12th International Congress on the Deterioration and Conservation of Stone
Columbia University, New York, 2012

RECORDING DATA FOR STONE CONSERVATION PROJECTS

Emily A. Tracey[1]

[1]*Building Stone Conservation, British Geological Survey, Murchison House, Edinburgh, United Kingdom*

Abstract

Organisations responsible for conserving our stone-built heritage need accurate information about buildings, building stone and stone condition in order to plan effective repair and maintenance strategies. To meet this need in the UK, the British Geological Survey (BGS) has developed a 'Building Stone Data Capture' module in its System for Integrated GeoScience Mapping (SIGMA - the BGS preferred tool for digital field capture of geoscience data). The module was developed for the documentation and investigation of a stone built environment, from small towns to large cities. Data are captured in the field on hand-held PC tablets running the SIGMA application. Individual buildings are recorded as separate entities and identified uniquely by GPS location. A set of predetermined data fields and supporting dictionaries guide and restrict the range of building and stone properties that can be recorded, ensuring a high degree of consistency in the dataset. Stone type and stone condition data can be recorded for different stone architectural elements over a single façade. The wide range of data for each building can be sorted, selected and combined quickly and easily, and presented as tabulations, statistical results, or in map form. GIS presentation of the data provides a powerful and versatile planning tool, which can be used to quantify material requirements, categorise maintenance issues and display a wide range of spatially referenced data.

A survey of 380 stone-built structures in the conservation area of Callander, a small town in Loch Lomond & The Trossachs National Park, UK, is used to demonstrate the utility and GIS output of the Building Stone Data Capture module.

Keywords: documentation, building stone, condition, repair, maintenance, conservation

1. Introduction

Organisations responsible for conserving our stone-built heritage need accurate information about the structures, the stone types used in them, and the stone condition, in order to design and implement effective repair and maintenance strategies. Many conservation charters require that the physical features of a built site, and every stage of work (including repairs), is recorded before intervention (Burra Charter 23 1979) and after (Venice Charter 16 1964) (Bell 1997). Finding ways to record data for stone-built structures efficiently, accurately and consistently is therefore becoming increasingly important. However, the considerable variability of stone-built structures, and their three-dimensional form, present significant challenges; a successful data collection system needs to be able to cope with this variability and easy to use.

Over the past two decades, several systems for mapping stone type and stone condition in built structures have been developed. A system using a classification of weathering forms to map stone deterioration across building façades (Fitzner et al. 1997; Fitzner 2004) has been applied to several stone-built world heritage sites. Simpler systems have also been developed; some use digital image processing to map different forms of surface decay (Zezza 1994, 2002) and others use a Geographic Information System (GIS) to store, display and analyse captured information (in one instance, to characterise the stability of rock art; Dorn et al. 2008).

Most of the existing documentation systems tend to focus on the classification and terminology for specific tasks and are not particularly flexible. None are suited to rapid surveys of multiple structures of varying type-the kind of survey that local authorities or conservation organisations (for example) may require in order to develop repair and maintenance strategies for a group of built sites (e.g. conservation area).

To meet this need in the UK, the British Geological Survey (BGS) has developed a 'Building Stone Data Capture' module in its System for Integrated GeoScience Mapping (SIGMA-the BGS preferred tool for digital field capture of geoscience data) that incorporates some elements of existing systems to document stone type and stone condition data. The module was developed as a portable, flexible system for digital field data capture that can be used for any number of stone-built structures in any setting.

2. The BGS ‘Building Stone Data Capture’ module

The System for Integrated GeoScience Mapping (SIGMA) is a digital tool that has been developed by BGS for field data recording and data collation. SIGMA is an open-source relational database system built under the BGS Spatial GeoScience Technology Programme, and is the BGS preferred tool for field data capture. Data are currently captured on Xplore iX104 tablet PCs running Microsoft XP.

SIGMA is designed to allow a wide range of geological and other data to be captured quickly and consistently. Separate modules are tailored to different types of survey (e.g. geological mapping and borehole logging activities). A ‘Building Stone Data Capture’ module has been developed recently to capture data arising from rapid surveys of stone-built structures. The module consists of a database of hierarchically arranged attribute fields, many of which are supported by dictionaries of defined terms that guide and restrict the way they can be populated. A simplified representation of the hierarchical structure of the Building Stone Data Capture module is shown in Figure 1 and a screenshot of the ‘Building Stone Data Capture’ module with predetermined data fields and supporting dictionaries is presented in Figure 2.

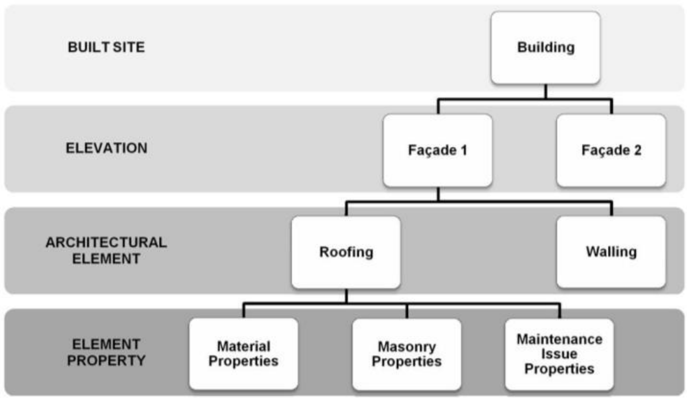

Figure 1 Simplified hierarchical diagram of the Building Stone Data Capture module demonstrating the relational database of a built site as surveyed in CCA.

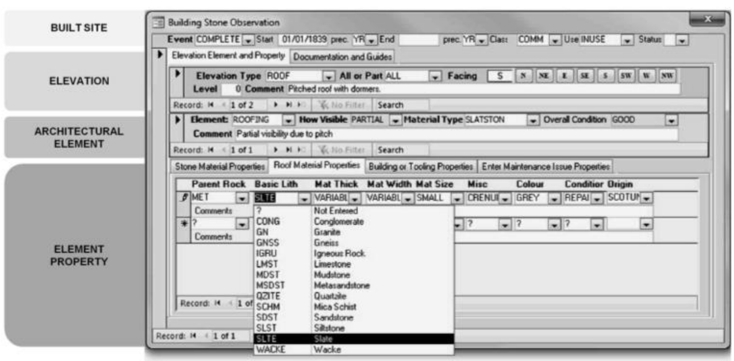

Figure 2 Module input form, as seen on tablet PCs used during survey, with hierarchy labelled on left hand side. The form is used to enter data into the relational database. The number of elevations and elements are selected, and properties are recorded for each element using a number of pre-defined fields with supporting drop-down dictionaries.

Both images will be explained further through the Callander Conservation Area survey case study presented below.

Capturing accurate survey data for stone-built sites in a concise, consistent way is made difficult because built sites vary enormously in many ways, including their physical attributes, materials and construction history. For example, an effective data capture system needs to be able to deal with any type of built structure (e.g. buildings, monuments, bridges, paved areas), and for buildings alone it needs to be able to deal with any number of façades, roof pitches and corresponding architectural elements (walling, dressings, chimneys, carvings, etc.).

The key features of the BGS 'Building Stone Data Capture' module are:

- Individual sites (e.g. buildings) are recorded as separate entities, with a unique identifier and GPS location.

- A set of predetermined data fields and supporting dictionaries guide and restrict the range of building and stone properties that can be recorded, ensuring a high degree of consistency in the dataset.
- Fields and dictionaries can be adapted to suit project requirements.
- Stone type and stone condition data can be recorded at any scale, e.g. for different architectural elements over a single façade, for a whole building, or for an entire settlement.
- Once the survey is completed, the recorded data can be transferred to data files that can be interrogated independently or used within a Geographic Information System (GIS).

The combined SIGMA-GIS approach provides a convenient means of systematically recording, storing, updating, interrogating and displaying a wide range of spatially referenced data. In its GIS form the dataset can be presented as tabulations, statistical results, or on a map. Queries can be used to quickly select, organise and view subsets of data, or to compare and contrast different aspects of the data, thereby providing a powerful and versatile planning tool.

The digital, hierarchical method of data capture and storage has two important advantages over traditional 'analogue' methods: (i) the pre-determined hierarchy of fields and the supporting dictionaries ensure a high degree of consistency in the dataset; (ii) data recorded for single attributes or combinations of attributes can be selected and manipulated easily, allowing statistical or geospatial patterns to be drawn from the data.

3. Callander Conservation Area case study

A building stone and slate survey of Callander Conservation Area, Loch Lomond & The Trossachs National Park, UK (Tracey et al. 2011) provides a useful case study to demonstrate the utility and GIS output of the BGS 'Building Stone Data Capture' module. The aim of the project was to inform planning decisions regarding repairs to, and construction of, stone-built structures within the Callander Conservation Area (CCA). The project objectives included (but were not limited to) the following:

- Provide an inventory of the stone and slate types used in the CCA.
- Illustrate the distribution of the identified stone and slate types.
- Identify stone and slate maintenance issues for the CCA.

These objectives were tackled by conducting a detailed survey of the stone-built structures within the conservation area using the 'Building Stone Data Capture' module, followed by a process of data interrogation and interpretation.

3.1 The survey

The project was designed to include all stone-built structures with street-facing façades in the conservation area. Prior to the survey, all stone-built structures were identified and recorded as individual 'polygons' in a geospatial vector data format (shapefile) for use in the SIGMA-GIS software (Figure 3). Each polygon was assigned a 'Field Observation Point' (FOP) or unique reference number for identification.

Figure 3 GIS aerial base map with geo-referenced polygons representing the limits of each unique built site. Each polygon has a Field Observation Point, or unique reference number, used for identification and data attribution.

For each FOP, stone and slate details (or 'properties') were recorded against three architectural elements: roofing, walling and dressings (window and door surrounds). Properties were categorized into three groups: material, masonry style and maintenance issues. Table 1 presents material and masonry style properties, and is followed by a brief description of maintenance issue properties. Supporting dictionaries were prepared for each recorded property to ensure consistency within the dataset and between surveyors. This also allows for data sorting and statistical analysis upon survey completion.

Building Stone		**Slate**	
Material Properties	Masonry Style	Material Properties	Masonry Style
visibility (e.g.visible, partially visible, not visible) rock type (e.g. sedimentary) basic lithology (e.g. sandstone) texture grain size colour origin (if known)	block shape coursing tooling	visibility rock type basic lithology thickness size lustre colour origin (if known)	coursing width

Table 1 List of material and masonry style properties, which can be recorded for stone and slate, as predetermined for the CCA survey. Each property also has a supporting dictionary.

'Maintenance issue properties' were also attributed to each surveyed architectural element. More than one maintenance issue can be recorded where necessary. Both causes and effects of stone deterioration (e.g. cause: face bedding, effect: delamination) were included in the dictionary.

The 'Building Stone Data Capture' module has no limitation on the number of façades and architectural elements data can be attributed to. Attributes, fields and dictionaries can be adapted according to project requirements. For example, the date of construction, structure type (i.e. residential, commercial, infrastructural, etc.), current use (i.e. vacant, occupied) and listing status were also recorded for every surveyed site in CCA. In this case study, the stone and slate material properties followed the classification and nomenclature of the BGS Rock Classification Scheme and the stone deterioration dictionary terms and definitions for the maintenance issue properties followed the ICOMOS-ISCS *Illustrated Glossary on Stone Deterioration Patterns* (Vergès-Belmin 2008).

3.2 Data interpretation

After the fieldwork was complete, all data were imported into a project database, checked for consistency, validated and then uploaded to a project GIS for data interpretation and delivery. For the complete work flow diagram and conceptual diagram of the module see Figure 4.

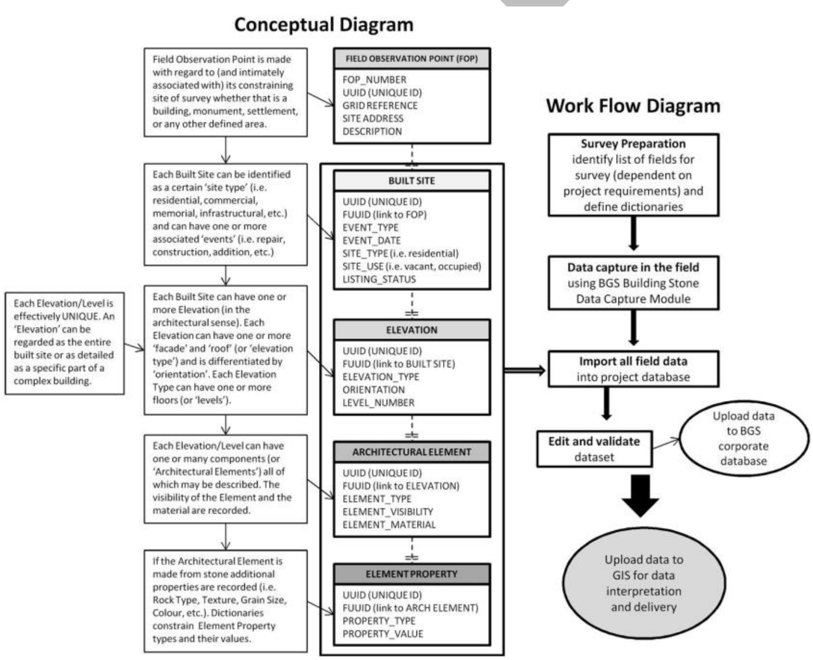

Figure 4 The conceptual diagram defines the relationship of the data elements in the Building Stone Data Capture module and the structure between them. The Work Flow diagram defines the process of population and data delivery.

Large, complex datasets stored in relational databases are difficult to display on 2-dimensional maps. However, with the data uploaded to a GIS, it is easy to quantify material requirements, categorise maintenance issues and display a wide range of spatially referenced data. Users are able to select and view data associated with each built site (or 'polygon') in attribute tables. Supplementary data relevant to the site can be uploaded (e.g. geological, historical and photographic information) and viewed as additional GIS layers, and data can be interrogated to produce useful datasets for planners (for example outputs of GIS queries see Figures 5 and 6).

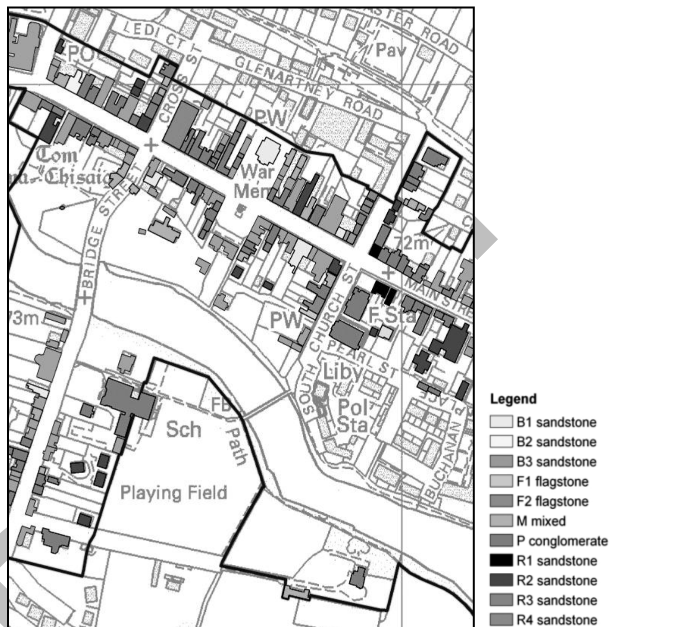

Figure 5 GIS topographic base map of Callander town centre with coloured (in grey-scale) polygons representing surveyed sites displaying the distribution of stone types used in WALLING (left) and the distribution of slate types (right) used in ROOFING in the Callander Conservation Area. This map is typically viewed in colour (not grey-scale) to better differentiate the distribution of stone and slate types to the user.

The building stone data collected during the CCA survey were used to assign a unique stone or slate 'code' to represent each of the different stone and slate types recorded in the conservation area. The appropriate code was then assigned to each corresponding architectural element (walling, dressing or roofing) allowing the distribution of stone and slate types to be displayed in GIS. The special prevalence of maintenances issues could also be displayed (Figure 6). Cross queries of stone or slate type with maintenance issues identified the most common conservation problems in Callander. As a result, identification of maintenance strategies and conservation techniques to mitigate damage and prevent further deterioration was possible.

Figure 6 GIS aerial base map of Callander Conservation Area displaying a cross query of all surveyed built sites with CONGLOMERATE walling and CEMENT POINTING AND PATCHING.

4. Conclusion

A building stone survey methodology and associated data capture module has been developed (based on the BGS System for Integrated GeoScience Mapping [SIGMA]) that allows a wide range of attributes describing stone/slate type and stone/slate condition to be linked to architectural elements within single geospatially referenced sites, rapidly and consistently, in a digital, hierarchical form, in the field.

The survey data are presented as attribute tables linked to 'polygons' (one polygon per surveyed site). This format allows subsets of the data to be sorted, selected and combined quickly and easily, and presented in either statistical form or map form, thereby providing a powerful and versatile planning tool.

The SIGMA-GIS approach provides the flexibility required for surveying stone-built sites. The module is able to adapt to any type of structure and it applies to any scale (ranging from an entire town, to a single building, architectural element, or single block of stone). A range of expertise is needed to fully populate the module; however, the data can be presented in a user-friendly visual manner in GIS or map form creating a powerful heritage planning tool. Additionally, the spatially referenced digital data can easily exploit the power of queries and be converted into statistical form due to the use of pre-determined, hierarchical fields and supporting dictionaries, which ensure a high degree of accuracy and consistency in the dataset. Other spatially referenced data can be imported into the GIS interface for comparison and further analysis.

These new methodologies can be applied generically-BGS will continue to use this survey methodology in future studies to ensure a consistency of approach and terminology. All of the data currently collected are also stored in the 'Building Stone Database of the United Kingdom', which is monitored, populated and maintained with the intention of open documentation and public accessibility by the

British Geological Survey. The key functions of this database are (i) to store and retrieve data for natural building stone; and (ii) to aid in stone matching.

5. Acknowledgements

This paper is published with the permission of the Executive Director, BGS (NERC).

6. References

Bell, D. 1997. 'Technical Advice Note 8: the Historic Scotland guide to international conservation charters'. In *Edinburgh: Technical conservation, research and education division of Historic Scotland*, Urquhart, D. (ed.) Edinburgh: Historic Scotland.

Dorn, R I, Whitley, D S, Cerveny, N V, Gordon, S J, Allen C D, and Gutbrod, E. 2008. 'The Rock Art Stability Index: A new strategy for maximizing the sustainability of rock art', *Heritage Management*, **1**(1): 37-70.

Fitzner, B, Heinrichs, K, and Kownatzki, R. 1997. 'Weathering forms at natural stone monuments: Classification, mapping and evaluation', *Restoration of Buildings and Monuments: an International Journal*, **3**(2): 105-124.

Fitzner, B. 2004. 'Documentation and evaluation of stone damage on monuments', in *Proceedings of the 10th International Congress on Deterioration and Conservation of Stone, Stockholm, June 27-July 2, 2004*, Kwiatkowski, D, and Lofvendahl, R. (eds). 677-690. Stockholm: ICOMOS Sweden.

Tracey, E A, Albornoz-Parra, L J, Everett, P A, and Gillespie, M R. 2011. 'A building stone and slate survey of the Callander Conservation Area: recording, matching and sourcing for the built heritage', B*ritish Geological Survey Research Report*, OR/11/011.

Verges-Belmin, V. 2008. *Illustrated Glossary on Stone Deterioration Patterns*. Paris: ICOMOS and ISCS.

Zezza, F. 1994. 'Stone decay diagnosis and control of treatments by computerized analytical techniques'. In *Conservation of Monuments in the Mediterranean Basin: Stone Monuments, Methodologies for the Analysis of Weathering and Conservation; Proceedings of the 3rd International Symposium, Venice, 22-25 June 1994.* Fassina, V, Ott, H, and Zezza, F. (eds.) 77-81. Venice: Soprintendenza ai beni artistici e storici di Venezia.

Zezza, F. 2002. 'Non-destructive technique for the assessment of the deterioration processes of prehistoric rock art in karstic caves: The Palaeolithic paintings of Altamira (Spain)', In *Protection and Conservation of the Cultural Heritage of the Mediterranean Cities*. Galan Huertos, E and Zezza, F. (eds.) 377-388. Lisse, Netherlands, and Exton, PA: Balkema.