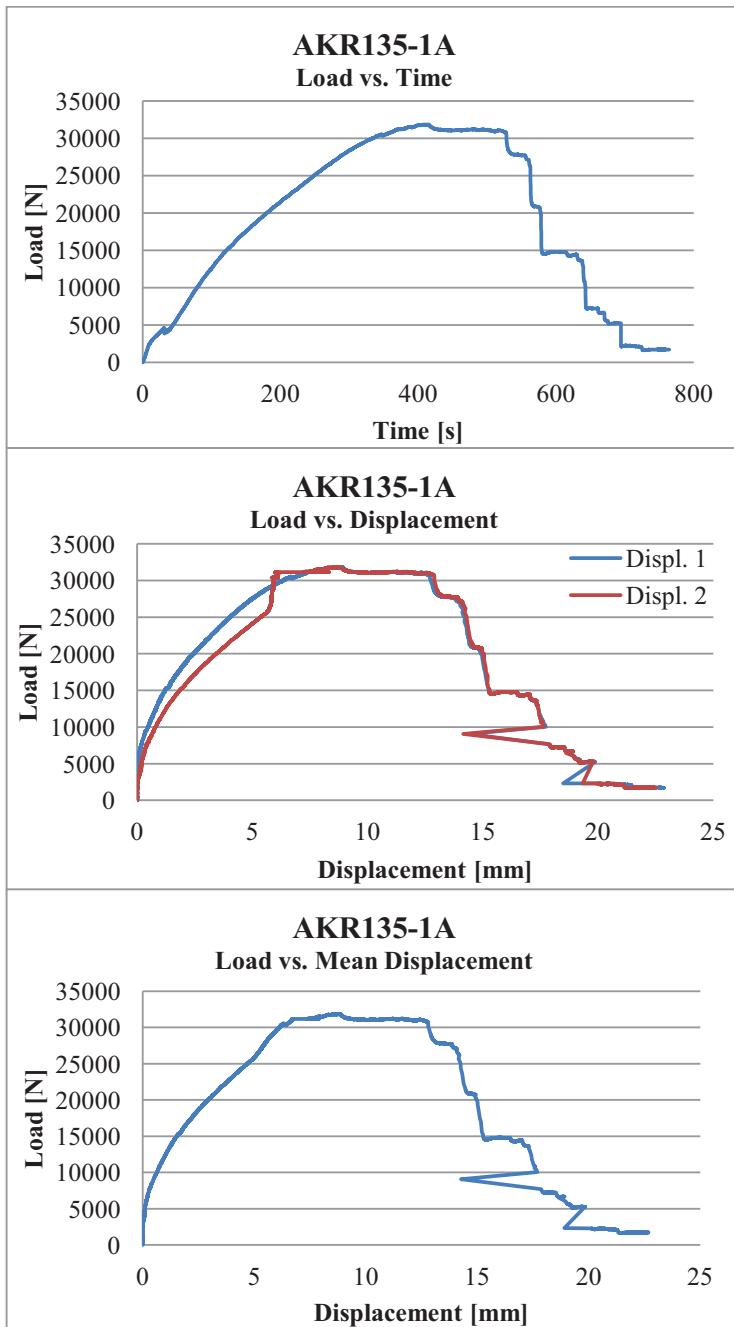
Failure	2
Failure load [N]	10967
Displacement 1 [mm]	4.65
Displacement 2 [mm]	5.03
Mean Displacement [mm]	4.84
Moisture [%]	9.78
Density [kg/m ³]	430



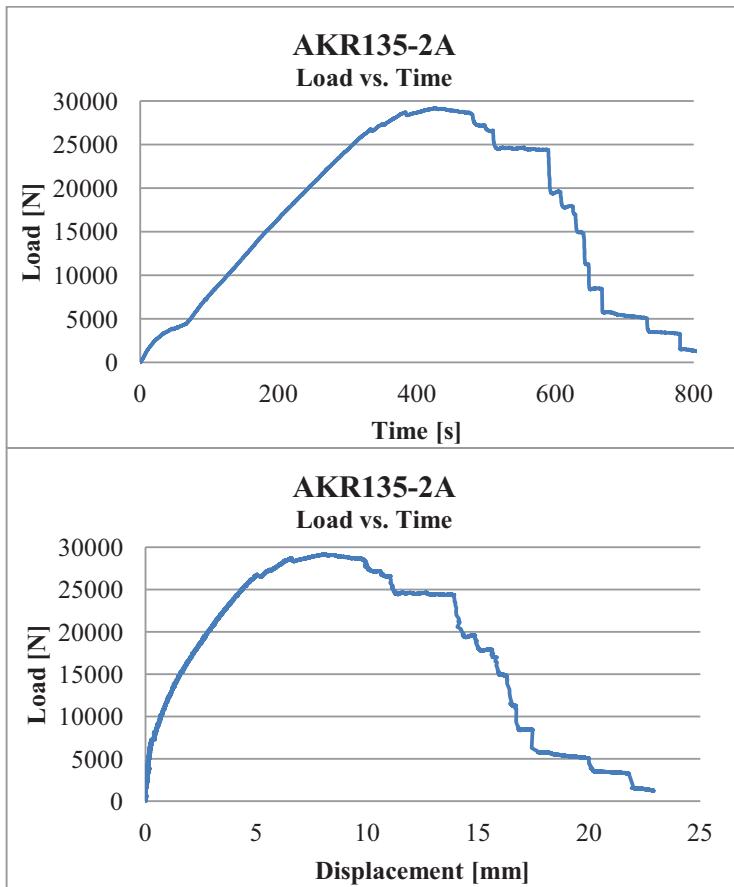
Failure	2
Failure load [N]	12363
Displacement 1 [mm]	5.74
Displacement 2 [mm]	7.02
Mean Displacement [mm]	6.38
Moisture [%]	8.54
Density [kg/m ³]	496

Series 3 – Angle connector AKR 135

Set 1 – 14 wooden screws 5x40 on the stud and 1 bolt M12 on the rail

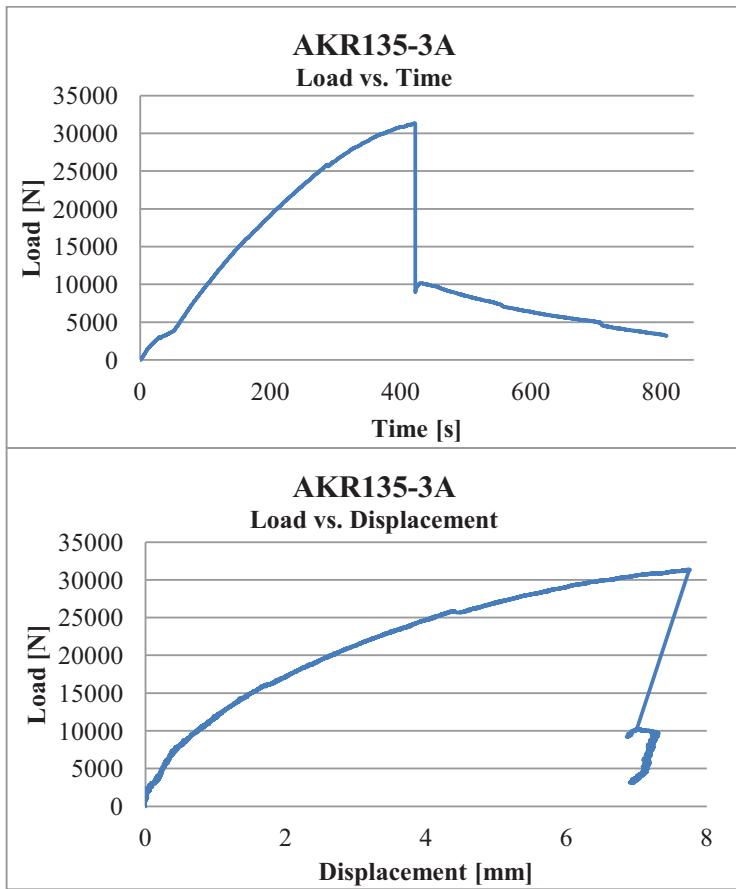


Failure	3a
Failure load [N]	31836
Displacement 1 [mm]	8.86
Displacement 2 [mm]	8.76
Mean Displacement [mm]	8.81
Moisture [%]	9.97
Density [kg/m ³]	405



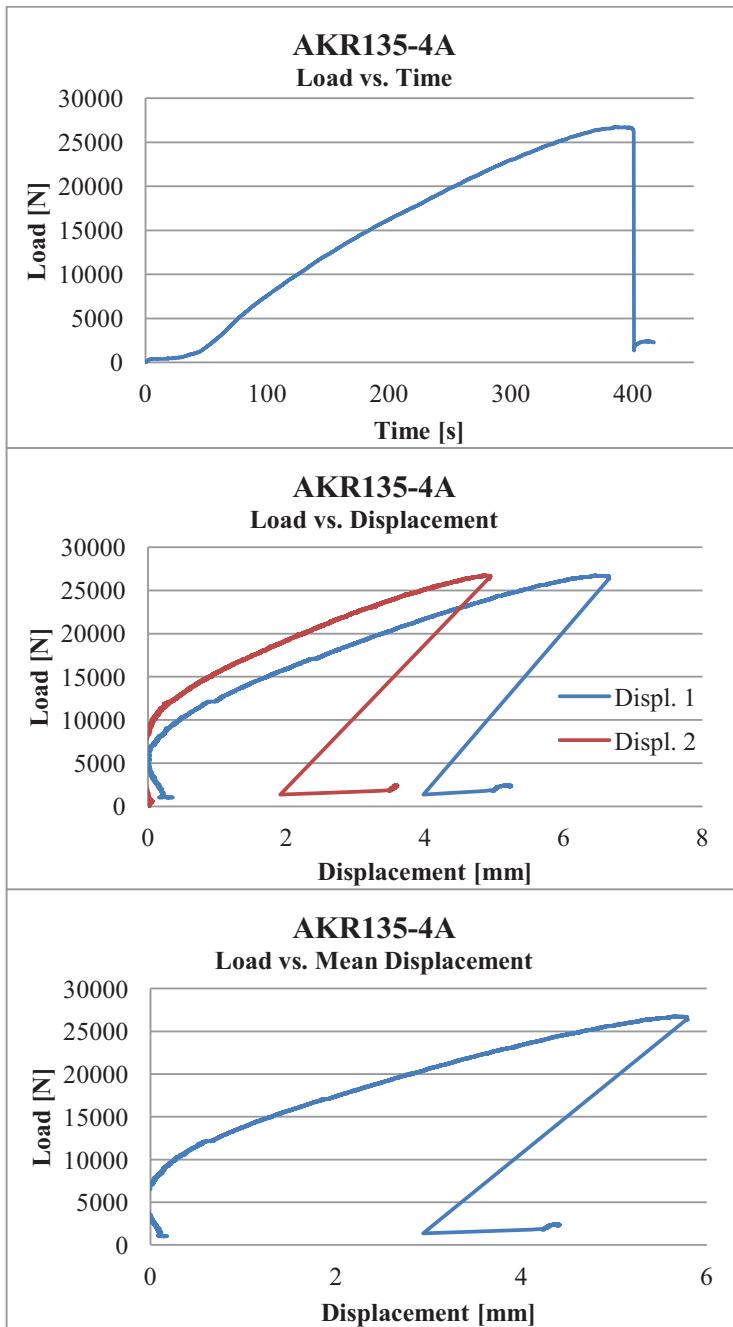
Failure	3a
Failure load [N]	29185
Displacement 1 [mm]	-
Displacement 2 [mm]	8.02
Mean Displacement [mm]	-
Moisture [%]	9.45
Density [kg/m ³]	410

The LVDT number 1 did not work.

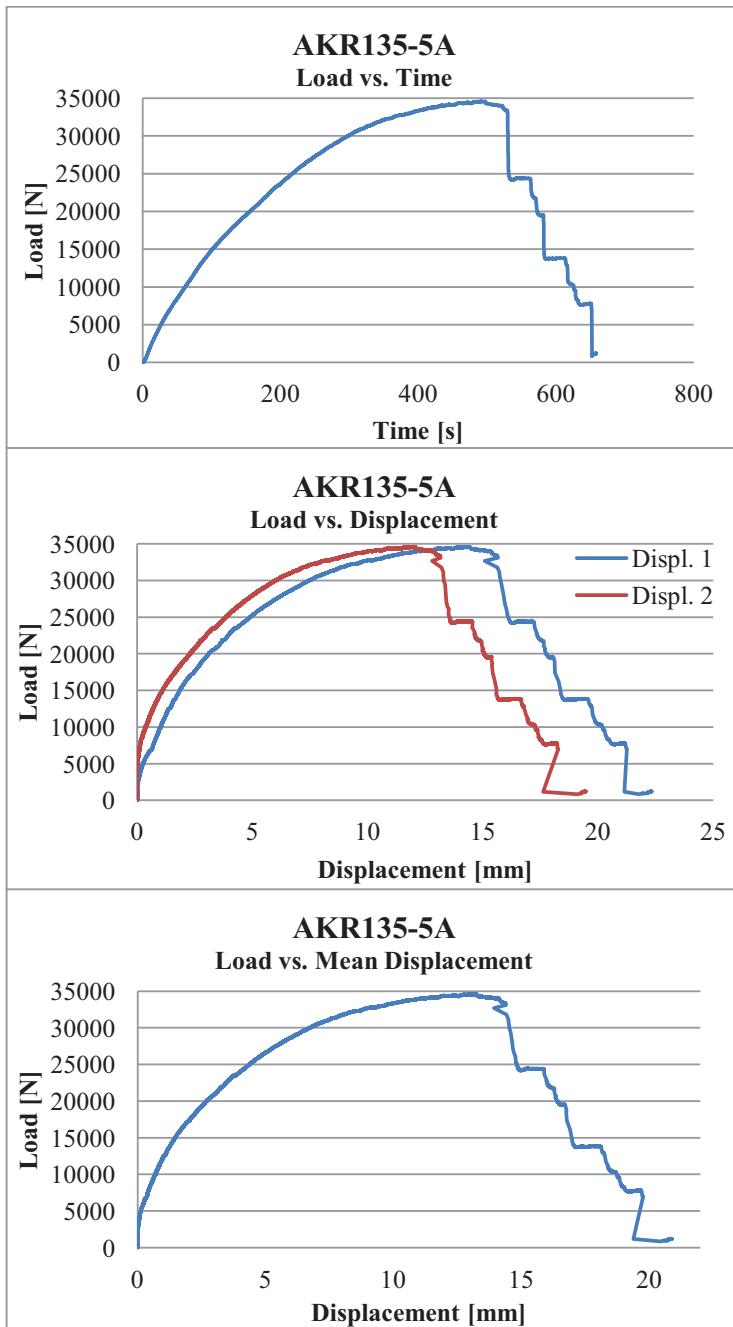


Failure	3b
Failure load [N]	31339
Displacement 1 [mm]	-
Displacement 2 [mm]	7.74
Mean Displacement [mm]	-
Moisture [%]	-
Density [kg/m ³]	392

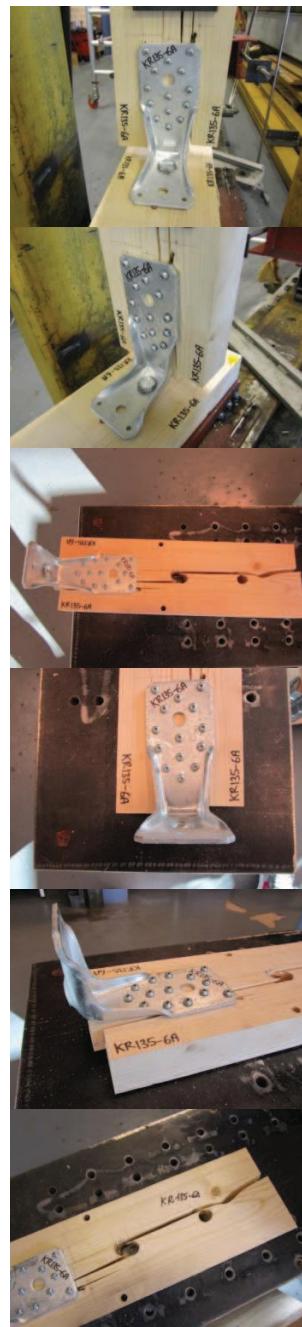
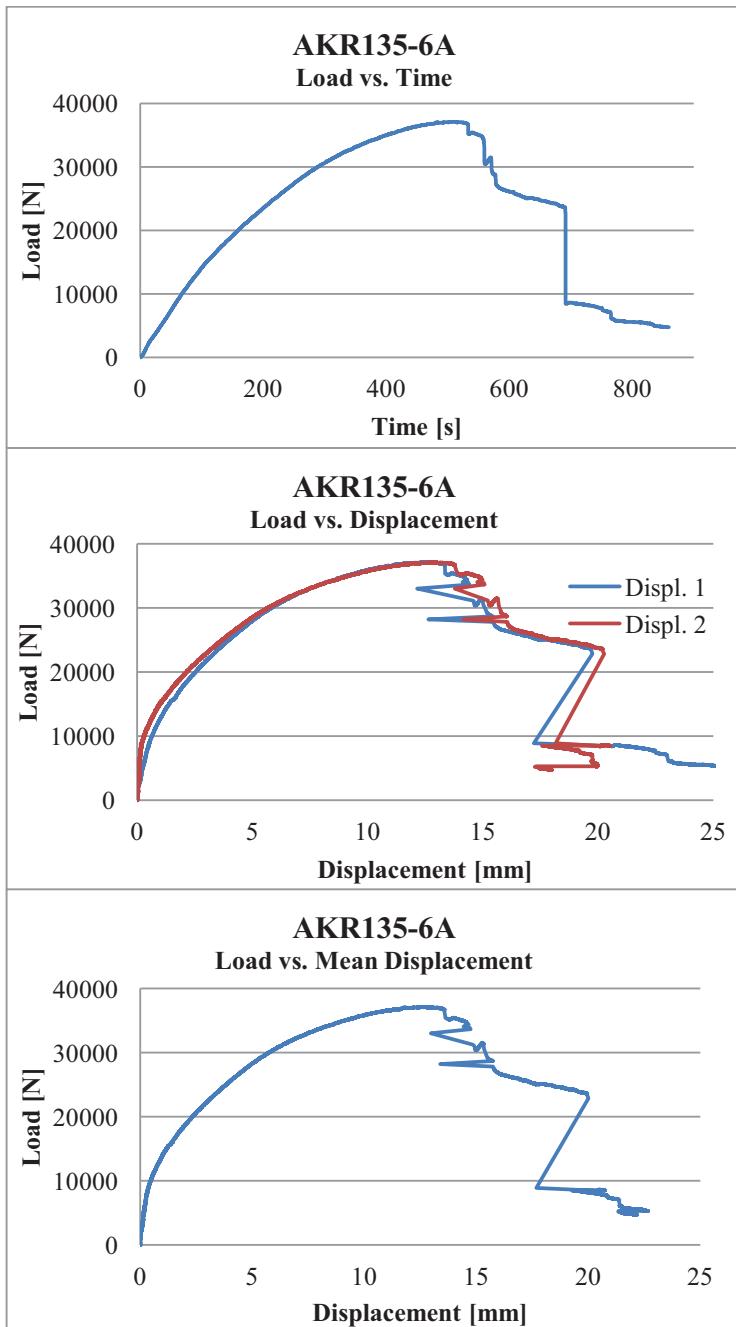
By mistake recording the weight the moisture was not measured.



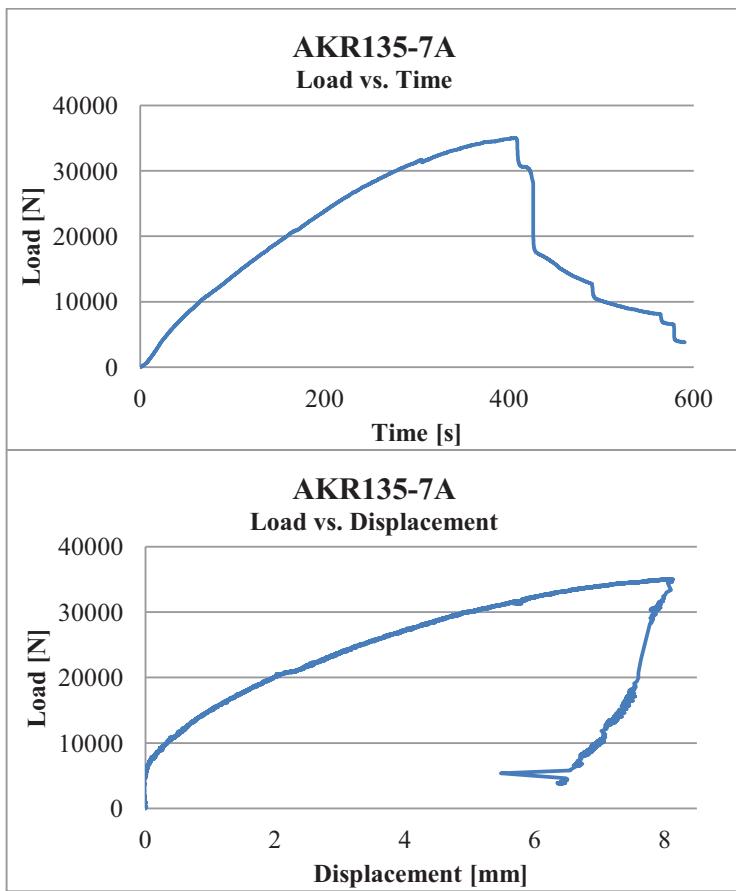
Failure	3b
Failure load [N]	26732
Displacement 1 [mm]	6.45
Displacement 2 [mm]	4.84
Mean Displacement [mm]	5.65
Moisture [%]	10.5
Density [kg/m ³]	378



Failure	3a
Failure load [N]	34586
Displacement 1 [mm]	14.4
Displacement 2 [mm]	12.1
Mean Displacement [mm]	13.2
Moisture [%]	9.23
Density [kg/m ³]	419

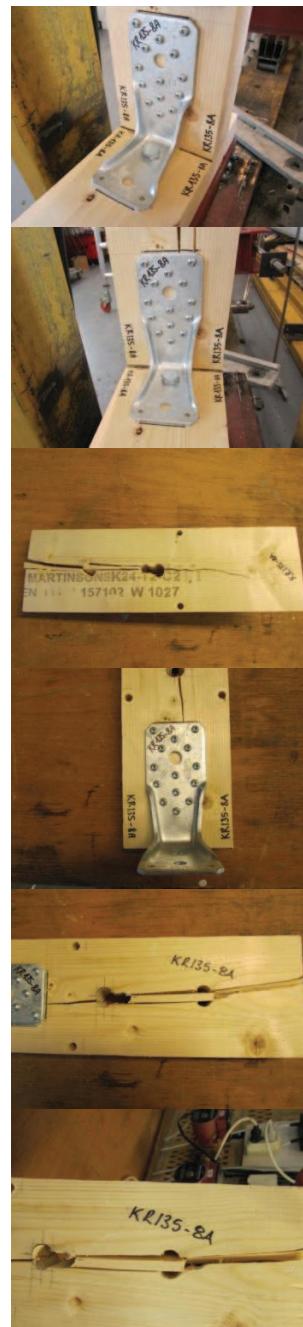
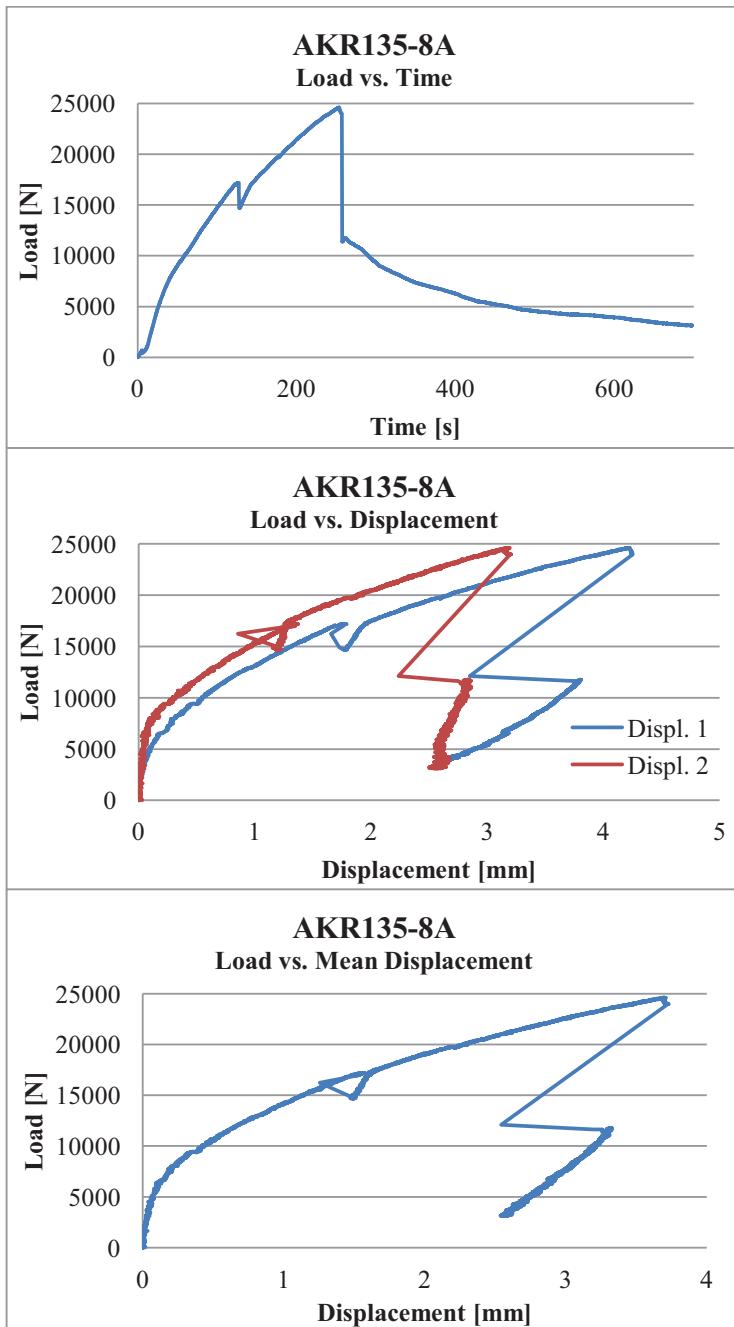


Failure	3a
Failure load [N]	37123
Displacement 1 [mm]	12.6
Displacement 2 [mm]	12.9
Mean Displacement [mm]	12.8
Moisture [%]	10.2
Density [kg/m ³]	376



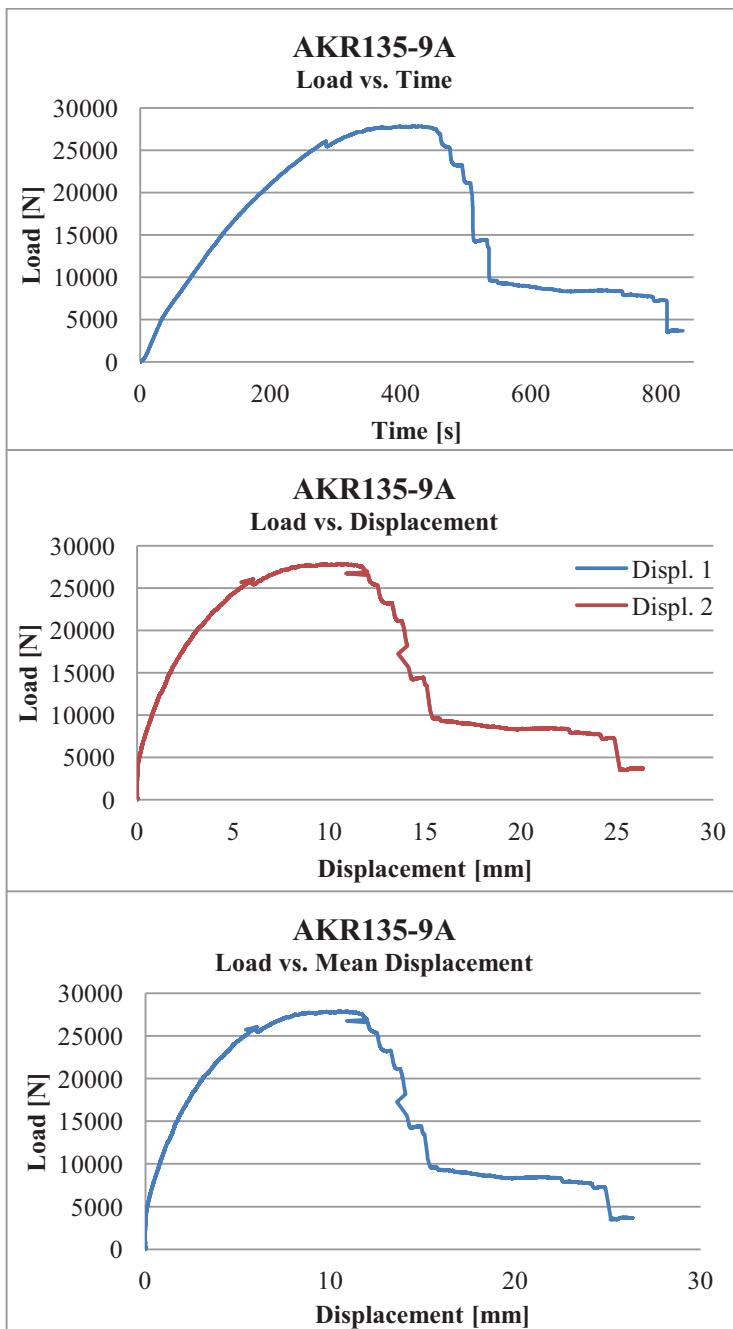
Failure	3b
Failure load [N]	35045
Displacement 1 [mm]	-
Displacement 2 [mm]	8.04
Mean Displacement [mm]	-
Moisture [%]	10.0
Density [kg/m ³]	481

The LVDT number 1 did not work.

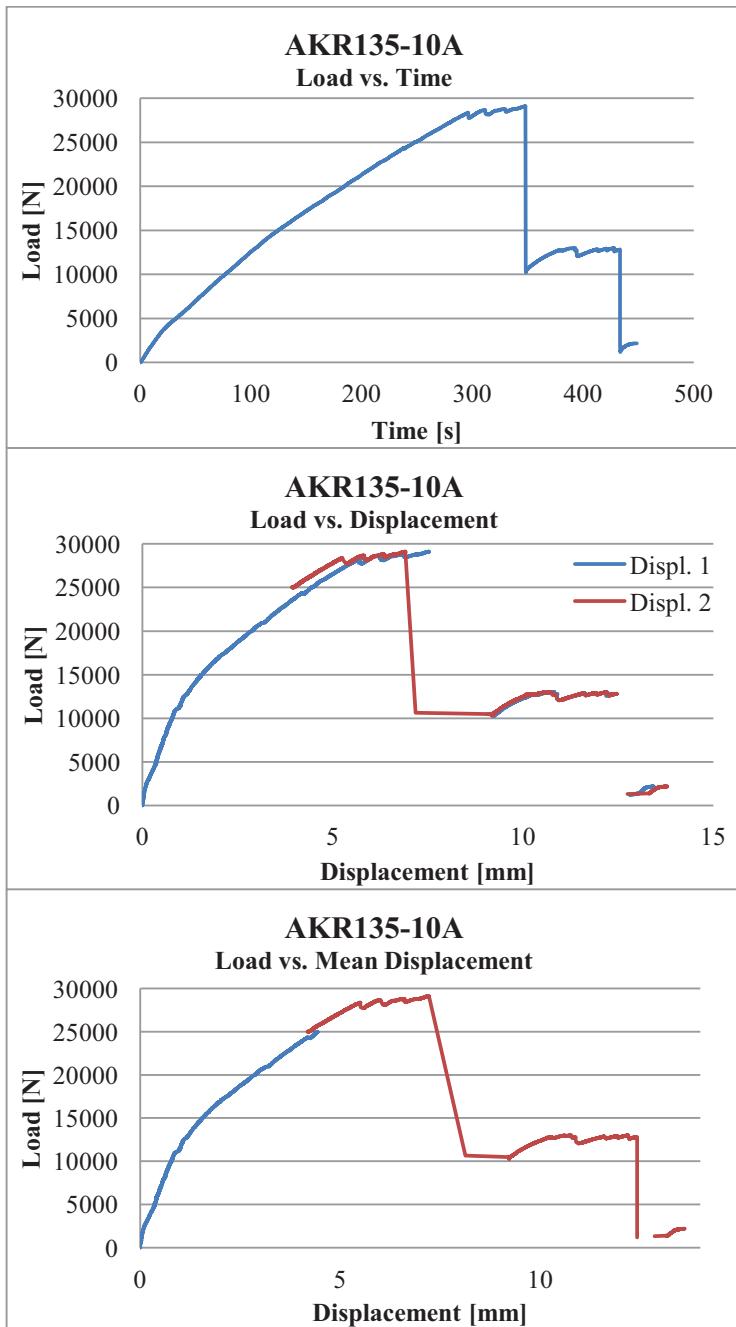


Failure	3b
Failure load [N]	24613
Displacement 1 [mm]	4.22
Displacement 2 [mm]	3.17
Mean Displacement [mm]	3.69
Moisture [%]	9.79
Density [kg/m ³]	357

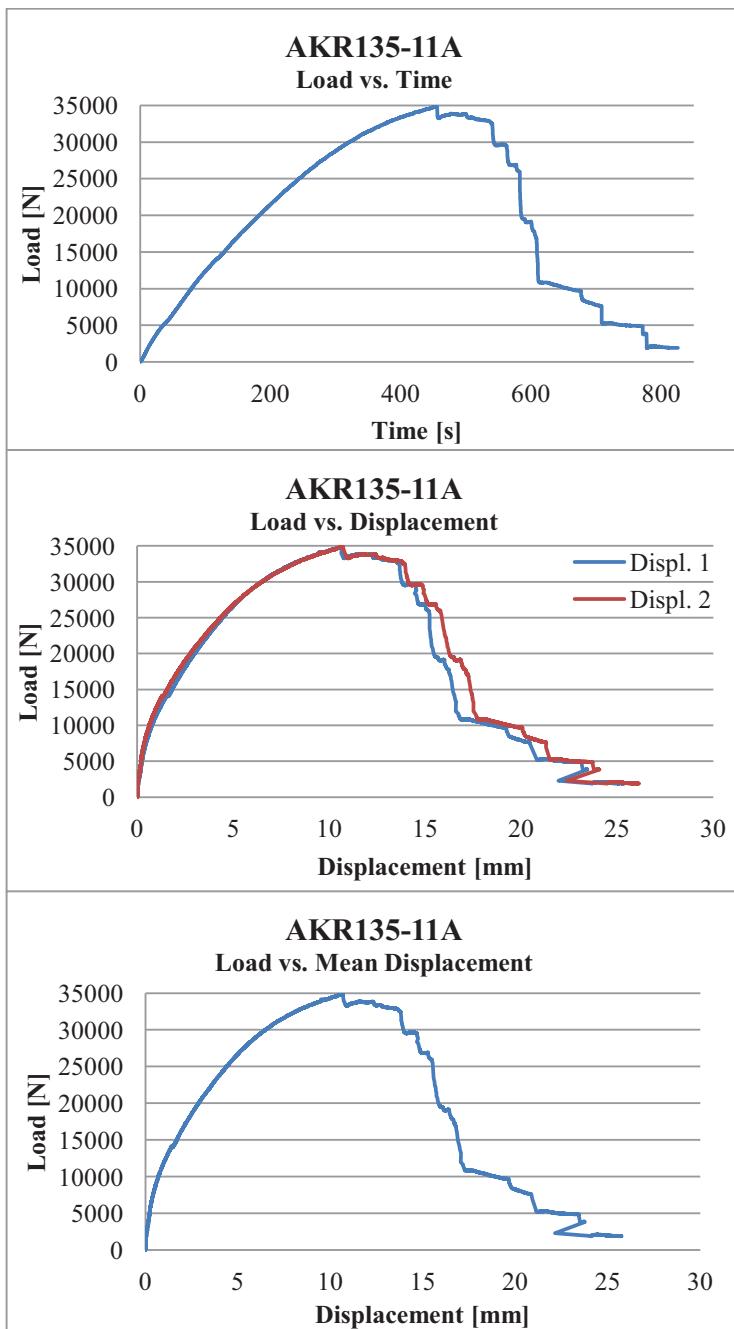
The failure load is less than other tests, probably there was some problem in the specimen.



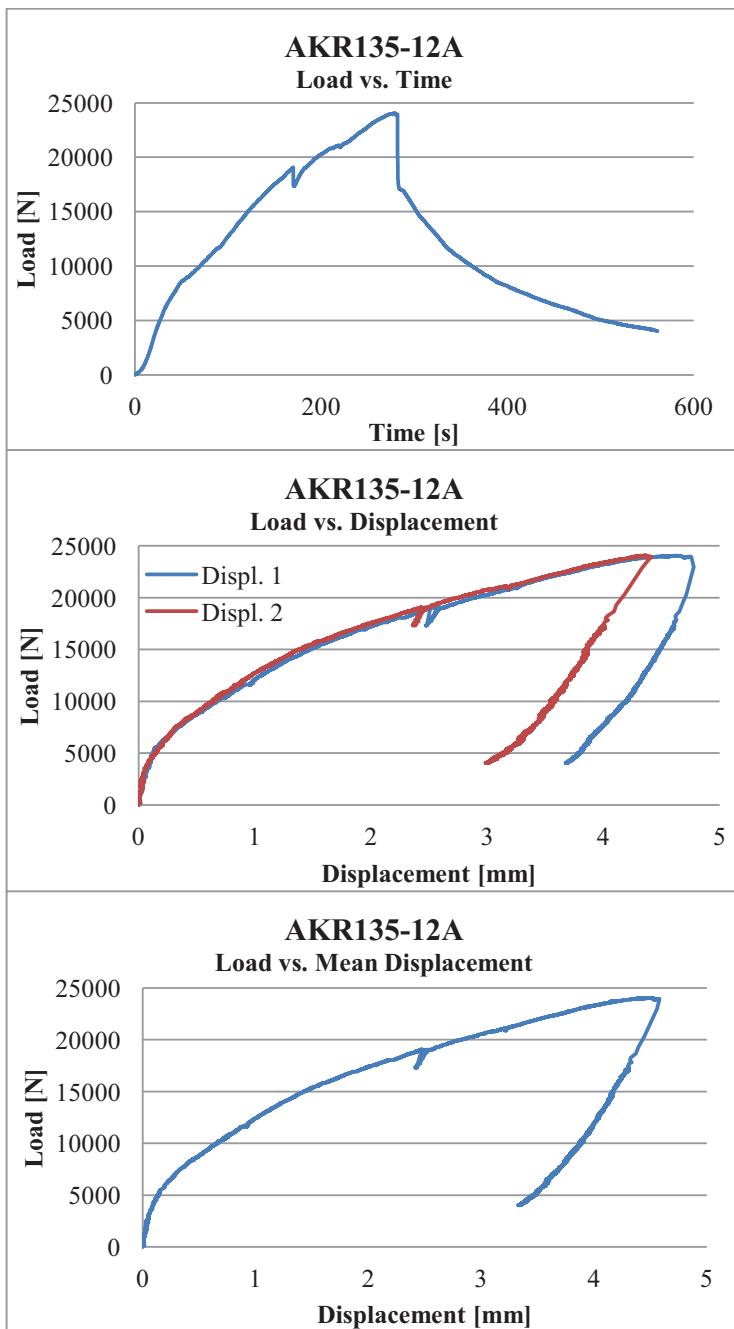
Failure	3a
Failure load [N]	27883
Displacement 1 [mm]	10.5
Displacement 2 [mm]	10.5
Mean Displacement [mm]	10.5
Moisture [%]	9.62
Density [kg/m ³]	357



Failure	3b
Failure load [N]	29111
Displacement 1 [mm]	7.53
Displacement 2 [mm]	6.91
Mean Displacement [mm]	7.22
Moisture [%]	10.9
Density [kg/m ³]	367



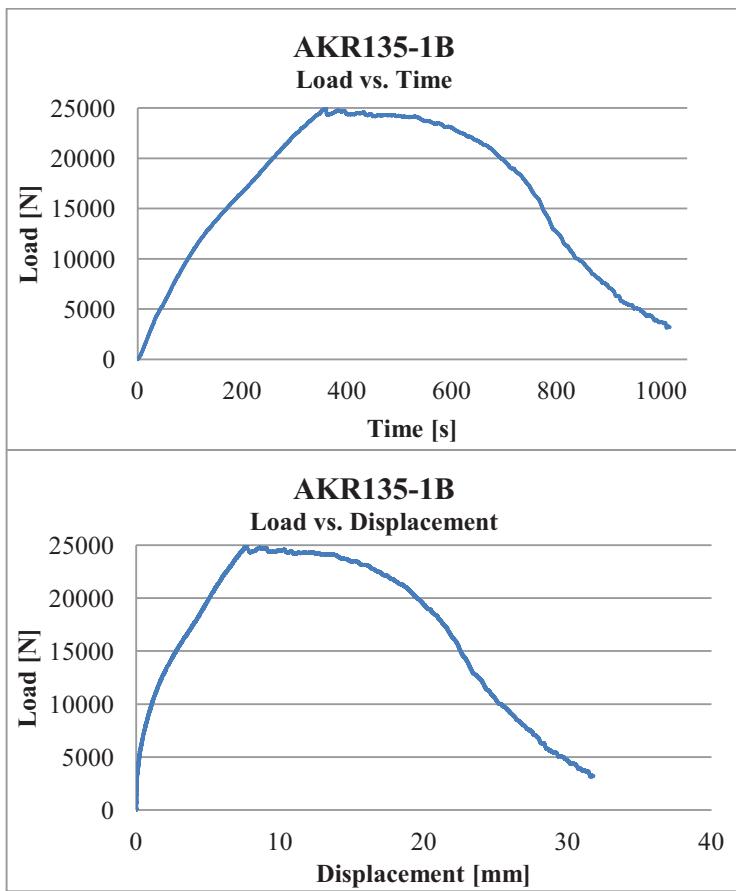
Failure	3a
Failure load [N]	34865
Displacement 1 [mm]	10.7
Displacement 2 [mm]	10.7
Mean Displacement [mm]	10.7
Moisture [%]	8.72
Density [kg/m ³]	375



Failure	3a
Failure load [N]	24044
Displacement 1 [mm]	4.63
Displacement 2 [mm]	4.34
Mean Displacement [mm]	4.49
Moisture [%]	9.96
Density [kg/m ³]	431

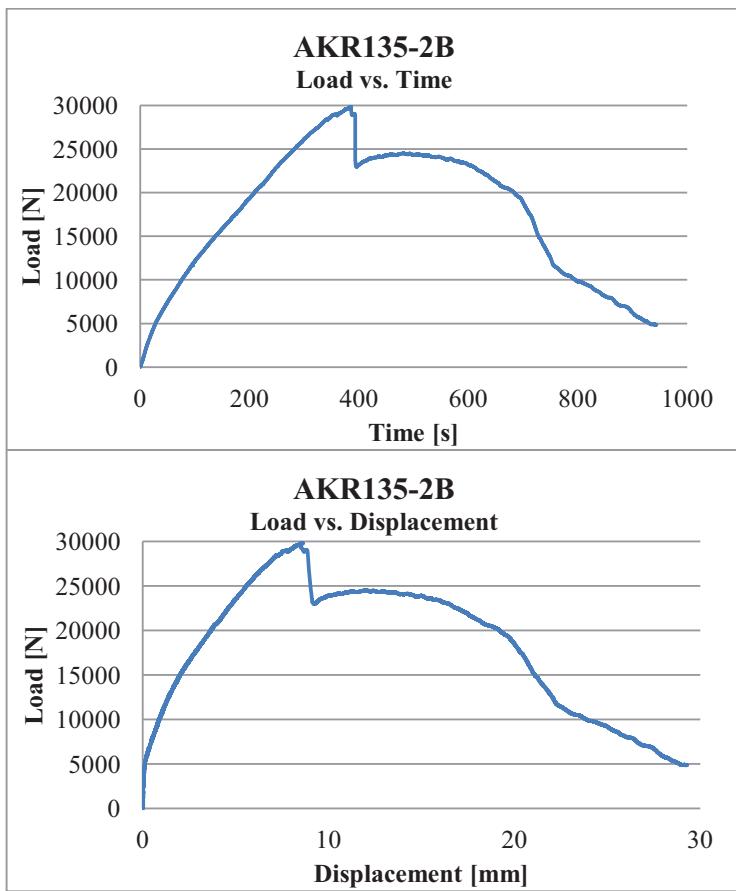
The LVDT number 1 after failure did not work well.

Set 2 – 14 annular ringed shank nails 4x40 on the stud and 1 bolt M12 on the rail



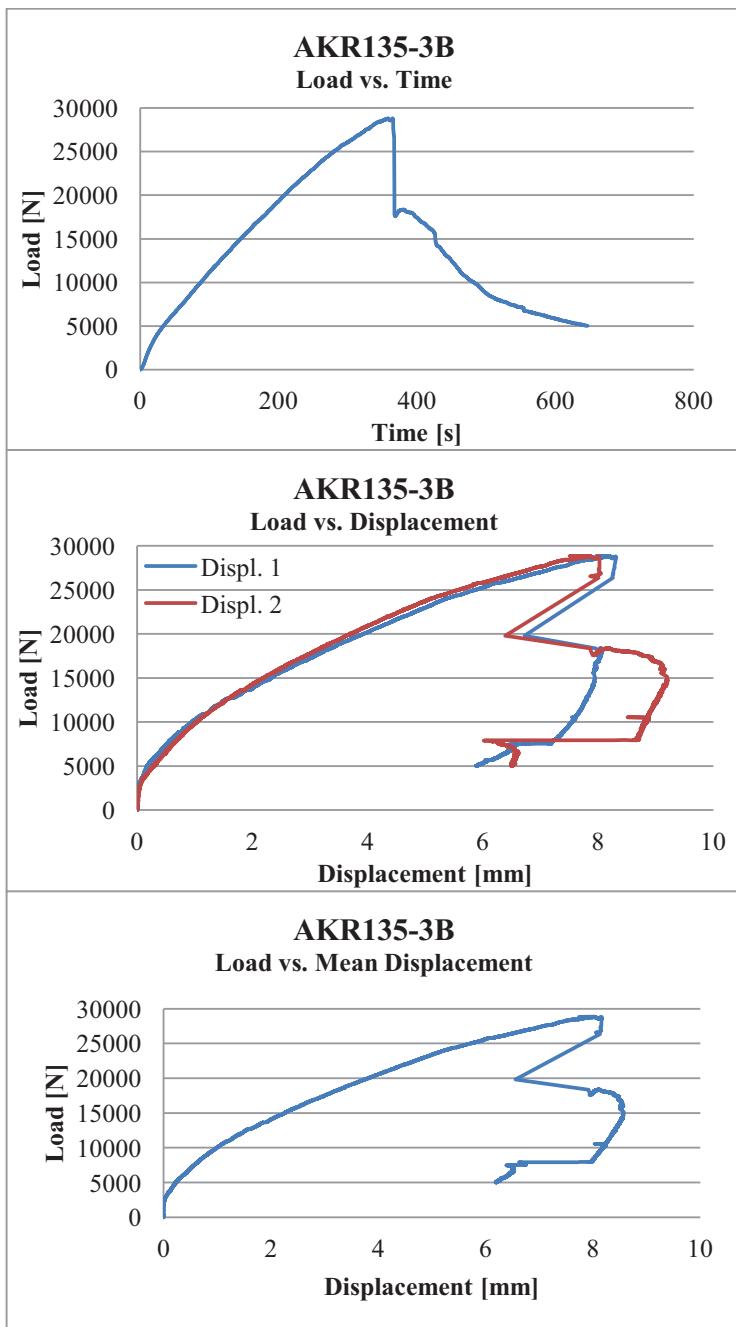
Failure	3a
Failure load [N]	25043
Displacement 1 [mm]	-
Displacement 2 [mm]	7.73
Mean Displacement [mm]	-
Moisture [%]	9.84
Density [kg/m ³]	357

The LDVT number 1 did not work.

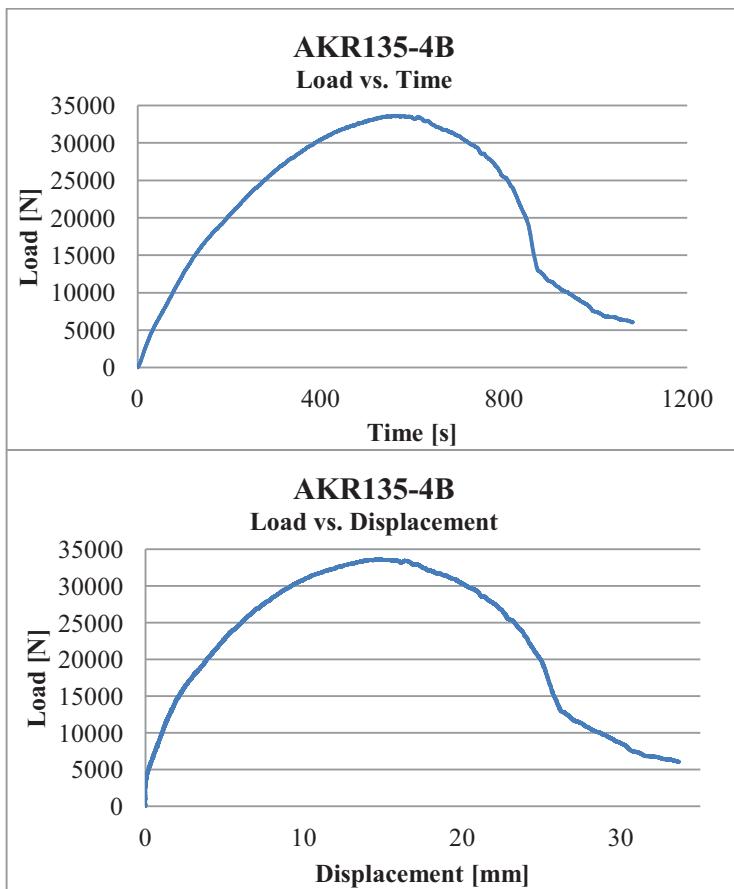


Failure	3a
Failure load [N]	29805
Displacement 1 [mm]	-
Displacement 2 [mm]	8.62
Mean Displacement [mm]	-
Moisture [%]	9.87
Density [kg/m ³]	389

The LVDT number 1 did not work.

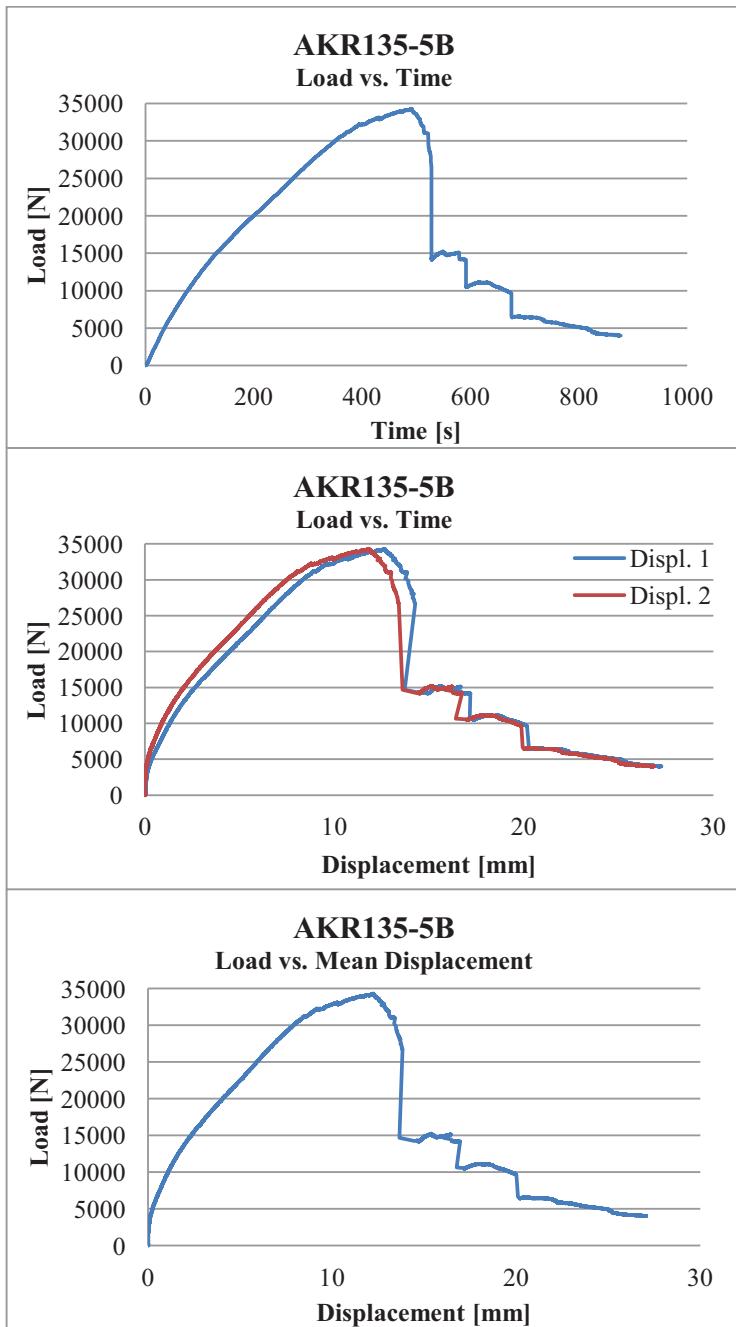


Failure	3b
Failure load [N]	28842
Displacement 1 [mm]	8.21
Displacement 2 [mm]	7.87
Mean Displacement [mm]	8.04
Moisture [%]	8.53
Density [kg/m ³]	452

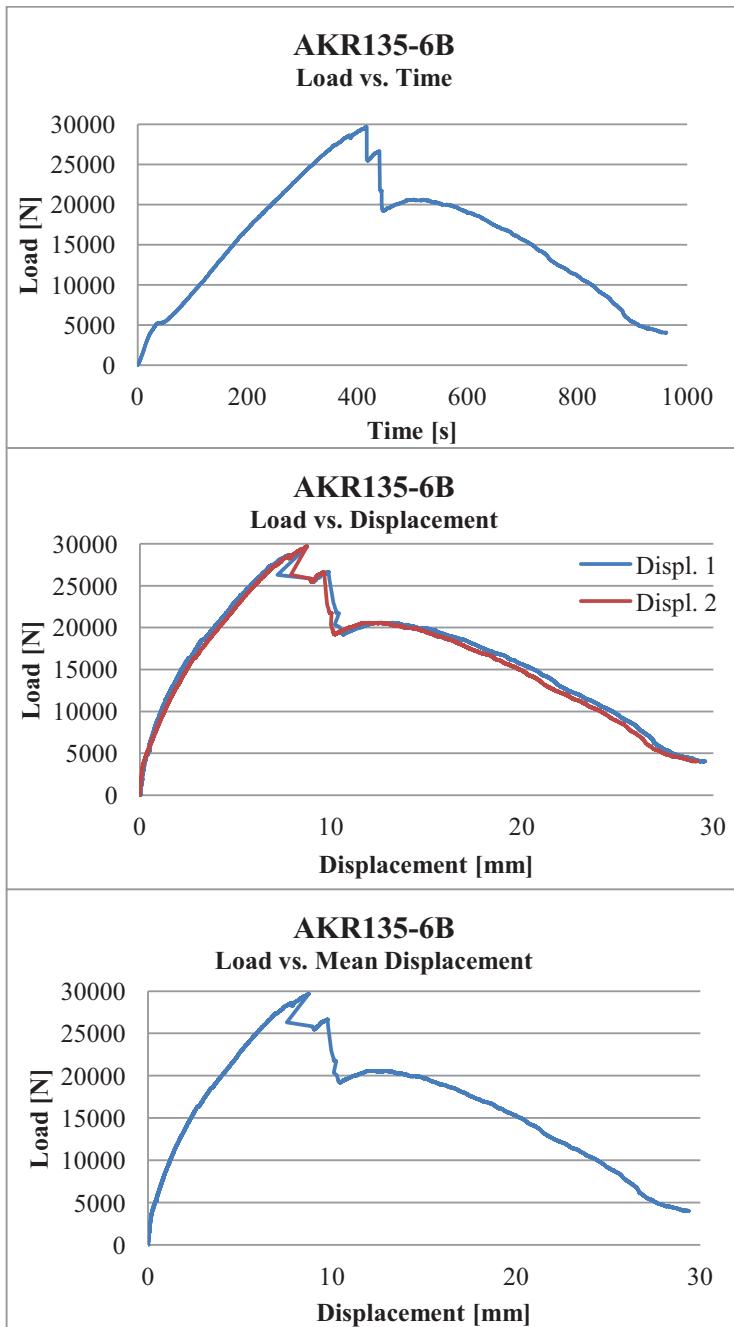


Failure	3a
Failure load [N]	33620
Displacement 1 [mm]	-
Displacement 2 [mm]	14.6
Mean Displacement [mm]	-
Moisture [%]	12.8
Density [kg/m ³]	483

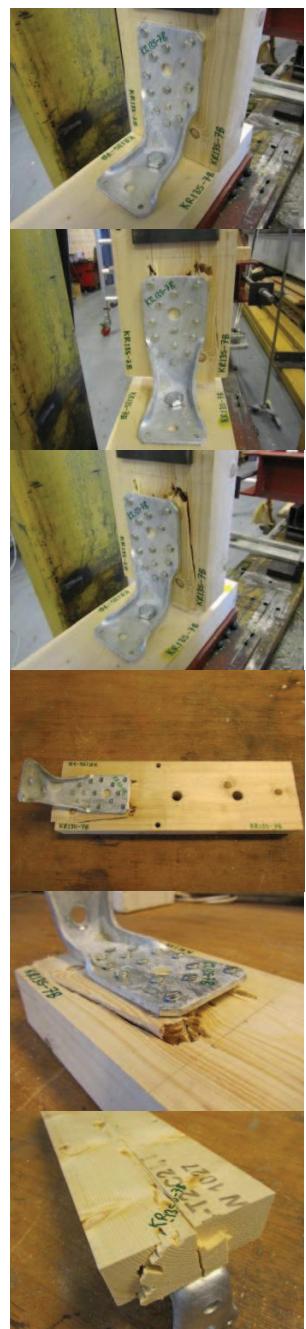
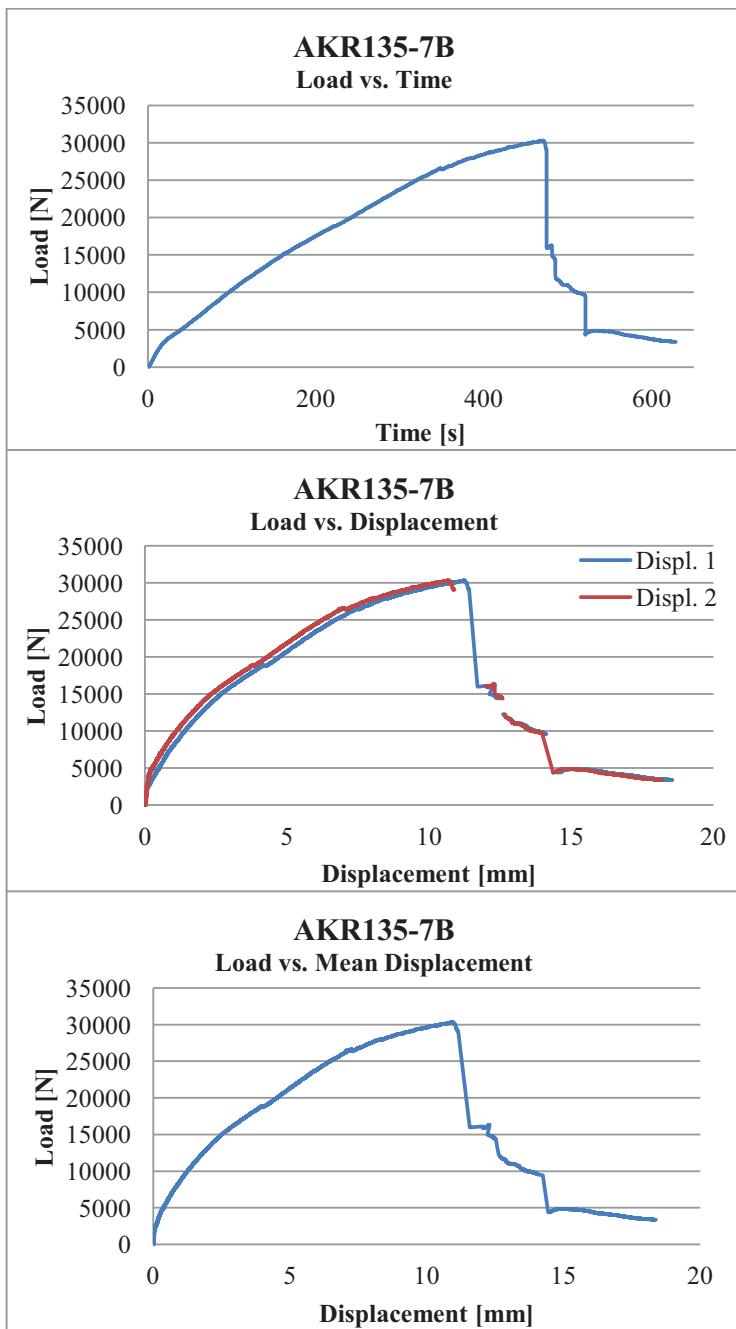
The LVDT number 1 did not work.



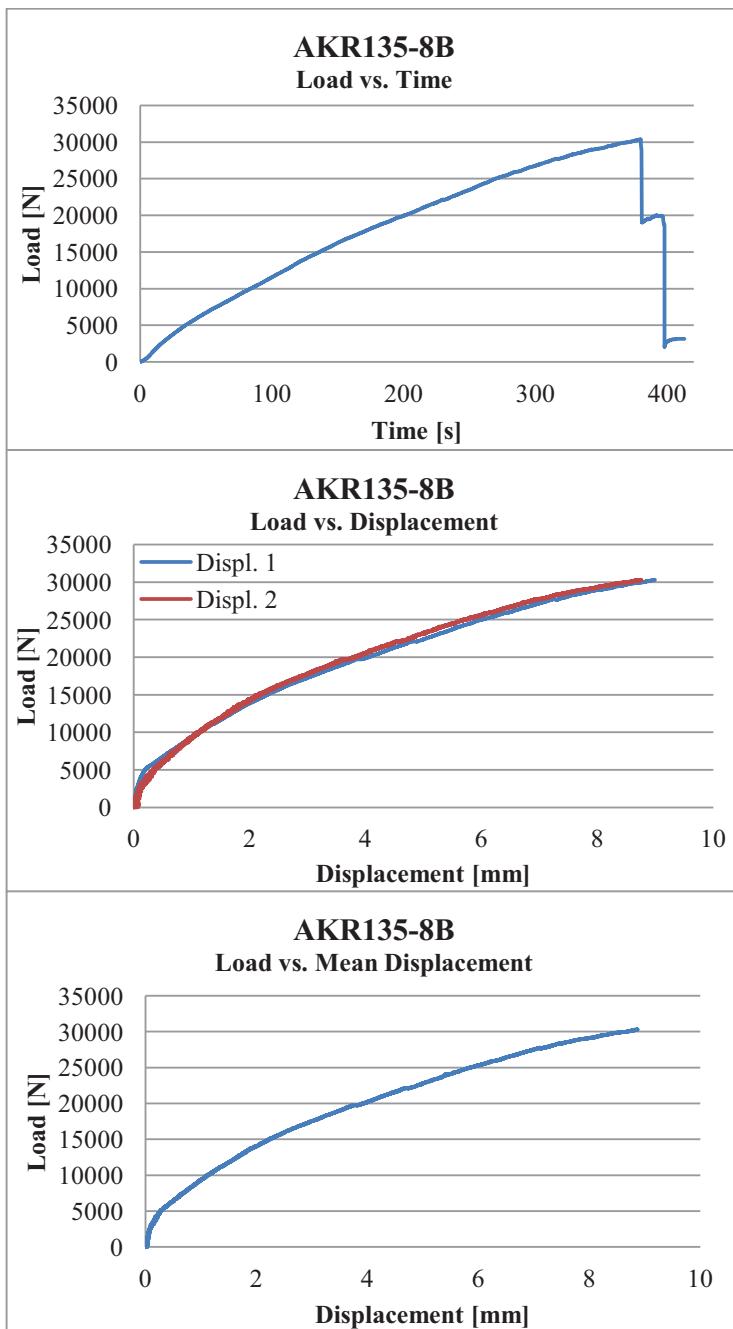
Failure	3a
Failure load [N]	34296
Displacement 1 [mm]	12.6
Displacement 2 [mm]	11.8
Mean Displacement [mm]	12.2
Moisture [%]	9.23
Density [kg/m ³]	444



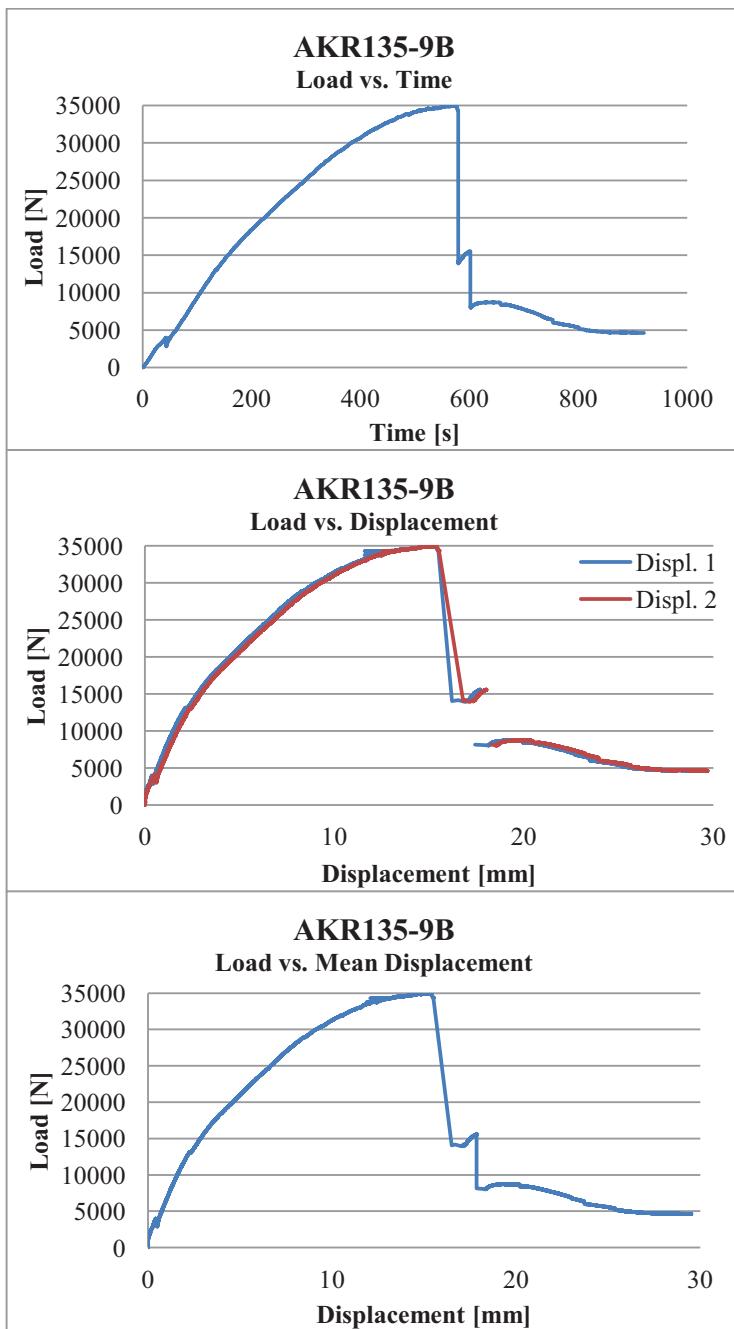
Failure	3a
Failure load [N]	29675
Displacement 1 [mm]	8.73
Displacement 2 [mm]	8.71
Mean Displacement [mm]	8.72
Moisture [%]	8.97
Density [kg/m ³]	367



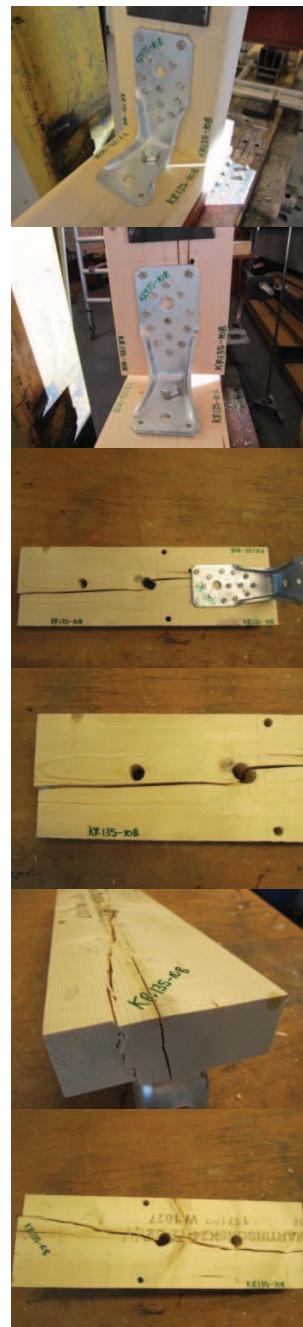
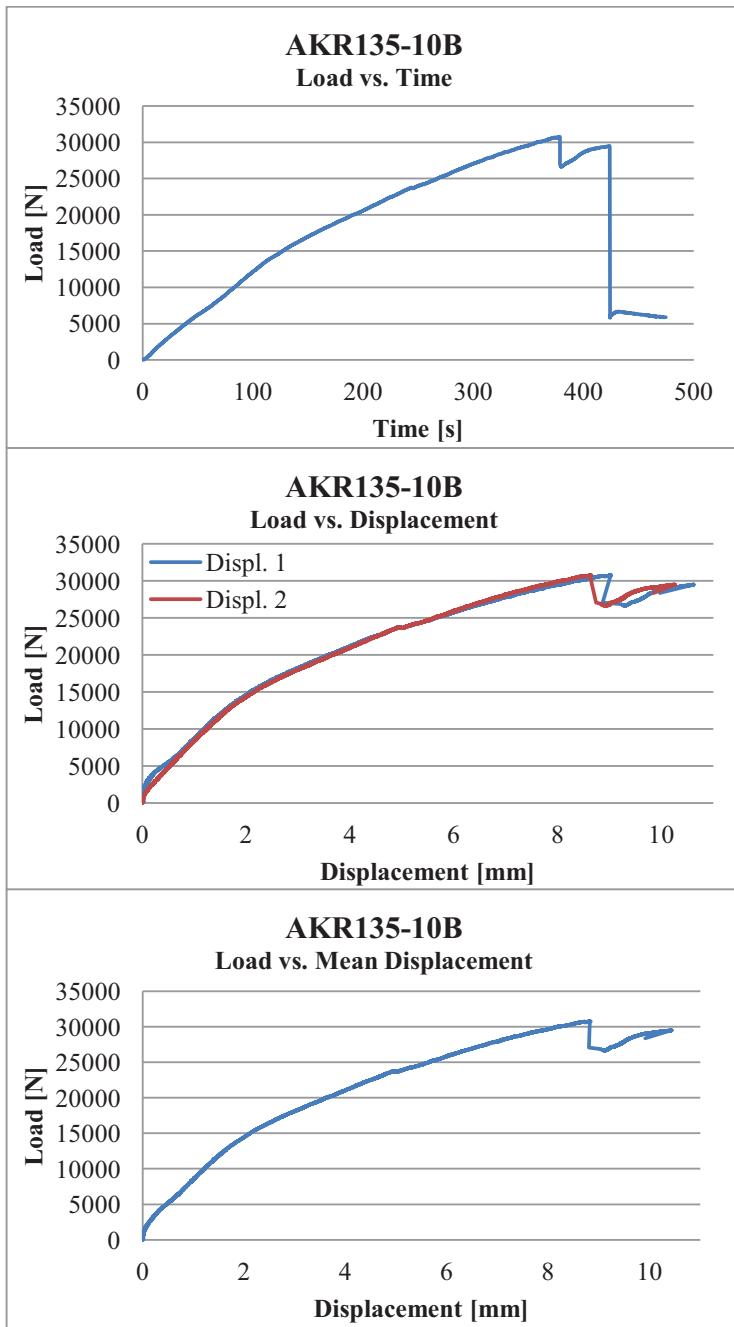
Failure	3b
Failure load [N]	30309
Displacement 1 [mm]	11.2
Displacement 2 [mm]	10.7
Mean Displacement [mm]	10.9
Moisture [%]	12.6
Density [kg/m ³]	382



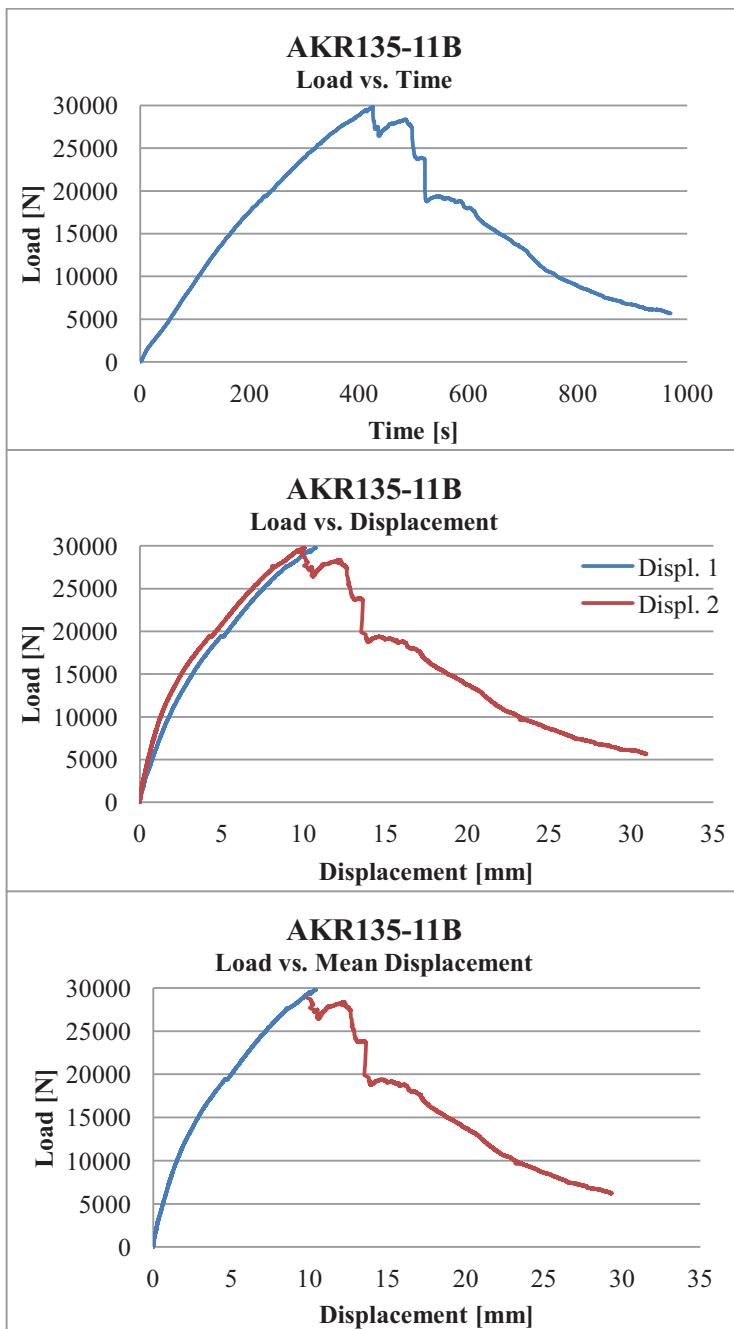
Failure	3b
Failure load [N]	30363
Displacement 1 [mm]	9.05
Displacement 2 [mm]	8.83
Mean Displacement [mm]	8.94
Moisture [%]	9.23
Density [kg/m ³]	530



Failure	3b
Failure load [N]	34980
Displacement 1 [mm]	15.2
Displacement 2 [mm]	15.2
Mean Displacement [mm]	15.2
Moisture [%]	11.4
Density [kg/m ³]	438

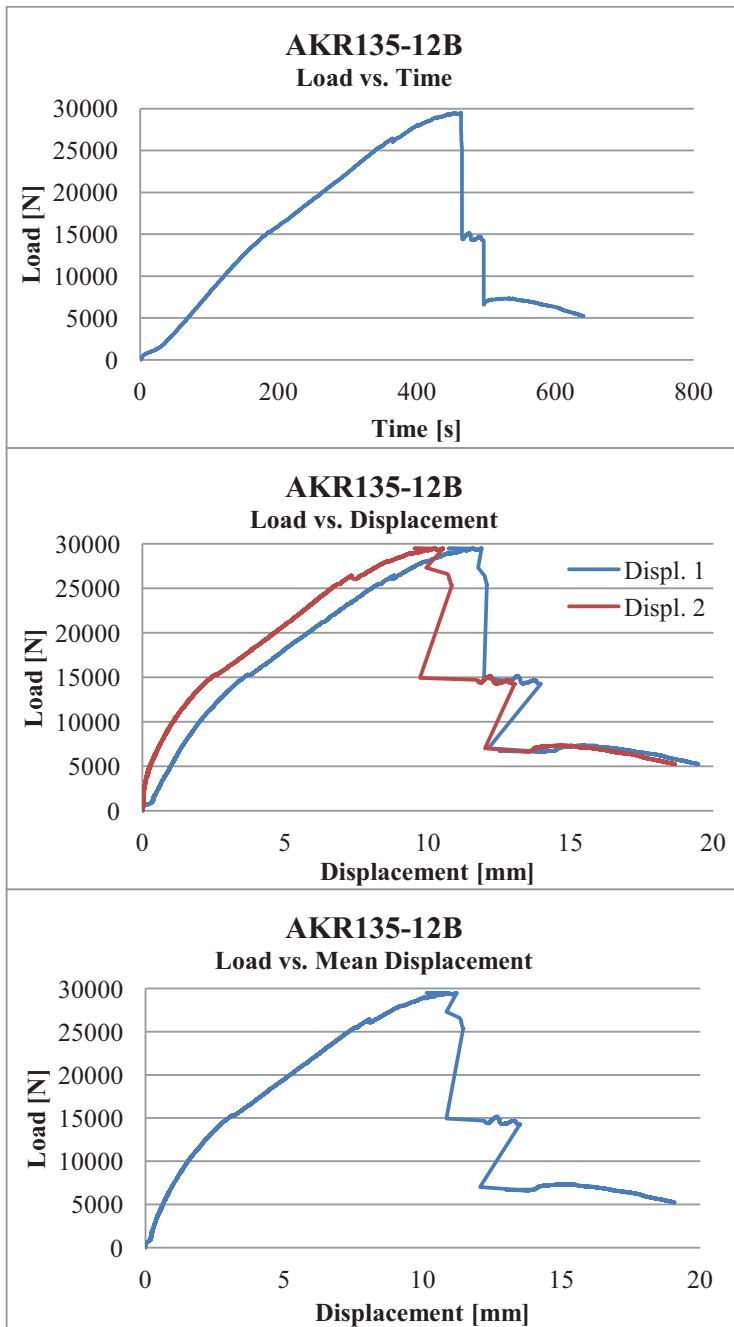


Failure	3b
Failure load [N]	30771
Displacement 1 [mm]	9.02
Displacement 2 [mm]	8.62
Mean Displacement [mm]	8.82
Moisture [%]	8.58
Density [kg/m ³]	381



Failure	3b
Failure load [N]	29782
Displacement 1 [mm]	10.7
Displacement 2 [mm]	10.0
Mean Displacement [mm]	10.4
Moisture [%]	9.70
Density [kg/m ³]	361

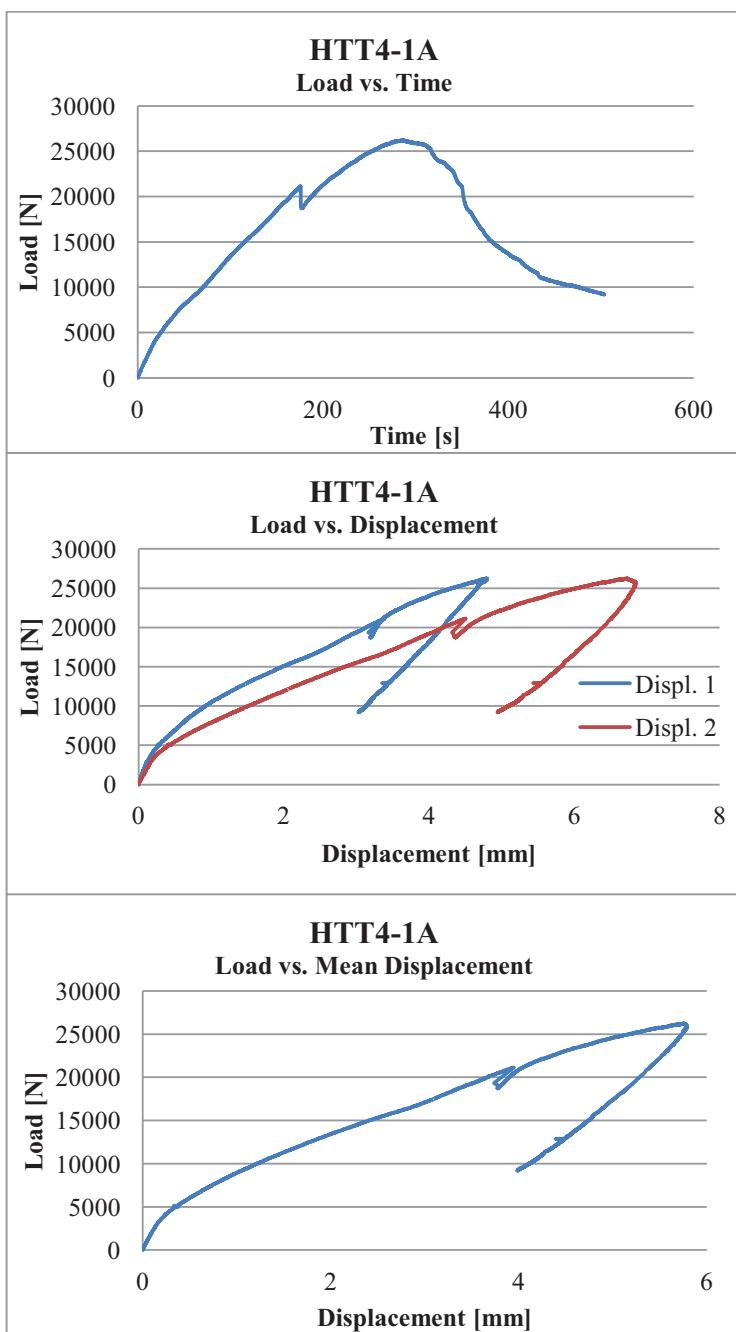
The LVDT number 1 did not work after failure.



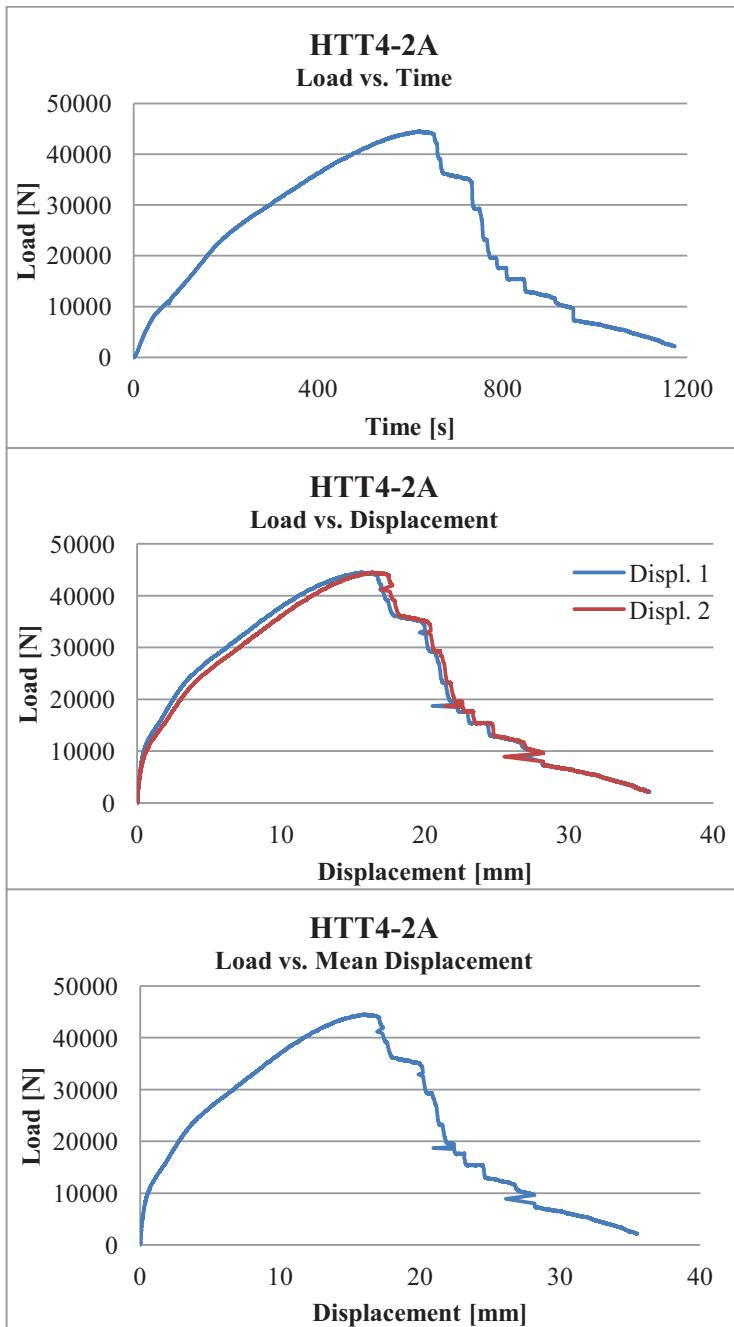
Failure	3b
Failure load [N]	29496
Displacement 1 [mm]	11.6
Displacement 2 [mm]	10.3
Mean Displacement [mm]	10.9
Moisture [%]	9.44
Density [kg/m ³]	372

Series 4 – Tension tie HTT4

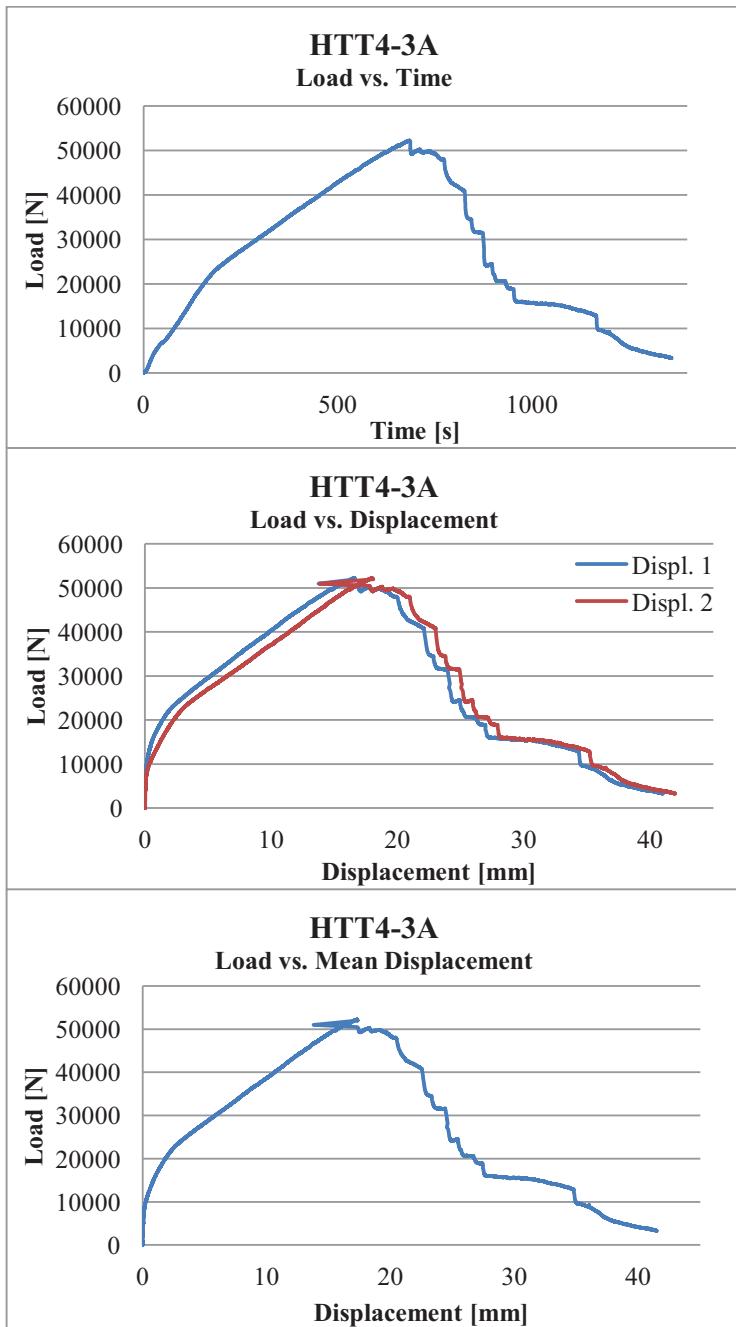
Set 1 – 18 wooden screws 5x40 on the stud and 1 bolt M16 on the rail



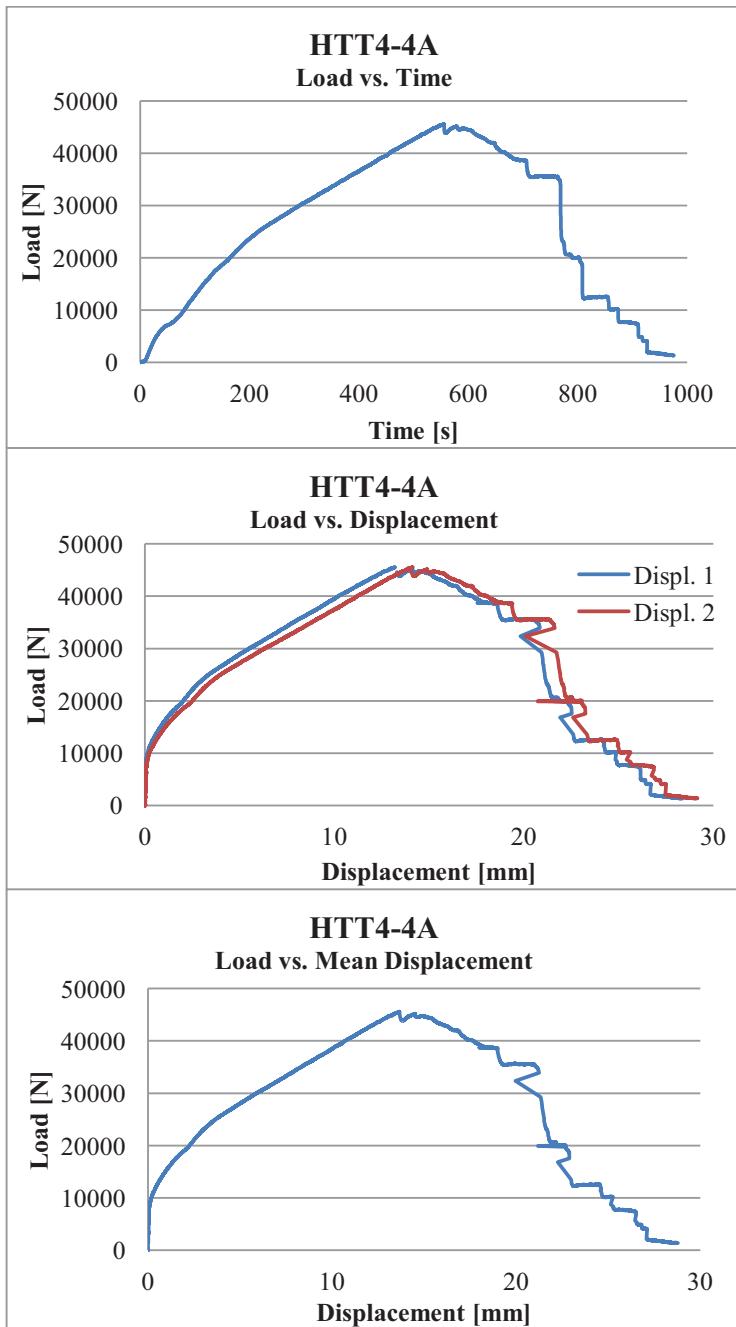
Failure	3b
Failure load [N]	26232
Displacement 1 [mm]	4.79
Displacement 2 [mm]	6.71
Mean Displacement [mm]	5.75
Moisture [%]	7.91
Density [kg/m ³]	387



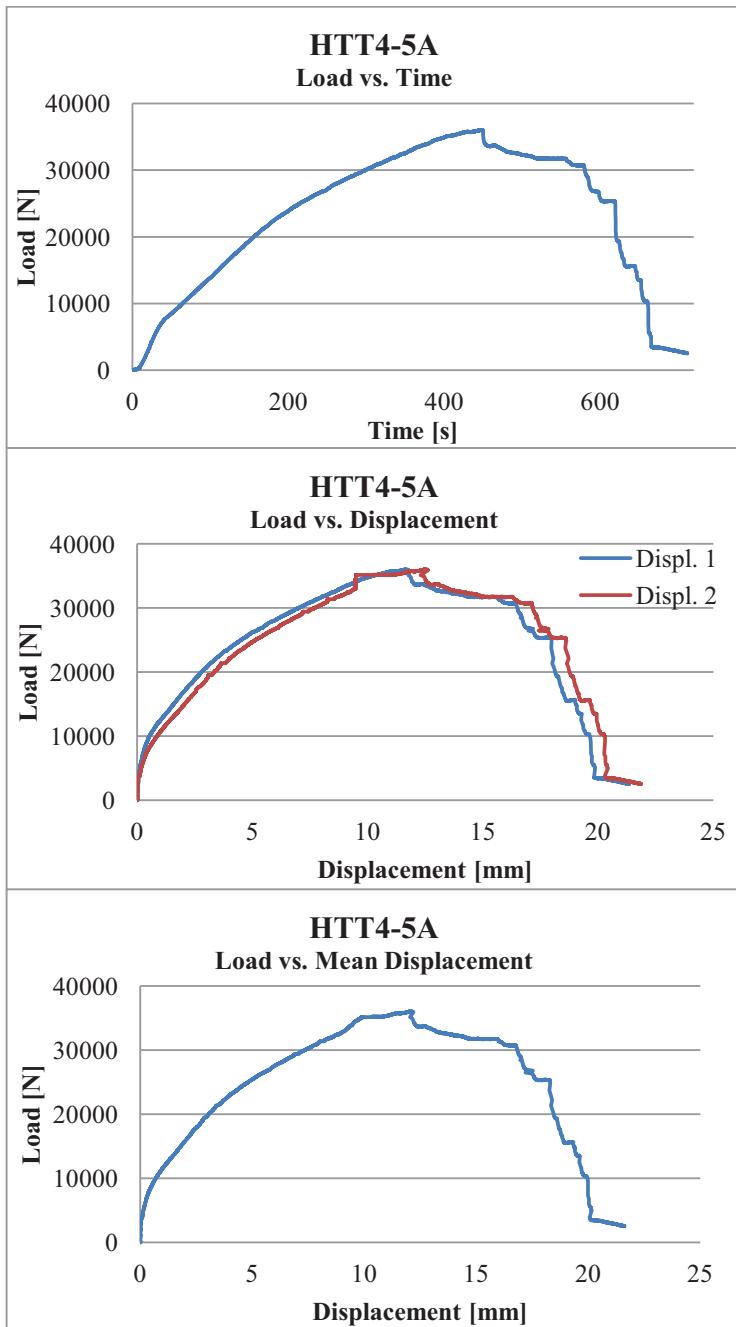
Failure	3a
Failure load [N]	44515
Displacement 1 [mm]	15.6
Displacement 2 [mm]	16.4
Mean Displacement [mm]	16.0
Moisture [%]	8.11
Density [kg/m ³]	327



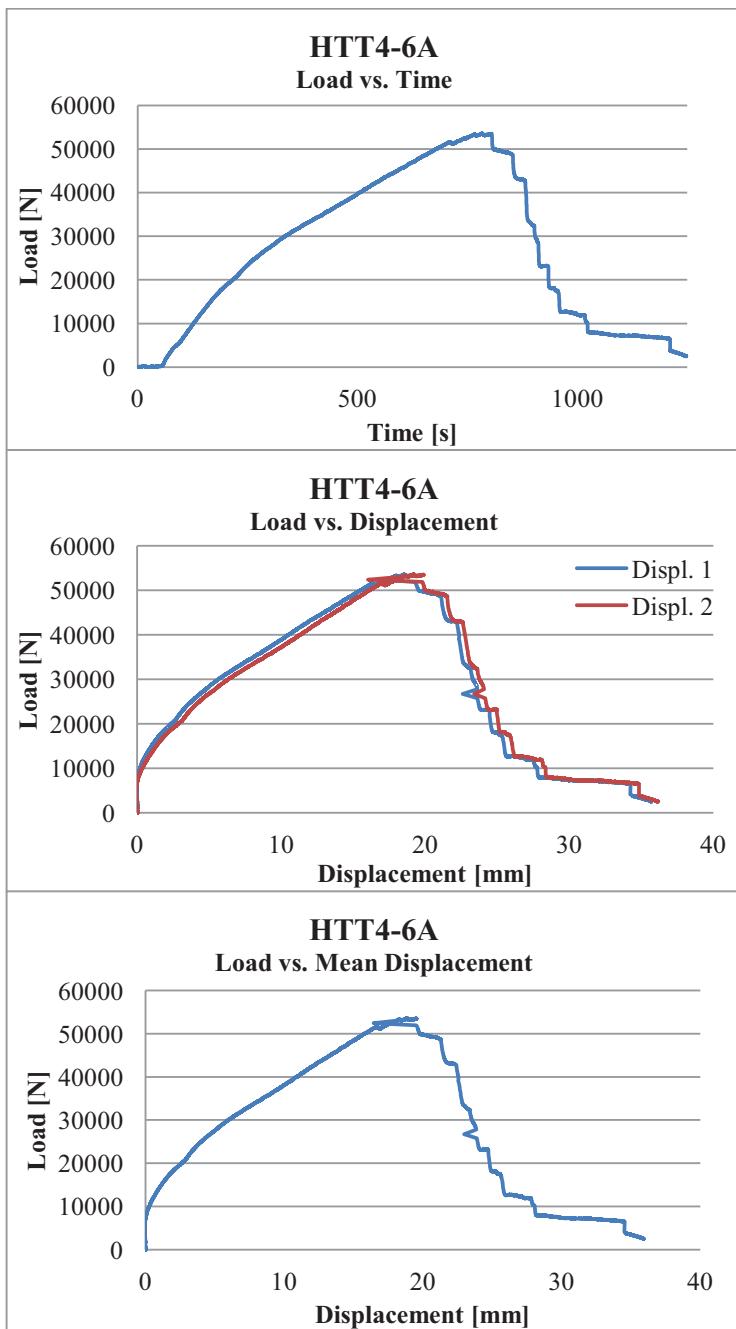
Failure	3a
Failure load [N]	52241
Displacement 1 [mm]	16.6
Displacement 2 [mm]	18.0
Mean Displacement [mm]	13.3
Moisture [%]	8.50
Density [kg/m ³]	414



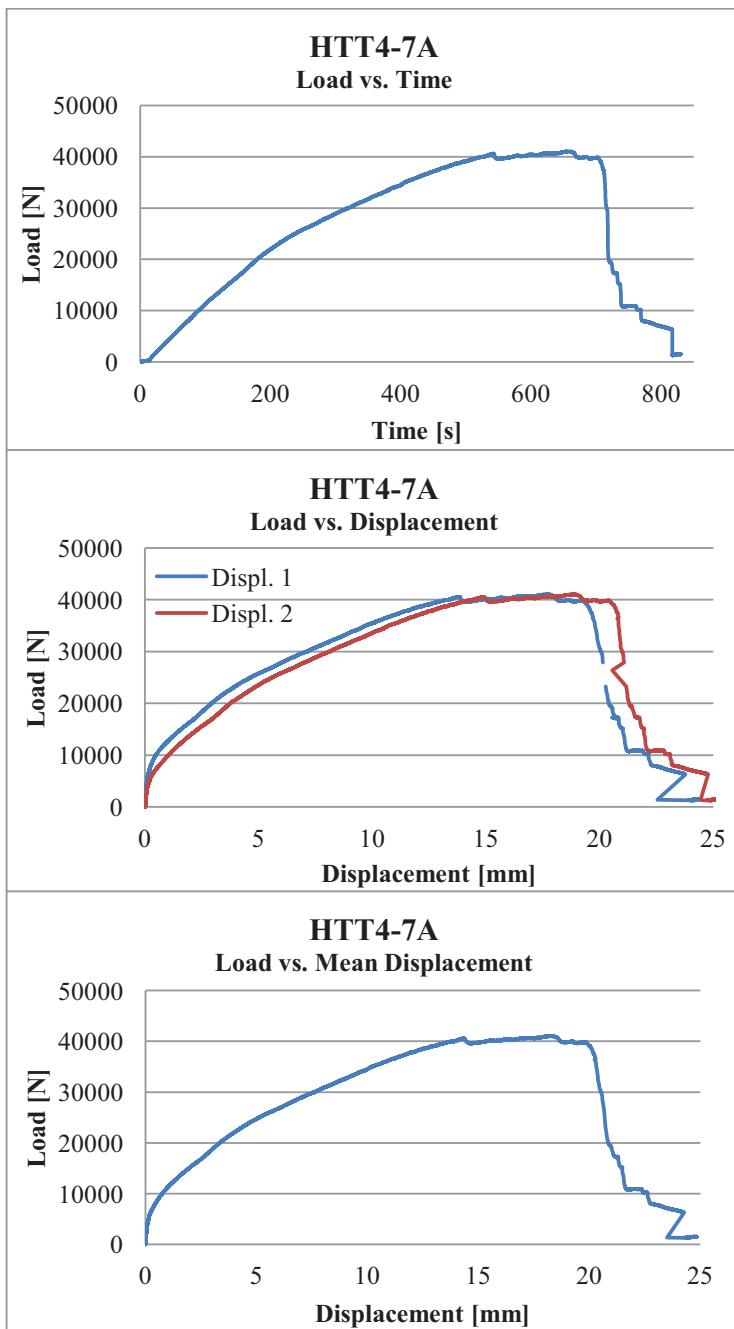
Failure	3a
Failure load [N]	45584
Displacement 1 [mm]	13.2
Displacement 2 [mm]	14.1
Mean Displacement [mm]	13.7
Moisture [%]	9.18
Density [kg/m ³]	433



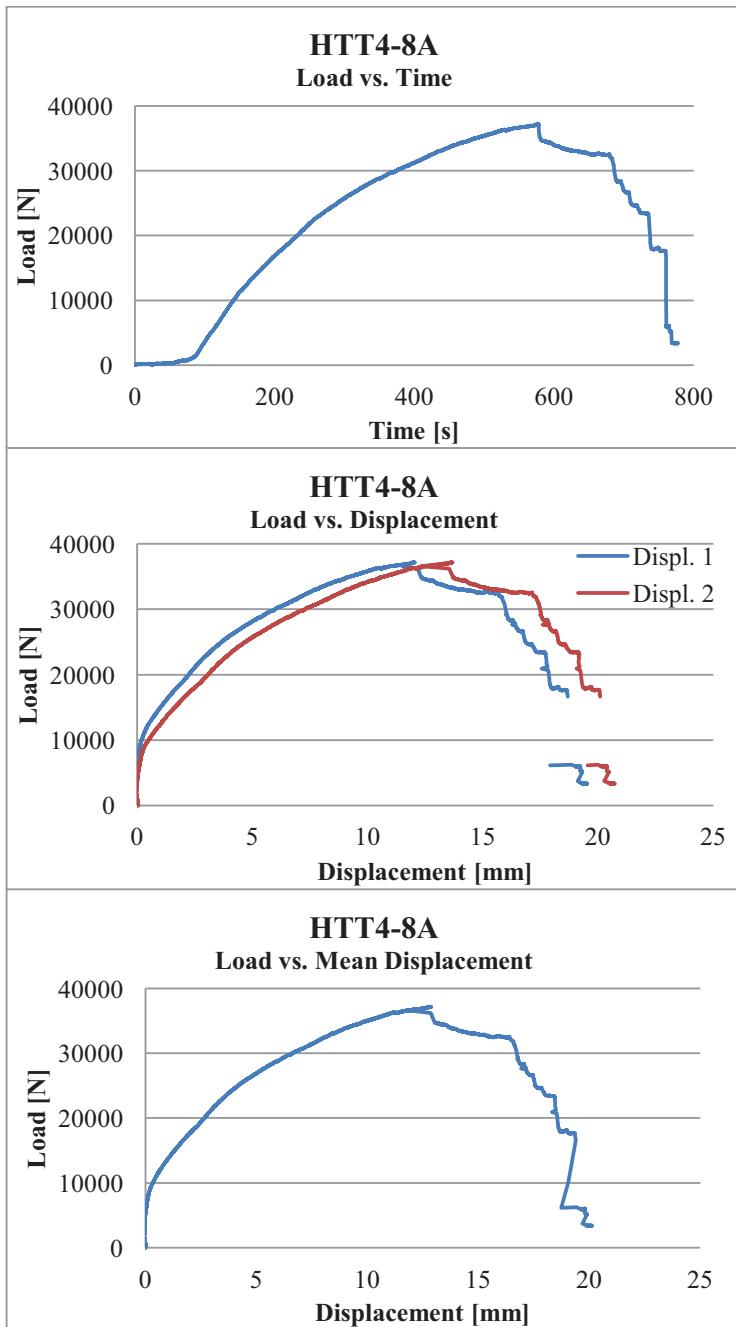
Failure	3a
Failure load [N]	36034
Displacement 1 [mm]	11.6
Displacement 2 [mm]	12.5
Mean Displacement [mm]	12.1
Moisture [%]	7.24
Density [kg/m ³]	327



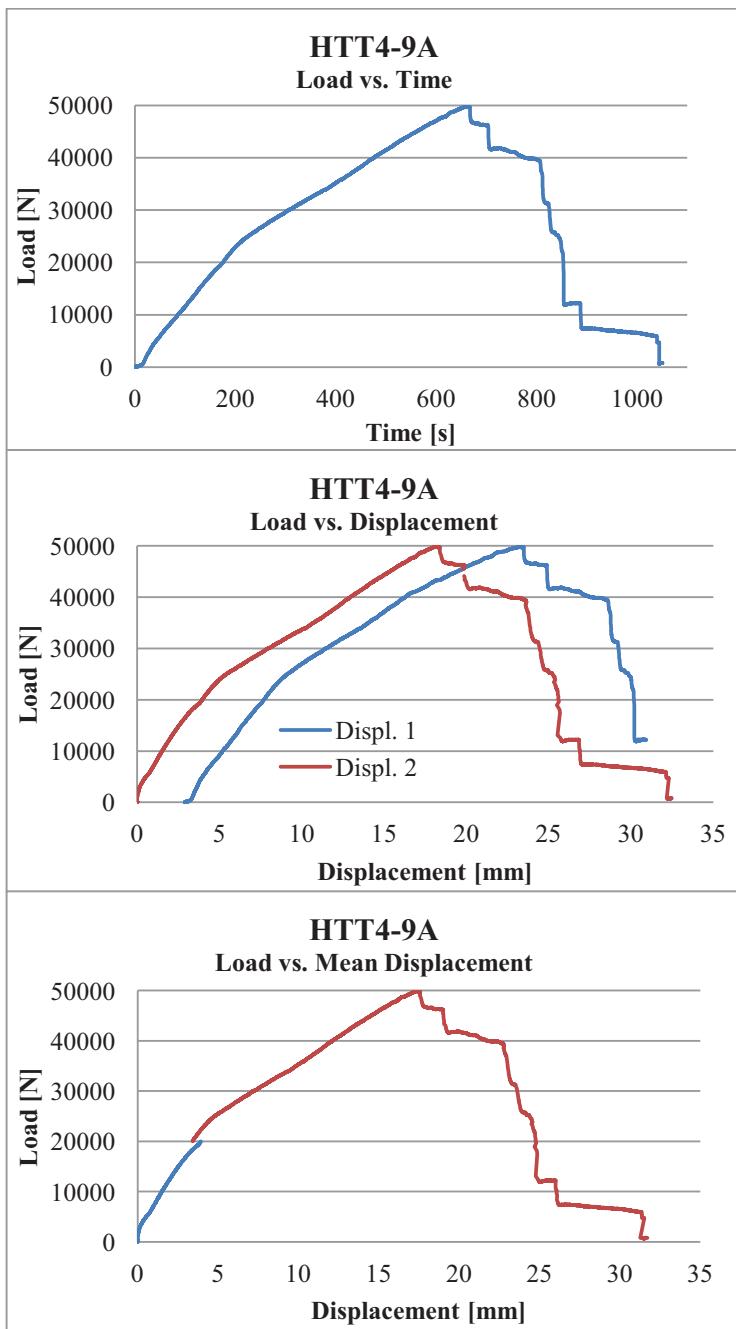
Failure	3a
Failure load [N]	53590
Displacement 1 [mm]	18.6
Displacement 2 [mm]	19.2
Mean Displacement [mm]	18.9
Moisture [%]	9.76
Density [kg/m ³]	456



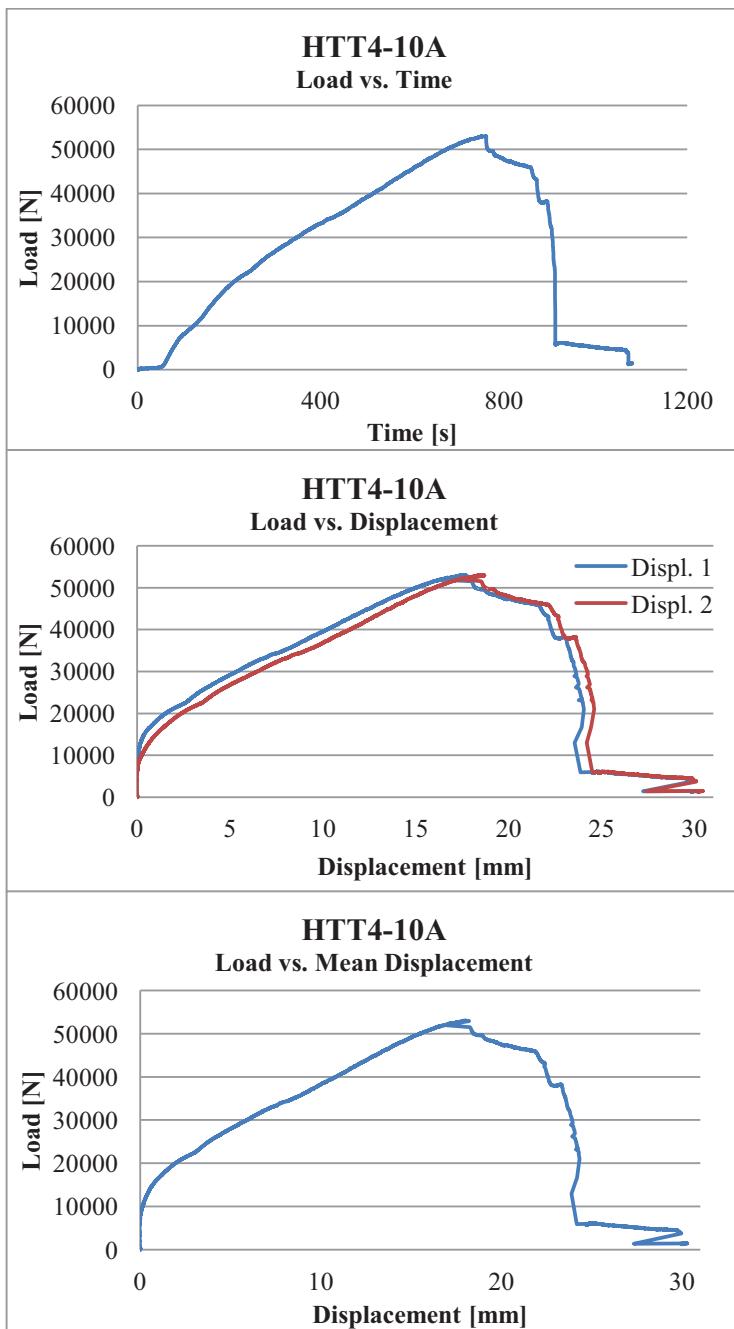
Failure	3a
Failure load [N]	41046
Displacement 1 [mm]	17.7
Displacement 2 [mm]	18.9
Mean Displacement [mm]	18.3
Moisture [%]	9.48
Density [kg/m ³]	440



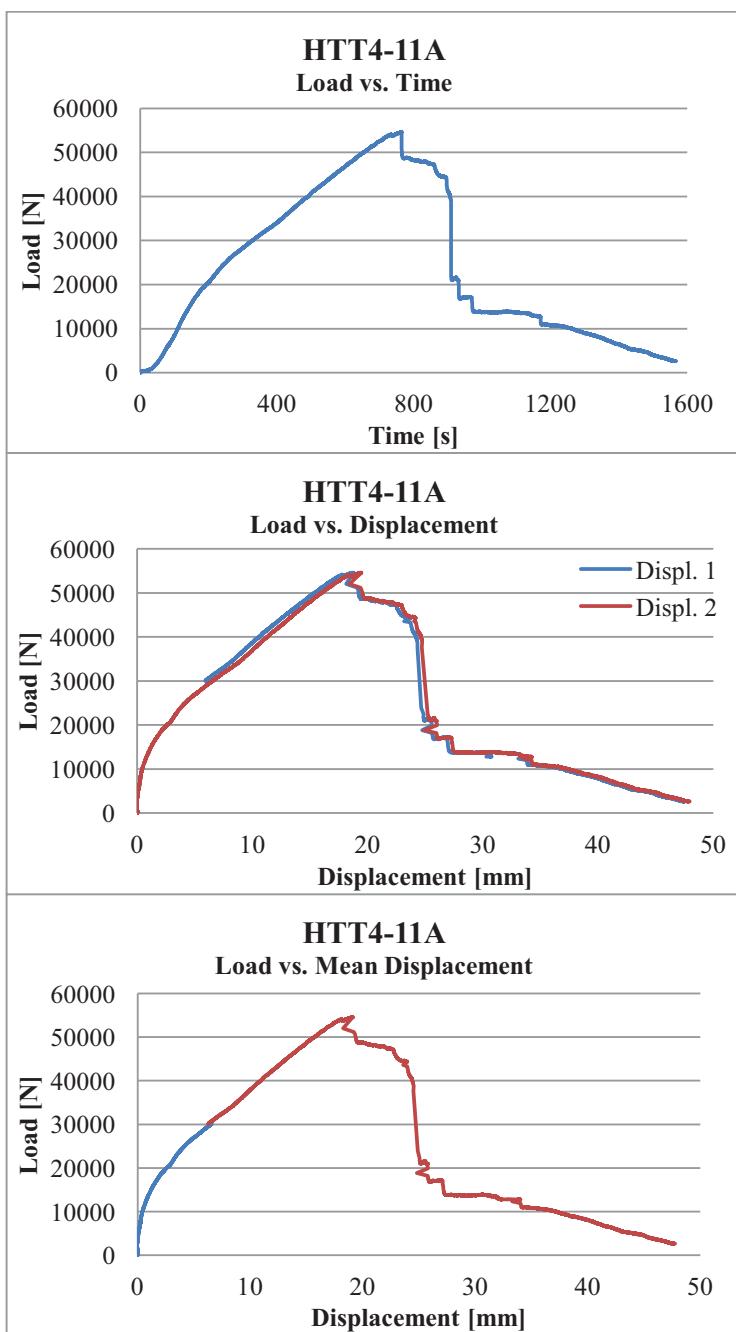
Failure	3a
Failure load [N]	37198
Displacement 1 [mm]	12.0
Displacement 2 [mm]	13.7
Mean Displacement [mm]	12.8
Moisture [%]	7.58
Density [kg/m ³]	336



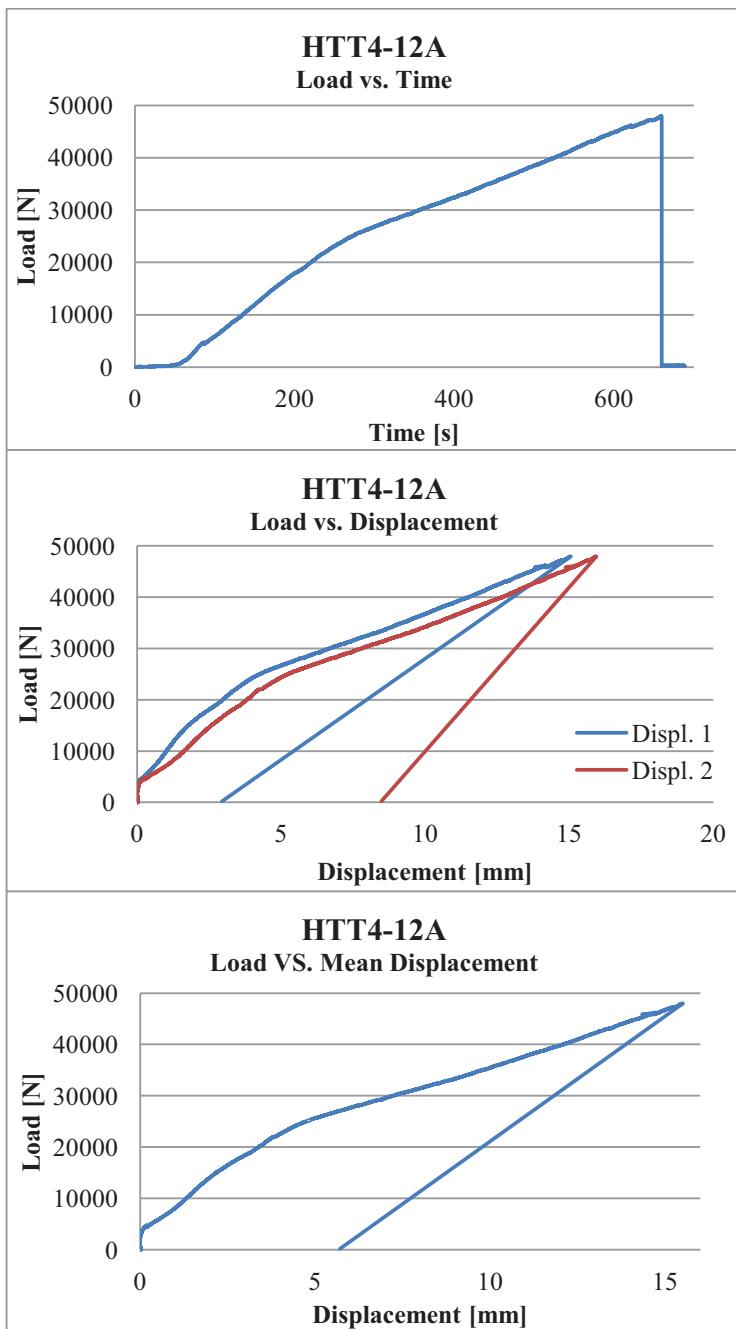
Failure	3a
Failure load [N]	49921
Displacement 1 [mm]	16.6
Displacement 2 [mm]	18.2
Mean Displacement [mm]	17.4
Moisture [%]	8.56
Density [kg/m ³]	409



Failure	3a
Failure load [N]	53022
Displacement 1 [mm]	17.5
Displacement 2 [mm]	18.4
Mean Displacement [mm]	18.0
Moisture [%]	9.57
Density [kg/m ³]	444

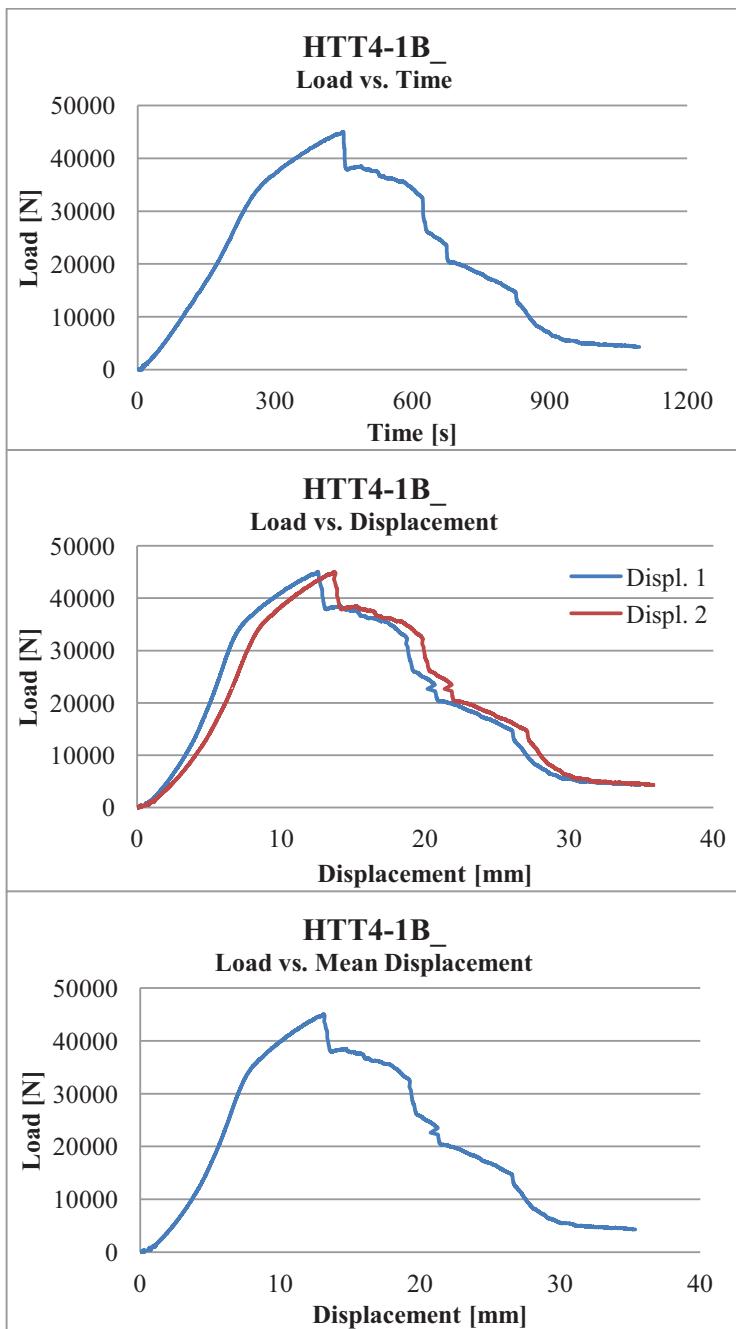


Failure	3a
Failure load [N]	54604
Displacement 1 [mm]	18.8
Displacement 2 [mm]	19.5
Mean Displacement [mm]	19.1
Moisture [%]	8.98
Density [kg/m ³]	458

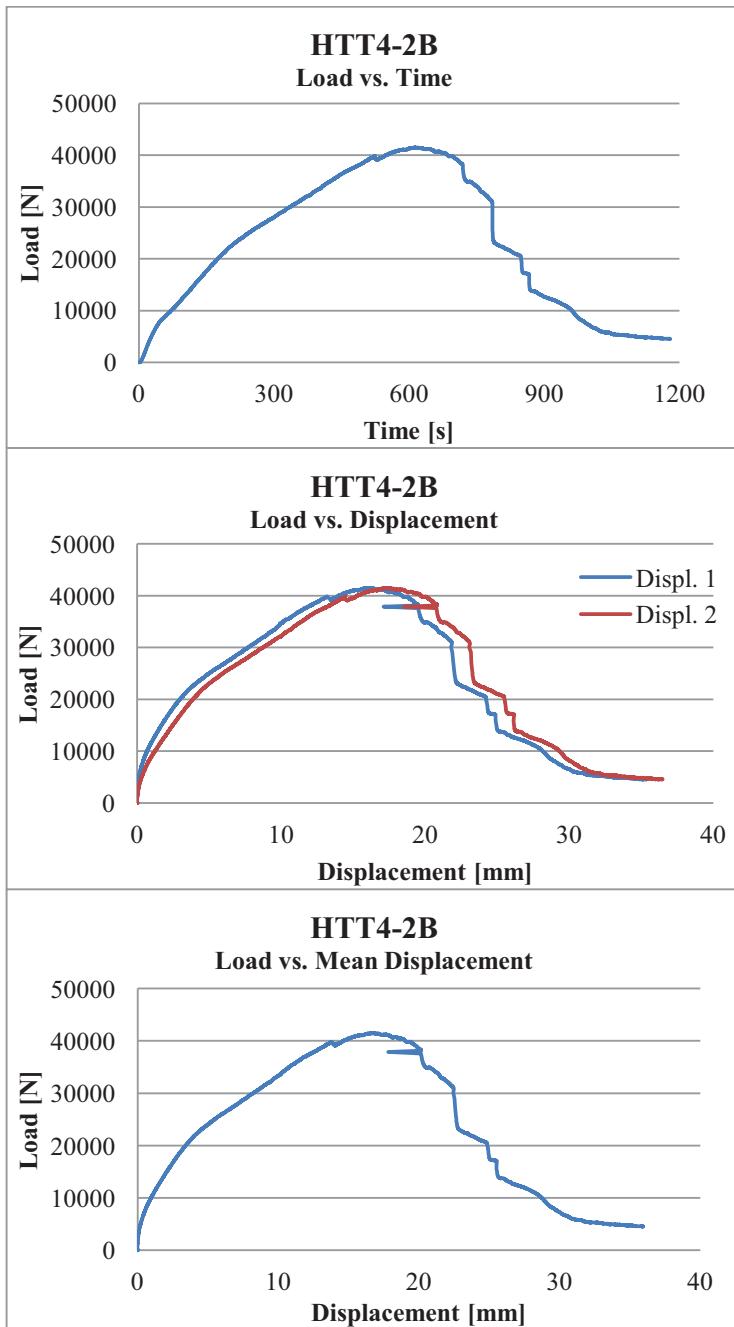


Failure	3b
Failure load [N]	47979
Displacement 1 [mm]	15.1
Displacement 2 [mm]	15.9
Mean Displacement [mm]	15.5
Moisture [%]	8.44
Density [kg/m ³]	369

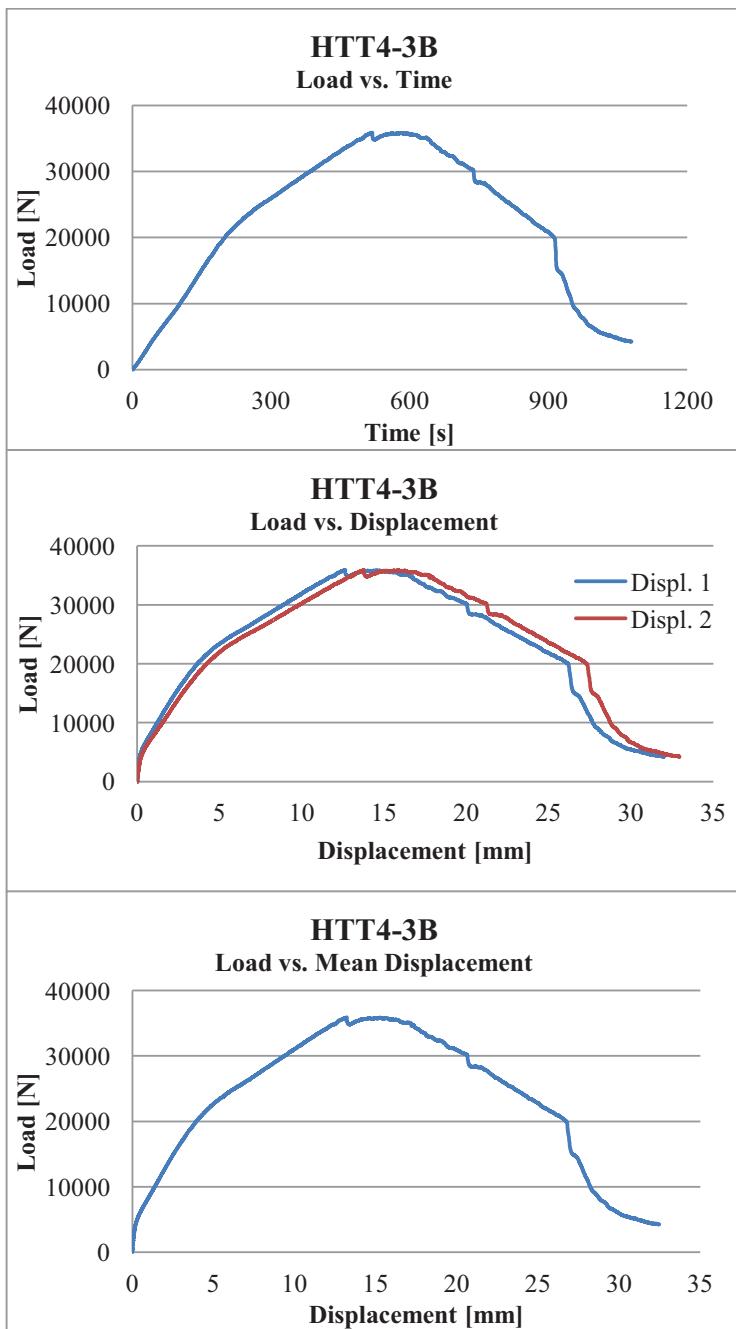
Set 2 – 18 annular ringed shank nails 4x40 on the stud and 1 bolt M16



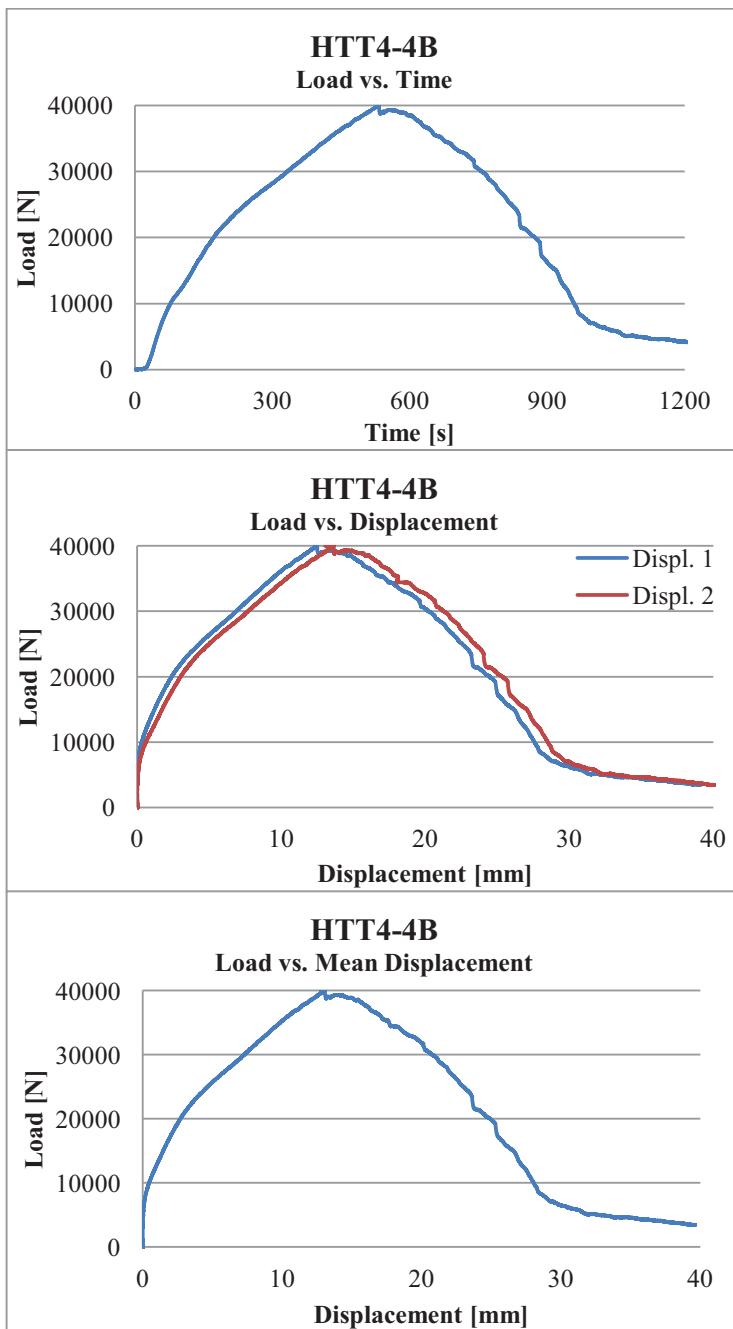
Failure	3a
Failure load [N]	45067
Displacement 1 [mm]	12.6
Displacement 2 [mm]	13.7
Mean Displacement [mm]	13.1
Moisture [%]	8.81
Density [kg/m ³]	383



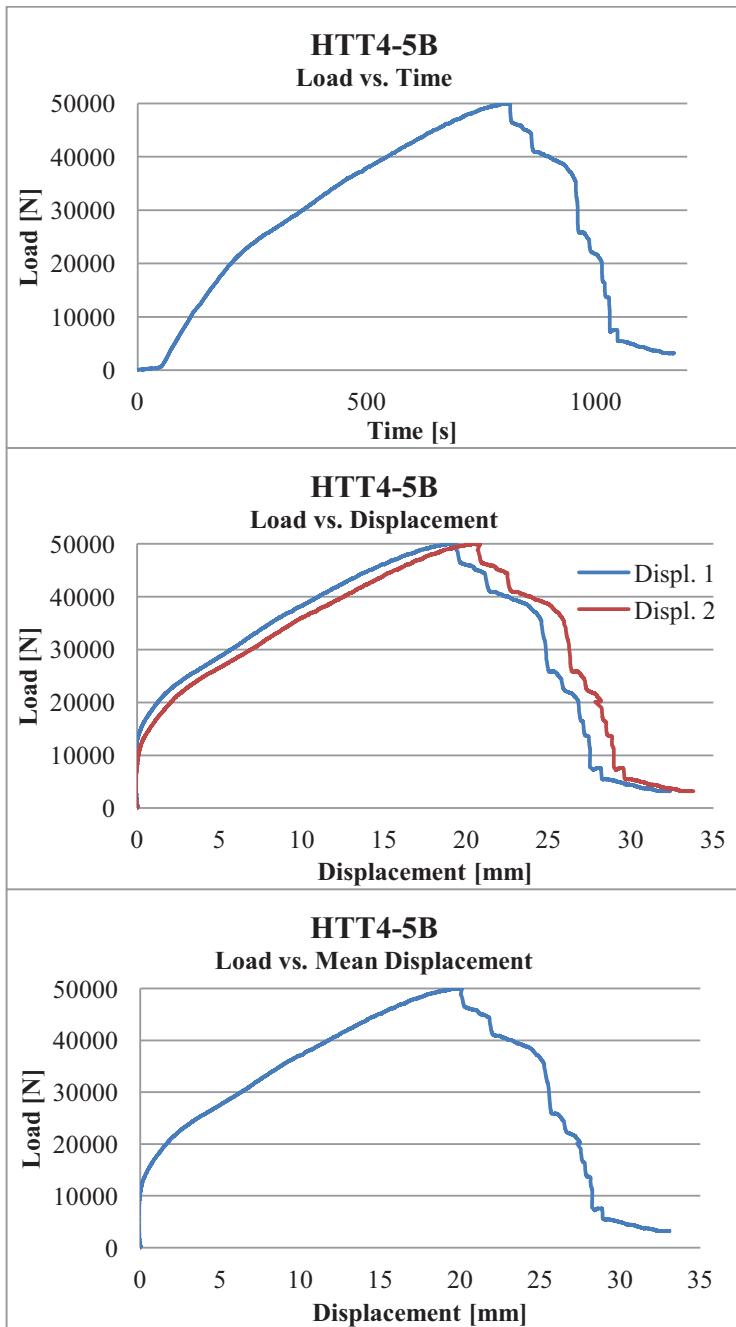
Failure	3a
Failure load [N]	41494
Displacement 1 [mm]	16.0
Displacement 2 [mm]	17.3
Mean Displacement [mm]	16.7
Moisture [%]	8.53
Density [kg/m ³]	400



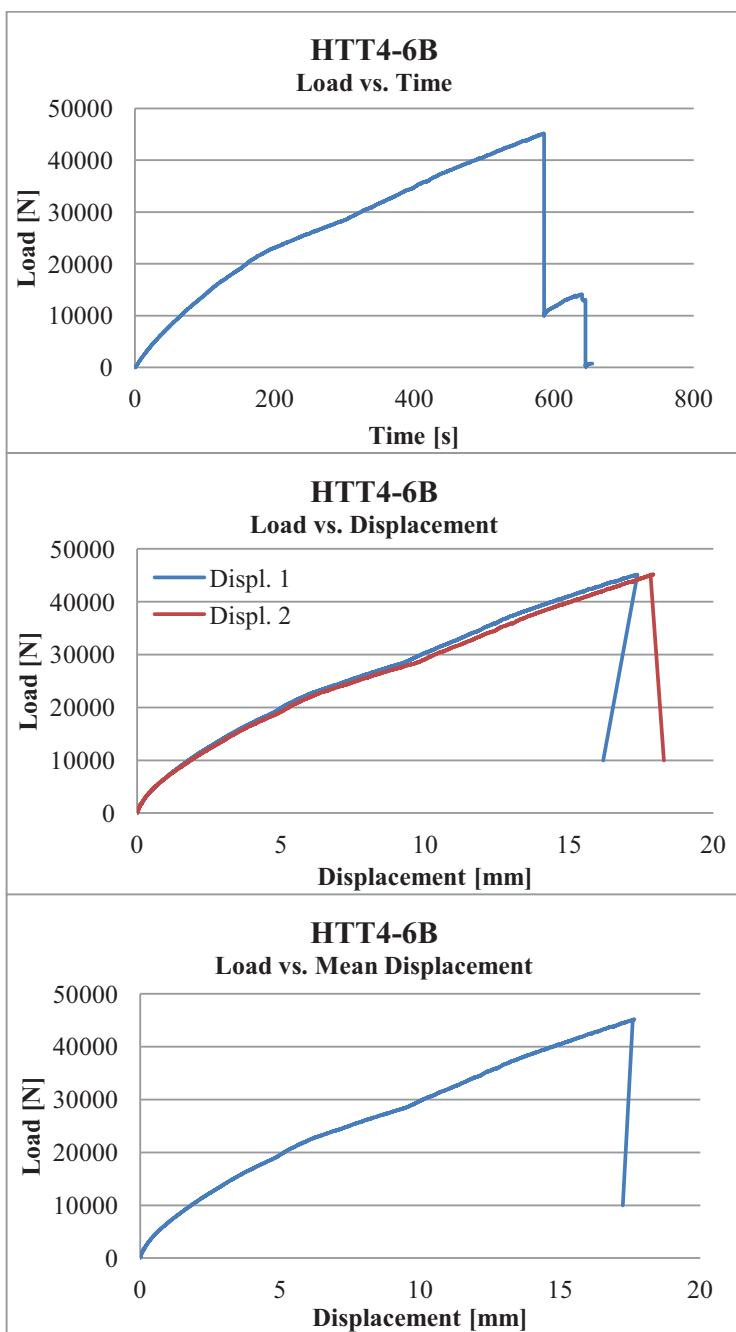
Failure	3a
Failure load [N]	35909
Displacement 1 [mm]	12.6
Displacement 2 [mm]	13.8
Mean Displacement [mm]	13.2
Moisture [%]	7.96
Density [kg/m ³]	330



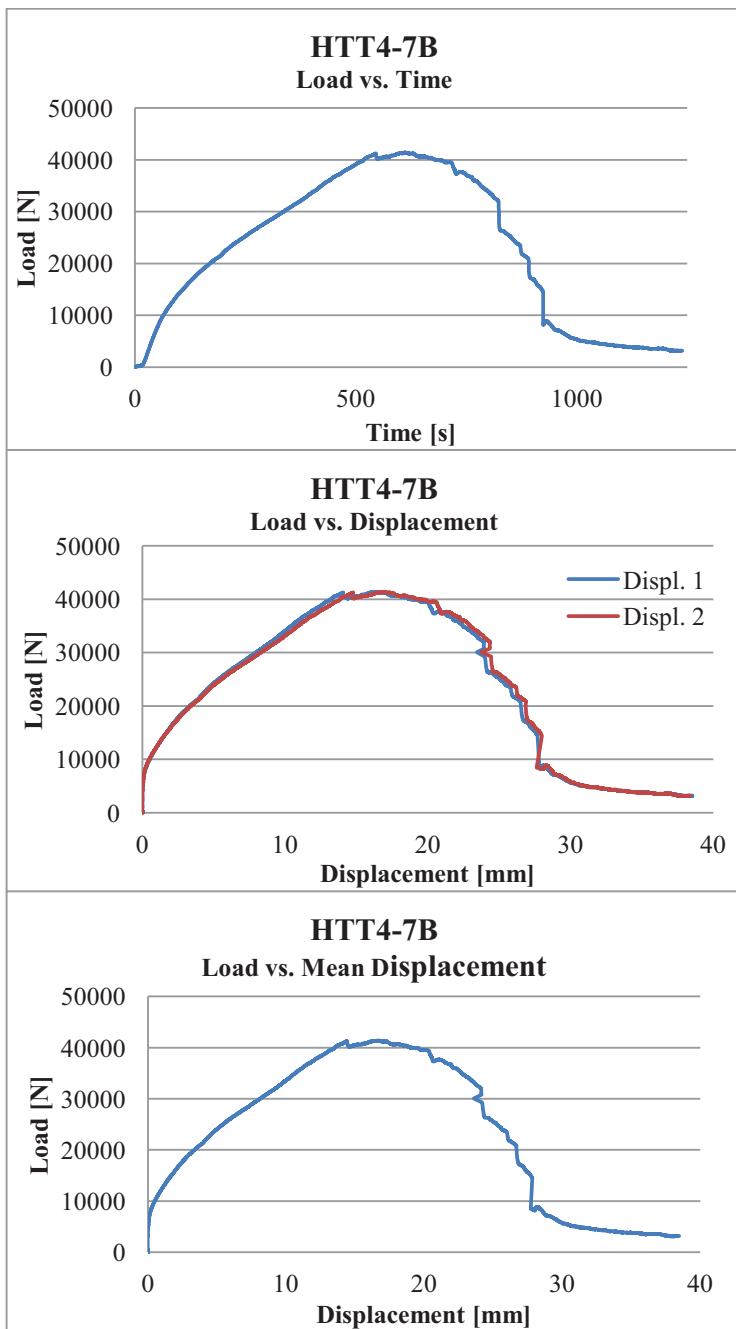
Failure	3a
Failure load [N]	40024
Displacement 1 [mm]	12.5
Displacement 2 [mm]	13.0
Mean Displacement [mm]	12.8
Moisture [%]	8.68
Density [kg/m ³]	379



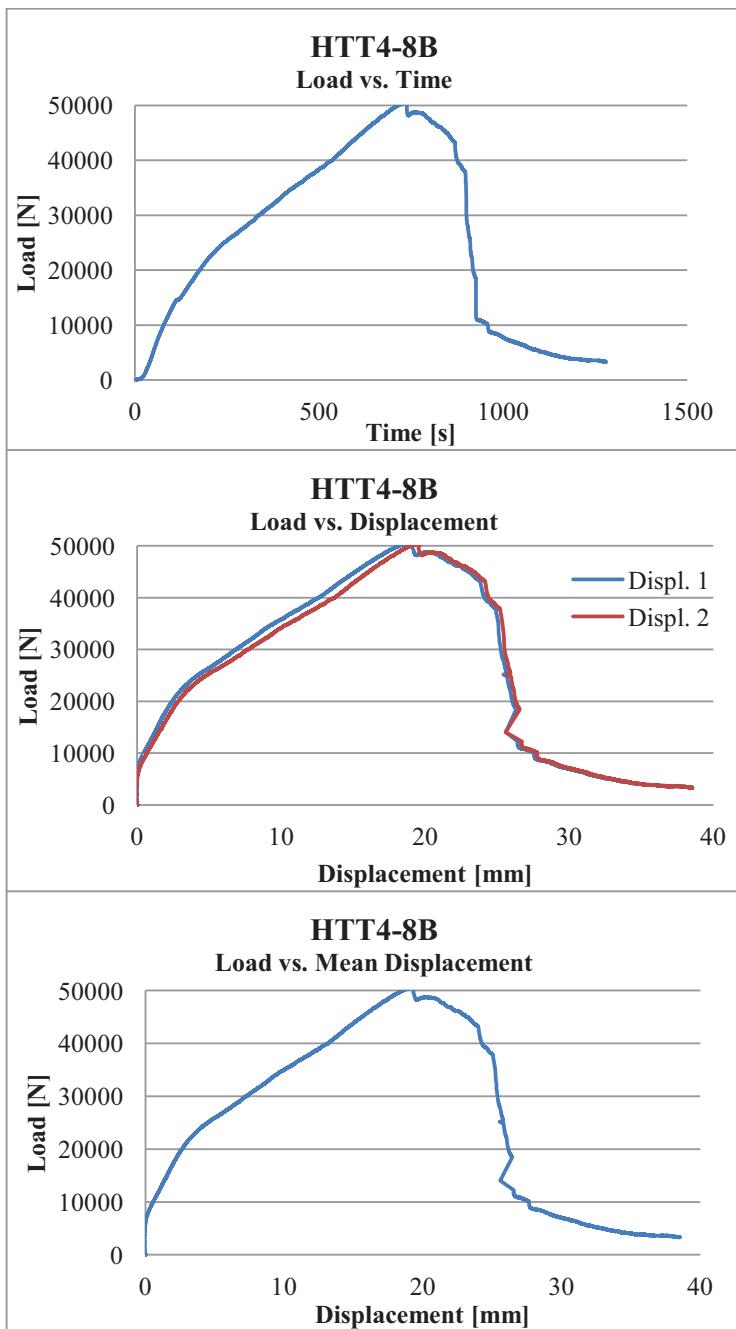
Failure	3a
Failure load [N]	50039
Displacement 1 [mm]	18.9
Displacement 2 [mm]	20.4
Mean Displacement [mm]	19.7
Moisture [%]	8.74
Density [kg/m ³]	396



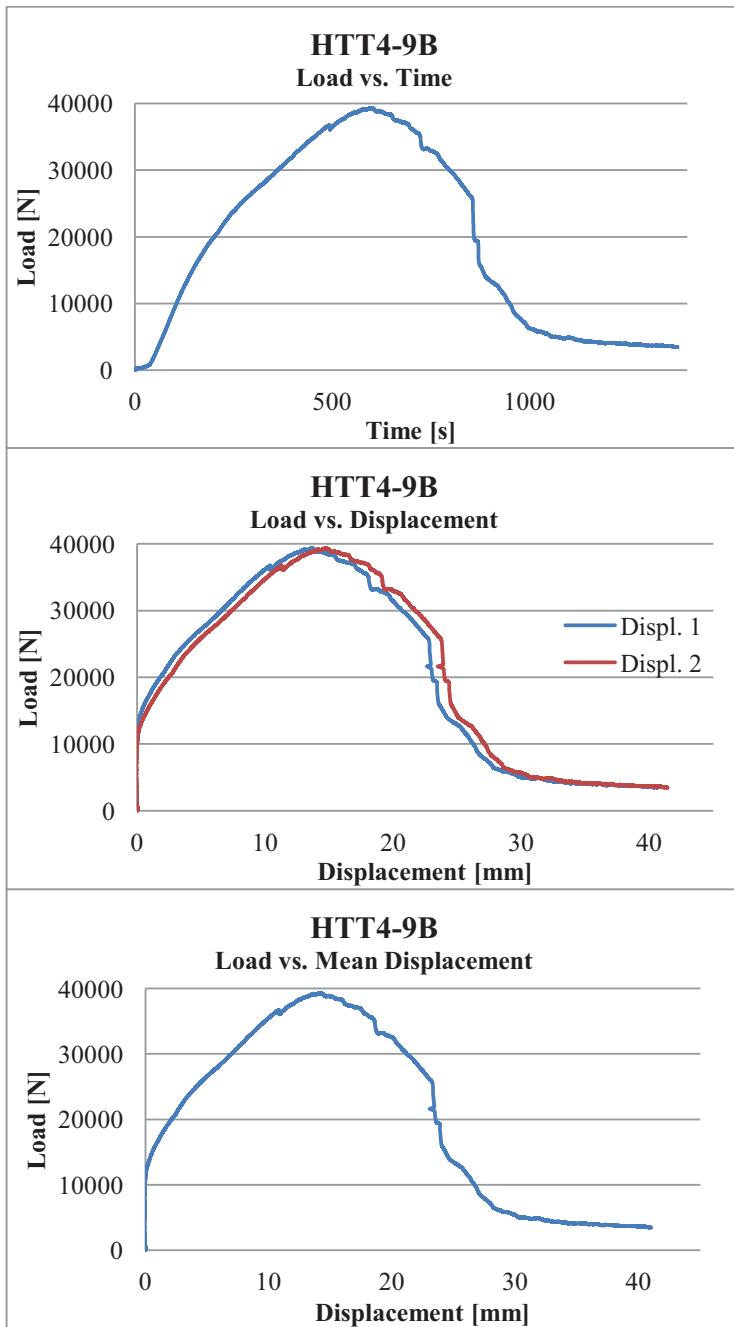
Failure	3b
Failure load [N]	45158
Displacement 1 [mm]	17.4
Displacement 2 [mm]	17.9
Mean Displacement [mm]	17.7
Moisture [%]	7.66
Density [kg/m ³]	385



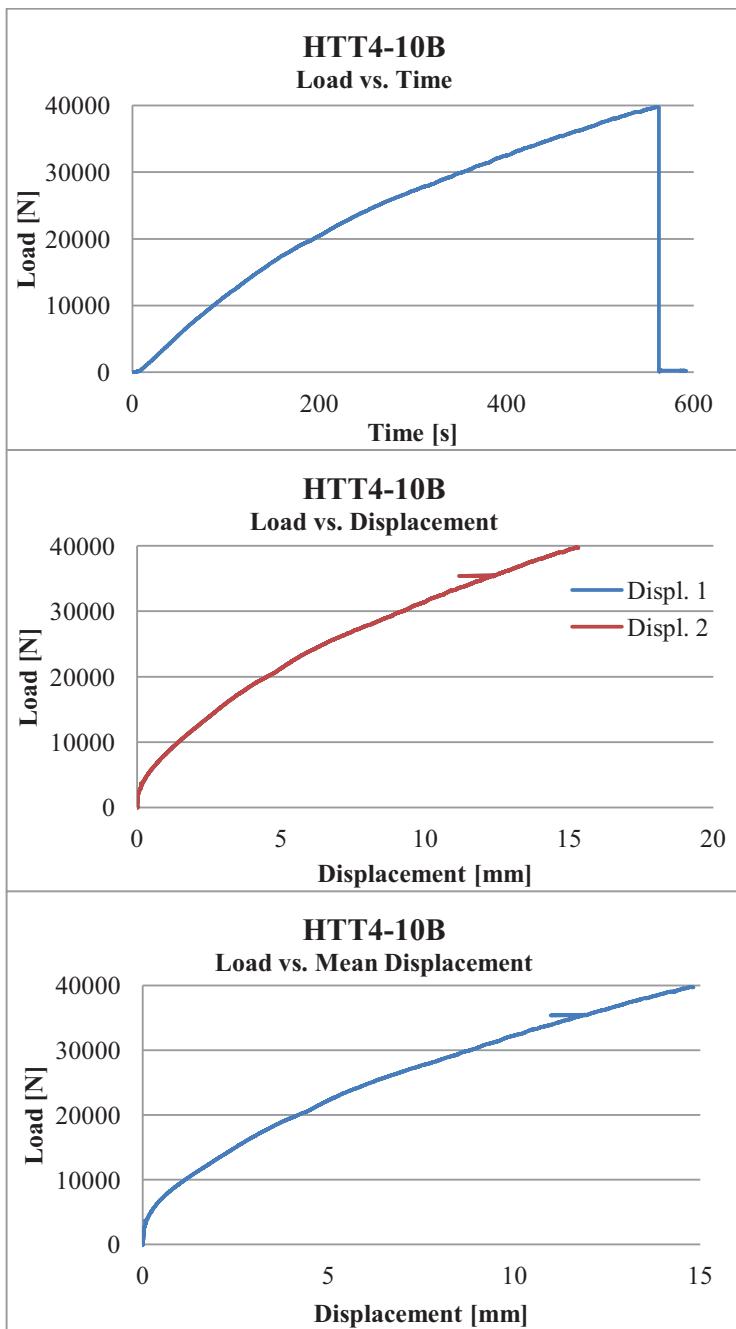
Failure	3a
Failure load [N]	41398
Displacement 1 [mm]	16.4
Displacement 2 [mm]	16.9
Mean Displacement [mm]	16.7
Moisture [%]	9.11
Density [kg/m ³]	450



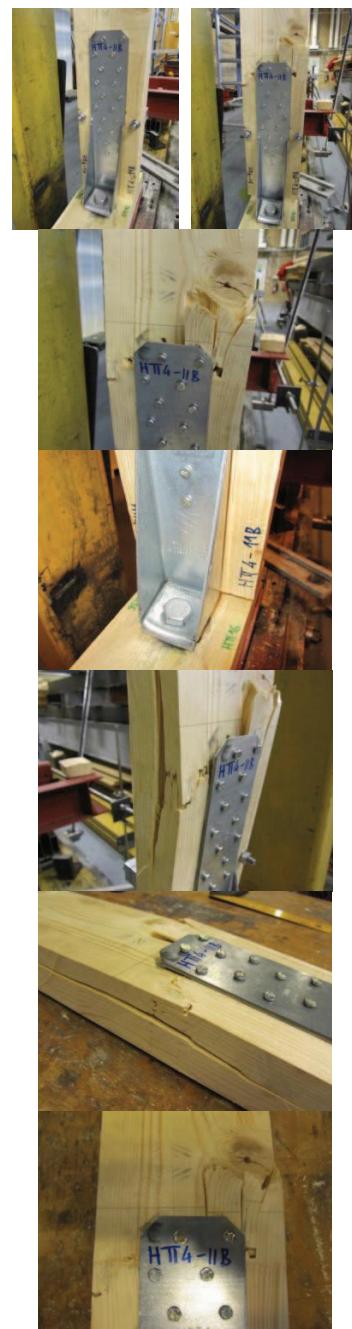
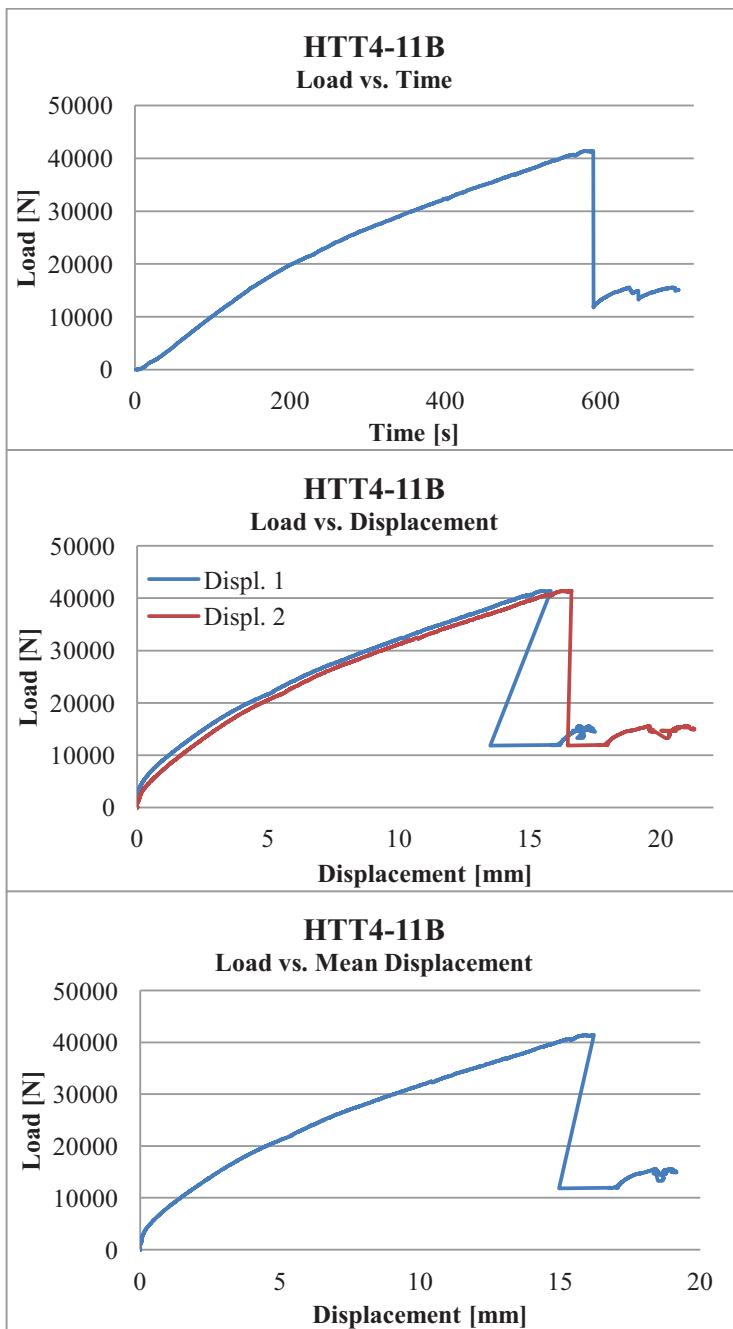
Failure	3a
Failure load [N]	50720
Displacement 1 [mm]	18.9
Displacement 2 [mm]	19.7
Mean Displacement [mm]	19.3
Moisture [%]	9.30
Density [kg/m ³]	425



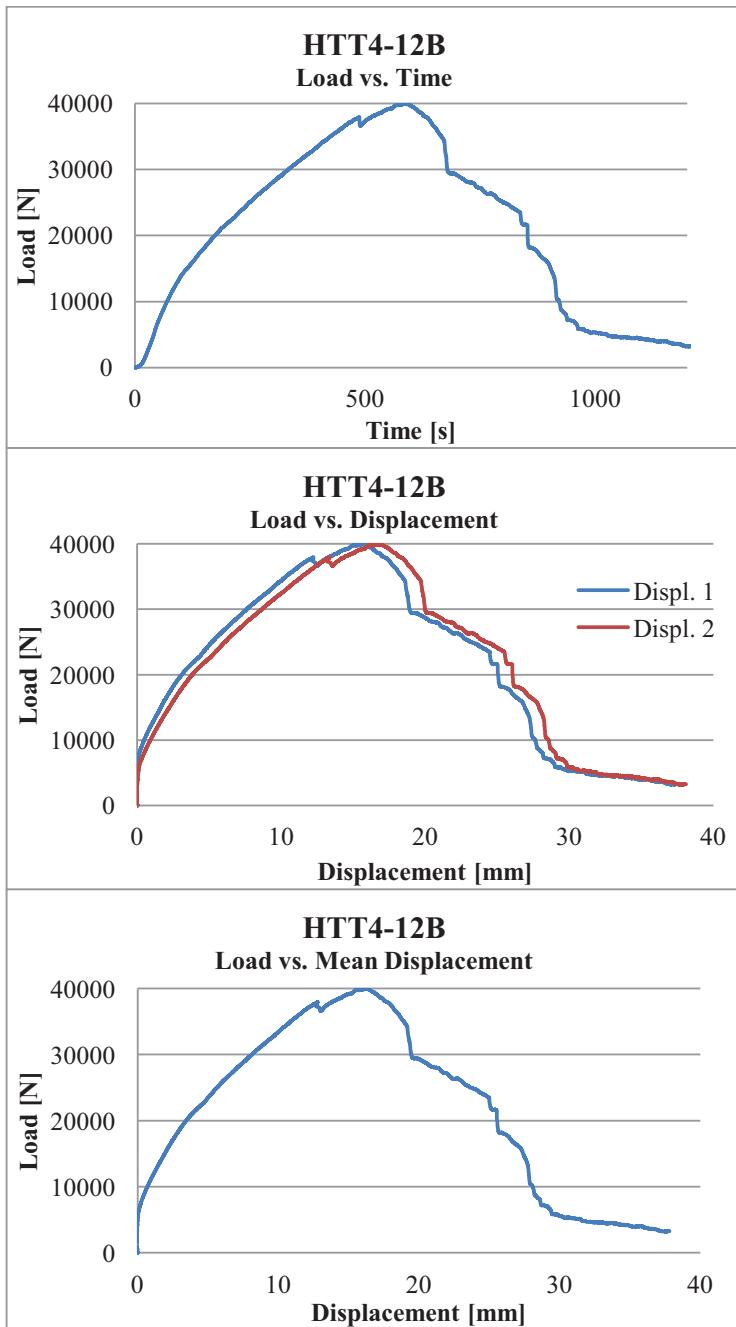
Failure	3a
Failure load [N]	39319
Displacement 1 [mm]	13.6
Displacement 2 [mm]	14.7
Mean Displacement [mm]	14.1
Moisture [%]	8.45
Density [kg/m ³]	395



Failure	3b
Failure load [N]	39760
Displacement 1 [mm]	14.3
Displacement 2 [mm]	15.3
Mean Displacement [mm]	14.8
Moisture [%]	8.81
Density [kg/m ³]	361



Failure	3b
Failure load [N]	41399
Displacement 1 [mm]	15.8
Displacement 2 [mm]	16.6
Mean Displacement [mm]	16.2
Moisture [%]	7.80
Density [kg/m ³]	387



Failure	3a
Failure load [N]	39979
Displacement 1 [mm]	15.8
Displacement 2 [mm]	16.9
Mean Displacement [mm]	16.3
Moisture [%]	8.68
Density [kg/m ³]	425

Appendix B – Chronological summary of the conduction of the tests

<i>Specimen</i>	<i>Construction date</i>	<i>Testing date</i>	<i>Dens. & Moist. C. Date</i>	<i>Comments</i>	<i>Failure mode</i>
AB55365-1A	25/02/2011	02/03/2011	11/03/2011	-	1
AB55365-2A	01/03/2011	02/03/2011	11/03/2011	-	1
AB55365-3A	01/03/2011	02/03/2011	11/03/2011	-	1
AB55365-4A	01/03/2011	02/03/2011	11/03/2011	-	1
AB55365-5A	01/03/2011	02/03/2011	11/03/2011	-	1
AB55365-6A	01/03/2011	02/03/2011	11/03/2011	-	1
AB55365-7A	01/03/2011	02/03/2011	11/03/2011	The LVDT number 1 did not work.	1
AB55365-8A	01/03/2011	02/03/2011	11/03/2011	-	1
AB55365-9A	01/03/2011	02/03/2011	11/03/2011	-	1
AB55365-10A	01/03/2011	02/03/2011	11/03/2011	-	1
AB55365-11A	01/03/2011	02/03/2011	11/03/2011	-	2
AB55365-12A	01/03/2011	02/03/2011	11/03/2011	-	1
AB55365-1B	14/02/2011	24/02/2011	25/03/2011	-	2
AB55365-2B	14/02/2011	24/02/2011	25/03/2011	The LVDT number 2 did not work.	2
AB55365-3B	14/02/2011	24/02/2011	25/03/2011	-	2
AB55365-4B	14/02/2011	24/02/2011	25/03/2011	-	2
AB55365-5B	14/02/2011	24/02/2011	25/03/2011	-	2
AB55365-6B	14/02/2011	24/02/2011	25/03/2011	-	2
AB55365-7B	14/02/2011	24/02/2011	25/03/2011	-	2
AB55365-8B	14/02/2011	24/02/2011	25/03/2011	-	2
AB55365-9B	14/02/2011	24/02/2011	25/03/2011	-	2
AB55365-10B	14/02/2011	01/03/2011	11/03/2011	The LVDT number 1 did not work.	2
AB55365-11B	14/02/2011	01/03/2011	11/03/2011	The LVDT number 1 did not work.	2
AB55365-12B	14/02/2011	01/03/2011	11/03/2011	-	2
ABR9020-1A	12/03/2011	14/03/2011	14/03/2011	The LVDT number 1 did not work.	2
ABR9020-2A	12/03/2011	14/03/2011	14/03/2011	-	2
ABR9020-3A	12/03/2011	14/03/2011	14/03/2011	-	2
ABR9020-4A	12/03/2011	14/03/2011	14/03/2011	-	2
ABR9020-5A	12/03/2011	14/03/2011	14/03/2011	-	2
ABR9020-6A	12/03/2011	14/03/2011	14/03/2011	-	2
ABR9020-7A	12/03/2011	15/03/2011	15/03/2011	-	2
ABR9020-8A	12/03/2011	15/03/2011	15/03/2011	-	2
ABR9020-9A	12/03/2011	15/03/2011	15/03/2011	-	2
ABR9020-10A	12/03/2011	15/03/2011	15/03/2011	-	2
ABR9020-11A	12/03/2011	15/03/2011	15/03/2011	-	2
ABR9020-12A	12/03/2011	15/03/2011	15/03/2011	-	2

ABR9020-1B	15/03/2011	18/03/2011	18/03/2011	-	2
ABR9020-2B	15/03/2011	18/03/2011	18/03/2011	The LVDT number 2 did not work.	2
ABR9020-3B	15/03/2011	18/03/2011	18/03/2011	-	2
ABR9020-4B	15/03/2011	18/03/2011	18/03/2011	-	2
ABR9020-5B	15/03/2011	18/03/2011	18/03/2011	-	2
ABR9020-6B	15/03/2011	18/03/2011	18/03/2011	-	2
ABR9020-7B	15/03/2011	18/03/2011	18/03/2011	-	2
ABR9020-8B	15/03/2011	18/03/2011	18/03/2011	-	2
ABR9020-9B	15/03/2011	18/03/2011	18/03/2011	-	2
ABR9020-10B	15/03/2011	18/03/2011	18/03/2011	The LVDT number 1 did not work.	2
ABR9020-11B	15/03/2011	18/03/2011	18/03/2011	The LVDT number 1 did not work.	2
ABR9020-12B	15/03/2011	18/03/2011	18/03/2011	-	2
ABR9020-1C	09/03/2011	09/03/2011	11/03/2011	By mistake the rate of this test was 5 mm/min instead 2 mm/min.	2
ABR9020-2C	09/03/2011	09/03/2011	11/03/2011	-	2
ABR9020-3C	09/03/2011	09/03/2011	11/03/2011	The LVDT number 1 did not work.	2
ABR9020-4C	09/03/2011	09/03/2011	11/03/2011	-	2
ABR9020-5C	09/03/2011	09/03/2011	11/03/2011	-	2
ABR9020-6C	09/03/2011	10/03/2011	11/03/2011	-	2
ABR9020-7C	09/03/2011	10/03/2011	11/03/2011	-	2
ABR9020-8C	09/03/2011	10/03/2011	11/03/2011	-	2
ABR9020-9C	09/03/2011	10/03/2011	11/03/2011	-	2
ABR9020-10C	09/03/2011	10/03/2011	11/03/2011	-	2
ABR9020-11C	09/03/2011	10/03/2011	11/03/2011	-	2
ABR9020-12C	09/03/2011	10/03/2011	11/03/2011	-	2
ABR9020-1D	18/03/2011	19/03/2011	19/03/2011	-	2
ABR9020-2D	18/03/2011	19/03/2011	19/03/2011	The LVDT number 1 did not work.	2
ABR9020-3D	18/03/2011	19/03/2011	19/03/2011	-	2
ABR9020-4D	18/03/2011	19/03/2011	19/03/2011	The LVDT number 1 did not work.	2
ABR9020-5D	18/03/2011	19/03/2011	19/03/2011	-	2
ABR9020-6D	18/03/2011	19/03/2011	19/03/2011	-	2
ABR9020-7D	18/03/2011	19/03/2011	19/03/2011	-	2
ABR9020-8D	18/03/2011	19/03/2011	19/03/2011	-	2
ABR9020-9D	18/03/2011	19/03/2011	19/03/2011	-	2
ABR9020-10D	18/03/2011	19/03/2011	19/03/2011	-	2
ABR9020-11D	18/03/2011	19/03/2011	19/03/2011	-	2
ABR9020-12D	18/03/2011	19/03/2011	19/03/2011	-	2
AKR135-1A	24/03/2011	24/03/2011	26/03/2011	-	3a

AKR135-2A	24/03/2011	25/03/2011	26/03/2011	The LVDT number 1 did not work.	3a
AKR135-3A	24/03/2011	25/03/2011	26/03/2011	By mistake recording the weight, the moisture was not measured.	3b
AKR135-4A	24/03/2011	25/03/2011	26/03/2011	-	3b
AKR135-5A	24/03/2011	25/03/2011	26/03/2011	-	3a
AKR135-6A	24/03/2011	25/03/2011	26/03/2011	-	3a
AKR135-7A	24/03/2011	25/03/2011	26/03/2011	The LVDT number 1 did not work.	3b
AKR135-8A	24/03/2011	25/03/2011	26/03/2011	The failure load is less than other tests, probably there was some problem in the specimen.	3b
AKR135-9A	24/03/2011	25/03/2011	26/03/2011	-	3a
AKR135-10A	24/03/2011	25/03/2011	26/03/2011	-	3b
AKR135-11A	24/03/2011	25/03/2011	26/03/2011	-	3a
AKR135-12A	24/03/2011	25/03/2011	26/03/2011	The LVDT number 1 after the failure did not work well.	3a
AKR135-1B	27/03/2011	28/03/2011	28/03/2011	The LVDT number 1 did not work.	3a
AKR135-2B	27/03/2011	28/03/2011	28/03/2011	The LVDT number 1 did not work.	3a
AKR135-3B	27/03/2011	28/03/2011	28/03/2011	-	3b
AKR135-4B	27/03/2011	28/03/2011	28/03/2011	The LVDT number 1 did not work.	3a
AKR135-5B	27/03/2011	28/03/2011	28/03/2011	-	3a
AKR135-6B	27/03/2011	28/03/2011	28/03/2011	-	3a
AKR135-7B	27/03/2011	28/03/2011	28/03/2011	-	3b
AKR135-8B	27/03/2011	28/03/2011	28/03/2011	-	3b
AKR135-9B	27/03/2011	28/03/2011	28/03/2011	-	3b
AKR135-10B	27/03/2011	28/03/2011	28/03/2011	-	3b
AKR135-11B	27/03/2011	28/03/2011	28/03/2011	The LVDT number 1 did not work after failure.	3b
AKR135-12B	27/03/2011	28/03/2011	28/03/2011	-	3b
HTT4-1A	07/04/2011	07/04/2011	07/04/2011	-	3a
HTT4-2A	07/04/2011	07/04/2011	07/04/2011	-	3a
HTT4-3A	07/04/2011	08/04/2011	08/04/2011	-	3a
HTT4-4A	07/04/2011	08/04/2011	08/04/2011	-	3a
HTT4-5A	07/04/2011	08/04/2011	08/04/2011	-	3a
HTT4-6A	07/04/2011	08/04/2011	08/04/2011	-	3a
HTT4-7A	07/04/2011	08/04/2011	08/04/2011	-	3a

HTT4-8A	07/04/2011	08/04/2011	08/04/2011	-	3a
HTT4-9A	07/04/2011	08/04/2011	08/04/2011	-	3a
HTT4-10A	07/04/2011	08/04/2011	08/04/2011	-	3a
HTT4-11A	07/04/2011	08/04/2011	08/04/2011	-	3a
HTT4-12A	07/04/2011	08/04/2011	08/04/2011	-	3b
HTT4-1B	09/04/2011	09/04/2011	10/04/2010	-	3a
HTT4-2B	09/04/2011	09/04/2011	10/04/2010	-	3a
HTT4-3B	09/04/2011	09/04/2011	10/04/2010	-	3a
HTT4-4B	09/04/2011	09/04/2011	10/04/2010	-	3a
HTT4-5B	09/04/2011	10/04/2010	10/04/2010	-	3a
HTT4-6B	09/04/2011	10/04/2010	10/04/2010	-	3b
HTT4-7B	09/04/2011	10/04/2010	10/04/2010	-	3a
HTT4-8B	09/04/2011	10/04/2010	10/04/2010	-	3a
HTT4-9B	09/04/2011	10/04/2010	10/04/2010	-	3a
HTT4-10B	09/04/2011	10/04/2010	10/04/2010	-	3b
HTT4-11B	09/04/2011	10/04/2010	10/04/2010	-	3b
HTT4-12B	09/04/2011	10/04/2010	10/04/2010	-	3a

Appendix C – Types of connector

Four different connectors were used during the tests.

- 1) Connector Simpson strong-tie AB 55365: steel angle connector (*Steel S250GD*) is used in small timber dimensions for timber joints or joints between timber beam and concrete. For fastening of timber used annular ringed shank nails CAN 4.0x40 mm or wooden screws CSA 5.0x40 mm. For fixing in concrete used a bolt M8.

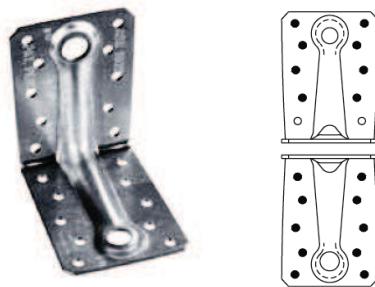
Dimension [mm]				Holes	
A	B	C	Thickness	\varnothing	Number
65	65	55	3	5 8.5	8+8 1+1



Connector AB 55365 has been used in Series 1.

- 2) Connector Simpson strong-tie ABR 9020: steel angle connector (*Steel S250GD*) is used for joints in load bearing timber structures. For fastening of timber used annular ringed shank nails CAN 4.0x40 mm or wooden screws CSA 5.0x40 mm. For fixing in concrete used a bolt M10.

Dimension [mm]				Holes	
A	B	C	Thickness	\varnothing	Number
90	90	65	2.5	5 11	10+10 1+1



Connector ABR 9020 has been used in Series 2.

- 3) Connector Simpson strong-tie AKR 135: steel angle connector (*Steel S235JR*) provided with edge rib reinforcement, which increases the fittings, stiffness and strength significantly. It is used to assemble of piece of timber on concrete. For fastening of timber used annular ringed shank nails CAN 4.0x40 mm or wooden screws CSA 5.0x40 mm. For fixing in concrete used a bolt M12.

Dimension [mm]				Holes	
A	B	C	Thickness	\varnothing	Number
135	85	65	4	5	14+2
				11	1
				13.5	1+1



Connector AKR 135 has been used in Series 3.

- 4) Connector Simpson strong-tie HTT4: steel angle connector (*Steel S235JR*) is used for anchoring the timber columns with concrete foundation. Fixing the column made with minimum 4 pieces of wooden screws CSA 5.0x40 mm. There must always nailed in the lower 4 holes. Connection at concrete foundation performed with bolt M16.

Dimension [mm]				Holes	
A	B	C	Thickness	\varnothing	Number
314	51	64	3 ⁽¹⁾ 12 ⁽²⁾	4.7 17.5	18 1

⁽¹⁾ Thickness of the vertical part of the connector

⁽²⁾ Thickness of the horizontal part of the connector



Connector HTT4 has been used in Series 4.

Appendix D – Statistical data of test results

LOAD											
Serie 1, Set 1	Serie 1, Set 2	Serie 2, Set 1	Serie 2, set 2	Serie 2, Set 3	Serie 2, Set 4	Serie 3, Set 1	Serie 3, Set 2	Serie 4, Set 1	Serie 4, Set 2		
5127,46	8975,25	9120,36	5061,03	10844,51	12458,13	31835,95	25043,32	26232,40	45067,32		
3629,96	8909,93	12377,81	7068,84	12803,72	11957,72	29184,64	29804,75	44514,99	41494,05		
6190,68	8540,95	10709,44	4955,87	10396,72	11452,86	31339,19	28842,40	52241,43	35909,28		
5617,80	9755,22	9503,48	5121,89	10396,11	11787,43	26732,37	33620,40	45584,26	40023,76		
5152,27	8980,89	10676,08	5148,22	9834,21	9954,87	34585,87	34296,13	36034,35	50038,62		
4628,05	8774,30	10144,86	6226,12	11560,23	10387,57	37122,77	29674,61	53589,54	45158,06		
6603,32	9675,52	9731,61	5306,26	8642,72	9650,09	35045,22	30309,11	41046,05	41397,81		
6904,47	8314,62	10871,80	7010,14	9088,48	12885,87	24612,81	30363,06	37197,57	50720,03		
6188,01	8414,77	12649,21	5945,34	11508,01	10650,04	27883,32	34980,40	49921,35	39319,18		
6523,06	7624,30	10870,12	4307,50	10781,11	10096,39	29111,24	30771,07	53022,33	39760,29		
7956,17	7366,91	11506,32	5702,93	9993,67	10967,21	34864,79	29782,06	54604,10	41399,18		
5547,34	8796,29	10669,74	4880,76	9937,90	12363,33	24044,28	29496,13	47979,00	39978,95		
5839,05	8677,41	10735,90	5561,24	10482,28	11217,63	30530,21	30581,95	45163,95	42522,21	Average	
1143,10	704,66	1065,24	856,11	1132,98	1084,81	4304,12	2688,03	8661,73	4421,41	St. Dev.	
19,58%	8,12%	9,92%	15,39%	10,81%	9,67%	14,10%	8,79%	19,18%	10,40%	Coeff. Of Var.	
3507,13	7239,91	8562,82	3814,79	8170,99	9004,61	21749,80	25098,38	27494,02	33502,54	Char. Value 0,05 [N]	
DENSITY											
Serie 1, Set 1	Serie 1, Set 2	Serie 2, Set 1	Serie 2, set 2	Serie 2, Set 3	Serie 2, Set 4	Serie 3, Set 1	Serie 3, Set 2	Serie 4, Set 1	Serie 4, Set 2		
327,00	469,97	392,16	401,91	399,61	480,27	404,73	356,51	386,60	383,22		
297,79	418,88	459,29	483,96	440,65	466,09	409,62	388,74	326,79	399,90		
336,60	420,33	402,13	421,10	377,28	477,38	391,73	451,67	413,61	329,95		
375,68	436,72	387,44	395,27	373,56	491,79	378,16	483,06	432,75	379,49		
374,80	505,75	417,99	475,66	398,50	412,99	419,36	443,57	327,21	396,15		
373,25	421,45	372,71	457,19	480,77	406,90	375,75	366,76	456,35	385,41		
371,73	458,88	396,86	390,56	367,21	402,03	481,49	382,22	439,99	449,72		
384,94	416,20	415,77	441,66	372,44	404,42	356,67	529,94	335,56	425,22		
425,54	450,69	422,05	407,56	467,42	464,93	356,73	437,88	409,22	394,93		
375,11	386,46	390,65	435,99	426,68	406,30	366,83	380,62	443,92	361,13		
427,12	392,95	444,94	443,08	410,34	430,36	375,10	361,41	457,95	386,72		
401,67	414,55	387,24	385,72	413,03	495,66	430,62	371,79	368,63	424,97		
372,60	432,74	407,44	428,30	410,63	444,93	395,56	412,85	399,88	393,07	Average	
37,86	33,77	25,51	33,22	37,43	37,62	36,23	55,52	49,89	31,20	St. Dev.	
10,16%	7,80%	6,26%	7,76%	9,11%	8,46%	9,16%	13,45%	12,48%	7,94%	Coeff. Of Var.	
295,37	363,85	355,40	360,54	334,28	368,17	321,66	299,59	298,10	329,42	Char. Value 0,05 [kg/m³]	

MOISTURE											
Serie 1, Set 1	Serie 1, Set 2	Serie 2, Set 1	Serie 2, set 2	Serie 2, Set 3	Serie 2, Set 4	Serie 3, Set 1	Serie 3, Set 2	Serie 4, Set 1	Serie 4, Set 2		
8,95	7,99	9,75	9,71	9,24	10,58	9,97	9,84	7,91	8,81		
8,85	7,89	9,97	8,29	8,23	9,36	9,45	9,87	8,11	8,53		
8,38	6,43	10,43	9,15	8,94	9,36		8,53	8,50	7,96		
7,31	7,17	10,33	11,19	8,41	8,34	10,47	12,84	9,18	8,68		
8,92	7,20	9,39	8,81	8,97	7,64	9,28	9,23	7,24	8,74		
8,23	9,33	11,01	10,20	8,60	10,97	10,22	8,97	9,76	7,66		
8,32	8,49	8,98	9,32	8,80	7,54	10,04	12,64	9,48	9,11		
8,34	6,32	8,53	9,67	9,51	8,11	9,79	9,23	7,58	9,30		
8,24	7,83	8,52	10,65	10,20	8,97	9,62	11,42	8,56	8,45		
8,72	6,87	7,36	10,75	9,29	9,08	10,94	8,58	9,57	8,81		
8,21	7,18	9,24	8,67	8,77	9,78	8,72	9,70	8,98	7,80		
7,12	8,13	9,86	8,85	9,67	8,54	9,96	9,44	8,44	8,68		
8,30	7,57	9,45	9,60	9,05	9,02	9,86	10,03	8,61	8,54	Average	
0,58	0,87	1,00	0,92	0,56	1,07	0,60	1,48	0,81	0,50	St. Dev.	
6,97%	11,54%	10,60%	9,62%	6,20%	11,88%	6,07%	14,71%	9,39%	5,90%	Coeff. Of Var.	
7,12	5,79	7,40	7,72	7,91	6,84	8,62	7,02	6,96	7,52	Char. Value 0,05 [%]	
DISPLAC. 1											
Serie 1, Set 1	Serie 1, Set 2	Serie 2, Set 1	Serie 2, set 2	Serie 2, Set 3	Serie 2, Set 4	Serie 3, Set 1	Serie 3, Set 2	Serie 4, Set 1	Serie 4, Set 2		
5,72	2,35		3,41	4,44	5,74	8,86		4,79	12,56		
4,96	1,64	6,59	4,25	4,17				15,59	16,01		
11,05	1,51	5,11	3,41		4,75		8,21	16,59	12,63		
6,58	2,06	4,29	4,47	4,67	4,98	6,45		13,20	12,49		
6,33	1,83	5,39	1,92	3,50	3,60	14,43	12,62	11,63	18,91		
7,41	0,87	4,92	5,30	6,29	5,65	12,59	8,73	18,55	17,37		
9,87	1,85	4,45	4,14	2,17	2,92		11,19	17,74	16,42		
11,13	1,63	4,55	5,61	4,09	4,66	4,22	9,05	12,03	18,93		
9,07	1,33	8,04	4,75	4,72	3,58	10,50	15,19	16,59	13,59		
11,91	6,94	4,28		6,27	3,25	7,53	9,02	17,47	14,25		
12,51	6,74	6,84		5,55	4,65	10,65	10,74	18,76	15,80		
5,36	9,30	4,16	5,09	4,77	5,74	4,63	11,61	15,06	15,75		
8,49	3,17	5,33	4,24	4,60	4,50	8,87	10,71	14,83	15,39	Average	
2,75	2,80	1,28	1,10	1,19	1,02	3,50	2,25	3,97	2,32	St. Dev.	
32,34%	88,28%	24,02%	25,86%	25,88%	22,70%	39,41%	21,02%	26,75%	15,07%	Coeff. Of Var.	
2,89	-2,54	2,68	1,94	2,14	2,39	1,39	5,89	6,74	10,66	Char. Value 0,05 [mm]	
DISPLAC. 2											
Serie 1, Set 1	Serie 1, Set 2	Serie 2, Set 1	Serie 2, set 2	Serie 2, Set 3	Serie 2, Set 4	Serie 3, Set 1	Serie 3, Set 2	Serie 4, Set 1	Serie 4, Set 2		
5,40		4,55	3,25	4,33	7,07	8,76	7,73	6,71	13,71		
4,87		5,53		5,37	7,51	8,02	8,62	16,37	17,31		
10,58		4,78	3,23	4,30	5,20	7,74	7,87	18,00	13,79		
6,62		4,66	4,80	5,09	5,26	4,84	14,64	14,13	13,03		
6,34		4,80	2,07	3,44	4,73	12,05	11,81	12,46	20,40		
7,34		4,00	5,55	6,05	5,77	12,94	8,71	19,22	17,92		
9,50		4,25	4,13	2,76	3,83	8,04	10,68	18,90	16,90		
10,36		3,95	5,63	5,36	5,79	3,17	8,83	13,66	19,72		
9,36		8,00	5,23	5,03	4,58	10,50	15,22	18,16	14,66		
11,55	6,75	5,37	5,34	7,11	4,00	6,91	8,62	18,43	15,26		
	6,30	5,59	8,11	4,48	5,03	10,69	10,03	19,45	16,58		
5,53	9,14	4,68	5,16	5,49	7,02	4,34	10,26	15,94	16,90		
7,95	7,40	5,01	4,77	4,90	5,48	8,17	10,25	15,95	16,35	Average	
2,38	1,53	1,08	1,60	1,15	1,20	3,05	2,49	3,73	2,34	St. Dev.	
29,96%	20,61%	21,61%	33,48%	23,53%	21,87%	37,37%	24,30%	23,39%	14,33%	Coeff. Of Var.	
3,02	2,53	2,80	1,46	2,55	3,04	1,94	5,17	8,34	11,57	Char. Value 0,05 [mm]	
MEAN DISPL.											
Serie 1, Set 1	Serie 1, Set 2	Serie 2, Set 1	Serie 2, set 2	Serie 2, Set 3	Serie 2, Set 4	Serie 3, Set 1	Serie 3, Set 2	Serie 4, Set 1	Serie 4, Set 2		
5,56			3,33	4,39	6,41	8,81		5,75	13,13		
4,91		6,06		4,77				15,98	16,66		
10,82		4,94	3,32		4,97		8,04	17,29	13,21		
6,60		4,48	4,63	4,88	5,12	5,65		13,67	12,76		
6,34		5,09	2,00	3,47	4,17	13,24	12,21	12,05	19,65		
7,38		4,46	5,43	6,17	5,71	12,77	8,72	18,89	17,65		
9,68		4,35	4,13	2,47	3,37		10,94	18,32	16,66		
10,75		4,25	5,62	4,73	5,23	3,69	8,94	12,84	19,32		
9,22		8,02	4,99	4,88	4,08	10,50	15,20	17,37	14,13		
11,73	6,85	4,83		6,69	3,62	7,22	8,82	17,95	14,76		
	6,52	6,21		5,01	4,84	10,67	10,39	19,10	16,19		
5,45	9,22	4,42	5,12	5,13	6,38	4,49	10,93	15,50	16,33		
8,04	7,53	5,19	4,29	4,78	4,90	8,56	10,47	15,39	15,87	Average	
2,47	1,47	1,15	1,20	1,14	1,02	3,51	2,23	3,85	2,33	St. Dev.	
30,68%	19,57%	22,15%	27,97%	23,88%	20,85%	40,98%	21,33%	24,99%	14,65%	Coeff. Of Var.	
2,93	2,83	2,81	1,72	2,42	2,79	1,05	5,69	7,55	11,13	Char. Value 0,05 [mm]	

References

- [1] Källsner B., and Girhammar U.A. Plastic design of partially anchored wood-framed wall diaphragms with and without openings, Proceedings CIB-W18 Meeting, Karlsruhe, Paper 38-15-7, 2005.