

## BRE Test Report

### Rain Penetration Tests on Manthorpe Plain Tile Vent

Prepared for: Ben Hales  
Date: 25<sup>th</sup> May 2017  
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Date 25<sup>th</sup> May 2017

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Date 5<sup>th</sup> June 2017

Signature

A handwritten signature in blue ink, appearing to read 'P. Blackmore', is written over a light blue horizontal line.

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## Executive Summary

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This report describes rain penetration tests carried out on a Manthorpe Interlocking Plain Tile Vent to assess its resistance to driving rain. The vent was tested at roof pitches of 30°, 25° & 22.5° on a roof with Marley Ashmore tiles and Gemini Forticrete tiles. 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 Interlocking Plain Tile Vent is better than that of the surrounding Marley Ashmore & Gemini Forticrete tiles.
- The Manthorpe Interlocking Plain Tile Vent will perform satisfactorily at a minimum roof pitch of 22.5°.
- The Manthorpe Interlocking Plain Tile Vent does not leak before the surrounding Marley Ashmore tiles at roof pitches of 22.5°. The Manthorpe Interlocking Plain Tile Vent does not leak before the surrounding Gemini Forticrete tiles at a roof pitches of 22.5°. As weathertightness performance improves with roof pitch, the Manthorpe Interlocking Plain Tile Vent is expected to also perform satisfactorily at roof pitches above 22.5°.



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## 1 Introduction

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This report describes rain penetration tests carried out on the Manthorpe Interlocking Plain Tile Vent when installed with Marley Ashmore and Gemini Forticrete tiles. The tests reported herein were carried out at BRE, Garston Watford during April & May 2017 at roof pitches of 22.5°, 25° and 30°.

This test is based on BRE Proposal No. P108129-1000 dated 28<sup>th</sup> March 2017, which was accepted by Mr Ben Hales.

The testing was witnessed by:

Mr Ben Hales & Mr Jed Brown from Manthorpe Building Products Ltd.



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## 2 Objective

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The objective of these tests was to assess the driving rain performance of the Manthorpe Interlocking Plain Tile Vent when installed with Marley Ashmore and Gemini Forticrete 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 roof pitches of 22.5°, 25° and 30°, 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 tiles were installed on the BRE test rig by Manthorpe employees. For these tests Marley Ashmore and Gemini Forticrete tiles were used on separate rigs. Figure 1 shows the vent installed on the Marley Ashmore rig. Figure 2 shows the vent installed on the Gemini Forticrete rig.



Figure 1 Interlocking Plain Tile Vent installed with Marley Ashmore tiles





Figure 2 Interlocking Plain Tile Vent installed with Gemini Forticrete Tiles

The performance of the roof vent was investigated using a purpose-built monopitch test roof of nominal size 2m x 2m. 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<sup>2</sup>) 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 3 & 4 show the roof vent and tiles under test.



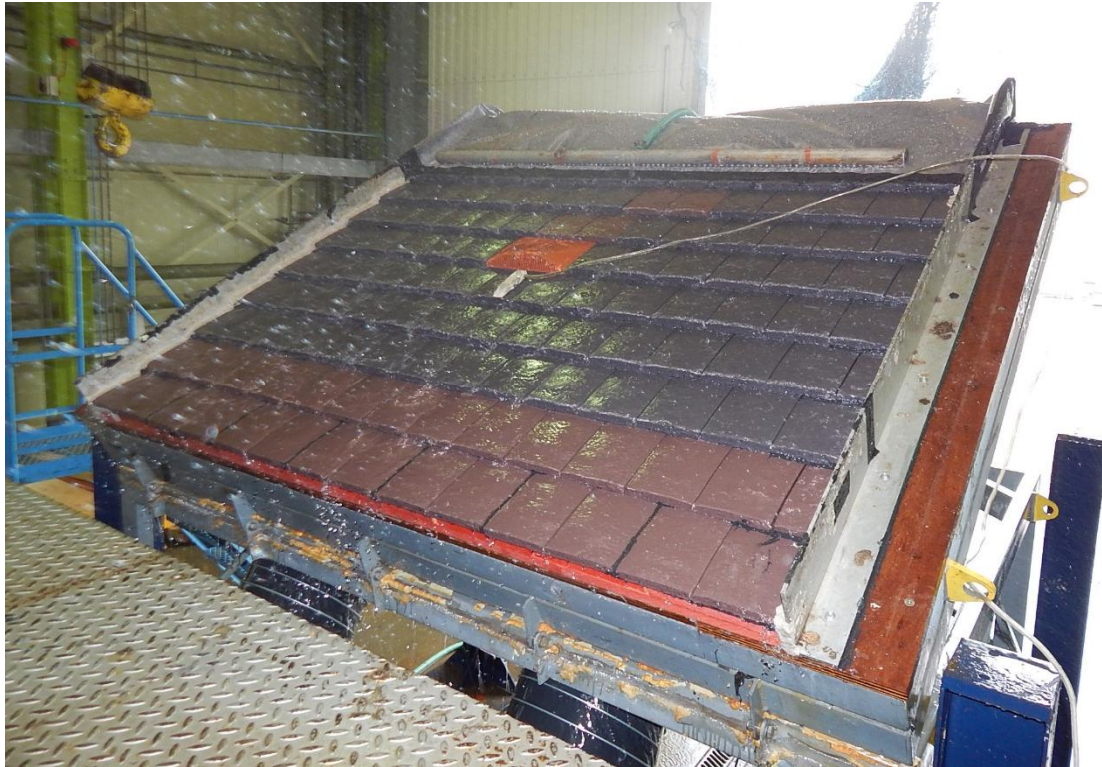


Figure 3 Manthorpe Interlocking Plain Tile Vent with Marley Ashmore tiles under test



Figure 4 Manthorpe Interlocking Plain Tile Vent with Gemini Forticrete tiles under test



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## 4 Test Procedure

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Tests were carried out on the roof tiles with no vent in order to obtain the benchmark performance of the tiles. The tests were then repeated with a single vent tile in place with surround roof tiles. Then test 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 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 roof 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 5. 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 roof 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.

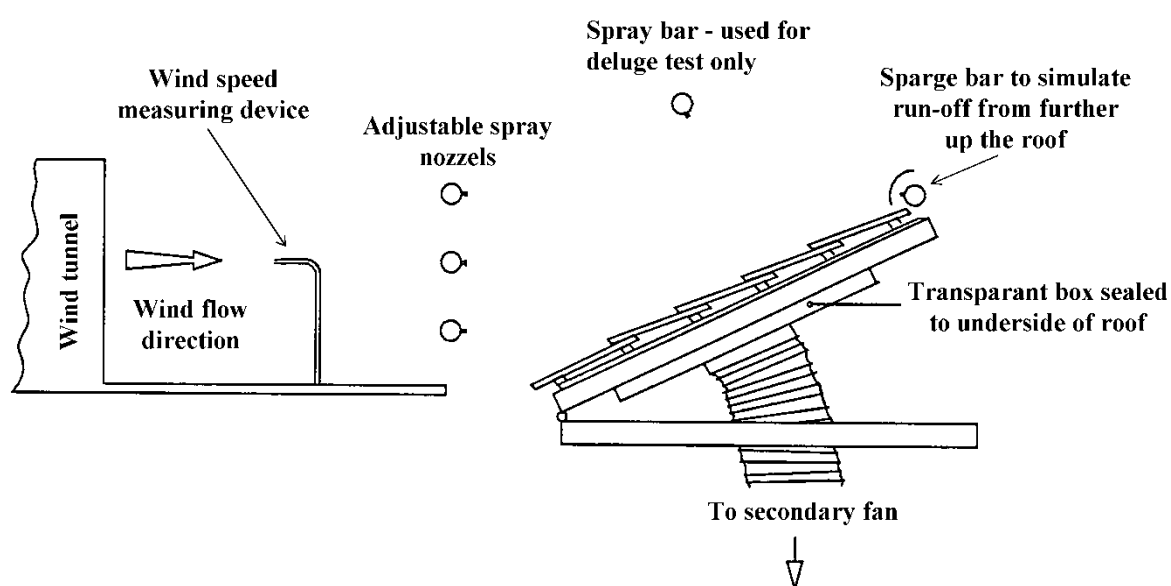


Figure 5 Schematic view of the BRE Rain Penetration Test Rig

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  $10\text{gr/m}^2/5\text{min}$  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 for the tiles 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

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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/m<sup>2</sup> 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 Interlocking Plain Tile Vent is compared with that of the surrounding Marley Ashmore and Gemini Forticrete tiles tested without the Interlocking Plain Tile 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

At roof pitches of 22.5°, 25° and 30° there were no leaks observed during the deluge test on either the tiled roof or the tiled roof with the Interlocking Plain Tile Vent at any part of the roof or from the tile vent.

### 5.2 Wind and Rain test – Sub-test B

In Fpr15601 the pressure (or suction factor) at which 10g/m<sup>2</sup>/5 min of water leakage occurs is taken as the measure of the water tightness in these tests. Table 1 shows the pressure factors for the Manthorpe Interlocking Plain Tile Vent with Marley Ashmore tiles as well as for the Marley Ashmore tiles installed on their own without the vent. Table 2 shows the pressure factors for the Manthorpe Interlocking Plain Tile Vent with Gemini Forticrete tiles as well as for the Gemini Forticrete tiles installed on their own without the vent.

The pressure factors given in Table 1 and Table 2 show the relative performance of the product, the larger (or more positive) the pressure factor the better the relative performance of the roof under wind driven rain conditions.

Figure 6 shows the pressure-leakage curves for the Manthorpe Interlocking Plain Tile Vent with Marley Ashmore tiles. Figure 7 shows the pressure-leakage curves for the Manthorpe Interlocking Plain Tile Vent with Gemini Forticrete Tiles.

It can be seen from Table 1 and Figure 6 that there is no significant difference in performance for the Manthorpe Small Format Slate Vent installed with Natural Slate tiles and for the Natural Slate tiles on their own without the vent. There is also no measurable difference in performance for the Manthorpe Small Format Slate Vent installed with Fibre Cement tiles and the Fibre Cement tiles installed on their own without the Vent.

At a roof pitch of 30° the pressure factors are 39Pa and 41Pa with and without the Small Format Slate Vent on a Natural Slate roof. At a roof pitch of 22.5° the pressure factors are 44Pa and 43Pa with and without the Small Format Slate Vent on a Fibre Cement roof.

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. The Vent was taken to high suction



pressures after leakage tests were completed yet no leakage was observed coming through the Vent. However, at these high suction pressures there was significantly more leakage from the surround Natural Slates and Fibre Cement slates. The Manthorpe Small Format Slate Vent did not cause any leakage at the tile interfaces or worsen the weathertightness performance of the roof.

Product	Pitch (°)	Pressure factor (Pa)
Marley Ashmore No vent	22.5°	-11
Marley Ashmore No Vent	25°	4
Marley Ashmore No Vent	30°	27
Marley Ashmore with Interlocking Plain Tile Vent	22.5°	-16
Marley Ashmore with Interlocking Plain Tile Vent	25°	-2
Marley Ashmore with Interlocking Plain Tile Vent	30°	23

Table 1 Pressure factors for the Marley Ashmore tiles and Manthorpe Interlocking Plain Tile Vent at a leakage rate of 10g/m<sup>2</sup>/5min

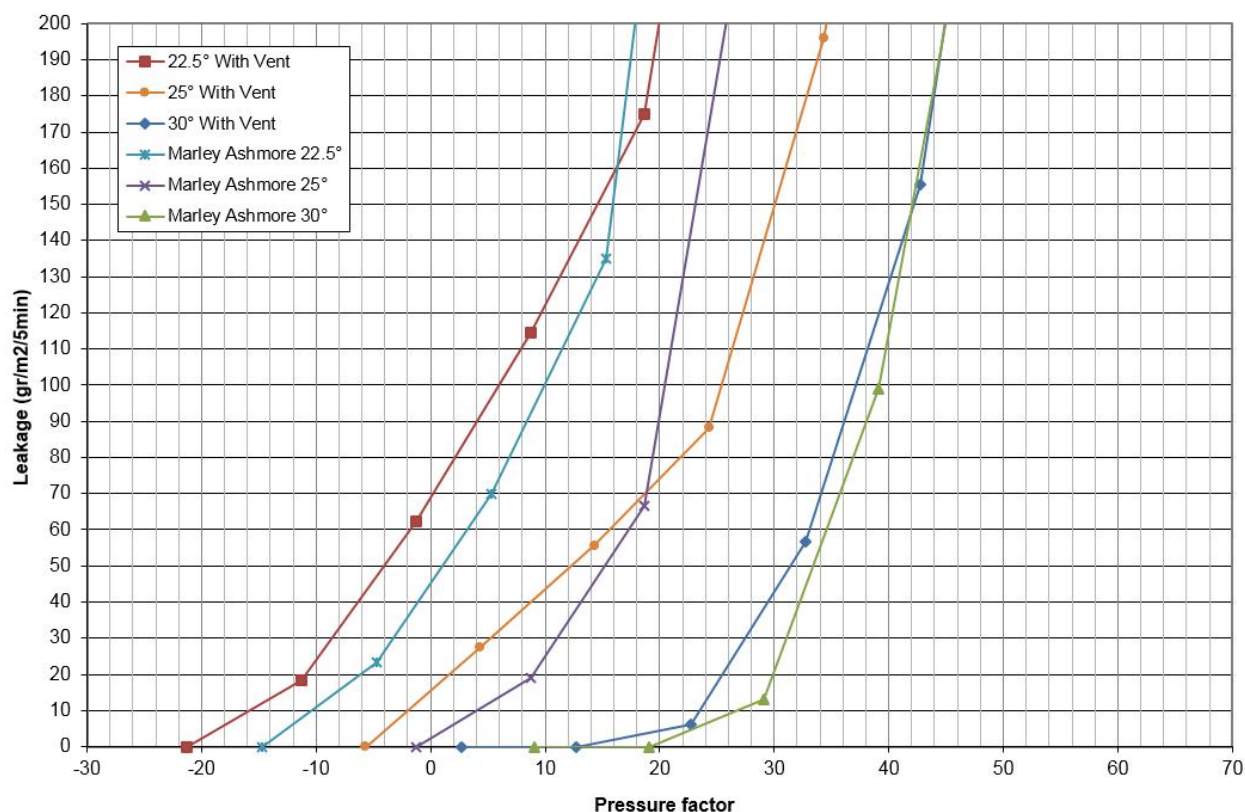


Figure 6 Pressure factor v leakage curves for the Marley Ashmore tiles and Manthorpe Interlocking Plain Tile Vent



Product	Pitch (°)	Pressure factor (Pa)
Gemini Forticrete No vent	22.5°	1
Gemini Forticrete No vent	25°	22
Gemini Forticrete No vent	30°	63
Gemini Forticrete with Interlocking Plain Tile Vent	22.5°	4
Gemini Forticrete with Interlocking Plain Tile Vent	25°	24
Gemini Forticrete with Interlocking Plain Tile Vent	30°	59

Table 2 Pressure factors for the Gemini Forticrete tiles and Manthorpe Interlocking Plain Tile Vent at a leakage rate of 10g/m<sup>2</sup>/5min

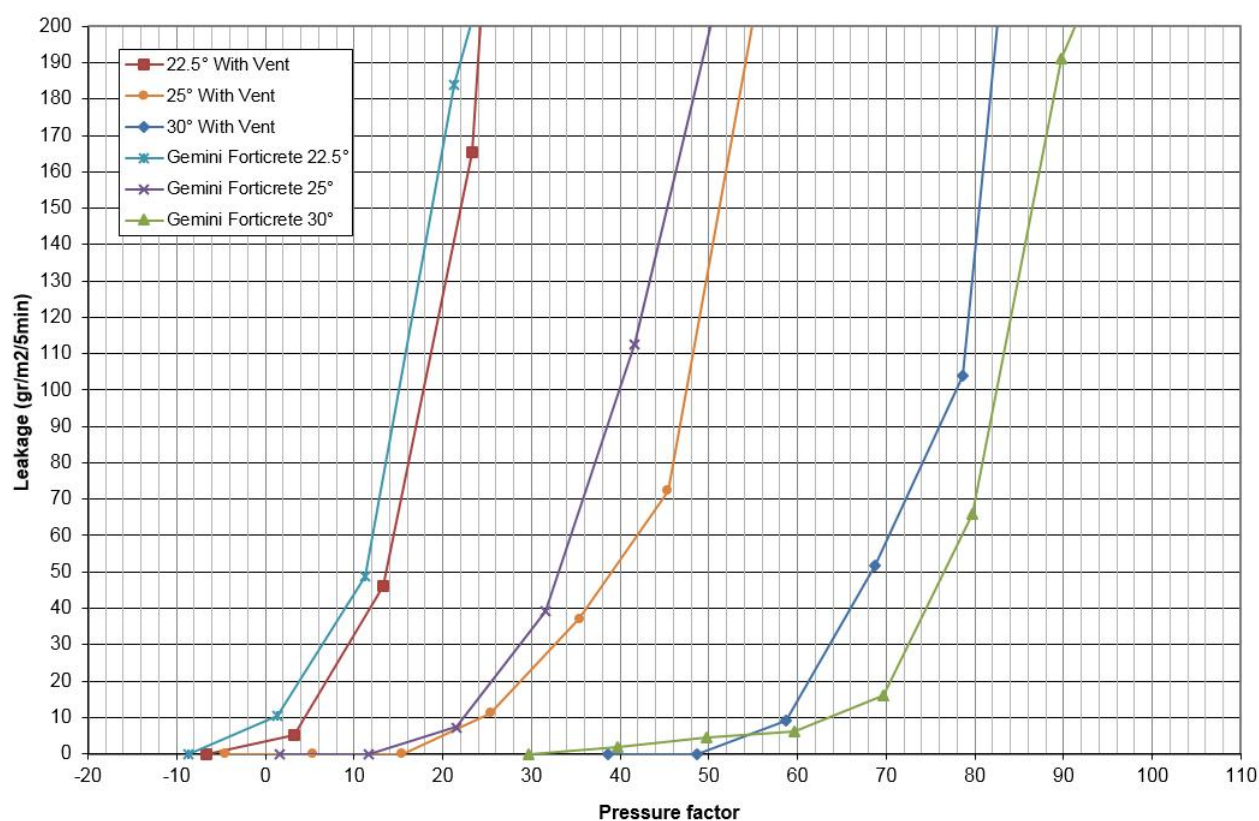


Figure 7 Pressure factor v leakage curves for the Gemini Forticrete tiles and Manthorpe Interlocking Plain Tile Vent



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## 6 Summary

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Tests to assess the relative performance of the Manthorpe Interlocking Plain Tile Vent were carried out according to the procedures of the wind-driven rain test method FprEN15601. The Manthorpe Interlocking Plain Tile Vent was tested with Marley Ashmore and Gemini Forticrete tiles at roof pitches of 30°, 25° and 22.5° respectively.

The results show that the weathertightness performance of the Manthorpe Interlocking Plain Tile Vent is better than that of the surrounding natural and fibre cement slates. At high suction pressures some leakage was observed falling from the edges of the vent but at these pressures the surrounding roof was leaking heavily.

The Manthorpe Interlocking Plain Tile Vent did not cause the surrounding Marley Ashmore tiles or the Gemini Forticrete tiles to leak earlier than they leaked without the vent in place.

The Manthorpe Interlocking Plain Tile Vent will perform satisfactorily at a minimum roof pitch of 22.5° on a Plain tiles roof.

As weathertightness performance improves with roof pitch, the Manthorpe Interlocking Plain Tile Vent is expected to perform satisfactorily at pitches above 22.5°.





## Appendix A - Test report sheets for the Manthorpe Plain Tile Vent

### Roof Pitch 22.5° - Marley Ashmore Tiles – no vent

1.Product name: Marley Ashmore	2.Client:Manthorpe
3. Bond: Quarter Bond	4.Lap: 90mm
5. Batten Gauge: 180mm	5.Material: Concrete
7. Fixing: Nailed	6. Pitch: 22.5°
9. Date commenced: 19/04/17	7: Other remarks: Witnessing the testing

Dry seal box pressure:	27.6
Wet seal box pressure relative roof:	17.8
Wet seal box pressure relative to the lab:	15.3
Manometer instrument number(s):	IN1928

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)		Water collected (g)	Comments:
	Start	End		
0	0	2	0	No Leakage



<b>Test : B</b> High wind speed with high rainfall rate				
Rainfall rate:60 mm/hr			Wind speed 13 m/s	
Top bar flow rate:3.9 l/min			Bottom bar flow rate:4.4 l/min	
Runoff bar flow rate: 11 l/min			Date of test:	
Pressure difference (Pa)	Time (min:sec) Start End		Water collected (g)	
20	0	5	67	Droplets coming from 2 <sup>nd</sup> course all sections, falling every 10-15 seconds. All leakage through side locks, most side locks across roof damp.
10	5	10	134	LHS 2 <sup>nd</sup> course, droplets coming through side lock every 8-10 seconds, some leakage also coming over the top of first course, occasional flurry. RHS 2 <sup>nd</sup> course droplets falling every 5-10 seconds.
0	10	15	188	1 <sup>st</sup> & 2 <sup>nd</sup> course droplets falling every 5-10 seconds on all sections. Central 2 <sup>nd</sup> course constant flow through side lock. Droplets also starting to fall from LHS 3 <sup>rd</sup> & 4 <sup>th</sup> course. Droplets also falling from RHS 6 <sup>th</sup> every 15-20 seconds.
-10	15	20	1131	RHS 2 <sup>nd</sup> & 6 <sup>th</sup> constant droplets falling, turning into stream of water. LHS 2 <sup>nd</sup> , 3 <sup>rd</sup> & 4 <sup>th</sup> course constant droplets falling every 1-3 seconds. Central as above, 4 <sup>th</sup> course beginning to leak heavily after 2 minutes, droplets every 2-5 seconds.



## Roof Pitch 22.5° - Marley Ashmore – with Interlocking Plain Tile Vent

1. Product name: Marley Ashmore with Interlocking Plain Tile Vent.	2. Client: Manthorpe
3. Bond: Quarter Bond	4. Lap: 90mm
5. Batten Gauge: 180mm	5. Material: Concrete
7. Fixing: Nailed	6. Pitch: 22.5°
9. Date commenced: 16/05/17	7. Other remarks: Witnessing the testing

Dry seal box pressure:	
Wet seal box pressure relative roof:	8.7
Wet seal box pressure relative to the lab:	3.7
Manometer instrument number(s):	IN1928

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)		Water collected (g)	Comments:
	Start	End		
0	0	2	0	No Leakage



<b>Test : B</b> High wind speed with high rainfall rate				
Rainfall rate:60 mm/hr			Wind speed 13 m/s	
Top bar flow rate:3.9 l/min			Bottom bar flow rate:4.4 l/min	
Runoff bar flow rate: 11 l/min			Date of test:	
Pressure difference (Pa)	Time (min:sec) Start End		Water collected (g)	
20	0	5	53	LHS 1 <sup>st</sup> & 2 <sup>nd</sup> droplets falling every 10-15 seconds. RHS 2 <sup>nd</sup> droplets falling every 10 seconds.
10	5	10	126	LHS 1 <sup>st</sup> & 2 <sup>nd</sup> constant droplets. RHS 2 <sup>nd</sup> course constant droplet. Central 1 <sup>st</sup> & 2 <sup>nd</sup> course very wet in side locks, occasional droplet.
0	10	15	151	As above, increasing slightly.
-10	15	20	174	As above. LHS 1 & 2 droplets becoming heavier.
-20	20	25	560	LHS courses 1-3 very wet. Constant flow of droplets falling from side locks. RHS courses 1, 2 & 3 constant droplets. Central 1 <sup>st</sup> course steady droplets falling every 2-4 seconds.
-30	25	30	1146+	Central courses 1-3 heavy constant flow of water. LHS courses 1-4 heavy constant droplets. RHS as above, constant flow of droplets.



## Roof Pitch 25° - Marley Ashmore Tiles – No Vent

1.Product name: Marley Ashmore	2.Client:Manthorpe
3. Bond: Quarter Bond	4.Lap: 90mm
5. Batten Gauge: 180mm	5.Material: Concrete
7. Fixing: Nailed	6. Pitch: 25°
9. Date commenced: 19/04/17	7: Other remarks: Witnessing the testing

Dry seal box pressure:	
Wet seal box pressure relative roof:	12.9
Wet seal box pressure relative to the lab:	18.7
Manometer instrument number(s):	IN1928

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)		Water collected (g)	Comments:
	Start	End		
0	0	2	0	No Leakage



<b>Test : B</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)	
10	0	5	55	LHS 2 <sup>nd</sup> course bubbling in side locks, drops falling every 20 seconds. Droplets coming from central 2 <sup>nd</sup> course every 10 seconds.
0	5	10	137	As above 4 <sup>th</sup> central section droplets coming through side lock every 5 seconds. LHS 2 <sup>nd</sup> course droplets increasing to every 10 seconds after 3 minutes.
-10	10	15	539	LHS 2 <sup>nd</sup> course constant droplet through side lock, back of tiles very wet. Central 4 <sup>th</sup> course as above, increasing after 2 minutes to constant flow of droplets. RHS 2 <sup>nd</sup> & 3 <sup>rd</sup> heavy leakage coming from side locks, almost constant flow of water. 5 <sup>th</sup> course bubbling, occasional flurry of droplets.
-20	15	20	1089	LHS 2 <sup>nd</sup> & 3 <sup>rd</sup> heavy leakage, steady flow of water coming in. Central 4 <sup>th</sup> course, constant flow of water. RHS 2 <sup>nd</sup> , 3 <sup>rd</sup> & 5 <sup>th</sup> heavy flow of water through side locks, constant throughout 5 minutes.



## Roof Pitch 25° - Marley Ashmore – with Interlocking Plain Tile Vent

1. Product name: Marley Ashmore with Interlocking Plain Tile Vent.	2. Client: Manthorpe
3. Bond: Quarter Bond	4. Lap: 90mm
5. Batten Gauge: 180mm	5. Material: Concrete
7. Fixing: Nailed	6. Pitch: 25°
9. Date commenced: 16/05/17	7. Other remarks: Witnessing the testing

Dry seal box pressure:	
Wet seal box pressure relative roof:	9.7
Wet seal box pressure relative to the lab:	14.3
Manometer instrument number(s):	IN1928

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)		Water collected (g)	Comments:
	Start	End		
0	0	2	0	No Leakage





<b>Test : B</b> High wind speed with high rainfall rate				
Rainfall rate:60 mm/hr			Wind speed 13 m/s	
Top bar flow rate:3.9 l/min			Bottom bar flow rate:4.4 l/min	
Runoff bar flow rate: 11 l/min			Date of test:	
Pressure difference (Pa)	Time (min:sec) Start End		Water collected (g)	
20	0	5	0	LHS 1 <sup>st</sup> & 2 <sup>nd</sup> course droplets forming. RHS 2 <sup>nd</sup> course droplets forming. Central 8 <sup>th</sup> course very damp.
10	5	10	79	As above, droplets starting to fall from LHS & RHS every 5-8 seconds.
0	10	15	81	As above.
-10	15	20	94	As above.
-20	20	25	310	LHS 1 <sup>st</sup> , 2 <sup>nd</sup> & 3 <sup>rd</sup> water in side locks, almost constant flow of water. RHS courses 2 & 3 constant flow of droplets. Central 7 <sup>th</sup> course droplets falling every 10-5 seconds. 8 <sup>th</sup> course very damp.
-30	25	30	1034	LHS courses 2 & 3 constant droplets. Central now constant flow though side lock of 7 <sup>th</sup> course. 8 <sup>th</sup> course droplets falling every 2-5 seconds. Droplets beginning to come through top left corner of vent side lock. RHS courses 2 & 3 constant flow of water. Occasional droplet over the top of the vent.



## Roof Pitch 30° - Marley Ashmore Tiles – No Vent

1.Product name: Marley Ashmore	2.Client:Manthorpe
3. Bond: Quarter Bond	4.Lap: 90mm
5. Batten Gauge: 180mm	5.Material: Concrete
7. Fixing: Nailed	6. Pitch: 30°
9. Date commenced: 16/05/17	7: Other remarks: Witnessing the testing

Dry seal box pressure:	
Wet seal box pressure relative roof:	19.1
Wet seal box pressure relative to the lab:	
Manometer instrument number(s):	IN1928

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



<b>Test : B</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)	
10	0	5	0	No leak. Some spray forming on LHS 1 <sup>st</sup> course.
0	5	10	0	Central 4 <sup>th</sup> course becoming damp. LHS 1 <sup>st</sup> course as above, becoming very damp.
-10	10	15	38	LHS 1 <sup>st</sup> & 2 <sup>nd</sup> course droplets forming from spray, starting to fall intermittently. Central 1 <sup>st</sup> course very damp, 4 <sup>th</sup> course droplets falling from side lock and from build-up of spray, every 20-30 seconds. RHS 2 <sup>nd</sup> course droplets falling every 20 seconds. 7 <sup>th</sup> course, broken tile causing leakage, droplets falling every 10 seconds.
-20	15	20	247	LHS 1 <sup>st</sup> & 2 <sup>nd</sup> course droplets falling every 2-5 seconds. Central as above. RHS 7 <sup>th</sup> course constant droplet falling. Course 1-3 very damp, droplets falling every 5-10 seconds.
-30	20	25	498	RHS constant flow of water from courses 1-3. 7 <sup>th</sup> course constant droplets falling. LHS 1-3 droplets falling every 1-2 seconds, almost constant. Central 4 <sup>th</sup> course droplets falling at steady rate, 2-4 seconds.
-40	25	30	1159	LHS courses 1-3 & 5 constant flow of water through side locks. Central 4 <sup>th</sup> & 5 <sup>th</sup> course heavy constant droplets. RHS as above, courses 1-3 constant heavy flow. 7 <sup>th</sup> course constant flow of water.



## Roof Pitch 30° - Marley Ashmore – with Interlocking Plain Tile Vent

1.Product name: Marley Ashmore with Interlocking Plain Tile Vent	2.Client:Manthorpe
3. Bond: Quarter Bond	4.Lap: 90mm
5. Batten Gauge: 180mm	5.Material: Concrete
7. Fixing: Nailed	6. Pitch: 30°
9. Date commenced: 16/05/17	7: Other remarks: Witnessing the testing

Dry seal box pressure:	
Wet seal box pressure relative roof:	12.7
Wet seal box pressure relative to the lab:	10.4
Manometer instrument number(s):	IN1928

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)		Water collected (g)	Comments:
	Start	End		
0	0	2	0	No Leakage



<b>Test : B</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)	
10	0	5	0	Some spray on lower courses & RHS 5 <sup>th</sup> course.
0	5	10	0	Spray forming on RHS 1 <sup>st</sup> & 2 <sup>nd</sup> course, droplets forming. LHS 5 <sup>th</sup> course spray on tiles, tiles becoming very damp.
-10	10	15	18	RHS 1 <sup>st</sup> course droplets falling every 20-30 seconds. LHS 2 <sup>nd</sup> & 3 <sup>rd</sup> course water bubbling in side locks, occasional droplet coming through. Central 3 <sup>rd</sup> course droplets falling every 20-30.
-20	15	20	145	RHS 1 <sup>st</sup> course steady droplets. LHS 2 <sup>nd</sup> course large amount of water in side locks, droplets falling every 15 seconds. Central courses 2 & 3 very damp, droplets falling every 10-15 seconds. 8 <sup>th</sup> course droplets falling every 5-10 seconds.
-30	20	25	285	LHS courses 2 & 3 droplets falling every 3-5 seconds, mostly through side locks, also from build-up of spray. RHS 1 <sup>st</sup> course constant flow. Central 8 <sup>th</sup> course very damp, steady droplets falling every 5 seconds. LHS 5 <sup>th</sup> course occasional flurry of water through the side lock.
-40	25	30	589	LHS courses 1-3 steady constant droplet. RHS courses 1-4 constant heavy droplets. Central 3 <sup>rd</sup> course droplets falling every 5-8 seconds. 8 <sup>th</sup> course droplets falling constantly. Droplets now coming from the left side lock of the vent, falling every 5-10 seconds.
-50	30	35	1163+	LHS courses 1-3 constant flow of water. RHS courses 1-4 constant flow of water. 6 <sup>th</sup> course constant droplet falling. Left side lock of vent droplets falling every 2-4 seconds. Central 8 <sup>th</sup> course constant flow of water.



## Roof Pitch 22.5° - Gemini Forticrete Tiles – No Vent

1.Product name: Forticrete Gemini	2.Client: Manthorpe
3. Bond: Quarter Bond	4.Lap: 90mm
5. Batten Gauge: 180mm	5.Material: Concrete
7. Fixing: Nailed	6. Pitch: 22.5°
9. Date commenced: 20/04/17	7: Other remarks: Witnessing the testing

Dry seal box pressure:	
Wet seal box pressure relative roof:	17.4
Wet seal box pressure relative to the lab:	21.3
Manometer instrument number(s):	IN1928

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)		Water collected (g)	Comments:
	Start	End		
0	0	2	0	No Leakage



<b>Test : B</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: 20/04/17	
Pressure difference (Pa)	Time (min:sec) Start End		Water collected (g)	
20	0	5	30	LHS 1 <sup>st</sup> , 2 <sup>nd</sup> & 4 <sup>th</sup> course dripping through side locks, falling every 3-5 seconds. Central 1 <sup>st</sup> course droplets falling every 2-4 seconds. LHS 8 <sup>th</sup> course, water in side lock.
10	5	10	110	LHS as above, courses 1-3 constant flow of droplets. Central 1 <sup>st</sup> course droplets falling constant. RHS 2 <sup>nd</sup> course droplets falling every 20 seconds. All side locks are damp up to the 8 <sup>th</sup> course, occasional droplets falling.
0	10	15	390	LHS as above, increasing. Central 1 <sup>st</sup> & 2 <sup>nd</sup> course droplets falling constant. 4 <sup>th</sup> course water bubbling in side lock, droplets falling every 5-10 seconds. RHS as above, increasing.
-10	15	20	784	LHS 2 <sup>nd</sup> course steady flow of water, 3 <sup>rd</sup> course steady drip. Central courses 1-3 constant flow. 4 <sup>th</sup> & 7 <sup>th</sup> course dripping every 5 seconds. RHS 1 <sup>st</sup> course droplets falling constant. 2 <sup>nd</sup> course droplets from side lock falling every 10-15 seconds.
-20	20	25	1107+	LHS as above, 7 <sup>th</sup> & 8 <sup>th</sup> course drops falling every 2-4 seconds. Central as above, 1-4 constant flow of water. 7 <sup>th</sup> course droplets falling every 2-3 seconds, 8 <sup>th</sup> course droplets falling every 10-15 seconds from side locks. RHS 2 <sup>nd</sup> as above, courses 3, 4 & 6 constant droplets. All side locks very wet.





## Roof Pitch 22.5° - Gemini Forticrete – with Interlocking Plain Tile Vent

1.Product name: Forticrete Gemini with Interlocking Plain Tile Vent	2.Client: Manthorpe
3. Bond: Quarter Bond	4.Lap: 90mm
5. Batten Gauge: 180mm	5.Material: Concrete
7. Fixing: Nailed	6. Pitch: 22.5°
9. Date commenced: 16/05/17	7: Other remarks: Witnessing the testing

Dry seal box pressure:	
Wet seal box pressure relative roof:	13.3
Wet seal box pressure relative to the lab:	15.6
Manometer instrument number(s):	IN1928

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)		Water collected (g)	Comments:
	Start	End		
0	0	2	0	No Leakage



<b>Test : B</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: 16/05/17	
Pressure difference (Pa)	Time (min:sec) Start End		Water collected (g)	
10	5	10	15	Some droplets forming occasionally falling. LHS 1-3 damp. RHS 2-3 droplets falling every 30 seconds.
0	10	15	118	Central 1-3 drops every 5 seconds. LHS 1-4 droplets falling every 2-5 seconds. RHS 2, 3 & 7 droplets falling every 15-20 seconds.
-10	15	20	343	Central as above, increasing. All tiles very damp. LHS 1-4 constant droplets from side locks, 7 <sup>th</sup> course droplets falling constant. RHS courses 1-4 constant droplets, courses 6 & 7 droplets start to fall constant after 2 minutes.
-20	20	25	1082	LHS courses 1-4, 6 & 7 constant droplets falling. RHS as above, increasing slightly. Central as above. Tile above vent very damp, leakage coming from top left corner of vent side lock. All sections of 1 <sup>st</sup> course constant flow of water.



## Roof Pitch 25° - Gemini Forticrete tiles – No Vent

1.Product name: Forticrete Gemini	2.Client: Manthorpe
3. Bond: Quarter Bond	4.Lap: 90mm
5. Batten Gauge: 180mm	5.Material: Concrete
7. Fixing: Nailed	6. Pitch: 25°
9. Date commenced: 20/04/17	7: Other remarks: Witnessing the testing

Dry seal box pressure:	
Wet seal box pressure relative roof:	17.2
Wet seal box pressure relative to the lab:	21.6
Manometer instrument number(s):	IN1928

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)		Water collected (g)	Comments:
	Start	End		
0	0	2	0	No Leakage



<b>Test : B</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: 20/04/17	
Pressure difference (Pa)	Time (min:sec) Start End		Water collected (g)	
20	0	5	0	No leakage
10	5	10	0	Central 1 <sup>st</sup> course droplets beginning to fall every 30 seconds.
0	10	15	21	Central 1 <sup>st</sup> course droplets falling every 15-20 seconds. 2 <sup>nd</sup> course droplets starting to fall from side lock after 2 minutes, every 15 seconds. LHS 1 <sup>st</sup> course droplets from side lock falling every 15 seconds. 2 <sup>nd</sup> course water bubbling in side lock.
-10	15	20	92	LHS 1 <sup>st</sup> course constant droplets falling, 2 <sup>nd</sup> course as above. Central 1 <sup>st</sup> & 2 <sup>nd</sup> as above. RHS 1 <sup>st</sup> & 2 <sup>nd</sup> occasional flurry of droplets, droplets falling every 15 seconds from side lock.
-20	20	25	324	LHS 1 <sup>st</sup> as above. 2 <sup>nd</sup> course droplets falling every 3-5 seconds. 3 <sup>rd</sup> course droplets falling every 5-10 seconds. Courses 4 & 5 water bubbling in side locks, occasional flurry of droplets. Central as above, 7 <sup>th</sup> course started leaking, droplets from side lock falling every 3-5 seconds, tile becoming very damp. RHS as above.
-30	25	30	619	LHS 1-4 constant droplets falling, 5 <sup>th</sup> course falling every 5 seconds, 6 <sup>th</sup> course every 15 seconds. Central as above, courses 1-3 constant droplets falling after 1 minute at -30Pa. 7 <sup>th</sup> course every 3-5 seconds. RHS 1 <sup>st</sup> & 2 <sup>nd</sup> droplets falling every 2 seconds, 4 <sup>th</sup> course every 5 seconds. 7 <sup>th</sup> course becoming very damp, water in side locks, droplets beginning to get drawn in.
-40	30	35	1083	As above. LHS 1-5 constant flow of water, 6 <sup>th</sup> course droplets every 2-3 seconds. Central 1-4 constant flow of droplets through side lock, 6 <sup>th</sup> & 7 <sup>th</sup> course droplets falling every 2 seconds. RHS as above, constant.



## Roof Pitch 25° - Gemini Forticrete – with Interlocking Plain Tile Vent

1.Product name: Forticrete Gemini with Interlocking Plain Tile Vent	2.Client: Manthorpe
3. Bond: Quarter Bond	4.Lap: 90mm
5. Batten Gauge: 180mm	5.Material: Concrete
7. Fixing: Nailed	6. Pitch: 25°
9. Date commenced: 16/05/17	7: Other remarks: Witnessing the testing

Dry seal box pressure:	
Wet seal box pressure relative roof:	5.4
Wet seal box pressure relative to the lab:	7.4
Manometer instrument number(s):	IN1928

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)		Water collected (g)	Comments:
	Start	End		
0	0	2	0	No Leakage



<b>Test : B</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: 16/05/17	
Pressure difference (Pa)	Time (min:sec) Start End		Water collected (g)	
10	5	10	0	Some spray building on lower courses.
0	10	15	0	Some water can be seen in side locks. 2 <sup>nd</sup> & 3 <sup>rd</sup> courses becoming damp across all sections.
-10	15	20	0	LHS 1 <sup>st</sup> & 2 <sup>nd</sup> course droplets beginning to form, falling occasionally. Central 1 <sup>st</sup> & 2 <sup>nd</sup> course droplets forming, occasionally falling. Most courses very damp.
-20	20	25	32	LHS courses 1, 2 & 4 droplets falling every 20 seconds. RHS 4 <sup>th</sup> course droplets forming in side locks, occasionally falling intermittently. Tile above vent damp.
-30	25	30	75	LHS courses 1-4 droplets falling every 10 seconds, not very heavy. RHS 4 <sup>th</sup> course droplets falling every 10-15. Central 2 <sup>nd</sup> & 3 <sup>rd</sup> course droplets every 20 seconds. No leakage around vent.
-40	30	35	208	LHS courses 1-4 steady droplets falling almost constant. Central courses 1-3 drops every 2-5 seconds. RHS 4 <sup>th</sup> course steady flow of droplets, 1 <sup>st</sup> course droplets falling every 5 seconds.
-50	35	40	598	LHS courses 1-4 heavy leak, constant flow of water from most side locks after 3 minutes. Central courses 1-3 constant droplets, all tiles very damp. 7 <sup>th</sup> course tile above vent very damp, no droplets falling. RHS as above.
-60	40	45	1122+	LHS 1-7 heavy constant flow of water. RHS 1-5 constant flow, 7 <sup>th</sup> course started after 1 minute, steady flow of droplets, almost constant. Central 1-4 constant flow of water. Leakage coming from top left corner of vent, steady flow of water.



## Roof Pitch 30° - Gemini Forticrete tiles – No Vent

1.Product name: Forticrete Gemini	2.Client: Manthorpe
3. Bond: Quarter Bond	4.Lap: 90mm
5. Batten Gauge: 180mm	5.Material: Concrete
7. Fixing: Nailed	6. Pitch: 30°
9. Date commenced: 20/04/17	7: Other remarks: Witnessing the testing

Dry seal box pressure:	
Wet seal box pressure relative roof:	19.7
Wet seal box pressure relative to the lab:	16.5
Manometer instrument number(s):	IN1928

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)		Water collected (g)	Comments:
	Start	End		
0	0	2	0	No Leakage





<b>Test : B</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: 20/04/17	
Pressure difference (Pa)	Time (min:sec) Start End		Water collected (g)	
10	0	5	0	No leakage
0	5	10	0	No leakage
-10	10	15	0	LHS droplets forming on 1 <sup>st</sup> & 2 <sup>nd</sup> course. Side lock of 7 <sup>th</sup> course bubbling. Central courses 1-3 side locks very damp. RHS 1 <sup>st</sup> course droplets forming.
-20	15	20	5	RHS 6 <sup>th</sup> course droplets falling every 20 seconds. LHS 1 <sup>st</sup> , 3 <sup>rd</sup> & 6 <sup>th</sup> course droplets falling every 15-20 seconds. Central courses 1, 2 & 7 droplets falling every 30 seconds.
-30	20	25	8	LHS as above, water bubbling in side lock of 8 <sup>th</sup> course. Central as above. RHS as above.
-40	25	30	18	LHS courses 5, 6 & 7 droplets falling every 20 seconds, 1 <sup>st</sup> course as above. Central 3 <sup>rd</sup> & 7 <sup>th</sup> course droplets falling every 20 seconds. RHS as above.
-50	30	35	46	As above
-60	35	40	144	LHS courses 1-4 & 8 droplets falling every 10 seconds from side locks. Central courses 1-4 & 7 droplets falling every 10-15 seconds. RHS 6 <sup>th</sup> & 7 <sup>th</sup> course droplets falling every 10-15 seconds. A lot of water bubbling in most side locks.
-70	40	45	361	LHS courses 1-4 constant flow of droplets, 8 <sup>th</sup> course every 2 seconds. Central courses 1 & 6-8 constant droplets falling, courses 3 & 4 droplets falling every 5 seconds. RHS courses 6 & 7 droplets falling every 2-4 seconds. 1 <sup>st</sup> course droplets falling every 10 seconds. All side locks water bubbling.
-80	45	50	713	RHS 7 <sup>th</sup> course constant flow of water, courses 1-4 droplets every 5 seconds. All areas increasing. LHS courses 1-8 constant flow of water. Central courses 2-5 droplets every 2 seconds. Courses 1, 6, 7 & 8 constant flow of heavy droplets.



## Roof Pitch 30° - Gemini Forticrete – with Interlocking Plain Tile Vent

1.Product name: Forticrete Gemini with Interlocking Plain Tile Vent	2.Client: Manthorpe
3. Bond: Quarter Bond	4.Lap: 90mm
5. Batten Gauge: 180mm	5.Material: Concrete
7. Fixing: Nailed	6. Pitch: 30°
9. Date commenced: 16/05/17	7: Other remarks: Witnessing the testing

Dry seal box pressure:	18.7
Wet seal box pressure relative roof:	6.1
Wet seal box pressure relative to the lab:	8.7
Manometer instrument number(s):	IN1928

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)		Water collected (g)	Comments:
	Start	End		
0	0	2	0	No Leakage



<b>Test : B</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: 16/05/17	
Pressure difference (Pa)	Time (min:sec) Start End		Water collected (g)	
0	5	10	0	Some spray on lower courses.
-10	10	15	0	All sections courses 1-3 spray building up. Some spray around edge of vent, 6 <sup>th</sup> course. RHS 6 <sup>th</sup> course spray building, moisture in side lock.
-20	15	20	0	Spray building on all sections. Tile above vent damp.
-30	20	25	0	As above. LHS 3 <sup>rd</sup> course occasionally droplets coming over top of tile.
-40	25	30	0	As above, Tiles becoming very damp. LHS courses 3-5 droplets forming a long batten. RHS courses 6 & 7 very damp, droplets beginning to fall.
-50	30	35	26	LHS courses 1-5 droplets starting to fall every 5-10 seconds. Central courses 3, 4 & 7 droplets falling every 10 seconds, not heavy. 1 or 2 droplets in the vent, not falling.
-60	35	40	123	Central courses 3 & 4 droplets through side locks every 2-5 seconds. LHS courses 1-5 droplets every 2 seconds, almost constant, 8 <sup>th</sup> course constant flow of droplets. RHS as above, courses 6 & 7 droplets falling every 10 seconds. Same droplets still sitting in vent, caused by build-up of water at the ribs of the vent.
-70	40	45	299	As above, increasing. Central 2 <sup>nd</sup> course droplets falling every 1-2 seconds. LHS courses 1-6 droplets falling almost constant. 8 <sup>th</sup> course constant flow of droplets. RHS 5-7 droplets falling every 5-10 seconds. 8 <sup>th</sup> course very damp. Central courses 3 & 4 started to leak after 32 minutes, becoming a constant flow of droplets. No more droplets seen in vent.
-80	45	50	715	LHS courses 1-8 constant leakage. Central courses 1-5 constant flow of droplets, some droplets falling from top left corner of vent every 30 seconds. Tile above vent very wet. RHS courses 5-7 as above, heavy leakage. Courses 2-4 constant flow of droplets.
-90	50	55	1142+	Vent still only original 2 droplets inside. Top left section of vent almost constant droplets, falling every 3-6 seconds. All areas heavy flow of droplets. RHS 5-7 constant flow of water. LHS courses 1-8 constant flow of water, very heavy.



## 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  $200 \pm 10$  mm over a flat boarded area which replaces the test specimen, at the relevant roof pitch. The calibration wind speed shall be  $10 \pm 0.5$  m/s at the centre of the test specimen. Figure B1 shows the end of the BRE wind tunnel and Figure B2 shows the wind speed calibration of the BRE test rig using ultrasonic anemometers.

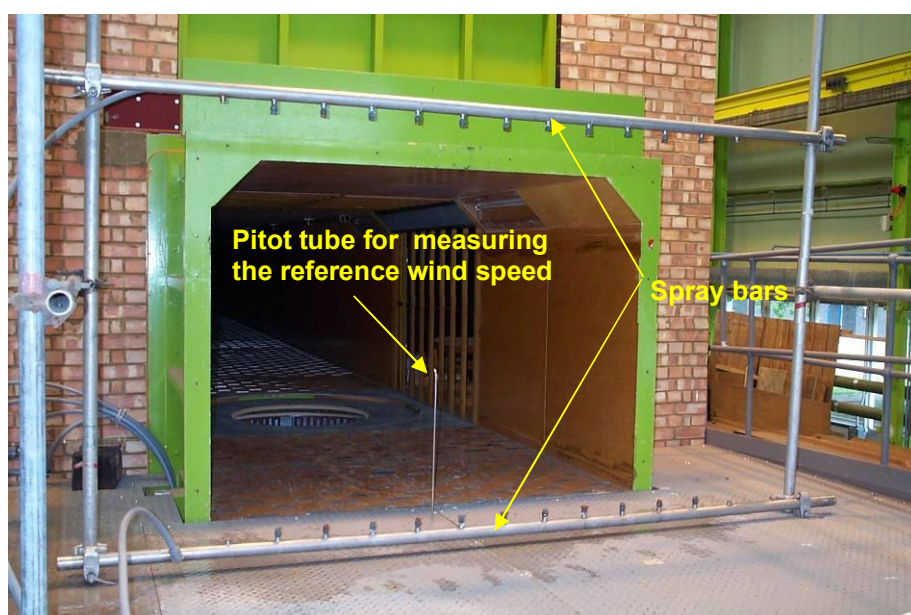


Figure B1 The end of the BRE wind tunnel



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

The standard requires the turbulence intensity ( $t$ ) in the oncoming wind to be less than 10 %. The turbulence intensity  $t$  (%) is expressed as  $t = 100u/U$ , where  $u$  and  $U$  are the RMS and mean wind speeds respectively, measured over a duration of not less than 5 minutes.  $u$  and  $U$  are defined as shown below:

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

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

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					locations (facing tunnel)		
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				

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 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  $124 \text{ mm/hr}$  and  $130 \text{ mm/hr}$  for pitches between  $15^\circ$  and  $45^\circ$ . In practice it is not possible to control the rainfall rate on the roof to such small tolerances. The degree of variation in rainfall rate allowed by the draft standard is  $\pm 35\%$  which is generally much wider than the range of rainfall rates specified for each pitch angle.

Figures B3 to B6 show the calibration of the driving rain in the BRE test rig. The results of the calibrations for Sub-Tests A, B and C for the Northern European Coastal climate are shown in Table B2. From Table B2 it can be seen that the degree of variability in Sub-Tests A, B and C is close to but just within the allowable limit of  $\pm 35\%$ .

% variation of water collected in buckets			
Bucket No	Test C	Test B	Test A
1	-3	-11	-7
2	-3	-21	-26
3	14	9	-22
4	-29	9	26
5	11	-2	22
6	16	-9	24
7	34	24	19
8	29	28	29
9	-17	-15	5
10	-22	3	-1
11	-8	7	-16
12	30	13	-4
13	-21	-29	-21
14	-18	-2	-28
15	-5	-5	-21
16	-9	3	23
Maximum %	34	28	29
Minimum %	-29	-29	-28

Table B2 Calibration of driving rain variability





Figure B3 Bottom spray bar



Figure B4 Top spray bar



Figure B5 View of the test rig at the end of the tunnel

bre



Figure B6 View of the 16 rainfall collection buckets on the test rig