

# BRE Test Report

## Wind Driven Rain Testing of Davinci Roofscapes Slates and Shakes to EN 15601

Prepared for: Chris Bowness,  
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BRE  
Watford, Herts  
WD25 9XX

Customer Services 0333 321 8811

From outside the UK:  
T + 44 (0) 1923 664000  
F + 44 (0) 1923 664010  
E [enquiries@bre.co.uk](mailto:enquiries@bre.co.uk)  
[www.bre.co.uk](http://www.bre.co.uk)

Prepared for:  
Chris Bowness  
Davinci Roofscapes, LLC,  
13890 W 101 Street,  
Lenexa,  
Kansas,  
66215



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## Prepared by

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Name Mr Simon Eastaugh

Position Laboratory Technician, Fire & Building Technology Group

Date 22<sup>nd</sup> January 2019

Signature 

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## Authorised by

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Name Dr Paul Blackmore

Position Associate Director, Fire & Building Technology Group

Date 22<sup>nd</sup> January 2019

Signature 

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## 1 Introduction

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This report describes rain penetration tests carried out on Davinci Roofscapes Plastic Slates and Plastic Shakes. The tests were carried out at roof pitches of 15° & 18.5° on the Davinci Shakes. The Bellaforte Slates were tested at 18.5°, 20°, 22.5° and 25°.

The testing was carried out at BRE on the 15<sup>th</sup> January 2019.

These tests are based on BRE Proposal No P113290 dated 8<sup>th</sup> August 2018.

The testing was witnessed by:

Nisha Sharma – BBA

Chris Bowness – Boca Building Group Ltd

Mark Kelly – Metrotile

Glenn Everest – Metrotile



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## 2 Objective

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The objective of these tests was to assess the driving rain performance of Davinci's Plastic Slates and Shakes to EN 15601.

The tests were carried out at roof pitches of 15° & 18.5° with Shakes and 18.5° & 20° to 25° at 2.5° increments with the Bellaforte Slates. 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 separate BRE test rigs by Metrotile 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°, 18.5°, 20°, 22.5° & 25°. 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<sup>2</sup>) 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 Bellaforte Slate installed on the BRE test rig.



Figure 2 View of the Davinci Plastic Shakes installed on the BRE test rig.





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## 4 Test Procedure

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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  $10\text{gr}/\text{m}^2/5\text{min}$  or as otherwise agreed with the customer.

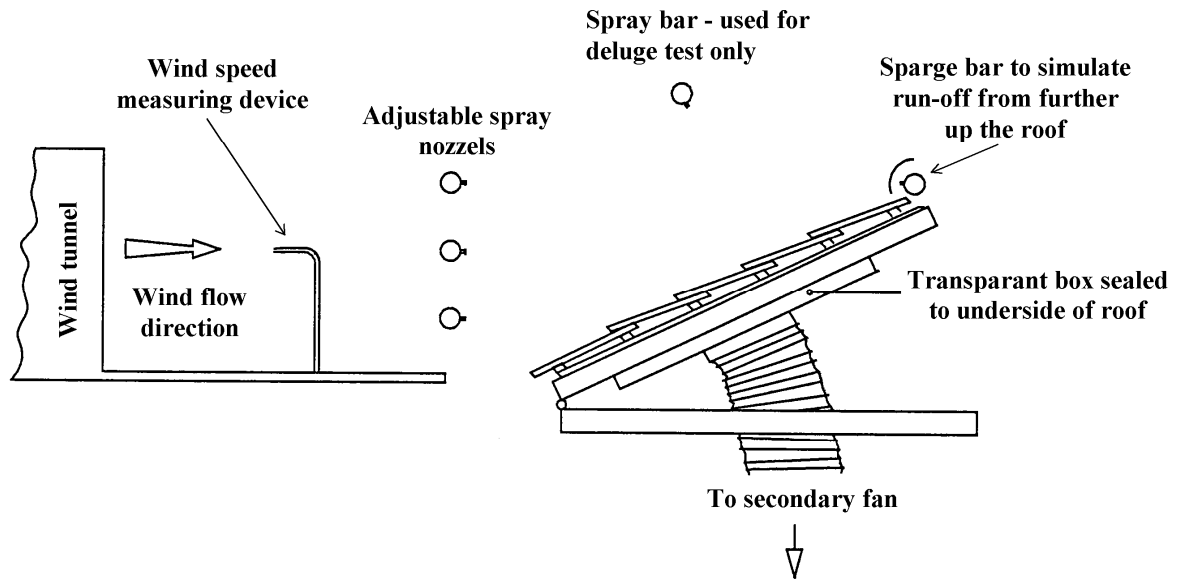


Figure 3 Schematic view of the BRE Rain Penetration Test Rig

#### 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.



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## 5 Results and Discussion

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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 natural slates at 15° and 20°, BRE do not have data for natural slates at 17.5°. Natural Slates were chosen as the reference product due to the the Shakes being installed with a double lap.

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 Davinci Shakes at roof pitches of 15° and 18.5°.

The were leaks observed from the Bellaforte Slates at roof pitches of 18.5°, 20°, 22.5° and 25°. Due to these leaks, no further testing was carried out on the Bellaforte Slates.

### 5.2 Wind and rain tests – Sub-test B

prEN 15601 suggests that the pressure (or suction factor) at which 10g/m<sup>2</sup>/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 Davinci Shakes 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 Davinci Shakes perform better at 15° than the Natural Slates with a pressure factor of 15Pa compared with -5Pa. As can be seen from Table 1 the Davinci Shakes installed at 18.5° perform worse than Natural Slates at 20° with a pressure factor of 25Pa compared with a pressure factor of 42Pa respectively.

Figures 5 and 6 show the Davinci Shakes and Slates under test.



Roof Pitch	Pressure factor (Pa) at a leakage rate of 10g/m <sup>2</sup> /5min
Davinci Plastic Shakes – 15° pitch	15Pa
Davinci Plastic Shakes – 18.5° pitch	25Pa
Natural Slate – 15° pitch	-5Pa
Natural Slate – 20° pitch	42Pa

Table 1 Pressure factors for the tests on the Davinci Plastic Shakes with reference products

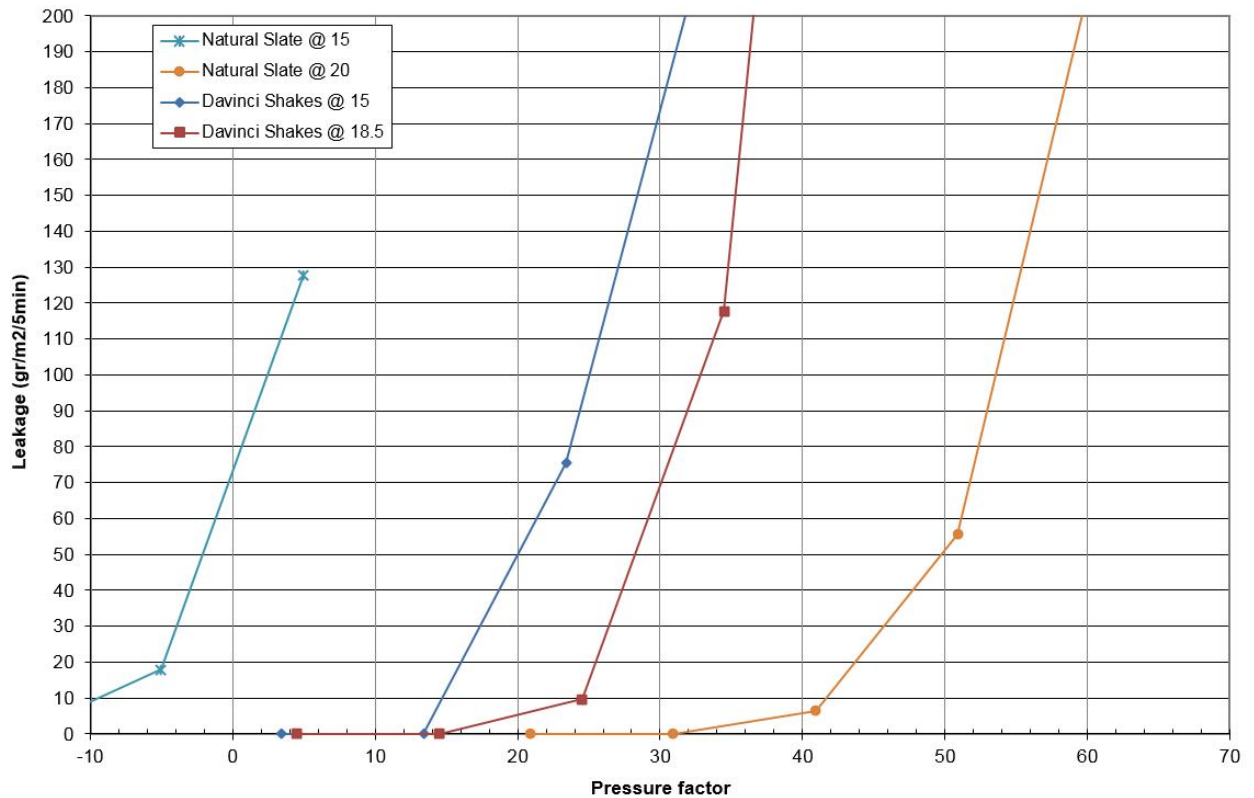


Figure 4 Pressure factor v leakage curves for Davinci Plastic Shakes with reference products



Figure 5 View of the Davinci Slates during testing



Figure 6 View of Davinci Shakes during testing





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## 6 Conclusion

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This report describes driving rain tests carried out by BRE to determine the performance of Davinci Bellaforte Slates tested at 18.5°, 20°, 22.5° & 25° to Test D and Shakes tested at 15°, 18.5°. The testing was carried out to the requirements of prEN15601.

The main conclusions from these tests are:

- At a pitch angle of 15° the performance of the Davinci Shakes is better than the Natural slates they are compared with.
- At a pitch angle of 18.5° the performance of the Davinci Shakes is worse than Natural slate installed at 20°.
- At a pitch angle of 18.5°, 20°, 22.5° & 25° the Davinci Bellaforte Slates did not pass the deluge test (Test D).

Note: Wind driven rain performance of roof tiles tends to improve with increasing roof pitch. Therefore, although not tested above a roof pitch of 18.5°, it is expected that the Davinci Shakes will also perform satisfactorily at roof pitches steeper than 18.5°.



## Appendix A Results from tests on Davinci Slates and Shakes

### BRE – Rain penetration Test Record

1.Product name: <u>Bellaforte</u> Slates	2.Client: Davinci Roofscapes
3. Bond: Broken	4.Lap: Single Lap - 80mm
5. Batten Gauge: 310mm	5.Material: Plastic Slate
7. Fixing: Nailed	6. Pitch: 18.5°, 20°, 22.5° & 25°
9. Date commenced: 15/01/2019	7: Other remarks: Witnessing the testing Nisha Sharma

Dry seal box pressure:	35.7
Wet seal box pressure relative roof:	
Wet seal box pressure relative to the lab:	
Manometer instrument number(s):	1928

<b>Test : D Deluge</b>				
Rainfall rate : 225mm/hr		Wind speed :0m/s		
Deluge bar flow rate:22 l/min		Run off bar flow rate:37 l/min		
Pitch: 18.5°				
Pressure difference (Pa)	Time (min:sec) Start	End	Water collected (g)	Comments:
0	0	2	763	Leakage all sections, courses 2-6 constant flow from side join.

<b>Test : D Deluge</b>				
Rainfall rate : 225mm/hr		Wind speed :0m/s		
Deluge bar flow rate:22 l/min		Run off bar flow rate:37 l/min		
Pitch: 20°				
Pressure difference (Pa)	Time (min:sec) Start	End	Water collected (g)	Comments:
0	0	2	598	Leakage all sections, courses 2-6 constant flow from side join.



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		
Pitch: 22.5°				
Pressure difference (Pa)	Time (min:sec) Start End		Water collected (g)	Comments:
0	0	2	292	Leakage all sections, courses 2-6 constant flow from side join.

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		
Pitch: 25°				
Pressure difference (Pa)	Time (min:sec) Start End		Water collected (g)	Comments:
0	0	2	113	Leakage all sections, courses 2-6 heavy flow from side join.





1.Product name: Davinci Shakes	2.Client: Davinci Roofscapes
3. Bond: Broken	4.Lap: Double Lapped – 60mm
5. Batten Gauge: 250mm	5.Material: Plastic
7. Fixing: Screwed	6. Pitch: 15°
9. Date commenced: 15/01/2019	7: Other remarks: Witnessing the testing Nisha Sharma

Dry seal box pressure:	
Wet seal box pressure relative roof:	23.4
Wet seal box pressure relative to the lab:	24.1
Manometer instrument number(s):	1928

<b>Test : D Deluge</b>				
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 leakage Observed



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:	
Pressure difference (Pa)	Time (min:sec) Start End		Water collected (g)	
20	0	5	0	No leakage Observed
10	5	10	0	No leakage Observed
0	10	15	217	LHS 5 <sup>th</sup> course steady flow of droplets from side join. Central 1 <sup>st</sup> course droplets falling every 1 – 2 seconds from side joins, almost constant flow of droplets.
-10	15	20	645	LHS 2 <sup>nd</sup> & 5 <sup>th</sup> course constant flow of droplets. Central 1 <sup>st</sup> & 3 <sup>rd</sup> course constant flow of droplets. RHS 2 <sup>nd</sup> course droplets falling every 2 seconds steady.



1.Product name: Davinci Shakes	2.Client: Davinci Roofscapes
3. Bond: Broken	4.Lap: Double Lapped – 60mm
5. Batten Gauge: 250mm	5.Material: Plastic
7. Fixing: Screwed	6. Pitch: 18.5°
9. Date commenced: 15/01/2019	7: Other remarks: Witnessing the testing Nisha Sharma

Dry seal box pressure:	24.4
Wet seal box pressure relative roof:	24.5
Wet seal box pressure relative to the lab:	24.1
Manometer instrument number(s):	1928

<b>Test : D Deluge</b>				
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 leakage Observed



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:	
Pressure difference (Pa)	Time (min:sec) Start End		Water collected (g)	
20	0	5	0	No leakage Observed
10	5	10	0	No leakage Observed
0	10	15	28	Some moisture seen on LHS 3 <sup>rd</sup> course, droplets falling every 20 – 30 seconds, occasional flurry.
-10	15	20	311	LHS 2 <sup>nd</sup> & 5 <sup>th</sup> course constant flow of droplets. Central 1 <sup>st</sup> & 3 <sup>rd</sup> course constant flow of droplets. RHS 2 <sup>nd</sup> course droplets falling every 2 seconds steady.
-20	20	25	1140	Central 4 <sup>th</sup> course constant flow of droplets, 2 <sup>nd</sup> course constant flow of droplets started after 1 minute at -20Pa. 1 <sup>st</sup> course droplets falling every 2 – 4 seconds. RHS 2 <sup>nd</sup> course constant flow of droplets from side join. 1 <sup>st</sup> course droplets falling every 1 – 2 seconds. LHS 5 <sup>th</sup> course constant flow of droplets from side join. 3 <sup>rd</sup> course droplets falling every 1 – 3 seconds.



## 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  $200 \pm 10$  mm over a flat boarded area which replaces the test specimen, at the relevant roof pitch. The calibration wind speed shall be  $10 \pm 0.5$  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.

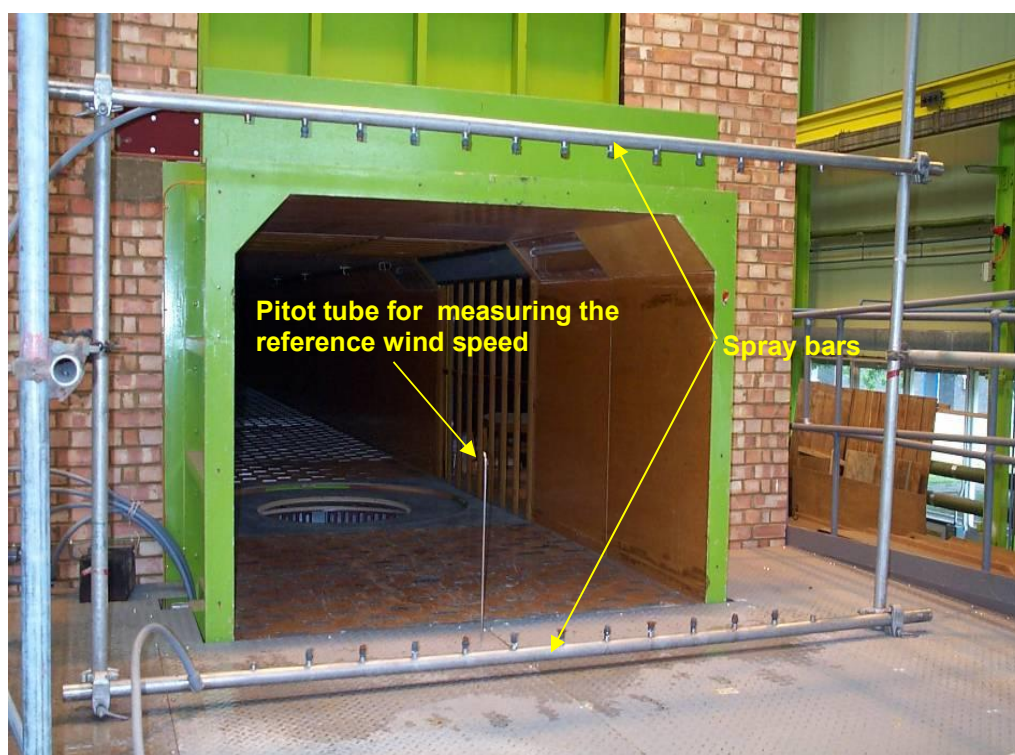


Figure B1 The end of the BRE wind tunnel



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:

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

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

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.



10m/s nominal speed				locations (facing tunnel)			
Location	mean wind speed			Variation from mean %	Turbulence intensity		
	U	V	W		U	u'	v'
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				

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  $\pm 35\%$  over the area of the test specimen during a time period of  $5 \text{ min} \pm 10\text{s}$ . During the same time period of  $5 \text{ min} \pm 10\text{s}$  the rainfall rate shall vary by not more than  $\pm 2\%$ . 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 rate 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  $124 \text{ mm/hr}$  and  $130 \text{ mm/hr}$  for pitches between  $15^\circ$  and  $45^\circ$ . 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  $\pm 35\%$  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  $\pm 35\%$ .

% 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