

BRE Test Report

Wind Driven Rain Testing of Manthorpe Cowled Universal Roof Vent to EN 15601

Prepared for: Ben Hales, Manthorpe Building Products

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Date 20th January 2020

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Date 22nd January 2020

Signature

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1 Introduction

This report describes rain penetration tests carried out on the Manthorpe Cowled Universal Roof Vent (CURV). The tests were carried out on three different tile types and a range of roof pitches from 12.5° to 30°.

A sample was first tested without the tile vent to get a baseline result, then the tile vent was installed and the sample tested again to determine the difference the tile vent had made.

The testing was carried out at BRE during November 2019.

These tests are based on BRE Proposal No. P113518-1002 dated 29th October 2019.

The testing was witnessed by:

Ben Hales - Manthorpe

Mike Challinor - Manthorpe



2 Objective

The objective of these tests was to assess the driving rain performance of the Cowled Universal Roof Vent (CURV) from Manthorpe with three different tile types:

Tests were carried out at roof pitches from 12.5° to 30° and three tile profiles of single lap concrete interlocking tiles from flat to bold roll profile. 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 specimens were installed on the BRE test rigs by Manthorpe personnel.

The performance of each test specimen was investigated using a purpose-built mono pitch test roof of nominal size 2m x 2m, at pitch angles from 12.5° to 30°. On the underside of the test roofs, and central to them, a 1.8m wide x 1.6m long shallow Perspex box (open area 2.88m²) was mounted. Figures 1-3 show the product installed on the BRE test rig on the three different tile types.

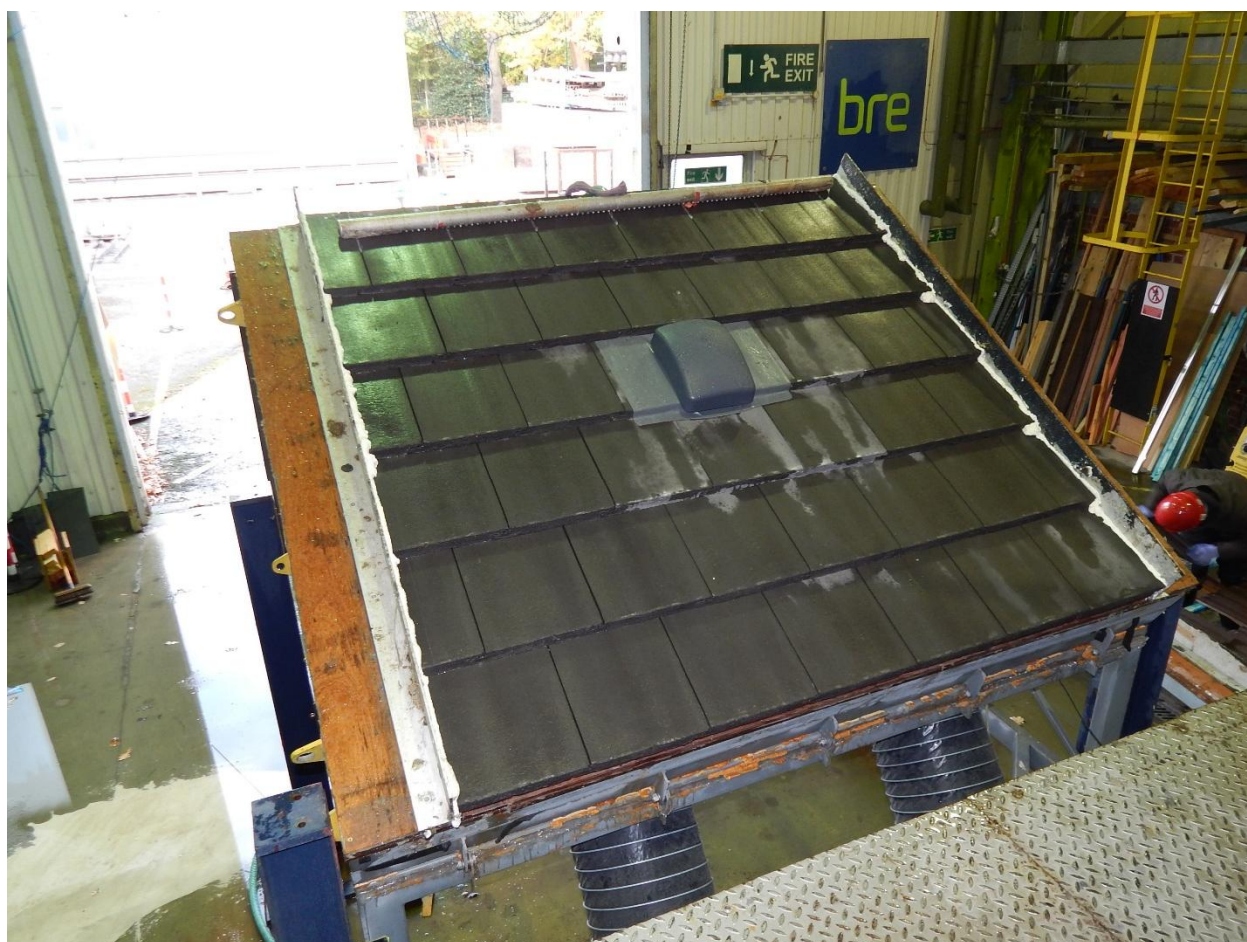


Figure 1 View of the Manthorpe Cowled Universal Roof Vent with a Large Format Flat Tile installed on the BRE test rig



Figure 2 View of the Manthorpe Cowled Universal Roof Vent with a Large Format Bold Roll Tile installed on the BRE test rig

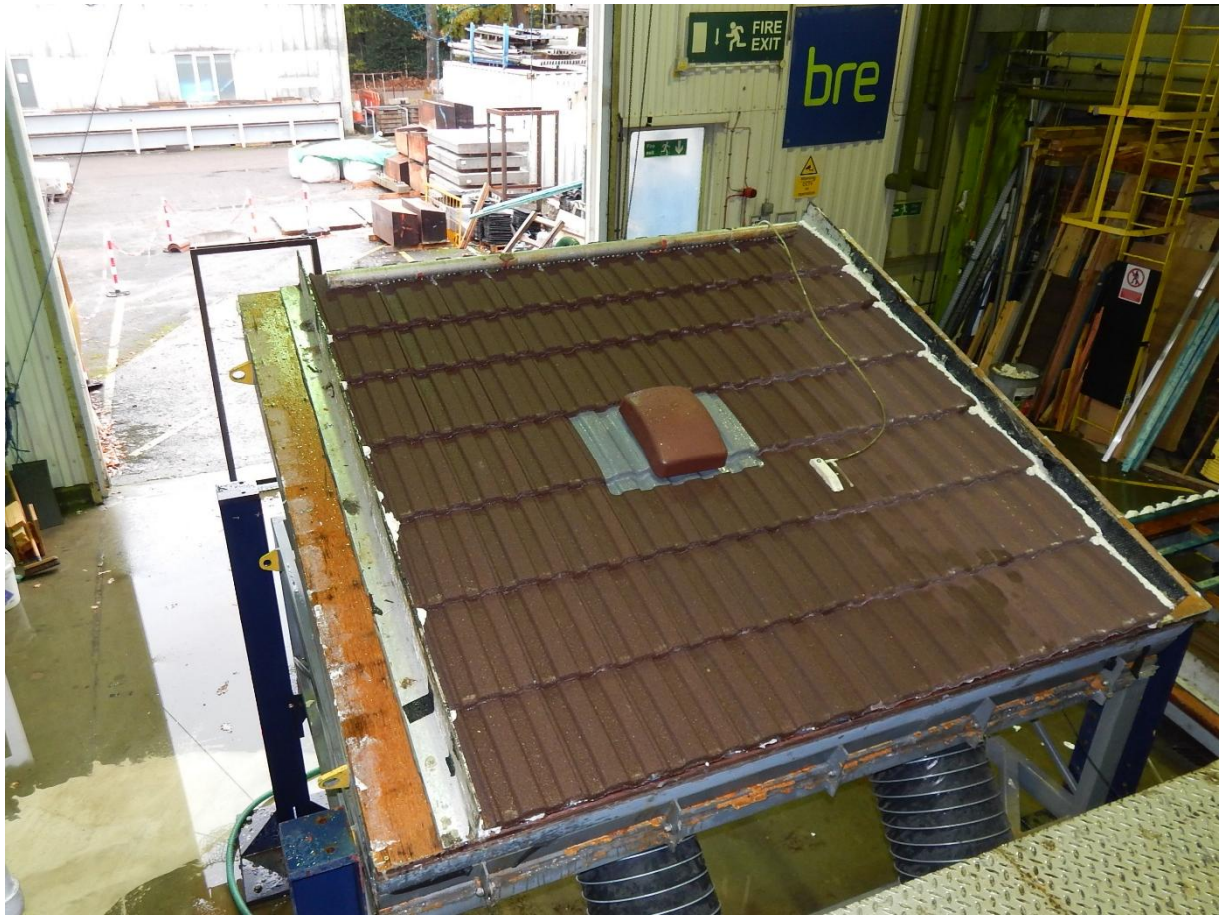


Figure 3 View of the Manthorpe Cowled Universal Roof Vent with a Small Format Castellated Tile installed on the BRE test rig



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 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 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 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. 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.

The 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 Appendix B.

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 $10\text{gr/m}^2/5\text{min}$ 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. The WSB pressure is adopted as the reference zero pressure for subsequent testing according to the procedure given in prEN 15601.

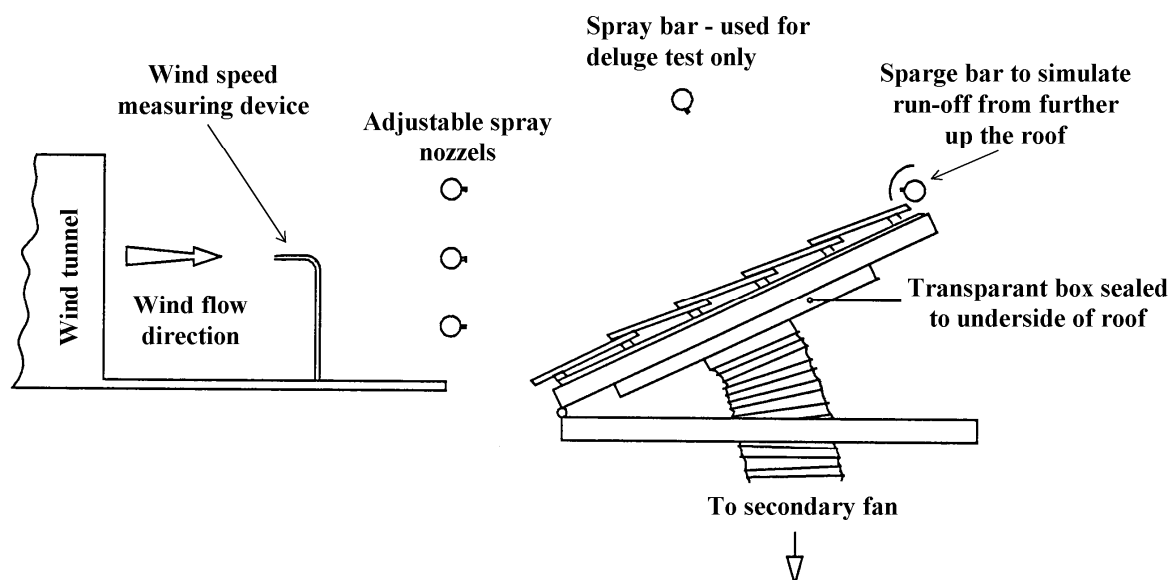


Figure 4: Schematic view of the BRE Rain Penetration Test Rig



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 control test. For the purposes of evaluating the performance of the Manthorpe Cowled Universal Roof Vent in each case the control test is made on a nominally identical sample without the product installed.

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

Figures 5, 7 and 9 show the specimens with Manthorpe Cowled Universal Roof Vent installed under test.

5.1 Deluge tests – Sub-test D

There were no leaks observed from any of the specimens at each of the roof pitches tested.

5.2 Wind and rain tests – Sub-test B

prEN 15601 suggests that the pressure difference (or suction) corrected for WSB pressure (pressure factor) at which $10\text{g/m}^2/5\text{ min}$ of water leakage occurs is taken as a measure of the watertightness of the specimen. Tables 1 to 3 show the pressure factors for the tests on each of the different configurations (tile type, pitch and with/without Manthorpe Cowled Universal Roof Vent) and Figures 6, 8 and 10 show the associated pressure factor v leakage curves. The pressure factors given in Tables 1 to 3 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.

The test specimens incorporating the Large Format Bold Roll Tile and Large Format Flat Tile were tested at two pitches, the specimen incorporating Small Format Castellated Tiles was tested at a single pitch. The pitches used for the testing was selected by the client.

WSB pressure was generally lower for the roofs incorporating the vents compared to the roofs of the same tile without. This was expected because of the air movement via the vent itself.

The test records are presented in Appendix A and detail the data recorded and any observations made during the testing relating to leakage paths/locations.



Figure 5 shows the Large Format Bold Roll Tile with vent under test



Roof Pitch	Pressure factor (Pa) at a leakage rate of 10g/m ² /5min
Large Format Bold Roll Tile @ 12.5° pitch	14Pa
Large Format Bold Roll Tile & Vent @ 12.5°pitch	11Pa
Large Format Bold Roll Tile @ 25° pitch	60Pa
Large Format Bold Roll Tile & Vent @ 25° pitch	40Pa

Table 1 Pressures (suction factors) for the tests on the Large Format Bold Roll Tile with and without the vent

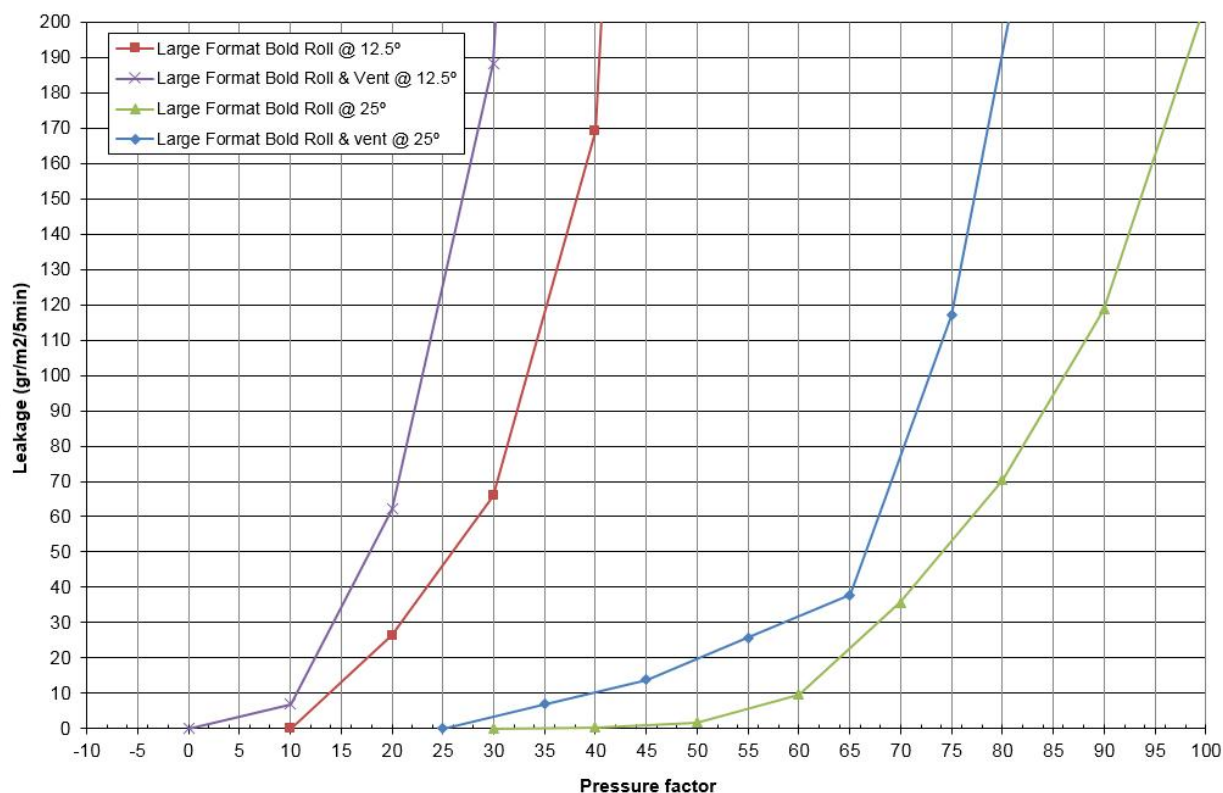


Figure 6 Pressure factor vs leakage curves for the Large Format Bold Roll Tile with and without the vent (Note that these curves are indicative and cannot be directly compared because the vent increases air flow in the roof; which is its intended function)

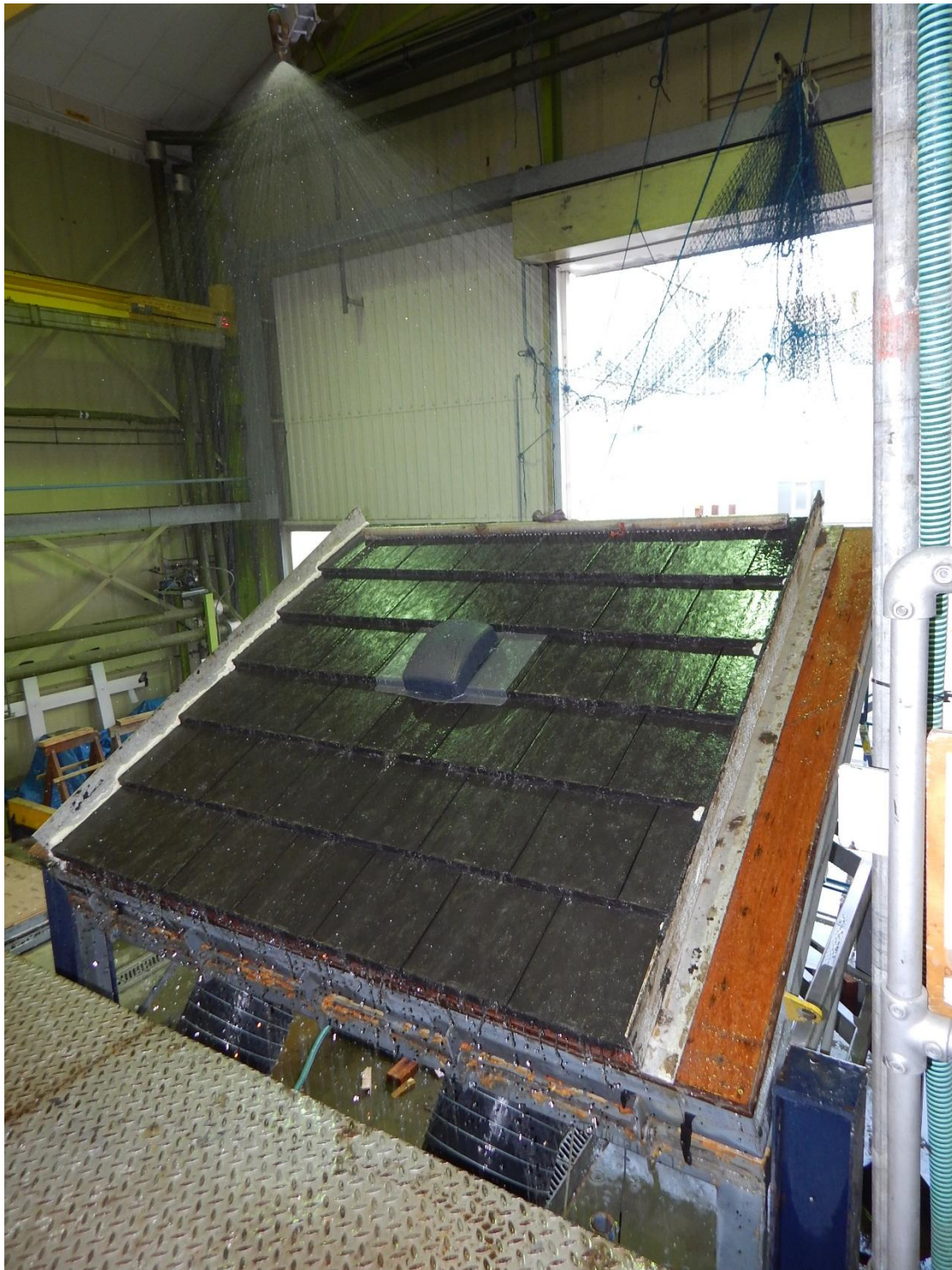


Figure 7 shows the Large Format Flat Tile with vent under test



Roof Pitch	Pressure factor (Pa) at a leakage rate of 10g/m ² /5min
Large Format Flat Tile @ 17.5° pitch	1.5Pa
Large Format Flat Tile & Vent @ 17.5°pitch	-5Pa
Large Format Flat Tile @ 30° pitch	19Pa
Large Format Flat Tile & vent @ 30° pitch	7Pa

Table 2 Pressure factors for the tests on the Large Format Flat Tile with and without the vent

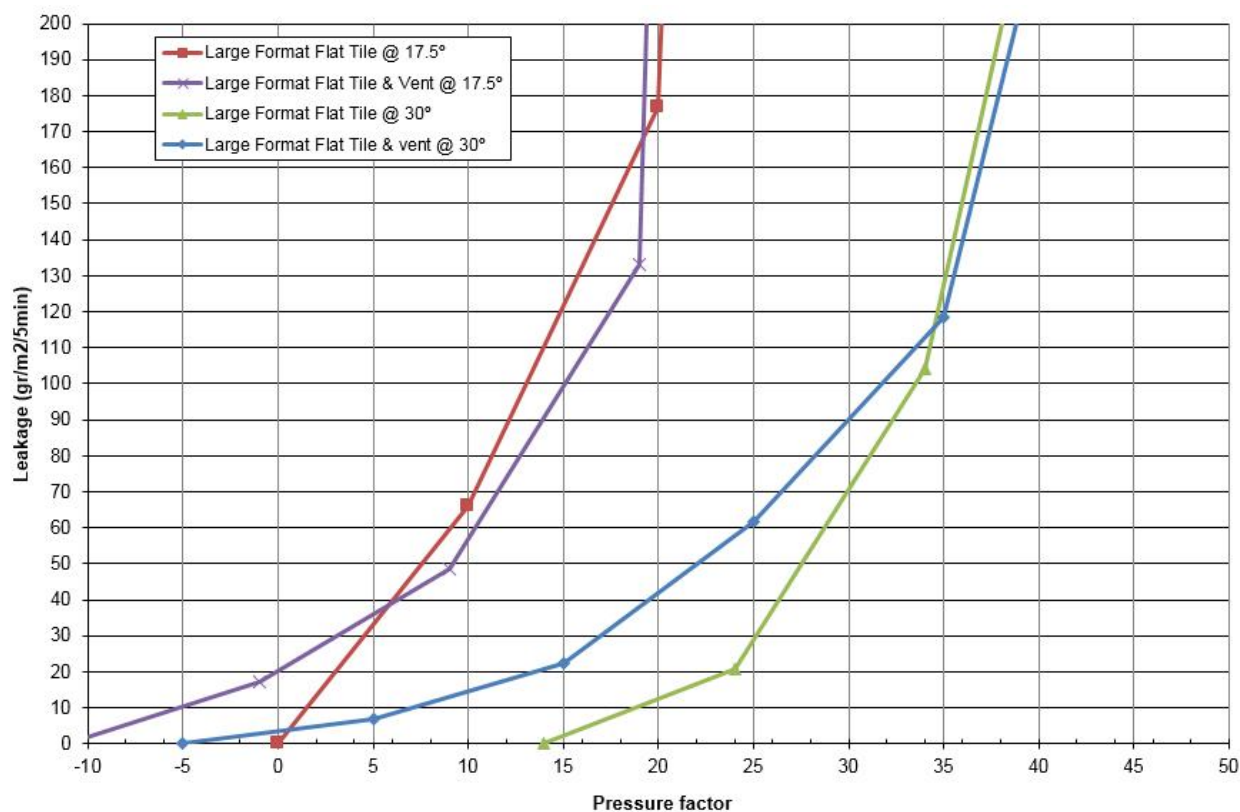


Figure 8 Pressure factor vs leakage curves for the Large Format Flat Tile with and without the vent

(Note that these curves are indicative and cannot be directly compared because the vent increases air flow in the roof; which is its intended function)



Figure 9 shows the Small Format Castellated Tile with vent under test

Roof Pitch	Pressure factor (Pa) at a leakage rate of 10g/m ² /5min
Small Format Castellated Tile @ 17.5° pitch	46Pa
Small Format Castellated Tile & Vent @ 17.5°pitch	49Pa

Table 3 Pressure factors for the tests on the Small Format Castellated Tile with and without the vent

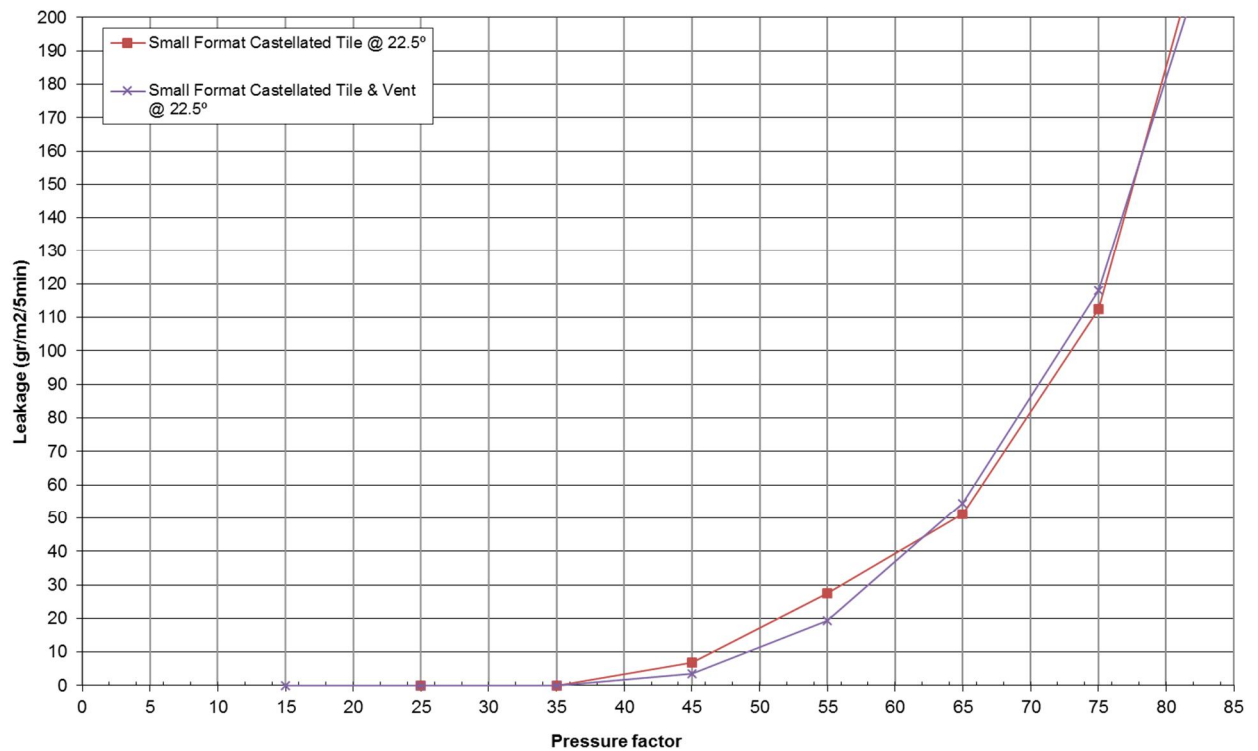


Figure 10 Pressure factor vs leakage curves for the Small Format Castellated Tile with and without the vent

(Note that these curves are indicative and cannot be directly compared because the vent increases air flow in the roof; which is its intended function)



6 Conclusion

This report describes driving rain tests carried out by BRE to determine the performance of Manthorpe Cowled Universal Roof Vent (CURV) to wind driven rain. The testing was carried out to the requirements of prEN15601.

The wet box sealed pressures for specimens without the vents were generally higher than for those specimens without vents due to the added air leakage through the vents themselves; which is the intended function of the vents.

Based on the observations made during the testing there was:

- no noticeable increase of leakage at the interface between the Manthorpe Cowled Universal Roof Vent and the surrounding tiles, and
- no visible ingress of water directly through the tile vent itself.

On this basis, installation of the Manthorpe Cowled Universal Roof Vent did not compromise the weathertightness performance of the roofs.



Appendix A Observations made during the testing

BRE – Rain penetration Test Record

1. Product name: Large Format Bold Roll	2. Client: Manthorpe
3. Bond: Broken	4. Lap: 100mm
5. Batten Gauge: 320mm	5. Material: Concrete
7. Fixing: Aluminium 3.5mmx75mm	6. Pitch: 12.5°
9. Date commenced: 01/11/2019	7. Other remarks: Witnessing the testing

Dry seal box pressure:	N/A
Wet seal box pressure relative roof:	40
Wet seal box pressure relative to the lab:	33
Manometer instrument number(s):	IN5211

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

Test : B				
High wind speed with high rainfall rate				
Rainfall rate:60 mm/hr			Wind speed 13 m/s	
Pressure difference (Pa)	Time (min:sec) Start End		Water collected (g)	
30	0	5	0	No leaks
20	5	10	76	4 th course up, 1 st tile across dripping now and again 6 th course up, 1 st tile across dripping now and again 6 th course up, 2 nd tile across dripping now and again
10	10	15	114	4 th course up, 1 st tile across dripping now and again 6 th course up, 1 st tile across dripping now and again 6 th course up, 2 nd tile across dripping now and again 4 th course up, 6 th tile across dripping now and again 5 th course up, 6 th tile across dripping now and again
0	15	20	297	4 th course up, 1 st tile across dripping now and again 6 th course up, 1 st tile across dripping now and again 6 th course up, 2 nd tile across dripping now and again 4 th course up, 6 th tile across dripping now and again 5 th course up, 6 th tile across dripping now and again 3 rd course up, 1 st tile across dripping approximately once every 3 seconds
-10	20	25	1570	4 th course up, 1 st tile across dripping approximately 3 time every second 6 th course up, 1 st tile across dripping approximately twice every second 6 th course up, 2 nd tile across water streaming approximately every 2 seconds 4 th course up, 6 th tile across dripping approximately twice every second 5 th course up, 6 th tile across dripping approximately twice every second 5 th course up, 6 th tile across water streaming approximately every second 3 rd course up, 1 st tile across dripping approximately once every 3 seconds



BRE – Rain penetration Test Record

1.Product name: Large Format Bold Roll with Vent	2.Client: Manthorpe
3. Bond: Broken	4.Lap: 100mm
5. Batten Gauge: 320mm	5.Material: Concrete
7. Fixing: Aluminium 3.5mmx75mm	6. Pitch: 12.5°
9. Date commenced: 01/11/2019	7: Other remarks: Witnessing the testing

Dry seal box pressure:	N/A
Wet seal box pressure relative roof:	30
Wet seal box pressure relative to the lab:	30
Manometer instrument number(s):	IN5211

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

Test : B				
High wind speed with high rainfall rate				
Rainfall rate:60 mm/hr			Wind speed 13 m/s	
Pressure difference (Pa)	Time (min:sec) Start End		Water collected (g)	
30	0	5	0	No leaks
20	5	10	20	1 st course up, 1 st tile across dripping now and again 1 st course up, 2 nd tile across dripping now and again
10	10	15	159	1 st course up, 1 st tile across dripping approximately once every second 1 st course up, 2 nd tile across dripping approximately once every second
0	15	20	383	1 st course up, 1 st tile across dripping approximately twice every second 1 st course up, 2 nd tile across dripping approximately twice every second 4 th course up, 2 nd tile across dripping approximately 3 time every second 5 th course up, 2 nd tile across dripping approximately twice every second
-10	20	25	1462	1 st course up, 1 st tile across water streaming in 1 st course up, 2 nd tile across water streaming in 4 th course up, 2 nd tile across water streaming approximately every 2 seconds 5 th course up, 2 nd tile across water streaming approximately every second



BRE – Rain penetration Test Record

1. Product name: Large Format Bold Roll	2. Client: Manthorpe
3. Bond: Broken	4. Lap: 100mm
5. Batten Gauge: 320mm	5. Material: Concrete
7. Fixing: Aluminium 3.5mmx75mm	6. Pitch: 25°
9. Date commenced: 01/11/2019	7. Other remarks: Witnessing the testing

Dry seal box pressure:	50
Wet seal box pressure relative roof:	50
Wet seal box pressure relative to the lab:	49
Manometer instrument number(s):	IN5211

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



Test : B				
High wind speed with high rainfall rate				
Rainfall rate:60 mm/hr			Wind speed 13 m/s	
Pressure difference (Pa)	Time (min:sec)		Water collected (g)	
	Start	End		
20	0	5	0	No leaks
10	5	10	1	4 th course up, 1 st tile across dripping now and again
0	10	15	4	4 th course up, 1 st tile across dripping now and again 4 th course up, 4 th joint across dripping now and again
-10	15	20	23	4 th course up, 1 st tile across dripping now and again 4 th course up, 4 th joint across dripping now and again
-20	20	25	75	4 th course up, 1 st tile across dripping approximately once every 3 seconds 4 th course up, 4 th joint across dripping now and again 5 th course up, 6 th joint across dripping now and again
-30	25	30	100	4 th course up, 1 st tile across dripping approximately once every 3 seconds 4 th course up, 4 th joint across dripping now and again 5 th course up, 6 th joint across dripping now and again
-40	35	40	139	4 th course up, 1 st tile across dripping now and again 4 th course up, 4 th joint across dripping approximately once every 3 seconds 5 th course up, 6 th joint across dripping approximately once every 3 seconds 6 th course up, 7 th dripping approximately once every 2 seconds
-50	40	45	251	4 th course up, 1 st tile across dripping now and again 4 th course up, 4 th joint across dripping approximately once every 3 seconds 5 th course up, 6 th joint across dripping approximately once every 3 seconds 6 th course up, 7 th water streaming approximately every 2 seconds
-60	45	50	276	4 th course up, 1 st tile across dripping now and again 4 th course up, 4 th joint across dripping approximately once every 3 seconds 5 th course up, 6 th joint across dripping approximately once every 3 seconds 6 th course up, 7 th water streaming approximately every 2 seconds
-70	50	55	390	4 th course up, 1 st tile across dripping now and again 4 th course up, 4 th joint across dripping approximately once every 3 seconds 5 th course up, 6 th joint across dripping approximately once every 3 seconds 6 th course up, 7 th water streaming approximately every 2 seconds
-80	55	60	459	4 th course up, 1 st tile across dripping approximately once every second 4 th course up, 4 th joint across dripping approximately once every 3 seconds 5 th course up, 6 th joint across dripping approximately once every 3 seconds 6 th course up, 7 th water streaming approximately every 2 seconds
-90	60	65	696	4 th course up, 1 st tile across dripping approximately once every second 4 th course up, 4 th joint across dripping approximately once every 3 seconds 5 th course up, 6 th joint across dripping approximately once every 3 seconds 6 th course up, 7 th water streaming approximately every 2 seconds 4 th course up, 2 nd tile across dripping approximately once every 2 seconds 4 th course up, 2 nd tile across dripping approximately twice every second
-100	65	70	948	4 th course up, 1 st tile across dripping approximately once every second 4 th course up, 4 th joint across dripping approximately once every 3 seconds 5 th course up, 6 th joint across dripping approximately once every 3 seconds 6 th course up, 7 th water streaming approximately every 2 seconds 4 th course up, 2 nd tile across dripping approximately once every 2 seconds 4 th course up, 2 nd tile across dripping approximately twice every second 2 nd course up, 1 st tile across dripping approximately once every 2 seconds 3 rd course up, 1 st tile across dripping approximately once every 2 seconds



BRE – Rain penetration Test Record

1. Product name: Large Format Flat	2. Client: Manthorpe
3. Bond: Broken	4. Lap: 100mm
5. Batten Gauge: 320mm	5. Material: Concrete
7. Fixing: Aluminium 3.5mmx50mm	6. Pitch: 17.5°
9. Date commenced: 31/10/2019	7. Other remarks: Witnessing the testing

Dry seal box pressure:	N/A
Wet seal box pressure relative roof:	20
Wet seal box pressure relative to the lab:	26
Manometer instrument number(s):	5211

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

Test : B				
High wind speed with high rainfall rate				
Rainfall rate:60 mm/hr			Wind speed 13 m/s	
Pressure difference (Pa)	Time (min:sec) Start End		Water collected (g)	
20	0	5	0	No leaks visible
10	5	10	190	A 1 st course, 3 rd tile from left - dripping now and again B 1 st course, 4 th tile from left - dripping approximately once every 2 seconds C 1 st course, 5 th tile from left - dripping now and again D 2 nd course, 6 th tile from left - dripping now and again
0	10	15	319	A - dripping now and again B - dripping approximately once every 3 seconds C - dripping now and again D - dripping now and again E - dripping now and again F 1 st course, 2 nd tile from left - dripping approximately once every 3 seconds
-10	15	20	3718	A-F - water streaming in



BRE – Rain penetration Test Record

1. Product name: Large Format Flat with vent	2. Client: Manthorpe
3. Bond: Broken	4. Lap: 100mm
5. Batten Gauge: 320mm	5. Material: Concrete
7. Fixing: Aluminium 3.5mmx50mm	6. Pitch: 17.5°
9. Date commenced: 31/10/2019	7. Other remarks: Witnessing the testing

Dry seal box pressure:	N/A
Wet seal box pressure relative roof:	9
Wet seal box pressure relative to the lab:	16
Manometer instrument number(s):	5211

Test : D Deluge

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

Test : B

High wind speed with high rainfall rate

Rainfall rate:60 mm/hr		Wind speed 13 m/s	
Pressure difference (Pa)	Time (min:sec) Start End	Water collected (g)	
20	0 5	0	No leaks visible
10	5 10	50	1 st course up, 4 th tile from left - dripping now and again 1 st course up, 3 rd tile from left - dripping approximately once every 3 seconds
0	10 15	90	1 st course up, 4 th tile from left - dripping now and again 1 st course up, 3 rd tile from left - dripping approximately once every 3 seconds 2 nd course up, 3 rd tile from left - dripping approximately once every 2 seconds
-10	15 20	243	1 st course up, 4 th tile from left - dripping now and again 1 st course up, 3 rd tile from left - dripping approximately once every 3 seconds 2 nd course up, 3 rd tile from left - dripping approximately once every 2 seconds 5 th course up, 1 st tile from left - dripping approximately once every 2 seconds 5 th course up, 2 nd tile from left - dripping approximately once every 3 seconds
-20	20 25	5123	1 st course up, 4 th tile from left - water streaming in 1 st course up, 3 rd tile from left - water streaming approximately every second 2 nd course up, 3 rd tile from left - water streaming approximately every 2 seconds 5 th course up, 1 st tile from left - water streaming in 5 th course up, 2 nd tile from left - water streaming in



BRE – Rain penetration Test Record

1.Product name: Large Format Flat	2.Client: Manthorpe
3. Bond: Broken	4.Lap: 100mm
5. Batten Gauge: 320mm	5.Material: Concrete
7. Fixing: Aluminium 3.5mmx50mm	6. Pitch: 30°
9. Date commenced: 31/10/2019	7: Other remarks: Witnessing the testing

Dry seal box pressure:	38
Wet seal box pressure relative roof:	17
Wet seal box pressure relative to the lab:	39
Manometer instrument number(s):	5211

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



Test : B				
High wind speed with high rainfall rate				
Rainfall rate:60 mm/hr			Wind speed 13 m/s	
Pressure difference (Pa)	Time (min:sec)		Water collected (g)	
	Start	End		
20	0	5	0	No leaks visible
10	5	10	0	No leaks visible
0	10	15	0	A 1 st course, 2 nd tile from left - dripping now and again
-10	15	20	60	A As above B 1 st course, 5 th tile from left - dripping now and again C 4 th course, 3 rd tile from left - dripping now and again
-20	20	25	240	A-B As above C - dripping approximately twice every second
-30	25	30	680	A-B As above C - dripping approximately 3 time every second D 3 rd course, 2 nd tile from left - dripping approximately once every 2 seconds
-40	35	40	2799	A-D - water streaming in



BRE – Rain penetration Test Record

1. Product name: Large Format Flat with vent	2. Client: Manthorpe
3. Bond: Broken	4. Lap: 100mm
5. Batten Gauge: 320mm	5. Material: Concrete
7. Fixing: Aluminium 3.5mmx50mm	6. Pitch: 30°
9. Date commenced: 31/10/2019	7. Other remarks: Witnessing the testing

Dry seal box pressure:	N/A
Wet seal box pressure relative roof:	5
Wet seal box pressure relative to the lab:	30
Manometer instrument number(s):	5211

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



Test : B				
High wind speed with high rainfall rate				
Rainfall rate:60 mm/hr			Wind speed 13 m/s	
Pressure difference (Pa)	Time (min:sec)		Water collected (g)	
	Start	End		
20	0	5	0	No leaks visible
10	5	10	0	No leaks visible
0	10	15	20	3 rd course up, 4 th tile from left dripping now and again
-10	15	20	45	3 rd course up, 4 th tile from left dripping now and again 3 rd course up, 2 nd tile from left dripping now and again
-20	20	25	113	3 rd course up, 4 th tile from left dripping now and again 3 rd course up, 2 nd tile from left dripping now and again 1 st course up, 5 th tile from left dripping now and again 1 st course up, 6 th tile from left dripping now and again
-30	25	30	163	3 rd course up, 4 th tile from left dripping now and again 3 rd course up, 2 nd tile from left dripping now and again 1 st course up, 5 th tile from left dripping now and again 1 st course up, 6 th tile from left dripping now and again 1 st course up, 4 th tile from left dripping now and again
-40	35	40	613	3 rd course up, 4 th tile from left dripping now and again 3 rd course up, 2 nd tile from left water streaming approximately every 2 seconds 1 st course up, 5 th tile from left dripping now and again 1 st course up, 6 th tile from left dripping now and again 1 st course up, 4 th tile from left dripping now and again
-50	40	35	1304	3 rd course up, 4 th tile from left dripping approximately once every 2 seconds 3 rd course up, 2 nd tile from left water streaming approximately every 2 seconds 1 st course up, 5 th tile from left dripping approximately 3 time every second 1 st course up, 6 th tile from left dripping approximately twice every second 1 st course up, 4 th tile from left dripping now and again



BRE – Rain penetration Test Record

1. Product name: Small format castellated	2. Client: Manthorpe
3. Bond: Straight	4. Lap: 90mm
5. Batten Gauge: 290mm	5. Material: Concrete
7. Fixing: Aluminium 3.5mmx50mm	6. Pitch: 22.5°
9. Date commenced: 31/10/2019	7. Other remarks: Witnessing the testing

Dry seal box pressure:	40
Wet seal box pressure relative roof:	45
Wet seal box pressure relative to the lab:	46
Manometer instrument number(s):	5211

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



Test : B				
High wind speed with high rainfall rate				
Rainfall rate:60 mm/hr			Wind speed 13 m/s	
Pressure difference (Pa)	Time (min:sec)		Water collected (g)	
	Start	End		
20	0	5	0	No leaks visible
10	5	10	0	No leaks visible
0	10	15	20	All nibs showing signs of water. Lots of water droplets forming
-10	15	20	59	1 st course up, 10 th across - dripping now and again 2 nd course up, 9 th across - dripping now and again
-20	20	25	68	1 st course up, 10 th across - dripping now and again 2 nd course up, 9 th across - dripping now and again
-30	25	30	177	1 st course up, 10 th across - dripping now and again 2 nd course up, 9 th across - dripping now and again 5 th course up, 2 nd , 3 rd , 10 th - dripping now and again 6 th course up, 11 th across - dripping now and again
-40	35	40	420	3 rd course up, 9 th across - dripping approximately once every second 4 th course up, 3 rd across - dripping approximately once every second 5 th course up, 2 nd across - dripping approximately once every second 5 th course up, 3 rd across - dripping approximately once every 2 seconds
-50	40	45	840	3 rd course up, 9 th across - dripping approximately twice every second 4 th course up, 3 rd across - dripping approximately twice every second 5 th course up, 2 nd across - dripping approximately twice every second 5 th course up, 3 rd across - dripping approximately once every second
-60	45	50	1450	3 rd course up, 9 th across - water streaming approximately every second 4 th course up, 3 rd across - water streaming in 5 th course up, 2 nd across - water streaming approximately every second 5 th course up, 3 rd across - water streaming approximately every 2 seconds



BRE – Rain penetration Test Record

1. Product name: Small format castellated + vent	2. Client: Manthorpe
3. Bond: Straight	4. Lap: 90mm
5. Batten Gauge: 290mm	5. Material: Concrete
7. Fixing: Aluminium 3.5mmx50mm	6. Pitch: 22.5°
9. Date commenced: 01/11/2019	7. Other remarks: Witnessing the testing

Dry seal box pressure:	30
Wet seal box pressure relative roof:	35
Wet seal box pressure relative to the lab:	35
Manometer instrument number(s):	5211

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



Test : B				
High wind speed with high rainfall rate				
Rainfall rate: 60 mm/hr			Wind speed 13 m/s	
Pressure difference (Pa)	Time (min:sec)		Water collected (g)	
	Start	End		
20	0	5	0	No leaks visible
10	5	10	0	No leaks visible
0	10	15	0	No leaks visible
-10	15	20	10	A 1 st course, 10 tile from left - dripping now and again B 2 nd course, 9 th tile from left - dripping now and again
-20	20	25	46	A As above B As above C 5 th course, 2 nd tile from left - dripping now and again D 5 th course, 3 tile from left - dripping now and again E 5 th course, 10 tile from left - dripping now and again F 6 th course, 11 th tile from left - dripping now and again
-30	25	30	101	A-F As above
-40	35	40	183	A-F As above G 3 rd course, 6 th tile from left - dripping approximately once every second H 4 th course, 3 rd tile from left - dripping approximately once every second I 5 th course, 2 nd tile from left - dripping approximately once every second J 5 th course, 3 rd tile from left - dripping approximately once every 2 seconds
-50	40	45	368	A - dripping approximately once every 3 seconds B - dripping approximately once every 3 seconds C - dripping approximately once every 3 seconds D - dripping approximately once every 3 seconds E - dripping approximately once every 3 seconds F - dripping approximately once every 3 seconds G - dripping approximately twice every second H - dripping approximately twice every second I - dripping approximately twice every second J - dripping approximately once every second
-60	45	50	879	A-J As above K 4 th course, 9 th tile from left - 3 L 5 th course, 8 tile from left - 3
-70	50	55	1077	A-L As above M 6 th course, 9 th tile from left - dripping approximately once every second N 6 th course, 2 nd tile from left - dripping approximately once every second



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.

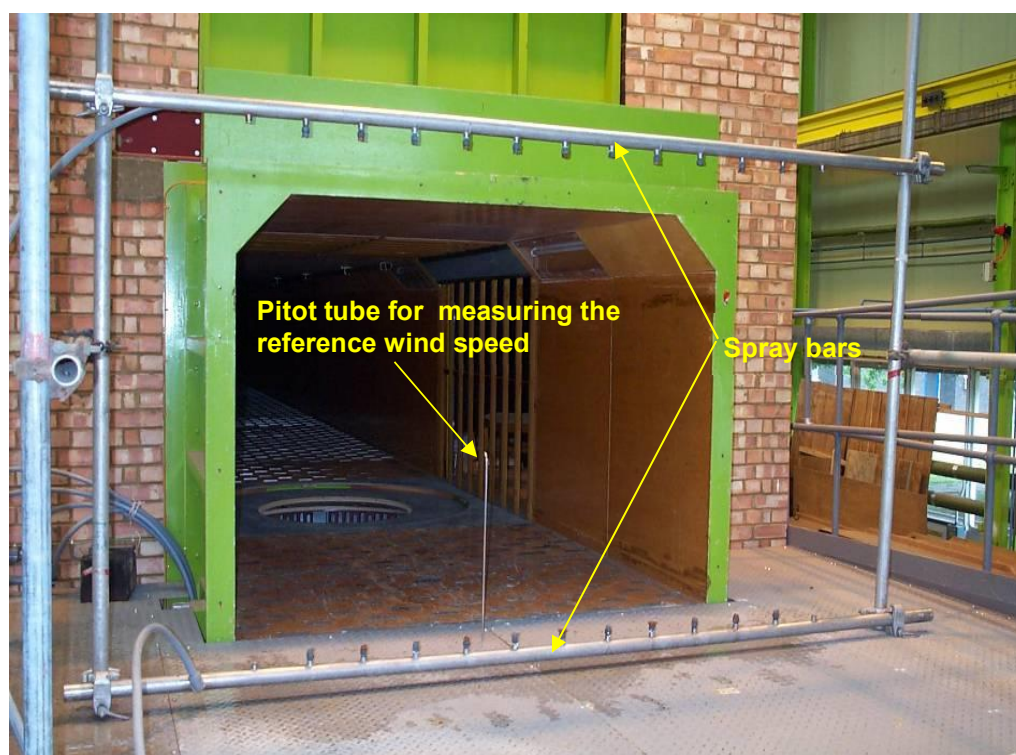


Figure B1 The end of the BRE wind tunnel



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:

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

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

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							
Location	mean wind speed			Variation from mean %	Turbulence intensity		
	U	V	W		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 $\pm 35\%$ 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 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 $\pm 35\%$ 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