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BRE Test Report

Wind Driven Rain Testing of Sig Design and Technology's Siga 65 Slate to EN 15601

Prepared for: Mark Boardman, Technical Manager

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1 Introduction

This report describes rain penetration tests carried out on Sig Design and Technologys Sig 65 Slates tested with and without Til-R 150mm Slate Hooks. The tests were carried out at roof pitches of 15º & 17.5° with the hooks and 17.5° and 20° with the slates nailed.

The testing was carried out at BRE on the 6th December 2018.

These tests are based on BRE Proposal No P112630 dated 2nd May 2018.

The testing was witnessed by:

Mark Boardman – Sig Design & Technology

2 Objective

The objective of these tests was to assess the driving rain performance of Sig Design and Technology's Siga 65 Slates with slate hooks and with nail fixings to assess the affect the Til-R 150mm Slate Hook had on the performance of the slates.

The tests were carried out at roof pitches of 15° & 17.5° with slate hooks and 17.5° and 20° with nails. The tests were carried out using the following wind and rain combinations:

- Deluge - simulating maximum rainfall with no wind (defined in prEN 15601 as the type D test)
- High rainfall with high wind speed (defined in prEN 15601 as the type B test)

3 Test Specimens

The test products were installed on two seperate BRE test rigs by Sig Design and Technology personnel. Details of the batten gauge, etc. are given in Appendix A.

The performance of the specimen was investigated using a purpose-built monopitch test roof of nominal size 2m x 2m, at a pitch of 15°, 17.5° & 20°. On the underside of the test roofs, and central to them, a 1.8m wide x 1.6m long shallow Perspex box (open area 2.88m^2) was mounted. It was this box that allowed the pressure underneath the specimen to be controlled. This test rig fully complies with the requirements laid down in prEN 15601:2009 and has been calibrated to give the required uniformity of wind speed and rain flow across the test specimens. Results of the calibration tests on the BRE test rig and details of the turbulence intensity in the flow are presented in Annex B. Figures 1 and 2 show the products installed on the BRE test rig.

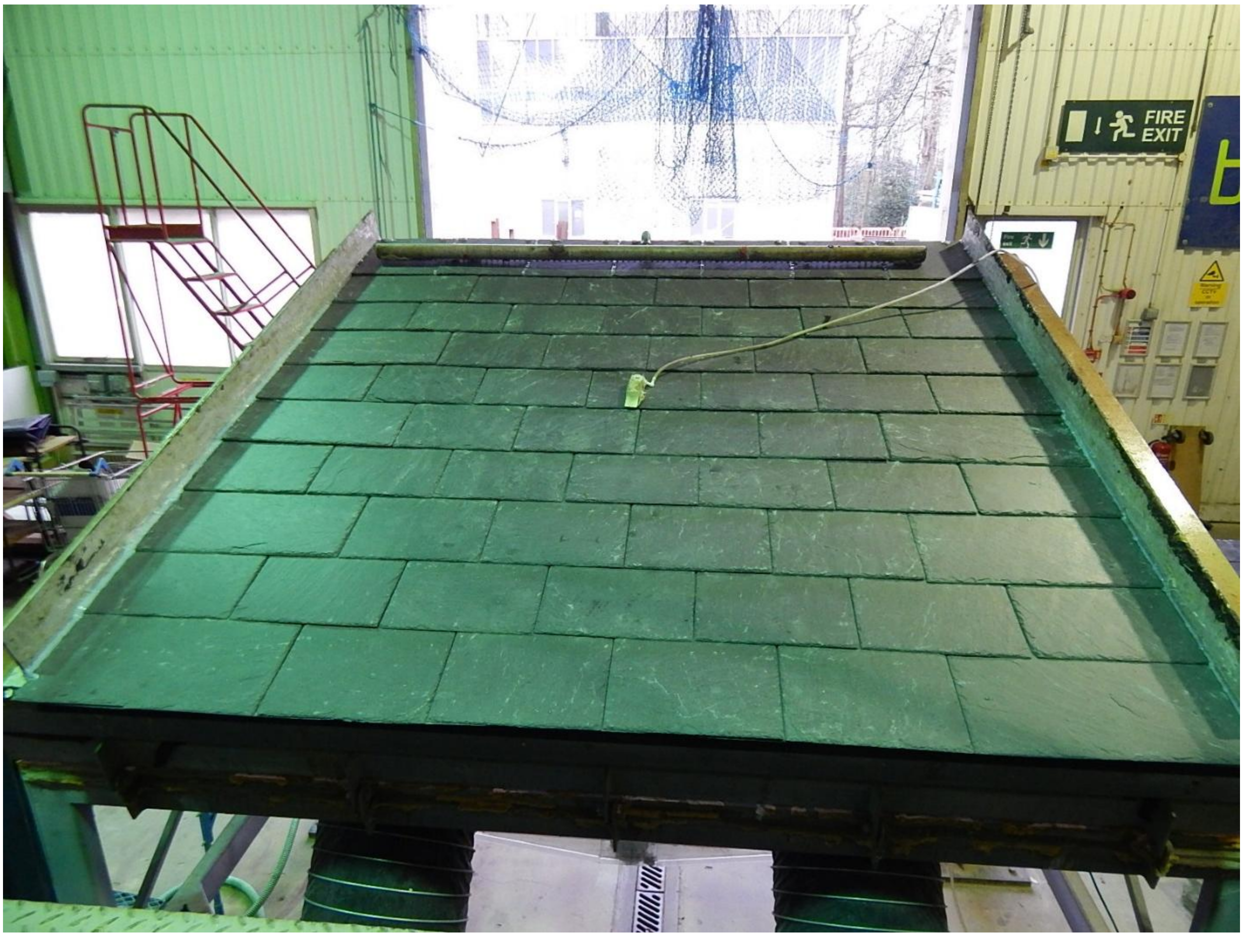

Figure 1 View of the Siga 65 Slate installed on the BRE test rig

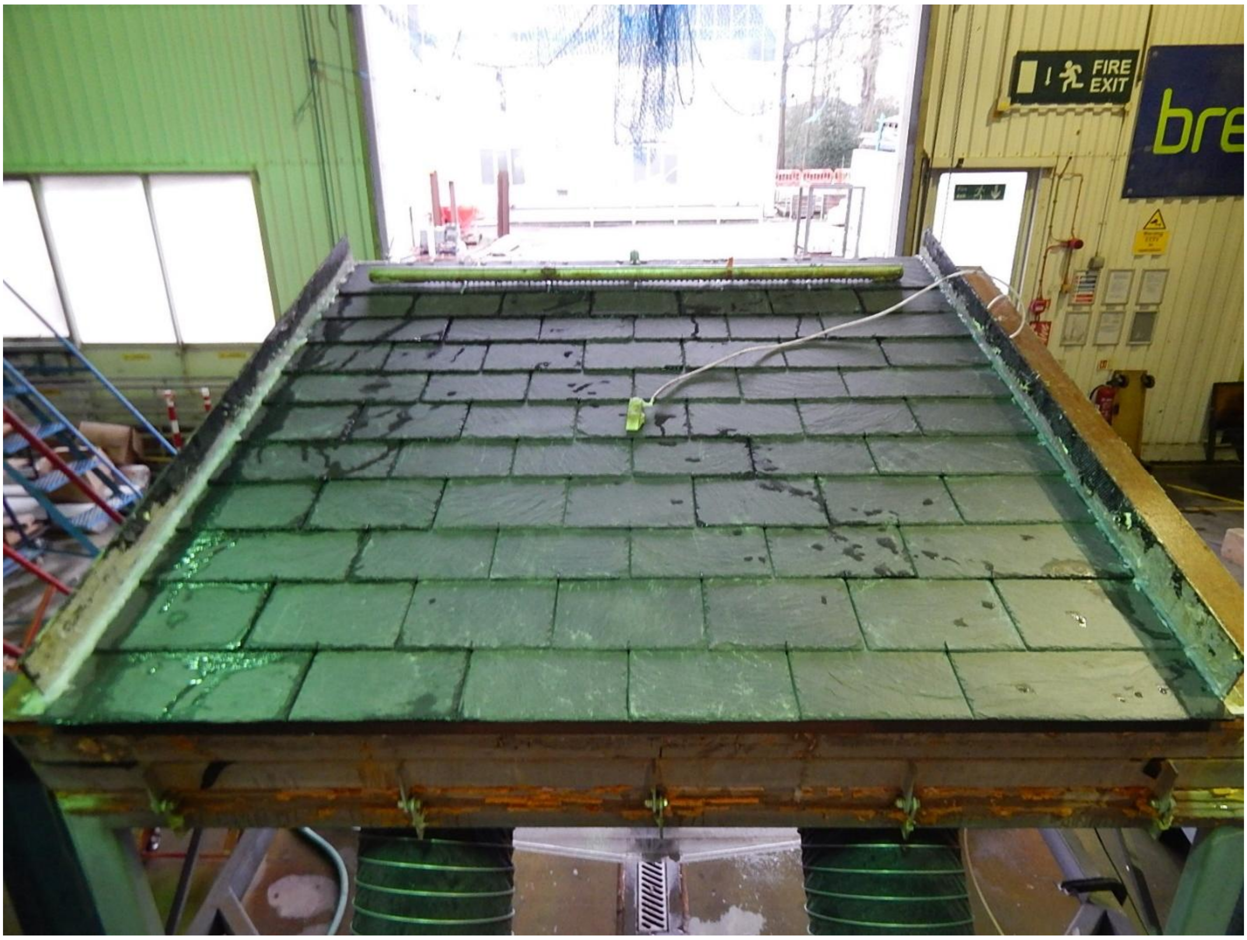

Figure 2 View of the Siga 65 Slate with slate hooks installed on the BRE test rig.

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4 Test Procedure

The specimens were installed on the BRE test rig positioned at the wind tunnel outlet. On the underside of the test rig, a Perspex pressure box enabled the pressure difference across the specimens to be varied during the testing. The edges around the pressure box were sealed to prevent the ingress of water during the rain penetration testing; this sealing also provided an effective aerodynamic seal between the air flow conditions above and below the covering.

The wind tunnel velocity was measured using a Pitot-static tube placed in the wind tunnel free stream. A calibrated micro manometer was connected to this Pitot-static tube, and monitored the wind tunnel velocity during the testing.

The pressure in the Perspex box was increased or decreased by the use of a variable speed fan. The pressure difference between the static pressure above the specimen and the pressure inside the pressure box was measured using a second calibrated micro manometer.

The test procedures complied with those set out in prEN 15601. The tests were carried out with the test roof mounted at the exit of BRE's No.3 Boundary Layer Wind Tunnel so that the wind flow was directed perpendicular to the eaves. Two horizontal spray bars were mounted at the exit from the tunnel, so that water could be sprayed into, and mixed evenly with the air stream. A schematic diagram of the test arrangement is shown in Figure 3.The test conditions represent the worst case wind and rain combination likely to occur in Northern Europe during any 50-year period.

A spray nozzle was mounted above the roof, so that water could be sprayed down onto the roof to provide deluge rain. The wind tunnel was not running during deluge rain testing.

To simulate a typical 7 metre rafter length, a sparge bar was mounted across the top edge of the roof. The sparge bar was used to provide the quantity of runoff water that could be expected from a further 5 metre run of roof up to the ridge.

Full details of the tests undertaken are given in the running sheets in Appendix A.

i) High wind speed and High rainfall combination (prEN 15601 Test B)

Water is sprayed at a rate equivalent to rainfall of 60mm/hour over the test area plus the run-off bar with a flow equivalent to 60mm/hour over the rest of a typical 7m roof. The wind speed was 13m/s. This represents conditions that on average will only occur once in any 50 year period in Northern Europe.

ii) Deluge Test – Maximum rainfall with no wind (prEN 15601 Test D)

Water was sprayed onto the roof, with no wind, at a rate equivalent to a rainfall of 225mm/hour over the whole roof. The run-off spray bar at the top of the test section simulated a rainfall of 225mm/hour over the rest of a typical 7m roof. The test lasts for two minutes with an observer, beneath the box, checking for leaks. This represents conditions that on average will only occur once in any 50 year period in Northern Europe.

The tests start with the pressure in the test box at the appropriate wet sealed box pressure (WSB), as described in Section 4.1. The pressure inside the box is then decreased by 10 Pascals increments and the cycle is repeated until the amount of measured leakage water exceeds 10gr/m^2/5min or as otherwise agreed with the customer.

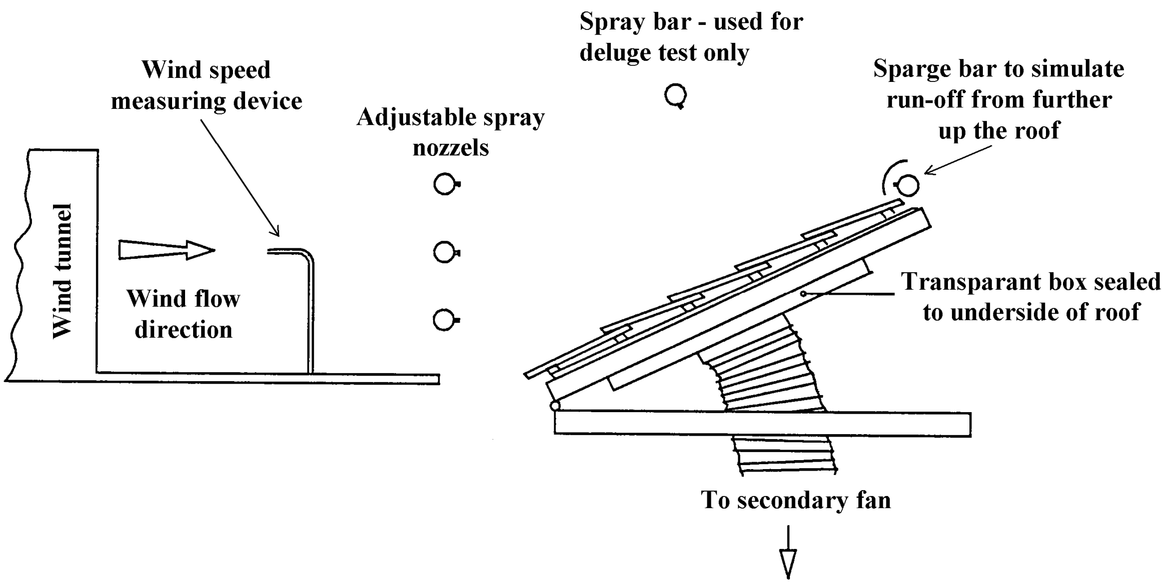

Figure 3 Schematic view of the BRE Rain Penetration Test Rig

4.1 Determining the wet sealed box pressure (WSB)

Before the driving rain testing starts, the WSB pressure must first be determined. This is the pressure that occurs within the pressure box at the appropriate wind speed and with the roof covering fully wetted (the pressure box is sealed during these measurements). This represents ambient conditions likely to occur on a real roof. The WSB pressure is adopted as the reference zero pressure for subsequent testing according to the procedure given in prEN 15601.

5 Results and Discussion

There is no pass-fail criterion given in prEN 15601. The test is intended as a comparative test and the results should be compared with the performance of reference products with known satisfactory wind driven rain performance. BRE have included test results from generic slates at 15° and 20°, BRE do not have data for natural slates at 17.5°.

Copies of the result sheets filled in during the tests and giving observations made at the time are contained in Appendix A.

5.1 Deluge tests – Sub-test D

There were no leaks observed from either specimens at a roof pitches of 15º, 17.5° with slate hooks & 17.5° and 20° with nail fixings.

5.2 Wind and rain tests – Sub-test B

prEN 15601 suggests that the pressure (or suction factor) at which 10g/m^2/5 min of water leakage occurs is taken as a measure of the watertightness of the specimen. Table 1 shows the pressure factors for the tests on the Siga 65 Slate with slate hooks and with nail fixings and Figure 4 shows the pressure v leakage curves.

The pressure factors given in Table 1 show the relative performance of the product, the larger (or more positive) the pressure factor the better the relative performance of the specimen under wind driven rain conditions. As can be seen from Table 1 the Siga 65 Slates perform better when they are installed using the Til-R 150mm Slate Hook, having pressure factors of 30Pa at 15° and 41Pa at 17.5° compared with pressure factors of 29Pa and 35Pa with the slates nailed at 17.5° and 20° respectively.

A direct comparison of pressure factors between the Siga 65 Slates installed with Til-R 150mm Slate Hook at 15° and nailed at 20° shows that the Slates performs only slightly better at 20° with a difference in pressure factors of 5Pa. However at 17.5° when installed with Til-R 150mm Slate Hook the slates perform considerably better with a pressure factor of 41Pa.

Figures 5 and 6 show the Siga 65 slates under test.

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Roof Pitch	Pressure factor (Pa) at a leakage rate of 10g/m²/5min
Sig 65 Slate – 17.5º pitch Sig 65 Slate – 20° pitch Sig 65 Slate with Til-R 150mm Slate Hook – 15° pitch Sig 65 Slate with Til-R 150mm Slate Hook – 17.5° pitch	29Pa 35Pa 30Pa 41Pa

Table 1 Pressure factors for the tests on the Sig 65 Slates with reference products

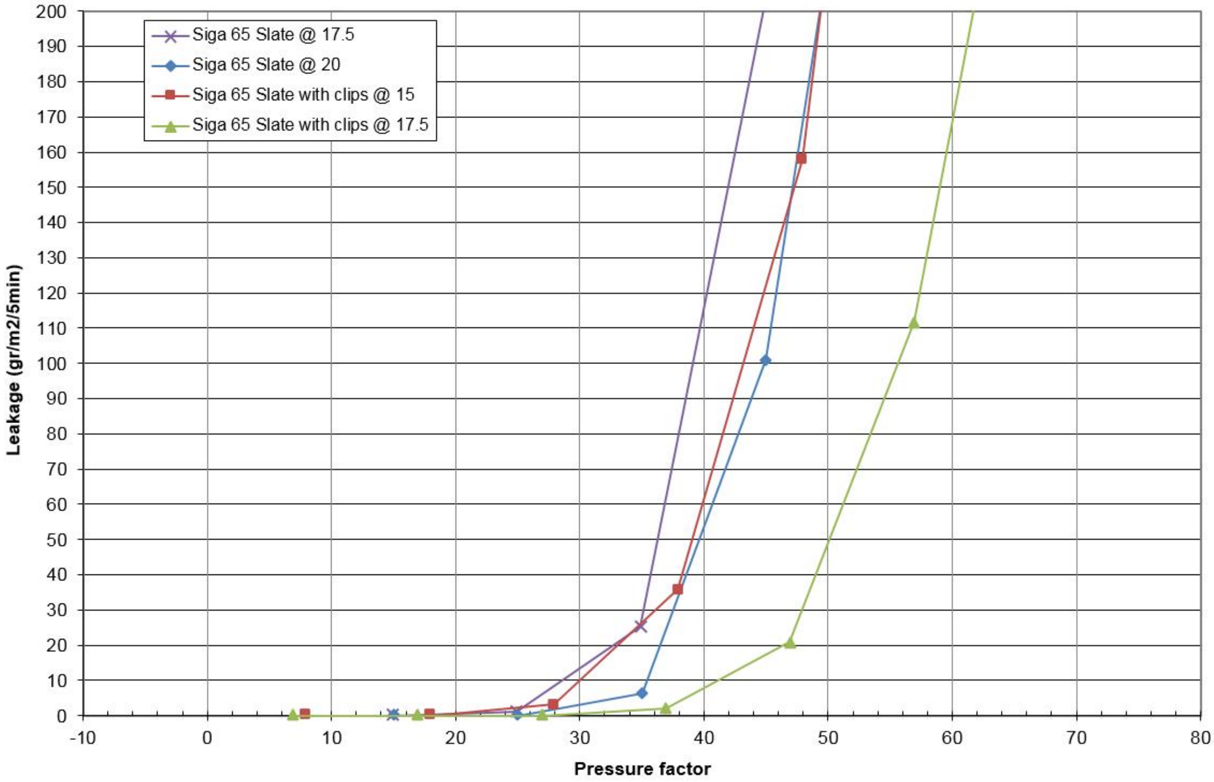

Figure 4 Pressure factor v leakage curves for Siga 65 Slates with Til-R 150mm Slate Hook and Nailed

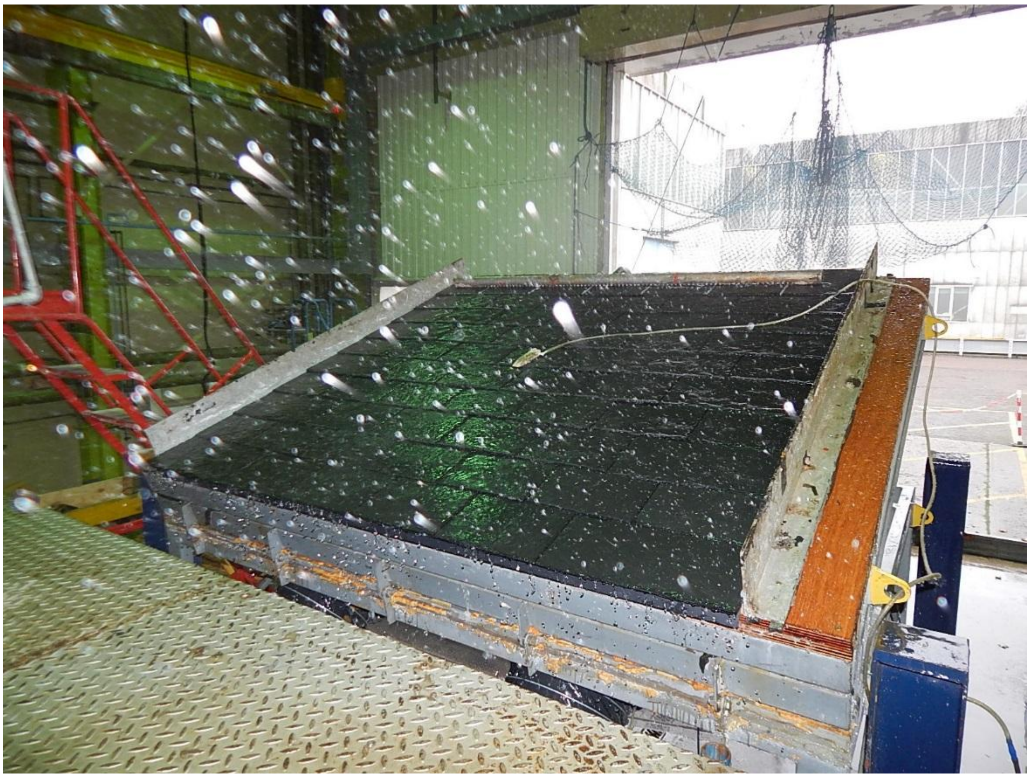

Figure 5 View of the Siga 65 Slates during testing

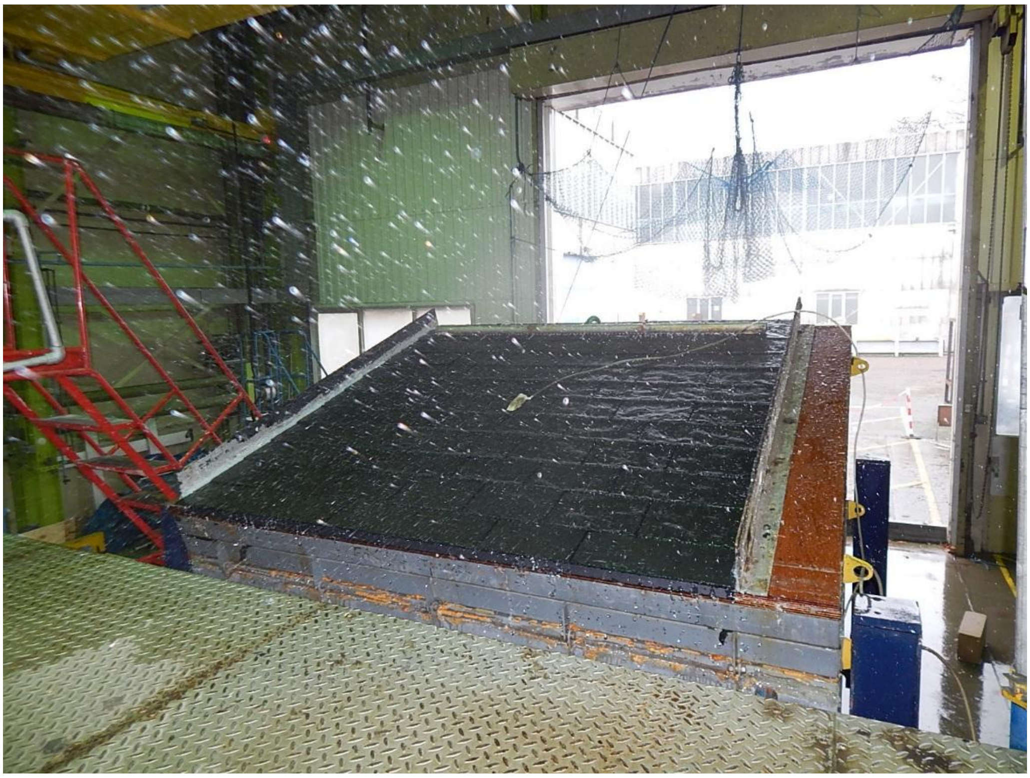

Figure 6 View of Siga 65 Slates with Til-R 150mm Slate Hooks during testing

6 Conclusion

This report describes driving rain tests carried out by BRE to determine the performance of Sig Design and Technologys Sig 65 Slates tested with Til-R 150mm Slate Hooks and when double nailed to wind driven rain. The testing was carried out to the requirements of prEN15601.

The main conclusions from these tests are:

- At a pitch angle of 17.5° the performance of the Siga 65 Slates is better when they are installed using the Til-R 150mm Slate Hook than when they are fixed with nails.
- At a pitch angle of 15° the performance of the Siga 65 Slates installed using the Til-R 150mm Slate Hook is slightly worse than when installed using nails at 20°.

Note: Wind driven rain performance of roof tiles tends to improve with increasing roof pitch. Therefore, although not tested above a roof pitch of 17.5°, it is expected that the Siga 65 Slates with Til-R 150mm Slate Hook will also perform satisfactorily at roof pitches steeper than 17.5°. It is expected that the Siga 65 Slates with nail fixings will also perform satisfactorily at roof pitches steeper than 20°.

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Appendix A Results from tests on Siga 65 Slate with Slate Hooks and when Nailed

BRE – Rain penetration Test Record

1.Product name: Siga 65 Slate	2.Client: SIG Design and Technology
3. Bond: Broken	4.Lap: 115mm
5. Batten Gauge: 193mm	5.Material: Slate
7. Fixing: Nailed	6. Pitch: 17.5°
9. Date commenced: 06/12/18	7: Other remarks: Witnessing the testing Mark Boardman

Dry seal box pressure:	51.2	
Wet seal box pressure relative roof:	34.9	
Wet seal box pressure relative to the lab:	32.7	
Manometer instrument number(s):	IN1928	

Test : D Deluge				
Rainfall rate : 225mm/hr		Wind speed :0m/s		
Deluge bar flow rate:22 l/min		Run off bar flow rate:37 l/min		
Date of test:				
Pressure difference (Pa)	Time (min:sec) Start	End	Water collected (g)	Comments:
0	0	2	0	No Leak

Test : B High wind speed with high rainfall rate					
Rainfall rate:60 mm/hr			Wind speed 13 m/s		
Top bar flow rate:3.9 l/min			Bottom bar flow rate:4.4 l/min		
Runoff bar flow rate: 11 l/min			Date of test: 06/12/18		
Pressure difference (Pa)	Time (min:sec) Start	End	Water collected (g)		
20	0	5	0	No Leak	
10	5	10	3	Central 5th course droplets falling every 5 seconds.	
0	10	15	70	LHS – Intermittent droplets falling from the 9th course. Central 2nd, 4th & 5th course droplets falling every 5 seconds. RHS 5th course droplets falling every 5 seconds.	
-10	15	20	509	LHS as above. Central continuous drops from 1st – 7th course. RHS 4th course droplets every 5 seconds.	
-20	20	25	1153	LHS 1st, 2nd & 9th course droplets falling constantly. Central 1st – 6th course constant flow of droplets. 9th course now constant flow of droplets after 2 minutes at -20Pa. RHS 1st, 2nd & 4th course droplets falling every 2 – 3 seconds. Occasional flurry of droplets falling.	

1.Product name: Siga 65 Slate	2.Client: SIG Design and Technology
3. Bond: Broken	4.Lap: 115mm
5. Batten Gauge: 193mm	5.Material: Slate
7. Fixing: Nailed	6. Pitch: 20°
9. Date commenced: 06/12/18	7: Other remarks: Witnessing the testing Mark Boardman

Dry seal box pressure:		
Wet seal box pressure relative roof:	35	
Wet seal box pressure relative to the lab:	34.1	
Manometer instrument number(s):	IN1928	

Test : D Deluge				
Rainfall rate : 225mm/hr		Wind speed :0m/s		
Deluge bar flow rate:22 l/min		Run off bar flow rate:37 l/min		
Date of test:				
Pressure difference (Pa)	Time (min:sec) Start	End	Water collected (g)	Comments:
0	0	2	0	No Leak

Test : B High wind speed with high rainfall rate	
Rainfall rate:60 mm/hr	Wind speed 13 m/s
Top bar flow rate:3.9 l/min	Bottom bar flow rate:4.4 l/min
Runoff bar flow rate: 11 l/min	Date of test: 06/12/18

Pressure difference (Pa)	Time (min:sec) Start	End	Water collected (g)	
20	0	5	0	Water can be seen in joins between tiles on central 2nd course, no droplets.
10	5	10	0	Centre – water running in join between tiles on 2nd – 4th course.
0	10	15	18	Centre – Droplets falling every 5 seconds on courses 4 & 8 course. RHS – Drops every 5 seconds from 6th course.
-10	15	20	273	LHS 8th & 9th course droplets falling every 5 seconds. Central 2nd – 6th, 8th & 9th course droplets falling every 2 – 3 seconds. RHS 1st, 2nd, 4th & 6th droplets falling every 2 – 3 seconds.
-20	20	25	657	LHS 1st, 4th & 6th course droplets falling every 2 – 3 seconds. Central courses 1 – 6 & 9 droplets falling almost constant, eases up to droplets every 2 seconds. RHS 1st, 4ht, & 6th course droplets falling every 2 – 3 seconds.

1.Product name: Siga 65 Slate	2.Client: SIG
3. Bond: Broken	4.Lap: 150mm
5. Batten Gauge: 175mm	5.Material: Slate
7. Fixing: Slate clips with nailed perimeter	6. Pitch: 15°
9. Date commenced: 06/12/18	7: Other remarks: Witnessing the testing Mark Boardman

Dry seal box pressure:		
Wet seal box pressure relative roof:	37.9	
Wet seal box pressure relative to the lab:	35.8	
Manometer instrument number(s):	IN1928	

Test : D Deluge				
Rainfall rate : 225mm/hr		Wind speed :0m/s		
Deluge bar flow rate:22 l/min		Run off bar flow rate:37 l/min		
Date of test:				
Pressure difference (Pa)	Time (min:sec) Start	End	Water collected (g)	Comments:
0	0	2	0	No Leak

Test : B High wind speed with high rainfall rate	
Rainfall rate:60 mm/hr	Wind speed 13 m/s
Top bar flow rate:3.9 l/min	Bottom bar flow rate:4.4 l/min
Runoff bar flow rate: 11 l/min	Date of test: 06/12/18

Pressure difference (Pa)	Time (min:sec) Start	End	Water collected (g)	
30	0	5	0	No leak
20	5	10	0	Centre – 2nd course -Water collecting on tile, flurry of droplets every so often. RHS – 9th course – Drops forming, occasionally falling.
10	10	15	9	Centre – 2nd course – Drops falling every 5 seconds RHS – 9th course – Drops falling every 40 seconds
0	15	20	94	LHS – 2nd/6th course – Drops falling every 8 seconds Centre – 2nd/4th course – Drops falling every 5 seconds RHS – 9th course – Drops falling every 40 seconds
-10	20	25	352	LHS – 5th course – Drops falling every 10 seconds Centre – 1st/2nd/3rd/7th course – Drops falling every 2-4 seconds RHS – 2nd/4th/6th – Drops falling every 5-8 seconds
-20	25	30	821	LHS – 4th to 6th course – Drops falling every 2-3 seconds Centre – 1st to 4th and 6th to 8th course – Drops falling every 3-5 seconds RHS – 1st/2nd/5th/7th/9th course – Drops falling every 1-2 seconds

1.Product name: Siga 65 Slate	2.Client: SIG
3. Bond: Broken	4.Lap: 150mm
5. Batten Gauge: 175mm	5.Material: Slate
7. Fixing: Slate clips with nailed perimeter	6. Pitch: 17.5°
9. Date commenced: 06/12/18	7: Other remarks: Witnessing the testing Mark Boardman

Dry seal box pressure:	50.7	
Wet seal box pressure relative roof:	36.9	
Wet seal box pressure relative to the lab:		
Manometer instrument number(s):	IN1928	

Test : D Deluge				
Rainfall rate : 225mm/hr		Wind speed :0m/s		
Deluge bar flow rate:22 l/min		Run off bar flow rate:37 l/min		
Date of test:				
Pressure difference (Pa)	Time (min:sec) Start	End	Water collected (g)	Comments:
0	0	2	0	No Leak

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Test : B High wind speed with high rainfall rate				
Rainfall rate:60 mm/hr			Wind speed 13 m/s	
Top bar flow rate:3.9 l/min			Bottom bar flow rate:4.4 l/min	
Runoff bar flow rate: 11 l/min			Date of test: 06/12/18	
Pressure difference (Pa)	Time (min:sec) Start	End	Water collected (g)	
20	0	5	0	No leak
10	5	10	0	No leak
0	10	15	6	Centre – 1st/2nd course – Drops falling every 5 seconds RHS – 9th course – Drops falling every 5 seconds
-10	15	20	54	LHS – 4th/5th – Drops falling every 3 seconds Centre – 1st to 4th course – Drops failing every 3 seconds RHS – 9th course – Drops falling every 3 seconds
-20	20	25	262	LHS – 4th to 6th course – Drops falling every 2 seconds Centre – 1st to 4th and 7th/8th course – Drops falling every 3 seconds RHS – 1st to 6th and 9th course – Drops falling every 2-4 seconds
-30	25	30	530	LHS – 4th to 6th course – As above. Centre – 1st to 4th and 7th/8th course – Drops falling every second, 8th increasing slightly. RHS – 1st to 6th and 9th course – Drops falling every almost constantly.

Appendix B – Calibration results for the BRE test rig

prEN 15601 requires details of the rig calibration to be included in the test report. The following information provides a brief description of the calibration of the BRE test rig.

prEN 15601 has specific calibration requirements for the test facility to ensure that the distribution and magnitude of the wind speed, driving rain and runoff water are all within required limits. The requirement for the wind speed generation is a fan system capable of generating wind blowing parallel to the rafters of the test specimen with a spatial variation of the wind speed over the specimen of not more than 10 %. This is achieved by measuring the wind speed at not less than 9 positions uniformly distributed at a height of 200 ± 10 mm over a flat boarded area which replaces the test specimen, at the relevant roof pitch. The calibration wind speed shall be 10 ± 0.5 m/s at the centre of the test specimen. Figure B1 shows the end of the BRE wind tunnel and Figure B2 shows the wind speed calibration of the BRE test rig using ultrasonic anemometers.

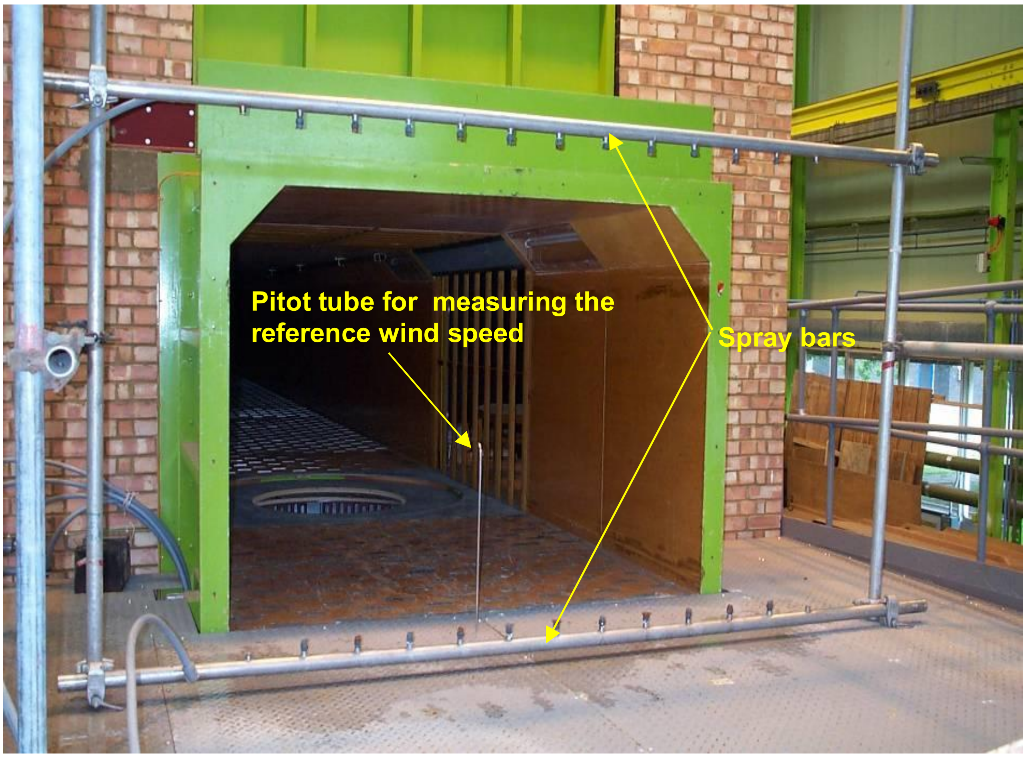

Figure B1 The end of the BRE wind tunnel

Figure B2 Calibration of the wind speed over the test specimen area

The standard requires the turbulence intensity (*t*) in the oncoming wind to be less than 10 %. The turbulence intensity *t* (%) is expressed as t = 100u/U, where *u* and *U* are the RMS and mean wind speeds respectively, measured over a duration of not less than 5 minutes. *u* and *U* are defined as shown below:

RMS (root mean square) wind speed $u = \sqrt{\frac{\sum_{i=1}^{n}(v_i^2 - U)}{n-1}}$

Mean wind speed $U = \frac{\sum_{i=1}^{n} v_i}{n}$

Where v_i is the individual wind speed measurement over the specimen;

n is the number of measurements

Table B1 shows the calibration measurements. The maximum turbulence intensity across the specimen is 5.57% and occurs at location 5 in the centre of the specimen. In all cases the turbulence intensity is within the limit of 10% allowed by the draft standard.

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10m/s nominal speed

Location	mean wind speed U	V	W	Variation from mean % U	Turbulence intensity u'	v'	w'
1	9.83	0.90	-0.69	-0.98	0.03	0.01	0.02
2	10.21	1.29	-0.30	2.85	0.03	0.02	0.02
3	9.56	0.10	0.83	-3.67	0.03	0.02	0.02
4	9.64	1.44	-0.26	-2.88	0.03	0.02	0.02
5	10.48	1.68	0.02	5.57	0.03	0.01	0.01
6	9.66	0.87	0.85	-2.69	0.03	0.02	0.03
7	9.86	1.02	0.60	-0.71	0.03	0.02	0.02
8	10.14	1.40	0.48	2.14	0.04	0.02	0.02
9	9.96	0.32	0.31	0.37	0.03	0.02	0.03
Mean	9.93	1.00	0.21				

locations (facing tunnel)

1	4	7
2	5	8
3	6	9

Table B1 Calibration measurements of wind speed in the BRE wind tunnel facility

The requirements for the rain generating device are a capability for generating a stable rain fall rate for the roof pitch under test. The spatial variation of rainfall must be not more than ±35% over the area of the test specimen during a time period of 5 min±10s. During the same time period of 5 min ±10s the rainfall rate shall vary by not more than ±2%. The actual rainfall rate that should be applied depends on the geographical location. Rainfall conditions are given in the draft standard for three climates: Northern European Coastal, Central Europe and Southern European. In all cases the rainfall rain varies with pitch angle. This means that the test rig must be calibrated for every pitch angle that is likely to be used. The variation in rainfall rate with pitch angle can be very small, for example in the Northern European climate Sub-Test A the rainfall rate varies between 124mm/hr and 130mm/hr for pitches between 15° and 45°. In practice it is not possible to control the rainfall rate on the roof to such small tolerances. The degree of variation in rainfall rate allowed by the draft standard is ±35% which is generally much wider than the range of rainfall rates specified for each pitch angle.

Figures B3 to B6 show the calibration of the driving rain in the BRE test rig. The results of the calibrations for Sub-Tests A, B and C for the Northern European Coastal climate are shown in Table B2. From Table B2 it can be seen that the degree of variability in Sub-Tests A, B and C is close to but just within the allowable limit of ±35%.

% variation of water collected in buckets			
Bucket No	Test C	Test B	Test A
1	-3	-11	-7
2	-3	-21	-26
3	14	9	-22
4	-29	9	26
5	11	-2	22
6	16	-9	24
7	34	24	19
8	29	28	29
9	-17	-15	5
10	-22	3	-1
11	-8	7	-16
12	30	13	-4
13	-21	-29	-21
14	-18	-2	-28
15	-5	-5	-21
16	-9	3	23
Maximum %	34	28	29
Minimum %	-29	-29	-28

Table B2 Calibration of driving rain variability

Figure B3 Bottom spray bar

Figure B4 Top spray bar

Figure B5 View of the test rig at the end of the tunnel

Figure B6 View of the 16 rainfall collection buckets on the test rig

Report Ends