RSK Environment Ltd
Tel: +44 (0) 1442 437500
Fax: +44 (0) 1442 437550
Email: info2@rsk.co.uk
Web: www.rsk.co.uk

Materials & Structures
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

UKAS TESTING
0278

Sample Details	
RSK sample reference	**Client sample Location**
18284/C1	Pile at B/H2
18284/C2	Capping beam at B/H 15
18284/C3	Capping beam at B/H 10
18284/C4	Capping beam at B/H 4
18284/C5	Capping beam at B/H 7
18284/C6b	Pile at B/H 1

Results						
RSK sample reference	18284/ C1	18284/ C2	18284/ C3	18284/ C4	18284/ C5	18284/ C6b
Determined Values (% by mass)						
Insoluble residue	77.8	77.5	75.1	77.2	74.1	77.5
Soluble silica	4.2	3.4	3.7	3.3	4.0	4.1
Calcium oxide	10.7	10.8	12.2	10.9	13.4	11.2
Sulfate (SO_3)	0.36	0.38	0.46	0.40	0.45	0.37
Calculated Values (% by mass)						
Portland cement ex silica	19.3	15.2	16.7	14.7	18.3	18.8
Portland cement ex lime	16.6	16.7	18.9	16.9	20.8	17.4
Preferred cement content value	16.6	15.2	16.7	14.7	18.3	17.4
Aggregate content	79.6	81.3	79.4	81.9	77.5	78.6
Sulfate (SO_3 % by mass of cement)	2.2	2.5	2.8	2.7	2.5	2.1
Mix Proportions (ratio by mass)						
Aggregate/cement ratio	4.8	5.3	4.8	5.6	4.2	4.5
Cement content (kg/m^3)	374	342	376	331	412	392

Assumptions	
Soluble silica in cement (% by mass)	20.2
Calcium oxide in cement (% by mass)	64.5
Soluble silica in aggregate (% by mass)	0.4
Calcium oxide in aggregate (% by mass)	0.0
Dry density of concrete (kg/m^3)	2250
Water of hydration of concrete (% by mass)	23

End of Certificate

RSK Environment Ltd
Tel: +44 (0) 1442 437500
Fax: +44 (0) 1442 437550
Email: info2@rsk.co.uk
Web: www.rsk.co.uk

Materials & Structures
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

Original Total Water/Cement Ratio of Concrete
BS 1881-124: 2015

1281066 Ugly Brown Building, 6a St Pancras Way, London, NW1 0TB

Client Details	
The Trustees of the St Pancras Way Block A Unit Trust & Big Lobster Ltd C/O Reef Group 51 Welbeck Street London W1G 9HL	
Contact name	Jason Russell of Reef Group

Sample Details			
Sample type	Concrete cores		
Sampled by	RSK	Sampling date	23/01/19
RSK batch no.	18284	No. of samples	3
Receipt dates	30/01/19 & 08/02/19	Test period	07-19/02/19

Methods	
Test	The analysis was carried out in accordance with BS 1881-124:2015 clause 9.4.
Remarks	The cement contents of the samples were determined (see certificate 1281066/60082).
Deviations	None.

Results

RSK sample reference	Location	Capillary porosity (% by mass)	Cement content (% by mass)	Original total water/cement ratio
18284/C1	Pile at B/H2	5.6	16.6	0.6
18284/C3	Capping beam at B/H 10	4.1	16.7	0.5
18284/C6-B	Pile at B/H 1	6.0	17.4	0.6

Certification			
Certificate prepared by  Tom Blight Trainee Chemistry Technician		Certificate reviewed by  Ben Stainton Principal Chemistry Technician	
Testing by	TTB/BJS	Certificate issue date	26/02/19

The results given in this certificate relate only to those samples submitted and specimens tested and to any materials properly represented by those samples and specimens.

End of Certificate

RSK Environment Ltd
Tel: +44 (0) 1442 437500
Fax: +44 (0) 1442 437550
Email: info2@rsk.co.uk
Web: www.rsk.co.uk

Materials & Structures
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

UKAS TESTING
0278

Chloride Content of Concrete
BS 1881-124:2015

1281066 Ugly Brown Building, 6a St Pancras Way, London, NW1 0TB

Client Details	
The Trustees of the St Pancras Way Block A Unit Trust & Big Lobster Ltd C/O Reef Group 51 Welbeck Street London W1G 9HL	
Contact name	Jason Russell of Reef Group

Sample Details			
Sample type	Drilled concrete dust		
Sampled by	RSK	Sampling period	23/01/19
RSK batch no.	18284	No. of samples	6
Receipt dates	30/01/19 & 08/02/19	Test period	30/01/19 – 22/02/19

Methods	
Test	The concrete was sampled in accordance with RSK procedure TP565 and tested for chloride content in accordance with in-house test procedure TP567, which is based on BS 1881-124: 2015. Titration was carried out potentiometrically using a silver/silver chloride electrode. Cement contents were determined using samples taken from the reported locations (see RSK cert 1281066/60082)
Deviations	None.
Precision	Repeatability limit from duplicate testing r = 0.011% by mass of sample.

Results

RSK sample reference	Location	Chloride (as Cl ion) % by mass of	
		sample	cement
18284/D1	Pile at B/H2	0.029	0.18
18284/D2	Capping beam at B/H 15	0.025	0.17
18284/D3	Capping beam at B/H 10	0.030	0.18
18284/D4	Capping beam at B/H 4	0.027	0.18
18284/D5	Capping beam at B/H 7	0.029	0.16
18284/C6-b	Pile at B/H 1	0.023	0.13

Certification

Certificate prepared by		Certificate reviewed by	
T. Blight Tom Blight Trainee Chemistry Technician		B Stainton Ben Stainton Principal Chemistry Technician	
Testing by	TTB/BJS	Certificate issue date	26/02/19

The results given in this certificate relate only to those samples submitted and specimens tested and to any materials properly represented by those samples and specimens. Any opinions and interpretations expressed herein are outside the scope of our UKAS accreditation.

End of Certificate

RSK Environment Ltd
Tel: +44 (0) 1442 437500
Fax: +44 (0) 1442 437550
Email: info2@rsk.co.uk
Web: www.rsk.co.uk

Materials & Structures
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

UKAS TESTING
0278

Certificate of Examination
ASTM C856-18
Petrographic Examination of Hardened Concrete

Site	Ugly Brown Building	**RSK Sample Ref.**	18284/C1
Client	The Trustees of the St Pancras Way Block A Unit Trust & Big Lobster Ltd C/O Reef Group 51 Welbeck Street London W1G 9HL	**Client Sample Ref.**	Pile at B/H2
		Sample Type	Concrete core
		Location	BH2 pile head
		Orientation	Vertical
		Sampled by/Date	RSK/23.01.19
		Date of Receipt	30.01.19
		Examined by/Date	KS/04-20.02.19

SAMPLE

The sample comprised a nominal 100 mm diameter concrete core, approximately 300 mm in length. The diameter and length of the submitted core were less than those preferred by the standard (ideally 152 mm diameter and 305 mm length).

METHODS OF EXAMINATION

A full description of the examination methods, including a glossary of descriptive terms, is given on the final page of this certificate.

EXAMINATION FINDINGS

The detailed petrographic examination findings are given in the following pages of this certificate along with record colour photographs and selected photomicrographs (photographs taken through the microscope). An overview of the findings is given below.

SUMMARY OVERVIEW

Composition and Constituents	Nominal 20 mm, natural chert (flint) gravel coarse aggregate and natural quartzitic sand fine aggregate, bound by a Portland-type cement matrix.
Mix Quality	Apparently well mixed and exhibiting good compaction. Excess voidage 3 %. Apparent water/cement ratio was estimated as being in the low end of the normal range (say, 0.35 to 0.45).
Condition	The matrix in the upper section of the core was observed to be friable and weaker than in the remainder of the core. The depth of the weaker area varied from 2 mm to 22 mm. A crack was observed running around approximately half of the diameter of the core. The crack ran from the upper surface and reached a maximum depth of 80 mm. Fine cracks were observed associated with the main crack. Common secondary calcite deposits were observed in the crack and fine cracks. Secondary calcite was also observed lining air voids in the upper, weaker section of the core. Secondary ettringite was observed lining air voids, aggregate partings and cracks. This was commonly observed in thin section A (0-45 mm depth) and rarely observed in thin section B (235-280 mm depth). Rare alkali-silica gel was observed in cracks in a single chert particle.
Other Remarks	The upper end surface of the sample was fractured, whilst the lower end surface was freshly fractured. A 5 x 4 mm deep clay rich area was observed at the upper surface. An approximately 35 x 25 mm metal object was present at approximately 10 mm depth from the upper surface. A larger dark greyish brown area was present around, and likely caused by, the metal.

NOTE

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

Certificate prepared by

Kathleen Smith
Geomaterials Scientist

Certificate reviewed by

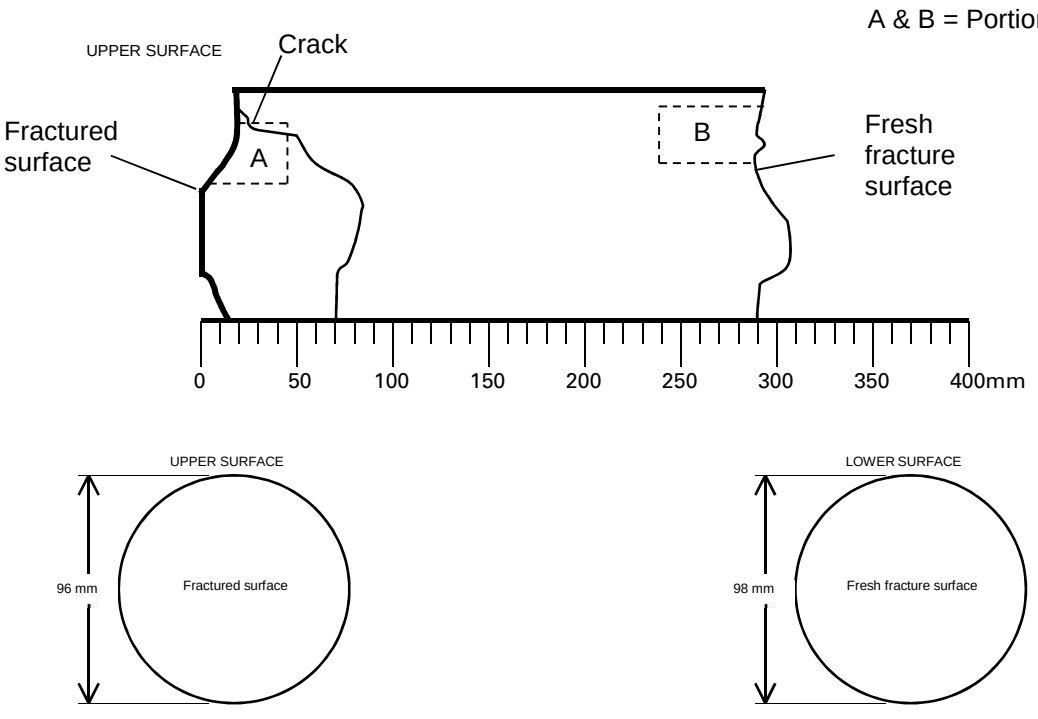
James Ferrari
Principal Geomaterials Scientist

Date of issue: 22 February 2019

Petrographic Examination of Hardened Concrete - ASTM C856-18

RECORD PHOTOGRAPH			
RSK Sample Ref.	18284/C1	**Client Sample Ref.**	Pile at B/H2
Description	View of the concrete as-received.		

SAMPLE/CORE SKETCH



Petrographic Examination of Hardened Concrete - ASTM C856-18

RECORD PHOTOGRAPH			
RSK Sample Ref.	18284/C1	**Client Sample Ref.**	Pile at B/H2
Description	Views of the upper and lower end surfaces of the core. Core diameter is 100 mm.		

UPPER SURFACE

LOWER SURFACE

Petrographic Examination of Hardened Concrete - ASTM C856-18

AS-RECEIVED CONCRETE CORE DETAILS			
RSK Sample Ref.	18284/C1	**Client Sample Ref.**	Pile at B/H2
Maximum Length, mm	301	**Diameter, mm**	100
Minimum Length, mm	253	**Number of Pieces**	1
Nature of Upper Surface	Fractured	**Nature of Lower Surface**	Freshly fractured
Portion Described	Representative thin sections sawn from 0-45 mm and 235-280 mm depth from the upper surface.		

AGGREGATE DETAILS*	
Coarse Aggregate *(incl. type, nominal max. size, shape, grading, distribution and orientation)*	Natural gravel, nominal 20 mm maximum sized, well rounded to very angular, continuously graded, evenly distributed and randomly orientated particles.
Coarse Aggregate, Constituents *(incl. hardness, colour and approx. percent of lithological types present, alteration, weathering and general features of engineering significance)*	Major CHERT – Very hard, medium light grey to dark grey, light brown or moderate brown particles comprising cryptocrystalline silica with trace proportions of opaque minerals and iron oxides. Rare particles contained major proportions of iron oxides and frequent particles contained trace proportions of chalcedony. Trace QUARTZ. SANDSTONE.
Cement:Aggregate Bond	Good, only rare interfacial partings in evidence.
Additional Observations *(incl. evidence of deterioration etc)*	None.
Fine Aggregate *(incl. type, nominal max. size, shape, grading, distribution and orientation)*	Natural quartzitic sand, 5 mm nominal maximum sized, rounded to angular, evenly distributed and randomly orientated particles.
Fine Aggregate, Constituents *(incl. hardness, colour and approx. percent of lithological types present, alteration, weathering and general features of engineering significance)*	Major QUARTZ – Very hard, translucent grey/white grains of silica. CHERT – Very hard, very pale orange, greyish orange or dark yellowish orange particles comprising cryptocrystalline silica with trace proportions of chalcedony, opaque minerals and iron oxides. Minor SHELL FRAGMENTS – Moderately hard, white particles comprising calcite. Trace FELDSPAR. LIMESTONE. QUARTZITE. SANDSTONE. OPAQUE MINERALS. GLAUCONITE. IRONSTONE.
Cement:Aggregate Bond	Good, only rare interfacial partings in evidence.
Additional Observations *(incl. evidence of deterioration etc)*	None.

*All aggregate proportions are estimated.

Petrographic Examination of Hardened Concrete - ASTM C856-18

RSK Sample Ref.	18284/C1	Client Sample Ref.	Pile at B/H2

CONCRETE FEATURES	
Apparent Cement Type and Matrix Details *(Portland, High Alumina, White, PBC, etc and incl. hardness, colour, colour distribution and matrix distribution)*	Moderately hard, medium light grey, evenly distributed Portland-type cement matrix. Exhibiting abundant, typically small to medium, but occasionally large sized, randomly distributed, unhydrated cement grains. The matrix in the upper section of the core was observed to be friable and weaker than in the remainder of the core. The depth of the weaker area varied from 2 mm to 22 mm.
Mineral Additions• *(incl. type, size, relative abundance, distribution and shape)*	None observed.
Air Void Details and Compaction *(incl. air void max. size, shape, distribution, orientation, presence of entrainment, excess voidage)*	15 mm maximum, typically <2 mm sized, irregular, evenly distributed and randomly orientated entrapped air voids. Estimated excess voidage was typically 3 %, however one side of the core exhibited a higher voidage of 7 %. Higher void content was also observed in the weaker upper section of the core (estimated to be approximately 15 %).
Microporosity and Water/Cement Ratio# *(incl., microporosity variations and relation to other features; assessment of original water/cement ratio)*	The cement paste typically exhibited low to normal microporosity, indicative of an overall original water/cement ratio in the low end of the normal range (say, 0.35 to 0.45). However, the weak upper section of the core exhibited a higher microporosity.
Carbonation* *(incl. depths, variations and relation to surface cracking)*	Depth of carbonation was difficult to determine due to the degraded nature of the upper section of the core. Areas of uncarbonated cement matrix were surrounded by secondary calcite deposits. Possible popcorn carbonation was observed in the areas of cement matrix.
Portlandite *(incl. size, shape, abundance and distribution of crystallites)*	The uncarbonated cement matrix exhibited common to frequent, small to medium sized, portlandite crystallites that were evenly distributed. The areas of cement matrix in the upper, weaker section were completely depleted in portlandite.
Other Concrete Details *(incl. applied finishes, inclusions and impurities)*	The upper end surface of the sample was fractured, whilst the lower end surface was freshly fractured.
Reinforcement *(incl. types, sizes, depths, orientations, evidence of corrosion)*	None present.
Evidence of Cracking *(incl. crack styles, abundance and relation to other features)*	A crack was observed running around approximately half of the diameter of the core. The crack ran from the upper surface and reached a maximum depth of 80 mm. Fine cracks were observed associated with the main crack.
Presence of Deposits *(incl. gel, sulfates, carbonates, oxides, soot and their location, abundance and distribution)*	Common secondary calcite deposits were observed in the crack and fine cracks. Secondary calcite was also observed lining air voids in the upper, weaker section of the core. Secondary ettringite was observed lining air voids, aggregate partings and cracks. This was commonly observed in thin section A (0-45 mm depth) and rarely observed in thin section B (235-280 mm depth). Rare alkali-silica gel was observed in cracks in a single chert particle.
Other Observations *(incl. sweaty patches, matrix alteration, bleeding, segregation, plastic settlement, loss of bond, embedded items)*	The aggregate was observed to stand slightly proud of the cement matrix in the upper ~50 mm of the core. A 5 x 4 mm clay rich area was observed at the upper surface. An approximately 35 x 25 mm metal object was present at approximately 10 mm depth from the upper surface. A larger dark greyish brown area was present around, and likely caused by, the metal.

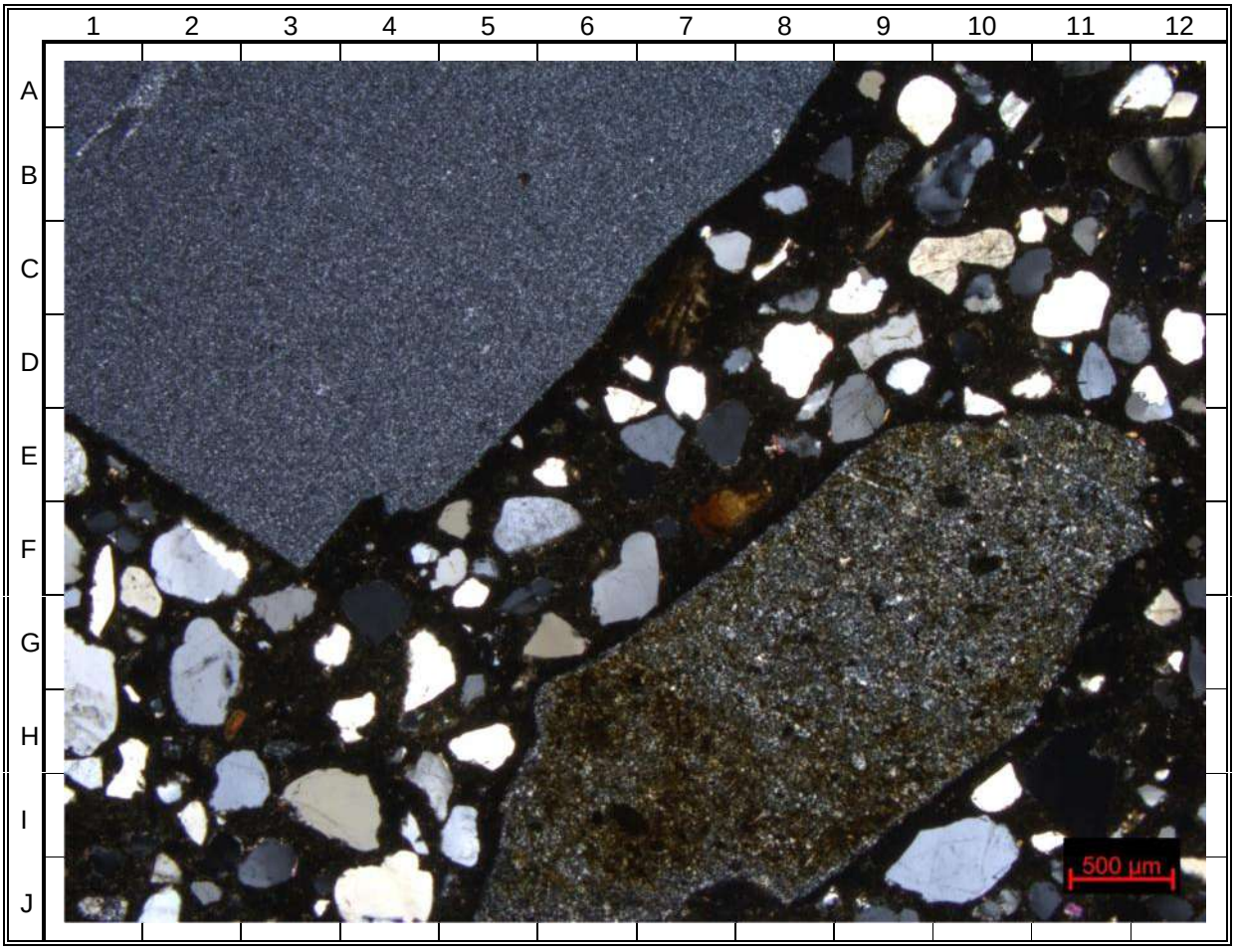
• some mineral additions are not easily identified by optical microscopy (e.g. microsilica, metakaolin)

* sometimes assisted by phenolphthalein indicator solution

estimated by fluorescence microscopy and based upon reference slides and images in Poole, A & Sims, I, *Concrete Petrography, A handbook of investigative techniques (second edition)*, Arnold, London, 2015.

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

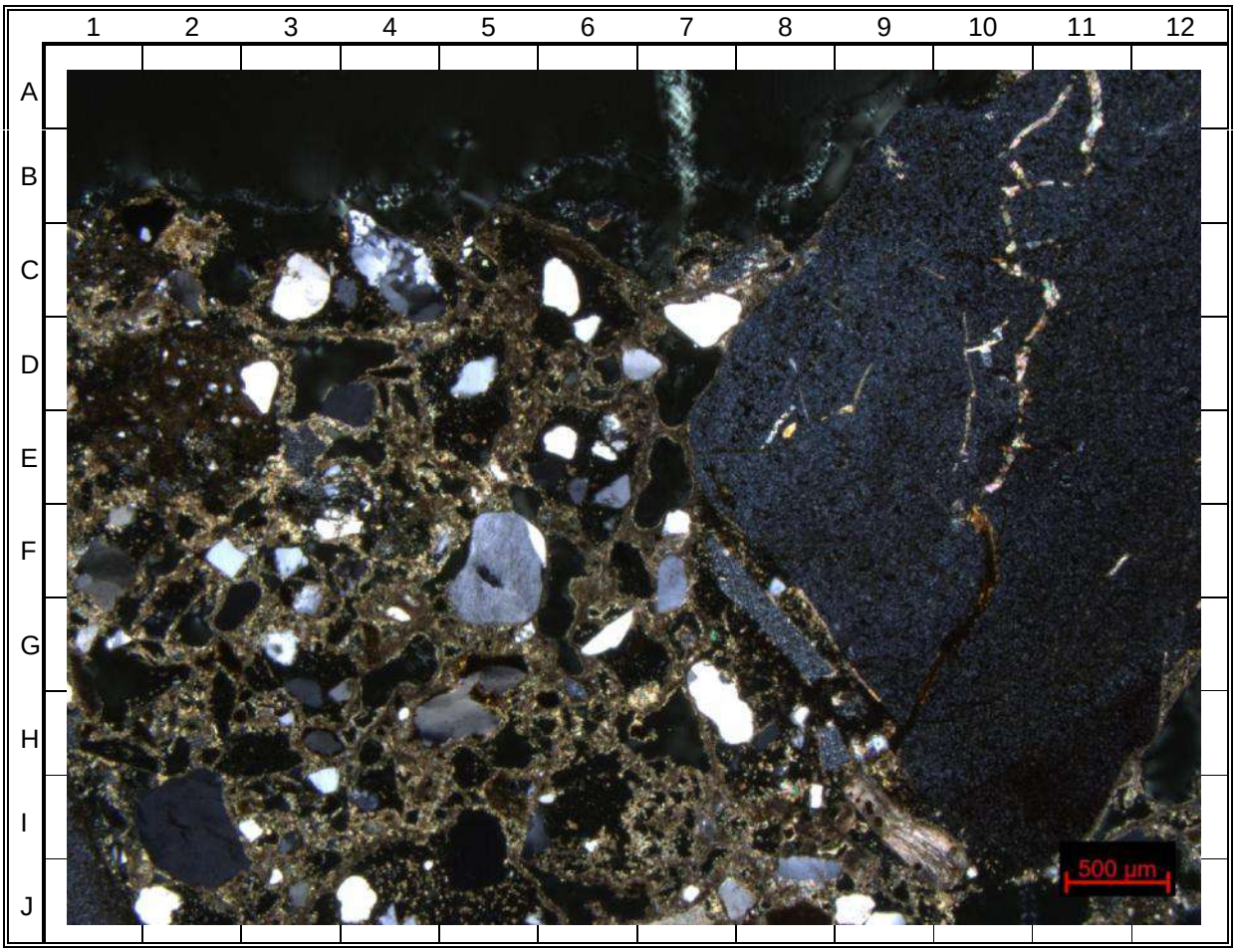
PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C1	**Client Sample Ref.**	Pile at B/H2
Approx. Magⁿ	×15.75	**Approx. Scale**	10 mm = 360 µm
Portion Described	Concrete	**Viewing Light**	Cross-polarised
Description	A general view, showing chert coarse aggregate particles (speckled grey:C1 to C6) with quartz (white or grey: F2), shell fragment (brown: C/D7) and chert (speckled grey: B9) fine aggregate particles, bound by a Portland-type cement matrix (black: E6).		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

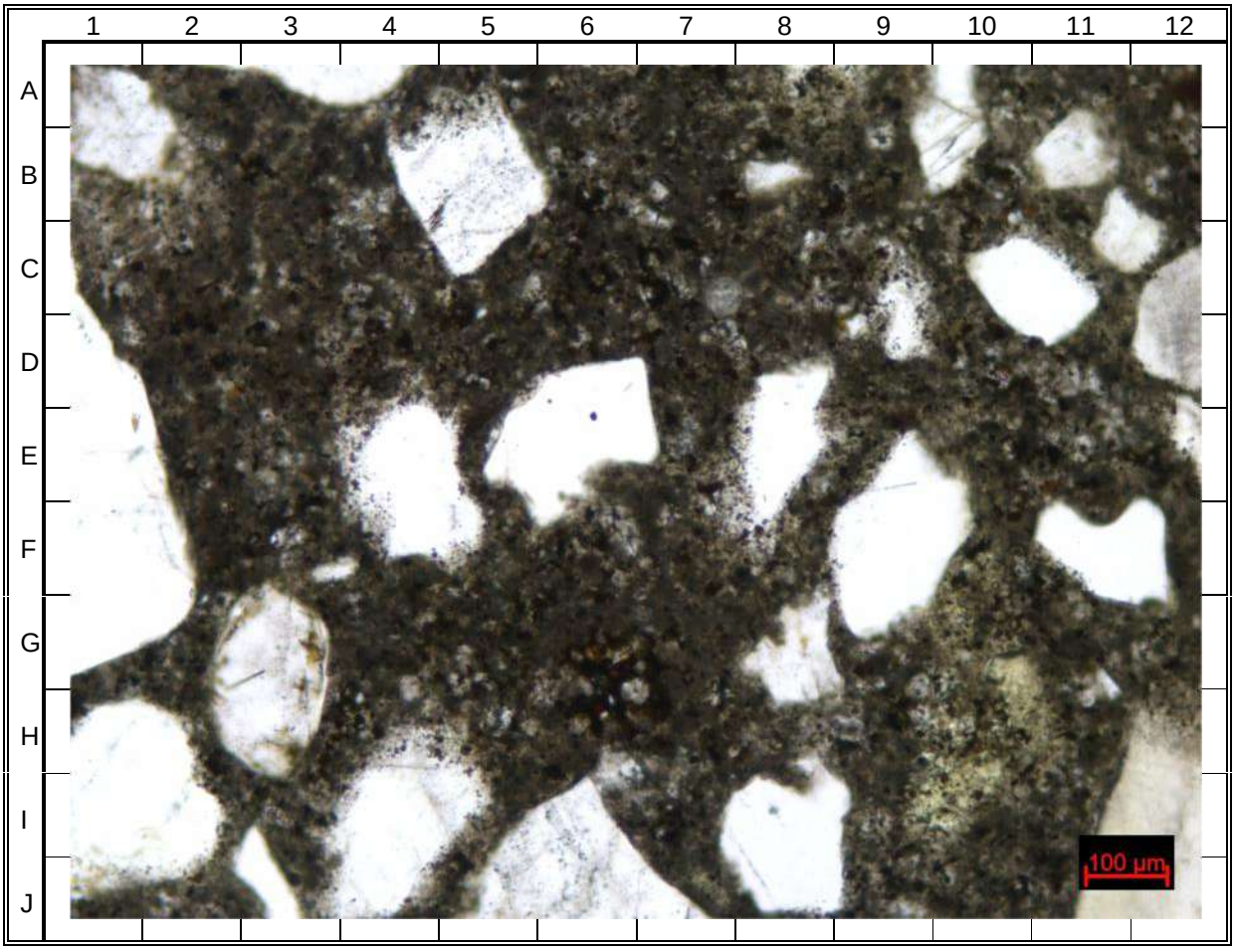
PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C1	**Client Sample Ref.**	Pile at B/H2
Approx. Mag^{n}	×15.75	**Approx. Scale**	10 mm = 360 µm
Portion Described	Concrete	**Viewing Light**	Cross-polarised
Description	A view of the upper surface (B1 to A10), showing chert (speckled grey: E7 to E12) and quartz (white or grey: F5) aggregate particles bound by a Portland-type cement matrix (black: D5) and secondary calcite (yellowish brown: F3). Air voids appear black (D3).		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

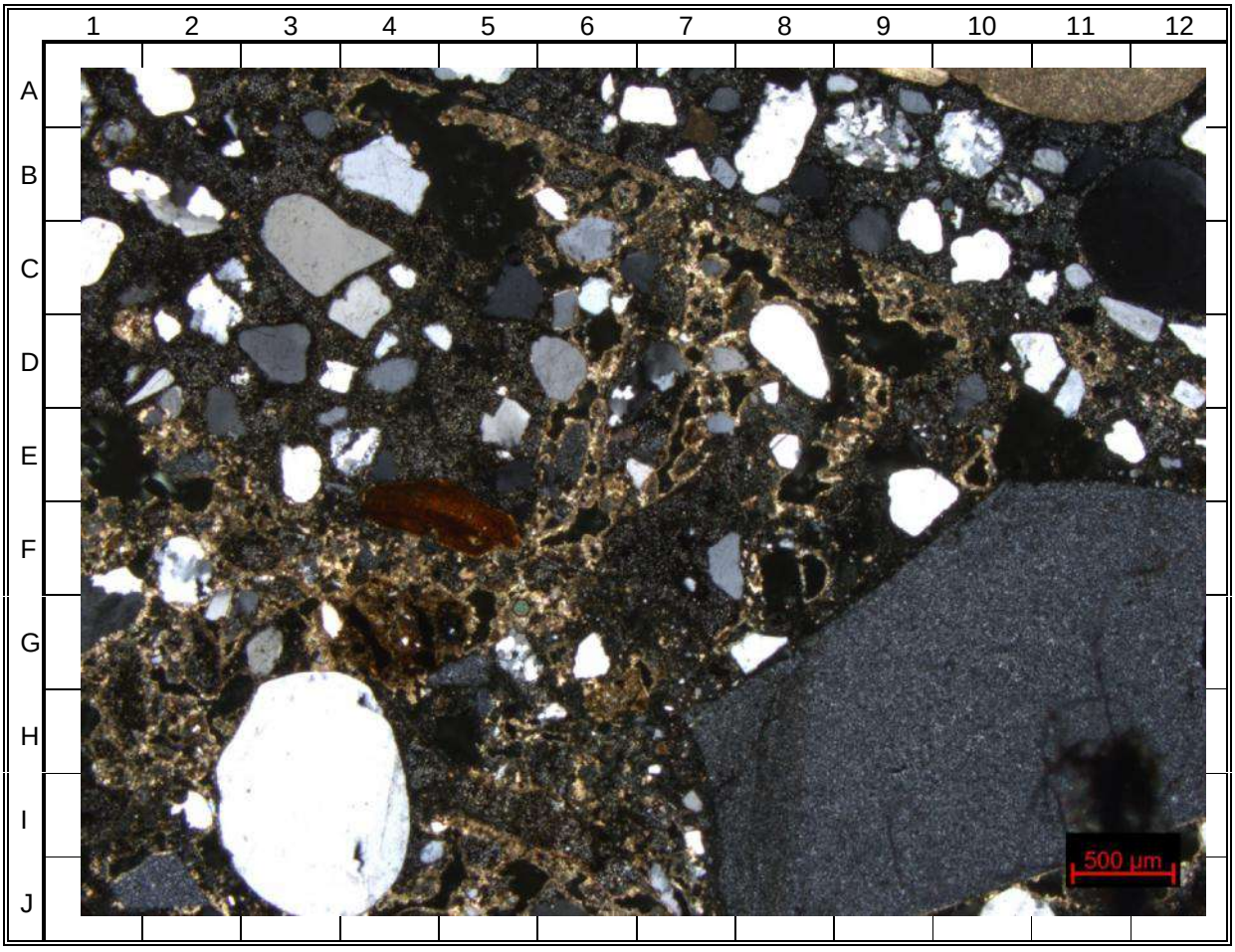
PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C1	**Client Sample Ref.**	Pile at B/H2
Approx. Mag^{n}	×63	**Approx. Scale**	10 mm = 90 µm
Portion Described	Concrete	**Viewing Light**	Plane-polarised
Description	A detailed view, showing fine aggregate particles (white: G3 to H3) and unhydrated cement grains (dark brown and white: G6 to H6), bound by a Portland-type cement matrix (brownish grey: B7). Air voids appear yellow (H10 to I10)		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

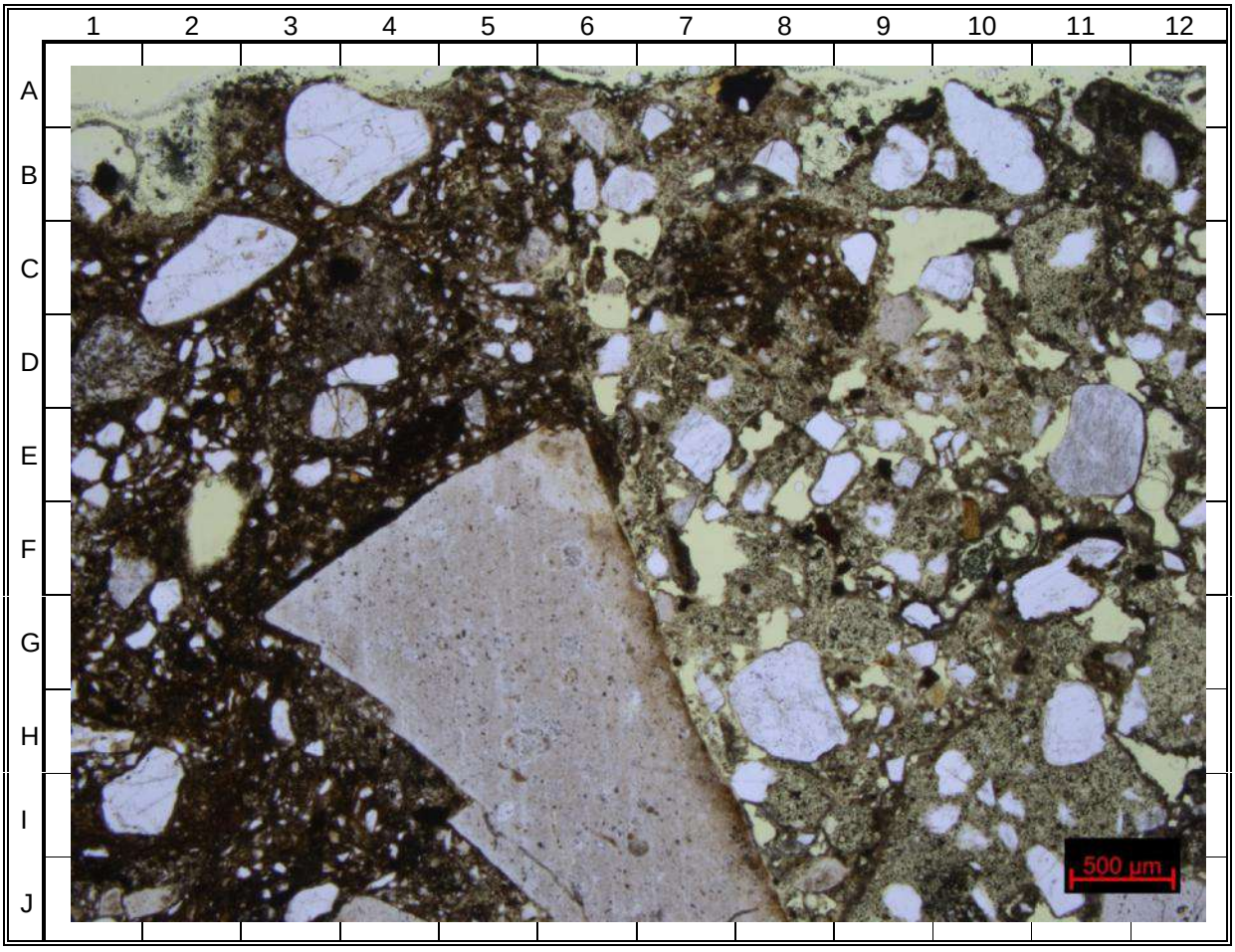
PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C1	**Client Sample Ref.**	Pile at B/H2
Approx. Magⁿ	×15.75	**Approx. Scale**	10 mm = 360 µm
Portion Described	Concrete	**Viewing Light**	Cross-polarised
Description	A view of the weaker upper section, showing areas of cement matrix (dark grey: C1 to D5) surrounded by secondary calcite (orangish brown: B6) and air voids (black: C7 to D9). Chert aggregate appears speckled grey (I8 to G12) and quartz aggregate appears white or grey (H3 to J3).		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

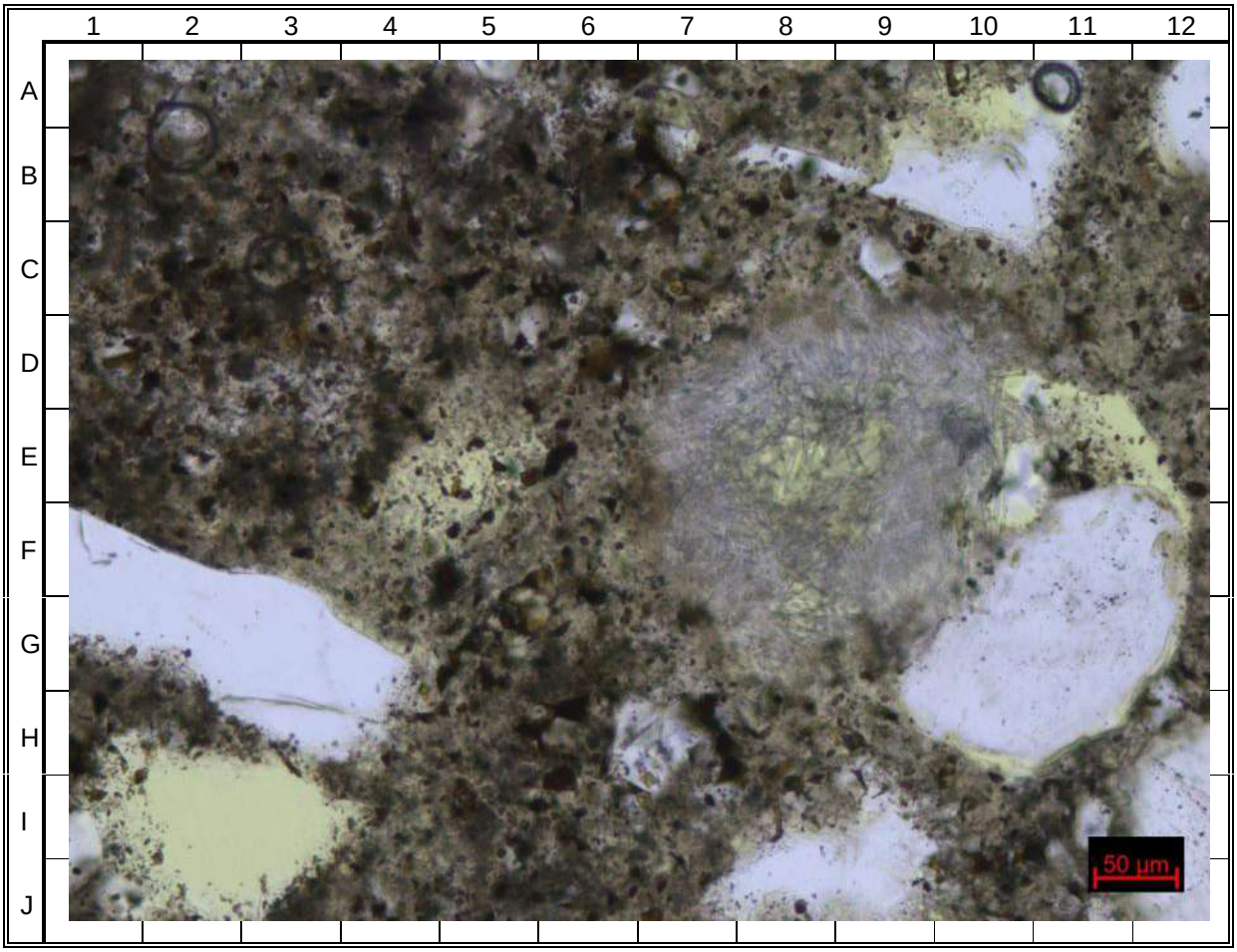
PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C1	**Client Sample Ref.**	Pile at B/H2
Approx. Magⁿ	×15.75	**Approx. Scale**	10 mm = 360 µm
Portion Described	Concrete	**Viewing Light**	Plane-polarised
Description	A view of the upper surface (B1 to B12), showing a clay rich area (reddish brown: E1 to E5) adjacent to weak concrete material (yellowish grey: D6 to D12). Aggregate particles appear white (G8 to H8)and air voids appear yellow (F7).		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

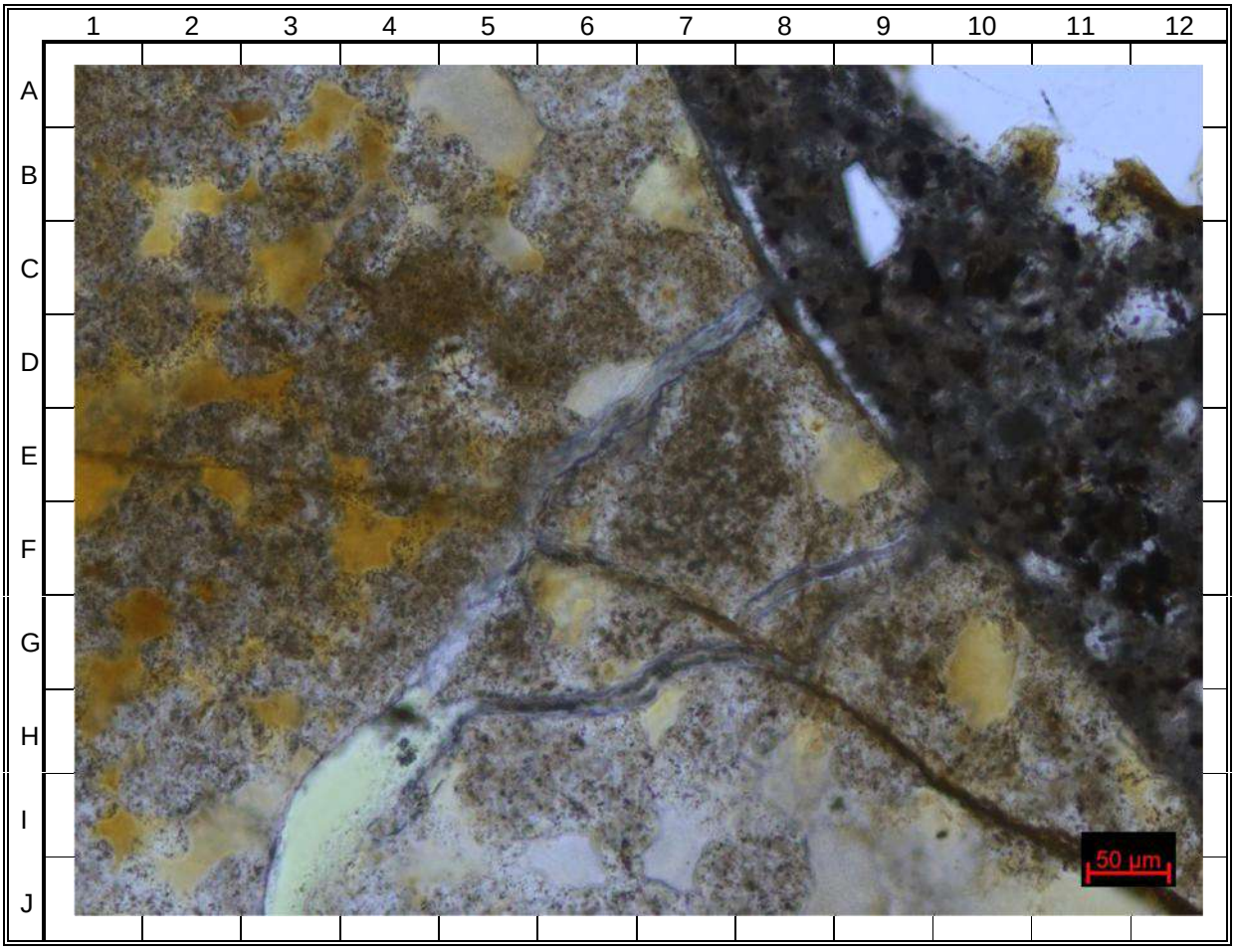
PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C1	**Client Sample Ref.**	Pile at B/H2
Approx. Magⁿ	×126	**Approx. Scale**	10 mm = 45 µm
Portion Described	Concrete	**Viewing Light**	Plane-polarised
Description	A detailed view, showing a secondary ettringite (grey needles: D8) filled air void (yellow: E7 to E11). Aggregate particles appear white (F1 to G4), unhydrated cement grains appear dark brown (B7) and the cement matrix appears greyish brown (J4). Bubbles from thin section preparation are visible (C3).		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C1	**Client Sample Ref.**	Pile at B/H2
Approx. Mag^{n}	×126	**Approx. Scale**	10 mm = 45 µm
Portion Described	Concrete	**Viewing Light**	Plane-polarised
Description	A view of alkali-silica gel (grey: G5 to D7) filling a crack (J3 to D7) running though a chert particle (orange and light grey: A4 to J4). Fine aggregate particles appear white (A10 to A12) and the cement matrix appears greyish brown (B8).		

Petrographic Examination of Hardened Concrete - ASTM C856-18

Methods of Examination

The submitted concrete sample was subjected to a petrographic examination following methods recommended by ASTM C856-18, Standard Practice for Petrographic Examination of Hardened Concrete. Estimation of excess voidage was carried out in accordance with Concrete Society Technical Report No 11, including Addendum (1987), Concrete Core Testing For Strength. The examination was supplemented (where required) by the determination of the cement type following methods given in BS 1881: Part 124: 2015. When the concrete is suspected to contain high alumina cement, the examination is supplemented by taking guidance from BRE Digest 392, Assessment of existing high alumina cement concrete construction in the UK, March 1994.

The sample was first visually and low-power microscopically examined using a high quality Leica MZ8 binocular zoom microscope employing magnifications up to ×50. A record colour photograph of the sample was prepared along with a diagram illustrating the main features of interest. A low-power photomicrograph (a photograph taken through the microscope) is sometimes prepared to illustrate certain features of importance.

The initial examination was used to determine the most appropriate location for a medium-area (45 x 30 mm) thin section to be taken for further, more detailed microscopical examination. The thin section was prepared from a diamond sawn slice which had been both consolidated with, and vacuum impregnated by, an epoxy resin usually containing an ultraviolet light sensitive fluorescent dye. In some cases (e.g. concretes suspected to contain thaumasite), a pair of thin sections is produced, one using fluorescent dye and one free of fluorescent dye. Where the specific cement type (e.g. 'ordinary' Portland or 'sulfate-resisting' Portland) was required a highly polished specimen was also prepared for examination of the matrix in reflected light.

The thin section and/or polished specimen were examined using a high quality, multi-functional, high-power microscope employing various magnifications up to ×630. The thin section was examined using transmitted plane-polarised and cross-polarised illuminations. One or more record colour photomicrographs were prepared to illustrate certain microscopical features of importance. The thin section was also examined under reflected ultraviolet illumination to allow an assessment of the void and micropore structure, evidence of cracking and any other features of relevance. When used the polished specimen was examined using reflected, polarised and brightfield illuminations and etched using appropriate solutions and vapours to assist with the identification of residual particles of unhydrated cement and any non-reacted mineral additions.

Glossary of Terms Used in the Descriptions

Aggregate abundance	Major	*>10 %*
	Minor	*2 to 10 %*
	Trace	*<2 %*
Carbonation (Increasing Carbonation ↑)	Complete	*no residual cement matrix other than occasional unreacted relics*
	Partial	*evidence of mixed carbonate crystallites with isotropic matrix*
	Faint	*occasional carbonate crystallites, <25 % of the area*
Compaction (Increasing Compaction ↑)	≤0.5 %	*very good*
	>0.5 % - ≤3.0 %	*á3.0 % = good (ie normal for structural concrete)*
	>3.0 % – ≤5.0 %	*medium*
	>5.0 % - ≤10.0 %	*poor*
	>10.0 %	*Very poor*
Cracks (Increasing Width ↓)	Fine microcracks	*<1 «m wide*
	Microcracks	*1-10 «m wide*
	Fine cracks	*10-100 «m wide*
	Cracks	*100 «m-1 mm*
	Large cracks	*>1 mm wide*
Frequency (Increasing Frequency ↓)	Rare	*only found by thorough searching*
	Sporadic	*only occasionally observed during normal examination*
	Common	*easily observed during normal examination*
	Frequent	*easily observed with minimal examination*
	Abundant	*immediately apparent to initial examination*

Hardness (Increasing Hardness ↓)	Very soft	*can be penetrated easily by a finger*
	Soft	*scores with a fingernail*
	Moderately soft	*scores using a copper coin*
	Moderately hard	*scores easily with a penknife*
	Hard	*not easily scored with a penknife*
	Very hard	*cannot be scored with a steel point*
Portlandite (Matrix)	Small	*<20 µm*
	Medium	*20-60 µm*
	Large	*60-100 µm*
	Very large	*>100 µm*
Relict cement	Small	*<20 µm*
	Medium	*20-60 µm*
	Large	*60-100 µm*
	Very large	*>100 µm*
Water/cement ratio	Low	*<0.35*
	Normal	*0.35-0.65*
	High	*>0.65*
Voids	Entrained	*Typically round in shape and <100 «m in diameter (taken to be all voids <1 mm diameter when undertaking air content analyses).*
	Entrapped	*typically irregular in shape and >1 mm in diameter*

RSK Environment Ltd
Tel: +44 (0) 1442 437500
Fax: +44 (0) 1442 437550
Email: info2@rsk.co.uk
Web: www.rsk.co.uk

Materials & Structures
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

UKAS TESTING
0278

Certificate of Examination
ASTM C856-18
Petrographic Examination of Hardened Concrete

Site	Ugly Brown Building	**RSK Sample Ref.**	18284/C2
Client	The Trustees of the St Pancras Way Block A Unit Trust & Big Lobster Ltd C/O Reef Group 51 Welbeck Street London W1G 9HL	**Client Sample Ref.**	Capping Beam at B/H 15
		Sample Type	Concrete core
		Location	BH 15
		Orientation	Vertical
		Sampled by/Date	RSK/24.01.19
		Date of Receipt	30.01.19
		Examined by/Date	KS/04-20.02.19

SAMPLE

The sample comprised a nominal 100 mm diameter concrete core, approximately 220 mm in length. The diameter and length of the submitted core were less than those preferred by the standard (ideally 152 mm diameter and 305 mm length).

METHODS OF EXAMINATION

A full description of the examination methods, including a glossary of descriptive terms, is given on the final page of this certificate.

EXAMINATION FINDINGS

The detailed petrographic examination findings are given in the following pages of this certificate along with record colour photographs and selected photomicrographs (photographs taken through the microscope). An overview of the findings is given below.

SUMMARY OVERVIEW

Composition and Constituents	Nominal 20 mm, natural chert (flint) gravel coarse aggregate and natural quartzitic sand fine aggregate, bound by a Portland-type cement matrix.
Mix Quality	Apparently well mixed and exhibiting good compaction. Excess voidage 3.0 %. Apparent water/cement ratio was estimated as being in the low end of the normal range (say, 0.35 to 0.45).
Condition	Sporadic microcracks were observed running through the cement matrix. Rare secondary ettringite was observed lining air voids and microcracks.
Other Remarks	The upper end surface of the sample was rough with exposed aggregate, whilst the lower end surface was freshly fractured. Apart from evidence of very minor leaching, the concrete appeared sound with no evidence of distress or deterioration.

NOTE

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

Certificate prepared by

Kathleen Smith
Geomaterials Scientist

Certificate reviewed by

James Ferrari
Principal Geomaterials Scientist

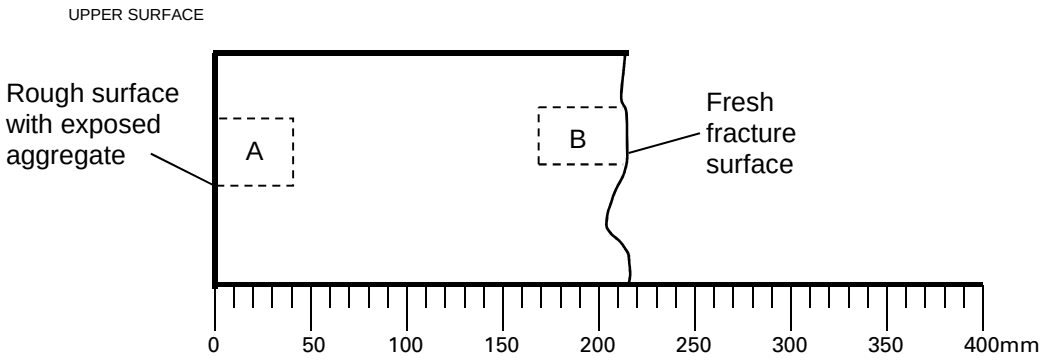
Date of issue: 22 February 2019

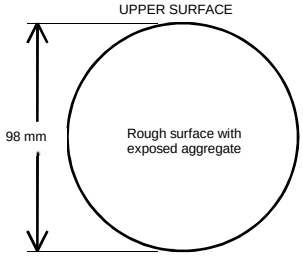
Petrographic Examination of Hardened Concrete - ASTM C856-18

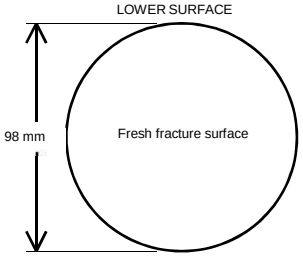
RECORD PHOTOGRAPH			
RSK Sample Ref.	18284/C2	**Client Sample Ref.**	Capping Beam at B/H 15
Description	View of the concrete as-received.		

SAMPLE/CORE SKETCH

A & B = Portions for thin section







Petrographic Examination of Hardened Concrete - ASTM C856-18

RECORD PHOTOGRAPH			
RSK Sample Ref.	18284/C2	**Client Sample Ref.**	Capping Beam at B/H 15
Description	Views of the upper and lower end surfaces of the core. Core diameter is 100 mm.		

UPPER SURFACE

LOWER SURFACE

Petrographic Examination of Hardened Concrete - ASTM C856-18

AS-RECEIVED CONCRETE CORE DETAILS			
RSK Sample Ref.	18284/C2	**Client Sample Ref.**	Capping Beam at B/H 15
Maximum Length, mm	221	**Diameter, mm**	100
Minimum Length, mm	205	**Number of Pieces**	1
Nature of Upper Surface	Rough with exposed aggregate	**Nature of Lower Surface**	Freshly fractured
Portion Described	Representative thin sections sawn from 0-45 mm and 165-221 mm depth from the upper surface.		

AGGREGATE DETAILS*	
Coarse Aggregate *(incl. type, nominal max. size, shape, grading, distribution and orientation)*	Natural gravel, nominal 20 mm maximum sized, well rounded to angular, continuously graded, evenly distributed and randomly orientated particles.
Coarse Aggregate, Constituents *(incl. hardness, colour and approx. percent of lithological types present, alteration, weathering and general features of engineering significance)*	Major CHERT – Very hard, medium light grey to dark grey, light brown, light olive grey, or moderate brown particles comprising cryptocrystalline silica with traces of iron oxides and opaque minerals. Rare particles contained minor proportions of iron oxides and sporadic particles contained trace proportions of chalcedony (95-99 %). Trace QUARTZ. SHELL FRAGMENTS.
Cement:Aggregate Bond	Good, only rare interfacial partings in evidence.
Additional Observations *(incl. evidence of deterioration etc)*	None.
Fine Aggregate *(incl. type, nominal max. size, shape, grading, distribution and orientation)*	Natural quartzitic sand, 5 mm nominal maximum sized, rounded to very angular, evenly distributed and randomly orientated particles.
Fine Aggregate, Constituents *(incl. hardness, colour and approx. percent of lithological types present, alteration, weathering and general features of engineering significance)*	Major QUARTZ – Hard, translucent grey/white grains of silica (65-70 %). CHERT – Very hard, pale brown, greyish orange, dark yellowish orange or dark grey particles comprising cryptocrystalline silica with trace proportions of iron oxides and opaque minerals (15-20 %). SHELL FRAGMENTS – Moderately hard, white fragments comprising calcite (10-15 %). Trace QUARTZITE. FELDSPAR. LIMESTONE.
Cement:Aggregate Bond	Good, only rare interfacial partings in evidence.
Additional Observations *(incl. evidence of deterioration etc)*	None.

*All aggregate proportions are estimated.

Petrographic Examination of Hardened Concrete - ASTM C856-18

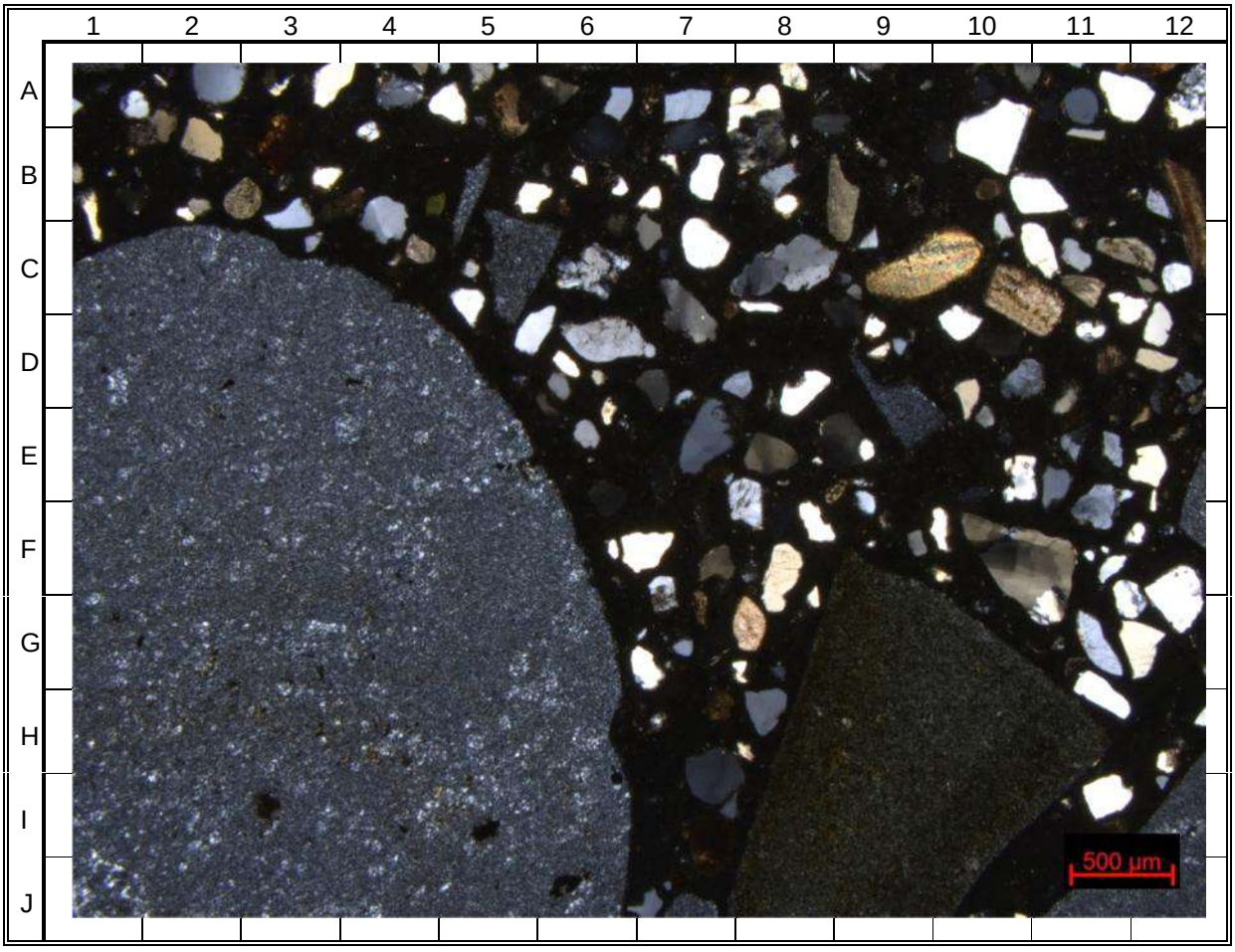
RSK Sample Ref.	18284/C2	Client Sample Ref.	Capping Beam at B/H 15

CONCRETE FEATURES	
Apparent Cement Type and Matrix Details *(Portland, High Alumina, White, PBC, etc and incl. hardness, colour, colour distribution and matrix distribution)*	Moderately hard, medium light grey, evenly distributed Portland-type cement matrix. Exhibiting abundant, typically medium to large, randomly distributed, unhydrated cement grains.
Mineral Additions• *(incl. type, size, relative abundance, distribution and shape)*	None observed.
Air Void Details and Compaction *(incl. air void max. size, shape, distribution, orientation, presence of entrainment, excess voidage)*	15 mm maximum, typically <2 mm sized, irregular, evenly distributed and randomly orientated entrapped air voids. Estimated excess voidage 3.0 %.
Microporosity and Water/Cement Ratio# *(incl., microporosity variations and relation to other features; assessment of original water/cement ratio)*	The cement paste typically exhibited low to normal microporosity, indicative of an overall original water/cement ratio in the low end of the normal range (say, 0.35 to 0.45).
Carbonation* *(incl. depths, variations and relation to surface cracking)*	The upper surface of the concrete was carbonated to a maximum depth of 2.5 mm.
Portlandite *(incl. size, shape, abundance and distribution of crystallites)*	The uncarbonated cement matrix exhibited frequent to abundant, small to medium sized, portlandite crystallites that were evenly distributed.
Other Concrete Details *(incl. applied finishes, inclusions and impurities)*	The upper end surface of the sample was rough with exposed aggregate, whilst the lower end surface was freshly fractured.
Reinforcement *(incl. types, sizes, depths, orientations, evidence of corrosion)*	None present.
Evidence of Cracking *(incl. crack styles, abundance and relation to other features)*	Sporadic microcracks were observed running through the cement matrix.
Presence of Deposits *(incl. gel, sulfates, carbonates, oxides, soot and their location, abundance and distribution)*	Rare secondary ettringite was observed lining air voids and microcracks.
Other Observations *(incl. sweaty patches, matrix alteration, bleeding, segregation, plastic settlement, loss of bond, embedded items)*	Apart from evidence of very minor leaching, the concrete appeared sound with no evidence of distress or deterioration.

• some mineral additions are not easily identified by optical microscopy (e.g. microsilica, metakaolin)
* sometimes assisted by phenolphthalein indicator solution
# estimated by fluorescence microscopy and based upon reference slides and images in Poole, A & Sims, I, *Concrete Petrography, A handbook of investigative techniques (second edition)*, Arnold, London, 2015.

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

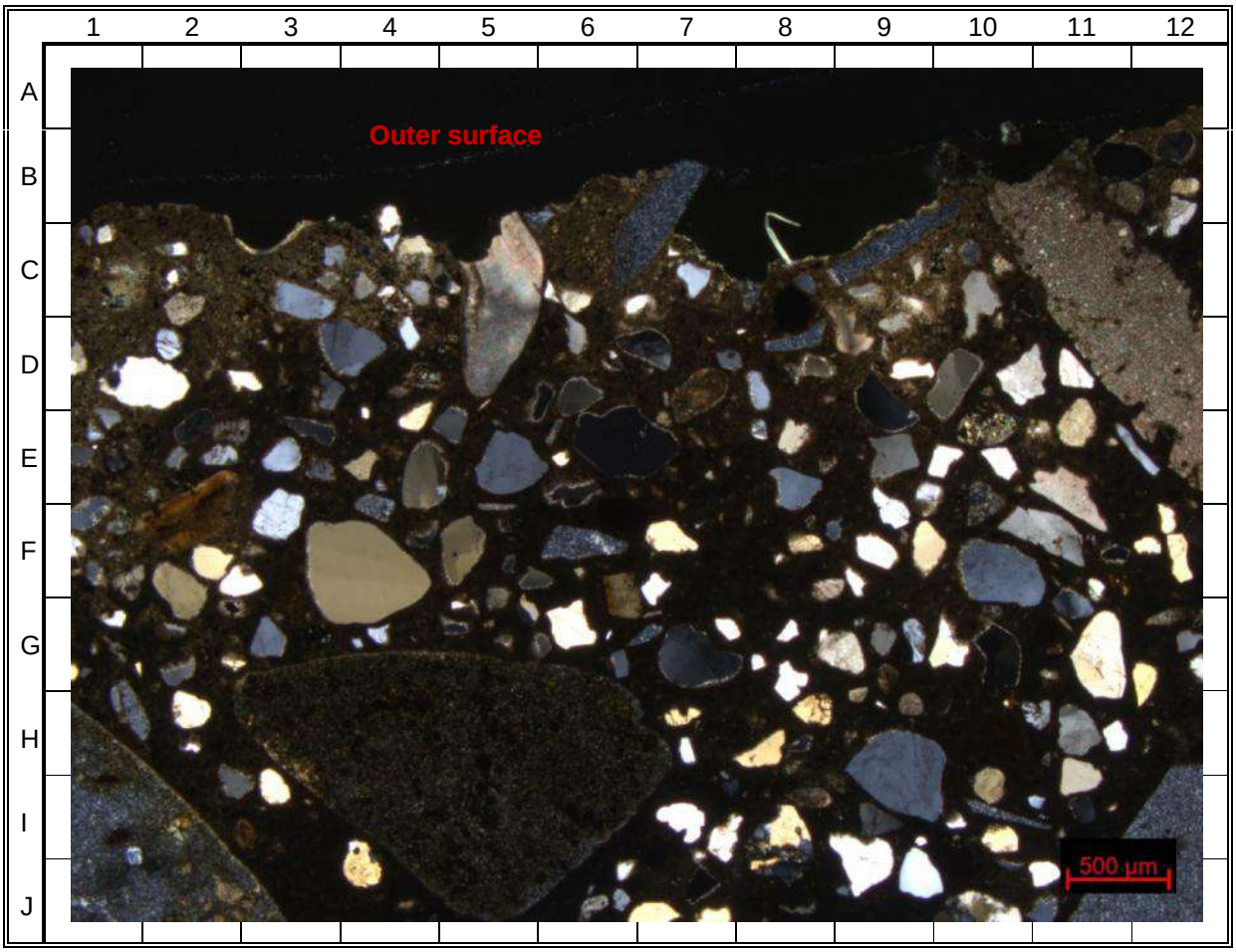
PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C2	**Client Sample Ref.**	Capping Beam at B/H 15
Approx. Magⁿ	×15.75	**Approx. Scale**	10 mm = 360 µm
Portion Described	Concrete	**Viewing Light**	Cross-polarised
Description	A general view, showing chert coarse aggregate (speckled grey: G1 to G6) with quartz (white or grey: C7), chert (speckled grey: C5) and shell fragment (orangish brown: C9) fine aggregate particles, bound by a Portland-type cement matrix (black: B9).		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

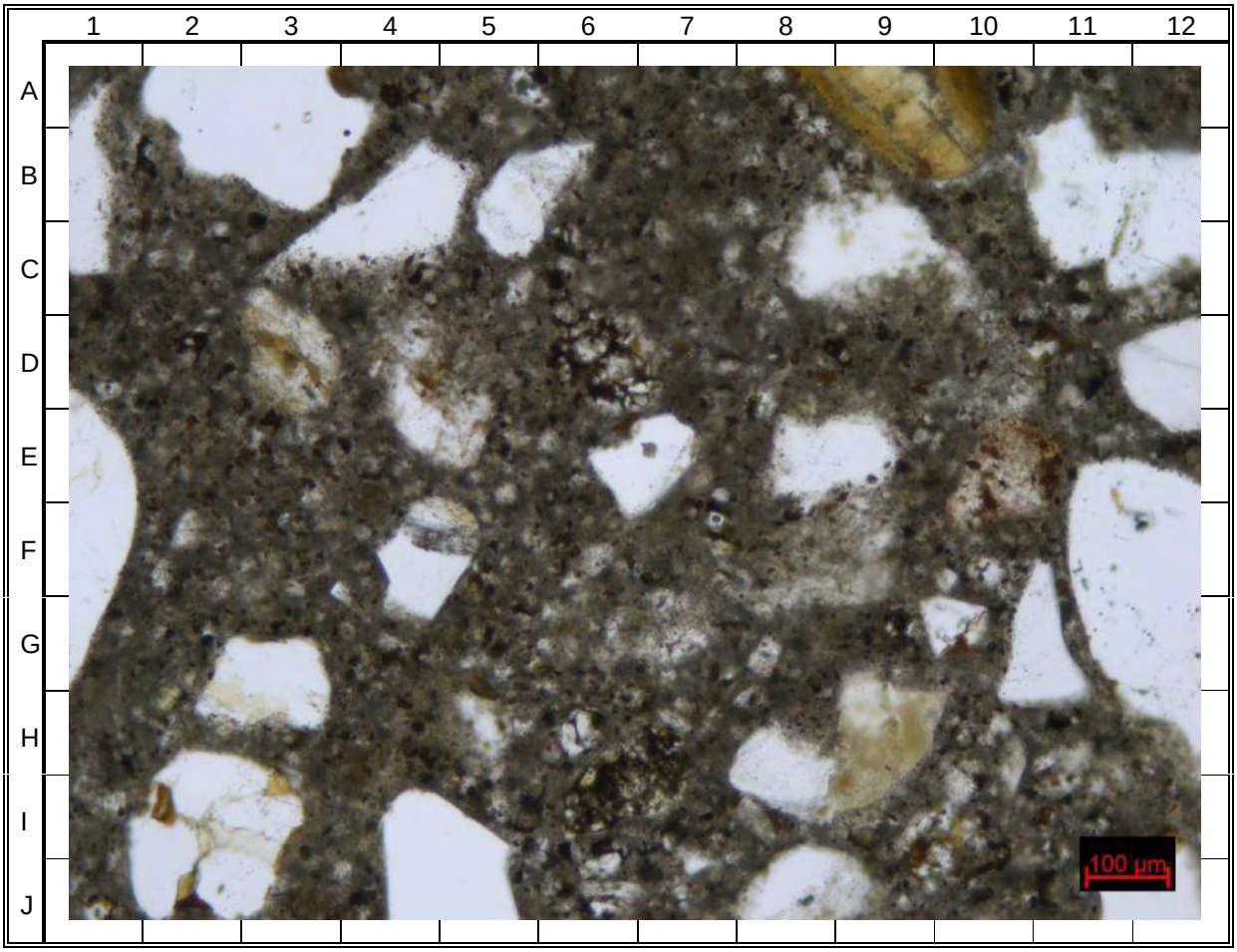
PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C2	**Client Sample Ref.**	Capping Beam at B/H 15
Approx. Mag^{n}	×15.75	**Approx. Scale**	10 mm = 360 µm
Portion Described	Concrete	**Viewing Light**	Cross-polarised
Description	A view of the outer surface (B1 to A12), showing quartz (white or grey: G11), chert (speckled grey: H3 to H6) and shell fragment (pinkish grey: B10 to E12) fine aggregate particles bound by a Portland-type cement matrix (black: J3) that is carbonated (brown: C1) at the outer surface.		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

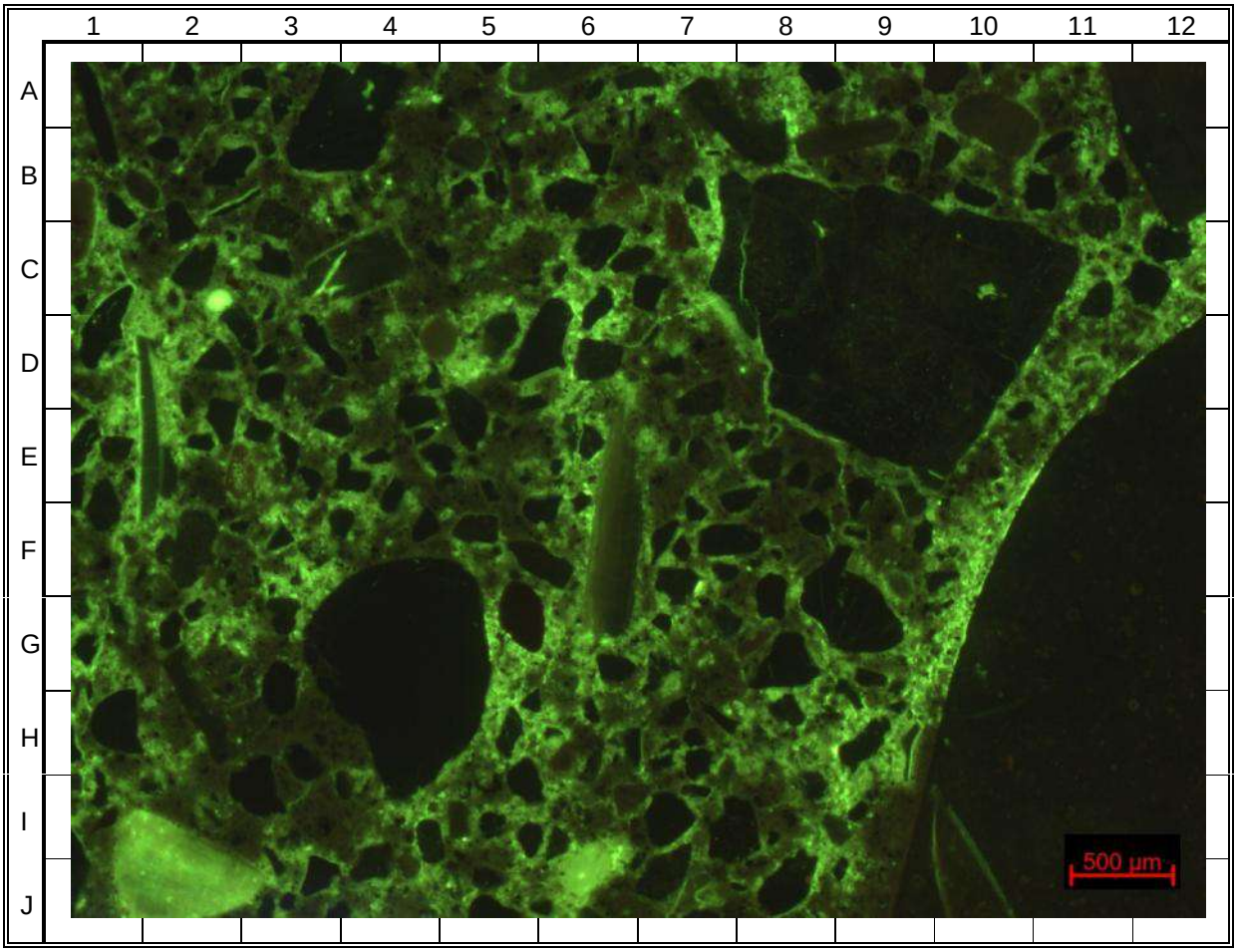
PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C2	**Client Sample Ref.**	Capping Beam at B/H 15
Approx. Magⁿ	×63	**Approx. Scale**	10 mm = 90 µm
Portion Described	Concrete	**Viewing Light**	Plane-polarised
Description	A detailed view, showing fine aggregate particles (white: B11 to B12) and unhydrated cement grains (white and brown: D6), bound by a Portland-type cement matrix (greyish brown: F3).		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C2	**Client Sample Ref.**	Capping Beam at B/H 15
Approx. Magⁿ	×15.75	**Approx. Scale**	10 mm = 360 µm
Portion Described	Concrete	**Viewing Light**	Reflected fluorescent
Description	A view of low to normal microporosity cement matrix (green to dark green: C5). Aggregate particles appear black (F4 to H4).		

Petrographic Examination of Hardened Concrete - ASTM C856-18

Methods of Examination

The submitted concrete sample was subjected to a petrographic examination following methods recommended by ASTM C856-18, Standard Practice for Petrographic Examination of Hardened Concrete. Estimation of excess voidage was carried out in accordance with Concrete Society Technical Report No 11, including Addendum (1987), Concrete Core Testing For Strength. The examination was supplemented (where required) by the determination of the cement type following methods given in BS 1881: Part 124: 2015. When the concrete is suspected to contain high alumina cement, the examination is supplemented by taking guidance from BRE Digest 392, Assessment of existing high alumina cement concrete construction in the UK, March 1994.

The sample was first visually and low-power microscopically examined using a high quality Leica MZ8 binocular zoom microscope employing magnifications up to ×50. A record colour photograph of the sample was prepared along with a diagram illustrating the main features of interest. A low-power photomicrograph (a photograph taken through the microscope) is sometimes prepared to illustrate certain features of importance.

The initial examination was used to determine the most appropriate location for a medium-area (45 x 30 mm) thin section to be taken for further, more detailed microscopical examination. The thin section was prepared from a diamond sawn slice which had been both consolidated with, and vacuum impregnated by, an epoxy resin usually containing an ultraviolet light sensitive fluorescent dye. In some cases (e.g. concretes suspected to contain thaumasite), a pair of thin sections is produced, one using fluorescent dye and one free of fluorescent dye. Where the specific cement type (e.g. 'ordinary' Portland or 'sulfate-resisting' Portland) was required a highly polished specimen was also prepared for examination of the matrix in reflected light.

The thin section and/or polished specimen were examined using a high quality, multi-functional, high-power microscope employing various magnifications up to ×630. The thin section was examined using transmitted plane-polarised and cross-polarised illuminations. One or more record colour photomicrographs were prepared to illustrate certain microscopical features of importance. The thin section was also examined under reflected ultraviolet illumination to allow an assessment of the void and micropore structure, evidence of cracking and any other features of relevance. When used the polished specimen was examined using reflected, polarised and brightfield illuminations and etched using appropriate solutions and vapours to assist with the identification of residual particles of unhydrated cement and any non-reacted mineral additions.

Glossary of Terms Used in the Descriptions

Aggregate abundance	Major	*>10 %*
	Minor	*2 to 10 %*
	Trace	*<2 %*
Carbonation (Increasing Carbonation ↑)	Complete	*no residual cement matrix other than occasional unreacted relics*
	Partial	*evidence of mixed carbonate crystallites with isotropic matrix*
	Faint	*occasional carbonate crystallites, <25 % of the area*
Compaction (Increasing Compaction ↑)	≤0.5 %	*very good*
	>0.5 % - ≤3.0 %	*á3.0 % = good (ie normal for structural concrete)*
	>3.0 % – ≤5.0 %	*medium*
	>5.0 % - ≤10.0 %	*poor*
	>10.0 %	*Very poor*
Cracks (Increasing Width ↓)	Fine microcracks	*<1 «m wide*
	Microcracks	*1-10 «m wide*
	Fine cracks	*10-100 «m wide*
	Cracks	*100 «m-1 mm*
	Large cracks	*>1 mm wide*
Frequency (Increasing Frequency ↓)	Rare	*only found by thorough searching*
	Sporadic	*only occasionally observed during normal examination*
	Common	*easily observed during normal examination*
	Frequent	*easily observed with minimal examination*
	Abundant	*immediately apparent to initial examination*

Hardness (Increasing Hardness ↓)	Very soft	*can be penetrated easily by a finger*
	Soft	*scores with a fingernail*
	Moderately soft	*scores using a copper coin*
	Moderately hard	*scores easily with a penknife*
	Hard	*not easily scored with a penknife*
	Very hard	*cannot be scored with a steel point*
Portlandite (Matrix)	Small	*<20 µm*
	Medium	*20-60 µm*
	Large	*60-100 µm*
	Very large	*>100 µm*
Relict cement	Small	*<20 µm*
	Medium	*20-60 µm*
	Large	*60-100 µm*
	Very large	*>100 µm*
Water/cement ratio	Low	*<0.35*
	Normal	*0.35-0.65*
	High	*>0.65*
Voids	Entrained	*Typically round in shape and <100 «m in diameter (taken to be all voids <1 mm diameter when undertaking air content analyses).*
	Entrapped	*typically irregular in shape and >1 mm in diameter*

RSK Environment Ltd
Tel: +44 (0) 1442 437500
Fax: +44 (0) 1442 437550
Email: info2@rsk.co.uk
Web: www.rsk.co.uk

Materials & Structures
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

UKAS TESTING
0278

Certificate of Examination
ASTM C856-18
Petrographic Examination of Hardened Concrete

Site	Ugly Brown Building	**RSK Sample Ref.**	18284/C3
Client	The Trustees of the St Pancras Way Block A Unit Trust & Big Lobster Ltd C/O Reef Group 51 Welbeck Street London W1G 9HL	**Client Sample Ref.**	Capping Beam at B/H 10
		Sample Type	Concrete core
		Location	BH10 capping beam
		Orientation	Vertical
		Sampled by/Date	RSK/24.01.19
		Date of Receipt	30.01.19
		Examined by/Date	KS/05-20.02.19

SAMPLE

The sample comprised a nominal 100 mm diameter concrete core, approximately 135 mm in length. The diameter and length of the submitted core were less than those preferred by the standard (ideally 152 mm diameter and 305 mm length).

METHODS OF EXAMINATION

A full description of the examination methods, including a glossary of descriptive terms, is given on the final page of this certificate.

EXAMINATION FINDINGS

The detailed petrographic examination findings are given in the following pages of this certificate along with record colour photographs and selected photomicrographs (photographs taken through the microscope). An overview of the findings is given below.

SUMMARY OVERVIEW

Composition and Constituents	Nominal 20 mm, natural chert (flint) gravel coarse aggregate and natural quartzitic sand fine aggregate, bound by a Portland-type cement matrix.
Mix Quality	Apparently well mixed and exhibiting good compaction. Excess voidage 3 %. Apparent water/cement ratio was estimated as being in the low end of the normal range (say, 0.35 to 0.45).
Condition	Rare microcracks were observed running through the cement matrix. Sporadic air voids were lined with small amounts of secondary ettringite.
Other Remarks	The upper end surface of the sample was rough with exposed aggregate, whilst the lower end surface was freshly fractured. Apart from evidence of very minor leaching, the concrete appeared sound with no evidence of distress or deterioration.

NOTE

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

Certificate prepared by

Kathleen Smith
Geomaterials Scientist

Certificate reviewed by

James Ferrari
Principal Geomaterials Scientist

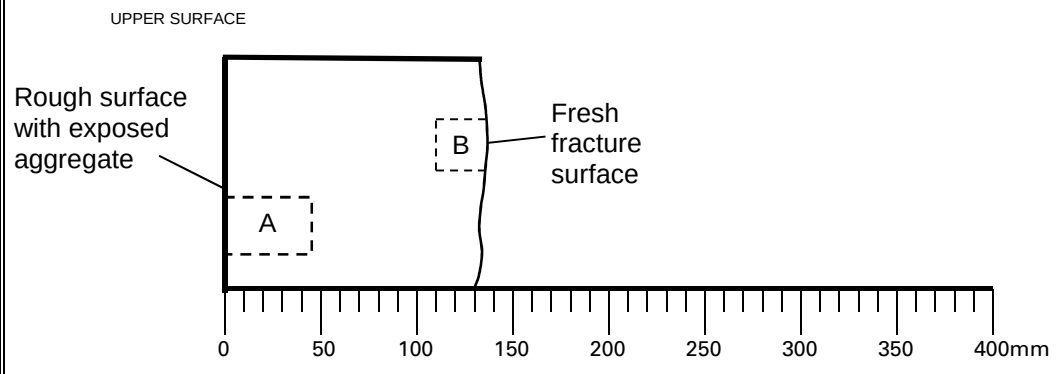
Date of issue: 22 February 2019

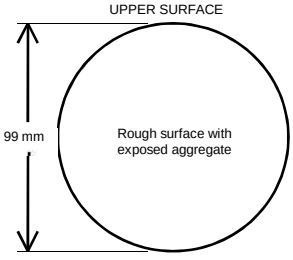
Petrographic Examination of Hardened Concrete - ASTM C856-18

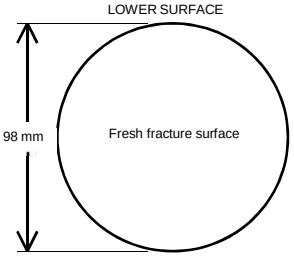
RECORD PHOTOGRAPH			
RSK Sample Ref.	18284/C3	**Client Sample Ref.**	Capping Beam at B/H 10
Description	View of the concrete as-received.		

SAMPLE/CORE SKETCH

A & B = Portions for thin section







Petrographic Examination of Hardened Concrete - ASTM C856-18

RECORD PHOTOGRAPH			
RSK Sample Ref.	18284/C3	**Client Sample Ref.**	Capping Beam at B/H 10
Description	Views of the upper and lower end surfaces of the core. Core diameter is 100 mm.		

UPPER SURFACE

LOWER SURFACE

Petrographic Examination of Hardened Concrete - ASTM C856-18

AS-RECEIVED CONCRETE CORE DETAILS			
RSK Sample Ref.	18284/C3	**Client Sample Ref.**	Capping Beam at B/H 10
Maximum Length, mm	137	**Diameter, mm**	100
Minimum Length, mm	128	**Number of Pieces**	1
Nature of Upper Surface	Rough with exposed aggregate	**Nature of Lower Surface**	Freshly fractured
Portion Described	Representative thin sections sawn from 0-45 mm and 110-137 mm depth from the upper surface.		

AGGREGATE DETAILS*		
Coarse Aggregate *(incl. type, nominal max. size, shape, grading, distribution and orientation)*	Natural gravel, nominal 20 mm maximum sized, well rounded to angular, continuously graded, evenly distributed and randomly orientated particles.	
Coarse Aggregate, Constituents *(incl. hardness, colour and approx. percent of lithological types present, alteration, weathering and general features of engineering significance)*	Wholly	CHERT – Very hard, greyish black to medium light grey, light brown or greyish orange particles comprising cryptocrystalline silica, with traces of iron oxides and opaque minerals. Sporadic particles contained trace chalcedony whilst rare particles contained major chalcedony. Rare particles contained minor proportions of iron oxides or trace proportions of calcite (100 %).
Cement:Aggregate Bond	Good, only rare interfacial partings in evidence.	
Additional Observations *(incl. evidence of deterioration etc)*	None.	
Fine Aggregate *(incl. type, nominal max. size, shape, grading, distribution and orientation)*	Natural quartzitic sand, 5 mm nominal maximum sized, rounded to very angular, evenly distributed and randomly orientated particles.	
Fine Aggregate, Constituents *(incl. hardness, colour and approx. percent of lithological types present, alteration, weathering and general features of engineering significance)*	Major	QUARTZ – Hard, translucent grey/white grains of silica (60-65 %). CHERT – Very hard, dark grey, greyish orange, light brown particles comprising cryptocrystalline silica with trace proportions of opaque minerals and iron oxides. Sporadic particles contained trace proportions of chalcedony (15-20 %). SHELL FRAGMENTS – Moderately hard, white fragments comprising calcite (10-15 %).
	Minor	IRONSTONE – Moderately hard, greyish brown particles comprising iron oxides/hydroxides (2-5 %).
	Trace	GLAUCONITE. LIMESTONE. MUDSTONE. QUARTZITE. OPAQUE MINERALS.
Cement:Aggregate Bond	Good, only rare interfacial partings in evidence.	
Additional Observations *(incl. evidence of deterioration etc)*	None.	

*All aggregate proportions are estimated.

Petrographic Examination of Hardened Concrete - ASTM C856-18

RSK Sample Ref.	18284/C3	Client Sample Ref.	Capping Beam at B/H 10

CONCRETE FEATURES	
Apparent Cement Type and Matrix Details *(Portland, High Alumina, White, PBC, etc and incl. hardness, colour, colour distribution and matrix distribution)*	Moderately hard, light grey, evenly distributed Portland-type cement matrix. Exhibiting abundant, typically medium to large, randomly distributed, unhydrated cement grains.
Mineral Additions• *(incl. type, size, relative abundance, distribution and shape)*	None observed.
Air Void Details and Compaction *(incl. air void max. size, shape, distribution, orientation, presence of entrainment, excess voidage)*	7 mm maximum, typically <2 mm sized, irregular, evenly distributed and randomly orientated entrapped air voids. Estimated excess voidage 3 %. The presence of common, well rounded, <1 mm sized air voids within the cement matrix suggests the presence of an admixture imparting some degree of air entrainment. To support this observation a section of the core can be submitted for air void analysis in accordance with ASTM C457-12¥.
Microporosity and Water/Cement Ratio# *(incl., microporosity variations and relation to other features; assessment of original water/cement ratio)*	The cement paste typically exhibited low to normal microporosity, indicative of an overall original water/cement ratio in the low end of the normal range (say, 0.35 to 0.45).
Carbonation* *(incl. depths, variations and relation to surface cracking)*	The upper surface of the concrete was carbonated to a maximum depth of 6 mm.
Portlandite *(incl. size, shape, abundance and distribution of crystallites)*	The uncarbonated cement matrix exhibited common, small sized, portlandite crystallites that were evenly distributed.
Other Concrete Details *(incl. applied finishes, inclusions and impurities)*	The upper end surface of the sample was rough with exposed aggregate, whilst the lower end surface was freshly fractured.
Reinforcement *(incl. types, sizes, depths, orientations, evidence of corrosion)*	None present.
Evidence of Cracking *(incl. crack styles, abundance and relation to other features)*	Rare microcracks were observed running through the cement matrix.
Presence of Deposits *(incl. gel, sulfates, carbonates, oxides, soot and their location, abundance and distribution)*	Sporadic air voids were lined with small amounts of secondary ettringite.
Other Observations *(incl. sweaty patches, matrix alteration, bleeding, segregation, plastic settlement, loss of bond, embedded items)*	Apart from evidence of very minor leaching, the concrete appeared sound with no evidence of distress or deterioration.

• some mineral additions are not easily identified by optical microscopy (e.g. microsilica, metakaolin)
¥ ASTM C457/C457M-12 Standard test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete. ASTM International, USA.
* sometimes assisted by phenolphthalein indicator solution
# estimated by fluorescence microscopy and based upon reference slides and images in Poole, A & Sims, I, *Concrete Petrography, A handbook of investigative techniques (second edition)*, Arnold, London, 2015.

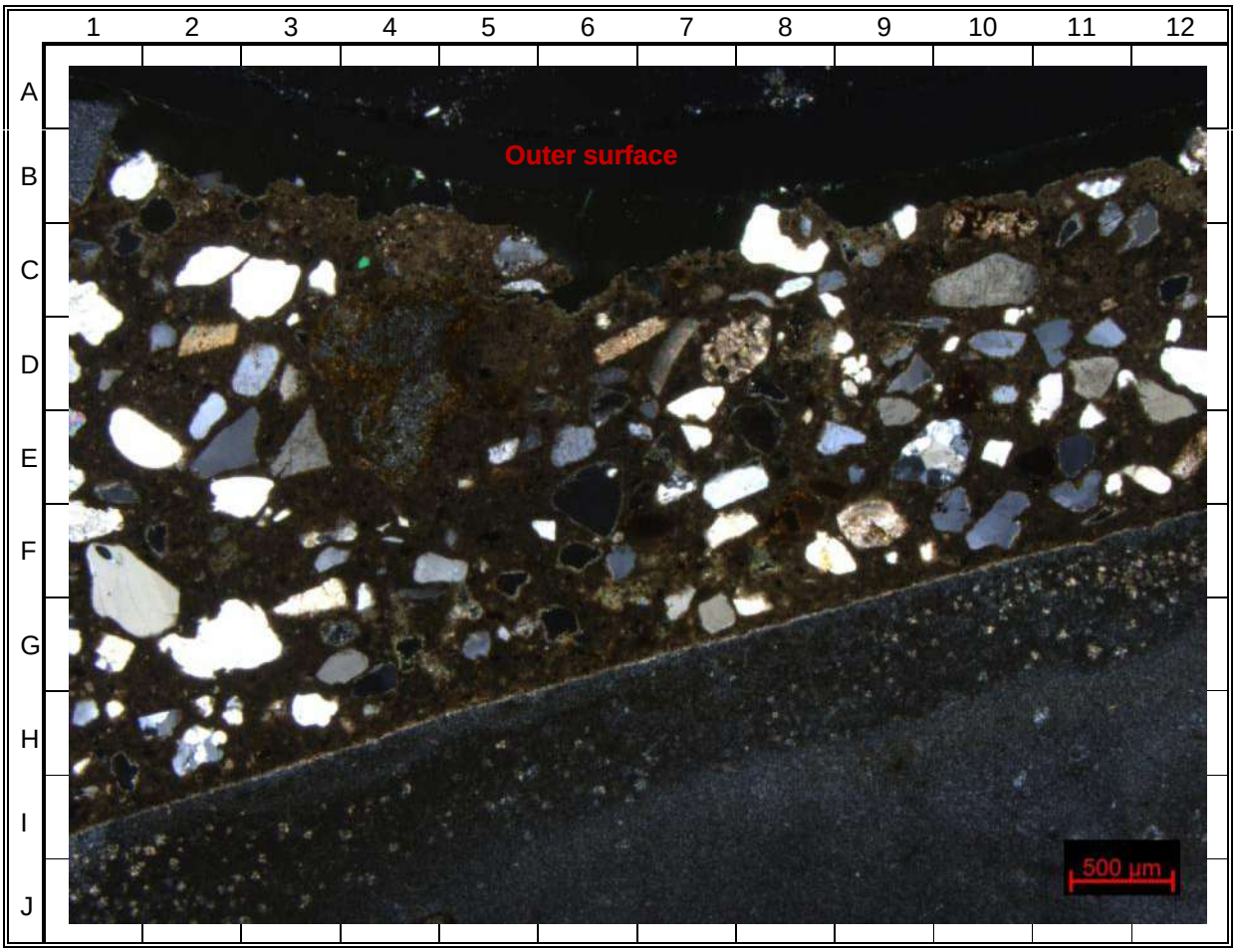
Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE

RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C3	**Client Sample Ref.**	Capping Beam at B/H 10
Approx. Mag^{n}	×15.75	**Approx. Scale**	10 mm = 360 µm
Portion Described	Concrete	**Viewing Light**	Cross-polarised
Description	A general view, showing chert coarse aggregate (speckled grey: H5 to H12) with quartz (white or grey: I3), chert (speckled grey: D5 to E6) and shell fragment (pinkish grey: J1) fine aggregate particles, bound by a Portland-type cement matrix (dark grey: A4). An air void appears black (H1 to H2).		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

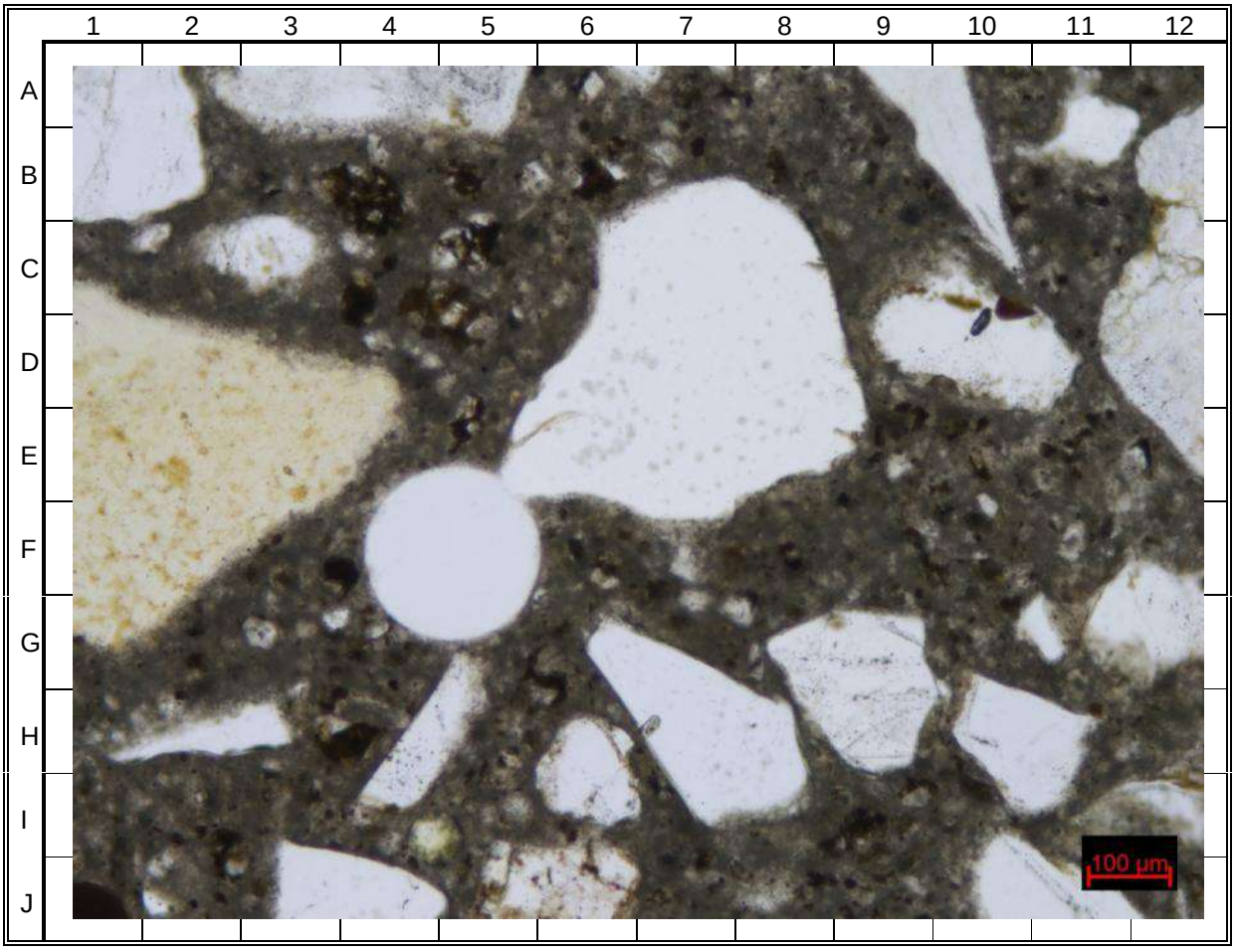
PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C3	**Client Sample Ref.**	Capping Beam at B/H 10
Approx. Mag^{n}	×15.75	**Approx. Scale**	10 mm = 360 µm
Portion Described	Concrete	**Viewing Light**	Cross-polarised
Description	A view of the outer surface (A1 to B12) showing chert coarse aggregate (speckled grey: J1 to H12) with quartz (white or grey: C3), chert (speckled grey: D4 to E4) and shell fragment (pinkish orange: D6) fine aggregate particles, bound by a carbonated Portland-type cement matrix (brown: D5).		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

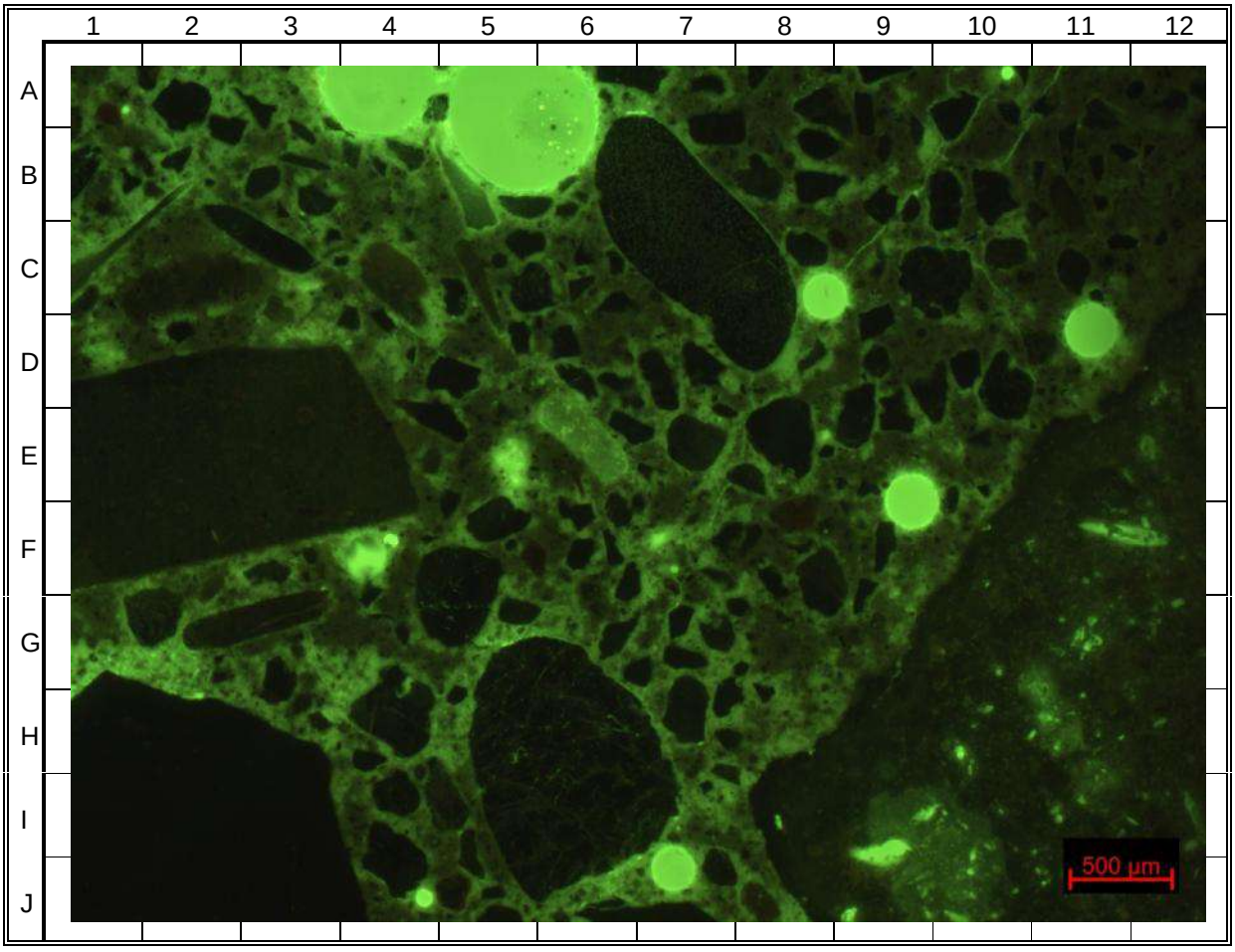
PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C3	**Client Sample Ref.**	Capping Beam at B/H 10
Approx. Mag^{n}	×63	**Approx. Scale**	10 mm = 90 µm
Portion Described	Concrete	**Viewing Light**	Plane-polarised
Description	A detailed view, showing fine aggregate particles (white: C7 to F7) and unhydrated cement grains (brown and white: B4), bound by a Portland-type cement matrix (greyish brown: F8). An air void appears white (F4 to F5).		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C3	**Client Sample Ref.**	Capping Beam at B/H 10
Approx. Mag^{n}	×15.75	**Approx. Scale**	10 mm = 360 µm
Portion Described	Concrete	**Viewing Light**	Reflected fluorescent
Description	A view of low to normal microporosity cement matrix (green and dark green: G8). Aggregate particles appear black (E1 to E4) and air voids appear bright green (E9). A microcrack (bright green) is visible running from C9 to A10.		

Petrographic Examination of Hardened Concrete - ASTM C856-18

Methods of Examination

The submitted concrete sample was subjected to a petrographic examination following methods recommended by ASTM C856-18, Standard Practice for Petrographic Examination of Hardened Concrete. Estimation of excess voidage was carried out in accordance with Concrete Society Technical Report No 11, including Addendum (1987), Concrete Core Testing For Strength. The examination was supplemented (where required) by the determination of the cement type following methods given in BS 1881: Part 124: 2015. When the concrete is suspected to contain high alumina cement, the examination is supplemented by taking guidance from BRE Digest 392, Assessment of existing high alumina cement concrete construction in the UK, March 1994.

The sample was first visually and low-power microscopically examined using a high quality Leica MZ8 binocular zoom microscope employing magnifications up to ×50. A record colour photograph of the sample was prepared along with a diagram illustrating the main features of interest. A low-power photomicrograph (a photograph taken through the microscope) is sometimes prepared to illustrate certain features of importance.

The initial examination was used to determine the most appropriate location for a medium-area (45 x 30 mm) thin section to be taken for further, more detailed microscopical examination. The thin section was prepared from a diamond sawn slice which had been both consolidated with, and vacuum impregnated by, an epoxy resin usually containing an ultraviolet light sensitive fluorescent dye. In some cases (e.g. concretes suspected to contain thaumasite), a pair of thin sections is produced, one using fluorescent dye and one free of fluorescent dye. Where the specific cement type (e.g. 'ordinary' Portland or 'sulfate-resisting' Portland) was required a highly polished specimen was also prepared for examination of the matrix in reflected light.

The thin section and/or polished specimen were examined using a high quality, multi-functional, high-power microscope employing various magnifications up to ×630. The thin section was examined using transmitted plane-polarised and cross-polarised illuminations. One or more record colour photomicrographs were prepared to illustrate certain microscopical features of importance. The thin section was also examined under reflected ultraviolet illumination to allow an assessment of the void and micropore structure, evidence of cracking and any other features of relevance. When used the polished specimen was examined using reflected, polarised and brightfield illuminations and etched using appropriate solutions and vapours to assist with the identification of residual particles of unhydrated cement and any non-reacted mineral additions.

Glossary of Terms Used in the Descriptions

Aggregate abundance	Major	*>10 %*
	Minor	*2 to 10 %*
	Trace	*<2 %*
Carbonation (Increasing Carbonation ↑)	Complete	*no residual cement matrix other than occasional unreacted relics*
	Partial	*evidence of mixed carbonate crystallites with isotropic matrix*
	Faint	*occasional carbonate crystallites, <25 % of the area*
Compaction (Increasing Compaction ↑)	≤0.5 %	*very good*
	>0.5 % - ≤3.0 %	*á3.0 % = good (ie normal for structural concrete)*
	>3.0 % – ≤5.0 %	*medium*
	>5.0 % - ≤10.0 %	*poor*
	>10.0 %	*Very poor*
Cracks (Increasing Width ↓)	Fine microcracks	*<1 «m wide*
	Microcracks	*1-10 «m wide*
	Fine cracks	*10-100 «m wide*
	Cracks	*100 «m-1 mm*
	Large cracks	*>1 mm wide*
Frequency (Increasing Frequency ↓)	Rare	*only found by thorough searching*
	Sporadic	*only occasionally observed during normal examination*
	Common	*easily observed during normal examination*
	Frequent	*easily observed with minimal examination*
	Abundant	*immediately apparent to initial examination*

Hardness (Increasing Hardness ↓)	Very soft	*can be penetrated easily by a finger*
	Soft	*scores with a fingernail*
	Moderately soft	*scores using a copper coin*
	Moderately hard	*scores easily with a penknife*
	Hard	*not easily scored with a penknife*
	Very hard	*cannot be scored with a steel point*
Portlandite (Matrix)	Small	*<20 µm*
	Medium	*20-60 µm*
	Large	*60-100 µm*
	Very large	*>100 µm*
Relict cement	Small	*<20 µm*
	Medium	*20-60 µm*
	Large	*60-100 µm*
	Very large	*>100 µm*
Water/cement ratio	Low	*<0.35*
	Normal	*0.35-0.65*
	High	*>0.65*
Voids	Entrained	*Typically round in shape and <100 «m in diameter (taken to be all voids <1 mm diameter when undertaking air content analyses).*
	Entrapped	*typically irregular in shape and >1 mm in diameter*

RSK Environment Ltd
Tel: +44 (0) 1442 437500
Fax: +44 (0) 1442 437550
Email: info2@rsk.co.uk
Web: www.rsk.co.uk

Materials & Structures
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

UKAS TESTING
0278

Certificate of Examination
ASTM C856-18
Petrographic Examination of Hardened Concrete

Site	Ugly Brown Building	**RSK Sample Ref.**	18284/C4
Client	The Trustees of the St Pancras Way Block A Unit Trust & Big Lobster Ltd C/O Reef Group 51 Welbeck Street London W1G 9HL	**Client Sample Ref.**	Capping Beam at B/H 4
		Sample Type	Concrete core
		Location	BH4 capping beam
		Orientation	Vertical
		Sampled by/Date	RSK/24.01.19
		Date of Receipt	30.01.19
		Examined by/Date	KS/05-20.02.19

SAMPLE

The sample comprised a nominal 100 mm diameter concrete core, approximately 180 mm in length. The diameter and length of the submitted core were less than those preferred by the standard (ideally 152 mm diameter and 305 mm length).

METHODS OF EXAMINATION

A full description of the examination methods, including a glossary of descriptive terms, is given on the final page of this certificate.

EXAMINATION FINDINGS

The detailed petrographic examination findings are given in the following pages of this certificate along with record colour photographs and selected photomicrographs (photographs taken through the microscope). An overview of the findings is given below.

SUMMARY OVERVIEW

Composition and Constituents	Nominal 20 mm, natural chert (flint) gravel coarse aggregate and natural quartzitic sand fine aggregate, bound by a Portland-type cement matrix.
Mix Quality	Apparently well mixed and exhibiting good compaction. Excess voidage 3 %. Apparent water/cement ratio was estimated as being in the low end of the normal range (say, 0.4 to 0.5).
Condition	Rare microcracks were observed running through the cement matrix. Common air voids were lined with small amounts of secondary ettringite.
Other Remarks	The upper end surface was rough with exposed aggregate, whilst the lower end surface was freshly fractured. Apart from evidence of very minor leaching, the concrete appeared sound with no evidence of distress or deterioration.

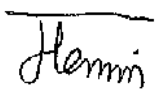
NOTE

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

Certificate prepared by

Kathleen Smith
Geomaterials Scientist

Certificate reviewed by



James Ferrari
Principal Geomaterials Scientist

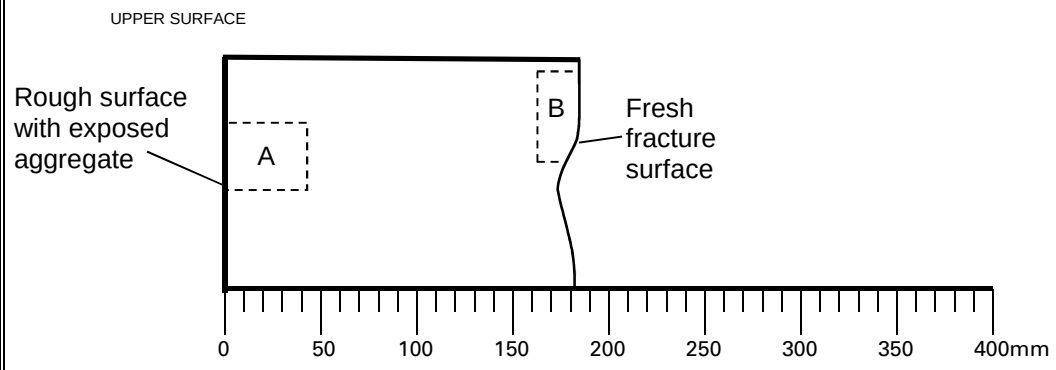
Date of issue: 22 February 2019

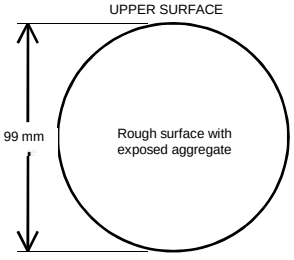
Petrographic Examination of Hardened Concrete - ASTM C856-18

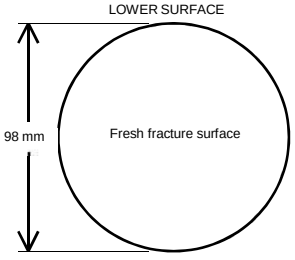
RECORD PHOTOGRAPH			
RSK Sample Ref.	18284/C4	**Client Sample Ref.**	Capping Beam at B/H 4
Description	View of the concrete as-received.		

SAMPLE/CORE SKETCH

A & B = Portions for thin section







Petrographic Examination of Hardened Concrete - ASTM C856-18

RECORD PHOTOGRAPH			
RSK Sample Ref.	18284/C4	**Client Sample Ref.**	Capping Beam at B/H 4
Description	Views of the upper and lower end surfaces of the core. Core diameter is 100 mm.		

UPPER SURFACE

LOWER SURFACE

Petrographic Examination of Hardened Concrete - ASTM C856-18

AS-RECEIVED CONCRETE CORE DETAILS			
RSK Sample Ref.	18284/C4	**Client Sample Ref.**	Capping Beam at B/H 4
Maximum Length, mm	181	**Diameter, mm**	100
Minimum Length, mm	171	**Number of Pieces**	1
Nature of Upper Surface	Rough with exposed aggregate	**Nature of Lower Surface**	Freshly fractured
Portion Described	Representative thin sections sawn from 0-45 mm and 160-181 mm depth from the upper surface.		

AGGREGATE DETAILS*	
Coarse Aggregate *(incl. type, nominal max. size, shape, grading, distribution and orientation)*	Natural gravel, nominal 20 mm maximum sized, well rounded to very angular, continuously graded, evenly distributed and randomly orientated particles.
Coarse Aggregate, Constituents *(incl. hardness, colour and approx. percent of lithological types present, alteration, weathering and general features of engineering significance)*	Major CHERT – Very hard, greyish black to light grey, light brown, moderate brown, very pale orange or greyish orange comprising cryptocrystalline silica, with trace proportions of opaque minerals and minor to trace proportions of iron oxides. Common particles contained trace chalcedony, whilst rare particles contained minor chalcedony (95-99 %). Trace QUARTZ. QUARTZITE.
Cement:Aggregate Bond	Good, only rare interfacial partings in evidence.
Additional Observations *(incl. evidence of deterioration etc)*	None.
Fine Aggregate *(incl. type, nominal max. size, shape, grading, distribution and orientation)*	Natural quartzitic sand, 5 mm nominal maximum sized, well rounded to very angular, evenly distributed and randomly orientated particles.
Fine Aggregate, Constituents *(incl. hardness, colour and approx. percent of lithological types present, alteration, weathering and general features of engineering significance)*	Major QUARTZ – Hard translucent grey/white grains of silica (70-75 %). CHERT – Very hard, dark yellowish orange, pale yellowish brown, light brown or dark grey particles comprising cryptocrystalline silica with trace proportions of opaque minerals and iron oxides. Sporadic particles contained trace proportions of chalcedony (10-15 %). SHELL FRAGMENTS – Moderately hard, white fragments comprising calcite (10-15 %). Trace GLAUCONITE. SILTSTONE. OPAQUE MINERALS. FELDSPAR. IRONSTONE.
Cement:Aggregate Bond	Good, only rare interfacial partings in evidence.
Additional Observations *(incl. evidence of deterioration etc)*	None.

*All aggregate proportions are estimated.

Petrographic Examination of Hardened Concrete - ASTM C856-18

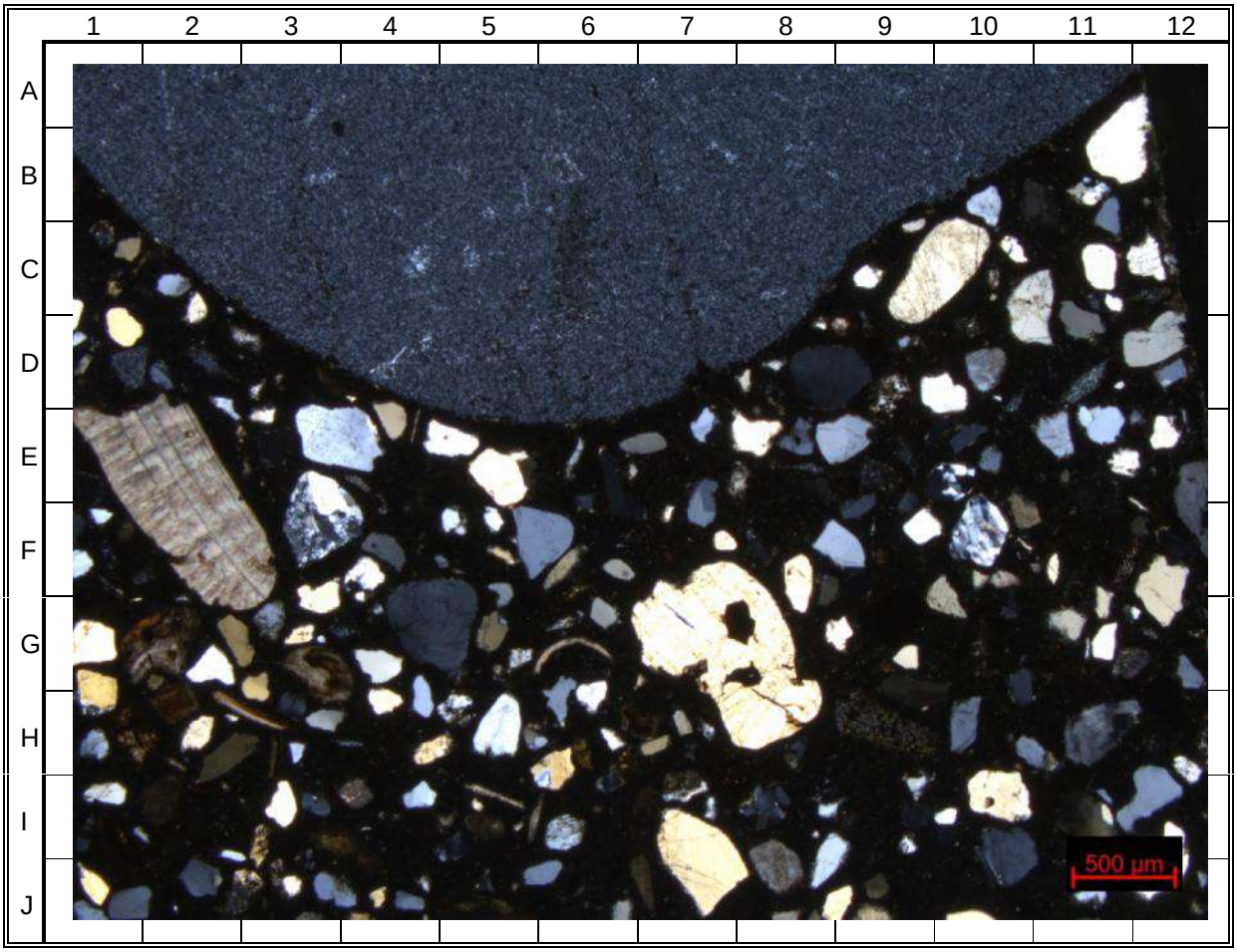
RSK Sample Ref.	18284/C4	Client Sample Ref.	Capping Beam at B/H 4

CONCRETE FEATURES	
Apparent Cement Type and Matrix Details *(Portland, High Alumina, White, PBC, etc and incl. hardness, colour, colour distribution and matrix distribution)*	Moderately hard, light grey, evenly distributed Portland-type cement matrix. Exhibiting abundant, typically small to large, but occasionally very large sized, randomly distributed, unhydrated cement grains.
Mineral Additions• *(incl. type, size, relative abundance, distribution and shape)*	None observed.
Air Void Details and Compaction *(incl. air void max. size, shape, distribution, orientation, presence of entrainment, excess voidage)*	16 mm maximum, typically <2 mm sized, irregular, evenly distributed and randomly orientated entrapped air voids. Estimated excess voidage 3 %. The presence of common, well rounded, <1 mm sized air voids within the cement matrix suggests the presence of an admixture imparting some degree of air entrainment. To support this observation a section of the core can be submitted for air void analysis in accordance with ASTM C457-12¥.
Microporosity and Water/Cement Ratio# *(incl., microporosity variations and relation to other features; assessment of original water/cement ratio)*	The cement paste typically exhibited low to normal microporosity, indicative of an overall original water/cement ratio in the low end of the normal range (say, 0.4 to 0.5).
Carbonation* *(incl. depths, variations and relation to surface cracking)*	The upper surface of the concrete was carbonated to a maximum depth of 0.5 mm and partially carbonated to a maximum depth of 2 mm.
Portlandite *(incl. size, shape, abundance and distribution of crystallites)*	The uncarbonated cement matrix exhibited frequent, small sized, portlandite crystallites that were evenly distributed.
Other Concrete Details *(incl. applied finishes, inclusions and impurities)*	The upper end surface of the sample was rough with exposed aggregate, whilst the lower end surface was freshly fractured.
Reinforcement *(incl. types, sizes, depths, orientations, evidence of corrosion)*	None present.
Evidence of Cracking *(incl. crack styles, abundance and relation to other features)*	Rare microcracks were observed running through the cement matrix.
Presence of Deposits *(incl. gel, sulfates, carbonates, oxides, soot and their location, abundance and distribution)*	Common air voids were lined with small amounts of secondary ettringite.
Other Observations *(incl. sweaty patches, matrix alteration, bleeding, segregation, plastic settlement, loss of bond, embedded items)*	Apart from evidence of very minor leaching, the concrete appeared sound with no evidence of distress or deterioration.

• some mineral additions are not easily identified by optical microscopy (e.g. microsilica, metakaolin)
¥ ASTM C457/C457M-12 Standard test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete. ASTM International, USA.
* sometimes assisted by phenolphthalein indicator solution
# estimated by fluorescence microscopy and based upon reference slides and images in Poole, A & Sims, I, *Concrete Petrography, A handbook of investigative techniques (second edition)*, Arnold, London, 2015.

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

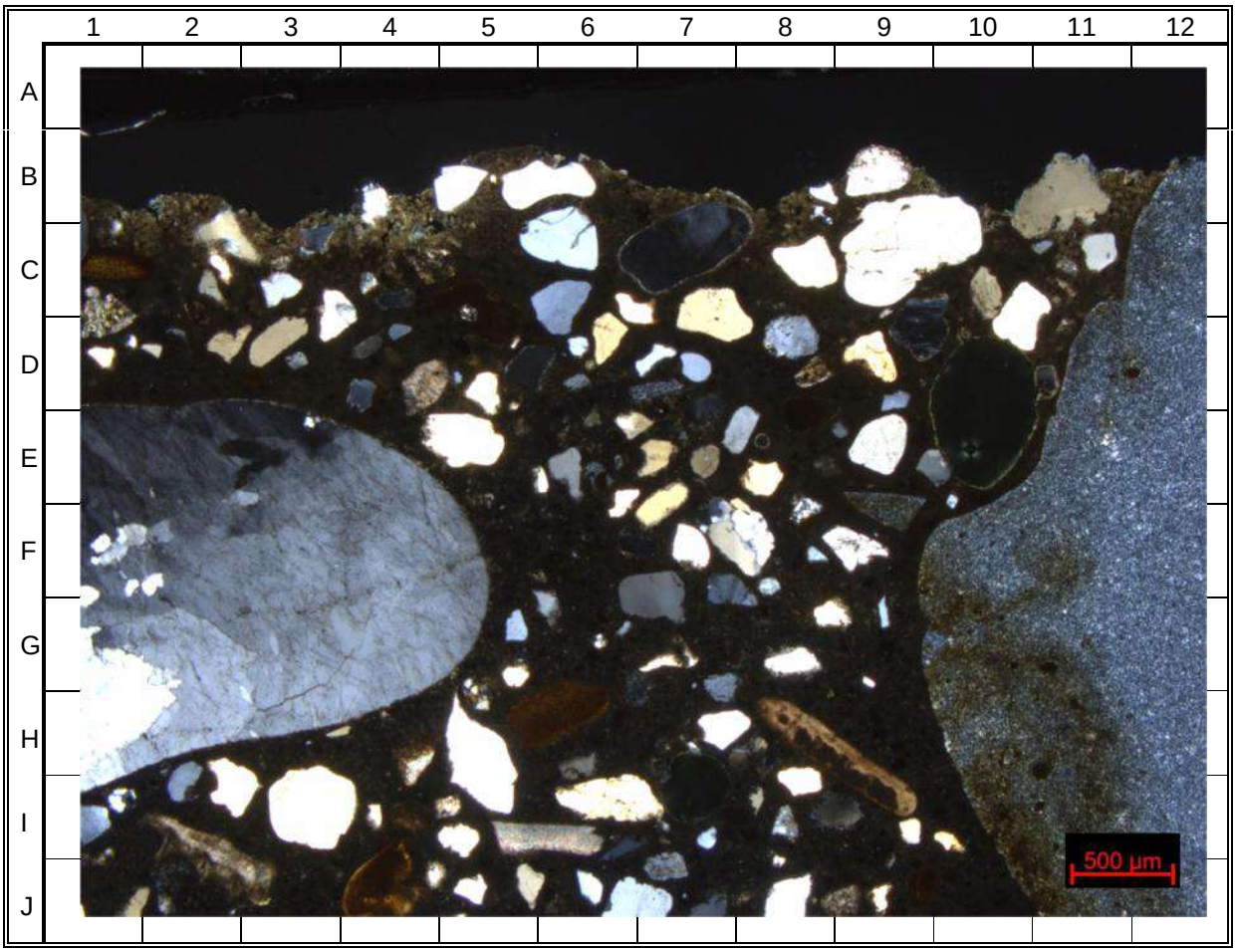
PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C4	**Client Sample Ref.**	Capping Beam at B/H 4
Approx. Magⁿ	×15.75	**Approx. Scale**	10 mm = 360 µm
Portion Described	Concrete	**Viewing Light**	Cross-polarised
Description	A general view, showing chert coarse aggregate (speckled grey: A1 to A11) with quartz (white and grey: G7 to H8) and shell fragment (pinkish grey: E1 to F3) fine aggregate particles, bound by a Portland-type cement matrix (black: G10).		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C4	**Client Sample Ref.**	Capping Beam at B/H 4
Approx. Mag^{n}	×15.75	**Approx. Scale**	10 mm = 360 µm
Portion Described	Concrete	**Viewing Light**	Cross-polarised
Description	A view of the outer surface (B1 to B12), showing chert coarse aggregate (speckled grey: J11 to B12), with quartz (white or grey: H5), chert (speckled grey: E9) and shell fragment (pinkish grey or brown: J4) fine aggregate particles, bound by a Portland-type cement matrix that is variably carbonated (yellowish brown: C4), partially carbonated (dark brown: C5) and uncarbonated (black: H9).		

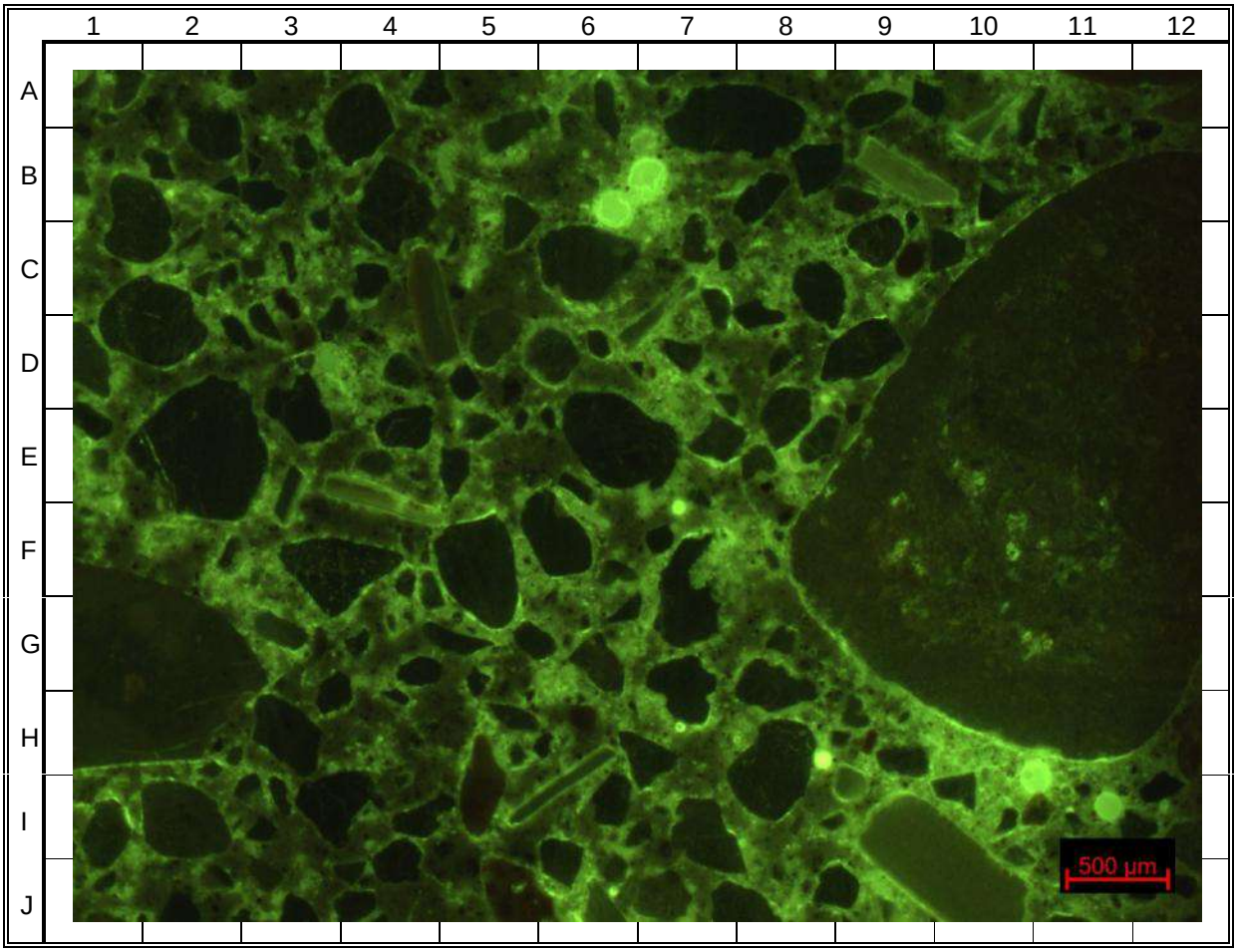
Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE

RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C4	**Client Sample Ref.**	Capping Beam at B/H 4
Approx. Mag^{n}	×63	**Approx. Scale**	10 mm = 90 µm
Portion Described	Concrete	**Viewing Light**	Plane-polarised
Description	A detailed view, showing fine aggregate particles (white: B10 to B11) and unhydrated cement grains (dark brown and white: A6) bound by a Portland-type cement matrix (grey: D2). An air void appears yellow (D9).		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C4	**Client Sample Ref.**	Capping Beam at B/H 4
Approx. Mag^{n}	×15.75	**Approx. Scale**	10 mm = 360 µm
Portion Described	Concrete	**Viewing Light**	Reflected fluorescent
Description	A view of low to normal microporosity cement matrix (green or dark green: H4). Aggregate particles appear black (E2) and air voids appear bright green (B6).		

Petrographic Examination of Hardened Concrete - ASTM C856-18

Methods of Examination

The submitted concrete sample was subjected to a petrographic examination following methods recommended by ASTM C856-18, Standard Practice for Petrographic Examination of Hardened Concrete. Estimation of excess voidage was carried out in accordance with Concrete Society Technical Report No 11, including Addendum (1987), Concrete Core Testing For Strength. The examination was supplemented (where required) by the determination of the cement type following methods given in BS 1881: Part 124: 2015. When the concrete is suspected to contain high alumina cement, the examination is supplemented by taking guidance from BRE Digest 392, Assessment of existing high alumina cement concrete construction in the UK, March 1994.

The sample was first visually and low-power microscopically examined using a high quality Leica MZ8 binocular zoom microscope employing magnifications up to ×50. A record colour photograph of the sample was prepared along with a diagram illustrating the main features of interest. A low-power photomicrograph (a photograph taken through the microscope) is sometimes prepared to illustrate certain features of importance.

The initial examination was used to determine the most appropriate location for a medium-area (45 x 30 mm) thin section to be taken for further, more detailed microscopical examination. The thin section was prepared from a diamond sawn slice which had been both consolidated with, and vacuum impregnated by, an epoxy resin usually containing an ultraviolet light sensitive fluorescent dye. In some cases (e.g. concretes suspected to contain thaumasite), a pair of thin sections is produced, one using fluorescent dye and one free of fluorescent dye. Where the specific cement type (e.g. 'ordinary' Portland or 'sulfate-resisting' Portland) was required a highly polished specimen was also prepared for examination of the matrix in reflected light.

The thin section and/or polished specimen were examined using a high quality, multi-functional, high-power microscope employing various magnifications up to ×630. The thin section was examined using transmitted plane-polarised and cross-polarised illuminations. One or more record colour photomicrographs were prepared to illustrate certain microscopical features of importance. The thin section was also examined under reflected ultraviolet illumination to allow an assessment of the void and micropore structure, evidence of cracking and any other features of relevance. When used the polished specimen was examined using reflected, polarised and brightfield illuminations and etched using appropriate solutions and vapours to assist with the identification of residual particles of unhydrated cement and any non-reacted mineral additions.

Glossary of Terms Used in the Descriptions

Aggregate abundance	Major	*>10 %*
	Minor	*2 to 10 %*
	Trace	*<2 %*
Carbonation (Increasing Carbonation ↑)	Complete	*no residual cement matrix other than occasional unreacted relics*
	Partial	*evidence of mixed carbonate crystallites with isotropic matrix*
	Faint	*occasional carbonate crystallites, <25 % of the area*
Compaction (Increasing Compaction ↑)	≤0.5 %	*very good*
	>0.5 % - ≤3.0 %	*á3.0 % = good (ie normal for structural concrete)*
	>3.0 % – ≤5.0 %	*medium*
	>5.0 % - ≤10.0 %	*poor*
	>10.0 %	*Very poor*
Cracks (Increasing Width ↓)	Fine microcracks	*<1 «m wide*
	Microcracks	*1-10 «m wide*
	Fine cracks	*10-100 «m wide*
	Cracks	*100 «m-1 mm*
	Large cracks	*>1 mm wide*
Frequency (Increasing Frequency ↓)	Rare	*only found by thorough searching*
	Sporadic	*only occasionally observed during normal examination*
	Common	*easily observed during normal examination*
	Frequent	*easily observed with minimal examination*
	Abundant	*immediately apparent to initial examination*

Hardness (Increasing Hardness ↓)	Very soft	*can be penetrated easily by a finger*
	Soft	*scores with a fingernail*
	Moderately soft	*scores using a copper coin*
	Moderately hard	*scores easily with a penknife*
	Hard	*not easily scored with a penknife*
	Very hard	*cannot be scored with a steel point*
Portlandite (Matrix)	Small	*<20 µm*
	Medium	*20-60 µm*
	Large	*60-100 µm*
	Very large	*>100 µm*
Relict cement	Small	*<20 µm*
	Medium	*20-60 µm*
	Large	*60-100 µm*
	Very large	*>100 µm*
Water/cement ratio	Low	*<0.35*
	Normal	*0.35-0.65*
	High	*>0.65*
Voids	Entrained	*Typically round in shape and <100 «m in diameter (taken to be all voids <1 mm diameter when undertaking air content analyses).*
	Entrapped	*typically irregular in shape and >1 mm in diameter*

RSK Environment Ltd
Tel: +44 (0) 1442 437500
Fax: +44 (0) 1442 437550
Email: info2@rsk.co.uk
Web: www.rsk.co.uk

Materials & Structures
18 Frogmore Road
Hemel Hempstead
Hertfordshire
HP3 9RT

UKAS TESTING
0278

Certificate of Examination
ASTM C856-18
Petrographic Examination of Hardened Concrete

Site	Ugly Brown Building	**RSK Sample Ref.**	18284/C6b
Client	The Trustees of the St Pancras Way Block A Unit Trust & Big Lobster Ltd C/O Reef Group 51 Welbeck Street London W1G 9HL	**Client Sample Ref.**	Pile at B/H 1
		Sample Type	Concrete core
		Location	BH1 pile
		Orientation	Vertical
		Sampled by/Date	RSK/06.02.19
		Date of Receipt	08.02.19
		Examined by/Date	KS/11-20.02.19

SAMPLE

The sample comprised a nominal 100 mm diameter concrete core, approximately 125 mm in length. The diameter and length of the submitted core were less than those preferred by the standard (ideally 152 mm diameter and 305 mm length). The received sample was a section from a longer core that had fractured at approximately 225 mm depth. Only the lower portion of the core (~225-355 mm) was submitted for petrographic examination.

METHODS OF EXAMINATION

A full description of the examination methods, including a glossary of descriptive terms, is given on the final page of this certificate.

EXAMINATION FINDINGS

The detailed petrographic examination findings are given in the following pages of this certificate along with record colour photographs and selected photomicrographs (photographs taken through the microscope). An overview of the findings is given below.

SUMMARY OVERVIEW

Composition and Constituents	Nominal 20 mm, natural chert (flint) gravel coarse aggregate and natural quartzitic sand fine aggregate, bound by a Portland-type cement matrix.
Mix Quality	Apparently well mixed and exhibiting good compaction. Excess voidage 2 %. Apparent water/cement ratio was estimated as being in the low end of the normal range (say, 0.35 to 0.45).
Condition	Rare microcracks were observed running through the cement matrix. Sporadic air voids were lined with small amounts of secondary ettringite.
Other Remarks	Both the upper and lower end surfaces of the sample were freshly fractured. Apart from evidence of very minor leaching, the concrete appeared sound with no evidence of distress or deterioration.

NOTE

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

Certificate prepared by

Kathleen Smith
Geomaterials Scientist

Certificate reviewed by

James Ferrari
Principal Geomaterials Scientist

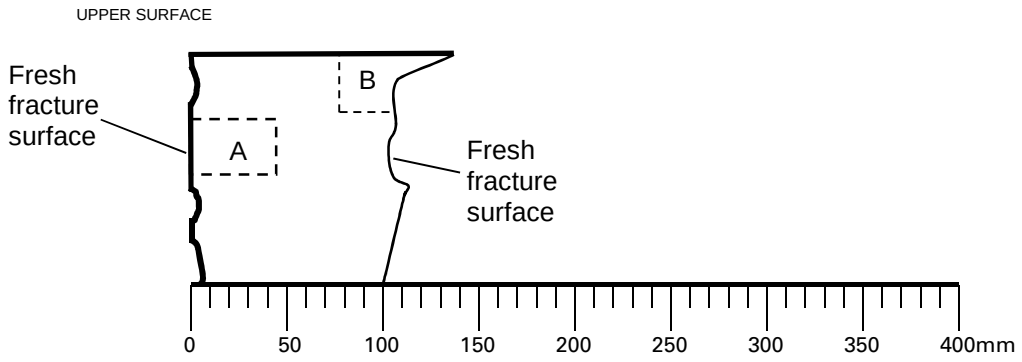
Date of issue: 22 February 2019

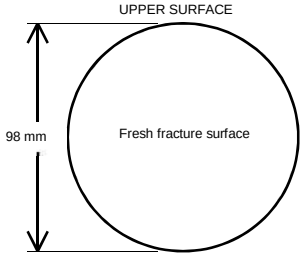
Petrographic Examination of Hardened Concrete - ASTM C856-18

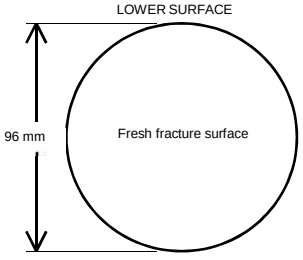
RECORD PHOTOGRAPH			
RSK Sample Ref.	18284/C6b	**Client Sample Ref.**	Pile at B/H 1
Description	View of the concrete as-received.		

SAMPLE/CORE SKETCH

A & B = Portions for thin section







Petrographic Examination of Hardened Concrete - ASTM C856-18

RECORD PHOTOGRAPH			
RSK Sample Ref.	18284/C6b	**Client Sample Ref.**	Pile at B/H 1
Description	Views of the upper and lower end surfaces of the core. Core diameter is 100 mm.		

UPPER SURFACE

LOWER SURFACE

Petrographic Examination of Hardened Concrete - ASTM C856-18

AS-RECEIVED CONCRETE CORE DETAILS			
RSK Sample Ref.	18284/C6b	**Client Sample Ref.**	Pile at B/H 1
Maximum Length, mm	129	**Diameter, mm**	100
Minimum Length, mm	94	**Number of Pieces**	1
Nature of Upper Surface	Freshly fractured	**Nature of Lower Surface**	Freshly fractured
Portion Described	Representative thin sections sawn from 0-45 mm and 75-129 mm depth from the upper surface.		

AGGREGATE DETAILS*	
Coarse Aggregate *(incl. type, nominal max. size, shape, grading, distribution and orientation)*	Natural gravel, nominal 20 mm maximum sized, well rounded to angular, continuously graded, evenly distributed and randomly orientated particles.
Coarse Aggregate, Constituents *(incl. hardness, colour and approx. percent of lithological types present, alteration, weathering and general features of engineering significance)*	Major CHERT – very hard, medium to dark grey, moderate brown, light brown or moderate yellowish brown particles comprising cryptocrystalline silica with trace proportions of opaque minerals and iron oxides. Sporadic particles contained minor iron oxides and common particles contained trace chalcedony. Trace QUARTZITE. RHYOLITE.
Cement:Aggregate Bond	Good, only rare interfacial partings in evidence.
Additional Observations *(incl. evidence of deterioration etc)*	None.
Fine Aggregate *(incl. type, nominal max. size, shape, grading, distribution and orientation)*	Natural quartzitic sand, 5 mm nominal maximum sized, rounded to very angular, evenly distributed and randomly orientated particles.
Fine Aggregate, Constituents *(incl. hardness, colour and approx. percent of lithological types present, alteration, weathering and general features of engineering significance)*	Major QUARTZ – hard, translucent grey/white grains of silica. CHERT – very hard, moderate yellowish brown, dark grey, greyish orange or light brown particles comprising cryptocrystalline silica with minor to trace proportions of iron oxides and trace opaque minerals and chalcedony. SHELL FRAGMENTS – moderately hard, white fragments comprising calcite. Trace FELDSPAR. GLAUCONITE. QUARTZITE. OPAQUE MINERALS. IRONSTONE.
Cement:Aggregate Bond	Good, only rare interfacial partings in evidence.
Additional Observations *(incl. evidence of deterioration etc)*	None.

*All aggregate proportions are estimated.

Petrographic Examination of Hardened Concrete - ASTM C856-18

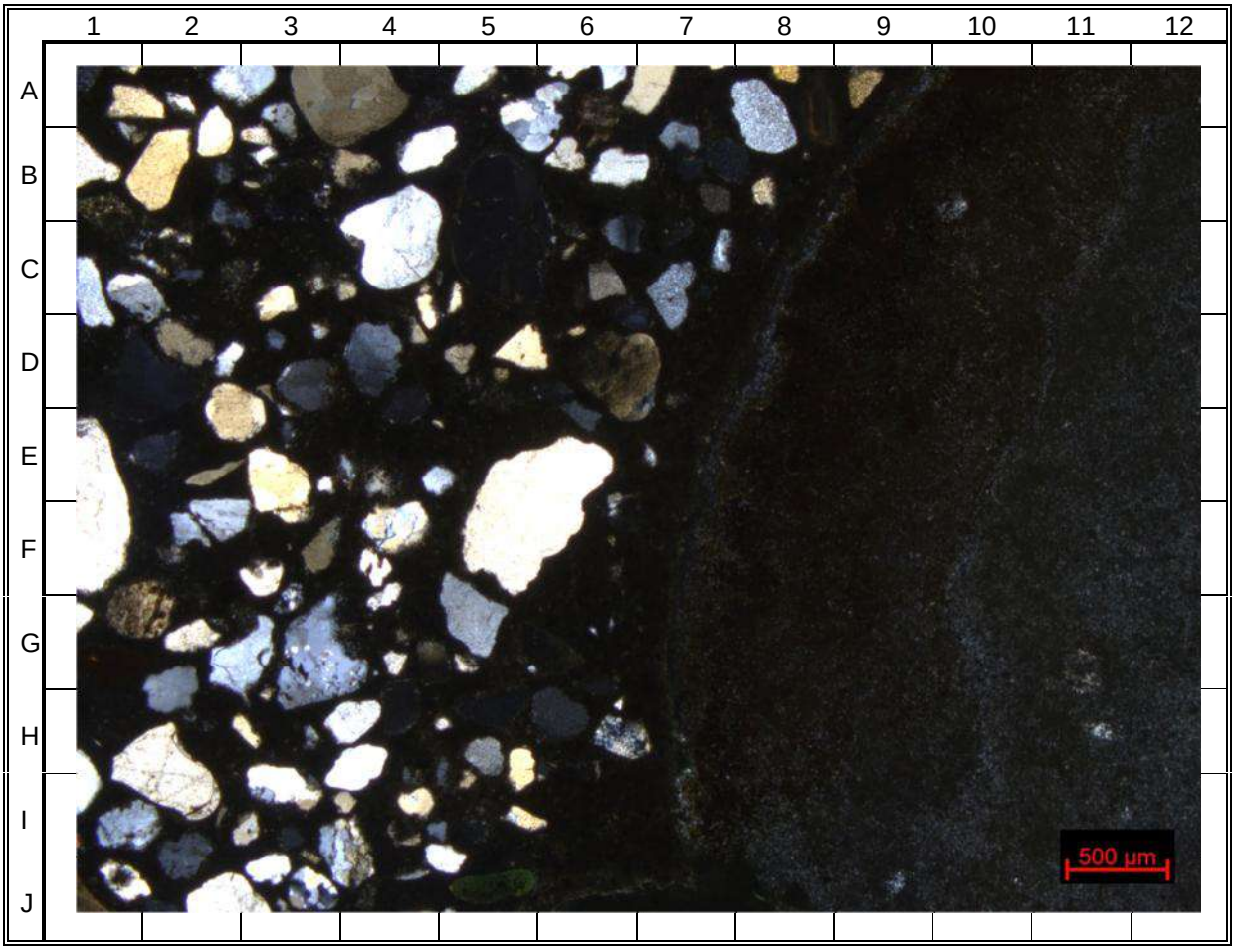
RSK Sample Ref.	18284/C6b	Client Sample Ref.	Pile at B/H 1

CONCRETE FEATURES	
Apparent Cement Type and Matrix Details *(Portland, High Alumina, White, PBC, etc and incl. hardness, colour, colour distribution and matrix distribution)*	Moderately hard, medium light grey, evenly distributed Portland-type cement matrix. Exhibiting abundant, typically small to large sized, randomly distributed, unhydrated cement grains.
Mineral Additions• *(incl. type, size, relative abundance, distribution and shape)*	None observed.
Air Void Details and Compaction *(incl. air void max. size, shape, distribution, orientation, presence of entrainment, excess voidage)*	6 mm maximum, typically <2 mm sized, irregular, evenly distributed and randomly orientated entrapped air voids. Estimated excess voidage 2 %. The presence of common, well rounded, <1 mm sized air voids within the cement matrix suggests the presence of an admixture imparting some degree of air entrainment. To support this observation a section of the core can be submitted for air void analysis in accordance with ASTM C457-12¥.
Microporosity and Water/Cement Ratio# *(incl., microporosity variations and relation to other features; assessment of original water/cement ratio)*	The cement paste typically exhibited low to normal microporosity, indicative of an overall original water/cement ratio in the low end of the normal range (say, 0.35 to 0.45).
Carbonation* *(incl. depths, variations and relation to surface cracking)*	The upper surface of the concrete was uncarbonated.
Portlandite *(incl. size, shape, abundance and distribution of crystallites)*	The uncarbonated cement matrix exhibited frequent, small to medium sized, portlandite crystallites that were evenly distributed.
Other Concrete Details *(incl. applied finishes, inclusions and impurities)*	Both the upper and lower end surfaces of the sample were freshly fractured.
Reinforcement *(incl. types, sizes, depths, orientations, evidence of corrosion)*	None present.
Evidence of Cracking *(incl. crack styles, abundance and relation to other features)*	Rare microcracks were observed running through the cement matrix.
Presence of Deposits *(incl. gel, sulfates, carbonates, oxides, soot and their location, abundance and distribution)*	Sporadic air voids were lined with small amounts of secondary ettringite.
Other Observations *(incl. sweaty patches, matrix alteration, bleeding, segregation, plastic settlement, loss of bond, embedded items)*	Apart from evidence of very minor leaching, the concrete appeared sound with no evidence of distress or deterioration.

• some mineral additions are not easily identified by optical microscopy (e.g. microsilica, metakaolin)
¥ ASTM C457/C457M-12 Standard test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete. ASTM International, USA.
* sometimes assisted by phenolphthalein indicator solution
# estimated by fluorescence microscopy and based upon reference slides and images in Poole, A & Sims, I, *Concrete Petrography, A handbook of investigative techniques (second edition)*, Arnold, London, 2015.

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

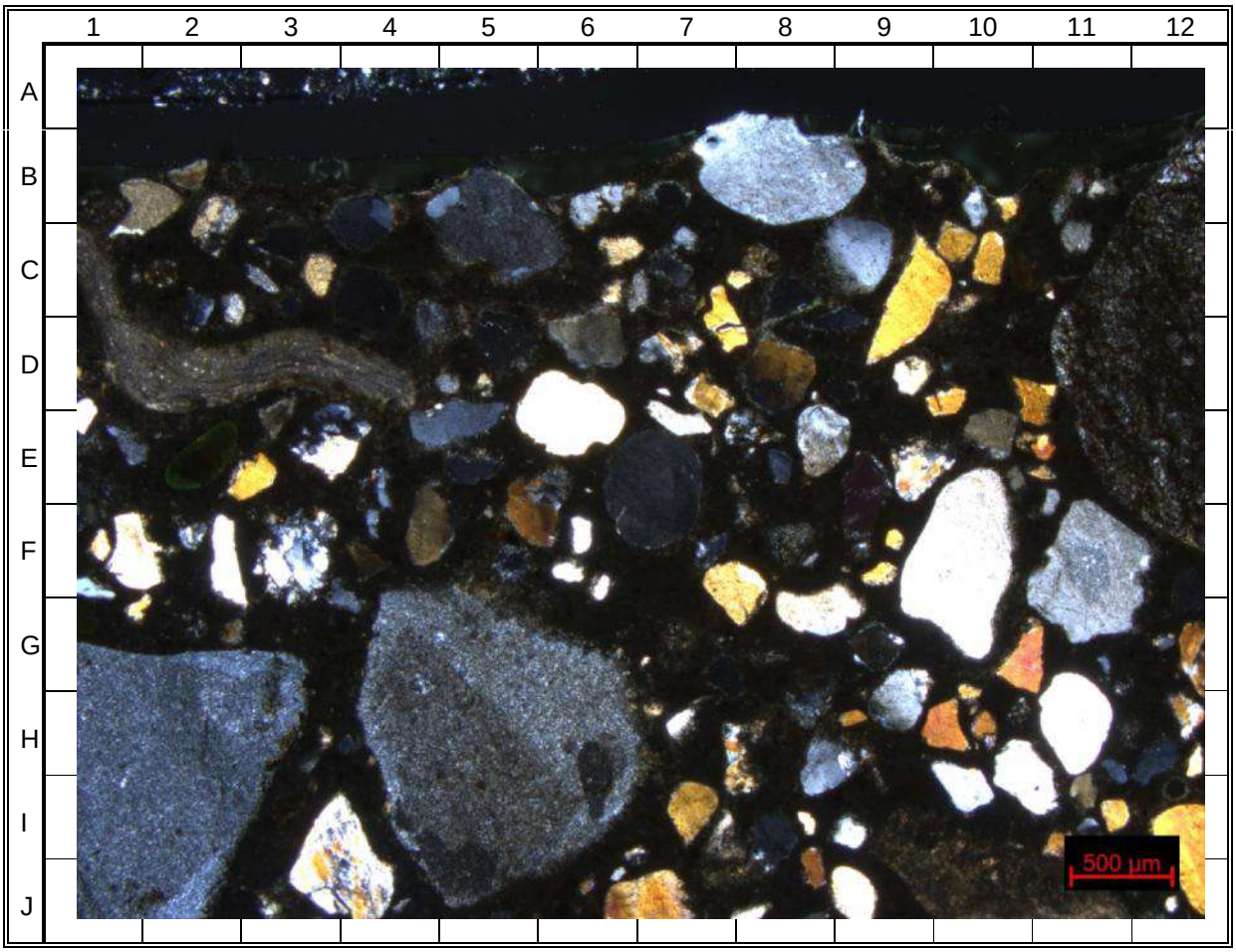
PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C6b	**Client Sample Ref.**	Pile at B/H 1
Approx. Magⁿ	×15.75	**Approx. Scale**	10 mm = 360 µm
Portion Described	Concrete	**Viewing Light**	Cross-polarised
Description	A general view, showing chert coarse aggregate (speckled grey: G7 to G12) and quartz (white or grey: F5 to E6), glauconite (green: J5) and shell fragment (pinkish brown: G1) fine aggregate particles, bound by a Portland-type cement matrix (black: I6).		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

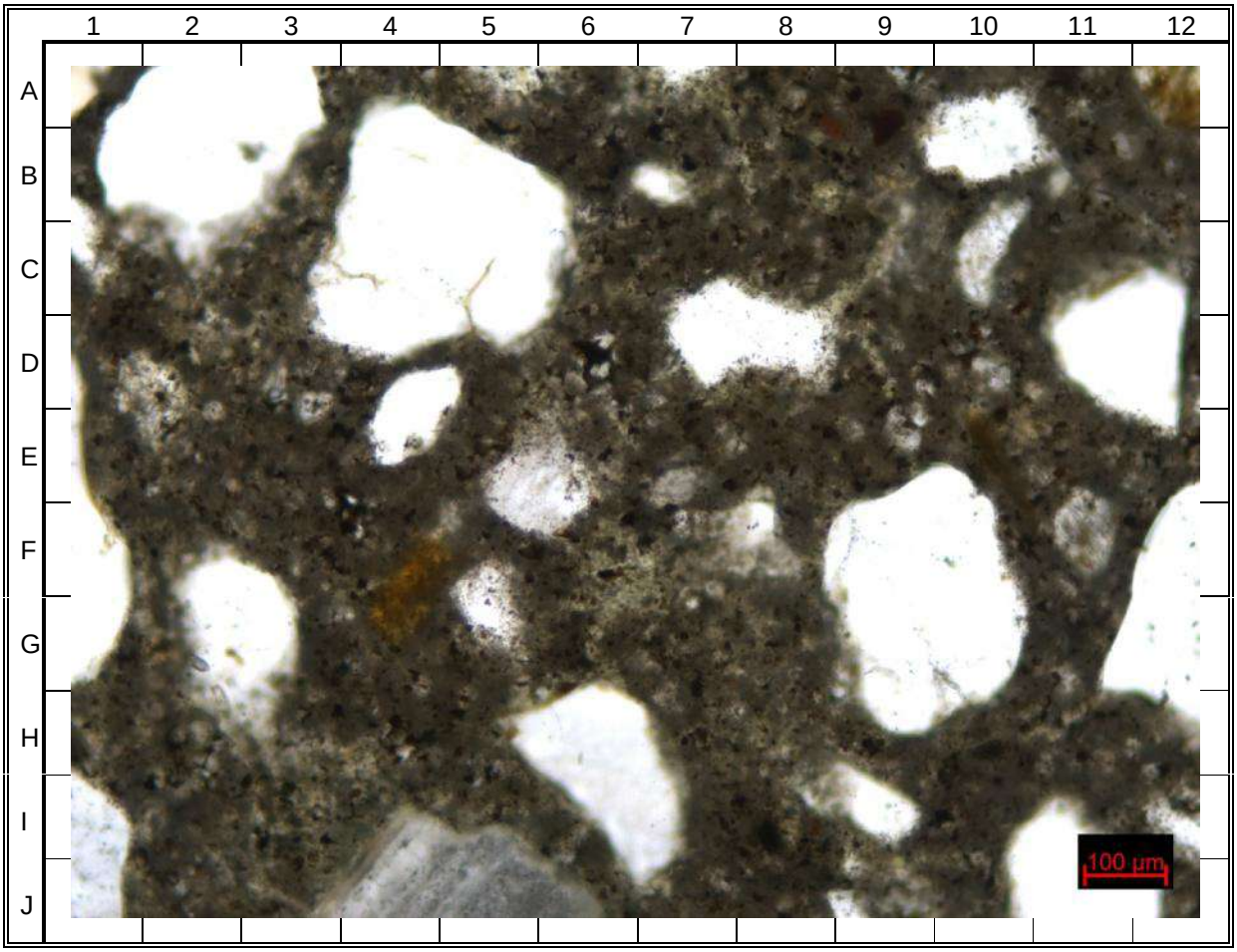
PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C6b	**Client Sample Ref.**	Pile at B/H 1
Approx. Mag^{n}	×15.75	**Approx. Scale**	10 mm = 360 µm
Portion Described	Concrete	**Viewing Light**	Cross-polarised
Description	A view of the upper surface (B1 to B12), showing quartz (white, yellow or grey: C9), chert (speckled grey: G2 to J2) and shell fragment (brown: C1 to D4) fine aggregate particles, bound by a Portland-type cement matrix (black: D10).		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

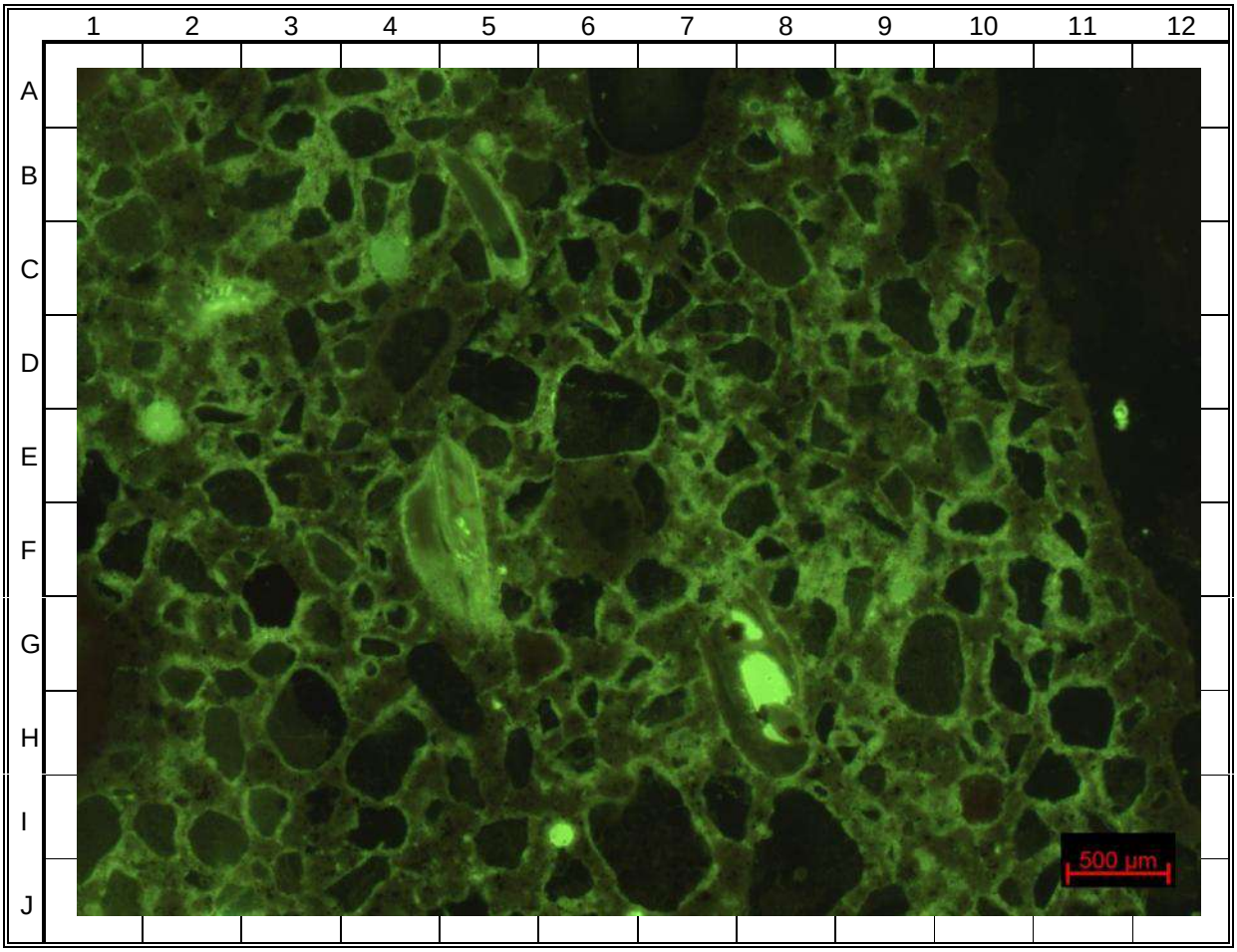
PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C6b	**Client Sample Ref.**	Pile at B/H 1
Approx. Mag^{n}	×63	**Approx. Scale**	10 mm = 90 µm
Portion Described	Concrete	**Viewing Light**	Plane-polarised
Description	A detailed view, showing fine aggregate particles (white: C4 to C5) and unhydrated cement grains (dark brown and white: D6), bound by a Portland-type cement matrix (brownish grey: I2).		

Petrographic Examination of Hardened Concrete - ASTM C856-18
High-Power Microscopical Observations

PHOTOGRAPH TAKEN USING ZEISS AXIOSCOPE



RECORD PHOTOMICROGRAPH			
RSK Sample Ref.	18284/C6b	**Client Sample Ref.**	Pile at B/H 1
Approx. Magⁿ	×15.75	**Approx. Scale**	10 mm = 360 µm
Portion Described	Concrete	**Viewing Light**	Reflected fluorescent
Description	A view of low to normal microporosity cement matrix (green or dark green: C3). Aggregate particles appear black (D5) and air voids appear bright green (I6).		

Petrographic Examination of Hardened Concrete - ASTM C856-18

Methods of Examination

The submitted concrete sample was subjected to a petrographic examination following methods recommended by ASTM C856-18, Standard Practice for Petrographic Examination of Hardened Concrete. Estimation of excess voidage was carried out in accordance with Concrete Society Technical Report No 11, including Addendum (1987), Concrete Core Testing For Strength. The examination was supplemented (where required) by the determination of the cement type following methods given in BS 1881: Part 124: 2015. When the concrete is suspected to contain high alumina cement, the examination is supplemented by taking guidance from BRE Digest 392, Assessment of existing high alumina cement concrete construction in the UK, March 1994.

The sample was first visually and low-power microscopically examined using a high quality Leica MZ8 binocular zoom microscope employing magnifications up to ×50. A record colour photograph of the sample was prepared along with a diagram illustrating the main features of interest. A low-power photomicrograph (a photograph taken through the microscope) is sometimes prepared to illustrate certain features of importance.

The initial examination was used to determine the most appropriate location for a medium-area (45 x 30 mm) thin section to be taken for further, more detailed microscopical examination. The thin section was prepared from a diamond sawn slice which had been both consolidated with, and vacuum impregnated by, an epoxy resin usually containing an ultraviolet light sensitive fluorescent dye. In some cases (e.g. concretes suspected to contain thaumasite), a pair of thin sections is produced, one using fluorescent dye and one free of fluorescent dye. Where the specific cement type (e.g. 'ordinary' Portland or 'sulfate-resisting' Portland) was required a highly polished specimen was also prepared for examination of the matrix in reflected light.

The thin section and/or polished specimen were examined using a high quality, multi-functional, high-power microscope employing various magnifications up to ×630. The thin section was examined using transmitted plane-polarised and cross-polarised illuminations. One or more record colour photomicrographs were prepared to illustrate certain microscopical features of importance. The thin section was also examined under reflected ultraviolet illumination to allow an assessment of the void and micropore structure, evidence of cracking and any other features of relevance. When used the polished specimen was examined using reflected, polarised and brightfield illuminations and etched using appropriate solutions and vapours to assist with the identification of residual particles of unhydrated cement and any non-reacted mineral additions.

Glossary of Terms Used in the Descriptions

Aggregate abundance	Major	*>10 %*
	Minor	*2 to 10 %*
	Trace	*<2 %*
Carbonation (Increasing Carbonation ↑)	Complete	*no residual cement matrix other than occasional unreacted relics*
	Partial	*evidence of mixed carbonate crystallites with isotropic matrix*
	Faint	*occasional carbonate crystallites, <25 % of the area*
Compaction (Increasing Compaction ↑)	≤0.5 %	*very good*
	>0.5 % - ≤3.0 %	*á3.0 % = good (ie normal for structural concrete)*
	>3.0 % – ≤5.0 %	*medium*
	>5.0 % - ≤10.0 %	*poor*
	>10.0 %	*Very poor*
Cracks (Increasing Width ↓)	Fine microcracks	*<1 «m wide*
	Microcracks	*1-10 «m wide*
	Fine cracks	*10-100 «m wide*
	Cracks	*100 «m-1 mm*
	Large cracks	*>1 mm wide*
Frequency (Increasing Frequency ↓)	Rare	*only found by thorough searching*
	Sporadic	*only occasionally observed during normal examination*
	Common	*easily observed during normal examination*
	Frequent	*easily observed with minimal examination*
	Abundant	*immediately apparent to initial examination*

Hardness (Increasing Hardness ↓)	Very soft	*can be penetrated easily by a finger*
	Soft	*scores with a fingernail*
	Moderately soft	*scores using a copper coin*
	Moderately hard	*scores easily with a penknife*
	Hard	*not easily scored with a penknife*
	Very hard	*cannot be scored with a steel point*
Portlandite (Matrix)	Small	*<20 µm*
	Medium	*20-60 µm*
	Large	*60-100 µm*
	Very large	*>100 µm*
Relict cement	Small	*<20 µm*
	Medium	*20-60 µm*
	Large	*60-100 µm*
	Very large	*>100 µm*
Water/cement ratio	Low	*<0.35*
	Normal	*0.35-0.65*
	High	*>0.65*
Voids	Entrained	*Typically round in shape and <100 «m in diameter (taken to be all voids <1 mm diameter when undertaking air content analyses).*
	Entrapped	*typically irregular in shape and >1 mm in diameter*