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Insulcon Cladding Bending, Shear and Fastener Testing

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CSIRO

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EXECUTIVE SUMMARY

1. Insulcon Pty Ltd required spanning capabilities and fixing requirements for their 40 mm thick Expanded Polystyrene (EPS) cladding product. Based upon tests performed at CSIRO in relation to the Insulcon system, the spanning and fixing requirements for the cladding were calculated.

2. After rationalising and allowing for capacity of the 40 mm thick Insulcon panel system in bending and shear, the following recommendations are made:

Maximum fastener spacings for given stud spacings for various wind classifications for 40 mm thick Insulcon cladding system remote from joints.

Stud Spacing (mm)	Location (mm)	Maximum fastener spacing (mm) Wind classification to AS 4055					
		N1	N2	N3	N4	N5	N6
450	**within 1200 of building edge**	600	400	300	200	150	NS
	elsewhere	600	600	600	400	250	200
600	**within 1200 of building edge**	400	400	250	NS	NS	NS
	elsewhere	600	600	400	300	200	NS

NS - denotes Not Suitable (exceeds strength limits of the 40 mm thick Insulcon cladding system).

A quality assurance system is required for the manufacture and installation of the system to ensure that the performance of the product is similar to that of the prototype test specimens.

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INSULCON CLADDING BENDING, SHEAR AND FASTENER TESTING

1. INTRODUCTION

Insulcon Pty Ltd required spanning capabilities and fixing requirements for their 40 mm thick Expanded Polystyrene (EPS) cladding product. Based upon tests performed at CSIRO in relation to the Insulcon cladding system, the spanning and fixing requirements for the cladding were calculated.

2. PRODUCT DESCRIPTION

The Insulcon cladding system as tested at CSIRO consisted of a 5 mm x 5 mm self adhesive fibre mesh applied to 40 mm thick EPS backing board which was fixed to pine timber studs. The mesh was coated with a primer which would normally be coated with render but for the current tests, no render was applied. The unrendered panel was fixed to the timber stud frame under 40 mm diameter plastic washers using a 75 mm long 10 gauge (4.8 mm outside diameter) Class 3 timber screw, about 30 mm into the studs.

3. BENDING AND SHEAR TESTS

3.1 Bending tests

Twelve bending test specimens were fabricated by Insulcon Pty Ltd. These specimens were 575 mm long x 300 mm wide with the fibre mesh on one side only. Details of the bending test are shown in Figure 1.

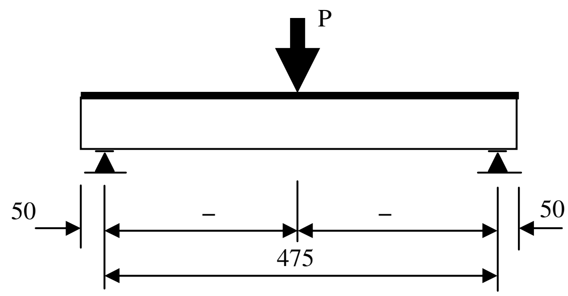

Figure 1 Bending test arrangement

Six bending tests were conducted with the fibre mesh side in compression i.e. on the top side (as shown in Figure 1), and six with the fibre mesh on the underside. Refer to Appendix A for photographs of bending test set up.

3.2 Shear tests

Eight shear test specimens were fabricated by Insulcon Pty Ltd. These specimens were 805 mm long x 300 mm wide with the fibre mesh on the top side only. The specimens were fixed to a timber frame with three supports (studs) in a similar manner to that specified by Insulcon Pty Ltd, including 2 plastic washered screws per stud. A load was applied 50 mm from the face of the central stud to provide a nominal shear force. Details of the shear test are shown in Figure 2 below.

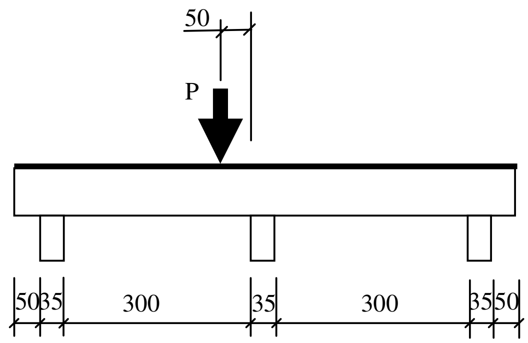

Figure 2 Shear test arrangement

Refer to Appendix A for photograph of shear test set up.

3.3 Fixing tests

3.3.1 Fixing test without joint

Five fixing test specimens without a joint were fabricated by Insulcon Pty Ltd. These specimens were 500 mm long x 250 mm wide with the fibre mesh on one side only. The specimens were fixed to a timber stud with one fixing in a similar manner to that specified by Insulcon Pty Ltd including a single plastic washered screw. The panel was held down and a load applied to the stud in order to attempt to pull the fixing through the panel. Details of the fixing test are shown in Figure 3 below.

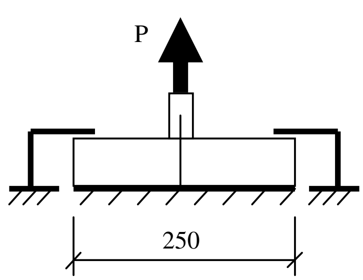

Figure 3 Fixing test arrangement without a joint

3.3.2 Fixing test with joint

3.3.2.1 Single fixing with joint

Five fixing test specimens with a joint incorporating a single screw fixing were fabricated by Insulcon Pty Ltd. These specimens were 500 mm long x 250 mm wide with a butt joint running along the centreline of the stud and the fibre mesh on one side only. The specimens were fixed to a timber stud with one fixing in a similar manner to that specified by Insulcon Pty Ltd in the middle of the butt joint including a single plastic washered screw. The panel was held down and a load applied to the stud in order to attempt to pull the fixing through the panel. Details of the fixing test are shown in Figure 4 below.

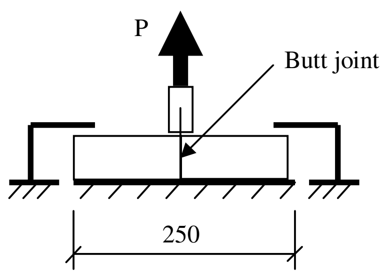

Figure 4 Fixing test arrangement with joint and single fixing

Refer to Appendix A for photograph of fixing test set up.

3.3.2.2 Double fixing with joint

Five fixing test specimens with a joint incorporating a double screw fixing were fabricated by Insulcon Pty Ltd. These specimens were 500 mm long x 250 mm wide with a butt joint running along the centreline of the stud and the fibre mesh on one side only. The specimens were fixed to a timber stud with two fixings in a similar manner to that specified by Insulcon Pty Ltd including two plastic washered screws. The panel was held down and a load applied to the stud in order to attempt to pull the fixing through the panel. Details of the fixing test are shown in Figure 5 below.

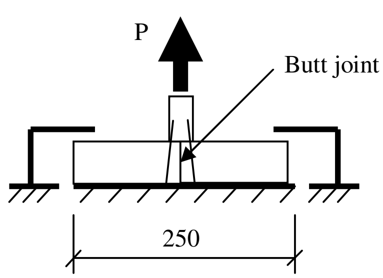

Figure 5 Fixing test arrangement with a joint and double fixing

Refer to Appendix A for photograph of fixing test set up.

4. SYSTEM CAPACITIES

4.1 Bending capacity between and over studs

Tables 1 and 2 below show the results of the bending testing giving the ultimate bending moment M_{ult}.

Table 1. Bending test results where fibre mesh was in tension

Specimen No.	Maximum load (kN)	M_{ult} (kNm)
B12RIT	0.490	0.058
B11RIT	0.509	0.061
B10RIT	0.495	0.059
B9RIT	0.522	0.062
B8RIT	0.522	0.062
B7RIT	0.543	0.065
	Mean	0.061
	SD	0.002
	COV	0.038

Table 2. Bending test results where fibre mesh was in compression

Specimen No.	Maximum load (kN)	M_{ult} (kNm)
B6RIC	0.522	0.062
B5RIC	0.475	0.057
B4RIC	0.461	0.055
B3RIC	0.505	0.060
B2RIC	0.418	0.050
B1RIC	0.505	0.060
	Mean	0.057
	SD	0.005
	COV	0.079

Refer to Appendix B for photographs of the specimens after testing. Plots of all the tests are given in Appendix C.

The lower of the above results i.e. where fibre mesh is in compression, were the ones used in the subsequent strength analysis. The evaluation of these results to determine a design capacity for use in limit states design was based on methods inferred in a range of Australian standards for structures used for a variety of building materials.

Coefficient of variation of test $V_{test} = 0.079$

Coefficient of variation of construction $V_{const} = 0.050$ (estimate)

Coefficient of variation of material $V_{mat} = 0.150$ (estimate)

$$V_{total} = \sqrt{0.079^2 + 0.05^2 + 0.15^2}$$
$$= 0.177$$

Sampling factor 1.54 from AS 4100 Supplement 1 [2] Table C17.5.2 for V=17.7% and 6 units tested.

Design moment capacity $\phi M = \dfrac{0.050}{1.54 \times 0.3}$
= 0.108 kNm/m width.

The 0.3 in the denominator is to convert the bending moment from that of the 300 mm wide test specimen to one for a 1 metre width.

It was assumed that the Insulcon panel would be supported on at least two studs in any installation. The Insulcon panel may be a single simply supported span or it may be continuous over two or more spans. The bending moment for the continuous case is the same as for the simply supported case. The limit states design uniformly distributed wind load capacity of the Insulcon cladding system for bending was determined as follows:

For 450 mm stud spacing (clear span 415 mm assuming 35 mm thick stud)

$M^* \leq \phi M$

where

M^* = design bending moment

ϕM = design moment capacity

$$w_u = \frac{8M^*}{l^2}$$

where

w_u = limit states design wind load

l = clear span between studs

$$w_u = \frac{8 \times 0.108}{0.415^2}$$

$= \underline{5.02\text{ kPa}}$

For 600 mm stud spacing (clear span 565 mm assuming 35 mm thick stud)

$$w_u = \frac{8 \times 0.108}{0.565^2}$$
$= \underline{2.71\text{ kPa}}$

4.2 Shear capacity adjacent to stud

Table 3 below show the results of the shear testing giving the ultimate shear force V_{ult}.

Table 3. Shear test results

Specimen No.	**V_{ult} (kN)**
S8	0.861
S7	0.920
S6	0.743
S5	0.831
S4	0.811
S3	0.972
S2	0.911
S1	0.779
Mean	0.854
SD	0.077
COV	0.090

Refer to Appendix B for photographs of the specimens after testing. Plots of all the tests are given in Appendix C.

The evaluation of these results to determine a design capacity for use in limit states design was based on methods inferred in a range of Australian standards for structures used for a variety of building materials.

Coefficient of variation of test $V_{test} = 0.090$

Coefficient of variation of construction $V_{const} = 0.050$ (estimate)

Coefficient of variation of material $V_{mat} = 0.150$ (estimate)

$$V_{total} = \sqrt{0.090^2 + 0.05^2 + 0.15^2}$$
$$= 0.182$$

Sampling factor 1.50 from AS 4100 Supplement 1 [2] Table C17.5.2 for V=18.2% and 8 units tested.

Design shear capacity
$$\phi V = \frac{0.743}{1.50 \times 0.3}$$
= 1.65 kN/m width.

The 0.3 in the denominator is to convert the shear from that of the 300 mm wide test specimen to one for a 1 metre width.

The limit states design uniformly distributed wind load capacity of the Insulcon cladding system for shear was determined as follows:

For 450 mm stud spacing (clear span 415 mm assuming 35 mm thick stud)

$V^* \leq \phi V$

where

V^* = design shear

ϕV = design shear capacity

$$w_u = \frac{2V^*}{l}$$

$$w_u = \frac{2 \times 1.65}{0.415}$$
= <u>7.96 kPa</u>

For 600 mm stud spacing (clear span 565 mm assuming 35 mm thick stud)

$$w_u = \frac{2\times1.65}{0.565}$$
$$= \underline{5.84\text{ kPa}}$$

Therefore shear capacity is much greater than bending capacity.

4.3 Fixing capacity

Table 4 below shows the results of the fastener testing giving the ultimate strength of each fastener without a joint.

Table 4. Fastener test results without a joint

Specimen No.	Maximum load all (kN)	Maximum load F3-F5 (kN)
F5	0.70	0.70
F4	0.79	0.79
F3	0.78	0.78
F2	0.56*	
F1	0.45*	
Mean	0.66	0.76
SD	0.148	0.049
COV	0.225	0.064

* these results were discarded due to premature failure from excessive hold down spacing

Refer to Appendix B for photographs of the specimens after testing.

The evaluation of these results to determine a design capacity for use in limit states design was based on methods inferred in a range of Australian standards for structures used for a variety of building materials.

Coefficient of variation of test $V_{test} = 0.07$

Coefficient of variation of construction $V_{const} = 0.05$ (estimate)

Coefficient of variation of material $V_{mat} = 0.15$ (estimate)

$$V_{total} = \sqrt{0.07^2 + 0.05^2 + 0.15^2}$$
$$= 0.173$$

Sampling factor — 1.98 from AS 4100 Supplement 1 [2] Table C17.5.2 for V=17.3% and 3 units tested.

Design fastener capacity — $$\phi V = \frac{0.70}{1.98}$$
$$= 0.35 \text{ kN}$$

Tables 5 and 6 below show the results of the fastener testing giving the ultimate strength of each fastener with a joint.

Table 5. Fastener test results with a joint and single fixing

Specimen No.	**Maximum load (kN)**
FJS5	0.98
FJS4	1.01
FJS3	1.01
FJS2	0.99
FJS1	0.95
Mean	0.99
SD	0.025
COV	0.025

Table 6. Fastener test results with a joint and double fixing

Specimen No.	**Maximum load (kN)**
FJD5	0.84
FJD4	1.00
FJD3	0.95
FJD2	1.00
FJD1	0.99
Mean	0.95
SD	0.066
COV	0.069

Refer to Appendix B for photographs of the specimens after testing.

The lower of the above results i.e. the joint with the double fixing, were the ones used in the subsequent strength analysis. The evaluation of these results to determine a design capacity for use in limit states design was based on methods inferred in a range of Australian standards for structures used for a variety of building materials.

Coefficient of variation of test $V_{test} = 0.07$

Coefficient of variation of construction $V_{const} = 0.05$ (estimate)

Coefficient of variation of material $V_{mat} = 0.15$ (estimate)

$$V_{total} = \sqrt{0.07^2 + 0.05^2 + 0.15^2}$$
$$= 0.173$$

Sampling factor 1.56 from AS 4100 Supplement 1 [2] Table C17.5.2 for V=17.3% and 5 units tested.

Design fastener capacity

$$\phi V = \frac{0.84}{1.56}$$
$$= 0.53 \text{ kN}$$

5. SYSTEM LOADS

The system has not been tested for fatigue loading, therefore only non-cyclonic loading will be considered. The non-cyclonic design gust wind speeds for ultimate limit state design are as follows:

V_z =	34	40	50	61	74	86	m/s
	(W28)	(W33)	(W41)	(W50)	(W60)	(W70)	Industry classification (Qld)
	(N1)	(N2)	(N3)	(N4)	(N5)	(N6)	AS 4055 classification
q_z =	0.69	0.96	1.50	2.23	3.38	4.44	kPa

Local pressure factor K_l from AS1170.2

Area supported by fastener = 0.6 x 0.6
= 0.36 m^2

Assuming building width of say 12 m

a = 0.2 x 12
= 2.4 m

$0.25 \times a^2 = 1\ m^2 > 0.36\ m^2 \Rightarrow$ SA2 $\Rightarrow K_l = 2.0$ within 1.2 m of building edge
and 1.0 elsewhere

C_{pe}= 0.65 x 2= 1.3   0.65
C_{pi} = 0.2 = 0.2   0.2
1.5 - C_p combined within 1.2 m of building edge   0.85 - C_p combined elsewhere

p_z = 1.03 1.44 2.25 3.35 5.07 6.66 kPa within 1.2 m of building edge

p_z = 0.59 0.82 1.23 1.90 2.87 3.77 kPa elsewhere

6. FASTENER SPACINGS

Spacings of fasteners so the above pressures p_z do not exceed the design capacity of the fastener of 0.35 kN are given in the table below:

Table 7. Maximum fastener spacings for given stud spacings for various wind classifications.

Stud Spacing (mm)	Location (mm)	N1	N2	N3	N4	N5	N6
450	within 1200 of building edge	755	540	346	232	153	117
	elsewhere	1318	949	632	409	271	206
600	within 1200 of building edge	566	405	259	174	115	88
	elsewhere	989	711	474	307	203	155

After rationalising and allowing for the bending and shear capacity of the Insulcon cladding system spanning between and over studs, the following recommendations are made:

Table 8. Maximum fastener spacings for given stud spacings for various wind classifications after rationalisation and accounting for the bending and shear strength of the 40 mm thick Insulcon cladding system.

Stud Spacing (mm)	Location (mm)	N1	N2	N3	N4	N5	N6
450	within 1200 of building edge	600	400	300	200	150	NS
	elsewhere	600	600	600	400	250	200
600	within 1200 of building edge	400	400	250	NS	NS	NS
	elsewhere	600	600	400	300	200	NS

NS - denotes Not Suitable (exceeds strength limits of the 40 mm thick Insulcon cladding system).

7. CONCLUSIONS AND RECOMMENDATIONS

After rationalising and allowing for capacity of the 40 mm thick Insulcon panel system in bending and shear, the following recommendations are made:

Table 9. Maximum fastener spacings for given stud spacings for various wind classifications for 40 mm thick Insulcon cladding system.

Stud Spacing (mm)	Location (mm)	Maximum fastener spacing (mm)					
		Wind classification to AS 4055					
		N1	N2	N3	N4	N5	N6
450	within 1200 of building edge	600	400	300	200	150	NS
	elsewhere	600	600	600	400	250	200
600	within 1200 of building edge	400	400	250	NS	NS	NS
	elsewhere	600	600	400	300	200	NS

NS - denotes Not Suitable (exceeds strength limits of the 40 mm thick Insulcon cladding system).

A quality assurance system is required for the manufacture and installation of the system to ensure that the performance of the product is similar to that of the prototype test specimens.

8. REFERENCES

1. Standards Australia/Standards New Zealand. Structural design actions Part 2: Wind actions. Australian/New Zealand Standard AS/NZS 1170.2 - 2002.

2. Standards Australia. Wind loads for housing. Australian Standard AS 4055 - 2006.

APPENDIX A

Test set ups.

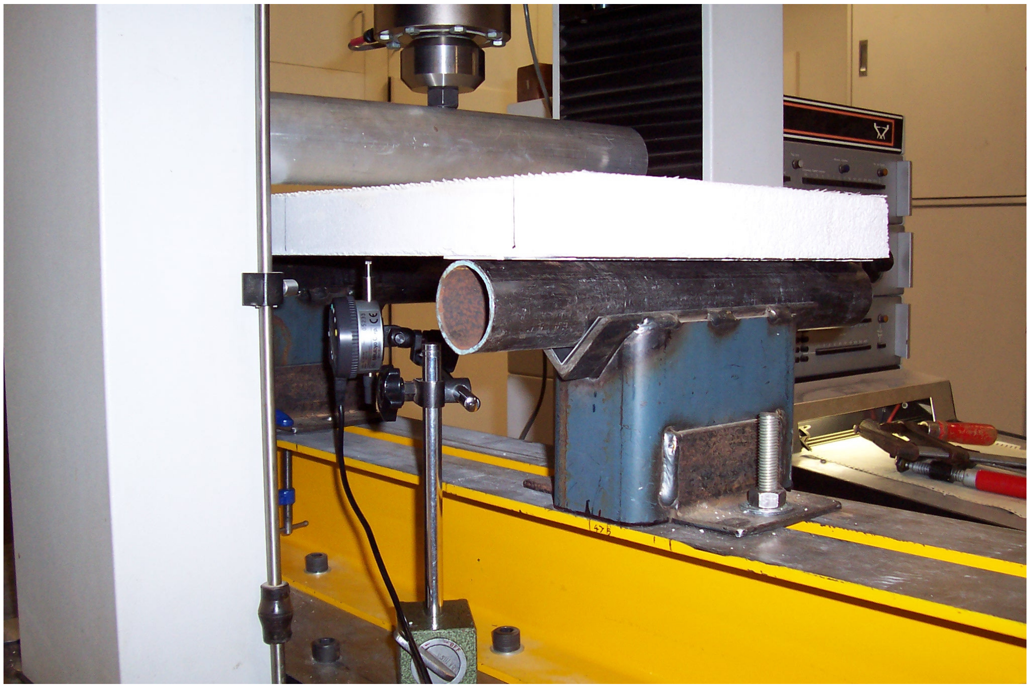

Figure A1 Bending test set up – fibre mesh in compression

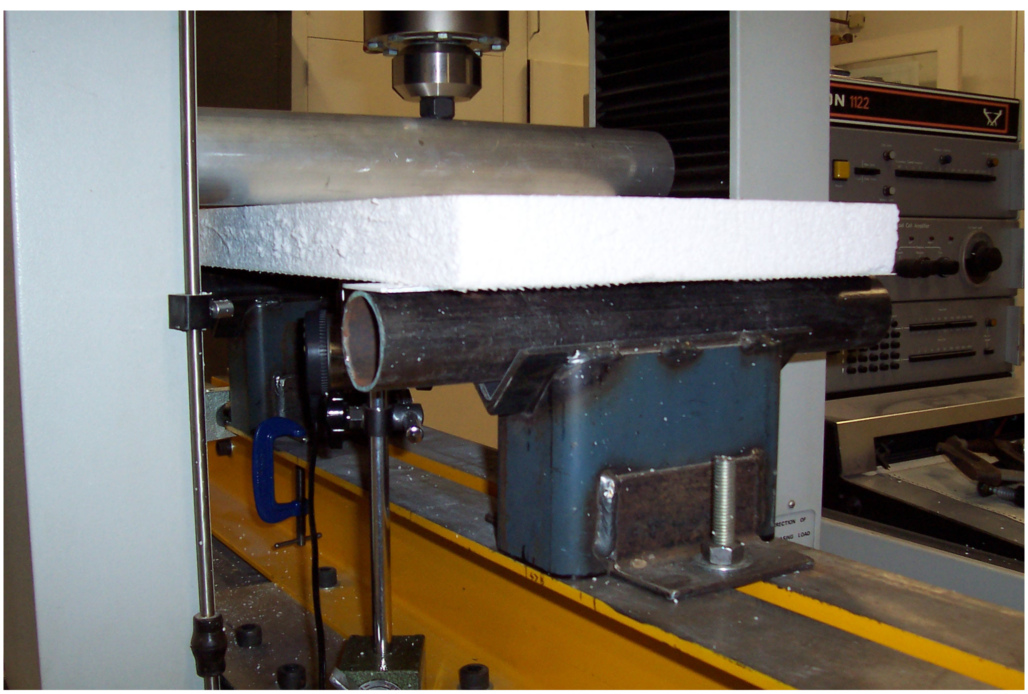

Figure A2 Bending test set up – fibre mesh in tension

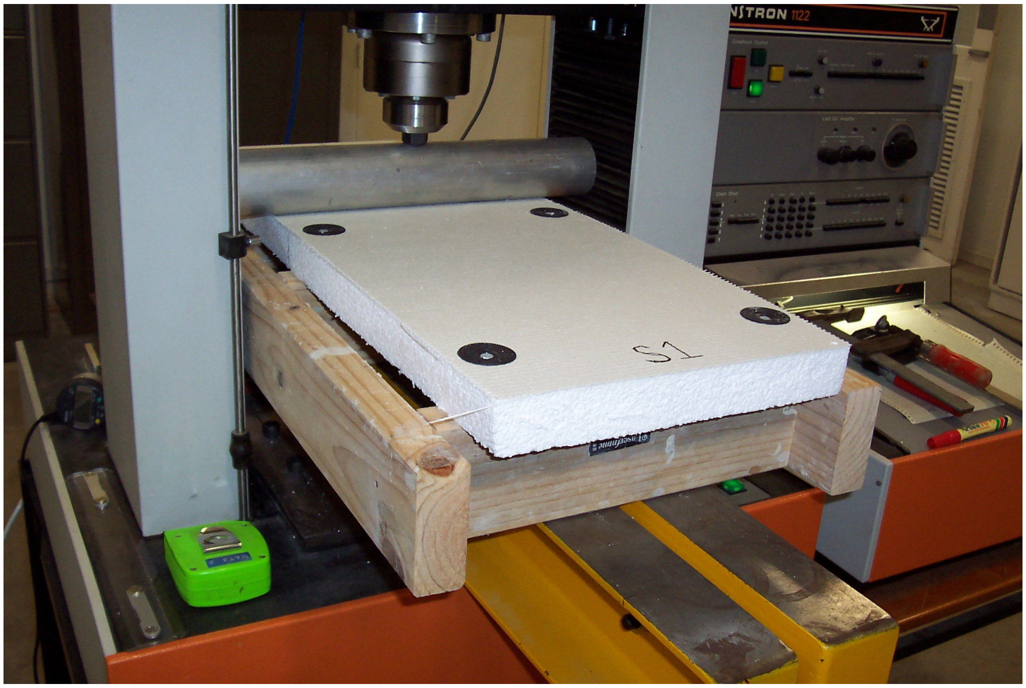

Figure A3 Shear test set up

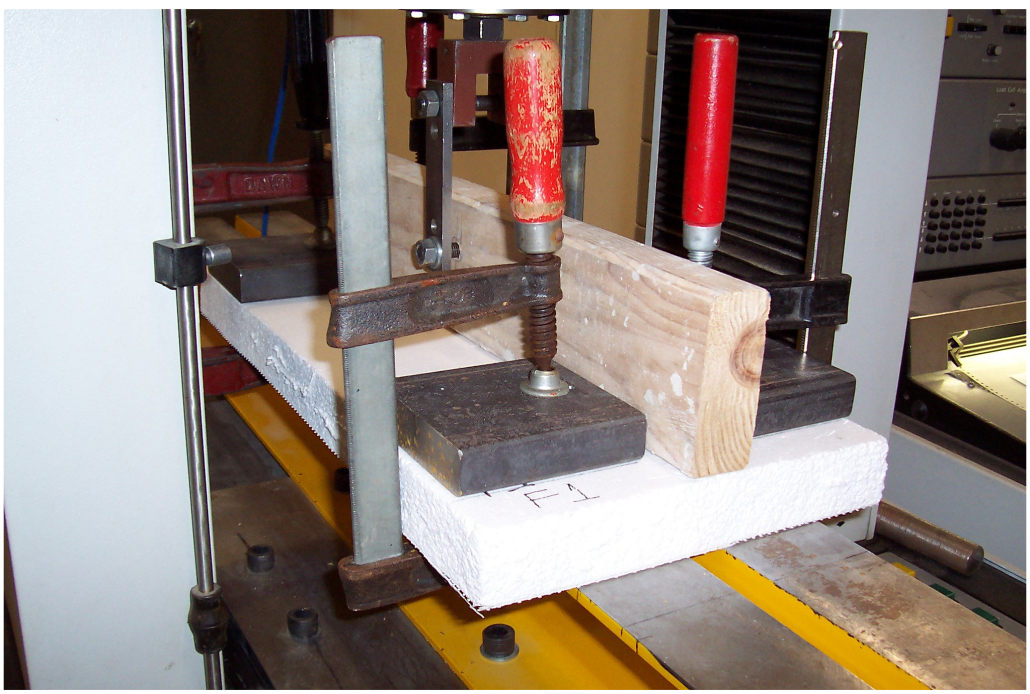

Figure A4 Fastener test set up

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APPENDIX B

Specimens after testing.

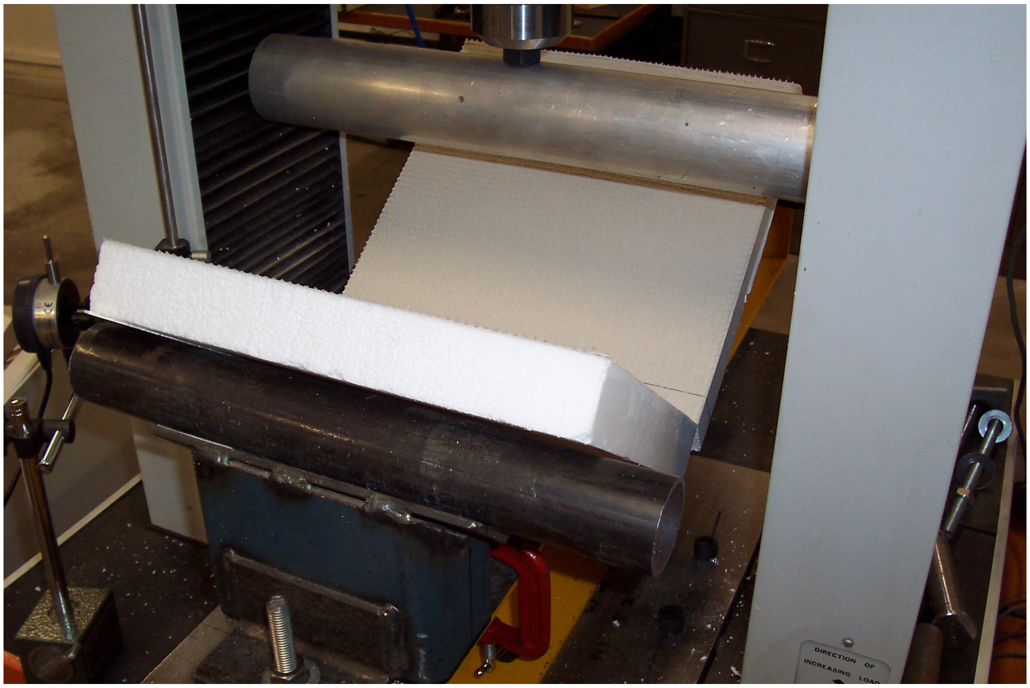

Figure B1 Typical bending test specimen after testing – fibre mesh in compression

Figure B2 Typical bending test specimen after testing – fibre mesh in tension

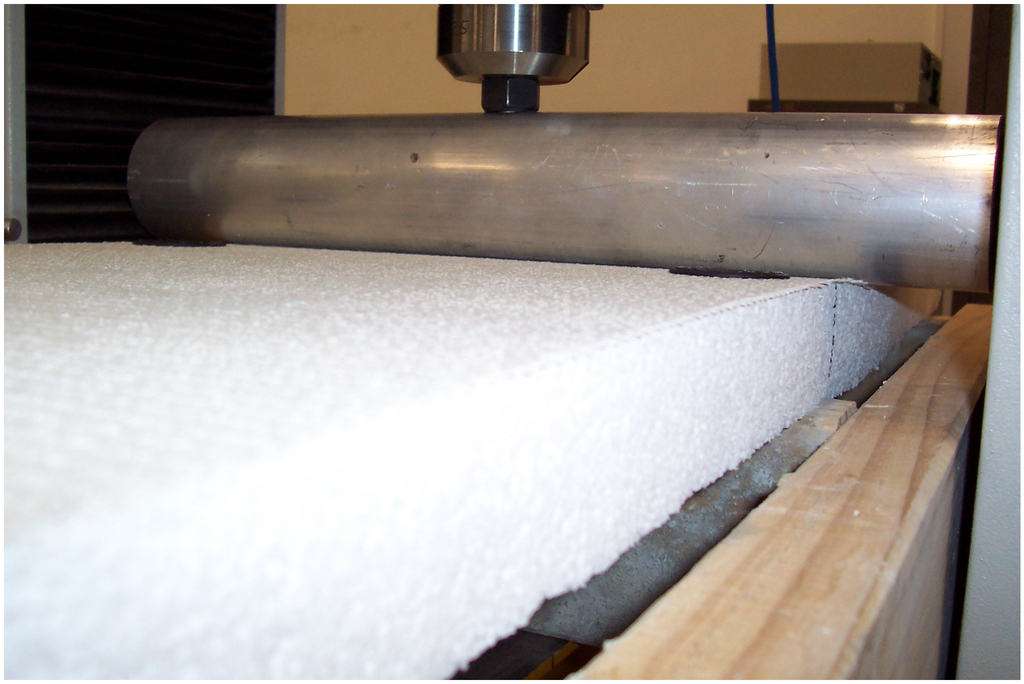

Figure B3 Shear test specimen after testing

Figure B4 Typical failure from fastener test