

REPORT 71256/G

**PETROGRAPHIC EXAMINATION AND
CHEMICAL ANALYSIS**

OF MORTAR SAMPLES

**PICCADILLY WAREHOUSE
11 BLOOM STREET
MANCHESTER, M1 3EF**

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PETROGRAPHIC EXAMINATION AND CHEMICAL ANALYSIS

OF MORTAR SAMPLES

PICCADILLY WAREHOUSE, 11 BLOOM STREET

MANCHESTER, M1 3EF

Manchester Design and Build Limited
Bridgewater House
58 - 60 Whitworth Street
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This report comprises
3 pages of text
Table 1 of 1 sheet
Appendix A of 5 sheets
Appendix B of 5 sheets

For the attention of Mr Neil Kelly & Ms Alex Radu

2 December 2021

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REPORT 71256/G

PETROGRAPHIC EXAMINATION AND CHEMICAL ANALYSIS

OF MORTAR SAMPLES

PICCADILLY WAREHOUSE, 11 BLOOM STREET

MANCHESTER, M1 3EF

Reference : Purchase Order No. 1155 dated 4 November 2021.

1. INTRODUCTION

Two mortar samples were received in our laboratory on 9 November 2021 and subjected to testing in accordance with your instructions.

We were asked to carry out a petrographic examination in accordance with ASTM C856-20 and chemical analysis to determine mix proportions for each mortar sample received.

2. SAMPLES RECEIVED

Sandberg Ref.	Client Ref./ Site Mark	Advised Location	Approximate Sample Weight, g
	Internal Mortar		
G51624	1 st Floor, Mid Height, Front Elevation, Bloom Street	Piccadilly Warehouse, 11 Bloom Street, Manchester, M1 3EF	219
G51625	2 nd Floor, Mid Height, Front Elevation, Bloom Street		40

3. TEST METHODS AND RESULTS

3.1 Petrographic Examination of Mortar Samples

The mortar samples were subjected to petrographic examination in accordance with the methods given in ASTM C856-20¹.

Each sample was first subjected to macroscopical and low power stereomicroscopical examination supported by simple physical and chemical tests and record colour photographs were taken.

Representative portions from each sample were impregnated with fluorescent epoxy resin, and used to prepare a large area thin section for each sample, which was examined under a high-power petrological microscope employing magnifications up to x1000 in transmitted, incident, plane, cross polarised and ultraviolet light.

The detailed results of the petrographic examination of each sample are given in Appendices A & B of this report together with selected photomicrographs.

The mortar samples (G51624 and G51625) were found to be very similar in texture and composition containing a natural sand fine aggregate, coal and/or furnace slag pieces, wood and vegetable fibres, and a non-hydraulic lime binder. No evidence of chemical attack or deterioration was identified in the mortar samples examined.

3.2 Chemical Analysis for the Determination of Mix Proportions of Mortar Samples

The mortar samples were prepared and analysed using a combination of hand separation and chemical analysis techniques in accordance with documented in-house methods, Sections 34.1 and 34.8, supported by qualitative chemical techniques where appropriate.

Examination of the analysis data in conjunction with the appearance, tactile properties and available background information for the samples suggested that the mixes consisted of non-hydraulic lime and sand, the mix proportions were calculated on this assumption, following documented in-house methods.

The lime contents were calculated from the acid soluble calcium contents making the assumptions shown in the analysis Tables. The approximate volume proportions were calculated using typical bulk densities for the constituents as indicated in the analysis tables.

Details of the analyses are given in Table 1 of this report, including details of the assumptions made in the calculations. The mix proportions are summarized below:

1

ASTM C856-20 'Standard Practice for Petrographic Examination of Hardened Concrete'.

Sandberg Reference	Client Reference	Mix Type	Mix Proportions	
			by weight	by volume
G51624	1 st floor	Non hydraulic lime : sand	1 : 5.7	1 : 2.3
G51625	2 nd floor	Non hydraulic lime : sand	1 : 7.0	1 : 2.9

It is not always possible by chemical analysis alone to distinguish with certainty between Portland cement and lime binders or between hydraulic and non-hydraulic limes.

Microscopical examination can usually ascertain the presence or otherwise of Portland cement in the mortar and of calcareous material in the aggregate. In the absence of such confirmatory work, interpretation of the analytical results is made on the basis of consideration of the analysis in conjunction with the appearance and any available background information for the mortar.

Mix proportions are traditionally expressed on the basis of volume ratios and, in the absence of information about the particular binder or aggregate, assumed bulk density values are used to calculate such proportions. Volume proportions can as a result be somewhat inaccurate and it may be desirable to use weight proportions if an attempt is made to match the mortar for renovation work.

The mix proportions given are based on the chemical analysis results and examination of the hand specimens in the light of our experience with historic mortar samples.

The mortar samples were found to comprise non-hydraulic lime and sand mixes.

The sulphate contents of the sample were found to be at normal levels.

The sample size was very small and therefore the results obtained should be treated with a degree of caution. Any decisions based on the results should be undertaken taking this into account.

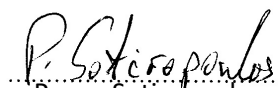
4. REMARKS

These results and comments conclude the testing requested to date. Please contact us if we can be of any further assistance in this matter.

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for Sandberg LLP

For the attention of Mr Neil Kelly & Ms Alex Radu


Panos Sotiropoulos

Principal Geologist

PS/Geocur/pd
File:71256g.Report Mortar Petro & Chemical Analysis.wpd

2 December 2021

MORTAR - CHEMICAL ANALYSIS
DETERMINATION OF MIX PROPORTIONS

Documented In-house Methods 34.1(*) and BS 4551:2005+A2:2013

Date of Test

26-29/11/21

Sandberg Reference	G51624	G51625		
Client Reference	1 st floor	2 nd floor		
Details	Mortar	Mortar		
CHEMICAL ANALYSIS				
	% by mass			
Insoluble Residue	80.50	83.09		
Soluble Silica, SiO ₂ *	0.19	0.20		
Acid soluble Alumina, Al ₂ O ₃ *	0.08	0.13		
Acid soluble Iron, Fe ₂ O ₃ *	0.06	0.07		
Acid soluble Calcium, CaO	10.04	8.25		
Acid soluble Magnesium, MgO	<0.01	<0.01		
Acid soluble Sulphate, SO ₃	0.15	0.28		
Loss on Ignition	8.91	7.89		
Total	99.94	99.92		

Calculated Mix Proportions				
Composition to nearest 0.5%	% by mass of dry mass			
Non-hydraulic lime : sand				
Lime	15.0	12.5		
Sand	85.0	87.5		
Calculated volume proportions	1 : 2.3	1 : 2.9		
Remarks	-	-		

Assumptions used in calculations	SiO ₂ %	CaO %	bulk density kg/m ³	material type
Sand	-	0.0	1400	siliceous
Non-hydraulic lime	-	75.6	575	non hydraulic

PETROGRAPHIC EXAMINATION OF HARDENED MORTAR ASTM C856 - 20

SHEET 1a - SAMPLE DETAILS AND RECORD PHOTOGRAPH



Sandberg Sample Ref:	G51624
Client Reference / Site Mark:	Mortar 1 st Floor, mid height, internal, front elevation, Bloom Street
Sample Location Details:	Piccadilly Warehouse, 11 Bloom Street, Manchester, M1 3EF
Sample Description: (compaction, voidage, cracking, honeycombing, sweaty patches, deposits, other features):	Pieces of mortar exhibiting greyish cream to greyish buff colour. The mortar was generally hard to moderately hard and moderately robust, as it is expected for a lime mortar (subjective assessment). The mortar appeared to exhibit a generally normal compaction with occasional irregular to elongate voids up to 2mm and commonly less than 1mm across.
Specimen Preparation: (impregnation)	A representative portion from the mortar pieces was impregnated with a resin containing fluorescent dye and used to prepare a large area thin-section.
Microscope Details: (type, magnification used)	Zeiss Stemi 508 stereoscopic zoom microscope and Leica DM4500P high power petrological microscopes employing magnifications up to x1000 and plane polarised, cross polarised and ultraviolet light.
Position of Specimen: (size, relationship to sample)	The thin section was taken along the length and through the thickness of mortar pieces. Thin section approximate dimensions (mm): 4No. pieces covering an area 67 x 45 approx.

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Appendix/Sheet

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Date - Test by

30.11.2021- PS

**PETROGRAPHIC EXAMINATION OF HARDENED MORTAR
ASTM C856 - 20**

SHEET 1b - SAMPLE RECORD PHOTOGRAPHS



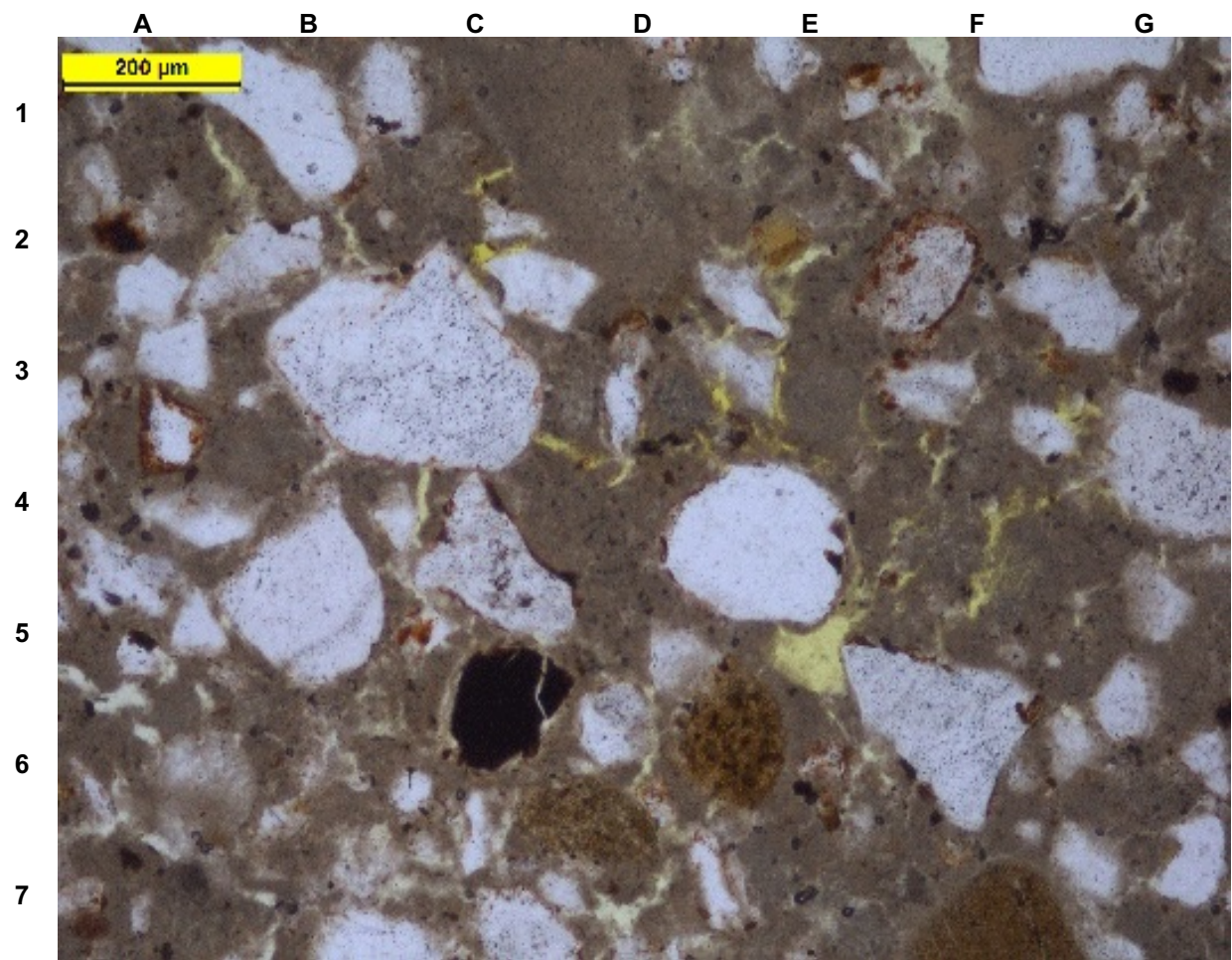
PETROGRAPHIC EXAMINATION OF HARDENED MORTAR ASTM C856-20

SHEET 1c - MORTAR COMPOSITION AND FEATURES

Sandberg Sample Reference:	G51624
Client Site Mark:	Mortar 1 st Floor, mid height, internal, front elevation, Bloom Street
Fine aggregate:	The aggregate was a natural sand with a maximum particle size up to 1mm and commonly less than 500µm across of mainly irregular to subround and occasionally elongate particle shape. The sand was found to comprise mainly quartz, quartzite/metaquartzite and sporadic chert/tuff, feldspar and limestone particles. Occasional coal or furnace slag particles up to 10mm long and 6mm across and sporadic brick pieces up to 10mm across and 20mm long were also present. The sand was generally evenly distributed and continuously graded. Wood slivers, fine wood pieces and vegetable fibres were also present.
Colour of Matrix:	Greyish cream to greyish buff in hand specimen and grey/brown in thin section.
Type of Binder:	Non-Hydraulic lime
Unhydrated grains: (incl. size, abundance and degree of hydration)	Frequent unburnt and/or partially burnt limestone particles and/or hemi-hydrated lime grains generally less than 500µm across. Also, sporadic clots of lime intermixed with clayey material were seen.
Mineral additives:	None definitively identified
Carbonation and Portlandite: (incl. depth and degree of carbonation, size and distribution of Ca(OH) ₂)	The mortar matrix appeared to be generally carbonated throughout with areas of partial carbonation.
Compaction and Void Details: (incl. microporosity and void types, sizes, distribution)	The mortar exhibited a generally normal compaction with occasional irregular to elongate voids up to 2mm and commonly less than 1mm across. The microporosity of the mortar paste was moderately low to moderately high.
Cracks and Microcracks: (incl. sizes, abundance, distribution relationships to other features)	Frequent desiccation cracks and microcracks (<30µm wide and <500µm long), occasionally associated with unburnt and/or partially burnt limestone particles and/or hemi-hydrated lime grains, and running through the mortar paste and along aggregate margins.
Secondary Deposits:	None identified.
Other Features: (incl. any evidence of alkali-reactivity, chemical attack etc.)	There was no evidence of chemical attack (including sulphate attack) or apparent deterioration in the sample examined.
General Comments:	The mortar binder was found to be a non-hydraulic lime.

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Appendix/Sheet
A/4
Plate
1

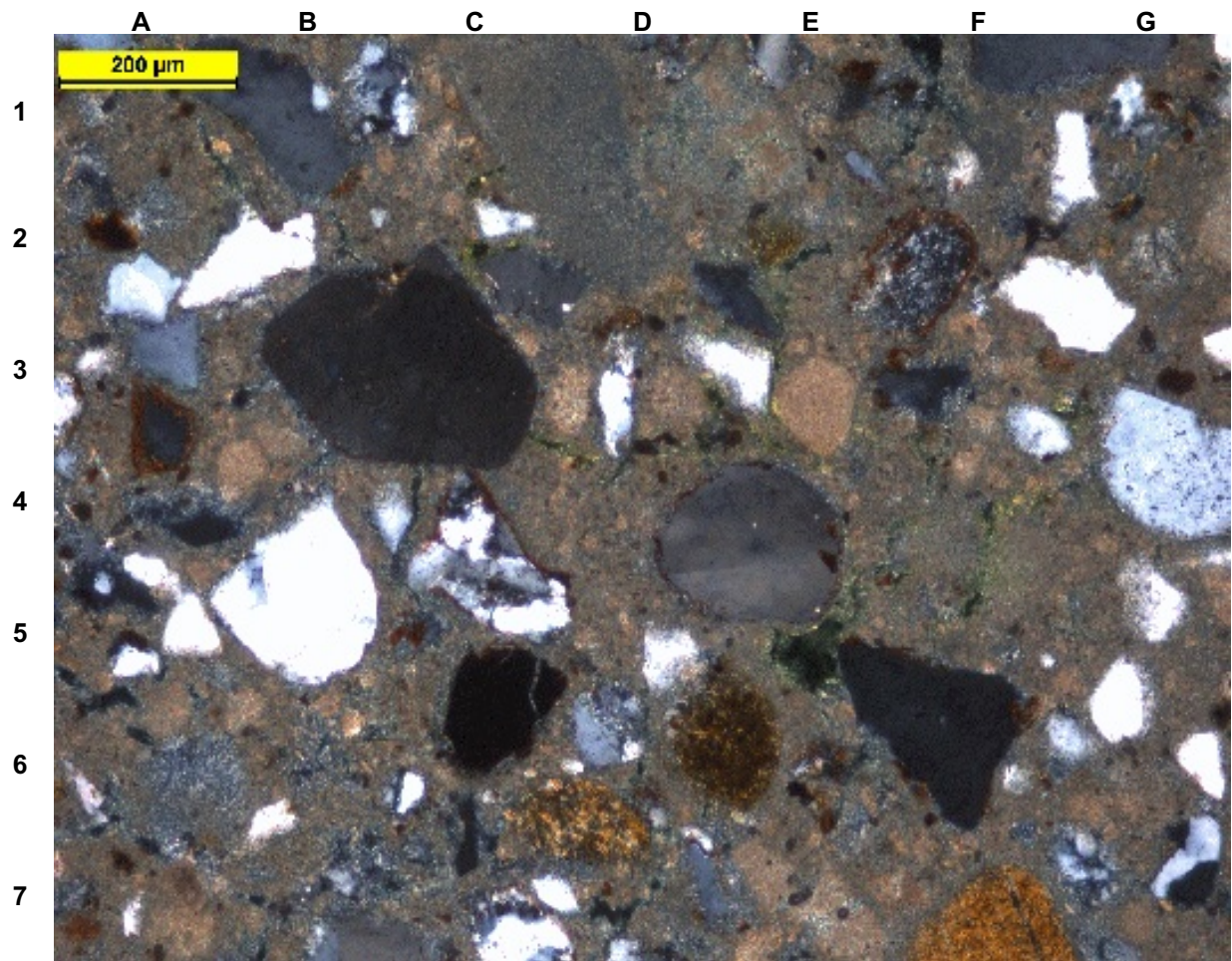
PETROGRAPHICAL EXAMINATION OF MORTAR - PHOTOMICROGRAPH



Photomicrograph Details			
Sandberg Sample Ref:	G51624	Client Ref/Site Mark:	1 st Floor Mortar
Microscope Light:	Plane polarised	Objective Magnification:	x10
Photomicrograph Description			
General view of mortar paste under plane polarised light. The non-hydraulic lime binder matrix exhibits desiccation cracks (yellow impregnating resin infilled), yellow fine lines, through the paste and along aggregate margins (e.g. D-E/2-5). A coal and/or furnace slag piece at C/5-6 exhibits a white fine crack and a peripheral (on the right). The aggregate (white grains) consist mainly of quartz quartzite/metaquartzite.			

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Appendix/Sheet A/5
Plate 2

PETROGRAPHICAL EXAMINATION OF MORTAR - PHOTOMICROGRAPH



Photomicrograph Details			
Sandberg Sample Ref:	G51624	Client Ref/Site Mark:	1 st Floor Mortar
Microscope Light:	Cross polarised	Objective Magnification:	x10
Photomicrograph Description			
General view of mortar paste under cross polarised light. The non-hydraulic lime binder matrix exhibits desiccation cracks black fine lines, through the paste and along aggregate margins (e.g. D-E/2-5). A coal and/or furnace slag piece at C/5-6 exhibits a fine crack and a peripheral (on the right). The aggregate (white, pale grey, grey and blue grey grains) consists mainly of mainly quartz quartzite/metaquartzite.			

PETROGRAPHIC EXAMINATION OF HARDENED MORTAR ASTM C856 - 20

SHEET 1a - SAMPLE DETAILS AND RECORD PHOTOGRAPH



Sandberg Sample Ref:	G51625
Client Reference / Site Mark:	Mortar 2 nd Floor, mid height, internal, front elevation, Bloom Street
Sample Location Details:	Piccadilly Warehouse, 11 Bloom Street, Manchester, M1 3EF
Sample Description: (compaction, voidage, cracking, honeycombing, sweaty patches, deposits, other features):	Pieces of mortar exhibiting greyish cream to greyish buff colour. The mortar was generally hard to moderately hard and moderately robust, as it is expected for a lime mortar (subjective assessment). The mortar appeared to exhibit a generally normal compaction with occasional irregular to elongate voids up to 2mm and commonly less than 1mm across.
Specimen Preparation: (impregnation)	A representative portion from the mortar pieces was impregnated with a resin containing fluorescent dye and used to prepare a large area thin-section.
Microscope Details: (type, magnification used)	Zeiss Stemi 508 stereoscopic zoom microscope and Leica DM4500P high power petrological microscopes employing magnifications up to x1000 and plane polarised, cross polarised and ultraviolet light.
Position of Specimen: (size, relationship to sample)	The thin section was taken along the length and through the thickness of mortar pieces. Thin section approximate dimensions (mm): 4No. pieces covering an area 67 x 45 approx.

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Appendix/Sheet

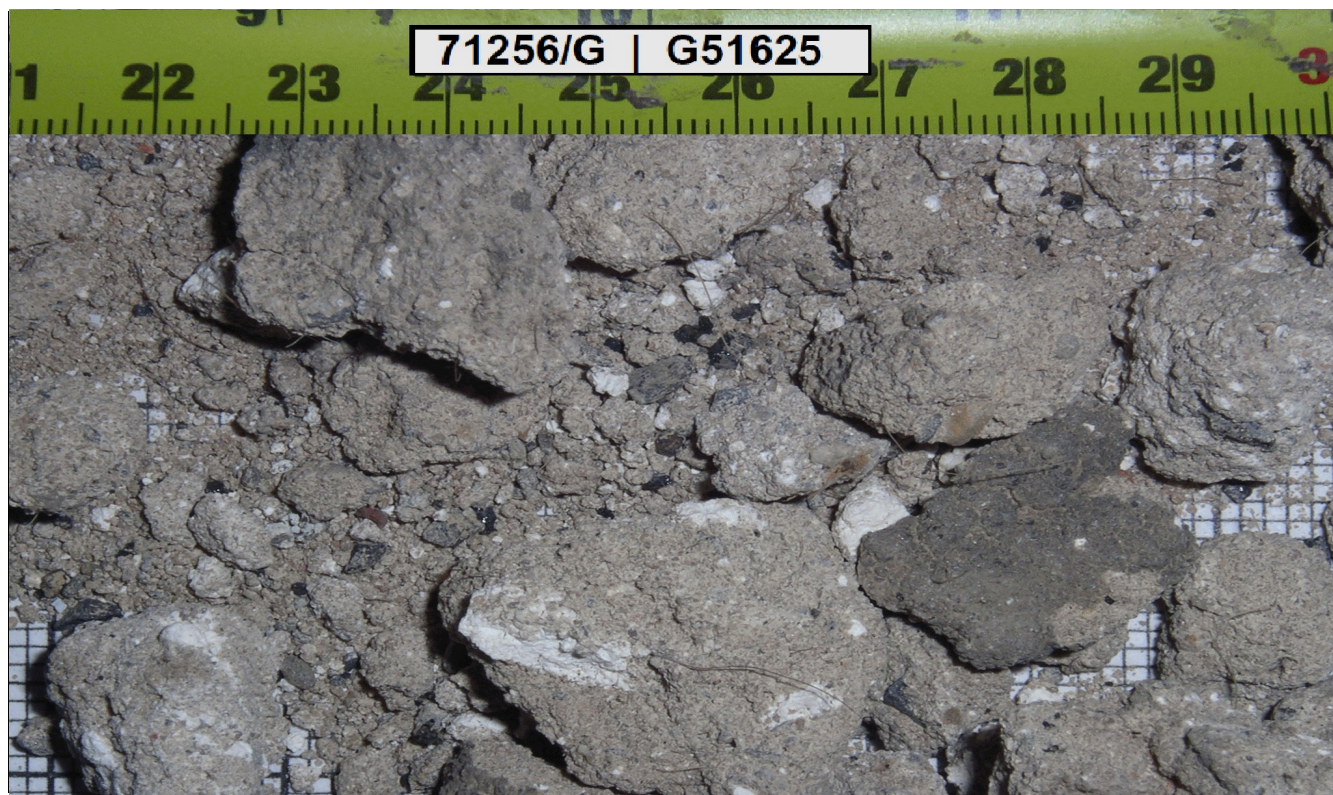
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Date - Test by

30.11.2021- PS

PETROGRAPHIC EXAMINATION OF HARDENED MORTAR ASTM C856 - 20

SHEET 1b - SAMPLE RECORD PHOTOGRAPHS



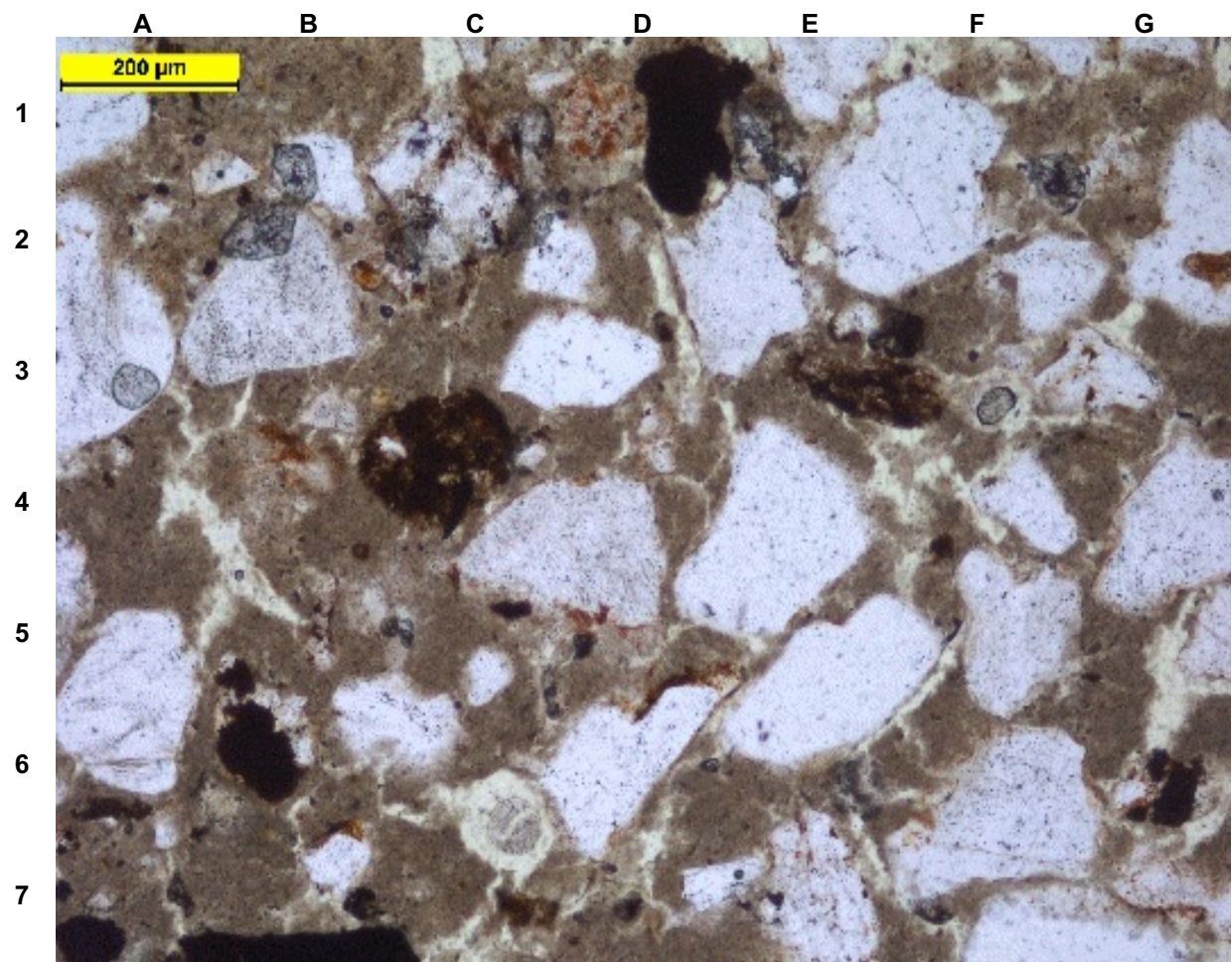
PETROGRAPHIC EXAMINATION OF HARDENED MORTAR ASTM C856-20

SHEET 1c - MORTAR COMPOSITION AND FEATURES

Sandberg Sample Reference:	G51625
Client Site Mark:	Mortar 2 nd Floor, mid height, internal, front elevation, Bloom Street
Fine aggregate:	The aggregate was a natural sand with a maximum particle size up to 1mm and commonly less than 500µm across of mainly irregular to subround and occasionally elongate particle shape. The sand was found to comprise mainly quartz, quartzite/metaquartzite and sporadic chert/tuff, feldspar and limestone particles. Occasional coal or furnace slag particles up to 10mm long and 6mm across and sporadic brick pieces up to 10mm across and 20mm long were also present. The sand was generally evenly distributed and continuously graded. Wood slivers, fine wood pieces and vegetable fibres were also present.
Colour of Matrix:	Greyish cream to greyish buff in hand specimen and grey/brown in thin section.
Type of Binder:	Non-Hydraulic lime
Unhydrated grains: <i>(incl. size, abundance and degree of hydration)</i>	Frequent unburnt and/or partially burnt limestone particles and/or hemi-hydrated lime grains generally less than 500µm across. Also, sporadic clots of lime intermixed with clayey material were seen.
Mineral additives:	None definitively identified
Carbonation and Portlandite: <i>(incl. depth and degree of carbonation, size and distribution of Ca(OH)₂)</i>	The mortar matrix appeared to be generally carbonated throughout with areas of partial carbonation.
Compaction and Void Details: <i>(incl. microporosity and void types, sizes, distribution)</i>	The mortar exhibited a generally normal compaction with occasional irregular to elongate voids up to 2mm and commonly less than 1mm across. The microporosity of the mortar paste was moderately low to moderately high.
Cracks and Microcracks: <i>(incl. sizes, abundance, distribution relationships to other features)</i>	Frequent desiccation cracks and microcracks (<30µm wide and <500µm long), occasionally associated with unburnt and/or partially burnt limestone particles and/or hemi-hydrated lime grains, and running through the mortar paste and along aggregate margins.
Secondary Deposits:	None identified.
Other Features: <i>(incl. any evidence of alkali-reactivity, chemical attack etc.)</i>	There was no evidence of chemical attack (including sulphate attack) or apparent deterioration in the sample examined.
General Comments:	The mortar binder was found to be a non-hydraulic lime.

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Appendix/Sheet B/4
Plate 1

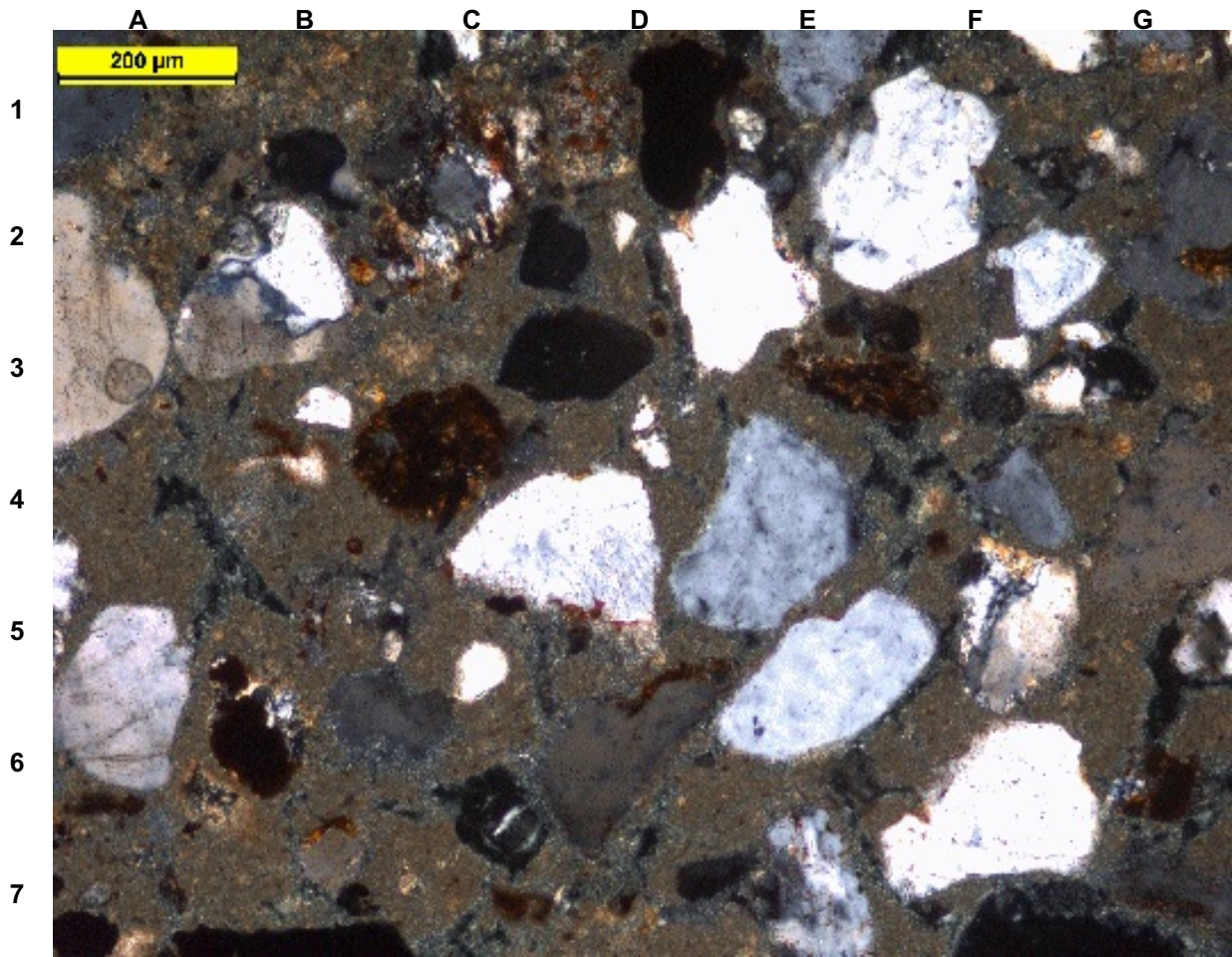
PETROGRAPHICAL EXAMINATION OF MORTAR - PHOTOMICROGRAPH



Photomicrograph Details			
Sandberg Sample Ref:	G51625	Client Ref/Site Mark:	2 nd Floor Mortar
Microscope Light:	Plane polarised	Objective Magnification:	x10
Photomicrograph Description			
General view of mortar paste under plane polarised light. The non-hydraulic lime binder matrix exhibits desiccation cracks, white s linear features, through the paste and along aggregate margins (e.g. A-B/4-5, E-F/5-6). Coal and/or furnace slag piece at B-C/3-4, D-E/1-2 exhibit white fine peripheral cracks. The aggregate (white grains) consist mainly of quartz quartzite/metaquartzite.			

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Appendix/Sheet B/5
Plate 2

PETROGRAPHICAL EXAMINATION OF MORTAR - PHOTOMICROGRAPH



Photomicrograph Details			
Sandberg Sample Ref:	G51625	Client Ref/Site Mark:	2 nd Floor Mortar
Microscope Light:	Cross polarised	Objective Magnification:	x10
Photomicrograph Description			
General view of mortar paste under cross polarised light. The non-hydraulic lime binder matrix exhibits desiccation cracks, white s linear features, through the paste and along aggregate margins (e.g. A-B/4-5, E-F/5-6). Coal and/or furnace slag piece at B-C/3-4, D-E/1-2 exhibit fine peripheral cracks. The aggregate (white, pale grey, grey and blue grey grains) consist mainly of quartz quartzite/metaquartzite.			

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Where test results are given, the results and our conclusions relate only to the samples tested and apply to the sample(s) as received, except where sampling has been conducted by Sandberg LLP.

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End of report.

