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INVESTIGATION INSPECTION
MATERIALS TESTING

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REPORT 41378/G/1

PETROGRAPHIC EXAMINATION

OF

NATURAL STONE

WESTERN RANGE, TRAIN SHED ROOF CILLS

KING'S CROSS

Stonewest Ltd
Lamberts Place
St. James's Road
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This Report consists of
3 pages of text
Table 1 of 3 sheets
Table 2 of 3 sheets

For the attention of Mr James Kennett

14 January 2010

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PETROGRAPHIC EXAMINATION

OF

NATURAL STONE

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Reference : Instructions from Mr James Kennett of Stonewest Ltd.

1. INTRODUCTION

We were requested to undertake a petrographic examination on natural stone in accordance with your instructions.

The purpose of the analysis was to identify the stone and provide an assessment of a potential matching source.

2. SAMPLES RECEIVED

The sample was received from Stonewest Ltd at Sandberg laboratories on 25 November 2009, as follows.

Sandberg Reference	Site Mark & Advised Location Details	Sample details
	Western range, train shed roof cills	
G34548	Stone lump 1	1 no. lump ; approx 40g
G34549	Stone lump 2	1 no. lump ; approx 290g

3. TEST METHOD AND RESULTS

Each sample was subjected to petrographic examination in accordance with the methods described in BS 5930:1999[1], ISRM[2] and BS EN 12407:2007[3].

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

A representative portion from each sample was used to prepare a large area thin section which was examined using an Olympus BH2 and Leica DM4500P high power petrological microscopes employing plane polarised and cross polarised light at magnifications up to x1000.

The detailed petrographic examination results are given in Tables 1 and 2 of this report.

The two samples were found to be similar buff to beige fine to medium grained sandstone/gritstone generally exhibiting similar composition and textures but slightly different structures (Sample 2/G34549 exhibited faint bedding lines) possibly originating from the same source quarry but a different face/bed or a different quarry within the same or similar formation/s.

Sample 1/G34548 sandstone was very small for a reliable source match but exhibited textural, compositional and colour similarities with Copp Crag quarry, Dunhouse quarry, York Stone Soil Hill quarry and Yorkshire Flagstone

Sample 2/G34549 could be matched to Moorside, Ladycross, Shipley, Elland Edge Flagrock and Yorkstone Watson quarry.

The above matches for the submitted samples in terms of colour and appearance, along with potential sources, is detailed below.

Sandberg Ref./ Site Mark	Potential Source Material	Degree of Confidence in Match
G34548/1	Copp Crag Quarry [Grid reference: NY 822 995]	Possible
	or Dunhouse Quarry [Grid reference: NZ 141 183]	Possible
	or York Stone Soil Hill Quarry [Grid reference: SE 079 314]	Possible
	or Yorkshire Flagstone [Grid reference: SE 121 355]	Possible

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1 BS 5930:1999. Code of Practice for Site Investigation, Clause 44, Description and Classification of Rocks for engineering Purposes.

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

3 BS EN 12407:2007. Natural Stone Test Methods - Petrographic Examination.

Sandberg Ref./ Site Mark	Potential Source Material	Degree of Confidence in Match
G34549/2	Moorside [Grid reference: SJ 951` 798]	Possible
	or	
	Ladycross [Grid reference: NY 945 555]	Possible
	or	
	Shipley [Grid reference: NY 015 209]	Possible
	or	
	Elland Edge Flagrock [Grid reference: SE 122 236]	Possible
	or	
	Yorkstone Watson Quarry [Grid reference: SE 125 235]	Possible

The samples received were compared against archived petrographic data and thin sections. It is therefore recommended that colour matching of the stone from the suggested potential sources with the material on site is carried out.

We would strongly recommend that the suggested source quarries are visited by an experienced geologist and samples are examined in detail with respect to compatibility of physical characteristics, durability and comparative performance. We would welcome the opportunity to assist in this process.

4. REMARKS

The stone matching was based upon the samples submitted. Stone sources may be expected to exhibit considerable lateral and vertical variations in composition and character over short distances and single samples are unlikely to be reliably representative of whole source areas or specific locations within these areas during continuing exploitation.

In addition, the above suggested quarries may have stopped operating or the new stone extracted may differ considerably in colour, texture and overall composition with that originally produced.

These results and comments conclude the testing requested to date. Please do not hesitate to contact us if we can be of further assistance.

Stonewest Ltd
Lamberts Place
St. James's Road
Croydon
Surrey
CR9 2HX

For the attention of Mr James Kennett

DJE/Geoman/vb

For Sandberg LLP

D J Ellis
Partner

14 January 2010

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41378/G/1

Table/Sheet
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Date of Test / by
12.1.2010/PS

PETROGRAPHICAL EXAMINATION OF ROCK

BS 5930:1999, ISRM Method and BS EN 12407:2007

SAMPLE DETAILS			
Sample Reference	G34548	Client Reference/Site Mark	Lump 1
Sample Type, Source and Sampling Location Details:	Stone lump ex. Western Range - Train shed roof cills		
Condition on Receipt:	Dry	Sample weight, g:	40
Methods of Preparation of Specimens and Examination Procedures:	The sample was first subjected to macroscopical and low power stereomicroscopical examination supported by simple physical and chemical tests. A representative slice specimen was diamond-sawn and used to prepare a thin section which was then examined under a high power petrological microscope.		
Any Other Details:	The slice specimen was taken along the thickness of the sample. Thin section dimensions, mm: 50 x 37		

MATERIAL DESCRIPTION:	Buff to beige, fine to medium grained SANDSTONE/GRITSTONE. The stone was moderately hard to moderately soft (subjective scratch test).

MATERIAL COMPOSITION:	
COMPONENT	Volume % (estimated)
Quartz Feldspar Chlorite Mica	75 7 15 3
TOTAL:	100

PETROGRAPHICAL DETAILS[n]

The stone was found to be a grain supported sandstone comprising predominantly irregular/angular to elongate grains of quartz, occasional chlorite and feldspar and sporadic mica. Quartz and feldspar were the clastic components and the main structural constituents, with the other components mainly as intergranular material. The clasts were angular to sub-angular and occasionally elongate, with medium to low sphericity.

Quartz ranged in size from 50µm to 400µm with most common size range between 100µm to 200µm and therefore fine to medium grained.

Quartz grains were occasionally strained, angular to subangular, irregular to elongate with medium to low sphericity exhibiting embayed boundaries.

Feldspar included plagioclase and possibly some microcline and exhibited alteration to chlorite and mica.

Chlorite was present as intergranular material frequently containing possibly iron or manganese oxide and was also stained brown/orange possibly due to oxidation. Chlorite was also associated with altered feldspar. The buff to beige colour of the stone was due to the stained chlorite.

Sparse mica, white (muscovite) and brown (biotite) grains were also present as intergranular material and frequently stained brown/orange.

The stone was moderately to well compacted with occasional voids up to 200µm across and commonly 30µmto 100µm in size. The intergranular chlorite however was microporous which contributed to the overall microporosity of the stone.

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

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

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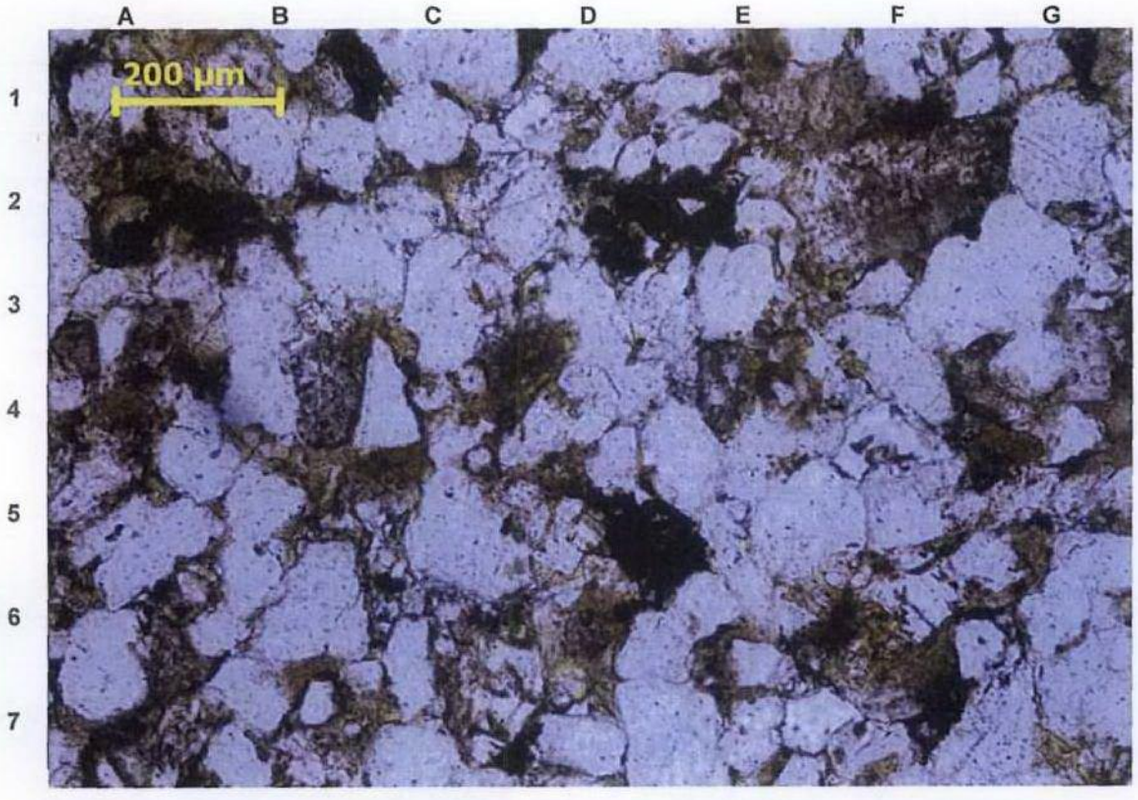
Plate 1

PETROGRAPHICAL EXAMINATION OF STONE - PHOTOMICROGRAPH



Photomicrograph Details			
Sandberg Sample Ref:	G34548	Client Ref/Site Mark:	Lump 1 Sandstone
Microscope Light:	Plane polarised	Objective Magnification:	x10
Photomicrograph Description			
General view of stone structure. White grains are quartz. Intergranular material is mainly chlorite which is microporous. Yellow colouration is due to fluorescent impregnating resin. Brown to dark brown interstitial material is iron or manganese oxide stained chlorite.			

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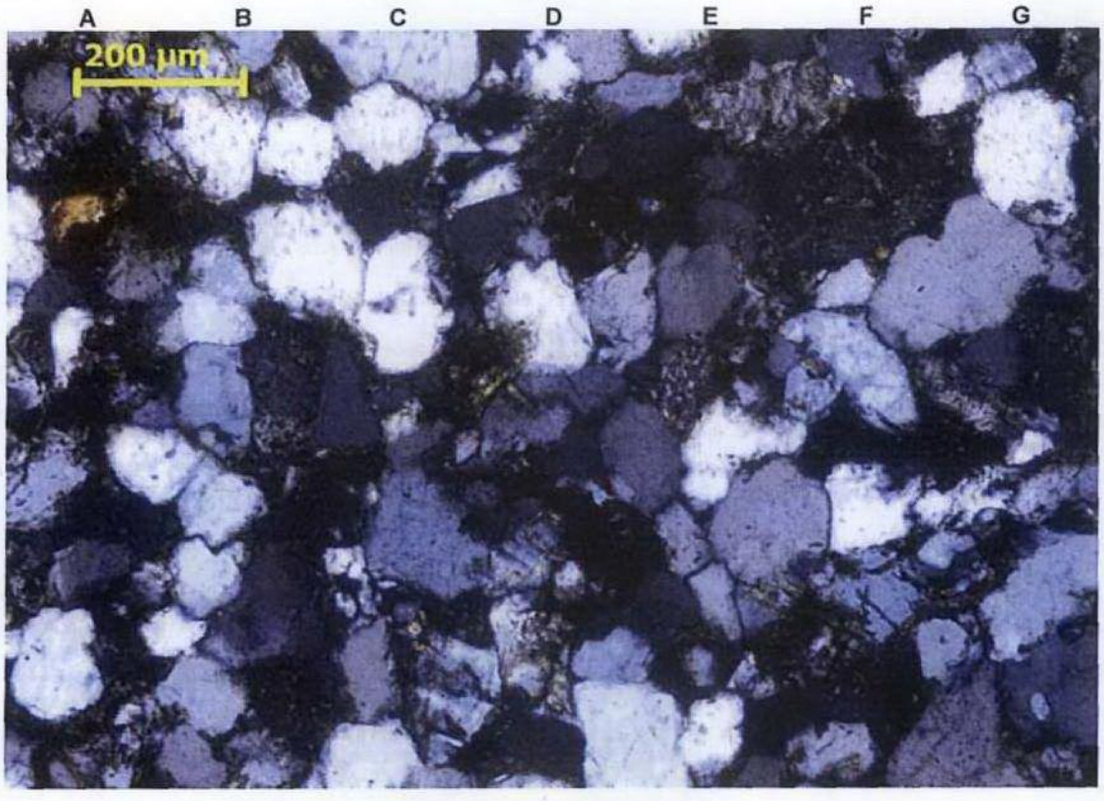
Plate 2

PETROGRAPHICAL EXAMINATION OF STONE - PHOTOMICROGRAPH



Photomicrograph Details			
Sandberg Sample Ref:	G34548	Client Ref/Site Mark:	Lump 1 Sandstone
Microscope Light:	Cross polarised	Objective Magnification:	x10
Photomicrograph Description			
General view of stone structure. White and blue grey grains are quartz. Intergranular material is mainly chlorite which is microporous. Yellow colouration is due to fluorescent impregnating resin.			

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Table/Sheet
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PETROGRAPHICAL EXAMINATION OF ROCK
BS 5930:1999, ISRM Method and BS EN 12407:2007

Date of Test / by
13.1.2010/PS

SAMPLE DETAILS			
Sample Reference	G34549	Client Reference/Site Mark	Lump 2
Sample Type, Source and Sampling Location Details:	Stone lump ex. Western Range, Train shed roof cills.		
Condition on Receipt:	Dry	Sample weight, g:	290
Methods of Preparation of Specimens and Examination Procedures:	The sample was first subjected to macroscopical and low power stereomicroscopical examination supported by simple physical and chemical tests. A slice specimen from the sample was diamond-sawn and used to prepare a large area thin section which was then examined under a high power petrological microscope.		
Any Other Details:	Diametrical slice 70mm x 50mm		

MATERIAL DESCRIPTION:	Buff, fine to medium grained SANDSTONE/GRITSTONE. The stone exhibited faint bedding planes (lines) running parallel to two surfaces of the lump sample. The stone was moderately hard to moderately soft (subjective scratch test).

MATERIAL COMPOSITION:	
COMPONENT	Volume % (estimated)
Quartz	75
Feldspar	7
Chlorite	15
Mica	3
Others	<1
TOTAL:	100

PETROGRAPHICAL DETAILS[n]

The stone was found to be a grain supported sandstone comprising predominantly irregular/angular to elongate grains of quartz, occasional chlorite and feldspar, sporadic mica and rare zircon.

The clastic components were quartz and feldspar ranging in size from 50µm to 300µm with the most common size range between 100µm to 200µm and therefore fine to medium grained. The clasts (i.e. quartz and feldspar) were angular to sub-angular and occasionally elongate, with medium to low sphericity and were the main structural constituents of the stone.

Quartz appeared occasionally strained with embayed boundaries, angular to subangular, irregular to elongate with medium to low sphericity. Feldspar included plagioclase and possibly microcline, both of which exhibited alteration to chlorite and mica.

Intergranular chlorite was microporous and frequently exhibited staining by iron or manganese oxide. Chlorite was also associated with altered feldspar. The buff to beige colour of the stone was due to the stained chlorite.

Intergranular mica was sporadically present as muscovite (white) and biotite (brown) mica and was occasionally seen to be aligned along bedding lines.

Iron and/or manganese oxide granules were mainly associated with chlorite and mica both of which exhibited brown/orange staining.

The stone was moderately to well compacted with occasional voids up to 200µm across and commonly less than 100µm in size infilled or partially infilled with chlorite. The presence of microporous chlorite and altered feldspar however may contribute to the overall porosity of the stone.

UE = Undulatory Extinction. ND = Not Determined. NA = Not Applicable. NS = Not Supplied.
[n] Details mainly relate to components or features of possible engineering significance.

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Table/Sheet 2/2
Plate 1

PETROGRAPHICAL EXAMINATION OF STONE - PHOTOMICROGRAPH

Photomicrograph Details			
Sandberg Sample Ref:	G34549	Client Ref/Site Mark:	Lump 2 Sandstone (bedded)
Microscope Light:	Plane polarised	Objective Magnification:	x10

Photomicrograph Description

General view of stone structure. White grains are quartz. Intergranular material is mainly chlorite which is microporous. Yellow colouration is due to fluorescent impregnating resin. Brown to dark brown interstitial material is iron or manganese oxide stained chlorite. Red arrow points to oxide stained mica.

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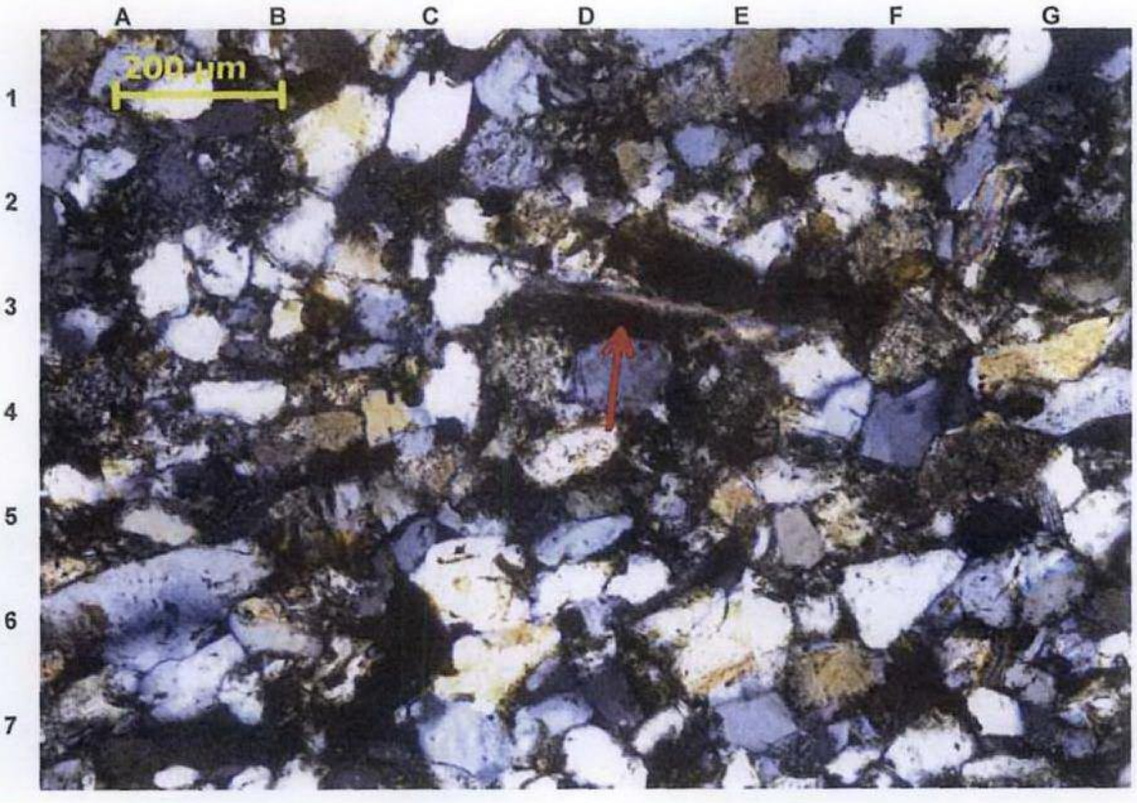
Plate 2

PETROGRAPHICAL EXAMINATION OF STONE - PHOTOMICROGRAPH



Photomicrograph Details			
Sandberg Sample Ref:	G34549	Client Ref/Site Mark:	Lump 2 Sandstone (bedded)
Microscope Light:	Cross polarised	Objective Magnification:	x10

Photomicrograph Description

General view of stone structure. White, pale yellow and blue/grey grains are quartz. Intergranular material is mainly chlorite which is microporous. Brown to dark brown interstitial material is iron or manganese oxide stained chlorite. Red arrow points to oxide stained mica. Another mica flake is at F-G/2-3 position.

3.2.6 Sandberg Consulting Engineers Report no. 41378/G/2

- West Elevation Cornices