Developing a future repairs strategy for a sandstone city: A petrographic investigation of building stone in Glasgow, Scotland

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ARTICLE DATA

Article history:
Received 22 May 2008
Received in revised form
30 September 2008
Accepted 1 November 2008

Keywords:
Sandstone
Petrography
Stone-matching
Quarries

ABSTRACT

Glasgow is the largest city in Scotland, and has some of the finest historic stone architecture in the United Kingdom. All the building stone quarries in the Glasgow area are closed and stone for repairs is now imported. Six types of 'blonde' sandstone and four types of 'red' sandstone have been identified from petrographic analysis of 126 samples from traditional buildings throughout the city. Currently available stone types from active quarries have been identified which have similar characteristics, in order to ensure compatibility of long-term performance for repairs. A number of the original sandstone types do not match with stone currently being quarried, and there is a need to reopen historic quarries, or new quarries which can supply similar stone. The data provide a framework to improve decision-making in the selection of appropriate stone for repairs to ensure the future long-term health of historic buildings in the city of Glasgow.

1. Introduction

Glasgow is recognised as having some of the finest Victorian architecture in the United Kingdom. As the industrial and commercial capital of Scotland it saw a rapid expansion from the late 18th century, through the 19th century and into the early 20th century, initially from the shipping and merchant trade and latterly through industrial production and manufacturing. Stone was the building material of choice, and the rapid urban growth resulted in a wide range of building types, from utilitarian high density residential blocks (tenements) to elegant terrace and villa developments, schools, churches, public and commercial buildings. By the 1890s Glasgow was known as the 'Sixth City of Europe' with some of the finest examples of architecture of its time.

Glasgow is a city characterised by sandstone, dominated by the locally-available pale- or cream-coloured 'blonde' sandstones of Carboniferous age. Following the arrival of the railways, 'red' sandstone of Permian/Triassic age was used from the mid-1880s, imported from quarries further to the south in Ayrshire and Dumfriesshire. By the early 20th century, red sandstone had become favoured for many public buildings, schools, churches and tenement fronts, and became important in the latter stages of stone construction in the city.

Today, many of Glasgow's buildings are of an age and condition where the masonry is showing signs of decay and requires repair. A legacy of former air pollution from industrial sources and domestic coal burning has accelerated stone decay in many parts of the city. Further significant deterioration of sandstone has been caused by inappropriate intervention and poor quality repairs. Stone cleaning, much of which took place during large-scale public-funded urban regeneration schemes in the second part of the 20th century, has resulted in widespread damage [1,2]. The proliferation of so-called 'plastic' repairs using impervious cement materials applied to the softer porous sandstones, often to stone damaged by stonecleaning, has also resulted in considerable damage. The extensive use of these techniques in the second half of the 20th century has

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doi:10.1016/j.matchar.2008.11.004

created a situation where many stone buildings in the city are now in need of urgent attention and stone replacement.

This paper describes results of a petrographic investigation of sandstone samples from buildings in Glasgow, undertaken as part of a recent large-scale project which was carried out to assess the future stone masonry skills and the stone materials needed to conserve and repair the stone-built heritage of Glasgow over the next 20 years. It is recognised that a shortage in the availability of stonemasonry skills and training, and a lack of supply of appropriate 'matching' stone for repairs is having a detrimental impact on the stone-built heritage of Glasgow, and Scotland in general. To address this issue the project 'Safeguarding Glasgow's Stone Built Heritage: Skills and Materials Requirements' was established by the Scottish Stone Liaison Group (SSLG), commissioned by Scottish Enterprise Glasgow. The British Geological Survey (BGS) was appointed to undertake stone condition surveys and petrographic analysis of stone samples, and it is these latter studies that are described in this paper. The full results of the project are published in a detailed report by the SSLG [3].

2. Materials and Methods

The project involved undertaking condition surveys of a representative sample of sandstone facades, selected in order to represent the range of stone buildings and stone types throughout the city [3]. The volumes of stone requiring replacement and the stonemason time and skills levels required for the repairs were calculated from these data, and extrapolated for the whole city. Characterisation of the types of sandstone required was undertaken by obtaining small samples of stone from selected buildings, followed by petrographic analysis to determine the variability of stone present. Representative core samples of ~45 mm diameter were obtained from buildings using a portable diamond core drill. Samples were prepared as standard petrological thin sections, impregnated with blue dye resin to highlight porosity.

A methodology for the facade surveys was designed to allow the rapid assessment of a large number of facades in order to produce quantitative data from which volumes of stone for repair were calculated. A total of 234 building facades were selected for survey, from 114 statutory listed buildings and 120 unlisted buildings, chosen to represent a range of building types from different parts of the city. A number of other criteria were used in the selection of buildings in order to ensure a representative sample of facades, including age of a building, geographical distribution within the city, style of masonry construction and facade orientation. Full details of the methodology used for the project are given in the project report [3].

The results of the facade surveys were produced as digital images rectified to scale, with areas of stone decay digitally overlaid onto the image, using software to automatically calculate the areas of stone decay (Fig. 1). The urgency of the repairs were highlighted on the digital images using different colours, and a series of codes were used to show different types of stone decay. A series of decay categories were devised specifically for this project which are relevant to stone buildings in Glasgow, based on published schemes by a number of recognised workers e.g. [4,5].

3. Sources of Stone Used for the Construction of Glasgow's Stone-Built Heritage

The blonde sandstone used for the majority of stone buildings in Glasgow was obtained from a large number of quarries within and around the city, and varies widely in character and quality. Approximately 75 known (i.e. named) sandstone quarries of significant size and output were present in the Glasgow district, although there were probably many more smaller scale excavations [6–8]. As in many other cities, the earliest quarries were located close to the city centre and subsequently became infilled or subsumed by urban development, and essentially sterilised from further use. Most quarries probably supplied only the local neighbourhood, whilst a lesser number of larger quarries were more significant, supplying stone more widely and for more prestigious buildings. For example, a series of quarries at Bishopbriggs and Giffnock (both located on the outskirts of the city) produced high quality freestones that were used throughout the city, as well as transported widely to other areas of Scotland and overseas (e.g. Giffnock stone was shipped to Ireland). Towards the end of the 19th century so much construction was going on that blonde sandstone had to be obtained from large quarries further afield in the central belt of Scotland (e.g. Stirlingshire and Lanarkshire).

As many local quarries became depleted and were engulfed by urban expansion, the arrival of the railways allowed the importation of red sandstone from Ayrshire and Dumfriesshire in southwest Scotland. This stone type quickly established itself in the city and the quarries were new and large and could produce large quantities of high quality stone. The red sandstone was also relatively easily worked and (being of aeolian as oppose to fluvial origin) was relatively free from impurities such as mud, clay and carbonaceous material. It is also possible that the use of red coloured stone became a fashionable alternative to the blonde sandstone which had dominated the city from its earliest times.

The large variety and mixture of sandstone types used in Glasgow (both local and 'imported' sandstone) gives a particular character to the city. It also means that there is a large variation in performance of stone in the city, with some types more prone to decay than others. This variety of stone types means that particular care has to be taken in the repair of Glasgow buildings through careful identification of stone and the selection of appropriate currently-available matching stone. None of the original quarries in the Glasgow district and throughout the Scottish central belt that supplied blonde sandstone for the construction of Glasgow are open today, and only a few of the original red sandstone quarries in southwest Scotland are still active. Almost all the blonde sandstone currently used for repairs (and new build) in the city has to be imported from sandstone quarries in the north of England. Recent research into the performance of replacement sandstone in nearby Edinburgh (also dominated by local pale coloured Carboniferous sandstones) has shown that the use of replacement sandstone with different characteristics to the original sandstones can result in damage to the remaining historic sandstone masonry in a building [9]. The first step to an improved understanding of the importance of careful