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REPORT 49215/G/9

**TESTING OF
PORTLAND LIMESTONE
PERRYFIELD SHELLY WHITBED**

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TESTING OF

PORTLAND LIMESTONE

PERRYFIELD SHELLY WHITBED

Portland Stone Firms Limited
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This report comprises
4 pages of text
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Table 6 of 3 sheets

For the attention of Mr Neil Fuller

4 July 2014

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TESTING OF

PORTLAND LIMESTONE

PERRYFIELD SHELLY WHITBED

Reference: Instructions from Mr Neil Fuller of Portland Stone Firms Limited.

1. INTRODUCTION

We were instructed to undertake testing of natural stone, advised to be Portland limestone Perryfield Shelly Whitbed, 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 16 May 2014, as follows.

Sandberg Reference	Specimen Size	Test
	Portland limestone Perryfield Shelly Whitbed	
G40423	6 no. 50 x 50 x 50mm	Density & porosity
G40424	6 no. 50 x 50 x 50mm	Water absorption at atmospheric pressure
G40425	6 no. 70 x 70 x 70mm	Water abs. coeff. by capillarity [BS EN 772-11]
G40426	10 no. 50 x 50 x 50mm	Compressive strength [BS EN 772-1]
G40427	10 no. 300 x 100 x 50mm	Flexural strength (4-point)
G40428	11 no. 300 x 50 x 50mm	Frost resistance Identification Test (Test B) (56 cycles) - visual inspection - dynamic modulus of elasticity - apparent volume

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
G40423	2190 - 2360	2290	12.0 - 18.3	14.8

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
G40424	2.3 - 4.9	3.7

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)
G40425	54.2

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	Orientation / Condition	Compressive Strength (MPa)	
		Range	Mean
G40426	Perpendicular - dry	31.98 - 56.30	42 *

* To nearest 1.0 MPa

3.5 Flexural strength (4-point) under constant moment

Specimens were tested in accordance with the method given in BS EN 13161 : 2008.

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 5 of this report and may be summarised as follows.

Sandberg Reference	Orientation / Condition	Flexural Strength (3-pt) (MPa)	
		Range	Mean
G40427	Perpendicular - dry	4.2 - 8.5	5.7

Statistical evaluation of the test results in accordance with the methods in BS EN 13161 : 2008 Annex A (normative) produced the following:-

Lowest Expected Value (MPa)

Perpendicular - dry

3.5

3.6 Frost resistance Identification Test (Test B)

Specimens were prepared and tested in accordance with BS EN 12371 : 2010 Identification Test (Test B).

It was instructed to continue the test to 56 cycles.

Specimens were visually inspected and tested for dynamic modulus of elasticity (fundamental resonance frequency) in an unknown bedding orientation and change in apparent volume in accordance with BS EN 14156 : 2004 at specified intervals (0, 14 and 56 cycles).

The detailed test results are given in Table 6 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 (%)
G40428 a	0	15.33	0.13
G40428 b	0	10.10	0.13
G40428 c	1	10.33	0.00
G40428 d	0	7.28	0.13
G40428 e	1	7.18	0.00
G40428 f	1	5.60	0.00
G40428 g	0	10.56	0.13
G40428 h	0	10.20	0.13
G40428 j	0	6.92	0.00
G40428 k	1	11.76	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%.

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
 Portland
 Dorset
 DT5 1BP

for Sandberg LLP

For the attention of Mr Neil Fuller

D J Ellis
 Partner

DJE/Geoman/ws

4 July 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

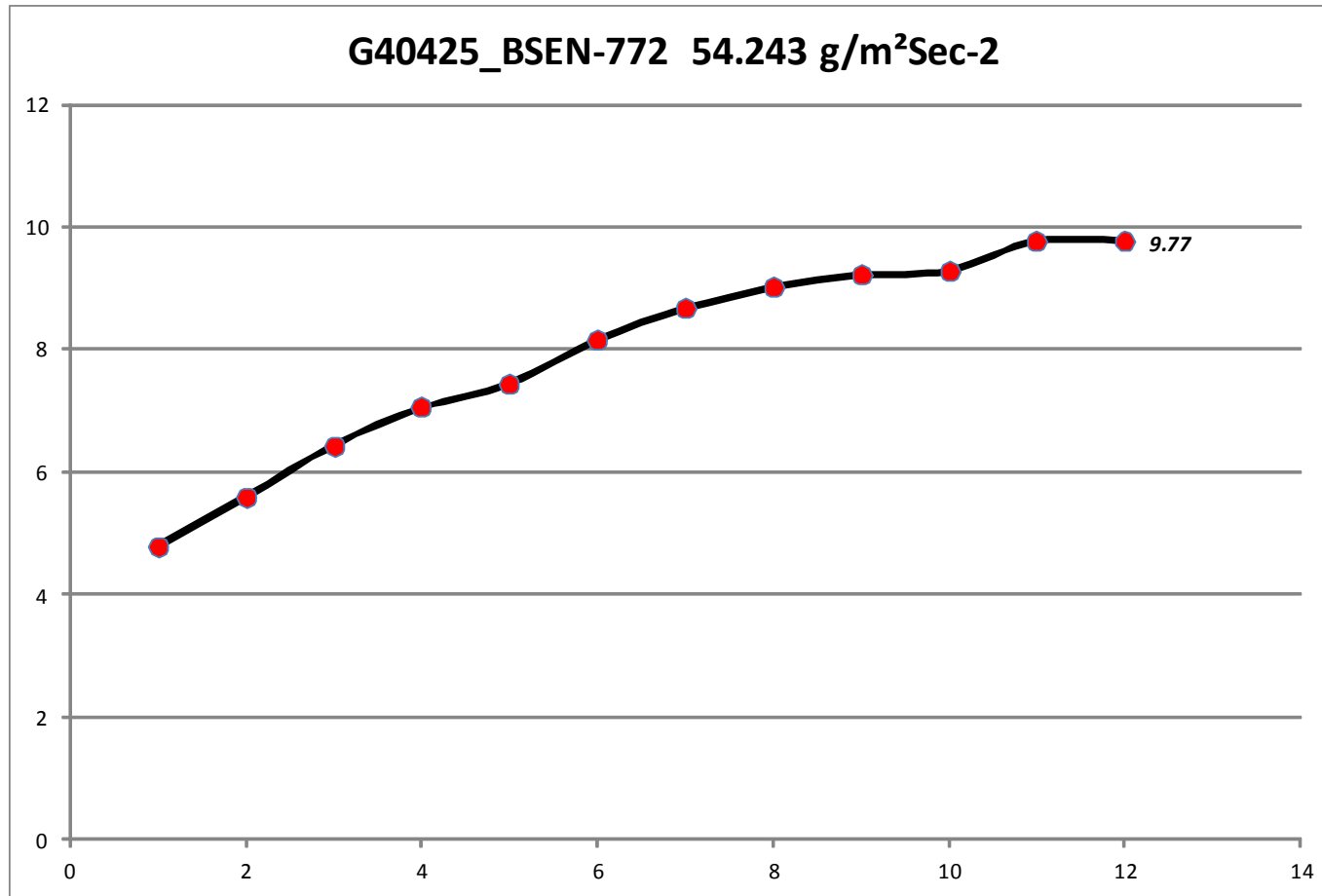
BS EN 1936 : 2006

Rock Name	Perryfield Shelly Whitbed			Test By/Date	MB / 21.05.14	
Rock Type	Portland limestone			Checked/Date	LN / 21.05.14	
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)
G40423 a	283.60	998	307.31	178.03	18.3	2190
G40423 b	306.52	998	322.14	192.32	12.0	2360
G40423 c	292.87	998	313.74	183.83	16.1	2250
G40423 d	285.28	998	306.17	179.14	16.4	2240
G40423 e	297.21	998	314.06	186.66	13.2	2330
G40423 f	309.54	998	326.44	194.54	12.8	2340
Mean					14.8	2290

WATER ABSORPTION AT ATMOSPHERIC PRESSURE

BS EN 13755 : 2008

Rock Name	Perryfield Shelly Whitbed	Test By / Date	MB / 05.06.14
Rock Type	Portland limestone	Checked / Date	HO / 05.06/14
Sandberg Sample Ref.	Oven Dried Mass (g)	Saturated Surface Dried Mass (g)	Water Absorption (%)
G40424 a	306.93	314.86	2.6
G40424 b	285.69	297.95	4.3
G40424 c	281.84	295.75	4.9
G40424 d	281.14	293.60	4.4
G40424 e	289.68	300.14	3.6
G40424 f	310.29	317.28	2.3
Average			3.7



Coefficient of water absorption by capillarity: 54.24 g/m².Sec⁻²

COMPRESSIVE STRENGTH

BS EN 772-1 : 2011

Load Orientation¹ : Perpendicular
Test Condition : Oven dried

Rock Name	Perryfield Shelly Whitbed				Test By/Date	MB / 19.05.14	
Rock Type	Portland limestone				Checked/Date	HO / 20.05.14	
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
G40426 a	89300	50.7	50.8	50.9	2586	34.53	Normal failure
G40426 b	81400	50.8	50.0	50.9	2545	31.98	Normal failure
G40426 c	118800	50.9	51.1	51.1	2611	45.50	Normal failure
G40426 d	143000	50.8	50.0	50.8	2540	56.30	Normal failure
G40426 e	100300	50.8	50.5	50.8	2565	39.10	Normal failure
G40426 f	107700	50.7	50.1	50.7	2540	42.40	Normal failure
G40426 g	126100	50.9	50.7	50.9	2581	48.86	Normal failure
G40426 h	93400	50.7	50.4	50.9	2565	36.41	Normal failure
G40426 j	112200	51.1	50.7	51.1	2591	43.30	Normal failure
G40426 k	116900	51.1	50.1	51.1	2560	45.66	Normal failure
Mean						42 *	
Std. Dev.						7 *	
Var. Coef.						0.2	

¹ Relative to bedding

* To nearest 1 MPa

FLEXURAL STRENGTH (UNDER CONSTANT MOMENT)

BS EN 13161 : 2008

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

Rock Name	Perryfield Shelly Whitbed			Test By/Date	MB / 19.05.14	
Rock Type	Portland limestone			Checked/Date	LN / 19.05.14	
Sandberg Sample Reference	Breaking Load (N)	Specimen Span (mm)	Specimen Width (mm)	Specimen Thickness (mm)	Flexural Strength (MPa)	Observations
G40427 a	8880	250	101.2	50.9	8.5	Normal Failure
G40427 b	5550	250	100.7	51.0	5.3	Normal Failure
G40427 c	4880	250	100.6	51.0	4.7	Normal Failure
G40427 d	6130	250	101.1	50.9	5.9	Normal Failure
G40427 e	4910	250	100.6	51.0	4.7	Normal Failure
G40427 f	7420	250	101.3	50.8	7.1	Normal Failure
G40427 g	5480	250	100.7	50.9	5.3	Normal Failure
G40427 h	4390	250	100.8	50.9	4.2	Normal Failure
G40427 j	6930	250	101.2	51.0	6.6	Normal Failure
G40427 k	4680	250	100.8	51.0	4.5	Normal Failure
Mean					5.7	
Std. Dev.					1.4	
Var. Coef.					0.2	

¹ With respect to bedding

Lowest Expected Value (MPa) : 3.5

FROST RESISTANCE

BS EN 12371 : 2010
Identification test (Test B)

Rock Name	Perryfield Shelly Whitbed										Test by/Date		HO / 01.07.14				
Rock Type	Portland limestone										Checked by/ Date		LN / 01.07.14				
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 (%)
G40428 a	0	0	0	-	-	-	99059	90776	8.36	83878	15.33	-	-	-	-	-	-
G40428 b	0	0	0	-	-	-	82561	77652	5.95	74220	10.10	-	-	-	-	-	-
G40428 c	0	0	1	-	-	-	84060	78900	6.14	75377	10.33	-	-	-	-	-	-
G40428 d	0	0	0	-	-	-	81397	79172	2.73	75475	7.28	-	-	-	-	-	-
G40428 e	0	0	1	-	-	-	98134	92863	5.37	91091	7.18	-	-	-	-	-	-
G40428 f	0	0	1	-	-	-	98237	94015	4.30	92733	5.60	-	-	-	-	-	-
G40428 g	0	0	0	-	-	-	91364	85052	6.91	81720	10.56	-	-	-	-	-	-
G40428 h	0	0	0	-	-	-	100710	95403	5.27	90436	10.20	-	-	-	-	-	-
G40428 j	0	0	0	-	-	-	91861	87543	4.70	85500	6.92	-	-	-	-	-	-
G40428 k	0	0	1	-	-	-	106674	103139	3.31	94130	11.76	-	-	-	-	-	-

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 Shelly Whitbed					Test by/Date	HO / 01.07.14		
Rock Type	Portland limestone					Checked by/ Date	LN / 01.07.14		
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 (%)
G40428 a	1684	1766	985	1684	1764	984	781	780	0.13
G40428 b	1651	1741	966	1650	1740	966	775	774	0.13
G40428 c	1591	1687	907	1590	1688	906	780	782	0.00
G40428 d	1571	1675	907	1568	1674	907	768	767	0.13
G40428 e	1647	1731	956	1646	1734	957	775	777	0.00
G40428 f	1717	1786	999	1716	1785	998	787	787	0.00
G40428 g	1636	1726	946	1636	1725	946	780	779	0.13
G40428 h	1665	1747	968	1664	1746	968	779	778	0.13
G40428 j	1633	1720	950	1632	1722	950	770	772	0.00
G40428 k	1721	1790	1006	1720	1789	1005	784	784	0.00

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

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