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BRE Test Report

Wind Driven Rain Testing of Tapco Classic Slate to PD CEN/TR 15601

Prepared for: Steve Duke

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1 Introduction

At the request of Steve Duke, Tapco Roofing Products, BRE issued proposal number P123532 on the 13th June 2022. Following acceptance, BRE completed testing on 6th September 2022. The tests on the specimen were carried out under the BRE Standard Terms and Conditions of Business for testing as BRE Project number P123532 -1000.

This report details the tests undertaken to assess the weathertightness performance of the Tapco Classic Slate at 10º & 12º roof pitches. The tests were caried out in accordance with PD CEN/TR 15601 (2012) at BRE, Bucknalls Lane, Watford, WD25 9XX, UK.

The tests were carried out using the following wind and rain combinations:

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

2 Test Specimens

The performance of the specimen was investigated using a purpose-built monopitch test roof of nominal size 2.5m x 2m. 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 PD CEN/TR 15601 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.

The specimen was installed on the BRE test rig by Steve Duke, Jeff Farrell and Lee Windass, Tapco Roofing Products.

25mm x 35mm battens were fixed at a batten gauge of 150mm on the BRE test rig. The leading edge of the first batten aligned with the leading edge of the test rig. The trailing edge of the last batten aligned with the trailing edge of the test rig. All battens were fixed in place via 4.5mm x 50mm wood screws. The battens used were compliant with the requirements set out in BS 5534.

445mm x 305mm (width includes 5mm horizontal spaces on each edge) Tapco Classic slates were installed on the test rig, as per the manufacturer’s installation guidelines. Half slates were used at the edges of alternate rows where required (cut to fit). Table 1 details the installation parameters of the slates.

Parameter	
Material	Recyclable blend of limestone and polypropylene
Slate size	445mm x 305mm
Batten dimension, mm	25mm x 50mm
Batten gauge, mm	150mm
Headlap, mm	295mm
Side lap, mm	N/A
Bond	Broken
Roof Pitch, °	10 & 12
Fixing strategy	2x per slate Timco 4.5mm x 30mm multipurpose screws

Table 1. Installation parameters of Tapco Classic Slate.

To form a closed system and avoid unrepresentative water leakage paths, two rows of 5mm wide foam gasket were attached to the underside of the first and last batten. Edge baffles were then installed at the edge of the specimen and fixed in place via screws. Expanding foam applied down the sides of the specimen at the interface between the two. Silicone sealant was applied at the trailing edge of the specimen to fill any gaps between the rig and the slates and also between courses of slates.

Figure 1. Installation of the Tapco Classic Slate on the BRE rig.

3 Test Procedure

The specimens were installed on the BRE test rig positioned at the wind tunnel outlet. A Perspex pressure box on the underside of the test rig enabled the pressure difference across the specimen 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 PD CEN/TR 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 2. 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. Additional spray bars were attached at the tunnel outlet to provide the wind driven rain component. Finally, a runoff bar was mounted across the top edge of the roof 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 (*PD CEN/TR 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 an additional 5m roof. The wind speed was 13m/s. At each pressure increment, the test lasts for 5 minutes. 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 (*PD CEN/TR 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 an additional 5m roof. The test lasts for two minutes. 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 3.1. The pressure inside the box is then decreased in increments and the cycle is repeated until the amount of measured leakage water exceeds 10gr/m^2/5min.

3.1 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 PD CEN/TR 15601.

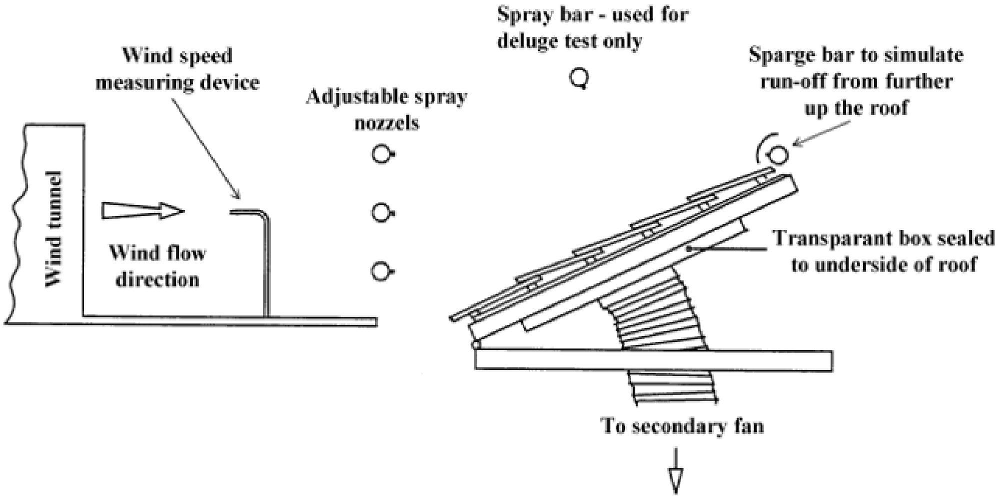

Figure 2. Schematic view of the BRE Rain Penetration Test Rig.

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4 Results and Discussion

There is no pass-fail criterion given in PD CEN/TR 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. Data for reference products were supplied by BRE.

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

4.1 Deluge tests – Sub-test D

Figure 3 shows the Tapco Classic Slate undergoing deluge testing.

There were no leaks observed from the Tapco Classic Slate specimen at 10° or 12° roof pitch angles.

Figure 3. Tapco Classic Slate undergoing deluge testing.

4.2 Wind and rain tests – Sub-test B

PD CEN/TR 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 2 shows the pressure factors for the tests completed on the Tapco Classic Slate specimen. Table 2 also includes the pressure factors of reference products for comparative purposes. Figure 4 shows the associated pressure vs leakage curves.

The pressure factors given in Table 2 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.

Roofing element	Pressure factor (Pa) at a leakage rate of $10g/m^2/5min$
Tapco Classic Slate, 10°	24.1 Pa
Tapco Classic Slate, 12°	38.6 Pa
Synthetic slate reference product 280mm headlap, 150mm batten gauge, 12°	54.9 Pa
Fibre cement reference, 110mm headlap, 200mm batten gauge, 12.5°	7.3 Pa

Table 2. Pressure factors for Tapco Classic Slate at 10° and 12° and reference product data.

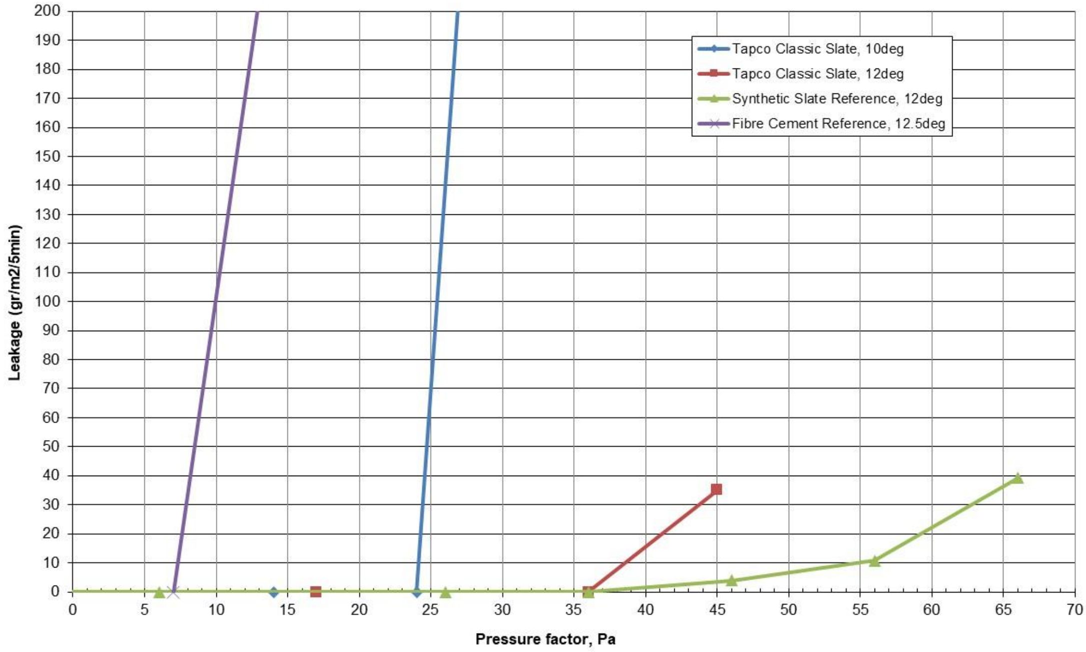


Figure 4. Pressure vs leakage for Tapco Classic Slate at 10° and 12° and data for two reference products.

Visible leakage was found to occur at the junction of the side lap joints between slates and head lap joints between courses, Figure 5.

Figure 5. Image to show where leakage occurred for the Tapco Classic Slate.

5 Conclusion

This report describes driving rain tests carried out by BRE to determine the performance of the Tapco Roofing Products Classic Slate to wind driven rain. The testing was carried out to the requirements of PD CEN/TR 15601.

The main conclusions from these tests are:

- For the Tapco Classic Slate at both 10° and 12° roof pitch angle, the majority of leaks occurred from the junction between the side lap joints between slates and head lap joints between courses
- At 12°, the Tapco Classic Slate performed worse than the synthetic slate reference product (for similar batten gauge and headlap) but performed better that the fibre cement reference product.
- We do not have suitable reference data for comparative purposes at 10° roof pitch.

Appendix A Test Results

Appendix A1 – Tapco Classic Slate, 10°

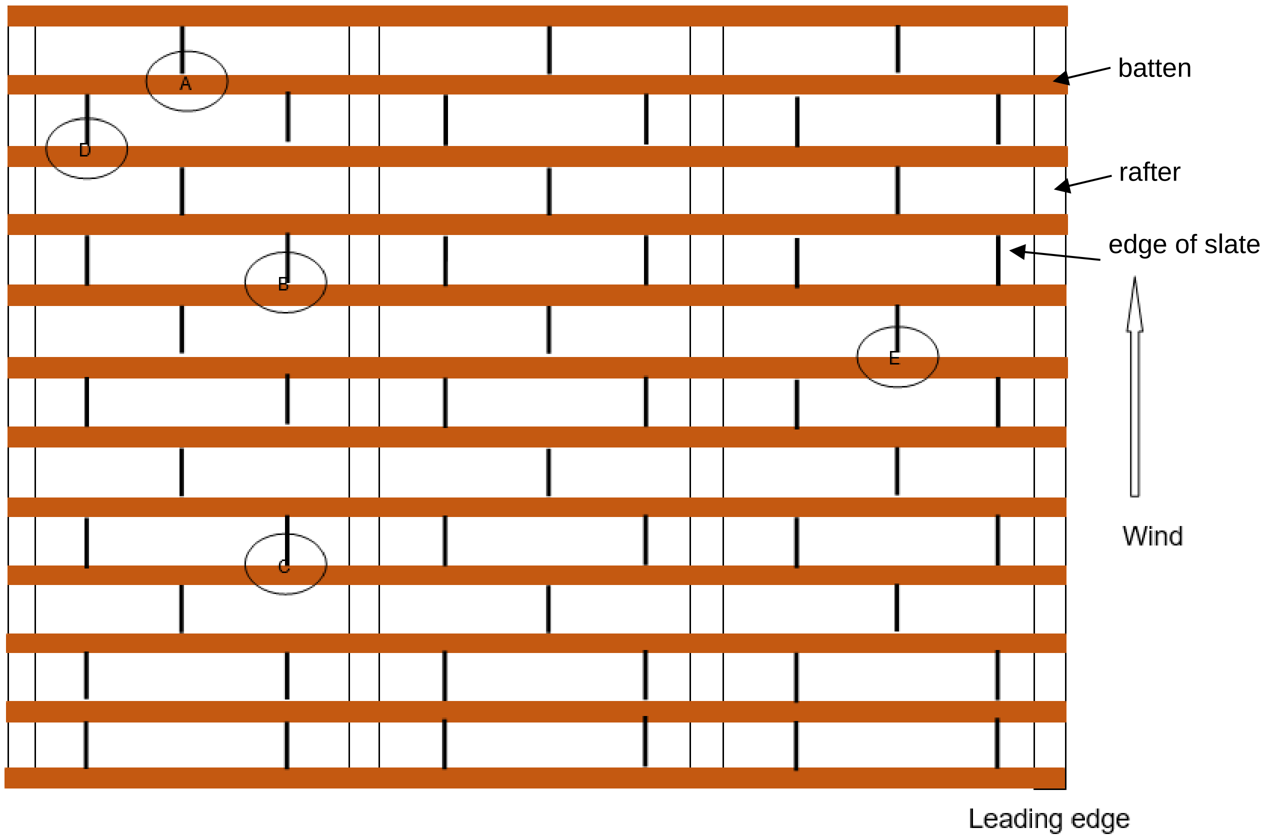
BRE – Rain penetration Test Record

Client: Tapco	**Product name**: Classic Slate
Product Description: Non-natural slate	**Product Dimensions:** 445mm x 305mm (to include 5mm horizontal spacers on each edge)
Product Material: Recyclable blend of limestone and polypropylene	
Bond (broken, straight, random): Broken	**Lap (head & side)**: 295mm headlap, N/A sidelap
Batten Dimension (H x W): 25mm x 50mm	**Batten Gauge**: 150mm
Fixing Strategy: Timco 4.5mm x 30mm multipurpose screws, 2 per slate	**Roof Pitch**: 10°
Test Date: 06/09/2022	**Witness:** Steve Duke, Jeff Farrell and Lee Windass

Dry seal box pressure relative to roof (Pa):	35
Dry seal box pressure relative to lab (Pa):	18
Wet seal box pressure relative roof (Pa):	44
Wet seal box pressure relative to the lab (Pa):	30
Manometer instrument number(s):	

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		
Pressure difference (Pa)	Time (min:sec) Start	End	Water collected (g)	Comments:
0	0	2	0	No leaks visible

<table>
<tr><td colspan="5">Test: B
High wind speed with high rainfall rate</td></tr>
<tr><td colspan="4">Rainfall rate:60 mm/hr</td><td>Wind speed 13 m/s</td></tr>
<tr><td colspan="4">Top bar flow rate: 3.9 l/min
Bottom bar flow rate: 4.4 l/min</td><td>Runoff bar flow rate: 11 l/min</td></tr>
<tr><td>Pressure difference (Pa)</td><td colspan="2">Time (min:sec)
Start End</td><td>Water collected (g)</td><td></td></tr>
<tr><td>30</td><td>0</td><td>5</td><td>0</td><td>No leaks or drips visible</td></tr>
<tr><td>20</td><td>5</td><td>10</td><td>0</td><td>No leaks or drips visible</td></tr>
<tr><td>10</td><td>10</td><td>15</td><td>2000+</td><td>A – water spurting every 2 seconds
B – water streaming in, spurting every second
C – water streaming in, spurting every second
D – water dripping 5 times every second
E - water spurting every 2 seconds</td></tr>
</table>



View from the underside of the sample

Appendix A2 – Tapco Classic Slate, 12°

BRE – Rain penetration Test Record

Client: Tapco	**Product name**: Classic Slate
Product Description: Non-natural slate	**Product Dimensions:** 445mm x 305mm (to include 5mm horizontal spacers on each edge)
Product Material: Recyclable blend of limestone and polypropylene	
Bond (broken, straight, random): Broken	**Lap (head & side)**: 295mm headlap, N/A sidelap
Batten Dimension (H x W): 25mm x 50mm	**Batten Gauge**: 150mm
Fixing Strategy: Timco 4.5mm x 30mm multipurpose screws, 2 per slate	**Roof Pitch**: 12°
Test Date: 06/09/2022	**Witness:** Steve Duke, Jeff Farrell and Lee Windass

Dry seal box pressure relative to roof (Pa):	
Dry seal box pressure relative to lab (Pa):	
Wet seal box pressure relative roof (Pa):	51
Wet seal box pressure relative to the lab (Pa):	40
Manometer instrument number(s):	

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		
Pressure difference (Pa)	Time (min:sec) Start	End	Water collected (g)	Comments:
0	0	2	0	No leaks visible

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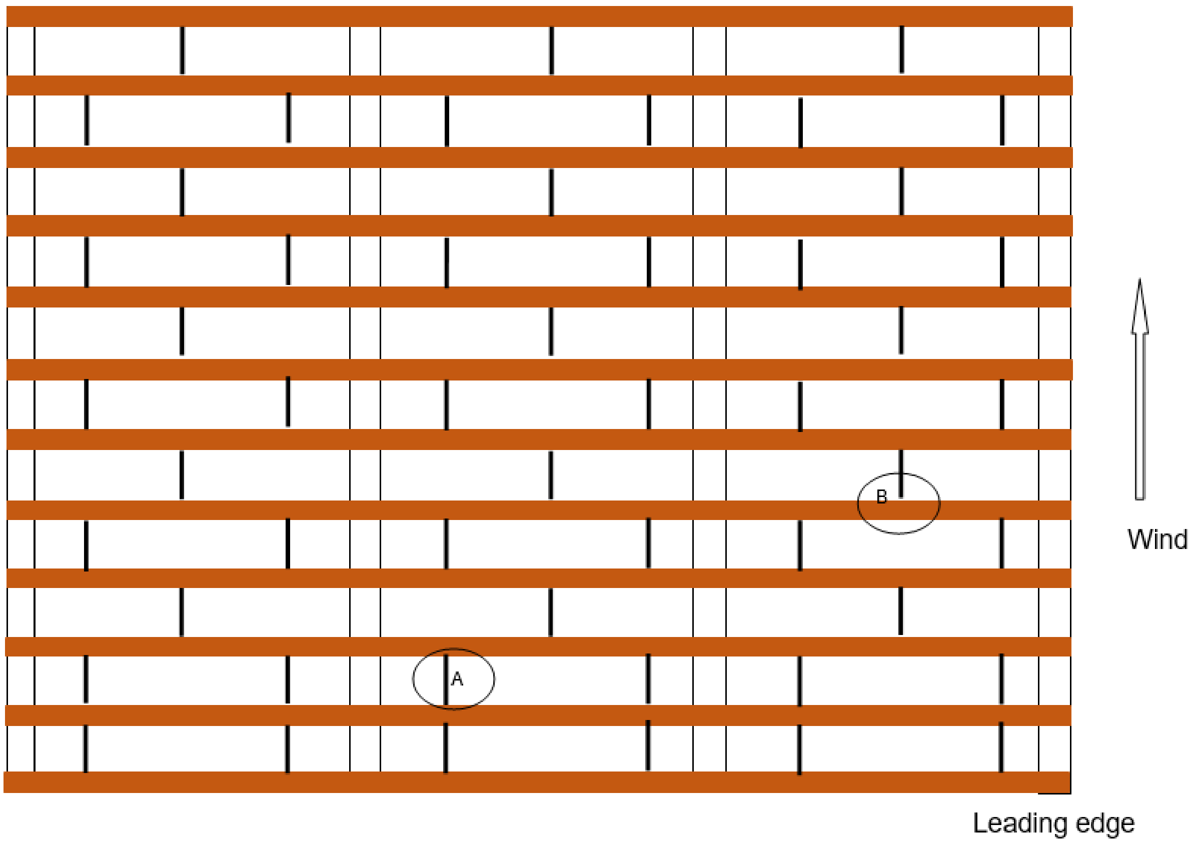
Test: B High wind speed with high rainfall rate				
Rainfall rate:60 mm/hr				Wind speed 13 m/s
Top bar flow rate: 3.9 l/min Bottom bar flow rate: 4.4 l/min				Runoff bar flow rate: 11 l/min
Pressure difference (Pa)	Time (min:sec) Start	End	Water collected (g)	
34	0	5	0	No leaks or drips visible
15	5	10	0	No leaks or drips visible
6	10	15	101	A – dripping three times a second B – dripping twice a second



View from the underside of the sample

Appendix B – Calibration results for the BRE test rig

PD CEN/TR 15601requires 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.

PD CEN/TR 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.

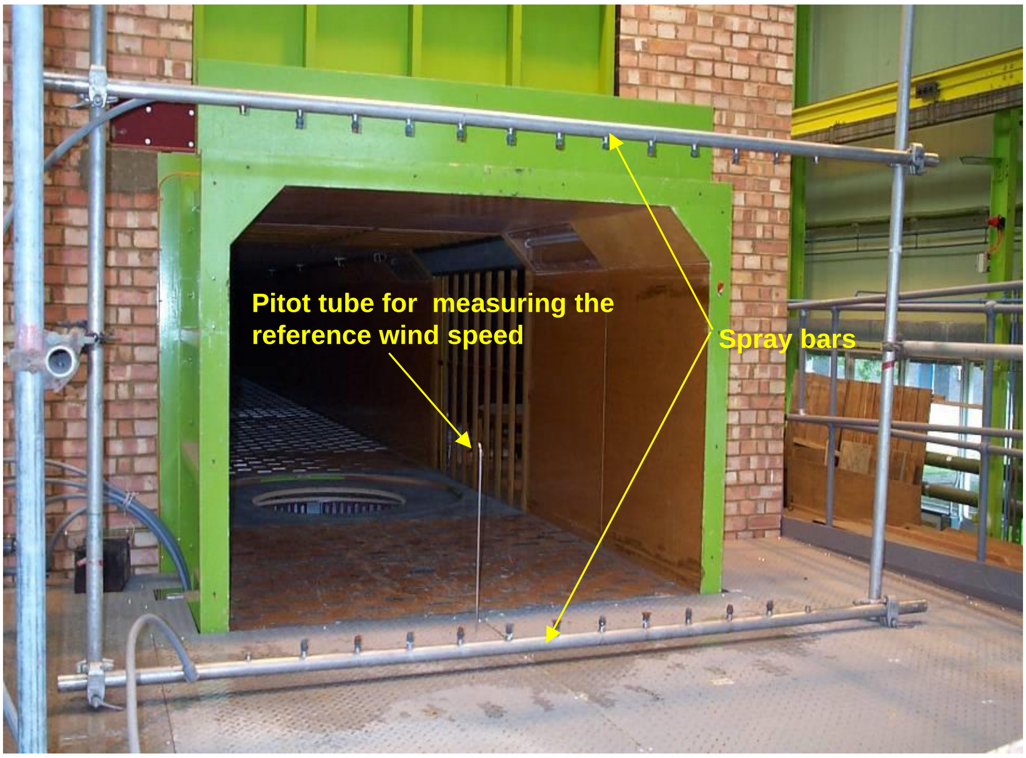


Figure B1 The end of the BRE wind tunnel

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 $u = \sqrt{\dfrac{\sum_{i=1}^{n}(v_i^2 - U)}{n-1}}$

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

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

	mean wind speed			Variation from mean %	Turbulence intensity		
Location	U	V	W	U	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