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REPORT 49215/G/1/A

**TESTING OF
PORTLAND LIMESTONE
PERRYFIELD BASEBED**

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TESTING OF

PORTLAND LIMESTONE

PERRYFIELD BASEBED

Portland Stone Firms Limited
99 Easton Street
Portland
Dorset
DT5 1BP

For the attention of Mr Neil Fuller

This report comprises
6 pages of text
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Table 7 of 1 sheet

30 January 2014

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TESTING OF

PORTLAND LIMESTONE

PERRYFIELD BASEBED

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 Basebed, in order to establish physical characteristics.

2. SAMPLES

Test specimens prepared ready for test were received from Portland Stone Firms Limited Marnhull Stone Limited at Sandberg laboratories on 20 September 2013, as follows.

Sandberg Reference	Specimen Size	Test
	Portland limestone Perryfield Basebed	
G39722	6 no. 50 x 50 x 50mm	Density & porosity
G39723	6 no. 50 x 50 x 50mm	Water absorption at atmospheric pressure
G39724	6 no. 70 x 70 x 70mm	Water abs. coeff. by capillarity [BS EN 772-11]
G39725	10 no. 50 x 50 x 50mm	Compressive strength [BS EN 772-1]
G39726	10 no. 300 x 100 x 50mm	Flexural strength (4-point)
G39727	13 no. 300 x 50 x 50mm	Frost resistance Identification Test (Test B) (56 cycles) - visual inspection - dynamic modulus of elasticity - apparent volume
G39728	6 no. 200 x 200 x 30mm	Slip resistance - 120 grit

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
G39722	2120 - 2140	2130	20.1 - 21.0	20.6

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
G39723	8.5 - 9.3	9.0

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)
G39724	44.8

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 (%)
G39727 a	3	Fail	0.00
G39727 b	0	5.05	0.00
G39727 c	2	1.97	0.00
G39727 d	1	1.78	0.00
G39727 e	0	5.59	-0.13
G39727 f	0	6.06	0.00
G39727 g	0	0.69	0.00
G39727 h	3	Fail	0.00
G39727 j	2	11.68	0.13
G39727 k	2	0.00	0.00
G39727 l	3	Fail	0.00
G39727 m	2	11.12	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 a 120 grit 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
G39728	55 slider - 120 grit	75	72

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.

Pendulum Test Value

Slip Potential

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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DT5 1BP

for Sandberg LLP

For the attention of Mr Neil Fuller

D J Ellis
Partner

DJE/Geoman/ws

30 January 2014

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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

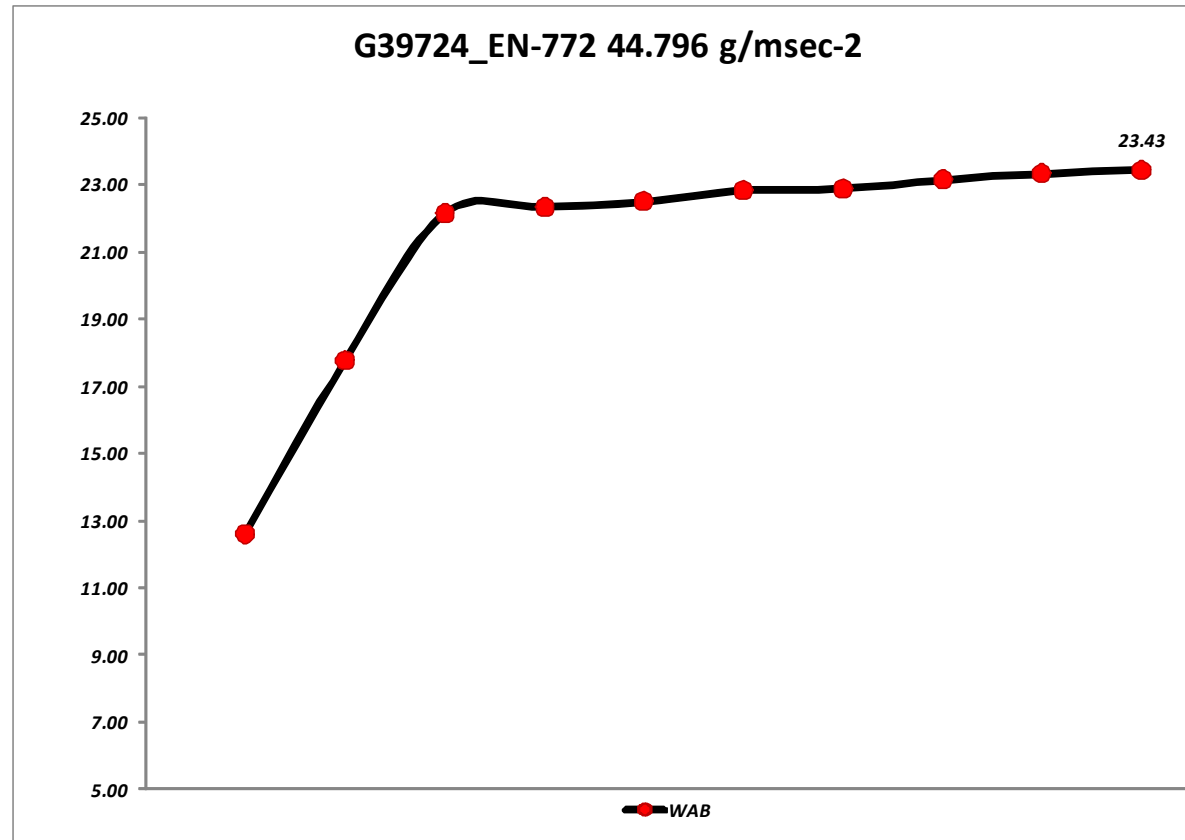
BS EN 1936 : 2006

Rock Name	Perryfield Basebed			Test By/Date	MB / 31.10.13	
Rock Type	Portland limestone			Checked/Date	LN / 31.10.13	
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)
G39722 a	261.66	998	286.26	164.26	20.2	2140
G39722 b	265.93	998	292.21	166.83	21.0	2120
G39722 c	262.46	998	288.35	164.71	20.9	2120
G39722 d	272.46	998	297.99	171.09	20.1	2140
G39722 e	267.35	998	292.98	167.92	20.5	2130
G39722 f	264.65	998	290.45	166.12	20.8	2120
Mean					20.6	2130

WATER ABSORPTION AT ATMOSPHERIC PRESSURE

BS EN 13755 : 2008

Rock Name	Perryfield Basebed	Test By / Date	MB / 12.11.13
Rock Type	Portland limestone	Checked / Date	HO / 12.11.13
Sandberg Sample Ref.	Oven Dried Mass (g)	Saturated Surface Dried Mass (g)	Water Absorption (%)
G39723 a	263.51	287.99	9.3
G39723 b	262.62	287.09	9.3
G39723 c	269.07	292.88	8.9
G39723 d	260.40	284.19	9.1
G39723 e	265.59	288.27	8.5
G39723 f	259.87	282.94	8.9
Average			9.0



Coefficient of water absorption by capillarity : 44.80 g/m².Sec⁻²

COMPRESSIVE STRENGTH

BS EN 772-1 : 2011

Load Orientation¹ : Perpendicular
Test Condition : Oven dried

Rock Name	Perryfield Basebed				Test By/Date	MB / 30.10.13	
Rock Type	Portland limestone				Checked/Date	LN / 30.10.13 + DJE / 13.11.13	
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
G39725 a	135800	50.0	51.2	49.3	2524	53.80	Normal failure
G39725 b	153100	50.1	50.1	49.4	2475	61.86	Normal failure
G39725 c	152300	50.0	50.9	49.4	2514	60.58	Normal failure
G39725 d	156700	50.4	51.8	49.8	2580	60.74	Normal failure
G39725 e	150500	50.0	49.9	49.4	2465	61.05	Normal failure
G39725 f	158800	50.1	50.8	49.7	2525	62.89	Normal failure
G39725 g	143000	50.1	50.0	49.80	2490	57.43	Normal failure
G39725 h	150300	50.1	49.8	49.8	2480	60.60	Normal failure
G39725 j	164400	50.1	50.2	49.2	2470	66.56	Normal failure
G39725 k	157100	50.0	50.2	50.0	2510	62.59	Normal failure
Mean						61 *	
Std. Dev.						3 *	
Var. Coef.						0.1	

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 Basebed			Test By/Date	MB / 30.09.13	
Rock Type	Portland limestone			Checked/Date	LN / 30.09.13	
Sandberg Sample Reference	Breaking Load (N)	Specimen Span (mm)	Specimen Width (mm)	Specimen Thickness (mm)	Flexural Strength (MPa)	Observations
G39726 a	5440	250	99.8	49.9	5.5	Normal Failure
G39726 b	5680	250	99.7	50.0	5.7	Normal Failure
G39726 c	6120	250	99.4	50.1	6.1	Normal Failure
G39726 d	5660	250	99.7	50.0	5.7	Normal Failure
G39726 e	5630	250	99.8	50.0	5.6	Normal Failure
G39726 f	5470	250	99.5	50.0	5.5	Normal Failure
G39726 g	5290	250	98.7	50.0	5.4	Normal Failure
G39726 h	6440	250	100.6	50.1	6.4	Normal Failure
G39726 j	3710	250	99.8	50.0	3.7 *	Normal Failure
G39726 k	5050	250	100.5	50.1	5.0 *	Normal Failure
Mean					5.5	
Std. Dev.					0.7	
Var. Coef.					0.1	

¹ With respect to bedding

Lowest Expected Value (MPa) : 4.0

* Traces of manganese along failure plane

FROST RESISTANCE

BS EN 12371 : 2010
Identification test (Test B)

Rock Name	Perryfield Basebed										Test by/Date	HO / 02.12.13					
Rock Type	Portland limestone										Checked by/ Date	MB / 03.12.13					
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 (%)
G39727 a	0	0	3	-	-	-	44142	41388	6.24	-	Fail	-	-	-	-	-	-
G39727 b	0	0	0	-	-	-	46032	45997	0.07	43706	5.05	-	-	-	-	-	-
G39727 c	0	1	2	-	-	-	61118	59188	3.16	59913	1.97	-	-	-	-	-	-
G39727 d	0	0	1	-	-	-	47496	47519	0.00	46650	1.78	-	-	-	-	-	-
G39727 e	0	0	0	-	-	-	45101	43784	2.92	42580	5.59	-	-	-	-	-	-
G39727 f	0	0	0	-	-	-	46553	45244	2.81	43730	6.06	-	-	-	-	-	-
G39727 g	0	0	0	-	-	-	47896	48421	0.00	47564	0.69	-	-	-	-	-	-
G39727 h	0	1	3	-	-	-	56107	55443	1.19	-	Fail	-	-	-	-	-	-
G39727 j	0	1	2	-	-	-	57627	51039	11.43	50898	11.68	-	-	-	-	-	-
G39727 k	0	0	2	-	-	-	47224	55944	0.00	55737	0.00	-	-	-	-	-	-
G39727 l	0	0	3	-	-	-	44171	43715	1.03	-	Fail	-	-	-	-	-	-
G39727 m	0	1	2	-	-	-	46049	49771	0.00	40927	11.12	-	-	-	-	-	-

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 Basebed					Test by/Date	HO / 02.12.13		
Rock Type	Portland limestone					Checked by/ Date	MB / 03.12.13		
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 (%)
G39727 a	1526	1633	848	1507	-	-	785	-	Fail
G39727 b	1548	1649	874	1548	1649	874	775	775	0.00
G39727 c	1639	1719	941	1639	1719	941	778	778	0.00
G39727 d	1572	1670	890	1573	1670	890	780	780	0.00
G39727 e	1566	1676	881	1565	1676	880	795	796	0.00
G39727 f	1545	1648	868	1543	1648	868	780	780	0.00
G39727 g	1606	1705	922	1604	1705	922	783	783	0.00
G39727 h	1608	1696	917	1607	-	-	779	-	Fail
G39727 j	1552	1643	880	1552	1643	881	763	762	0.00
G39727 k	1655	1743	947	1655	1743	947	796	796	0.00
G39727 l	1519	1627	852	1517	-	-	775	-	Fail
G39727 m	1600	1692	906	1599	1692	906	786	786	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
G39728 a	Perryfield Basebed	120 grit	A	59.2	21	22	77	76	75	75
			180° to A	-	21	22	75		74	
G39728 b	Perryfield Basebed	120 grit	A	55.7	21	22	78	78	71	72
			180° to A	-	21	22	77		72	
G39728 c	Perryfield Basebed	120 grit	A	55.3	21	22	76	76	70	71
			180° to A	-	21	22	76		71	
G39728 d	Perryfield Basebed	120 grit	A	53.3	21	22	75	75	71	73
			180° to A	-	21	22	74		75	
G39728 e	Perryfield Basebed	120 grit	A	60.6	21	22	75	74	72	73
			180° to A	-	21	22	72		73	
G39728 f	Perryfield Basebed	120 grit	A	58.2	21	22	73	73	70	70
			180° to A	-	21	22	73		70	

SRV dry (6 no. specimens) : 75
SRV wet (6 no. specimens) : 72

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