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REPORT 49215/G/5

**TESTING OF
PORTLAND LIMESTONE
PERRYFIELD ROACH**

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MATERIALS TESTING

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TESTING OF

PORTLAND LIMESTONE

PERRYFIELD ROACH

Portland Stone Firms Limited
99 Easton Street
Portland
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DT5 1BP

For the attention of Mr Neil Fuller

This report comprises
6 pages of text
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27 March 2014

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TESTING OF

PORTLAND LIMESTONE

PERRYFIELD ROACH

Reference: Instructions from Mr Neil Fuller of Portland Stone Firms Limited.
Purchase Order no. : M0454 dated 8 July 2013.

1. INTRODUCTION

We were instructed to undertake testing of natural stone, advised to be Portland limestone Perryfield Roach, in order to establish physical characteristics.

2. SAMPLES

Test specimens prepared ready for test were received from Portland Stone Firms Limited at Sandberg laboratories on 29 January 2014, as follows.

Sandberg Reference	Specimen Size	Test
	Portland limestone Perryfield Roach	
G40117	6 no. 50 x 50 x 50mm	Density & porosity
G40118	6 no. 50 x 50 x 50mm	Water absorption at atmospheric pressure
G40119	6 no. 70 x 70 x 70mm	Water abs. coeff. by capillarity [BS EN 772-11]
G40120	10 no. 50 x 50 x 50mm	Compressive strength [BS EN 772-1]
G40121	10 no. 300 x 100 x 50mm	Flexural strength (4-point)
G40122	13 no. 300 x 50 x 50mm	Frost resistance Identification Test (Test B) (56 cycles) - visual inspection - dynamic modulus of elasticity - apparent volume
G40123	6 no. 200 x 200 x 30mm	Slip resistance

3. TEST METHODS AND RESULTS

3.1 Density and porosity

Specimens were tested in accordance with BS EN 1936 : 2006.

Detailed test results are given in Table 1 of this report and are summarised as follows:

Sandberg Reference	Apparent Density (kg/m ³)		Open Porosity (%)	
	Range	Mean	Range	Mean
G40117	2120 - 2200	2150	17.9 - 20.8	19.7

3.2 Water Absorption at atmospheric pressure

Specimens were tested in accordance with BS EN 13755 : 2008.

Detailed test results are given in Table 2 of this report and are summarised as follows:

Sandberg Reference	Water Absorption (%)	
	Range	Mean
G40118	5.5 - 7.6	6.3

3.3 Water absorption coefficient by capillarity

Specimens were tested in accordance with BS EN 772-11 : 2011.

Detailed test results are given in Table 3 of this report and are summarised as follows:

Sandberg Reference	Water absorption coefficient by capillarity (g/m ² .sec ⁻²)
G40119	52.8

3.4 Compressive strength

Specimens were tested in accordance with the method given in BS EN 772-1 : 2011.

Tests were carried out with the load applied in a perpendicular to bedding orientation and in an oven dried condition.

The detailed test results are given in Table 4 of this report and may be summarised as follows:

Sandberg Reference	Visual inspection score at 56 cycles (Nc)	Decrease in dynamic elastic modulus at 56 cycles (%)	Change in apparent volume at 56 cycles (%)
G40122 a	0	1.73	0.00
G40122 b	1	11.79	0.00
G40122 c	1	1.53	0.00
G40122 d	1	1.36	0.00
G40122 e	0	2.65	0.00
G40122 f	1	8.04	0.00
G40122 g	1	2.42	0.00
G40122 h	1	7.44	0.00
G40122 j	1	1.06	0.00
G40122 k	1	7.39	0.00
G40122 l	1	4.04	0.00
G40122 m	3	2.14	0.00

Note : A test set is defined as having failed when two or more samples show a visual score of 3 and/or a decrease in dynamic elastic modulus of 30%.

3.7 Slip resistance

Specimens with an as received surface finish were tested for slip resistance in accordance with BS EN 14231 : 2003 using a portable skid resistance tester (pendulum tester).

Testing was carried out in dry and wet conditions.

Surface roughness measurements were also carried out using a Surtronic Duo R_z roughness meter whilst the slip resistance measurements were being made.

Detailed results of the slip resistance test are given in Table 7 and are summarised below.

Sandberg Reference	Average Slip Resistance Value (SRV) (55 rubber)	
	Dry	Wet
G40123 55 slider - as received	56	58

The TRL pendulum tester has a range of readings from 0 to 150, high values indicate good slip resistance. Guidance on the interpretation of results is suggested by the UK Slip Resistance Group¹. These are generally accepted limits and are given below.

<u>Pendulum Test Value</u>	<u>Slip Potential</u>
0 - 24	High
25 - 35	Moderate
36+	Low

The surface roughness measurements are a guide to slip resistance particularly in borderline regions. It is recognised that increased roughness of the floor surface can give an improvement in slip resistance in wet conditions.

Surfaces contaminated with pure water generally require a surface roughness of at least 10µm R_z to provide a moderate level of slip resistance and at least 20µm R_z to indicate low slip potential. More viscous contaminants require higher surface roughness².

The slip resistance results relate to the samples in their as-received condition. It should be noted that the slip resistance of surfaces in service can be altered by various factors such as abrasion, polishing and contamination. Overall assessment of the potential for slip should take into account conditions of use and the environment, in addition to test results.

¹ The assessment of Floor Slip Resistance. The UK Slip Resistance Group, Issue 4, 2011.

² Roughness measurements should not be solely relied upon to evaluate the potential slip resistance of a floor.

4. REMARKS

These results conclude the requested programme of testing. Please do not hesitate to contact us if we can be of any further assistance in this matter.

Portland Stone Firms Limited
99 Easton Street
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for Sandberg LLP

For the attention of Mr Neil Fuller

D J Ellis
Partner

DJE/Geoman/ws

27 March 2014

File:49215/G/5.rep

Materials, samples and test specimens are retained for a period of 2 months from the issue of the final report.

Tests reported on sheets not bearing the UKAS mark in this report/certificate are not included in the UKAS accreditation schedule for this laboratory.

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

APPARENT DENSITY AND OPEN POROSITY

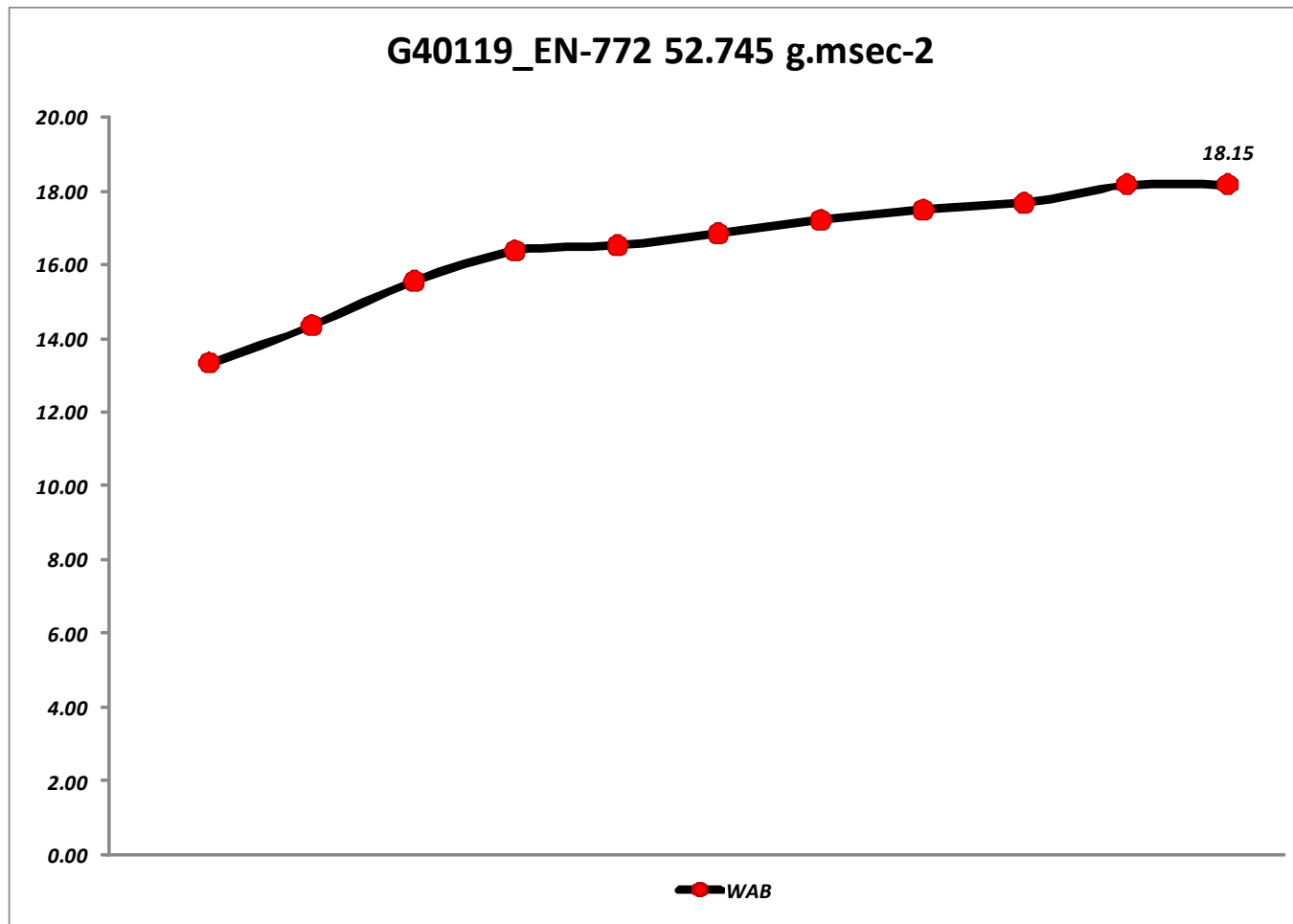
BS EN 1936 : 2006

Rock Name	Perryfield Roach			Test By/Date	MB / 06.02.14	
Rock Type	Portland limestone			Checked/Date	LN / 06.02.14	
Sandberg Sample Ref.	Oven Dried Mass in Air (g)	Density of Water (kg/m ³)	Vacuum Saturated Mass in Air (g)	Vacuum Saturated Mass in Water (g)	Open Porosity (%)	Apparent Density (kg/m ³)
G40117 a	264.32	998	290.14	165.93	20.8	2120
G40117 b	262.18	998	287.94	164.28	20.8	2120
G40117 c	276.41	998	298.85	173.73	17.9	2200
G40117 d	270.45	998	294.30	169.87	19.2	2170
G40117 e	274.50	998	298.61	172.18	19.1	2170
G40117 f	265.21	998	290.06	166.58	20.1	2140
Mean					19.7	2150

WATER ABSORPTION AT ATMOSPHERIC PRESSURE

BS EN 13755 : 2008

Rock Name	Perryfield Roach	Test By / Date	MB / 11.02.14
Rock Type	Portland limestone	Checked / Date	LN / 11.02.14
Sandberg Sample Ref.	Oven Dried Mass (g)	Saturated Surface Dried Mass (g)	Water Absorption (%)
G40118 a	272.71	288.36	5.7
G40118 b	271.17	286.52	5.7
G40118 c	256.17	275.53	7.6
G40118 d	265.69	282.01	6.1
G40118 e	259.46	277.80	7.1
G40118 f	271.09	285.98	5.5
Average			6.3



Coefficient of water absorption by capillarity: 52.75 g/m².Sec⁻²

Table
3

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COMPRESSIVE STRENGTH

BS EN 772-1 : 2011

Load Orientation¹ : Perpendicular
Test Condition : Oven dried

Rock Name	Perryfield Roach				Test By/Date	MB / 05.02.14	
Rock Type	Portland limestone				Checked/Date	HO / 05.02.14	
Sandberg Sample Reference	Breaking Load (N)	Specimen Height (mm)	Mean Lateral Dimension (mm)	Mean Lateral Dimension (mm)	Cross Section Area (mm ²)	Compressive Strength ^a (MPa)	Observations
G40120 a	58900	50.2	50.1	50.6	2535	23.23	Normal failure
G40120 b	71000	50.3	50.4	50.2	2530	28.06	Normal failure
G40120 c	84400	50.3	50.6	50.3	2545	33.16	Normal failure
G40120 d	82200	50.2	50.2	50.6	2540	32.36	Normal failure
G40120 e	94700	49.7	50.5	49.8	2515	37.65	Normal failure
G40120 f	66700	50.2	50.5	50.4	2545	26.21	Normal failure
G40120 g	128500	49.6	50.8	50.2	2550	50.39	Normal failure
G40120 h	57500	50.3	50.3	50.4	2535	22.68	Normal failure
G40120 j	83000	50.3	50.3	50.6	2545	32.61	Normal failure
G40120 k	75300	50.3	50.5	50.7	2560	29.41	Normal failure
Mean						32 *	
Std. Dev.						8 *	
Var. Coef.						0.3	

¹ Relative to bedding

* To nearest 1.0 MPa

FLEXURAL STRENGTH (UNDER CONSTANT MOMENT)

BS EN 13161 : 2008

Load Orientation¹ : Perpendicular
Finish : Sawn
Test Condition : Oven dried

Rock Name	Perryfield Roach			Test By/Date	MB / 07.02.14	
Rock Type	Portland limestone			Checked/Date	LN / 10.02.14	
Sandberg Sample Reference	Breaking Load (N)	Specimen Span (mm)	Specimen Width (mm)	Specimen Thickness (mm)	Flexural Strength (MPa)	Observations
G40121 a	3020	250	100.4	50.3	3.0	Normal Failure
G40121 b	4000	250	100.2	50.2	4.0	Normal Failure
G40121 c	4110	250	100.7	50.1	4.1	Normal Failure
G40121 d	2750	250	100.3	50.8	2.7	Normal Failure
G40121 e	3850	250	100.4	50.7	3.7	Normal Failure
G40121 f	1470	250	100.3	50.9	1.4	Normal Failure
G40121 g	3940	250	100.7	50.8	3.8	Normal Failure
G40121 h	3470	250	100.4	49.9	3.5	Normal Failure
G40121 j	2750	250	100.6	50.5	2.7	Normal Failure
G40121 k	1820	250	100.3	50.7	1.8	Normal Failure
Mean					3.1	
Std. Dev.					0.9	
Var. Coef.					0.3	

¹ With respect to bedding

Lowest Expected Value (MPa) : 1.4

FROST RESISTANCE

BS EN 12371 : 2010
Identification test (Test B)

Rock Name	Perryfield Roach										Test by/Date	HO / 18.03.14					
Rock Type	Portland limestone										Checked by/ Date	MB / 18.03.14					
Sandberg Sample Ref.	Visual inspection score						Dynamic elastic modulus (% decrease)										
	0	14	56	84	140	168	0 (MPa)	14 (MPa)	14 (%)	56 (MPa)	56 (%)	84 (MPa)	84 (%)	140 (MPa)	140 (%)	168 (MPa)	168 (%)
G40122 a	0	0	0	-	-	-	49312	48694	1.25	48457	1.73	-	-	-	-	-	-
G40122 b	0	1	1	-	-	-	50592	47902	5.32	44628	11.79	-	-	-	-	-	-
G40122 c	0	1	1	-	-	-	51939	51469	0.90	51144	1.53	-	-	-	-	-	-
G40122 d	0	1	1	-	-	-	49985	49787	0.40	49303	1.36	-	-	-	-	-	-
G40122 e	0	0	0	-	-	-	46362	45442	1.98	45132	2.65	-	-	-	-	-	-
G40122 f	0	1	1	-	-	-	52815	49703	5.89	48571	8.04	-	-	-	-	-	-
G40122 g	0	1	1	-	-	-	48255	47621	1.31	47089	2.42	-	-	-	-	-	-
G40122 h	0	1	1	-	-	-	51925	51001	1.78	48061	7.44	-	-	-	-	-	-
G40122 j	0	1	1	-	-	-	69209	70544	0.00	68477	1.06	-	-	-	-	-	-
G40122 k	0	1	1	-	-	-	47282	44353	6.19	43786	7.39	-	-	-	-	-	-
G40122 l	0	1	1	-	-	-	54285	54939	0.00	52090	4.04	-	-	-	-	-	-
G40122 m	0	3	3	-	-	-	75491	74014	1.96	73879	2.14	-	-	-	-	-	-

Bedding direction : Unknown
Surface finish : Sawn

FROST RESISTANCE

BS EN 12371 : 2010
Identification test (Test B)

Note : Failure is defined in BS EN 12371 : 2010 clause 7.3.2.5 as when two or more specimens show either ; - a visual inspection score of 3
- decrease in dynamic elastic modulus of 30%

Visual inspection score :	0	Specimen intact
	1	Very minor damage (minor rounding of corners and edges) which does not compromise the integrity of the specimen
	2	One or several minor cracks (≤ 0.1 mm width) or detachment of small fragments (≤ 10 mm ² per fragment)
	3	One or several cracks, holes or detachment of fragments larger than those defined for the '2' rating, or alteration of material in veins.
	4	Specimen broken in two or with major cracks.
	5	Specimen in pieces or disintegrated.

FROST RESISTANCE

BS EN 12371 : 2010

Identification test (Test B)

Rock Name	Perryfield Roach					Test by/Date	HO / 18.03.14		
Rock Type	Portland limestone					Checked by/ Date	MB / 18.03.14		
Sandberg Sample Ref.	Measurement of apparent volume (% decrease)								
	Initial dry mass (g)	Initial saturated mass (g)	Apparent mass in water (g)	Dry mass at 56 cycles (g)	Saturated mass at 56 cycles (g)	Apparent mass at 56 cycles (g)	Initial apparent volume (ml)	Apparent volume at 56 cycles (ml)	Change in apparent volume 56 cycles (%)
G40122 a	1602	1682	926	1601	1684	926	756	758	0.00
G40122 b	1573	1657	909	1572	1657	909	748	748	0.00
G40122 c	1625	1705	939	1623	1706	939	766	767	0.00
G40122 d	1624	1713	926	1622	1714	926	787	788	0.00
G40122 e	1626	1702	944	1625	1707	944	758	763	0.00
G40122 f	1621	1701	943	1619	1706	943	758	763	0.00
G40122 g	1601	1676	933	1600	1678	933	743	745	0.00
G40122 h	1616	1693	945	1614	1696	943	748	753	0.00
G40122 j	1611	1688	944	1609	1692	944	744	748	0.00
G40122 k	1657	1734	947	1655	1738	947	787	791	0.00
G40122 l	1616	1688	948	1615	1690	943	740	747	0.00
G40122 m	1592	1673	934	1589	1674	927	739	747	0.00

Nc : Maximum number of cycles (56) or number of cycles completed to failure

Sandberg Reference	Material	Surface Finish	Orientation	Surface Roughness ¹ R _z , μm	Temperature °C		Slip Resistance Value (SRV)			
					Surface	Ambient	Dry		Wet	
							Mean [5 readings]	Mean	Mean [5 readings]	Mean
G40123 a	Perryfield Roach	As received	A	16.2	20	20	55	54	55	52
			180° to A	-	20	20	52		49	
G40123 b	Perryfield Roach	As received	A	20.8	20	20	54	55	52	49
			180° to A	-	20	20	56		45	
G40123 c	Perryfield Roach	As received	A	18.8	20	20	55	58	50	54
			180° to A	-	20	20	60		57	
G40123 d	Perryfield Roach	As received	A	30.0	20	20	56	55	59	57
			180° to A	-	20	20	54		55	
G40123 e	Perryfield Roach	As received	A	28.0	20	20	55	54	62	59
			180° to A	-	20	20	53		55	
G40123 f	Perryfield Roach	As received	A	42.2	20	20	57	61	80	79
			180° to A	-	20	20	65		77	

SRV dry (6 no. specimens) : 56
SRV wet (6 no. specimens) : 58

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Where our involvement consists exclusively of testing samples, the results and our conclusions relate only to the samples tested.