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BRE Test Report

Rain Penetration Tests on Manthorpe In-Line Slate Vent with fibre cement roof slates

Prepared for: Ben Hales

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Executive Summary

This report describes rain penetration tests carried out on a Manthorpe In-line slate vent with a 600mm x 300mm fibre cement roof slates to assess its resistance to driving rain. The vent was tested at a roof pitch of 22.5º. The tests were carried out using a monopitch roof test rig according to the procedures in CEN standard FprEN 15601. The test roof was positioned in the exit air flow of the BRE No.3 Boundary Layer Wind Tunnel. Two sets of test conditions were used, as follows:

- Sub test B - High rainfall with high wind speed
- Sub test D - Deluge - simulating maximum rainfall with no wind

These test conditions represent typical worse case conditions expected in Northern Europe during a 50 year return period. The following main conclusion can be drawn from this testing:

- The weathertightness performance of the Manthorpe In-line slate vent is better than that of the surrounding fibre cement roof slates

- The Manthorpe in-line slate vent does not leak before the surrounding 600mm x 300mm fibre cement roof slates at a roof pitch of 22.5º. As weathertightness performance improves with roof pitch, the in-line slate vent is expected to also perform satisfactorily at roof pitches above 22.5º.

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1 Introduction

This report describes rain penetration tests carried out on the Manthorpe In-line slate vent when installed with 600mm x 300mm fibre cement slates. The tests reported herein were carried out at BRE, Garston Watford during May 2015 at a roof pitch of 22.5º.

This test is based on BRE Proposal No. 137-758 dated 2nd April 2015, which was accepted by Mr Ben Hales on 2nd April 2015.

The testing was witnessed by:

Mr Ben Hales and Mr Mike Challinor from Manthorpe Building Products Ltd.

2 Objective

The objective of these tests was to assess the driving rain performance of the Manthorpe In-line slate vent with 600mm x 300mm fibre cement slates according to the procedures given in CEN standard FprEN 15601: Hygrothermal performance of buildings: Wind-driven rain on roof coverings with discontinuously laid small elements – test method.

Tests were carried out at a roof pitch of 22.5º. The testing was carried out using the following wind and rain combinations:

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

3 Test Specimen

The vent and slates were installed on the BRE test rig by Manthorpe employees. Details of the slate fixing specifications are given in Appendix A. For these tests 600mm x 300mm fibre cement slates were used, these are expected to be representative of the generic range of slates available in the market. Figure 1 shows the vent installed in the rig.

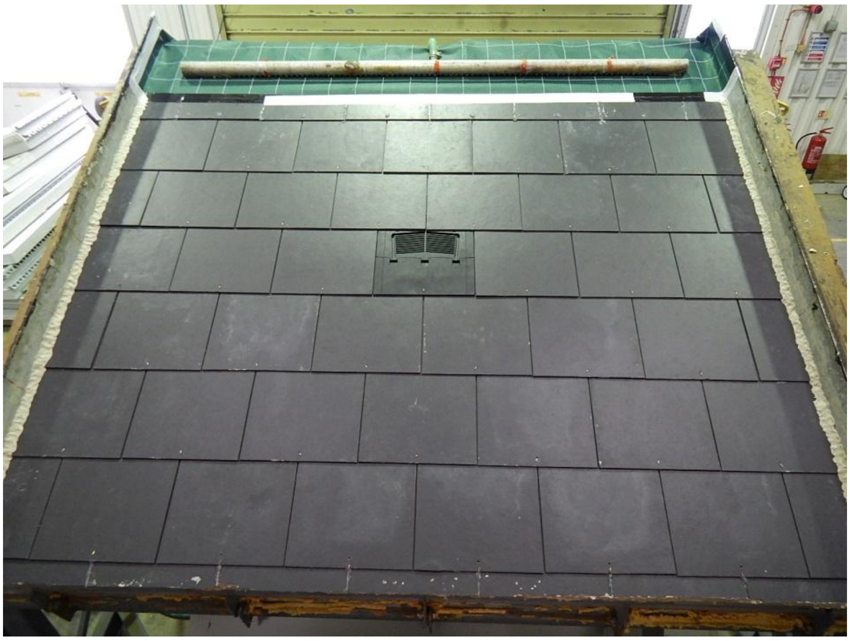

Figure 1 Vent slate installed on the roof

The performance of the roof vent with slates was investigated using a purpose-built monopitch test roof of nominal size 2m x 2m, at a pitch angle of 22.5º. On the underside of the test roof, and central to it, 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 slates to be controlled. This test rig fully complies with the requirements laid down in FprEN 15601:2006 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. Figure 2 shows the roof vent and slates under test.

Figure 2 Manthorpe In-line slate vent with 600mm x 300mm fibre cement slates under test

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4 Test Procedure

The Manthorpe In-line slate vent and fibre cement slates 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 slates 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 slates.

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 slates and the pressure inside the pressure box was measured using a second calibrated micro manometer.

The test procedures complied with those set out in FprEN 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.

It should be noted that the variable speed fan used to generate the pressure difference across the slates has a finite performance range. Hence the conditions stated below represent test conditions that are usually attainable. If these conditions could not be achieved (e.g. because the air leakage through the roof system is too great), conditions as near to the limits as possible were tested. Full details of the tests undertaken are given in the running sheets in Annex A.

i) High wind speed and High rainfall combination (FprEN 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.

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ii) Deluge Test – Maximum rainfall with no wind (FprEN 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 2m square 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.

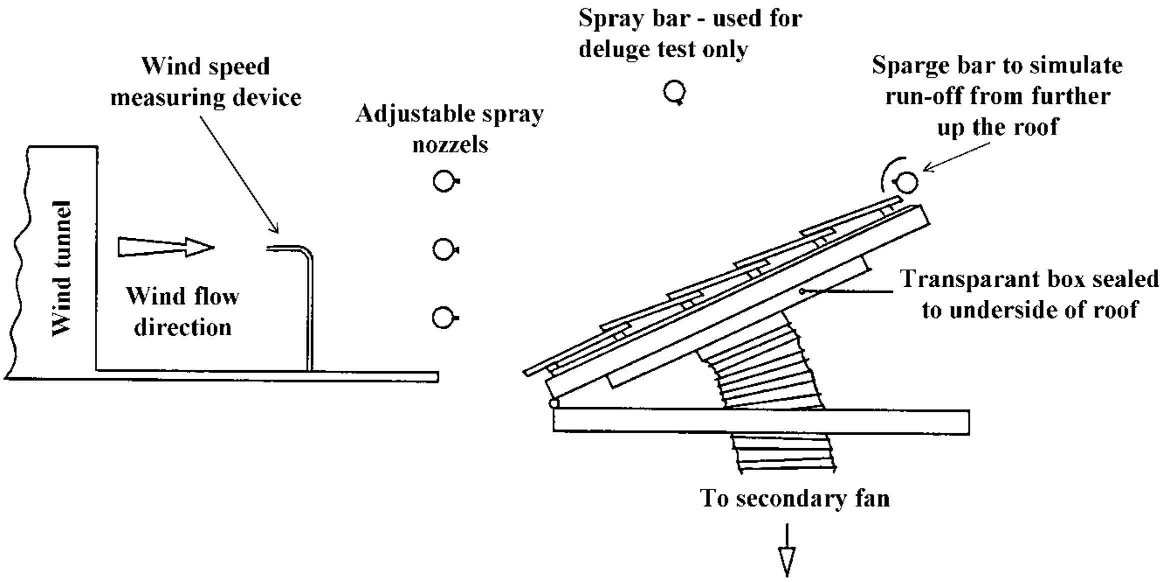

Figure 3 Schematic view of the BRE Rain Penetration Test Rig

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.

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 for the slate under test. The WSB pressure is adopted as the reference zero pressure for subsequent testing according to the procedure given in FprEN 15601.

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5 Results and Discussion

There is no pass-fail criterion given in FprEN 15601; this standard requires performance of a test product to be compared with the performance of a reference product which has known satisfactory performance under the same wind-rain conditions. Informative Annex C of this standard titled ‘Use of test results’ states that ‘For satisfactory performance of the product, the applied suction required to cause leakage of 10g/m2 per 5-minute step in the test specimen shall not be less than the applied suction value of the reference product test specimen at the same leakage rate and wind-rain conditions.’

For these tests the performance of the in-line slate vent is compared with that of the surrounding fibre cement slates tested without the in-line slate vent.

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

5.1 Deluge Test – Sub-test D

There were no leaks observed during the deluge test at any part of the slated roof, through the Manthorpe In-line slate vent or the interface between the two.

5.2 Wind and Rain test – Sub-test B

In Fpr15601 the pressure (or suction factor) at which 10g/m2/5 min of water leakage occurs is taken as the measure of the water tightness of the Manthorpe In-line slate vent and fibre cement roof slates. Table 1 shows the pressure factors for the Manthorpe In-line slate vent with fibre cement slates and for the fibre cement roof slates installed on their own without the vent.

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 slate under wind driven rain conditions.

Figure 4 shows the pressure-leakage curves for the Manthorpe In-line slate vent with fibre cement slates.

It can be seen from Table 1 and Figure 4 that the Manthorpe In-line slate vent performs at least as well as the surrounding fibre cement slates. At a roof pitch of 22.5º the pressure factors are 44Pa and 46Pa with and without the in-line slate vents.

The log sheets in Appendix A showing observations made during the testing show that no rain leakage was observed coming through the vent at normal suction pressures. Some water was observed leaking at the vent side interface with the surrounding roof slates but this occurred well after the interfaces between the slates themselves started to leak and the level of leakage was less than that observed from the interfaces between the surrounding roof slates themselves.

Product	Pitch (°)	Pressure factor (Pa)
Fibre Cement slates	22.5	46
Manthorpe In-line slate vent with fibre cement slates	22.5	44

Table 1 Pressure factors for the Manthorpe In-line slate vent with fibre cement slates at a leakage rate of 10g/m^2/5min

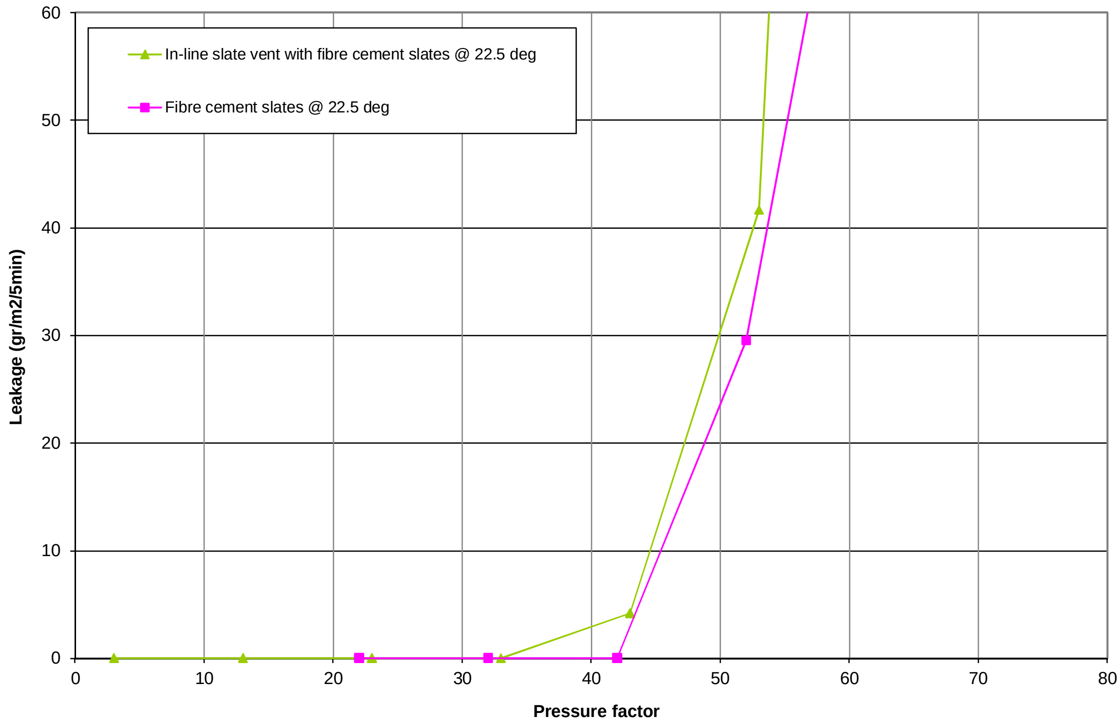

Figure 4 Pressure factor v leakage curves for the Manthorpe In-line slate vent with fibre cement slates and for fibre cement slates on their own

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6 Summary

Tests to assess the relative performance of Manthorpe In-line slate vent with 600mm x 300mm fibre cement slates were carried out according to the procedures of the wind-driven rain test method FprEN15601. The Manthorpe In-line slate vent was tested with fibre cement slates at a roof pitch of 22.5º.

The results show that the weathertightness performance of the Manthorpe In-line slate vent is better than that of the surrounding fibre cement roof slates. Some water was observed leaking at the interface between the vent and adjacent roof slates when under very high suction pressure, however, the degree of leakage was much less than and occurred after the leakage observed from the interfaces between the slates themselves.

The Manthorpe In-line slate vent did not cause the surrounding fibre cement roof slates to leak earlier than they leaked without the vent in place.

As weathertightness performance improves with roof pitch, the in-line slate vent is expected to perform satisfactorily at pitches above 22.5º.

It is expected that the Manthorpe In-line slate vent will perform similarly with other generic types of fibre cement roof slates.

Appendix A - Test report sheets for the Manthorpe In-line slate vent and fibre cement slates

Reference test with fibre cement slates and no roof vent

1.Product name:	600mm x 300mm fibre cement slate	**2.Client:**	Manthorpe
3. Bond:	Broken	**4.Lap:**	100mm
5. Batten Gauge:	250mm	**5.Material:**	Fibre Cement Slate
7. Fixing:	Copper nails and disc rivets	**6. Pitch:**	22.5
9. Date commenced:	16-04-15	**7: Other remarks:**	Witnessing the testing Ben Hales and Mike Challinor Control test, no vent installed

Wet seal box pressure relative roof:	22Pa
Wet seal box pressure relative to the lab:	
Manometer instrument number(s):	IN2405

Test : D Deluge				
Rainfall rate : 225mm/hr		Wind speed :0m/s		
Date of test:				
Pressure difference (Pa)	Time (min:sec) Start	End	Water collected (g)	Comments:
0	0	2	0	No visible leaks

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)	
0	0	5	0	No Leakage observed.
-10	5	10	0	No Leakage observed.
-20	10	15	0	No Leakage observed.
-30	15	20	85	Small droplets forming between slates on central section and RHS 2nd, 3rd and 5th course, droplets falling every 10 – 20 seconds. Water running onto 2nd and 3rd batten causing consistent droplets to fall.
-40	20	25	185	As above, droplets becoming heavier and more consistent. Droplets on 2nd batten constant stream of water. Droplets falling from edge of slates on 2nd, 3rd and 4th course central and RHS.
-50	25	30	251	As above. Water now streaming off battens 2 and 3, 5 heavy leakage on RHS. Slates all along 2nd, 3rd and 5th course heavy leakage constant droplets falling.

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Reference test with fibre cement slates and roof vent

1.Product name: Fibre Cement Slates With Manthorpe Vent	2.Client: Manthorpe
3. Bond: Broken	4.Lap: 100mm
5. Batten Gauge: 250mm	5.Material: Fibre Cement Slate
7. Fixing: Copper nails and disc rivets	6. Pitch: 22.5º
9. Date commenced: 29/05/15	7: Other remarks: Witnessing the testing – Ben Hales and Mike Challinor With Vent installed

Dry seal box pressure:	7pa	
Wet seal box pressure relative roof:	3pa	
Wet seal box pressure relative to the lab:		
Manometer instrument number(s):	IN 2405	

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 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)	
0	0	5	0	No Leakage Observed
-10	5	10	0	No Leakage Observed
-20	10	15	0	No Leakage Observed
-30	15	20	0	No Leakage Observed
-40	20	25	0	Some water beginning to form droplets in between slates on LHS, 1st course.
-50	25	30	108	Droplets now falling from LHS, 1st course. Droplets now falling constantly from 1st, 2nd and 3rd course on LHS between slates. Droplets falling from 3rd course on RHS and 2nd course central section constantly dripping. No leakage on any slates around the vent, or through the vent itself.
-60	30	35	685	Water pouring in through LHS 2nd and 3rd course, Central section 2nd course and RHS courses 2 and 4 water now constant streams between slates. No water coming in around vent or slates immediately connected to vent.
-70	35	40	1155+	As above. LHS courses 2, 3, 4 and 5 constant stream of water. 1 droplet coming in at edge of vent, all surrounding slates still dry. LHS and RHS all courses now constant stream of water coming through edges of slates. Slate below vent beginning to have frequent droplets.
-100	40	45	NA	No water coming through vent, occasional droplet at the side. Water pouring in everywhere else on the rig.

Appendix B - Calibration results for the BRE test rig

FprEN 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.

FprEN 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.

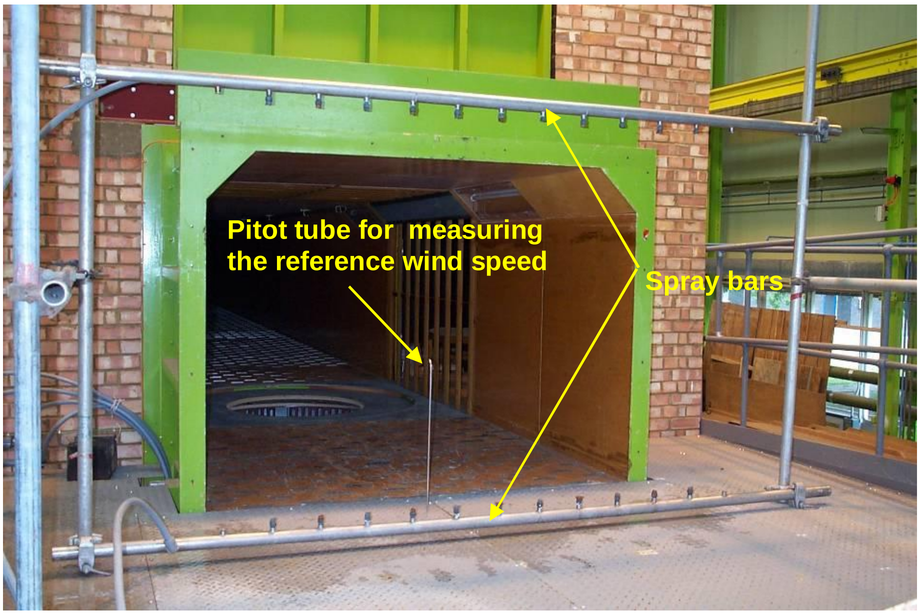

Figure B1 The end of the BRE wind tunnel

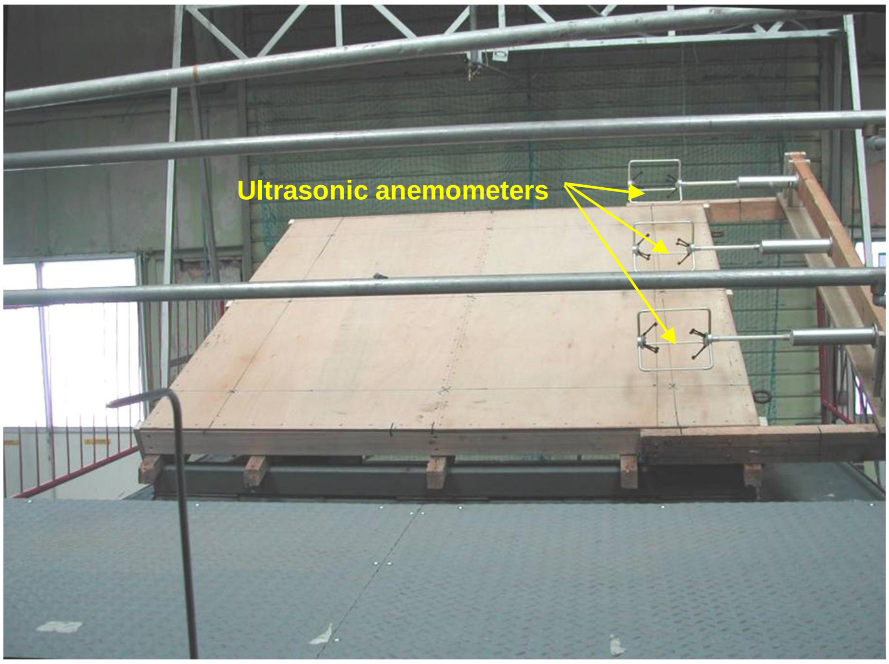

Figure B2 Calibration of the wind speed over the test specimen area

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						
	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