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REPORT 72361/G

TESTING OF

WOODKIRK YORKSTONE

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TESTING OF

WOODKIRK YORKSTONE

Calder Masonry Ltd.
Britannia Quarries
Rein Road
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Leeds
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For the attention of Ms Nicola Howgate

This report comprises
6 pages of text
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1 June 2022

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TESTING OF

WOODKIRK YORKSTONE

Reference : Instructions from Ms Nicola Howgate of Calder Masonry Ltd.

1. INTRODUCTION

We were instructed to undertake testing of natural stone, advised to be Woodkirk Yorkstone, in order to establish petrographic, physical, strength, durability and performance characteristics.

The following sample information was not supplied ; petrographic name, direction of any existing plane of anisotropy, name of the person who carried out the sampling.

2. SAMPLES

Test specimens prepared ready for test were received from Calder Masonry Ltd. at Sandberg laboratories on 26 April 2022, as follows.

Sandberg Reference	Specimen Size	Test
	Woodkirk Yorkstone	
G52216	1 no. 150 x 150 x 50mm	Petrographic examination
G52217	6 no. 50 x 50 x 50mm	Density & porosity
G52218	6 no. 50 x 50 x 50mm	Water absorption
G52219	10 no. 50 x 50 x 50mm	Compressive strength, dry
G52220	10 no. 300 x 100 x 50mm	Flexural strength (3-pt), dry
G52221	10 no. 300 x 100 x 50mm	Frost resistance (56 cycles) - Flexural strength (3-pt), dry
G52222	6 no. 100 x 70 x 50mm	Abrasion resistance
G52223	6 no. 200 x 200 x 50mm	Slip resistance

3. TEST METHODS AND RESULTS

3.1 Petrographic Examination

A sample was subjected to petrographic examination in accordance with the methods described in BS 5930:2015+A1:2020[1], ISRM[2] and BS EN 12407:2019[3].

The sample was first subjected to macroscopical and low power stereoscopic microscope examination supported by simple physical and chemical tests.

Record photographs of a sawn surface of the sample are presented in Table 1.

A representative portion from the sample was used to prepare a large area thin section which was examined using a Leica DM4500P high power petrological microscope employing plane polarised and cross polarised light at magnifications up to x1000.

The detailed petrographic examination results are given in Table 1 and can be summarised as follows ;

Woodkirk Yorkstone
Pale grey/blue, fine to medium grained SANDSTONE / GRITSTONE, well to very well compacted, hard to very hard and robust (subjective assessment). The stone exhibited occasional dark grey to black streaks mainly less than 1mm in width and 2mm to 30mm long generally running along the thickness of the slab sample, imparting a faint bedding structure to the stone. Occasional shining mica flakes, up to 0.1mm across, were seen on the sample principal surfaces.

3.2 Density and Porosity

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

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

Sandberg Reference	Apparent Density (kg/m^3)		Open Porosity (%)	
	Range	Mean	Range	Mean
G52217	2330 - 2330	2330	13.7 - 13.9	13.8

1 BS 5930:2015+A1:2020. Code of Practice for Site Investigation, Clause 44, Description and Classification of Rocks for engineering Purposes.

2 Rock Characterisation Testing and Monitoring. International Society for Rock Mechanics (ISRM) Suggested methods. Petrographic Description of Rocks p.73, 1981 Edition.

3 BS EN 12407:2019. Natural Stone Test Methods - Petrographic Examination.

3.3 Water Absorption at Atmospheric Pressure

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

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

Sandberg Reference	Water Absorption (%)	
	Range	Mean
G52218	4.2 - 4.5	4.4

3.4 Compressive Strength

Specimens were tested in accordance with the method given in BS EN 1926 : 2006.

Tests were carried out with the load applied in an unknown 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
G52219	Unknown - dry	65.30 - 85.20	77 *

Statistical evaluation of the test results in accordance with the method in BS EN 1926 : 2006 Annex C (normative) produced the following:-

	Lowest Expected Value (MPa)
Unknown - dry	66 *

* To nearest 1.0 MPa

3.5 Flexural Strength (3-point) Under Concentrated Load

Specimens were tested in accordance with the method given in BS EN 12372 : 2006.

Tests were carried out with the load applied in an unknown 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
G52220	Unknown - dry	9.7 - 12.3	11.2

Statistical evaluation of the test results in accordance with the methods in BS EN 12372 : 2006 Annex A (normative) produced the following:-

	Lowest Expected Value (MPa)
Unknown - dry	9.7

3.6 **Frost Resistance (56 Cycles) - Flexural Strength Under Concentrated Load**

Specimens were tested in accordance with BS EN 12371 : 2010 Technology Test (Test A) to 56 no. cycles.

On completion of the cycling period the specimens were tested for flexural strength in accordance with BS EN 12372 : 2006.

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

The detailed test results are given in Table 6 of this report and may be summarised as follows.

Sandberg Reference	Orientation / Condition	Flexural Strength (3-pt) (MPa) Post-freeze/thaw **56 cycles** Range	Mean
G52221	Unknown - dry	10.6 - 12.4	11.4

Visual inspection of the test specimens (post-56 cycles) indicated a classification of '0' (intact).

Statistical evaluation of the test results in accordance with the method in BS EN 12372 : 2006 Annex A (normative) produced the following:-

	Lowest Expected Value (MPa)
Unknown - dry	10.3

3.7 **Abrasion Resistance**

Specimens were tested in accordance with BS EN 14157 : 2017.

The detailed test results are given in Table 7 of this report and may be summarised as follows.

Sandberg Reference	Individual Abrasion Value Range (mm)	Mean Abrasion Value (mm)
G52222	24.5 - 25	25

BRE IP10/00 (Flooring, paving and setts) proposes guidance on the interpretation of abrasion results performed to BS EN 1341 : 2000 Annex C.

The guidance does not take into account the cleaning and maintenance regime of a floor.

The guidance values presented are as follows:

Abrasion resistance value	Suggested usage
<23	Intensive use (e.g. shopping malls)
23 - 30	Moderate (e.g. office buildings)
>30	Individual (e.g. houses)

3.8 **Slip Resistance**

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

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

Detailed results of the slip resistance test are given in Table 8 and are summarised below.

Sandberg Reference	Average Slip Resistance Value (SRV) (55 rubber)	
	Dry	Wet
G52223 - as received	98	80

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 Group[4] . 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 the 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 roughness[5].

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.

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.

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for Sandberg LLP

For the attention of Ms Nicola Howgate

David Ellis
Partner

DJE/Geoman

1 June 2022

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[4] The assessment of Floor Slip Resistance. The UK Slip Resistance Group, Issue 5, 2016.

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

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SAMPLE PHOTOGRAPHS



G52216. Woodkirk Yorkshire sandstone. General view of sample received.



G52216. Woodkirk Yorkshire sandstone. Close-up view of sample received.

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Table/Sheet 1/2

Date of Test / by 17.05.2022/PS

PETROGRAPHICAL EXAMINATION OF ROCK

BS EN ISO 14689:2018, BS 5930:2015+A1:2020, ISRM Method, BS EN 12407:2019, ASTM C1721-15

SAMPLE DETAILS			
Sample Reference	G52216	Client Reference/Site Mark	-
Sample Type, Source and Sampling Location Details:	Woodkirk Yorkshire sandstone		
Condition on Receipt:	Dry	Slab Dimensions, mm:	150 x 150 x 50
Methods of Preparation of Specimens and Examination Procedures:	The sample was first subjected to macroscopical and low power stereomicroscopical examination supported by simple physical and chemical tests. A representative portion from the sample was diamond-sawn perpendicular to the principal surfaces, across the thickness of the slab sample, and used to prepare a large area thin section which was then examined under a Leica DM4500P high power petrological microscope employing magnifications up to x1000.		
Any Other Details:	Thin section was taken perpendicular to the principal surfaces of the slab sample. Thin section completed 05.05.2022. Thin section dimensions, mm: 70 (length) x 47 (across thickness).		

MATERIAL DESCRIPTION:	Pale grey/blue, fine to medium grained SANDSTONE / GRITSTONE, well to very well compacted, hard to very hard and robust (subjective assessment). The stone exhibited occasional dark grey to black streaks mainly less than 1mm in width and 2mm to 30mm long generally running along the thickness of the slab sample, imparting a faint bedding structure to the stone. Occasional shining mica flakes, up to 0.1mm across, were seen on the sample principal surfaces.

MATERIAL COMPOSITION:

COMPONENT	Volume % (estimated)
Quartz	65
Chlorite	15
Mica	6
Feldspar	10
Iron and/or manganese oxide	4
Zircon & apatite	<1
TOTAL:	100

PETROGRAPHICAL DETAILS[n]

The stone was found to be a grain supported, generally poorly sorted, medium to coarse grained sandstone, with a grain size range from 50µm to 400µm and commonly 100µm to 300µm across, comprising predominantly quartz, lesser amounts of feldspar, chlorite and mica. Iron and/or manganese oxide stained chlorite, mica and altered feldspar and rare zircon and possibly apatite.

Quartz was irregular/angular and elongate with medium to low sphericity, and had embayed and sutured grain boundaries. Quartz grains were mainly polycrystalline and appeared to be the main structural component of the stone.

Feldspar was a lesser structural constituent and included plagioclase and alkali feldspar (orthoclase and microcline), occasionally exhibiting alteration to chlorite and mica.

Chlorite and mica were mainly intergranular and occasionally were associated with altered feldspar and were frequently stained with grey and brown iron and/or manganese oxide.

Mainly white muscovite and minor proportions of brown biotite grains up to 200µm across and 500µm long were mainly seen along grain boundaries or infilled intergranular spaces together with chlorite. The majority of mice appeared intermixed with chlorite.

Iron and/or manganese oxide stained mainly intergranular material (i.e. chlorite and mica) and altered feldspar.

The stone was well to very well compacted with rare irregular intergranular voids up to 100µm and commonly less than 50µm across. The stone however may be microporous, due to intergranular chlorite and fine mica which may increase the overall porosity.

UE = Undulatory Extinction. ND = Not Determined. NA = Not Applicable. NS = Not Supplied.

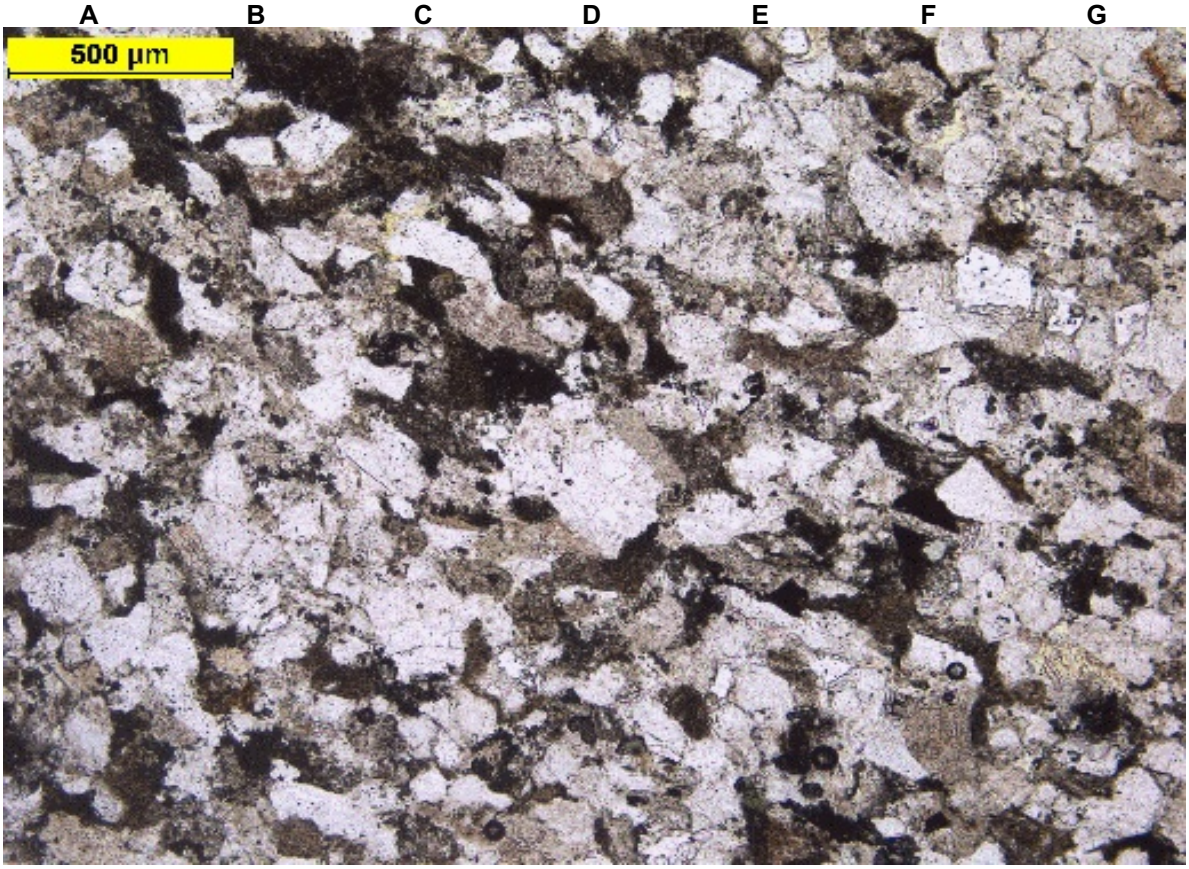
[n] Details mainly relate to components or features of possible engineering significance.

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Table/Sheet 1/3
Plate 1

PETROGRAPHICAL EXAMINATION OF STONE - PHOTOMICROGRAPH



Photomicrograph Details

Sandberg Sample Ref:	G52216	Client Ref/Site Mark:	Woodkirk Yorkshire sandstone
Microscope Light:	Plane polarised	Objective Magnification:	x5

Photomicrograph Description

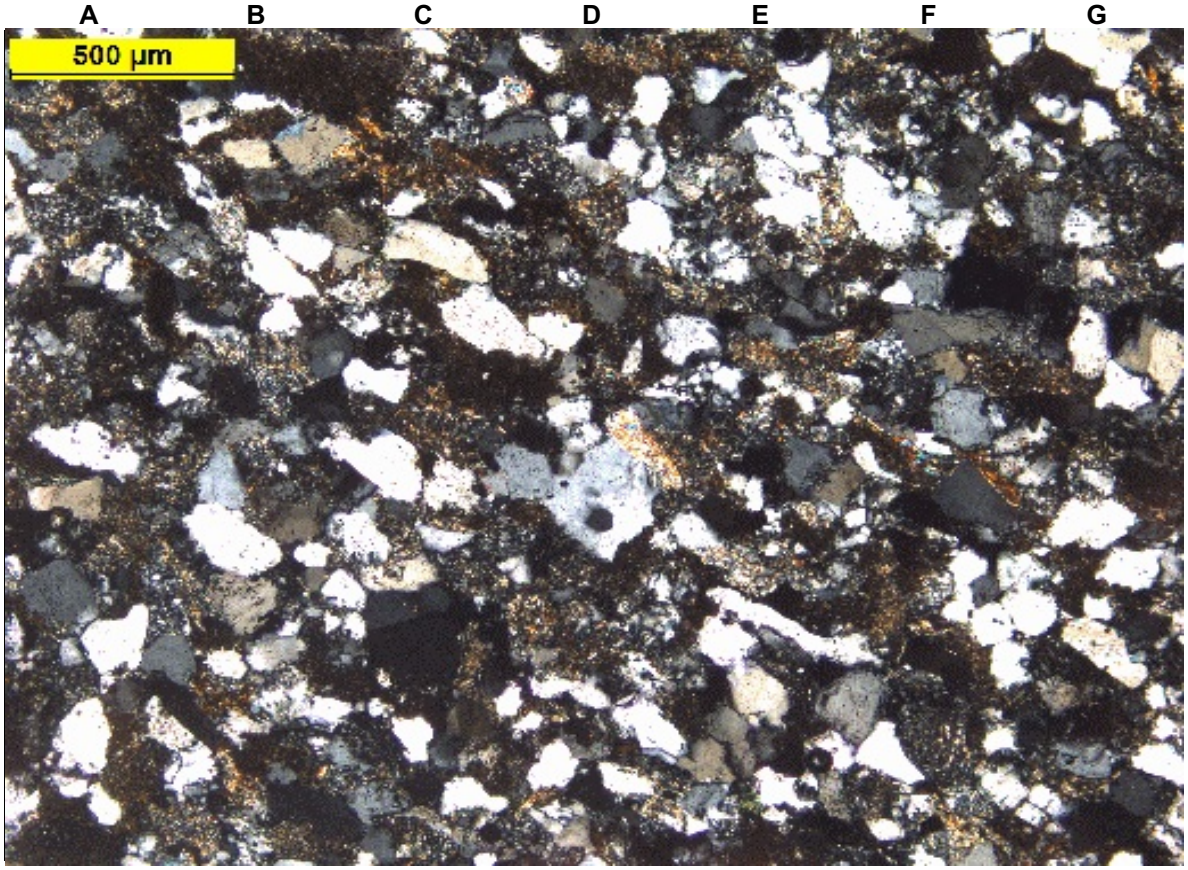
General view of stone structure. White irregular and elongate grains are predominantly quartz and some feldspar. Intergranular dark to dark brown and black material is chlorite intermixed with fine mica and iron and/or manganese oxide.

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Table/Sheet 1/4
Plate 2

PETROGRAPHICAL EXAMINATION OF STONE - PHOTOMICROGRAPH



Photomicrograph Details

Sandberg Sample Ref:	G52216	Client Ref/Site Mark:	Woodkirk Yorkshire sandstone
Microscope Light:	Cross polarised	Objective Magnification:	x5

Photomicrograph Description

General view of stone structure. White, pale grey and dark grey irregular and elongate grains are predominantly quartz and some feldspar. Intergranular dark to dark brown and black material, is mainly stippled with bright fine to very grains of mica material is chlorite intermixed with fine mica and iron and/or manganese oxide.

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Table
2

APPARENT DENSITY AND OPEN POROSITY

BS EN 1936 : 2006

Rock Name	Woodkirk Yorkstone			Test By/Date	MB / 06.05.22	
Rock Type	Sandstone / Gritstone			Checked/Date	MMc / 06.05.22	
Sandberg Sample Ref.	Oven Dried Mass in Air (g)	Density of Water (kg/m³)	Vacuum Saturated Mass in Air (g)	Vacuum Saturated Mass in Water (g)	Open Porosity (%)	Apparent Density (kg/m³)
G52217 a	301.76	999	319.71	190.10	13.9	2330
G52217 b	308.54	999	326.86	194.54	13.9	2330
G52217 c	306.27	999	324.22	193.15	13.7	2330
G52217 d	308.46	999	326.87	194.72	13.9	2330
G52217 e	306.27	999	324.40	193.06	13.8	2330
G52217 f	306.51	999	324.52	193.12	13.7	2330
Mean					13.8	2330

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Table
3

WATER ABSORPTION AT ATMOSPHERIC PRESSURE

BS EN 13755 : 2008

Rock Name	Woodkirk Yorkstone	Test By / Date	MB / 10.05.22
Rock Type	Sandstone / Gritstone	Checked / Date	MMc / 10.05.22

Sandberg Sample Ref.	Oven Dried Mass (g)	Saturated Surface Dried Mass (g)	Water Absorption (%)
G52218 a	301.84	315.17	4.4
G52218 b	308.34	321.61	4.3
G52218 c	310.93	324.31	4.3
G52218 d	301.10	314.22	4.4
G52218 e	306.36	319.34	4.2
G52218 f	303.33	316.89	4.5
Average			4.4

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Table
4

COMPRESSIVE STRENGTH

BS EN 1926 : 2006

Load Orientation[1] : Unknown
Test Condition : Oven dried

Rock Name	Woodkirk Yorkstone				Test By/Date	MB / 04.05.22	
Rock Type	Sandstone / Gritstone				Checked/Date	MMc / 06.05.22	
Sandberg Sample Reference	Breaking Load (N)	Specimen Height (mm)	Mean Lateral Dimension (mm)	Mean Lateral Dimension (mm)	Cross Section Area (mm^2)	Compressive Strength (MPa)	Observations
G52219 a	203200	50.8	50.9	51.3	2611	77.82	Normal failure
G52219 b	198300	51.5	50.7	51.2	2596	76.39	Normal failure
G52219 c	196600	51.1	50.7	50.5	2560	76.80	Normal failure
G52219 d	170500	50.9	51.3	50.9	2611	65.30	Normal failure
G52219 e	189900	51.2	50.4	50.6	2550	74.47	Normal failure
G52219 f	206700	50.9	50.8	51.3	2606	79.32	Normal failure
G52219 g	191800	51.2	50.4	50.4	2540	75.51	Normal failure
G52219 h	219900	51.4	50.7	50.9	2581	85.20	Normal failure
G52219 j	196100	50.7	51.1	50.4	2575	76.16	Normal failure
G52219 k	208700	51.2	50.7	51.6	2616	79.78	Normal failure
Mean						77 *	
Std. Dev.						5 *	
Var. Coef.						0.07	

[1] Relative to bedding

Lowest Expected Value (MPa) : 66 *

* To nearest 1.0 MPa

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Table
5

FLEXURAL STRENGTH (UNDER CONCENTRATED LOAD)

BS EN 12372 : 2006

Load Orientation[1] : Unknown
Finish : Sawn
Test Condition : Oven dried

Rock Name	Woodkirk Yorkstone			Test By/Date	MB / 29.04.22	
Rock Type	Sandstone / Gritstone			Checked/Date	MMc / 03.05.22	
Sandberg Sample Reference	Breaking Load (N)	Specimen Span (mm)	Specimen Width (mm)	Specimen Thickness (mm)	Flexural Strength (MPa)	Observations
G52220 a	7480	250	101.6	50.3	10.9	Normal Failure
G52220 b	8270	250	101.0	50.3	12.1	Normal Failure
G52220 c	7630	250	101.0	50.2	11.2	Normal Failure
G52220 d	7610	250	100.6	50.2	11.3	Normal Failure
G52220 e	7110	250	101.4	50.2	10.4	Normal Failure
G52220 f	6560	250	100.0	50.3	9.7	Normal Failure
G52220 g	7780	250	100.9	50.2	11.5	Normal Failure
G52220 h	8210	250	100.5	51.0	11.8	Normal Failure
G52220 j	8370	250	100.9	50.2	12.3	Normal Failure
G52220 k	7610	250	101.9	50.2	11.1	Normal Failure
Mean					11.2	
Std. Dev.					0.8	
Var. Coef.					0.1	

[1] With respect to bedding

Lowest Expected Value (MPa) : 9.7

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Table
6

FLEXURAL STRENGTH (UNDER CONCENTRATED LOAD)

BS EN 12372 : 2006
After 56 Cycles of Freeze-Thaw to BS EN 12371 : 2010

Load Orientation[1] : Unknown
Finish : Sawn
Test Condition : Oven dried

Rock Name	Woodkirk Yorkstone			Test By/Date	MB/ 31.05.22	
Rock Type	Sandstone / Gritstone			Checked/Date	MMc / 31.05.22	
Sandberg Sample Reference	Breaking Load (N)	Specimen Span (mm)	Specimen Width (mm)	Specimen Thickness (mm)	Flexural Strength (MPa)	Observations
G52221 a	7570	250	101.3	50.2	11.1	Normal Failure
G52221 b	8400	250	100.9	50.2	12.4	Normal Failure
G52221 c	7810	250	101.1	50.2	11.5	Normal Failure
G52221 d	8180	250	101.0	50.1	12.1	Normal Failure
G52221 e	7800	250	100.4	50.1	11.6	Normal Failure
G52221 f	7720	250	100.9	50.2	11.4	Normal Failure
G52221 g	7340	250	101.0	50.6	10.6	Normal Failure
G52221 h	7550	250	100.5	50.8	10.9	Normal Failure
G52221 j	7570	250	100.3	50.8	11.0	Normal Failure
G52221 k	7860	250	101.0	51.0	11.2	Normal Failure
Mean					11.4	
Std. Dev.					0.5	
Var. Coef.					0.1	

[1] With respect to bedding

Lowest Expected Value (MPa) : 10.3

Visual Code 0 = No cracks or loss of material

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Table
7

ABRASION RESISTANCE

BS EN 14157 : 2017

Rock Name	Woodkirk Yorkstone	Test by/Date	HO / 20.05.22
Rock Type	Sandstone / Gritstone	Checked by/Date	MB / 23.05.22
Sandberg Sample Reference	Individual abrasion value (mm)	Mean abrasion value (mm)	
G52222 a	24.5	25	
G52222 b	25		
G52222 c	25		
G52222 d	24.5		
G52222 e	25		
G52222 f	25		

Note : 1) No sample preparation (clause C.5) carried out.
2) Only one determination carried out on each specimen.
3) Test results apply only to the specimens tested.

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Sandberg Reference	Material	Surface Finish	Orientation	Surface Roughness R_z,µm	Temperature °C		Slip Resistance Value (SRV)			
							Dry		Wet	
					Surface	Ambient	Mean [5 readings]	Mean	Mean [5 readings]	Mean
G52223 a	Woodkirk Yorkstone	As received	A	64.8	24.4	24.1	96	97	75	74
			180° to A	-	-	-	97		72	
G52223 b	Woodkirk Yorkstone	As received	A	60.9	24.4	24.1	97	97	80	79
			180° to A	-	-	-	96		78	
G52223 c	Woodkirk Yorkstone	As received	A	69.8	24.4	24.1	96	97	80	78
			180° to A	-	-	-	97		76	
G52223 d	Woodkirk Yorkstone	As received	A	67.1	24.4	24.1	97	97	83	81
			180° to A	-	-	-	96		78	
G52223 e	Woodkirk Yorkstone	As received	A	65.3	24.4	24.0	98	98	83	82
			180° to A	-	-	-	97		80	
G52223 f	Woodkirk Yorkstone	As received	A	64.4	24.4	24.1	102	100	86	83
			180° to A	-	-	-	98		79	

SRV dry (6 no. specimens) : 98
SRV wet (6 no. specimens) : 80

SLIP RESISTANCE TESTING - RUBBER SLIDER TYPE : 55
BS EN 1341:2012 and UK SRG Issue 5 : 2016

Test By/Date	Table	Job No.
HO / 16-17.05.22	8	72361/G

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