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BRE Test Report

Testing of Flick Stone

Prepared for: Julian Veal
Date: 25 August 2022
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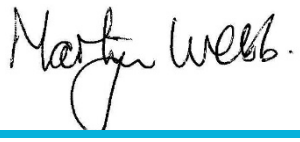
Prepared by

Name Dr Martyn Webb

Position Principal Consultant, Construction Testing, Assurance Division

Date 25 August 2022

Signature 

Authorised by

Name Dr Tim Yates

Position Technical Director, Assurance Division

Date 25 August 2022

Signature 

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1 Introduction

Following instruction from Julian Veal (Oxfordshire Minerals Group & The Great Tew Estate) BRE has completed a series of tests on a stone reported to be Flick Stone.

The stone samples were delivered to BRE on the 01/06/2022.

This report provides a factual account of the testing carried out on the samples received.

2 Test programme

BRE have carried out the following tests:

BS EN 12407:2007, Natural stone test methods. Petrographic examination*

BS EN 1936:2006, Natural stone test methods. Determination of apparent density*, and open porosity*

BS EN 13755:2008, Natural stone test methods. Determination of water absorption at atmospheric pressure*

BS EN 772-1:2011, Methods of test for masonry units — Part 1: Determination of compressive strength*

BS EN 772-11:2011, Methods of test for masonry units - Part 11: Determination of water absorption of aggregate concrete, manufactured stone and natural stone masonry units due to capillary action and the initial rate of water absorption of clay masonry units*

BS EN 12371: 2010, Natural stone test methods. Determination of frost resistance - identification test

* BRE is UKAS accredited for this test

3 Test Results

Given below is a summary of the test results for Flick Stone, full details can be found in the Appendix.

Test	Standard	Result	Unit
Apparent density	BS EN 1936	2440	kg/m^3
Open porosity	BS EN 1936	10.2	% by volume
Water absorption at atmospheric pressure	BS EN 13755	3.6	% by weight
Coefficient of water absorption by capillarity (for masonry)	BS EN 772 - 11	15	$g/(m^2.s^{0.5})$
Compressive strength (for masonry)	BS EN 772 -1	92.5	MPa
Frost resistance – Identification test (for masonry)	BS EN 12371	56	cycles
Petrographic examination	BS EN 12407	Oolitic limestone (Oosparite)	

Note: Values in brackets are the Lower Expected Values (LEV).

Appendix A Detailed Test Results

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BSEN 1936: 2006: Determination of open porosity and apparent density

Name of Stone:	Flick		Petrographic Nature:	Limestone
Block No:	No data supplied		Anisotropic Features:	None
Supplier:	Oxfordshire Minerals Group		Country of Origin:	UK
Dimensions (mm):	50 x 50 x 50		Project Reference:	P122768
Surface Finish:	Sawn		Preparation:	BS EN 1936
Date Tested:	21/06/2022	23/06/2022	Tested by:	I. Rance

BRE No.	Md	Mh	Ms	Apparent Density	Open Porosity
P122768/22/	g	g	g	kg.m^{-3}	%
251	291.85	184.58	303.29	2450	9.6
252	305.25	193.09	318.14	2440	10.3
253	305.88	193.48	318.66	2440	10.2
254	297.51	188.23	310.09	2440	10.3
255	309.77	196.01	321.21	2470	9.1
256	304.40	192.54	318.76	2410	11.4
			Mean	2440	10.2

* The calculation of apparent density assumes the density of water to be 998 kg.m^{-3} at 20^{o}C
Open Porosity is defined as the ratio of volume of open pores to the apparent volume of the specimen
Apparent Density is defined as the ratio of the mass of the dry specimen to its apparent volume

Mean open porosity (p_o): **10.2** %

Mean apparent density (ρ_b) **2440** kg.m^{-3}

Approved by: Martyn Webb. Date: 28/07/2022

UKAS TESTING 0578

Name: Dr Martyn Webb

Position: Principal Consultant Construction Testing, Assurance Division

BSEN 13755: 2008: Determination of water absorption at atmospheric pressure

Name of Stone:	Flick		Petrographic Nature:	Limestone
Block No	No data supplied		Anisotropic Features:	None
Supplier:	Oxfordshire Minerals Group		Country of Origin:	UK
Dimensions (mm):	50 x 50 x 50		Project Reference:	P122768
Surface Finish:	Sawn		Preparation:	Prepared to BS EN 13755
Date Tested:	17/06/2022	24/07/2022	Tested by:	I. Rance

	Dry mass	Wet mass	Wet mass		
BRE No.	**1 hr md**	**48 hrs mi2**	**72 hrs ms**	Difference (ms-mi2)	**Water Absorption**
P122768/22/	g	g	g	%	**%**
241	309.64	320.25	320.30	0.016	**3.4**
242	309.18	319.63	319.67	0.013	**3.4**
243	308.35	319.45	319.53	0.024	**3.6**
244	305.84	317.13	317.18	0.016	**3.7**
245	303.26	315.23	315.28	0.015	**4.0**
246	299.98	309.69	309.74	0.016	**3.3**
				Mean	**3.6**

Mean Water Absorption (A_b): 3.6 %

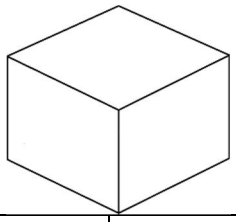
Approved by: Martyn Webb. Date: 29/07/2022

Name: Dr Martyn Webb

Position: Principal Consultant — Construction Testing, Assurance Division

UKAS TESTING 0378

BS EN 772 -1 : 2011 Methods of test for masonry units. Determination of compressive strength, Tested dry



Name of Stone:	Flick	Petrographic Nature:	Limestone
Block No	No data supplied	Anisotropic Features:	None
Supplier:	Oxfordshire Minerals Group	Country of Origin:	UK
Dimensions (mm):	70 x 70 x 70	Project Reference:	P122768
Surface Finish:	Sawn	Preparation:	BS EN 772-1
Date Tested:	26/06/2022	Tested by:	I. Rance

BRE No.	Load Rate	Height	Mean Width	Mean Length	Failure Load	Comp. Strength
P122768/22/	MPa s-1	mm	mm	mm	kN	MPa
161	0.6	64.1	70.8	71.0	525	104.4
162	0.6	63.4	70.9	70.7	489	97.5
163	0.6	63.5	70.9	70.9	555	110.4
164	0.6	63.5	70.9	71.4	569	112.4
165	0.6	62.6	70.9	71.4	239	47.2
166	0.6	64.0	70.9	70.8	572	113.9
167	0.6	64.1	70.9	71.4	443	87.5
168	0.6	63.3	71.1	70.8	492	97.7
169	0.6	62.4	70.9	70.5	214	42.8
170	0.6	64.0	70.9	70.8	556	110.8
					Mean	**92.5**
					St. Dev	**26.35**
					Co of var	**0.28**

Note. Tested dry to BSEN 772-1 Part 7.3.2

Approved by: Martyn Webb. Date: 08/08/2022

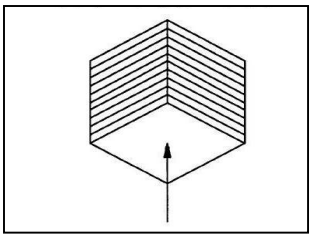
Name: Dr Martyn Webb

Position: Principal Consultant

Construction Testing, Assurance Division

UKAS TESTING 0378

BS EN 772 -11 :2011 : Determination of water absorption of natural stone masonry units due to capillarity action



Name of Stone:	Flick		Petrographic Nature:	Limestone
Block No	No data supplied		Anisotropic Features:	None
Supplier:	Oxfordshire Minerals Group		Country of Origin:	UK
Dimensions (mm):	70 x 70 x 70		Project Reference:	P122768
Surface Finish:	Sawn		Preparation:	BS EN 772-11
Date Tested:	26/06/2022	11/07/2022	Tested by:	I. Rance

	Width 1	Width 2	Water absorption *
BRE No.			
P122768/22/	m	m	$gm^2s^{-0.5}$
116	0.0709	0.0704	14
117	0.0708	0.0707	16
118	0.0708	0.0708	14
119	0.0710	0.0711	9
120	0.0710	0.0705	15
121	0.0709	0.0708	20

*Calculated following the method given in Clause 8.2 of the standard

Mean coefficient of water absorption: $c_{w,s}$ 15 $g/(m^2.s^{0.5})$

Approved by: Martyn Webb. Date: 08/08/2022

Name: Dr Martyn Webb

Position: Principal Consultant, Construction Testing, Assurance Division

BS EN 12371: 2010, Natural stone test methods. Determination of frost resistance Using the Identification Test - change in dynamic modulus of elasticity

Name of Stone:	Flick	Petrographic Nature:	Limestone	
Block No:	No data supplied	Anisotropic Features:	None	
Supplier:	Oxfordshire Minerals Group	Country of Origin:	UK	
Dimensions (mm):	300 x 50 x 50	Project Reference:	No data supplied	
Surface Finish:	Sawn	Preparation:	Prepared to BS EN 12371	
Date Tested:	12/06/2022 19/08/2022	Tested by:	I. Rance	

	0 cycles	**14 cycles**			**56 cycles**		
BRE No. P122768/22/	E MPa	E MPa	% Change	Visual Inspection	E MPa	% Change	Visual Inspection
101	48231	46638	-3	0	45955	-5	0
102	48200	47026	-2	0	46490	-4	0
103	48388	47056	-3	0	46702	-3	0
104	42872	41552	-3	1	38099	-11	1
105	48263	47072	-2	0	46567	-4	0
106	47195	45985	-3	0	45455	-4	0

The test continues until two or more of the specimens are classed as failed using either of the following criteria:

Score of the visual inspection attains 3;

Decrease of dynamic elastic modulus reaches 30 %.

Declared cycles of frost resistance **56**

Approved by: Martyn Webb Date: 19/08/2022

Name: Dr Martyn Webb

Position: Principal Consultant, Construction Testing, Assurance Division

BS EN 12407 Petrographic Examination of Natural Stone

Sample Description

Name of Stone:	Flick	Petrographic Nature:	Limestone
Block No:	No data supplied	Anisotropic Features:	None
Supplier:	Oxfordshire Minerals Group	Country of Origin:	UK
Dimensions (mm):	50 x 50 x 50	Project Reference:	P122768
Surface Finish:	Sawn	Preparation /Conditioning:	BS EN 12407
Date Tested:	27/07/2022	Tested By:	Martyn Webb
Project no	P122768	Sample I.D Number	P122768/22/146

Figure 1: Image of hand specimen, width of sample is 50 mm

Results summary

Based on the mineralogy identified in thin section and the texture seen in hand specimen, the stone has been given the classification of **Oolitic limestone (Oosparite).**

Final approved by: Date: 25/08/2022

Name: Dr Tim Yates Position: Technical Director

Macroscopic Examination of P122768/22/146

In hand specimen the stone was fine grained, uniform in appearance and having a pale orange-grey colour which was darker when wetted (Figure 1).

A white/off white cement/matrix was visible, with enclosed grains often being pale orange, grey or colourless with a micrite rim. Ooliths and fragmented bioclasts were noted. There was little evidence of compaction with most constituents being cement/matrix supported.

There was no evidence of weathering or deterioration. The stone reacted vigorously to dilute hydrochloric acid and absorbed water readily. The stone scratched easily.

Microscopic Examination of P122768/22/146

In thin section the stone consisted of a number of different particle types generally being oolitic in nature, with the majority possessing a micrite rim. Quartz formed an appreciable proportion of the grains visible, consisting of approximately 10 – 15 % of the total. Concentric layering was sometimes visible within the micrite rim. Other particles consisted of fragmented bioclasts (many elongate), carbonate crystals, lithoclasts and ore mineral grains. Ooliths with radiating concentric structure were seen, as were peloids with a typically ovoid shape. The typical appearance of the stone in thin section is shown in Figure 2, with details shown in Figure 3.

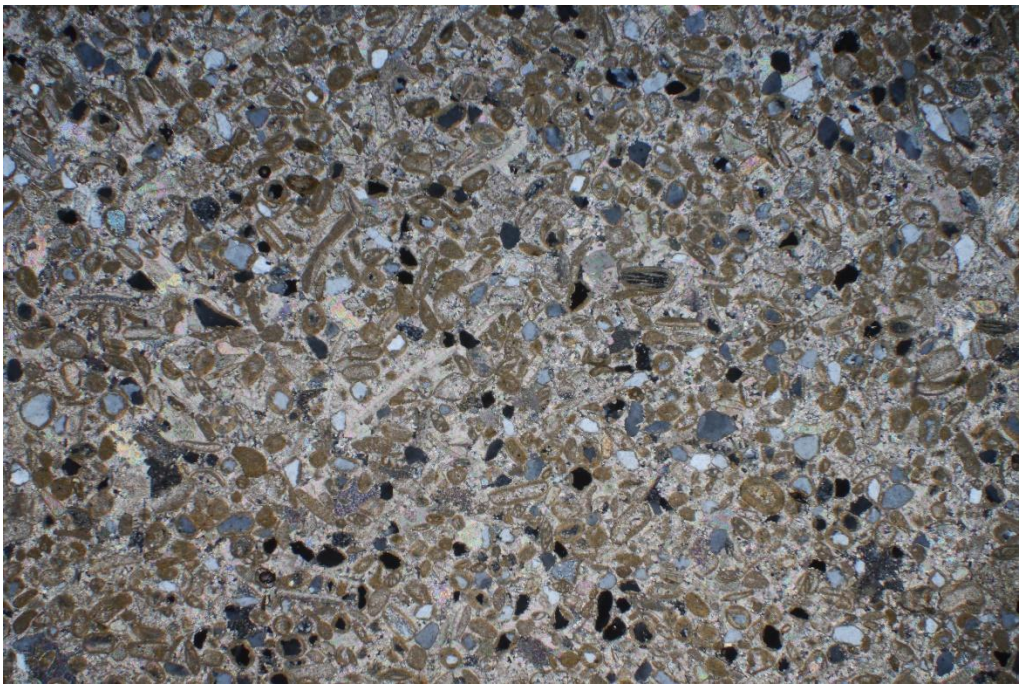


Figure 2. Typical appearance of Flick Stone in thin section (quartz grains grey). Cross polarised light, magnification x25.

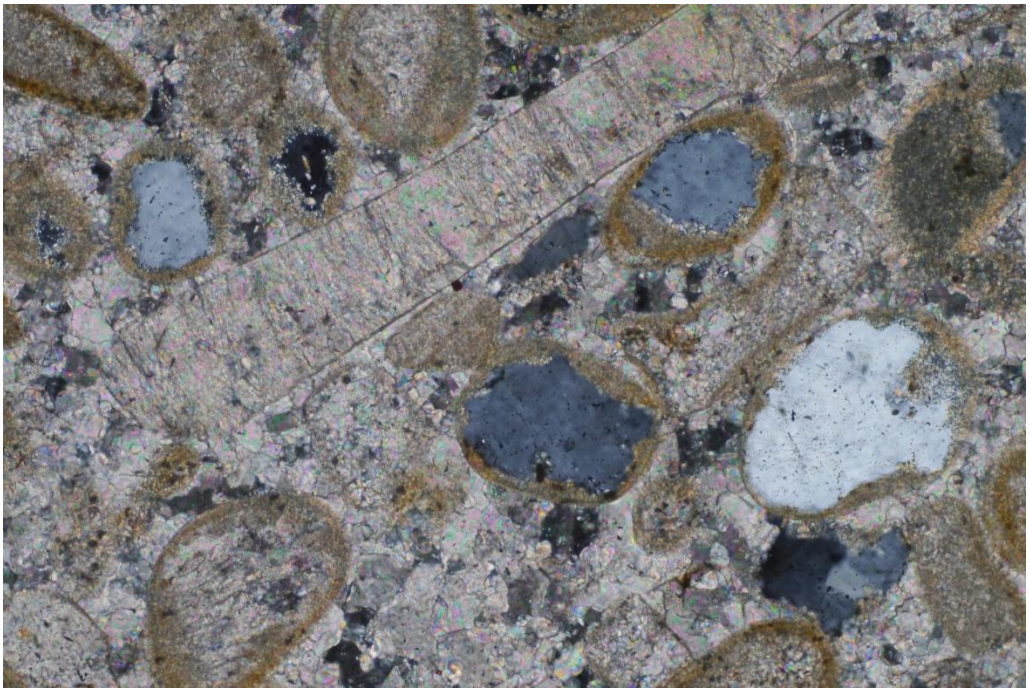


Figure 3. Detail of Flick Stone in thin section (quartz grains grey). Cross polarised light, magnification x200.

The constituent grains showed minimal grain to grain contact, with the majority being held within a fine sparite cement (Figure 4). Despite the presence of the cement, pore spaces were still visible within the stone. In some areas of the section minute iron rich grains were present, imparting a slight orange colouration to the surrounding fabric (Figure 5). Carbonate staining showed the carbonate to be predominantly ferroan calcite.

The approximate composition of the stone is given below:

Constituent	**Estimated proportion (%)**
Ooliths	40-50
Quartz	10-15
Bioclasts	5-10
Sparite cement	20-25
Pore spaces	5-10

Based on the mineralogy identified in thin section and the texture seen in hand specimen, the stone has been given the classification of **Oolitic limestone (Oomicrite).**

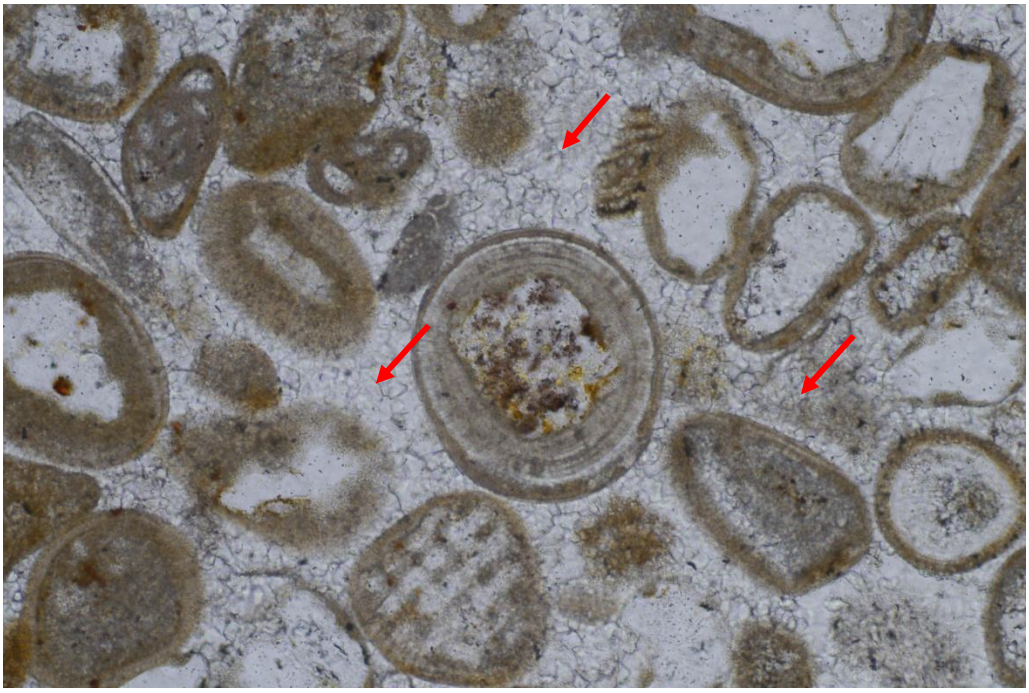


Figure 4. Detail image showing constituents within the fine sparite cement (arrowed). Plane polarised light, magnification x200.

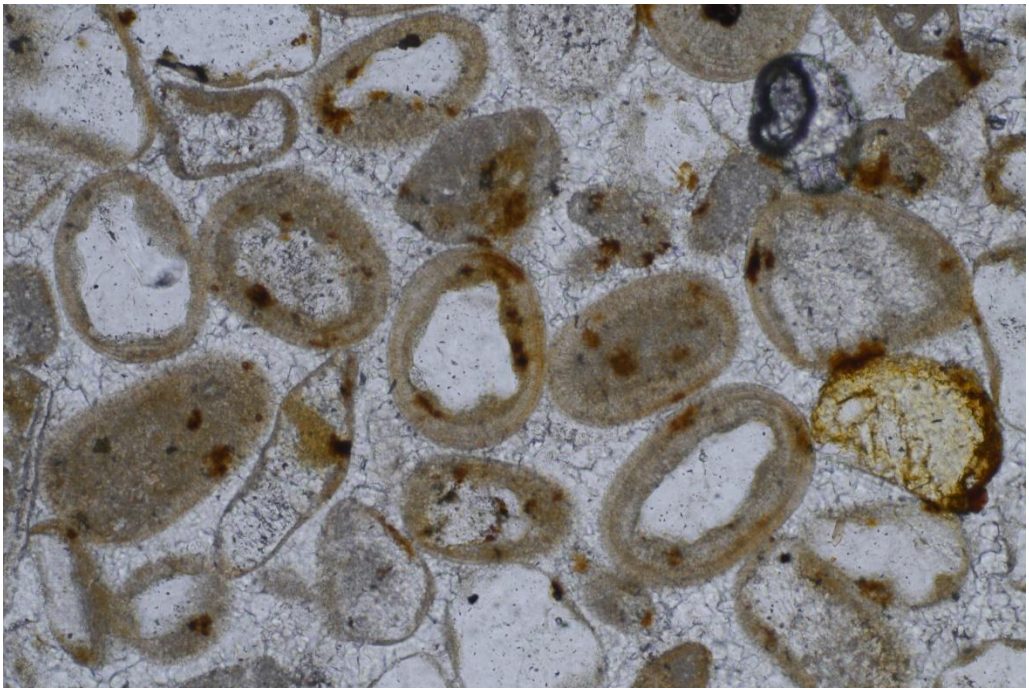


Figure 5. Minute iron rich grains (orange-brown) within constituent particles. Plane polarised light, magnification x200.