

FORT CUMBERLAND, EASTNEY, PORTSMOUTH AN INVESTIGATION OF SOME WINDOW GLASS

TECHNOLOGY REPORT

David Dungworth



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SUMMARY

The chemical analysis of fifteen fragments of window glass from Fort Cumberland was undertaken to identify the composition of glass used during the use of Casemate 54 and the repair of the Guardhouse (c 1940). The fragments of window glass from the Guardhouse all share the same composition and this compares well with reported values for glass manufactured in the middle of the 20th century. The fragments of window glass from Casemate 54 all share the same composition but this differs from reported 19th century glass. It is likely that all of the glass in casemate 54 was replaced in the later 20th century.

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ARCHIVE LOCATION

Fort Cumberland, Fort Cumberland, Road Eastney, Portsmouth, PO4 9LD

DATE OF RESEARCH

2007–2009

CONTACT DETAILS

Fort Cumberland, Fort Cumberland Road, Eastney, Portsmouth, PO4 9LD
David Dungworth, Tel: 023 9285 6783, david.dungworth@english-heritage.org.uk

INTRODUCTION

The analysis of fragments of window glass from Fort Cumberland was undertaken as part of a much larger project investigating the chemical composition of window glass produced and used in Britain during the past five centuries. Samples of window glass have been selected from archaeological excavations (including glass production sites) and from historic buildings. These have been analysed to determine their chemical composition. A comparison of the chemical composition with the available dating evidence shows that a series of changes in window glass manufacturing took place during this period. The aim of this research is to provide a technique to date the manufacture of individual panes of glass in historic buildings. This knowledge will allow architects and others to make more informed judgements about which glass to retain and which can be replaced (Clark 2001).

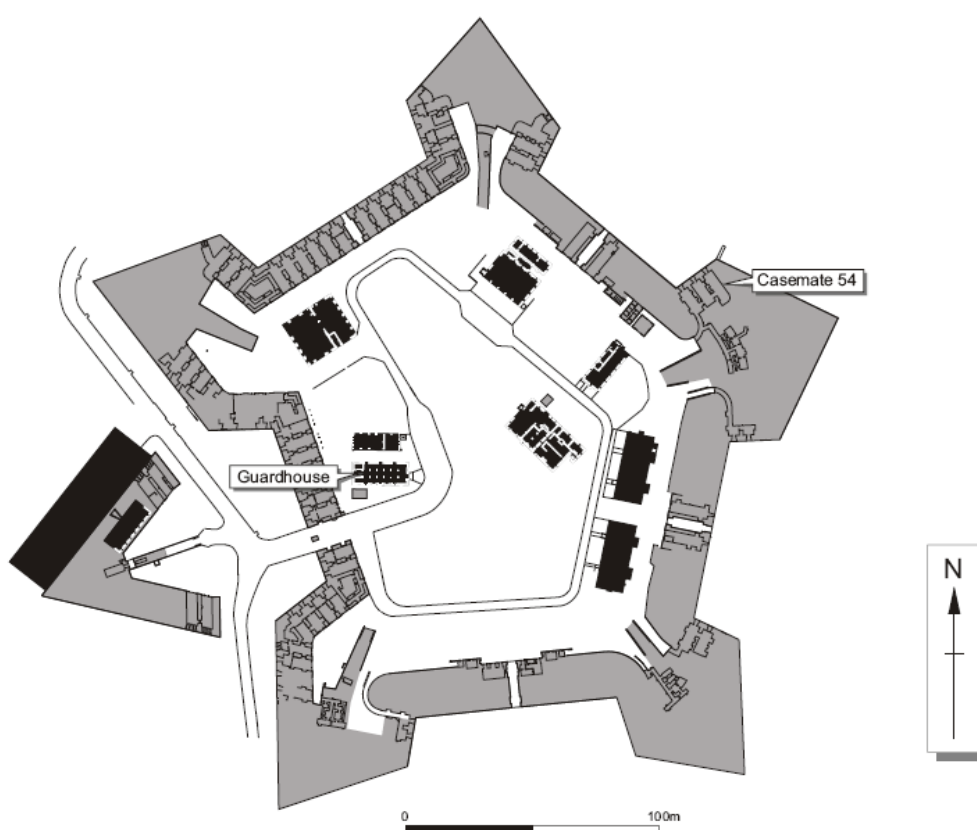


Figure 1. Plan of Fort Cumberland showing the location of the two structures from which window glass samples were taken (drawing by Vince Griffin)

Fort Cumberland lies on the south-eastern tip of Portsea Island and controls access to Langstone Harbour. The fort was originally constructed in the mid 18th century but was completely rebuilt in brick and Portland stone between 1783 and 1812. The guardhouse is one of the few buildings from the mid 18th-century fort which survived the rebuilding. The second fort incorporated casemates within the curtain wall which were used as

stores and accommodation. Fort Cumberland remained in by the armed forces through the 19th and 20th centuries.

Window glass was recovered from two structures within Fort Cumberland: the guardhouse and a blocked window in Casemate 54 (see Figure 1). The window glass from the guardhouse was *in situ* at the time of sampling (2009) and was collected when the windows were being replaced. While the window glass from the guardhouse could be as early as its construction (1748–49) it is most likely that these windows were replaced in late 1940 following bomb damage. The window glass from casemate 54 comprised fragments of glass found lying in the vicinity of a window. This window glass could be as early as the construction of the casemate (1810) but might represent later replacement. The window is believed to have been blocked prior to the early 1950s.

METHODS

All of the fragments of glass were mounted in epoxy resin and ground and polished to a 3-micron finish to expose a cross-section through the glass. The samples were inspected using an optical microscope (brightfield and darkfield illumination) to identify corroded and uncorroded regions. None of the Fort Cumberland samples exhibited any substantial corroded surfaces. The samples were analysed using two techniques to determine chemical composition: SEM-EDS and EDXRF. The energy dispersive X-ray spectrometer (EDS) attached to a scanning electron microscope (SEM) provided accurate analyses of a range of elements while the energy dispersive X-ray fluorescence (EDXRF) spectrometer provided improved sensitivity and accuracy for some minor elements (in particular manganese, iron, arsenic, strontium and zirconium) due to improved peak to background ratios.

The SEM used was a FEI Inspect F which was operated at 25kV with a beam current of approximately 1.2nA. The X-ray spectra generated by the electron beam were detected using an Oxford Instruments X-act SDD detector. The quantification of detected elements was achieved using the Oxford Instruments INCA software. The EDS spectra were calibrated (optimised) using a cobalt standard. Deconvolution of the X-ray spectra and quantification of elements was improved by profile optimisation and element standardisation using pure elements and compounds (MAC standards). The chemical composition of the samples is presented in this report as stoichiometric oxides with oxide weight percent concentrations based on likely valence states (the exception being chlorine which is expressed as element wt%). The accuracy of the quantification of all oxides was checked by analysing a wide range reference materials (Corning, NIST, DGG and Newton/Pilkington). A number of elements were sought but not detected: phosphorus, vanadium, chromium, manganese, cobalt, nickel, copper, zinc, arsenic, tin, antimony, rubidium, barium and lead.

Table 1. Minimum Detection limits (MDL) and analytical errors for each oxide

	SEM-EDS		EDXRF		
	MDL	Error		MDL	Error
Na ₂ O	0.1	0.1	V ₂ O ₅	0.02	0.03
MgO	0.1	0.1	Cr ₂ O ₃	0.02	0.03
Al ₂ O ₃	0.1	0.1	MnO	0.02	0.03
SiO ₂	0.1	0.2	Fe ₂ O ₃	0.02	0.03
P ₂ O ₅	0.1	0.1	CoO	0.02	0.02
SO ₃	0.1	0.1	NiO	0.02	0.03
Cl	0.1	0.1	CuO	0.02	0.01
K ₂ O	0.1	0.1	ZnO	0.02	0.01
CaO	0.1	0.1	As ₂ O ₃	0.03	0.01
TiO ₂	0.1	0.1	SnO ₂	0.1	0.05
BaO	0.2	0.1	Sb ₂ O ₅	0.15	0.07
			Rb ₂ O	0.005	0.005
			SrO	0.005	0.005
			ZrO ₂	0.005	0.005
			PbO	0.03	0.02

RESULTS

All of the Fort Cumberland samples are soda-lime-silica glasses typical of glass produced since the glass industry began to use synthetic soda in place of plant ashes c1830 (Dungworth 2009). The samples form two tight compositional clusters with no overlap between the guardhouse samples and the casemate 54 samples (Table 2). The variation in chemical composition of the guardhouse samples is extremely low (less than the analytical precision) and there can be little doubt that all of this glass was made at the same time by the same glass manufacturer. The glass from casemate 54 shows slightly more chemical variation: sample C54.02 has slightly less silica than the other samples and C54.04 contains slightly more calcium and less iron than the other samples.

*Table 2. Chemical composition of the Fort Cumberland glass samples
(GH = guardhouse; C54 = casemate 54)*

#	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	SO ₃	Cl	K ₂ O	CaO	TiO ₂	Fe ₂ O ₃	SrO	ZrO ₂
GH.01	14.54	2.96	0.20	72.71	0.23	<0.05	<0.05	9.24	<0.05	0.103	0.009	0.005
GH.02	14.49	2.91	0.23	72.78	0.16	<0.05	<0.05	9.25	0.06	0.108	0.009	0.008
GH.03	14.49	2.98	0.22	72.73	0.17	<0.05	<0.05	9.29	<0.05	0.107	0.009	0.005
GH.04	14.38	2.85	0.23	72.76	0.21	0.05	<0.05	9.39	<0.05	0.104	0.008	0.009
GH.05	14.54	2.96	0.23	72.68	0.19	<0.05	<0.05	9.28	<0.05	0.106	0.009	0.007
GH.06	14.52	2.92	0.22	72.77	0.21	<0.05	<0.05	9.23	<0.05	0.105	0.006	0.008
GH.07	14.58	2.88	0.24	72.69	0.19	<0.05	<0.05	9.23	0.06	0.100	0.008	0.007
GH.08	14.53	2.92	0.19	72.75	0.19	<0.05	<0.05	9.30	<0.05	0.101	0.007	0.009
C54.01	13.67	3.94	1.30	72.53	0.21	<0.05	0.49	7.61	<0.05	0.230	0.010	0.009
C54.02	13.43	3.78	1.35	72.37	0.22	0.06	0.52	7.95	0.07	0.233	0.010	0.008
C54.03	13.28	3.86	1.30	72.56	0.22	<0.05	0.55	7.92	0.07	0.251	0.008	0.009
C54.04	13.21	3.77	1.36	72.54	0.27	<0.05	0.53	8.11	<0.05	0.176	0.010	0.007
C54.05	13.36	3.90	1.23	72.57	0.19	<0.05	0.53	7.97	<0.05	0.233	0.007	0.010
C54.06	13.44	3.91	1.25	72.57	0.18	<0.05	0.50	7.84	0.06	0.233	0.006	0.007
C54.07	13.39	3.85	1.34	72.51	0.19	<0.05	0.53	7.95	<0.05	0.235	0.006	0.009

DISCUSSION

All of the samples of window glass from the Guardhouse share the same chemical composition and this corresponds almost exactly with Smrcek's data for drawn glass produced between 1930 and 1960 (Table 3). The composition of this glass contrasts with late 19th-century glass which has very low concentrations of magnesium (<0.5wt% MgO). It is known that magnesia was deliberately added to glass from c1930 in order to overcome problems of devitrification during the drawing process (Cable 2004). Smrcek's data shows that glass of this period tended to contain very low concentrations of iron compared to both earlier and later glass; a phenomenon which is also apparent in the Guardhouse samples.

The window glass from casemate 54 does not correspond with any known 19th-century glass (Table 3). In particular the magnesium concentration of the casemate 54 glass is much higher than any 19th-century glass. The chemical composition of the casemate 54 glass corresponds most closely to glass made after 1960 using the float process. Such glass can be distinguished from drawn glass of the middle of the 20th century by its slightly higher magnesium and iron content. The chemical composition of the glass (and the date of manufacture which this implies) is not consistent with the archaeological/architectural context which would place manufacture before 1960.

Table 3. Chemical composition of some 19th- and 20th-century flat glass
(Sources: 1 = Dungworth 2009; 2 = Hatton 2004; 3 = Dungworth and Wilkes 2010;
4 = Dungworth 2010; 5 = this report; 6 = Smrcek 2005, nr = not reported)

	Source	Date	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	SO ₃	K ₂ O	CaO	Fe ₂ O ₃	As ₂ O ₃
Chatsworth	1	1837–40	14.0	<0.1	0.7	70.3	0.34	<0.1	14.1	0.20	0.41
Nailsea	2	1830–70	13.1	0.2	0.8	68.9	0.60	0.1	13.5	0.33	0.22
Wentworth I	3	1877	11.9	0.4	0.7	71.5	0.24	0.3	14.3	0.28	<0.02
Welch Road	4	1894–95	11.6	0.1	1.5	72.5	0.30	0.6	13.1	0.20	<0.02
Fort Cumberland (GH)	5	1940	14.5	2.9	0.2	72.7	0.19	<0.1	9.3	0.10	<0.02
Drawn	6	1930–60	14.6	2.1	1.0	72.0	0.45	0.1	9.8	0.12	nr
Fort Cumberland (C54)	5		13.4	3.9	1.3	72.5	0.21	0.5	7.9	0.23	<0.02
Float	6	1960–99	13.8	4.1	1.1	71.9	0.19	0.6	8.1	0.19	nr

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