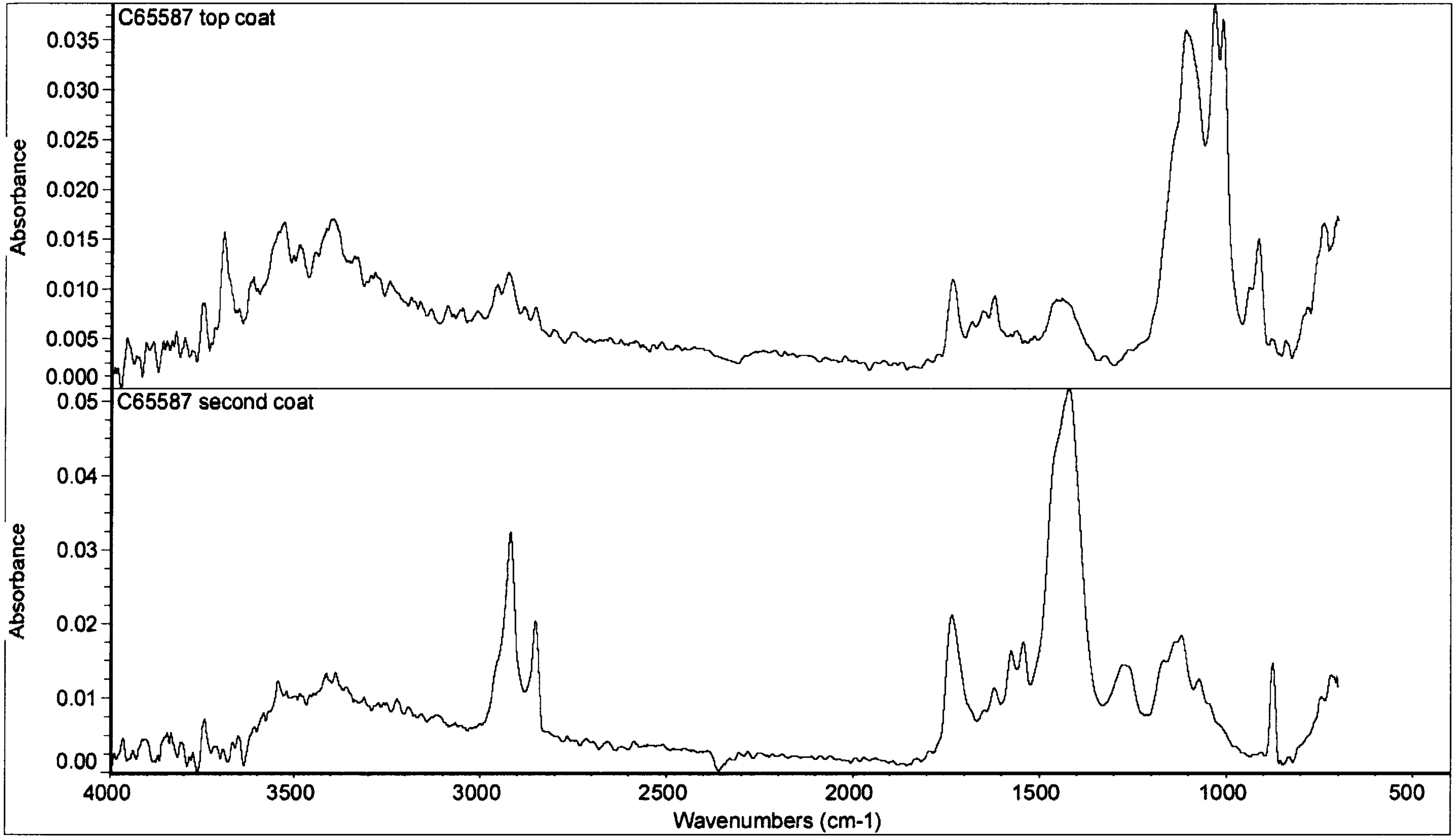
APPENDIX A

INFRARED SPECTRA OF PAINT SAMPLE LAYERS

SANDBERG

40319/C

Infrared spectra of paint sample layers



7.4 Appendix D – Brick and Mortar Specification

Wienerberger

PRODUCT TECHNICAL INFORMATION SHEET

PRODUCT NAME	:	SMEED DEAN BELGRAVE YELLOW STOCK
REF. CODE	:	24230100
DESCRIPTION	:	YELLOW
MANUFACTURE	:	SOFT MUD, MOULDED STOCK
APPEARANCE	:	SANDED STOCK
CONFIGURATION	:	FROGGED - MAX 20%
WORK SIZE *	:	215 x 102.5 x 65

GUARANTEED PROPERTIES EN771-1: 2003

COMPRESSIVE STRENGTH	:	MIN. 15N/mm^2
WATER ABSORPTION	:	MAX. 22%
DURABILITY DESIGNATION	:	F2
ACTIVE SOLUBLE SALTS	:	S2
SIZE TOLERANCE * (/ RANGE)	:	T1- R1
GROSS DENSITY (Tolerance)	:	1380Kg/m^3 (D1)
NET DENSITY (Tolerance)	:	1660Kg/m^3 (D1)
THERMAL CONDUCTIVITY (λ_{10},dry)	:	P=90% 0.51W/m.K
INITIAL RATE OF WATER ABS.	:	2.8Kg/m^2.minute
BOND STRENGTH (General Mortar)	:	0.15N/mm^2 (fixed value)
REACTION TO FIRE	:	Class A1
WATER VAPOUR PERMEABILITY (μ)	:	5/10 (tabulated)
PACK QUANTITY - SIZE	:	500 no - 1100 x 640 x 1120 H
TYPICAL PACK WEIGHT	:	1073 Kg
PACKAGING	:	Shrink Wrapping [YES] Pallet [NO]
BATCH IDENTIFICATION	:	Shrink Wrapping [YES] Product [NO]
ADDITIONAL FEATURES	:	Quality (Kitemark) Certified [YES]
	:	Packaging – CE Marked [NO]

ISSUE : MARCH 2007

TERCA

Pre mixed Natural Lime Mortar

20/04/2009

Pre mixed natural hydraulic lime and sand. A general purpose mortar for building or pointing stone, brick and block: available in different strengths, sand gradings and colours.

Composition

Lime green Natural mortar is a combination of different sands mixed with St Astier pure and natural hydraulic lime with further additions including pigments where required.
Four different sand gradings are available;
TF (0-1mm) **F** (0-2mm) **M** (0-3mm) and **G** (0-5mm).
Lime green has wide range of colour options; a colour chart available on request.

Packing and availability

Available in 25 kg paper bags and sealed one tonne bulk bags for use with the mini silo system. Off white M grade in all three mortar strengths is kept in stock, others are made to order.

Bulk density and consumption

Average bulk density:
Dry: 1550kg/m³: +/-100
Wet: 1550 kg/m³ +/-50.
Repointing: 20kg/m² stonework; 7kg/m² brickwork.
Per 1m³ of wet mortar: building 1200-1800 bricks. All figures approx.

Guidance on mortar choice

Mortar application	Natural Lime Mortar type
Internal use, external walls, soft bricks	Soft mortar *Based on St Astier **NHL2** lime*
General solid masonry Dense masonry, parapets and lintels	Medium mortar *Based on St Astier **NH3.5** lime*
Above roofline, below DPC incl. Copings and cappings Earth retaining walls	Strong mortar *Based on St Astier **NHL5** lime*
The correct specification for any mortar should consider the structural requirements, nature and condition of the background, site exposure, time of the year and type of finish required. Less porous masonry units and harsh climates require greater mortar strength.	

Mixing

Add the whole bag of pre mixed mortar into drum or forced action mixer, avoid creating excessive dust. Add only 4 to 5.5 litres of clean water per bag. Pour the water in slowly as the product mixes, using just enough to achieve the correct workability. Mix for 3 to 10min. Lime green mortars may be reworked up to 24hrs. Please contact us for further information.

Application

Before pointing and building clean and remove all dust and loose material from joints and masonry, and adequately dampen dry or high suction surfaces. Pointing and building mortars should be finished the same day or the following day in cooler periods. Lime mortars will require longer curing times than cement, but the methods and principles of application are similar. When pointing or laying hard impervious masonry and / or during damp cool weather lime mortars may take a few weeks before being fully able to resist frosts. Do not use in temperatures less than 5 ºC or over 30ºC.

Curing

Hydraulic lime mortars do not set as quickly as modern cement based materials; hydraulic lime starts to set once water is added and also hardens by reacting with carbon dioxide: this is a slow process. Strength and long term durability are achieved over a months, not days. Success relies on proper curing of the mortar, protecting it against the effects of drying winds, strong sunlight, rain and frost.
In warm weather gently mist spray with water after application and cover if required with damp hessian sheets. In cool periods cover with protective sheeting, to avoid frost damage.

Further information available upon request.

Performance

Product type	Strong mortar	Medium mortar	Soft mortar
Mortar class	M2	M1	M1
Compressive strength N/mm2 28 days	>2	>1.5	>1
Compressive strength N/mm2 90 days	>5	>4	>2.5
Resistance to Freeze Thaw / sulphates	High	Medium	Medium/Low
Elasticity moduli MPa	9500	7300	6250
Vapour exchange Gm air x m2 x hour x mmHg	0.5	0.64	0.71
Capillary water absorption $kg(m^2.min^{0.5})$	0.59	0.34	0.29

Health & safety

Risk Phrases

R36/37/38 Irritating to eyes, respiratory system and skin

R66 Repeated exposure may cause skin dryness or cracking

Safety phrases

S22 Do not breathe dust

S26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.

S24/25 Avoid contact with skin and eyes

S36 Wear suitable protective clothing

7.5 Appendix E – Petrographic Analysis of Stone

7.5.1 Location of Sample Taken

7.5.2 Report

King's Cross

London

West Range

Characterisation of a stone sample from the West Range, together with recommendations on replacement material

June 2009

Jefferson Consulting Limited

Geology & Petrography in Conservation, Restoration & Archaeology

The Old Armoury
Crown Business Park
Old Dalby, Melton Mowbray
Leicestershire, LE14 3NQ, England

www.jeffersonconsulting.co.uk

Telephone: 01664 822309
Fax: 01664 822666
Cellphone: 078 02 949458
e-mail: enquiries@jeffersonconsulting.co.uk

King's Cross
London
West Range

Characterisation of a stone sample from the West Range, together with recommendations on replacement material

SUMMARY

The sample of stone which was received for analysis is a fine-grained sandstone, probably from the Silesian 'Coal Measures' of West Yorkshire. Although a large number of quarries were producing building stone at the time when King's Cross was being built, the current range of materials is now extremely limited. However, it is considered that the stone sample is very close in composition to modern Woodkirk stone. It is therefore suggested that this stone is used as a replacement, being compatible with the original. The Woodkirk stone which is being currently produced can be greenish grey in colour, weathering to reddish brown. The stone from the higher beds is already naturally weathered to a more reddish colour. It is strongly recommended that suitable blocks are selected on site at the quarry if a more rapid colour blending is required.

CONTENTS

1 INTRODUCTION

King's Cross railway station was built by Lewis Cubitt in 1851-2 for the Great Northern Railway. The West Range was part of the complex and, in common with other parts of the station, incorporated both brick and stone in its construction. Restoration is currently being undertaken at the site. Due to the historical importance of the buildings, it is important to ensure that any stone used for repairs at King's Cross are as close as possible to the original both in appearance and petrography. This will ensure that any potential adverse chemical or weathering reactions with the existing fabric are avoided. It is therefore necessary to characterise the original stone in order to identify a similar material which is currently available. This is achieved by petrographic analysis of samples of stone from the building.

2 SAMPLE FROM THE STONEWORK

A sample of stone from the West Range was submitted by Stonewest Limited for analysis. The actual location of the stonework and the position from which the sample was obtained, are not known. It has been assumed, therefore, that the sample is representative of the stonework to be repaired. The slab-like sample appears to have been removed from the corner of a larger block, two edges being dressed smooth whilst, whilst a third large side, at right angles to the other two is weathered and worn. The bedding is at right angles to this large side and parallel to one of the smooth surfaces. Unlike previous samples from the site, there is little sign of contamination apart from a little iron staining, presumably from associated ironwork.

3 ANALYSIS OF THE SAMPLE

The sample is fine-grained and is typically yellowish brown in colour, about 10YR 6/4 on the Munsell® colour scale. However, there are slight variations from this colour due to the presence of reddish coloured banding in the stone. This is due to variations in iron content of the material and is not related to the bedding, being a late-stage feature in the stone. Such colour variations can vary in intensity and it is not known whether or not those in the sample studied, which are relatively minor, are typical of the building stone in the West Range.

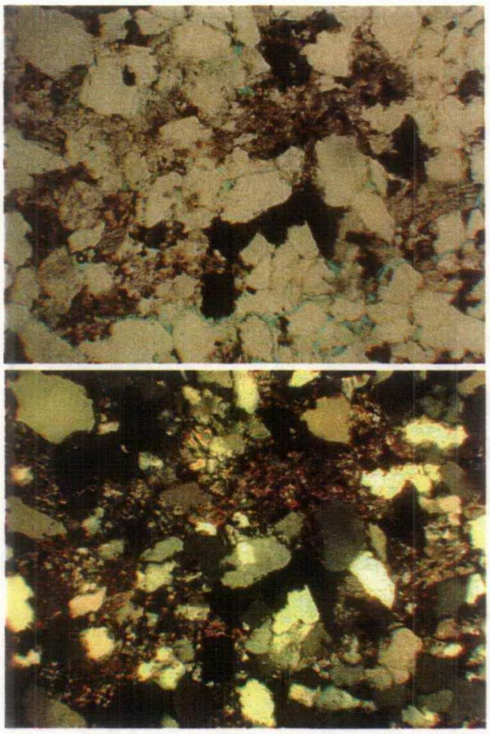


Figure 1. Photomicrograph of the sample of stone from the West Range. Upper picture photographed in ordinary light, the lower picture is the same view in polarized light. The clear grains in the upper picture, which are various shades of grey in polarized light, are quartz. The finely composite grains, both brown and cloudy in ordinary light, are metamorphic rock fragments. The porosity is shown in blue in the upper picture. Width of the pictures is 1.36 mm.

In thin section the stone is seen to be composed of sub-angular to sub-rounded clasts, relatively uniform in size, being about 220 microns in diameter; the rub-rounded particles tend to be the result of syntaxial mineral growth on original sub-angular grains. The particles consist of quartz and fine-grained metamorphic rock, although there are also small quantities of feldspar and traces of mica, the latter sometimes chloritized. There are also traces of carbonaceous material. The iron mineral, which gives the stone its colour, is goethite, although some grains of ilmenite have been identified. The stone is well compacted with no discernable matrix. This has resulted in a low porosity of about 4%. The natural cement in the stone is silica often, as noted above, in the form of syntaxial rims which have grown out from individual clasts and merged to give the stone its structural strength. A photomicrograph of the stone is shown in Figure 1.

The petrography of this stone is typical of many of the sandstones found in the Silesian Westphalian Series, previously known as the Coal Measures, of the Carboniferous succession in West Yorkshire. It appears likely, therefore, that the stone for the West Range was imported from this area, where innumerable quarries existed at the time that King's Cross was being built.

4 REPLACEMENT STONE

Although large numbers of sandstone quarries existed in West Yorkshire at the time the station was being developed, the number of available sandstones is now extremely limited. Petrographic comparison with those which are currently available suggests that Woodkirk stone from Morley would be the most compatible material. A photomicrograph of this stone is shown in Figure 2 for comparison with the sample from the West Range. However, modern Woodkirk from low in the quarry can be greenish grey in colour, although it becomes more reddish brown on weathering. The stone from the higher beds, that is those worked in the 19th century, is already naturally weathered to a more reddish brown colour similar to that in the station. It is strongly recommended, therefore, that suitable blocks are selected on site at the quarry in Morley if a more rapid colour blending is required. The supplier is -

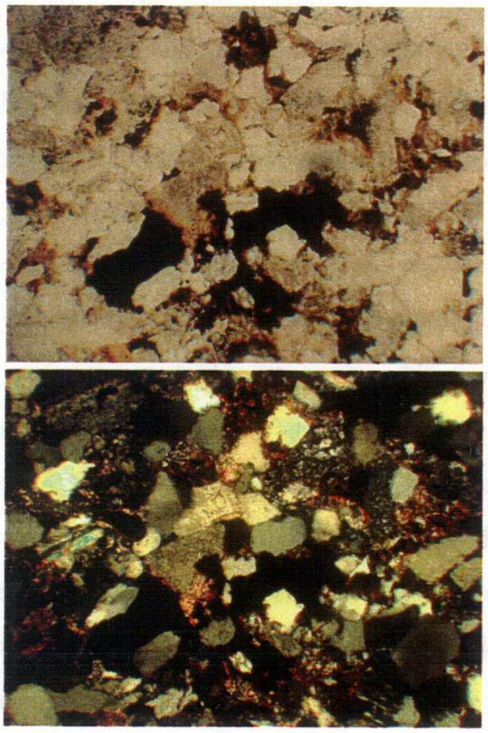


Figure 2. The similarity in the petrography of this sample of Woodkirk stone with the stone from the Western Range, shown in Figure 1, is shown in this photomicrograph. The width of the pictures is 1.36 mm.

Woodkirk Stone
Brittania Quarry
Rein Road
Morley
Leeds
Yorkshire
LS27 0SW
Telephone : 0113 2530464

5 CONCLUSIONS

The sample of stone from the Western Range which was received for analysis and characterisation, is a fine-grained sandstone, probably from the Silesian 'Coal Measures' of West Yorkshire. Although a large number of quarries were available for the supply of stone at the time when King's Cross was being built, the range of materials now available is extremely limited. However, it is considered that the stone from the Western Range is very close in composition to modern Woodkirk Stone. It is therefore suggested that Woodkirk stone is used as a replacement. However, since the Woodkirk stone which is being currently produced is from the lower benches in the quarry, it is greenish grey in colour, although it becomes more reddish brown on weathering. The stone from the higher beds, that is those worked in the 19th century, is already naturally weathered to a more reddish colour. It is strongly recommended that suitable blocks are selected on site at the quarry if a more rapid colour blending is required.

Dr David Jefferson
B.Sc (Hons), Ph.D., C.Eng., C.Sci., F.G.S., F.I.Q., M.I.M.M.M.