Rain Penetration Tests on Manthorpe Plain Tile Roof Vent with Redland Rosemary plain clay tiles

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Executive Summary

This report describes rain penetration tests carried out on a Manthorpe plain tile vent with Redland Rosemary plain clay tiles to assess its resistance to driving rain. The vent was tested at a roof pitch of 35º. 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 Manthorpe plain tile roof vent does not leak before the surrounding Redland Rosemary plain clay tiles
- The Manthorpe plain tile roof vent performs well with the plain tiles and when installed correctly there is no issue with leaks on the interfaces between the two.

Contents

1 Introduction

This report describes rain penetration tests carried out on the Manthorpe plain tile roof vent with Redland Rosemary plain clay tiles. The test reported herein was carried out at BRE, Garston Watford during May 2013 at a roof pitch of 35º.

This test is based on BRE Proposal No. 133-439 dated 19th April 2013, which was accepted by Mr Ben Hales on 17th May 2013.

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 plain tile roof vent with Redland Rosemary plain clay tiles 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 35° with the perimeter tiles and every fifth course of tiles nailed with 35mm aluminium roofing nails. The test 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 Specimens

The tiles were installed on the BRE test rig by Manthorpe employees. Details of the tile fixing specifications are given in Annex A.

The performance of the roof vent with tiles was investigated using a purpose-built monopitch test roof of nominal size 2m x 2m, at a pitch angle of 35º. 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 tiles 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 1 shows the roof vent and tiles laid on the BRE test rig.

Figure 1 Manthorpe plain tile roof vent with Redland Rosemary plain clay tiles installed on the BRE driving rain test rig

4 Test Procedure

The Manthorpe plain tile roof vent and Redland Rosemary plain clay tiles 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 tiles 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 tiles.

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 tiles 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 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.

It should be noted that the variable speed fan used to generate the pressure difference across the tiles 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.

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.

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

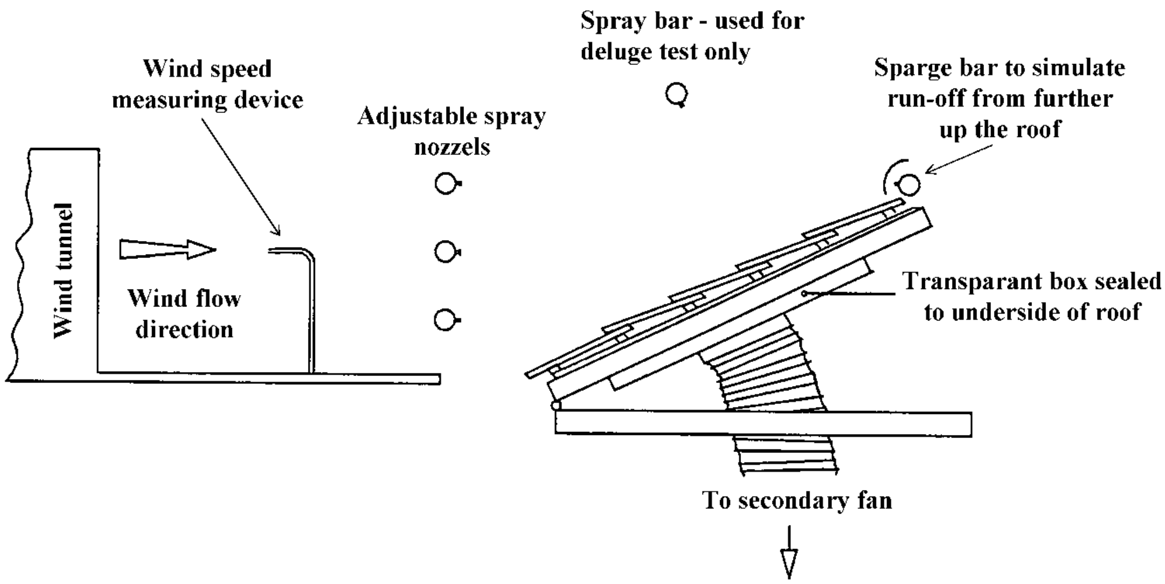

Figure 2 Schematic view of the BRE Rain Penetration Test Rig

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

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 tile vent is compared with that of the surrounding plain tiles.

Typed copies of the result sheets filled in during the tests and giving observations made at the time are contained in Annex A. It should be noted that the remark 'no change' refers to the visible behaviour of the leakage. As the pressure difference across the test roof is reduced, in reality there is likely to be a progressive degradation of the weather-tightness. The other comments stated therein are self explanatory.

5.1 Deluge tests – Sub-test D

There were no leaks observed during the deluge test at any part of the tiled roof, through the Manthorpe plain tile roof vent or the interface between the two.

5.2 Wind and rain tests – Sub-test B

In Fpr15601 the pressure (or suction factor) at which $10g/m^2/5$ min of water leakage occurs is taken as the measure of the water tightness of the Manthorpe plain tile roof vent, interface and tiles. Table 1 shows the pressure factors for the Manthorpe plain tile roof vent and tiles.

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 tile under wind driven rain conditions.

Figure 3 shows the pressure-leakage curves for the Manthorpe plain tile roof vent with Redland Rosemary plain clay tiles. Also included are results from a generic flat concrete tiles and generic fibre cement slates for reference.

Table 1 Pressure factors for the Manthorpe plain tile roof vent with Redland Rosemary plain clay tiles with generic flat concrete and fibre cement slates at a leakage rate of 10g/m^2/5min

Product	Pitch (°)	Pressure factor (Pa)
Manthorpe plain tile roof vent with Redland Rosemary plain clay tiles	35	65
Generic flat concrete tile	22.5	29
Generic fibre cement slate	22.5	70

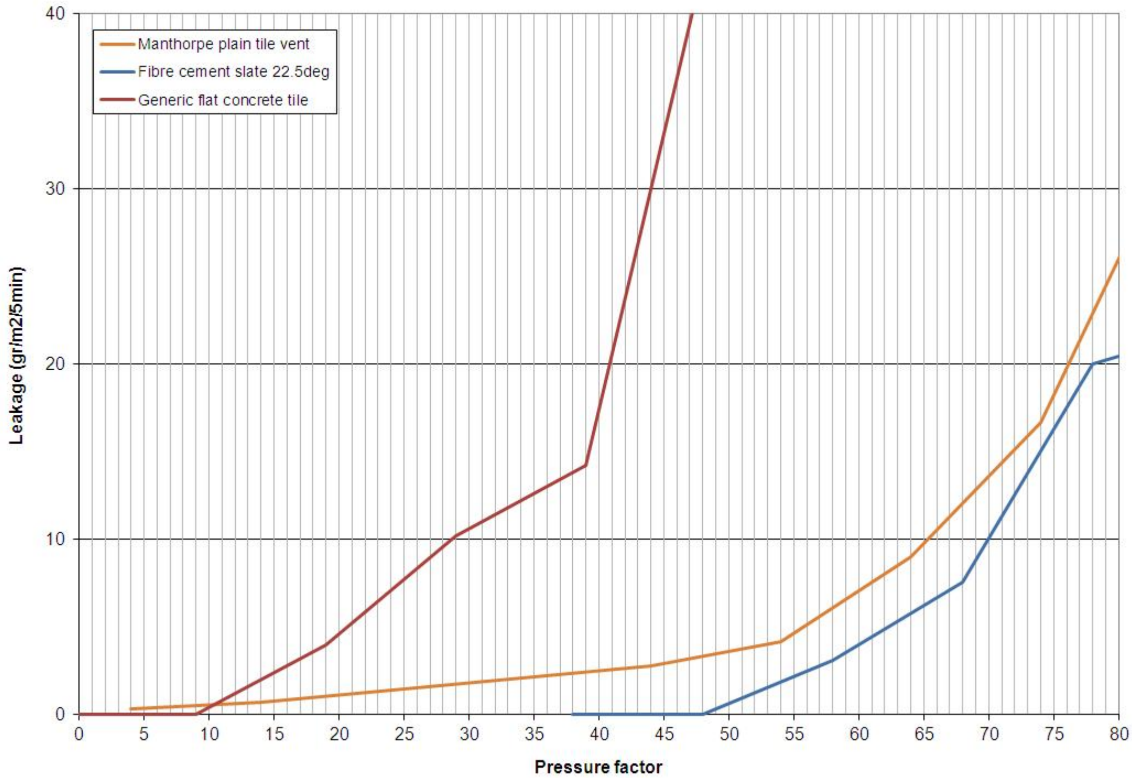

Figure 3 Pressure factor v leakage curves for the Manthorpe plain tile roof vent with Redland Rosemary plain clay tiles

6 Summary

Tests to assess the relative performance of Manthorpe roof vent with Redland Rosemary plain clay tiles were carried out according to the procedures of the wind-driven rain test method FprEN15601. The Manthorpe roof vent with Redland Rosemary plain clay tiles was tested at a roof a pitch of 35º. The test was carried out with the Manthorpe roof vent with Redland Rosemary plain clay tiles completely dry before tests.

The results show that the Manthorpe roof vent performs better than the surrounding Redland Rosemary plain clay tiles. There was no rain leakage at the interfaces between the vent and surrounding tiles.

Appendix A1 – Test report sheets for the Manthorpe tile vent with Redland Rosemary plain clay tiles.

Product name: Manthorpe plain tile roof vent with Redland Rosemary plain clay tiles	Company: Manthorpe Building Products Ltd.
Bond: Broken, double lapped	Lap: 175mm
Material: Clay	Pitch: $35^{0.}$
Fixing: 35mm Aluminium nails	Batten gauge: 100
Additional:	Date commenced: 07/05/2013

Observations with regard to left and right are as seen from underneath the test rig looking towards the wind tunnel.

Wet seal pressure roof to pressure box +14Pa
Wet seal pressure lab to pressure box +40Pa

Test : D Maximum rainfall rate, no wind (Deluge).				
Rainfall rate : 225mm/hr		Wind speed :0m/s		
Date of test: 07/05/2013				
Pressure difference (Pa)	Time (min:sec) Start	End	Water collected (g)	Comments:
0	0	2	0	No leaks

Test : B Low wind speed with high rainfall rate. 60 mm/h				
Rainfall rate: 60 mm/hr		Wind speed 13 m/s		
Date of test: 07/05/2013				
Pressure difference (Pa)	Time (min:sec) Start	End	Water collected (g)	Observations
40	0	5	0	No leaks
30	5	10	0	No Change
20	10	15	0	No Change
10	15	20	1	Centre, left hand side, 6th batten down from top, irregular short spells of dripping at approximately 1 drip every 2 minutes. droplets forming on the inside of vent none running
0	20	25	1	Centre, 3rd, 4th and 6th battens down from top drip irregular. Left, 4th batten down from top droplets still on the inside of vent none running
-10	25	30	2	Drip on course below either side of vent, Previous drips continues.
-20	30	35	2	No Change
-30	35	40	2	Previous drips continue and droplets formed inside of vent have now dried out.
-40	40	45	4	Previous drips continue and centre, left 6th batten down dripping more frequently 1 per minute.
-50	45	50	14	Previous drips continue and 11th batten down right of centre water on underside of tile constant drip, 1 drip every 2 seconds.
-60	50	55	22	Previous drips increased in rate slightly, right 10th and left 5th batten dripping 1 drip every 2 seconds.
-70	55	60	45	Previous drips continue, left 7th batten dripping 1 drip every 2 seconds, left 4th battens, irregular dripping with short spells at 1dps

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.

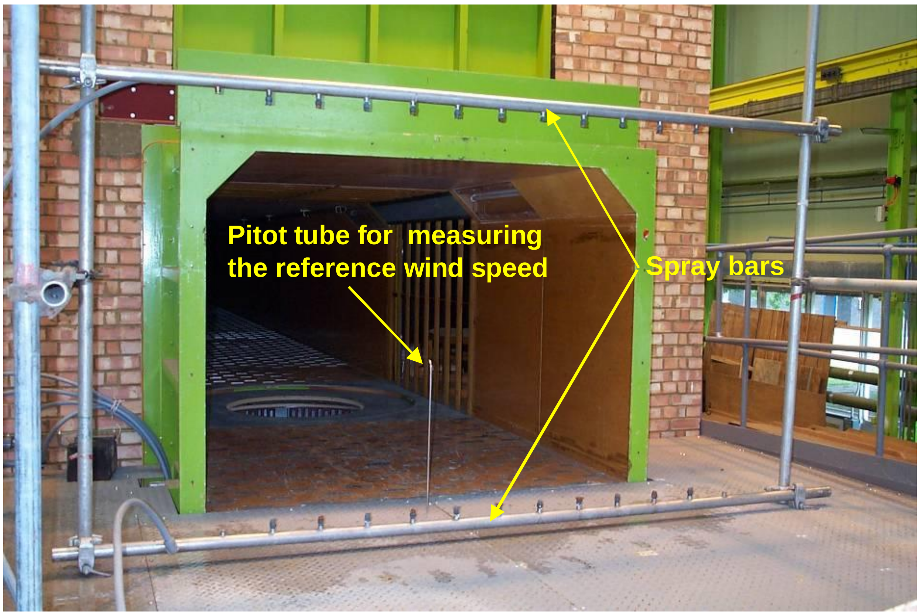

Figure B1 The end of the BRE wind tunnel

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

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.

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