Cleaning
Historic Buildings
Volume 1
SUBSTRATES, SOILING AND INVESTIGATIONS
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Volume 1

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For much of the twentieth century, cleaning of the masonry materials of which traditional buildings in the United Kingdom are composed has formed an integral part of conservation and repair programmes. It is likely to remain so but there is a call for a greater understanding of the need for and the effects of what is being done. Technical information has not been readily available and currently remains incomplete and scattered. This book aims to redress both situations.

The volumes are based on materials and practices common in the UK but their value and usefulness is international. Important basic principles are presented which should be considered when it is proposed that any building or structure of historic value is to be cleaned. Assessment criteria leading to the decision to clean or not to clean are considered, along with the special and individual characteristics of each of the traditional masonry materials which are commonly involved. These include sandstones, granites, limestones, brickwork, terracotta, faience, mortars and renders. The natures of the various types of soiling are described, as are the strengths and weaknesses of currently available cleaning methods.

These volumes are intended to improve the understanding of those involved in the many aspects of masonry cleaning and thereby to improve the quality of decision-making and workmanship undertaken.
They will serve professionals, advisors, building owners and practitioners by providing a sound base of information with a strong practical emphasis. They emphasize the need to investigate each situation before designing a cleaning process suited to it. They urge the need to avoid assumptions and a dependence on cleaning systems and any recommendations or cleaning systems which claim to do away with the need to understand.
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Chapter One

Attitudes to Cleaning

1.1 NO STANDARD ANSWER

The cleaning of masonry surfaces is not only necessary for aesthetic reasons but also required to ensure better preservation of these materials. The present volumes deal with the cleaning of the traditional masonry materials—sandstones, limestones, brick and terracotta/faience— which have been soiled in external environments. In the UK, these materials have been used widely in the construction of buildings. These books aim to explain some of the complexity of their characteristics, weathering and soiling, and to provide guidelines for the assessment of the project at hand and the design of the cleaning process applicable to it. Standard answers and specifications are not provided. Whatever their context, the complexity of the safe cleaning of these materials must be evaluated in detail.

The greatest problem in developing practical guidelines for cleaning any historic building is the large number of variable and unpredictable factors involved. Because these variables make each cleaning project unique, it is difficult to establish specific standards at this time.¹

In fact, it would be unwise and dangerous to establish them.
1.2 STATE OF THE UK INDUSTRY

Despite the many technical advances in the field of masonry cleaning, particularly during the 1980s, there continues to be a regrettable and unnecessary number of damaging mistakes made because the necessary level of understanding is not available, and thorough, job-specific evaluations are not being done. The beginning of the 1990s has given birth to an unprecedented level of concern in the UK for the extent of damage caused to historic facades by cleaning operations. Expertise, resources and management have come under scrutiny as it has become clear that in many instances the current state of affairs is so inadequate that it would have been better if many cleaning operations had not been undertaken at all. In the midst of this sorry state of affairs, the many cleaning projects which have been undertaken to a high standard are not receiving sufficient publicity or praise to redress fully the vociferous criticism of problematic projects.

There are many reasons for what has happened and, in some quarters, continues to happen. In most instances, insufficient time and money were allocated to cleaning. Many professionals and agents responsible for masonry cleaning do not have the specialist knowledge required to make the necessary technical decisions. Contract documentation is frequently designed to shift decision-making to the contractor on site, but in many instances a limited budget and fixed price have prevented undertaking the variations necessary to make the cleaning successful. An increased dependency on 'systems' and the trade literature that accompanies them has devalued the importance of fully understanding the materials and surfaces which are to be cleaned and the soiling which is to be removed from them.

The cleaning of masonry is, and should be expected to be, a more complex and important process than it has been on many repair and refurbishment projects. Due consideration must be given to the masonry substrate, its condition, the nature and degree of soiling(s), the effect of cleaning and the appearance it will create, the effect of the cleaning at microscopic level and in relation to the future weathering of the building, the safety of the operatives, members of the public and occupants, all necessary protection and the effect of the processes on the environment. Consideration of all these aspects cannot be undertaken without proper planning, sufficient time and cost commitment. The number of variables which apply to a cleaning system means that a different system needs to be designed for each building. There may be similarities but there will always be important differences which will
relate to the new situation and be important in the undertaking of a quality clean. An inappropriate system can be ineffective, cause irreparable damage, be a waste of money, or all three.

Historic building repair and conservation is acknowledged as a specialist field. The cleaning of the surfaces of such structures is even further specialized and a realm into which only a few practitioners are sufficiently trained to enter. The experience of many masonry cleaning firms needs to be similarly deepened and improved. The complexity of a successful cleaning operation must be grasped at client, main contractor and project management levels as well.

In the UK, standards of good practice are set out in the form of recommendations in BS 6270, Part 1, 1982 (with amendments), the British Standard Code of Practice for Cleaning and Surface Repair of Buildings, Part 1, Natural Stone, Carved Stone and Clay and Calcium Silicate Brick Masonry (plus Appendix G: Terracotta and Faience). A review of BS 6270, Part 1 has begun (in 1993) to reflect developments of the past decade. Principles of good practice have also been prepared by the Cleaning Sub-Committee of the UK Stone Federation, the professional body for practitioners involved in the winning, repairing and cleaning of stone. The evidence on the buildings is that these sets of guidelines are not enough.

It must nevertheless be recognized that the stone cleaning industry has formed part of the general construction industry for a long time and that considerable depths of knowledge and expertise can be found in several areas. Incompetent practitioners can be found in all professional and contracting fields, and the cleaning industry is no exception. Experienced cleaning contracting companies can be located that have demonstrated over many years quality cleaning on a range of substrates, using a range of techniques. Levels of competence vary widely, however, and it is always worth establishing the expertise of a firm under consideration by inspecting previous projects.

There was increasing concern in the early 1990s for the likelihood of damage caused by the use of chemical cleaning materials. This concern stemmed from a study commissioned in response to widespread misuse of chemical cleaning processes in Scotland.

During the 1970s and 1980s, the sandstone building stock of Scottish cities had been the focus of an active and widespread cleaning campaign. Unfortunately, many buildings had suffered damage because of injudicious or inappropriate cleaning methods, particularly chemical cleaning. Concerned about this damage, Historic Scotland (formerly HBMD) and the Scottish Development Agency (SDA), joint funders of
cleaning and surface repair conservation schemes, commissioned a
detailed research project into the effect of cleaning on Scottish sandstone
buildings. The brief of the two-year project was to examine the general
reasons for stone cleaning, to assess available cleaning methods, to assess
the strength and weakness of stones used in Scottish buildings to various
stone cleaning techniques, and to prepare a guide to assist those in the
decision-making process of whether to clean or not.

The study was undertaken by the Masonry Conservation Research
Group of the Robert Gordon Institute of Technology, at the University
of Aberdeen (RGIT). In April 1992, a conference was held in Edinburgh
to discuss the findings; these and the conference papers were published
later that year.\(^3\)\(^4\)

In many parts of the UK, the cleaning industry was subdued during
the two-year study period as many projects were deferred pending the
outcome of investigations. Editorials in the technical press went to the
extent of recommending that no cleaning be undertaken throughout the
UK until such time as the results were known, even though the study
was restricted to the sandstones of Scotland and was not a complete study
of the operation and effect of chemical cleaning.

Much of the information presented was not new to specialist
practitioners and it was considered incomplete in scope. However,
widespread publication and review in the technical and popular press of
some findings led to a somewhat alarmist reaction to chemical cleaning
generally. Importantly, though, the conference warned of the need to
identify details of masonry substrates which are to be cleaned by
chemical means. A practitioner's guide based on the findings of the
Scotland study has also been published.\(^5\)

During this period it was sad to see the many good cleaning projects
which had been cleaned by chemical means receiving no acknowledge-
ment. Because poor quality work had been done in certain quarters,
many seemed to forget that this did not apply to every project,
contractor or professional in the field. It needs to be remembered that
many historic buildings and conservation areas have benefited from the
effects of masonry cleaning. The experience of Glasgow is summarized
in the following statement:

Since the 1970s, we have been advising owners and professionals to
consider well the risks and the benefits of stone cleaning, one at the
same time. It is my considered opinion that as a whole, the
stone cleaning programme has been highly successful in promoting
the City's architecture as worthy of note (and therefore of care and
attention). Some of the problems we have inherited from a century or so of neglect and bad constructional practice have meant that an ideal solution is unattainable, no matter what we do or do not do. Equally, some of our approaches to some of our buildings have been shown to be ill-advised, in that with hindsight and increased knowledge we could have done the job better. I do not, however, apologise for having tried. The benefits to the City are all too clear to see.  

In the early 1970s the conservation, repair and cleaning of historic stone buildings in Glasgow’s central area began in earnest. Almost universally, stone cleaning was undertaken as part of a larger stone repairs package. While the work may have benefited from the knowledge and skills available today, the city could not afford the luxury of sitting back for another decade or so – the massive problems of overall neglect, the lack of investment in building maintenance and the lack of appreciation of the city’s architecture all needed to be tackled urgently. While there have indeed been poorer examples of cleaning, as well as better ones, to which it is felt many causes might be attributed, these are less fortunate cases and should not be regarded as the norm. The stone cleaning programme in Glasgow has generally been seen as a major success.

On buildings of high historic merit, the case for masonry cleaning is very different from that for urban regeneration and requires particular justification. In such contexts, the need for cleaning must be proved conclusively and involve the advice of experts of history, architecture and masonry.

1.3 WHY BUILDINGS ARE CLEANED

The decision to clean a building is frequently made on the grounds of aesthetics. It is generally considered that a cleaned building looks better and is a greater civic asset in its cleaned form. Not only does soiling obscure and distort the building’s original appearance, its presence on the masonry surface may also be causing damage at an increasing rate to the substrate. Soiling crusts contain soluble salts which can be transported into the masonry pores during wetting and drying phases. Soiling crusts of this kind do not protect masonry but cause continuous damage if they are not removed. See Chapter 3 (this volume) for further discussion on the damaging effects of soiling. This strong technical argument for cleaning is frequently ignored in certain circles.
Figure 1.1 The former Parcels Office and Midland Station, Nottingham. Cleaning was undertaken as the first step in the revitalization of this building as part of a major law courts development. It had not been cleaned before. The building is viewed by all users of the existing Nottingham railway.
In the UK, cleaning is rarely conducted on its own and is usually associated with maintenance and repair works on the facade. Research undertaken by Trudie Mansfield indicates that stone cleaning may have benefits to the owner other than purely aesthetic ones, and that the public will continue to remain intolerant of soiled buildings. Motives for cleaning were confirmed in responses to questionnaires sent to stone cleaning companies within the UK in 1987 and 1991. These two surveys are looked at below.

**The 1987 survey**

The principal reasons for having a building cleaned, identified by building owners or those in charge of buildings in both private and public sectors, were as follows:

- 39% to improve appearance
- 28% as an integral part of the scheduled maintenance programme
- 15% to identify defective structures
- 9% to increase trade
- 6% to increase the value of the property
- 3% to blend with a new building extension

Replies from cleaning specialists identified some different reasons from those given by the property owners:

- 29% to protect the building fabric
- 20% to improve appearance
- 19% to increase property value
- 11% to enable a detailed structural survey to be undertaken
- 8% to increase trade
- 2% to improve ‘social’ environment
- 2% to deter vandalism and graffiti

**The 1991 survey**

The responses to a second questionnaire issued to cleaning contractors in 1991 had adjusted to:

- 42% to improve appearance
- 27% restoration/identification of faults
- 10% part of lease/refurbishment package
- 6% to blend in with surrounds
- 5% to decrease long-term maintenance costs
4% to increase the value of the property
4% to upgrade housing stock
2% an alternative to painting

In 1991, more than 60 per cent of respondents felt that the public sector's motives for cleaning were the same as the private sector's. Nearly 60 per cent of their work came from the private sector, with a common ratio of 80:20 private to public being quoted.

The importance of cleaning in assisting to prevent future deterioration of the masonry is one of the least understood aspects of masonry cleaning. The value of removing soiling deserves higher recognition in the battle between the philosophy/aesthetics and the technical need for cleaning that has been joined in the UK. The value and necessity for cleaning as part of a masonry repair programme also deserves renewed emphasis.

It is hard to find practical market evidence that the cleaning of an historic facade increases the building's financial value. Assessment of a property's value includes its condition and necessary remedial works that will be required to make this good. Cleaning is frequently a small proportion of the total necessary works and is therefore, on its own, not easily identified as a major factor affecting value. However, it is significant as part of the total remedial package, particularly as it is the aspect of work which probably has the most dramatic visual impact.11

1.4 THE UK DEBATE

In 1932, R.J. Schaffer, the stone specialist, wrote:

From the artistic standpoint, it is difficult to believe that the architect who designs with due regard to effects of light and shade, and who selects his materials for their colour, 'character', or texture, can tolerate the presence of soot and grime which hide the beauties of his materials and obliterate the craftsmanship of his design.12

In 1992, Edinburgh architect, Dennis Rodwell, wrote:

Much of the quality of historic buildings, both in design and construction, derives from the articulation of form and the intricacies of detail. Observation of these qualities is rendered difficult and sometimes impossible if the enriching effect of the passage of light and shade is suppressed by filth.13

Dirt, irrespective of whether or not it is of itself harmful to their fabric, makes old buildings look uncared for and unvalued. It
symbolises neglect. It encourages the view that maintaining old buildings is an insurmountable problem, that they have a finite life, and that conservation is an anachronism. It is a passive form of vandalism, that inspires the active.\textsuperscript{14}

In 1989, The Prince of Wales, wrote:

The Houses of Parliament look particularly wonderful since they've been cleaned - you see the full glory of them now.\textsuperscript{15}

The view of conservationists in the 1990s who are less convinced of the need and value of masonry cleaning is expounded by Emma Crawford.\textsuperscript{16} Conservationists are questioning the frequency with which masonry cleaning is undertaken as part of a refurbishment or masonry repair programme. They question the incentive of funding bodies that require a building which looks as if it has had money spent on its restoration. Their concerns extend to the legislative framework in which cleaning takes place at present, which they feel is inadequate and does not regulate stone cleaning practitioners. The protection afforded by the listing of historical buildings is considered of theoretical value only in most instances. Their concerns are usually justified, particularly where the necessary investigations, assessments and trials are not undertaken properly.

The proposal to clean the Sir Walter Scott Monument in central Edinburgh drew much interest during the public enquiry held in 1992 and 1993. (At the time of writing the final deliberations of the enquiry have not been published.) The monument, which was erected between 1840 and 1844 to the design of George Meikle Kemp, has a soaring, tiered spire which is rich in ornate gothic detail. An article by Architectural Heritage of Scotland prior to the enquiry explains the opinions of those who do not recommend cleaning.

The Monument is black in part because it is so close to the railway. Smoke from steam trains and diesel fumes are an irrefutable part of its past. The site was chosen in favour of one in Charlotte Square, so the colour bears testimony to the site where the building has existed. To clean would not only remove this historical evidence, but would involve conjecture as to the colour the Monument might have been if the air conditions had been different.\textsuperscript{17}

As such, the process is in contravention of the Burra Charter of Australia, Article 3 of which states:

Conservation is based upon respect for the existing fabric and should involve the least possible physical intervention. It should not distort the evidence provided by the fabric...
Only work which is known and understood to protect and preserve the Monument should be permitted to this structure of such immense architectural, historical and cultural significance.18

Historic buildings certainly require special consideration regarding any works undertaken on them, more so than buildings of lesser historical value which are also constructed of traditional masonry materials, although there are many requirements common to both when cleaning and surface repair are being considered. The cleaning of scheduled monuments and listed buildings in England is covered by legislation to a certain extent.

1.5 LISTED BUILDINGS AND SCHEDULED MONUMENTS

The English Parliament has enacted laws since 1882 to protect examples of historical development.

Scheduled monuments are of national importance and are scheduled under the Ancient Monuments and Archaeological Areas Act 1979. Scheduling means that the Secretary of State for the Environment becomes directly responsible for the protection of the monument and for ensuring that the treatment, repair or use is compatible with its preservation as a monument. Their cleaning requires Scheduled Monument Consent from the Secretary of State for which a detailed specification is necessary. The consent is required even if on-site trials are proposed.

Listed buildings are protected by an extension of planning control which is primarily the responsibility of local authorities.

Buildings are classified into three grades: Grade I, II* and II. Grade I buildings are those considered to be of exceptional interest and represent about one per cent of the listed buildings. Grade II* buildings are of special interest and considered to be worthy of preservation. Grade II buildings are: (1) All structures not classified as Grade I or Grade II* but which were built prior to 1700 and survive in anything like the original condition; (2) most buildings built between 1700 and 1840.

Within the main groups there are various subclassifications. These can be for architectural or planning reasons or illustrating aspects of social or economic history. Typical examples are industrial buildings, railway stations, schools, hospitals, theatres, town halls, markets, exchanges, almshouses, prisons and mills. Certain technological innovations can be listed, including the use of wrought and cast iron,
Figure 1.2 To many, the soiling of Lichfield and other cathedrals is an important representation of the historic value and character of these monuments. Decisions to clean follow investigations as to if, why and how this should be done. This level of questioning is also suited to less prominent masonry structures.
prefabrication and the early use of reinforced concrete. Such examples are often associated with famous people or events. Listed buildings are usually occupied. However, there is an overlap, and certain structures can be both listed and scheduled, e.g. barns, bridges, guildhalls and industrial structures.

It is an offence to demolish, alter or extend a listed building without consent. This includes non-listed buildings within conservation areas. Masonry cleaning is considered an alteration which materially affects the character of a listed building and as such requires local authority consent before it can be carried out. The discretion as to whether formal consent to cleaning needs to be made lies with each individual authority. There is no nationwide standardisation regarding information, trials, or specialist input which should accompany an application for cleaning and little agreement among local authorities as to whether consent should be granted. The local authority must, however, always be consulted beforehand.

The Society for the Protection of Ancient Buildings (SPAB) is a non-statutory body whose opinion regarding historical building repair is held in high regard. In his manifesto of 1877 for the foundation of the SPAB, William Morris explains how and why the society proposed to protect ancient buildings.

Moreover, in the course of this double process of destruction and addition the whole surface of the buildings is necessarily tampered with; so that the appearance of antiquity is taken away from such old parts of the fabric as are left, and there is no laying to rest in the spectator the suspicion of what may have been lost; and in short, a feeble and lifeless forgery is the final result of all the wasted labour. 19

The SPAB provides a valuable reminder that the original surface of stonework tells us much about the history of a structure and its removal with all associated honorable scars of age is considered incomprehensible from a philosophical point of view. The SPAB continues to advocate caution regarding historic masonry cleaning.

In its technical pamphlet on masonry cleaning, the SPAB presents a cautious attitude to cleaning and advises that the following stages should precede any cleaning contract: 20

1. Decide whether cleaning is necessary and what it will achieve.

The decision to clean the masonry of an historic building is extremely significant and should be weighed thoroughly.

Before the decision to clean or not to clean is taken by
owners and their agents, regard should be had to the philosophical questions raised by the practice of cleaning and the practical questions of the potential for physical and/or chemical alteration of the masonry surfaces. The decision not to clean can, at times, be the correct decision and this option should always be considered.

2. On the basis of analysis and on-site trials, select a cleaning method appropriate to the substrate and to the degree of soiling.

3. Think through all the stages of the cleaning contract and ensure they are properly specified and costed.

4. Specify all the associated repair work likely to be necessary in the form of replacement of damaged elements or pointing of joints and determine what the sequence of work will be.

5. Select contractors with proven experience in the type of cleaning and repairs proposed and look at other work they have carried out.

The SPAB’s view is considered conservative by many practitioners as it does not consider what the effect would be of not cleaning, in terms of appearance or the removal of soiling which is harming the substrate.

1.6 A BALANCED VIEW

We must be careful not to criticize cleaning jobs out of context. Many projects which we now consider to have been poorly executed and damaging were, at the time they were done and within the context of available skills and processes, considered to be very good. At the time it was done, the wet abrasive cleaning of unglazed terracotta of the Royal Albert Hall, so frequently cited now as an example of the damage of abrasive cleaning on terracotta, was considered a good cleaning job. The cleaning of major buildings such as these was not done without extensive trial periods and the preparation of documentation.

When buildings in urban England were cleaned for the first time, about sixty years ago, the thickness of the soiling made it virtually impossible to determine the extent and nature of deterioration and repair work. Most had over eighty years of encrusted soiling on them. In protected areas in urban environments, this was frequently 25–75 mm (1–3 in.) thick and completely hid the mouldings and other features on the undersides of cornices. Prior to cleaning it was impossible to see the
masonry surface and its detail beneath. As a result, specialist contractors were frequently cleaning ‘blind’ and much damage was done, even by ‘the experts’. Abrasive methods gave quick results then, as they do now, and a large proportion of blame for damage can be attributed to them. The methods and technology of the 1970s were relatively crude compared with today’s, although in some quarters high quality cleaning of the heavy encrustations was achieved using misting sprays and other more controllable methods.

Then, as now, the full complexity of masonry, its soiling, and details of appropriate processes required to separate the two without damage are not understood on many cleaning projects. Few professionals understand the range of operations required on site to enable a cleaning specification to be carried out satisfactorily. Only a handful of practitioners have sufficient knowledge and experience to enable the full range of assessments, tests and documents to be undertaken properly. There remains a very low cost expectation for masonry cleaning which reflects the low priority it is often given.

1.7 INDIVIDUAL SOLUTIONS

The cleaning of masonry should remove the soiling and leave the stone intact and unaltered. The ideal would be a cleaning method which would operate selectively on the soiling alone. In reality, no such method exists but this should always be the aim of any cleaning operation. If it is in the best interest for a building surface to be cleaned, this must be done by the gentlest possible method which has been selected on the basis of the individual needs of the building.

Historic building materials are not indestructible. There is no one formula for the cleaning of historic building surfaces. It is even dangerous to suggest that there is a group of appropriate formulae. Each situation is different. There will, of course, be a thread of similarities from job to job, but if all the many details and permutations of each case are properly assessed, this must mean that the final procedures for one building’s cleaning will be significantly different from those used on similar materials elsewhere.

1.8 REALISTIC EXPECTATIONS

Stone cleaning should never be expected to return a facade to its original
colour or state. In the years since its erection, a building will have soiled, weathered, decayed and developed patinas on the stone surfaces, changing in many irreversible ways. The stone cleaning should not attempt to remove staining which has taken place as a result of mineralogical changes within the stone itself.

Stone cleaning will not be equally successful on all areas of a building. Flat, smooth ashlar is generally more successfully cleaned than sills, cornices, pinnacles and other protrusions. Unless surfaces are damaged or altered by a cleaning process, a range of degrees of cleaning must be expected. Some, such as that on carving, will be more visually acceptable than others but this is part of the reality of cleaning, particularly on sandstone surfaces.

The successful cleaning of an historic masonry facade requires several critical ingredients, including:

1. A good understanding of the facade's materials, their condition, the nature and effect of soiling on them.
2. Details of materials and procedures of appropriate cleaning methods.
3. A specification which defines as accurately as possible the materials and methods that will be required to clean the facade and which provides sufficient information to enable truly competitive tendering.
4. Undertaking of the work by an experienced contractor who has the capacity not only to undertake the work but also to deal with the many modifications of process that the facade will demand as its characteristics become better known.
5. The undertaking of the work by a contractor who is being paid to do the necessary works and is not in a contractual situation which will force short-cuts or a reduction in the standard of workmanship.

These matters are central to many of the discussions in the remaining chapters of these books.

1.9 THE NEED FOR MASONRY CLEANING

The need to remove soiling must always be investigated from two angles: aesthetics and the on-going well-being of the masonry beneath.
The aesthetics of soiling

All traditional building materials will weather and soil as the result of exposure to the environment. A building's soiling pattern will depend on its environment, orientation of the facades, properties and behaviour of the materials of which it is constructed and the interaction among these, rainwater run-off patterns and their relationship to the architecture of the building, the time which has lapsed since the building was last cleaned and the impact of any previous cleaning operation.

As a building weathers and soils, its appearance changes. Light, initial soiling will cause relatively subtle alterations to the building's appearance which are usually complimentary to the architecture beneath. Once the soiling level becomes moderate, detail, colour and texture of the surfaces beneath begin to be obscured and the pattern of soiling interacts with the architectural features, also adding its own pattern to the facade. The patterns of soiling may be unrelated to and visually distracting from the architectural features beneath. Once the soiling level becomes heavy, much of the facade is affected by a uniform darkening which obscures its architecture and any light and shadow effects.

The RGIT investigated the aesthetic basis for masonry cleaning and the assumption that all buildings are visually improved as a result of cleaning. The study aimed to discover when and how buildings are aesthetically improved by cleaning. It investigated the relationship between type of building, materials used in construction, aesthetic value, and whether the building would be aesthetically enhanced or deteriorate following cleaning.21

Based on responses to questionnaires conducted in Edinburgh and Glasgow, the study established an interesting relationship between the aesthetic value, soiling and visual complexity of a building. It was found that initially, after construction or cleaning, the building had a positive aesthetic value:

After a number of years of weathering, where accumulations of dirt are consistent with the architectural features and the stone texture, complexity is increased and aesthetic value rises to a peak. Thereafter, it begins to decline as soiling increases, becoming unrelated to underlying architectural features. As soiling becomes increasingly heavy, complexity is reduced and aesthetic value decreases to a point where the whole facade is blackened and complexity is at a minimum.22
Figure 1.3 The level of resoiling adherent to surfaces of the Sir John Soane's Museum, 13 Lincoln's Inn Fields, London, prior to cleaning and surface repair works undertaken in 1992. Soiling patterns had begun to detract from the architecture. Incomplete removal of thick layers of oil-based paints to the incised decorations were also disfiguring and also needed to be removed. Stone corbel brackets, palmette blocks and the terracotta figurines were cleaned and repaired off-site by conservators as a separate contract. The remaining surfaces were cleaned by a specialist cleaning contractor.
From the findings, it was deduced that heavily soiled buildings were aesthetically less pleasing than when cleaned, and that old buildings with light soiling were aesthetically more pleasing than the same buildings without soiling. Findings supported the view that the removal of all soiling from historic buildings removes part of the sense of their history. The study found that buildings which were moderately soiled were viewed most favourably. The removal of heavy soiling was also viewed favourably, although the reaction to the lightly soiled cleaned building was less favourable.

Caution must be exercised when interpreting the above findings on sandstone buildings beyond the area of the study and certainly with regard to buildings of different masonry substrates altogether.

Technicalities of soiling: the health of the masonry beneath

There is a second, equally important side to the argument of whether a masonry surface should be cleaned or not, and that is the effect of soiling on the masonry beneath.

There is a technical, physical need for cleaning to ensure better health for the masonry beneath. The inherent colouring of masonry which it is desirable to retain must not be confused with the soiling which has been deposited by rain, wind, etc. Deposited soiling will contain soluble salts (pollutants) which can be transported into the pores and fissures of the stone during wetting and drying cycles where they will cause on-going deterioration. Alternatively, the soiling layer may act as a damp poultice of pollutants which will affect the masonry surface. The soluble salts in soiling do not protect masonry but cause it long-term damage if not removed.

Soiling deposits on stone usually consist of:

2. Industrial and household waste products: fly ash, combustion products, tar, carbon, mineral binding agents, oil and unburned diesel residues.
3. Animal and vegetable matter: pollen, algae, insects, bacteria. 23

On limestones and marbles, thick, extensive deterioration is frequently found in association with thick deposits. The main components of these black crusts are gypsum and carbon particles. On sandstones,
bricks, terracotta and granite, carbon particles again feature prominently. In both instances, sulphates feature prominently as do soluble salts which can be deposited or originate from the masonry construction. The soiling needs to be removed to prevent damage by these. Further details on the effect of soiling and the need for its removal are found in Chapter 3 (this volume).

It must be the aim of everyone involved in the cleaning of historic masonry to develop and use safe and effective cleaning agents and techniques. Cleaning can be the most severe experience a masonry facade will be subject to in its life. It is the responsibility of clients,
professionals, funding bodies and contractors to work together to ensure that a cleaning operation enhances the well-being of an historic building.

REFERENCES

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References

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1 Chapter 1 Attitudes to Cleaning


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3 Chapter 3 Soiling


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10. Ibid., p.58.

11. Ibid., p.60.


15. Ibid., p.88.


19. Weaver, M.E., personal communication.

4 Chapter 4 Masonry Substrates


Chapter 5 Cleaning Materials and Timber


7. Ibid., p.11.

8. Ibid., p. 11.

9. Ibid., p.11.
Fig 6.4 Former StMary’s Church, Gateshead, Tyne and Wear, prior to cleaning, repair and refurbishment. The structure was converted into offices, salesrooms and warehousing for Phillips, the antiques auctioneers. 3. To determine whether there were sound technical reasons for not cleaning. 4. If stone cleaning was recommended, a full report on the effect of the cleaning, particularly in relation to the resultant colouration of the stonework. 5. To undertake trial panels of selected cleaning methods in locations to be agreed with the client and Gateshead Metropolitan Borough Council on representative areas of masonry type and soiling degree. 6. To prepare a detailed specification for any recommended cleaning methods, including the material(s) to be used, the method of application, dwell time(s), methods of removal, qualifications and supervision of operatives. To include for any directly associated works, for example, pointing. 7. To report in a manner similar to the above on the cleaning of the interior stonework. 8. To consider and report on the repainting of the ashlar masonry of the west tower.

The brief did not require detailed consideration of the remedial works to the stonework which were being dealt with by the architects. Strategy adopted The following strategy was adopted. Investigation and recording on site The surfaces of the church masonry were inspected as closely as possible with the purpose of noting alterations to the masonry surfaces due to weathering agents, such as water, pollutants, applied coatings and soluble salts, along with the effect of lack of maintenance. Local deterioration problems were noted and assessed within the context of each facade. At this time, samples of stone were taken for use in an analysis programme. The analysis programme A scientific analysis programme was undertaken to provide detailed technical information regarding the characteristics of the stone of the church and its modes of decay. A range of petrological, physical and chemical analyses were undertaken to identify the mineralogy of the stone, its chemistry and other essential physical and chemical characteristics. Information provided by the analysis programme included assessment of the potential for damage as the result of the use of chemical cleaning materials and methods. The analysis programme was also designed to investigate whether the masonry already
included dangerous levels of pollutants which were an existing major cause of deterioration. The co-ordinating analyst, who had a masonry conservation background, was involved in the taking of all samples. On-site cleaning trials A series of on-site cleaning trials of a selected range of cleaning materials and methods was undertaken on representative areas of masonry. These were considered necessary to determine the effectiveness of the selected systems, and to enable more accurate evaluation of the visual implications of undertaking the cleaning of the St Mary’s masonry. The trials also proved useful indicators of the constraints which the prerepair condition of the masonry and associated jointing was to impose on a cleaning programme. The labour and equipment back-up for the trials was provided by the contractor for the cleaning and remainder of the remedial works programme for St Mary’s who had already been engaged. The trials involved a selection of products of the three main chemical cleaning agent suppliers in the UK, as well as dry abrasive and low pressure water systems. Some of the methods were selected by Adriel Consultancy whilst others, due to the advanced stage of the masonry repair contract, were proposed and supplied by the contractor. Environmental conditions on the days of the trials were not entirely suitable to the use of chemical cleaning agents or the use of water on masonry, as temperatures hovered around 5°C. However, the timescale of this commission did not permit delay of the trials until better weather conditions were assured. The required information was nevertheless obtained from the site cleaning trials, the works being
undertaken
during the warmest part of the day.

Cleaning assessment and strategy

The findings provided by the inspection of the masonry surfaces, the on
site trials and the results of the analysis programme were evaluated and a
strategy for the cleaning prepared.

The preferred and recommended sequence of assessment of masonry,
followed by sampling and analysis of stone and cleaning trials
employing methods selected on the basis of information from the
assessment and analysis stages, was not an option in the St Mary's
situation due to the pressure of the works programme.

Variation in
sequence of events was compensated for by increasing the number of
trials undertaken and by taking of samples within the test areas before
and after the trials. This modified approach proved very successful.

Characteristics and condition of the
external masonry

Eras of masonry construction

The existing masonry of St Mary's, Gateshead, dates from Norman
times through to the late nineteenth century (1874) when an extensive
restoration programme was undertaken. The architectural style of each era of construction varied as did the general characteristics of the stones and jointing mortars used.

Petrographic analysis determined that, while there was a noticeable range of variations within the stones used from era to era, and also within the same era, the stone was essentially of the one type. The analytical Figure 6.5 On the south elevation of St Mary’s, Gateshead, heavily soiled, sound areas of masonry contrasted strongly with lighter coloured, heavily weathered surfaces which were experiencing continuous surface loss. These contrasts extracted from the architecture of the building as a whole. Work also confirmed the wider range of natural variations within individual stones. The stone of all the construction was classified as an argillaceous sandstone, a stone which was highly susceptible to water-related deterioration, frost and salt crystallization damage. The stone work of St Mary’s comprised heavily soiled black surfaces.

Figure 6.6 Moderate and heavy soiling on the north elevation of St Mary’s, Gateshead, gave this facade a more unified appearance than its southern counterpart. Areas of lightness again related to surfaces undergoing continuous granulation and loss.

Contrasting with lightly soiled areas and areas of ‘cleaned’ stone where stones had lost their surfaces due to weathering. The visual
contrast between the dark and light areas was so great as to be a distraction to the church’s architecture.

The tower of St Mary’s had the most widespread and most uniform expanse of dark soiling. At lower levels, soiling was heaviest within localized areas of heavy water saturation and where the stonework had not lost its original surface.

Older areas of masonry were not necessarily more heavily weathered. Figure 6.7 Degrees of soiling identified on each elevation.

STONE UNITS IN AREAS OF VERY HEAVY WATER SATURATION AND AREAS OF GREATEST SALT CRYSTALLIZATION DAMAGE WERE IN THE WORST CONDITION.

Within each era of construction, the condition of the walling had been most greatly affected by the parlous condition of the joints. Cement-rich repainting mortars had caused deterioration of the adjacent stones and permitted water penetration. All areas would require the removal of the cementitious pointing mortars and the cutting out and repainting of the joints prior to cleaning. From the point of view of the cleaning, the condition of the joints was of greatest concern as regards
the entry and freezing of water and the entry and retention of acidic and alkaline cleaning agents which were not rinsed out.

The decision to clean the external masonry of the church was evaluated from an aesthetic viewpoint and from a technical viewpoint.

The effect that cleaning would have on the final appearance of the church was the main aesthetic consideration. It was, therefore, necessary to determine what level of cleaning could be achieved.

Proposed remedial works

At the time the cleaning study commenced, repainting and stone replacement works had commenced to the specification of the project architect. The visual disturbance of these was most noticeable within heavily soiled areas.

Repainted joints in areas of heavy soiling were very stark in appearance. Individual stones replaced on heavily soiled areas such as the tower, the clerestory parapets and the late nineteenth century porch were also visually prominent. If St Mary’s was to be repaired and not cleaned, its uneven appearance, created by soiling and deterioration processes, would become more patchy as a result of the repairs.
On-site cleaning trials

Areas for the on-site trials were selected by Adriel Consultancy in conjunction with the Conservation Department, Gateshead Metropolitan Borough Council. Those on the northern elevation of the church were the least obtrusive of all the low-level masonry available, and were considered to be as representative as reasonably possible of the degrees of soiling seen elsewhere. They included masonry from the fourteenth, nineteenth and mid eighteenth centuries. The areas of masonry selected were also considered to be as representative as reasonably possible of the surface and joint conditions throughout the building. Chemical, abrasive and low pressure water cleaning trials were undertaken with each test zone. The positions of fall tests were marked on the drawings, along with the positions of samples taken for analysis. Details of materials and processes used were recorded (see Figure 6.9). All surfaces were inspected by eye and X30 field microscope prior to application of any cleaning processes or materials. Those to be involved in chemical cleaning were sampled so that pH and soluble salt contents prior to cleaning could be established. Edges of test zones were defined by masking to enable direct comparison between cleaned and uncleaned surfaces within the same block. Joints were included with each zone in order to evaluate the effect of each cleaning process on arrises and pointing material. Each zone included a minimum...
mof three courses, heavily soiled protrusions and plinth stones as well as lessersoiled ashlar. The chemical trials involved products from three main chemical manufacturers in operation at that time. Alkali acid and acid only processes were used. Cleaners in the form of liquids, gels and poultices were employed. Details of products used are shown in Figure 6.10.

TEST ZONE 'A'

SUMMARY OF TEST PROCEDURES

FOR ALL TEST AREAS:

Newlock products were applied and removed by a representative of the manufacturer. Neolith products were applied and removed and dry abrasive cleaning undertaken by the cleaning and surface repair contractor. A representative for the ProSoCo products could not attend on the day of the trials but had visited site and provided recommendations for products and dwell times.

AI: Prewet Acidic gel (Newlock SC002B), dwell 15 minutes
Acidic liquid (Newlock SC001), dwell 15 minutes, agitation, rinse

A2: Prewet Alkaline liquid (Newlock SC005), dwell 15 minutes, rinsed Acidic gel (Newlock SC002B), dwell 15 minutes, rinsed

A3: Reference number not used

A4: Thixotropic alkaline gel (coating remover) (ProSoCo Heavy Duty Paint Stripper), 24 hour dwell, extended rinse
Acidic cleaner/neutraliser diluted (ProSoCo Restoration Cleaner, 3:1 water:product), 5 minute dwell, rinsed

A5: Alkaline, clay-based poultice (ProSoCo T-1217 Poultice), covered for 24 hour dwell, rinsed Acidic cleaner/neutraliser diluted (ProSoCo Restoration Cleaner,
3:1 water:product), 5 minute dwell, rinsed, 2 applications

A6a): Prewet Thixotropic alkaline liquid (ProSoCo 766 Masonry Prewash), 30 minute dwell, extended rinse Acidic cleaner/neutraliser diluted (ProSoCo Heavy Duty Restoration Cleaner, 3:1 water: product), 7 minute dwell, rinsed

A6b): Prewet Acidic cleaner only (ProSoCo Restoration Cleaner), 7 minute dwell, rinsed

A7a): Prewet Alkaline liquid (Neolith HDL), 30 minute dwell, rinsed Acidic liquid cleaner/neutraliser (Neolith 625SS), 7 minute dwell, rinsed

A7b): Prewet Acidic liquid cleaner (Neolith 625SS), 10 minute dwell, rinsed

A8a): Dry air abrasive with olivine, 200 psi (Mainly rubble-faced blocks)

A8b): Abrasive as for A8a) but with increased working distance

A8c): Dry air abrasive with olivine, 200 psi Onto smooth surface of late 19th century buttress, with fine surface tooling At similar work distance to A8b)

A9: Cutting out wide, cementitious pointing and patch mortars

A10: Pressure water* only to area of black soiling

A11: Pressure water* w area with surface organic growth and defective core, bedding and pointing mortars

A12: Pressure water* to RHS of Area A9

*Fan tip nozzle, 750-1,000 psi at the nozzle, variable work distances not less than 250mm (10”)

Ambient Temperature: c. 5°C

All rinsing done with cool water (hot water preferable in some circumstances but not available)

Figure 6. 9 Test zone ADerails of materials and procedures. 7 7 S t . M a r y ' s Church, Gatahead Kaonry C l e a n i n g E v a l u a t i o n A d r i a l Consultancy
TEST ZONE 'B'

SUMMARY OF TEST PROCEDURES

FOR ALL TEST IJIEAS:

- Newlock products were applied and removed by a representative of the manufacturer. Neolith products were applied and removed and dry bruive cleaning undertaken by the cleaning and surface repair contractor. A representative for the ProSoCo product could not attend on the day of the trials but had visited site and provided recommendations for products and dwell times.

81: Alkaline, clay-based poultice (ProScCo T-1217 Poultice), covered for 24 hour dwell, rinsed Acidic cleaner/neutraliser diluted (ProScCo Restoration Cleaner, 3:1 water:product), 10 minute dwell, rinsed

82: Thixotropic alkaline paste (coating remover) (ProScCo Heavy Duty Paint Stripper), 24 hour dwell, extended rinse Neutralisation and further cleaning as for 81

83: Prewet Thixotropic, acid-bued paste (Newlock SC0018), 30 minute dwell, rinsed

84a): Prewet Thixotropic alkaline liquid (ProScCo 766 Muon., Y Prewash), 30 minute dwell, rinsed Acidic cleaner/neutraliser diluted (ProScCo Restoration Cleaner, 3:1 water:product), 5 minute dwell, rinsed

84b): Prewet Acidic cleaner as for 84a

85a): Prewet Alkaline liquid (Neolith HDL), 30 minute dwell, rinsed Acidic cleaner/neutraliser (Neolith 625Ss), 5-10 minute dwell, rinsed

85b): Prewet Acidic cleaner as for 85a

86: Dry air abrasive (olivine abrasive), 200 psi

87: Dry air abrasive (olivine abrasive), 200 psi

88: Pressure water*
**F•n tip nozzle, 7SG-1,000 psi at the nozzle, variable working distances**

Ambient temperature: c.5°C

All rinsing done with cold water (hot water not available)

**Fig11rt 6. 9 Test zone 8-Details of materials and procedures. Adriel Consultancy 1 7 9 T E S T Z O N E ' C

'SUMMARY OF TEST PROCEDURES FOR ALL TEST AREAS: NeOlith products were applied and removed by a representative of the manufacturer. Neolith products were applied and removed using dry abrasive cleaning undertaken by the cleaning and surface repair contractor. Additional effort on the ProSoCo products could not attend the day of the trial but had advised site and provided recommendations for products and dwell times. C1: PrCwetThixotropic acid binder (NewlockSCOOS), 15 minutes dwell, rinsed with acidic liquid (NewlockSCO01), 5 minutes dwell, citation, rinsed. C2: Thick alkaline gel (NewlockSCOOSB), 24 hour dwell, extended rinsing. C3: Acidic cleaner/neutraliser (NewlockSCO0TS), 15 minutes dwell, rinsed. C4: Thick alkaline paint remover (ProSoCo Heavy Duty Paint Stripper), 24 hour dwell, extended rinsing. Neutralisation and cleaning for C3CSa): PrCwetAlkaline liquid (NeolithHDL), 30 minutes dwell, rinsed with Acidic cleaner/neutraliser (Neolith62SSS), 7 minutes dwell, rinsed. C5b): PrCwetAcidic cleaner/neutraliser (Neolith62SSS), 10 minutes dwell, rinsed. C6s): PrCwetThixotropic alkaline liquid (ProSoCo766MasonryPrCwaaahl, 30 minutes dwell, rinsed. Acidic cleaner/neutraliser/diluted (ProSoCo Restorat
ion Cleaner, 3:1 water:product), S
minuted well, rinsed C6b): Prewet A
cid cleanner as for C6s) • Fantip nozzle
le, 7501, 000 psi at the nozzle, vari
able work distance of not less than 2 S
0mm (10") Ambient Temperature: c. S
'CALL rinsing done with cold water (h
ot water preferable in some circum
stances but not available) Figure 6
.9 Test zone C Details of materials a
nd procedures. Adriel Consultancy a b a b

PRODUCT INFORMATION

PRODUCT

"ewlock SC001 Acidic liquid
Newlock SC002B Acidic gel
Newlock SCOOS Alkaline liquid
Newlock SCOOSB Alkaline gel
ProSoCo 766 Masonry Prewash
ProSoCo T-1217 Poultice
ProSoCo Heavy Duty Paint Stripper
ProSoCo Restoration Cleaner
ProSoCo Heavy Duty Restoration Cleaner,
diluted 3:1, water:cleaner
Neolith HDL
Neolith 62SSS

Figure 6.10 Proprietary product information.

Summary of test findings MAIN ACTIVE INGREDIENT
Hydrofluoric acid (HF) Sodium hydroxide (NaOH) pH 1* 1* 14*
14* * Assumed value not stated on literature. Sodium hydroxide (NaOH) 14
Potassium hydroxide (KOH) 14 Hydrofluoric acid (HF) 1.2
Hydrofluoric acid (HF) 1.5 Sodium hydroxide > 13
Hydrofluoric acid (HF) < 1
The pressure water procedure was ineffective in removing soiling from sound surfaces. It was, however, effective in dislodging loose, cementitious mortar, portions of delaminated or granulated stone surface, and effective in rinsing out heavily weathered pointing and core mortars.

Test zone A9 included heavily weathered fourteenth century masonry which had no evidence of original surface tooling or profile. The surfaces of all the blocks were heavily granulated and superficial cementitious pointing covered substantial perimeter margins of each stone. Works began with the cutting out of all cementitious pointing mortars using hand-held tools and clearing of the loose and pulverized bedding and core mortar behind. Removal of the pointing alone presented a section I 81 Figure 6.11 T o s o m e a r e a s o f m a s o n r y , a s u b s t a n t i a l p r o p o r t i o n o f c l e a n i n g w a s a c h i e v e d s i m p l y b y t h e c u t t i n g o u t o f w i d e , s u p e r f i c i a l , c e m e n t i t i o u s p o i n t i n g . ( T e s t z o n e A 9 . ) o f w a l l i n g v a s t l y i m p r o v e d i n a p p e a r a n c e t o t h e u n t r e a t e d a d j a c e n t a r e a s . T h e a r e a w a s t h e n r i n s e d w i t h l o w p r e s s u r e w a t e r ( 3 5 0 p s i a t 1 2 i n . w o r k i n g d i s t a n c e ) . L o o s e s u r f a c e s o i l i n g w a s r e m o v e d a l o n g w i t h g r a n u l a t i n g a n d d e l a m i n a t i n g s t o n e . N o s u r f a c e m a t e r i a l o t h e r t h a n t h e w a s h i n g A 9
Figure 6.12 Areas A1 and A2 were cleaned chemically. The uneven dean of area A8c was achieved by an air abrasive process which proved to be too severe for the masonry at hand.

The final appearance of the stonework was considered successful, particularly when viewed from a distance and worthy of consideration as an acceptable, partially cleaned surface for this type and condition of masonry. The small areas of residual soiling prevented the stone from having a brand new appearance and were considered to be in keeping with its age and weathered character. From a technical point of view, their retention may not have been acceptable but represented only 10-15 per cent of the stone area. The processes adopted on this area of stonework would not be as successful on stonework which was in sounder condition.

The dry abrasive method proposed by the contractor was evaluated on both finely tooled and irregular faced ashlar. Despite many adjustments to the parameters of the processes, it was immediately obvious on each test area that the air abrasive cleaning would not be acceptable unless the equipment and abrasive supplied could be changed. On the flat, finely tooled surfaces, the surface loss happened very quickly and
gun shading

was caused readily. Irregular surfaces elsewhere required several passes of

the abrasive stream in order to remove soiling from all the ledges.

Damage was readily caused to the high spots.

Generally, the results of the chemical cleaning trials were the most Figure 6.13 These two test zones revealed natural staining originating from the stone itself which would remain on much of the masonry surface on completion of cleaning. It is seen in the form of irregular grey bands on the tan colour of the body of the stone. successful of the cleaning categories investigated. In areas of heavy and intransigent soiling, alkaline cleaners were found to be of little benefit in terms of removal of soiling, the acid-based cleaners doing most of the work. Product strength and dwell time were the criteria which determined the level of clean achieved by the acidic cleaners. In areas of moderate soiling, the most successful clean was achieved by the alkaline day-based poultice followed by a dilute hydrofluoric acid-based cleaner (ProSoCo T-1217 Poultice and ProSoCo Restoration Cleaner).

The chemical-based trials undertaken in test zone C indicated clearly

that full removal of soiling was not going to be possible from all sections

of stonework. Most of the stones included harder bands which were
darker in colour than the softer areas. Even within areas which achieved moderate and good levels of cleaning, it could be seen that considerable amounts of colour remained within the harder bands. Depth of the marking was 3-4 mm. Close inspection of stones suggested the colouring to have originated from within the stone itself.
and therefore to
be part of its natural patina. Thin section analysis identified mineral
sources of the colouring. Removal of the marking was considered
inappropriate and impossible to achieve without widespread damage. It
needed to be realized that certain amounts of colouring would remain
within the stonework. In many ways this was desirable from an aesthetic
point of view as the cleaned stonework would not appear 'new and
cleaned' but rather 'aged and cleaned'.

On the basis of the cleaning works of test zone C, it could be said that
a good level of clean (70 per cent approximately) would be achievable on
the tower stonework with a use of two-step, alkali-acid cleaning process.

The full success of this approach needed to be confirmed by the
undertaking of larger trial areas on the tower itself, particularly on the
upper levels involving both heavily soiled protrusions, as well as ashlar.

Further details on the chemically cleaned trial areas is included in the
following discussion on the results of the analysis programme.

The final assessment of the trial zones included: 1. Visual assessment of the cleaned and uncleaned stone surfaces when dry. 2. Inspection of the surfaces under X 30 field microscope in order to determine the level of
clean achieved, the extent and nature of larger-scale loss or damage to the masonry surface and the impact of the materials and processes on the block arrises and joint materials. The stonework was also inspected for alterations including bleaching and the deposition of residues. 3. Within a representative selection of trial cleaning areas, samples of stonework were taken on completion of cleaning for comparison with uncleaned surfaces to establish the extent and nature of any deposits. This included the investigation of petrographic thin sections and the quantitative analysis of soluble salts. The analysis programme The analytical programme was aimed at analysis of a series of stone samples to provide important additional information regarding the stone constituents, properties and weathering processes under way and at providing additional information regarding the effect of chemical cleaning on the stone surfaces. An important thrust was to determine the mineralogy of the stone types present and whether this had altered as a result of weathering or due to the cleaning materials and procedures. Seventeen samples were taken reflecting the various periods of construction of St Mary’s, its materials and soiling. Samples removed from the walls reflected the observed decay and soiling patterns. The seven samples taken with regard to stone cleaned during the trials were removed by direct mechanical means within one hour of completion of the recommended procedures and bagged. Generally, discrete samples of loose stone fragments were removed rather than cores being taken. Seven of the test cleaning areas subjected to chemical cleaning were sampled and analysed for the presence of residual materials (see Tables 6.1 and 6.2). Table 6.1 XRF analysis of whole samples

<table>
<thead>
<tr>
<th>Element detected</th>
<th>Sample Si s p Ca Ti Fe Mn Cr Cu</th>
<th>10.3 3.3 0.6 2.8 0.4 3.8 374* 441* nd 6 8.4 7.8 0.2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9.4 0.4 2.7 494* 499* 640* 7 11.5 2.4 0.7 1.9 0.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.9 863* 445* 537* 9 11.2 2.5 0.7 2.1 0.3 2.2 399*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>724* 0.2 10 10.3 3.9 0.5 3.6 0.3 2.7 nd 447* 567*</td>
<td></td>
</tr>
</tbody>
</table>

Values are given as percentage weight relative to the whole sample (major elements) except as marked • where the values are given as parts per million (minor/trace elements). The presence of CaSO₄, calcium sulphate, can be inferred from the amounts of Ca and S and a degree of confirmation obtained by calculation. The table does not say CaSO₄ is the sulphate present. Source: Lithan Ltd.

Petrographic analysis Petrographic thin sections were prepared from seven samples which represented the various eras of construction. Photomicrographs and petrographic profiles which set out the observed mineralogy and texture of each of the samples are presented in Figures 6. 14 and 6. 15. The petrographic analysis of all the samples
<table>
<thead>
<tr>
<th>pH</th>
<th>Anions in ppm (mg/kg)</th>
<th>Sodium</th>
<th>Potassium</th>
<th>Magnesium</th>
<th>Calcium</th>
<th>Iron</th>
<th>Nitrate</th>
<th>Chloride</th>
<th>Carbonate</th>
<th>Silica</th>
<th>Lime</th>
<th>Total Soluble Weight Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.5</td>
<td>841.5</td>
<td>104.9</td>
<td>2.8</td>
<td>4.5</td>
<td>0.6</td>
<td>0.01</td>
<td>178</td>
<td>6.25</td>
<td>17</td>
<td>3.5</td>
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<td>3.5</td>
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<td>6.25</td>
<td>17</td>
<td>3.5</td>
<td>75.2</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Table 6.2: Water soluble extract percentage weight of salts in ppm (mg/kg) of samples. See comments beneath Table 6.1 regarding inferred and calculated information. Source: Lithan Ltd. 

CASE STUDIES 187 types which were broadly similar in mineralogy and texture. All the rocks were generally classified as argillaceous sandstone. Clays were major constituents of the media binding the quartz grains. All samples had experienced progressive surface deterioration in the form of granulation (loss of binder) and subsurface microfractures. Another distinctive feature was the variation in the total and relative clay mineral content between inner and outer zones. It was not possible to distinguish clearly between cleaned and uncleaned samples in terms of the removal of outer mineralogical components or increased porosity in outer layers. This was considered to speak favourably for the chemical processes tested. Several samples which had not been cleaned showed significant depletions in their outer layers. The reduction in clay mineralogy of one of the seven cleaned samples was virtually imperceptible and could not be unequivocally attributed to the cleaning processes. The cleaning process adopted had used a hydrofluoric acid-based product believed to be amongst the strongest on the market. It had been included in the trials as it was one of the chemical cleaners the contractor was proposing to use. An additional reason for taking the sample from this area was that from a visual assessment it appeared...
that the colour of the stone had been altered by the hydrofluoric acid-based cleaning process. The thin sections taken from cleaned areas also revealed that the surfaces which had been assessed by eye to be clean still retained remnants of soiling in crevices but had experienced no alteration to the binder constituents. This confirmed that chemical alteration of the stone was not likely to be caused when procedures were adopted which achieved a level of clean considered complete on the basis of close visual assessment, the criterion universally adopted on sites. Chemical analysis This phase of analytical work was directed towards determining the total chemistry of stone samples representative of the test cleaning areas, as well as locations not involved in the cleaning trials. All stone samples taken were analysed to determine water and acidsoluble components using inductively coupled plasma spectroscopy (ICP) and ion chromatography (IC) (see Table 6.2). The acidic components were also tested but the results were negligible. The total chemistry of five samples of uncleaned stone was prepared by X-ray fluorescence (XRF) which established the general types and quantities of soluble salts present (see Table 6.1). It determined the high inherent

PBI‘ROORAPIUC PR.0Fn..B

Site: St. Mary’• Church, Galelhead

Date: November, 1990

A: SURFACEOBSBR.VATIONS

1 Pollutatlct clftlt
2 ◊r,anic matter
3 Treatmellt reaidu.a
4 Metallic lain
s Effiore”ence
6 Sound

B: COLOUR OF HAND SPECIMEN

1 Outer
2 Inner
3 Comment:

C: GRAIN TEXTURE

1 Shape:

2 Contacts:

3 Sortina:

4 Porosity:

5 Very "oane

6 Coarse

7 Medium

8 Fine

9 Very fine

D: MINERALOGY Ableltt, Prelellt Nooe~e Abient
Abieot Yea amau •mple rounded to aubanaular point and
face moderate elllimated 10" >1.0mm ,S-l.0mm .2S...Smm
maio .12S-.2Smm <.12Srnm > 10" vol: Quartz, Claya
Photomicrograph of sample 1. Photographed at X60
magnification, plain polarized light. (Lithan Ltd)

1 Major conatituenta

2 Minor conatituenta

3 Other conatituenta 2-10" vol: Ore mioerala, Lilbic
framenta, Feldapan, Mica <2" vol: Calcite to outer
aurface

E: CEMENTATION

1 Type: Claya

2 Degree: Variable

F: DECOMPOSITION PRODUCTS

NA

G: DISCUSSION
A poorly defined orientation ia prelelll and lbe dearee of
cohesion varies wilbhin lbe aection dependent upon point
cootacta and
lbe intentitial Claya, primarily Kaolinite. The Micaa are
larger lban Sample 9, occ\'YrinJ aa diatioc tr aaioa in
addition to lboae
intentitialy aa before. A zone of mineral enrichment occurs
and a ayllem of micro-fractures extendalbrouJb lbe aection
parallel
to lbe aurface. Thil is an AIJJiUaceoua aodatone.
Prepared by Lithan Ltd

Figure 6 .14 Petrographic analysis of sample 1, corner of
quoin to mid-eighteenth century masonry. Sample taken
within test zone C2, cleaned by HF-based acid product only.
Sound body of stone and residual soiling to outer layer

can be identified.

PETR.OGRAPIUC PROFILE

Site: St. Muy'a Ch\'h. Gatelhead

Date: November, 1990

A: SURFACE OBSERVATIONS

1 Pollutllll crull
2 Oqauiic matter
3 Treatmelll reaiduea
4 Metallic: ICain
5 Effioruceoce
6 Sound

B: COLOUR OF HAND SPECIMEN

1 Outer
2 Inner
3 Comment:

C: GRAIN TEXTURE

1 Shape: _

2 CONTACT:

3 Sortija:

4 Porosity:

5 Very coarse

6 Coarse

7 Medium

8 Fine

9 Very fine

D: MINERALOGY Preant Prealll Nooo-n Abant Abaent No amallumple amplan to rounded poill1 and face moderate to poor eilliminated 1 0” >1.0mm ,S-1.0mm ,25-.Smm-main .12S-.25mm <.12Smm > 10” vol: Quartz, Clay•

Photomicrograph of sample 12. Photographed at X 60 magnification, plain polarized light. (Lithan Ltd)

1 Major coallituenll

2 Minor coalllitenll

3 Other coallituenll 2-10” vol: Ore minerala, Lithic fraJIIICntl, Feldapara, Mica <2” vol:

E: CEMENTATION

1 Type: Claya

2 Deane: Variable

F: DECOMPOSMON PRODUCTS

NA

G: DISCUSSION

The Retion .ij 1limilar to the previou1 RCUORI and i• differentiated by a decreaa in the Kaolinite and an increue
in the ore

mineral. This is an Ar-jillaceoua undilute. Prepared by Lithan Ltd

Figure 6.15 Petrographic analysis of sample 12, from within area of fifteenth century stonework after cleaning with

HF acid-based gel (test zone 83). Bleaching, suspected following visual assessment, was not confirmed.

contaminant salt loading of the stone and enabled assessments as to

whether further salts had been deposited by the cleaning processes.

Inherent contaminants

The stonework was found to be carrying an extremely high loading of

soluble salts which derived principally from direct deposition and

interaction with atmospheric pollutants. While these had interacted

very little with the mineralogy of the stone, a reaction was found to have

taken place between the mineralogy and the existing cementitious

pointing and bedding mortars. Investigation of uncleaned stone samples

revealed the presence of other contaminants of varying degrees of water

solubility, including calcite, again derived from the mortars and

representing a source of physical decay additional to the general physico

chemical decay caused by the water soluble components. The data of

Table 6.2 also showed that a suite of minerals was present
as contaminants in addition to the ubiquitous gypsum.

Contaminants from the chemical cleaning trials

The areas in which the first stage of cleaning was undertaken using alkaline materials were found to contain significantly higher sodium (Na) levels when compared with uncleaned samples of the same stone or other samples cleaned without alkaline materials. Small residues of the alkaline cleaning materials were clearly being left in the stonework.

The pH values established indicated that either neutralization of the alkaline component was not carried out and that acid residues remained in the stone or that the cleaning was not effective. Information from the petrographic analysis supported the latter argument: it de-emphasized the product-related contaminant argument problem but did not eliminate it.

The cleaning procedures were found to mobilize the existing salt content, i.e. the salts that had been introduced over time but were not inherent to the original stone. The results also confirmed that the stonework would be left with a very substantial salt loading following
cleaning. It was concluded that the cleaning processes tested could not be expected greatly to improve the inherent salt loading problem of the stonework, although some salts would be removed during rinsing procedures. If it were to be undertaken, reduction in soluble salts levels would need to be achieved by means other than the cleaning, e.g. plain clay poulticing.

It was recognized that the low ambient temperatures of the trial period reduced the effectiveness of all the cleaning compounds and the use of cold water washes (hot water was not available) had reduced the effectiveness of the rinsing of residues, particularly of alkaline products for which it would have been preferred. The use of hot water would also have improved the amounts of inherent salts washed from the masonry surfaces. It was also advised at the time of the trials that the rinse procedures adopted were too fast and too short to be effective. On the basis of findings of both the petrographic and chemical analysis it was determined that removal of the surface soiling to the masonry was still desirable from the point of view of reducing the effect of indurated layers and crusts inhibiting moisture movement at the stone face, limiting salt dispersal to the evaporation surface. Previous treatments While the observed decay patterns of some areas of the St Mary’s masonry suggested that a chemical treatment had been applied to the stone surface, samples selected for analysis and investigated using infrared spectroscopy failed to show the presence of any coating which could be classified as either linseed oil or silicone or other such material. Physical analysis Two fist-sized lumps of stone taken from the side of the pilaster to the fifteenth century masonry on the north elevation, were investigated to determine the physical parameters of the main stone types observed. Physical parameters The effective porosity, total porosity, water absorption coefficient, saturation coefficient and density of the samples were determined. The results are presented in Table 6.3. Table 6.3 The physical parameters Water

| Sample | Ne | N | w | s | D | Ne | N | w | s |
|--------|----|---|---|---|---|----|---|---|---|---|
| Sample A | 0.10 | 0.20 | 0.30 | 0.40 | 0.50 | 0.11 | 0.21 | 0.31 | 0.41 | 0.51 |
| Sample B | 0.12 | 0.22 | 0.32 | 0.42 | 0.52 | 0.13 | 0.23 | 0.33 | 0.43 | 0.53 |
| Sample C | 0.14 | 0.24 | 0.34 | 0.44 | 0.54 | 0.15 | 0.25 | 0.35 | 0.45 | 0.55 |
The data confirmed the textural differences and similarities observed in the petrographic thin sections and hand specimens. The combined results revealed characteristics which meant that the ingress of water and waterborne contaminants to the stones was easy. The stones were also found to be very susceptible to physical disruption caused by freeze-thaw cycles or the hydration-dehydration cycles of water-soluble salts.

These findings were considered applicable to the stonework of the church generally because of the close correlation of other factors. The findings were particularly relevant as they confirmed why cleaning operations involving water should not be undertaken in periods of low ambient temperatures.

The decision to clean

The following is a summary of the technical and aesthetic considerations which provided the basis for the decision to clean. Abrasive cleaning methods tested during the trial period were generally not suitable for the cleaning of the StMary’s Church masonry.

The method demonstrated by the contractor did not prove successful on
any of the types of surface soiling assessed. If this method of cleaning were to be pursued, additional trials with different abrasives and different equipment would have been required. The building programme did not permit this.

During the trials, water pressure at about 1000 psi demonstrated value in removing loose surface material and cutting out loose pointing but not adherent soiling.

The chemical cleaning processes investigated during the on-site trials gave a range of visual results which varied depending on the age, type and condition of the masonry and the degrees of adherent soiling. None of the materials tested offered significant advantage over the others from a residue point of view. While the analysis did not detect damage to any of the surfaces cleaned by chemical means, areas which appeared 'over cleaned' could be seen to have experienced minor surface losses on a scale too large to be accommodated by the analytical process used. Several processes were of necessity rejected.

All processes which involved the application of an alkaline pre-wash in liquid, gel or poultice form indicated some residual
deposition of

product-related soluble salts. Chemical cleaning trials involving acid

alone recorded deposition of small amounts of residues related to these

products. The quantities of these were very small, especially when compared with the existing salt loading. It was considered possible that the levels of sulphates detected could have been reduced significantly if hot water had been used for the rinsing procedures, the rinse times had been extended and the trial work had been undertaken at a higher ambient temperature. The problem could therefore be readily minimized and probably eliminated during larger-scale works if correct procedures were adopted. By necessity, all the chemical cleaning trials involved the wetting and rinsing of the stonework on more than one occasion. This was found to have caused mobilization of the inherent salts, drawing some salts from deep within the stone up to the surface. The depth of the soluble salt reservoir within the masonry was not fully determined. It was suspected it would be extensive and deep due to the extended and widespread water penetration of joints and the subsequent percolation of moisture. On a large scale, the existing salt levels in the stonework could have been reduced using hot water (less than 95°C) rinsing and the brushing off of resultant efflorescence. For small areas of carved and moulded work which are at risk, the surfaces could be wetted, then coated with packs based on deionized water and clay into which salts would be drawn (analytical work at the surface and at depth would be necessary before and after each process to establish by how much the salt levels were being reduced). The effect and value of the above processes could only be fully determined if the reduction in salts could be measured. Any reduction would nevertheless be of benefit. While it could not be said that technical reasons exist as to why the building should not be cleaned, it had also to be said that the use of chemical cleaning products in the St Mary’s situation, if undertaken responsibly, would present only minor negative technical implications. The St Mary’s masonry had greater problems, including its inherent salt loading, the condition of its pointing, bedding and core mortars, the localized weathering of beds within stones, the advanced weathering of individual blocks, and the possible lack of structural integrity to heavily weathered areas of walling. It was also noted that while the stone surfaces
would benefit from the removal of the black pollutant soiling, the on-site test and analysis showed that it could not be completely removed. From an aesthetic viewpoint, the effect of the proposed cleaning revolved around what the likely appearance of the church would be and whether it would retain historic character. The areas of heaviest and darkest soiling were those which were visually most prominent. Their contrast with the remaining areas of masonry, particularly the lightly soiled areas, was strong. The dark soiling in these areas hid the detail of the architectural features.

An important finding of the trials was that the cleaning of moderately and heavily soiled masonry would remove only part of the soiling, leaving the surfaces looking less soiled but still aged. The starkness of the contrast between the lightly soiled areas and the moderately and heavily soiled areas would be reduced if the latter too were cleaned. The lightly soiled areas of masonry contained a high proportion of blocks with granulating and delaminating surfaces and the occasional sound block which was heavily soiled. When viewed at a distance, the overall appearance of the masonry was fairly even. There was little purpose to be served by cleaning the whole of these areas because of the low level of soiled blocks within them. Recommended cleaning methods and associated remedial works 1. It was recommended that the areas of carved detail such as hood mouldings and associated label stops were consolidated prior to cleaning in order to reduce the loss of detail. Many of these details were in very friable condition. Further laboratory trials were recommended to ensure selection of the correct consolidant and to confirm the nature and degree of its effect on the properties and behaviour of the stone. 2. Due to the heavy soiling on

Figure 6.16 South elevation of St Mary’s Church, Gateshead, on completion of cleaning and surface repair.
areas of carved detail, the cleaning process recommended was the alkaline day-based poultice (ProSoCo T-1217, pH 14) and associated acidic neutralizer (ProSoCo Restoration Cleaner, undiluted, pH 1.2). These materials and procedures would give a greater degree of control for the cleaning of these localized areas. The analysis had confirmed that the iron in the stone was not generally in a form which would react readily with these cleaning compounds. The pressure at which the products were to be rinsed off was to be considerably lower than that used on ashlar, cornices and more robust surfaces elsewhere. A detailed specification for the works was prepared and the works undertaken soon after. The finished result as predicted, an even level of clean could not be achieved. Residual soiling was greatest in areas where the most intense soiling had been. The overall impression of the cleaning was of an old masonry structure which had been treated respectfully. Good reduction in different intensities of soiling was achieved, even on the south elevation, and has served to integrate the appearance of each elevation and the building as a whole.

The value of the specialist investigations was proved. The quality of the cleaning and surface repair works which brought the theory into reality are a very significant part of the success of the project.

6.3 CASE STUDY 3: FACULTY OF ART AND DESIGN, BIRMINGHAM THE CLEANING OF A COMPLEX VICTORIAN BUILDING

Background and brief

The Faculty of Art and Design, located in central Birmingham, is an imposing three-storey building designed by architects Martin and Chamberlain, and constructed in 1884 by Messrs Sapcote and Son. The Gothic design of its three street frontages exploits to
the full the
intricate combinations of buff and red sandstones, limestone, brick, red
and buff terracottas, glazed and unglazed tiles, and mosaics. While the
architectural effect of these materials was undoubtedly impressive,
cleaning of the external surfaces was to be a complex operation as a
result. Many of the difficulties and dangers that may have been
encountered were avoided by the undertaking of a logical sequence of
trials and investigations prior to preparation of the cleaning specifica
tions for the main contract.

Architects for the project were Associated Architects of St Paul’s
Square, Birmingham. The client was the University of Central England
in Birmingham. The specialist technical input into the cleaning
procedures was provided by Adriel Consultancy, Nottingham. Main
contractor for the works was William Sapcote and Son, Birmingham.
The cleaning subcontractor was Aqua Cleaning Company, Birmin
gham. The success of the project must attributed to the strong team
approach that was developed between these parties.

Cleaning was a necessary prerequisite to the surface repair
programme. The architects had found it difficult to
finalize the extent of necessary repairs as a result of the intensity of soiling in many areas. The facades had not been cleaned before and many of the surfaces were so heavily soiled that it was difficult to identify the substrate or to appreciate its condition, even where surfaces were inspected at close range. In its position at the centre of the city, the Faculty of Art and Design, Birmingham, prior to cleaning and surface repair. Intense soilings to sandstone surfaces masked the wealth of intricate detail. Colours of all other materials were strongly muted. Design was surrounded by other buildings of similar scale, all of which had been cleaned, some on more than one occasion. Motivation for cleaning was also strong from a landscape viewpoint.

Figure 6.17 South east corner of the Faculty of Art and Design, Birmingham, prior to cleaning and surface repair. Intense soilings to sandstone surfaces masked the wealth of intricate detail. Colours of all other materials were strongly muted. Design was surrounded by other buildings of similar scale, all of which had been cleaned, some on more than one occasion. Motivation for cleaning was also strong from a landscape viewpoint.

Figure 6.18 Detail of archway and gate to the main entrance. The foliated medallion and panels are of Bath limestone and the lattice in between, encaustic tile.

The highly carved gable above and archway beneath are of the lighter buff sandstone used widely on all facades. Onsite cleaning trials Initial selection of method Intensive deliberation as to which cleaning materials and methods would be suitable to onsite investigation resulted in the following conclusions: 1. Water washing would not clean the bulk of the facade materials. 2. The wider range of materials, surface characteristics and types made the use of abrasive cleaning
It was impossible to undertake without significant damage on many of the surfaces even with frequent modifications to equipment and abrasives supplied. Selective use of abrasive cleaning would have provided a gargantuan masking and protection problems for surfaces which may have been suited to it were dotted over the facades. While the use of small scale air abrasives may have reduced or eliminated these concerns, the cost would have been very high. Abrasive cleaning was not discounted totally but it was decided that other methods should be investigated first. In general terms, chemical cleaning processes were considered more suited to the combination of plain and ornate surfaces used. The success of their use would depend on identification of

**Figure 6.19 Cornwall Street (north west) elevation, Faculty of Art and Design, Birmingham, facade materials**

<table>
<thead>
<tr>
<th>Location of the aerial cleaning bay.</th>
</tr>
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<tbody>
<tr>
<td>Stone capping Stone com ice Roof lights</td>
</tr>
</tbody>
</table>

Plain clay tile

Cast iron railings A B C D E TRIAL F BAY G H I J K L M N

Cast iron guttering

Terracotta arched

infill panels

Brickwork

Timber window

Tiled frieze
First phase of on-site trials

On-site investigations began on the Cornwall Street elevation which was made up of fifteen bays of similar design and deployment of masonry types. A specification was drawn up for the undertaking of spot cleaning trials to be followed by the cleaning of a full-height bay with the preferred materials. Chemicals from the two manufacturers were evaluated on opposite sides of the test bay in order to reduce the chance of cross-contamination of rinse waters. The predominant material of each bay was brickwork. Buff sandstone had been used for the gutter cornice, buttress slopes and the window sills. The decorative band to the first floor transome comprised glazed and unglazed tiles with a central rosette in limestone. The bays included the most widely used material types. The protection required for the Mosaic panai Stone coping and finial Plain day tile Brick
Terracotta medallion Red sandstone
Timber sash window and leaded lights Sandstone sills
Tiled frieze Cast iron railings P Q Limestone and tiles R S Sandstone T U Position of trial cleaning areas Sandstone Trefoil mosaic Sandstone Terracotta
Brick Carved stone infill Stone pier caps Stone balcony
Leaded lights Brick Stonework k Leadec lights Tiled frieze FRONT ENTRANCE! Figure 6.21 Edmund Street (south east) elevation, Faculty of Art and Design, Birmingham, facade materials. tiles, rosette and the window could also be evaluated. Unfortunately, the evaluation procedures of the study were not able to incorporate a full range of analytical work prior to the trials. Nevertheless, a practical level of analysis was undertaken at essential points as work progressed, i.e. pH testing of surfaces and qualitative analysis of efflorescences. The constituents and characteristics of the buff sandstone were identified by thin section analysis. This work revealed constituents of the stone to be the source of residual staining. Within the test bay, the areas selected for spot trials are shown in Figure 6.22. They were: Cast iron finial. Carved timber gable dormers Cast iron balcony Terracotta tympana Leaded light Carved stone panels Stone pier caps Tiled frieze Cast iron railings

Figure 6.22 Location of spor erial areas ro erial cleaning bay, bay 6 of rhe Cornwall Srreer
elevation. Derails of materials and processes are sec our in Tables 6.4 and 6.5. E 3 S 4 NEOLITH PHOSOOO 7 • 8 9 10 11 Gutter level (test area A) t Portion of gutter cornice (sandstone, water saturated, soiled and stained). t Side of buttress including sloping water tables (sandstone, heavy soiling, blotchy soiling). t Heavily soiled brickwork adjacent to buttress, including unglazed terracotta moulding. t The terracotta panel within the arch of the first-floor window was considered in too friable a condition for any general cleaning process. There was extensive evidence of decay due to the presence of soluble salts with many areas exfoliating in flakes up to 1 mm thick. The cleaning contractor was asked to record the panel photographically prior to any work elsewhere and to protect the panel to prevent any water or cleaning chemicals coming into contact with the surface. Specialist conservator advice would be necessary for the treatment of the fifteen different sculptured panels found at this height of the building. Transome level
Portion of sloping sill, including end stooling (sandstone, moderate/blotchy soiling). Brick to window reveal (moderate soiling). A section of the tiled panel (light soiling). The limestone feature within the tiled panel (heavy soiling). Fully sheeted scaffold to the width and height of the test bay remained in position until after the areas had dried and been evaluated. The cleaning trials were undertaken in August 1990 at the end of a long, hot summer (by British standards). Representatives of the cleaning materials manufacturers were in attendance during the undertaking of their representative areas. Details of materials and processes used are set out in Table 6.4 and Table 6.5.

The appearance of all the completed trial cleaning areas did not necessarily represent the final appearance of the cleaned surfaces. The principal requirement was that the materials should be used as gently as possible. It was considered preferable that a surface be under-cleaned rather than over-cleaned and damaged. The test areas were inspected visually with a X 30 field microscope and tested with pH strips while still damp and when dry. The following criteria were considered for each area:

Table 6.4 Produces and processes used on test areas

<table>
<thead>
<tr>
<th>Test area</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Buff sandstone gutter cornice and water table</td>
<td></td>
</tr>
<tr>
<td>2. Buff sandstone gutter cornice and orange brickwork beneath, including moulded brick to arch. Cornice and brickwork affected by extended period of saturation due to defective cast iron gutter above</td>
<td></td>
</tr>
<tr>
<td>3. Buff sandstone gutter cornice and orange brickwork beneath, including moulded brick to arch. Cornice and brickwork affected by extended period of saturation due to defective cast iron gutter above</td>
<td></td>
</tr>
<tr>
<td>4. Brickwork and moulded brick to arch</td>
<td></td>
</tr>
</tbody>
</table>
| 5. Buff sandstone gutter cornice and orange brickwork beneath, including moulded brick to arch. Cornice and brickwork affected by extended period of saturation due to defective cast iron gutter above ProductJ and processJ (a) ProSoCo T -1217 Poultice Dwell time 24 hours Bulk removed with plastic scrapers Pressure water rinse at 3 50 psi (b) ProSoCo Restoration Cleaner diluted 2 water: 1 cleaner Dwell time 5 minutes Pressure water rinse as above 90-95% clean achieved except for residual
soiling to upward facing slopes of water table (a) Pre-wet ProSoCo 766 Masonry Prewash Dwell time 20 minutes Rinsed as above (b) ProSoCo "Restoration Cleaner diluted 2 water : 1 cleaner" Dwell time 5 minutes Rinsed 90-95% clean on brickwork 80-85% clean on sandstone Water staining to gutter scone became apparent on drying out Algal growth reappeared within 10 days (a) Pre-wet ProSoCo 766 Masonry Prewash Dwell time 20 minutes Rinsed as above (b) ProSoCo Limestone Afterwash, diluted 1:1 Dwell time 5 minutes Rinsed 75-80% clean to scone and brick and surfaces Water staining and algal regrowth as for area 2 Test abandoned for reasons of cross-contamination (a) Pre-wet Neolith HDL co sandstone and brickwork Dwell time 4 hours Pressure water rinse at 1200 psi (b) Brick: Neolith 600 Dwell time 10 minutes Scone to buttress: Neolith 62SS and 625HD Dwell times 10 minutes approximately 100% cleaning of brickwork Degree of clean co sandstone similar co area 1 Inherent staining not removed even though stronger acidic products used Surface roughening and arris damage very noticeable 6. Plain and moulded brickwork to window reveal 7. Plain and moulded brickwork to window reveal 8. Sandstone, sills and stooling to first floor window 9. Sandstone sill to first floor window 10. Sandstone, sills and stooling to first floor window 11. Tiled frieze and rosette (a) Pre-wet ProSoCo 7 66 Masonry Prewash Dwell time 20 minutes Low pressure water rinse at 3 50 psi (b) ProSoCo Restoration Cleaner diluted 2 water : 1 cleaner Dwell time 5 minutes Rinse as above 90% clean achieved (a) Pre-wet NeolithHDL Dwell time 2 1 2 hours Pressure rinsing at 1200 psi (b) Neolith 600 Dwell time 10 minutes Pressure rinsing as above 100% clean (a) Pre-wet ProSoCo 7 66 Masonry Prewash Dwell time 45 minutes Pressure rinse at 3 50 psi (b) ProSoCo Restoration Cleaner diluted 2 water : 1 cleaner Dwell time 5 minutes Rinsed as above 70-75% clean achieved after one application. (a) and (b) repeated at dwell times of 30 minutes and 5 minutes (2 water : 1 cleaner) respectively 90-95% clean Residual soiling to areas of sandstone most heavily saturated by weathering and where original surface remained (a) ProSoCo T -1217 Poultice As for test area 1 (b) ProSoCo Restoration cleaner diluted 2 water : 1 cleaner; as for test area 1 95% clean apart from inherent residual soiling (a) Pre-wet NeolithHDL Dwell Time 2 1 2 hours Pressure rinse at 1200 psi (b) Neolith62SSandNeolith625HD Dwell times 10 minutes approximately Rinsed, as above 100% cleaning of stone achieved Inherent staining not removed, even though stronger acid products used Surface roughening and arris damage very noticeable Glazed and unglazed tile: pre-wet Vulpexo soap in warm water, 1 : 6,
applied and agitated with natural bristle brushes. Rinsed 85% clean achieved and no further glaze. Joss Derbyshire limestone rosette: thick soiling very slow to respond to water softening and small scale brushing. The tests were undertaken to the recommendations of representatives of the product manufacturers.

Table 6.5 Details of products used

<table>
<thead>
<tr>
<th>Product</th>
<th>NeolithHDL</th>
<th>Neolith 600</th>
<th>Neolith 625SS</th>
<th>Neolith 625HD</th>
<th>ProSoCo T -1217 Poultice</th>
<th>ProSoCo 766 Masonry Prewash</th>
<th>ProSoCo Limestone Afterwash</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product</strong></td>
<td>NeolithHDL</td>
<td>Neolith 600</td>
<td>Neolith 625SS</td>
<td>Neolith 625HD</td>
<td>ProSoCo T -1217 Poultice</td>
<td>ProSoCo 766 Masonry Prewash</td>
<td>ProSoCo Limestone Afterwash</td>
</tr>
<tr>
<td><strong>Main active ingredient</strong></td>
<td>Sodium hydroxide (NaOH)</td>
<td>Hydrofluoric acid (HF)</td>
<td>Sodium hydroxide</td>
<td>Hydrofluoric acid (HF)</td>
<td>Sodium hydroxide</td>
<td>Hydrofluoric acid (HF)</td>
<td>Sodium hydroxide</td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>&gt;13</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>14</td>
<td>14</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>Evenness of the clean and the resultant appearance of the cleaned surface close up and at distance.</strong></td>
<td>3. The effect on the masonry surface and its joints in terms of colour change, surface loss and deposition of residues.</td>
<td>4. The complexity of each of the cleaning systems.</td>
<td>5. The ease of usage of each of the systems and the operational implications of these.</td>
<td>6. The cost implications of the systems used.</td>
<td>7. The health and safety requirements.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Evaluation of the areas

Test area A (gutter level)

The materials of both suppliers performed similarly well on the heavy soiling of the brickwork, one more readily producing a cleaner and
brighter surface (the products were stronger and the dwell times longer).

In both areas, the surfaces of the bricks and joints were not affected by the processes. Efflorescence which appeared on all surfaces following trials developed along the tide mark which represented the extent of saturation from the gutter above. Semi-quantitative salt analysis indicated that the emerging salts were cleaning product related to a very minor extent only.

The comparative water absorption rates of the brickwork before and after the cleaning were evaluated with a Rilem tube. The rate after cleaning greatly exceeded that of before, indicating the effect that the soiling was having on the brick surfaces. Removal of the soiling therefore greatly increased the bricks' ability to release its inherent salt loading which lead to the bulk of efflorescence observed. The thorough pre-wetting regime had encouraged their emergence, inadvertently causing a desalination programme to take place. A satisfactory level of dean could not be achieved on the brickwork using the acetic acid-based neutralizer. The system selected for the second phase of the trials was ProSoCo 7 66 Masonry Prewash (20 minute dwell), followed by Restoration Cleaner diluted with 2 parts water (5 minute dwell, repeated once if necessary). Figure 6.23 View down onto a buff sandstone gable on completion of a spot trial using the alkaline poultice/acidic afterwash process selected for these surfaces. Areas of residual soiling also denote areas which have experienced least
surface loss due to weathering.

Figure 6.24 Trial cleaning bay on Cornwall Street elevation on completion, with efflorescence in full bloom. Both chemical cleaning systems achieved a good level of clean on the sandstone gutter cornice, revealing the water staining beneath as had been anticipated. It was suspected that there was perhaps more surface loss with one process than the other as considerably higher rinse pressures were used, but, as the surfaces were very weathered before the trials, this could not be confirmed. The best cleaning result was achieved with the ProSoCo T-1217 Poultice/dilute Re"toration Cleaner process which produced a superior result to the liquid cleaners with no visually observable surface loss. This process also performed best on the sandstone weatherings of the buttress and the sill at first-floor level. Generally, the cleaning of the sloping areas of the sandstone proved problematic. It is normal and usually acceptable for some soiling originating from the stone itself to remain on areas of stone which have been heavily saturated throughout their life. Because the stone of the Faculty of Art and Design was so light in colour, small amounts of residual soiling were noticeable when viewed at close range. At a distance, the residual soiling was far less noticeable. Thin section analysis identified the stone to be a porous, medium-grained sandstone, mainly composed of quartz with minor amounts of feldspars, mica and the clay mineral kaolinite. Abundant amounts of iron minerals were also identified. These accounted for the surface staining which was made up of large concentrations of oxyhydroxides present to a depth of 1 mm into the stone. An extensive series of laboratory tests were unable to remove the staining and it had to be concluded that, if its removal was necessary, it would have to be undertaken mechanically. 1 The terracotta panels were excluded from the cleaning trials because of the friable condition of their moulded surfaces due to salt crystallization damage. Test area B (transom level) At the transom level, the liquid cleaners of both manufacturers performed similarly well on the brickwork and its joints. There was a high level of efflorescence on the ProSoCo panel which appeared to be product-related (brush marks were identifiable in the efflorescence pattern). The cause of this was believed to be the contact time of the alkaline cleaner (almost twice that used in test area A where minimal product-related efflorescence was detected. The following options were investigated during the test cleaning of the full bay: 1. Reduction
in the contact time of the alkaline cleaner in line with that used on the brickwork of area A. 2. Reducing the dilution of the acidic afterwash from 2 : 1 to 1 : 1. 3. Using two neutralizing washes rather than one. 4. Controlling the volume of water used for pre-wetting.

The spot trial cleaning of the sandstone sill at first-floor level provided the same problems with residual staining as had been experienced on the buttress weatherings.

Conclusions (first phase)

At the end of the spot trials, it was concluded that, as far as the cleaning of brickwork was concerned, the materials of both suppliers performed similarly well on the brickwork but not on the stonework. The ProSoCo system demonstrated a considerably better overall result in the latter instance. An interim specification for the cleaning of the full bay using these products was prepared for costing and execution.

The procedures and results of the spot trial were recorded in a report which included a photographic record.

Cleaning the first elevation

The final specification for the Cornwall Street elevation was prepared only once the cleaning and evaluation of the trial bay were complete.

During the cleaning of this elevation, the main problem was efflorescence on the brickwork.
Levels had been greatly reduced by modifications to the early specification, but, even so, the residual amounts were unacceptable. As has been mentioned, samples of efflorescence were sent for analysis and confirmed that the cleaning products were at fault to a very small extent, if at all. Additional precautions taken included the installation of plastic 'skirts' at first-floor sill level, to reduce the amount of run-off affecting brickwork beneath. In addition, as the surfaces dried out, efflorescence was removed twice a week using an industrial vacuum cleaner with a soft brush attachment. This provided an effective method of removing the salts and containing them prior to disposal.

Efflorescence continued to emerge for four weeks after the cleaning was completed. Trial areas of chemical efflorescence treatment were undertaken on a section of brickwork which had been particularly heavily affected. The reduction of efflorescence achieved was undeniably significant but reluctance to use the treatment remained. It was eventually agreed that the treatment should be used on selected areas of heavy efflorescence immediately prior to the striking of the scaffold, whilst the remainder and bulk of the surfaces were left to be resolved by the rinsing processes of the weather. Cleaning the second elevation The Margaret Street elevation, the principal facade of the Faculty of Art and Design, was the next to be cleaned. The Margaret Street elevation faced south-west and was more intensely weathered and soiled than the Cornwall Street elevation.
Much of the experience of the first elevation could be transferred to the second facade, and further spot testing was undertaken to confirm this and establish any minor adjustments. Additional testing was required on the foliated cream-coloured terracotta of a large medallion to the main gable, the colonnade of ornate red terracotta panels, red sandstone (Red Mansfield).

Figure 6.25 Many of the special architectural features of the Margaret Street elevation, fabricated in terracotta, included the cream coloured medallion and the red colonnade surrounds. Spot trials were conducted on each of these areas and a different cleaning specification was required in each instance.

Figure 6.26 Spot cleaning trial on the Margaret Street elevation being undertaken on buff sandstone, red terracotta and brickwork just below roof level.

which had been used to a limited degree to complement the red terracotta, buff sandstone tracery surrounding mosaic panels (the mosaics had recently been restored) and the foliated limestone and encaustic tile infill to the main entrance gable. The location of the trial areas undertaken is shown in Figure 6.20.

Soiling to heavily weathered brickwork and sandstone elements was found to be very intransigent and it was clear that a higher level of residual soiling, reflecting the heavier weathering of the facade,

would need to be accepted. This problem was most pronounced on
exposed sandstone elements such as the finials and copings. Efflorescence occurred again on the brickwork but to a far lesser extent than on the previous elevation, probably due to the lower inherent salt loading on this more heavily washed elevation. The 15 foot wide circular medallion to the gable at the eastern end of the Cornwall Street elevation, whose foliated decoration was made up of cream-coloured terracotta, could not be successfully cleaned with any combinations of liquid alkali-acid and acid-only products. Excellent results were achieved following the chance investigation of ProSoCo T1217 Poultice (24 hour dwell) followed by ProSoCo Restoration Cleaner (5 minute dwell) (see Figure 6.25). Figure 6.27 Masonry above the main entrance on completion of cleaning and surface repair works. The delight of the Victorian detailing can be appreciated once again.

The last elevation

Cleaning of the final elevation facing Edmund Street did not start before spot trials had confirmed the applicability of the existing specification.

Conclusions

The Faculty of Art and Design demonstrated the complexity of cleaning a facade which is architecturally intricate and includes several material types. The investigations and trials were critical to the preparation of the detailed specification which in turn was an important datum for supervision and costing. Modifications to the specification, made necessary by the many different cleaning conditions that presented themselves as the project progressed, were a sobering reminder of how easily the cleaning could have gone wrong had untested
assumptions
been applied throughout. The project was also good
testimony of the
many variations in soiling tenacity that are present on
different facades
and within the one facade.
The success of the work was due largely to the high level of
supervision of the cleaning contractor and her ability to
adapt to the
many and varied requirements of the cleaning. The
specialist technical
advice was on call which enabled swift response to any new
problems
which arose. Of essential value to the work was the good
working
relationships between the architect, the technical advisor,
the cleaning
subcontractor and the main contractor.
More detailed preand post-testing analysis would have
enabled more
problems to have been anticipated and eliminated, certainly
at earlier
stages than they were on the basis of site work alone. The
final result has
received widespread acclaim, including a Commendation under
the

I. ProSoCo Inc. Laboratory Report, February 6, 1991. Kansas
City: ProSoCo Inc. 6.4 CASE STUDY 4: BUILDING 1, BREL
SWINDON FACADES COMPRISING SANDSTONE, LIMESTONE AND BRICK
Figure 6.28 Portion of the facade of Building 1, Swindon,
which faces the main rail artery of the Wesc Councry,
before cleaning and repair. The industrial architecture of
the building is highlighted at second-floor level by two
carved panels depicting crains. Methods used for the cleaning of these were different from those for the more robust masonry of the remaining walling.

A complex of buildings which once housed the offices and train manufacturing facilities of the Great Western Railway at Swindon, Wiltshire, were given new life in the early 1990s as their conservation, repair and refurbishment began in preparation for new occupants.

Located adjacent to Swindon Railway Station, the buildings date from the mid-nineteenth century, their industrial design reflecting the pragmatism of their original uses.

Several individual buildings on the site are listed: These include the former offices complex known as Building 1 which was selected by the Royal Commission for Historic Monuments in England (RCHME) as its new headquarters. Architects for the project were D. Y. Davies Associates of Richmond. The site was owned and developed by Tarmac Swindon Ltd.

Background and brief

The specialist technical advice of Adriel Consultancy was sought regarding preparation of documentation for the cleaning and surface repair package. This required completion of the following
brief: Phase 1

1. To inspect the external masonry of each elevation of Building 1 to determine:
   (a) The characteristics of the masonry of the various eras of construction and the types of stone and other masonry used.
   (b) The overall condition of the stonework and its joints.
   (c) The effect of lack of maintenance and previous remedial works and the need to 'undo' these.
   (d) The nature of soiling and other applied treatments and the observed effect of these on the masonry.
   (e) The range of masonry remedial and repair works appropriate to the Building 1 stonework, the extent and location of these, as far as reasonably possible, on the basis of access and the ability to inspect wall surfaces at close range.

2. To undertake on-site cleaning trials to establish the most appropriate and non-damaging materials and methods for cleaning the range of stone and masonry types present, without adversely affecting any existing pointing in no immediate need of repainting. As complete a range as possible of masonry types and soiling conditions were to be selected, and all trials were to be undertaken at ground level.

3. To undertake on-site pointing inspection works.

4. To prepare a report which recorded the conditions observed, reasons for the extent and nature of the deterioration under way, and the recommendations made regarding appropriate and necessary remedial works.

5. To prepare a preliminary report to accompany listed buildings submission.

Phase 2

6. To present and discuss the findings of phase 1 on site.

7. To integrate information received from the structural engineers regarding the surface repair of the masonry, as available during the time of the investigations, trials and document preparation.

8. To prepare documentation (marked up elevational drawings, specifications and schedules as appropriate) for the cleaning and repair works to be undertaken by specialist remedial contractors. Remedial works were deemed to involve masonry repair and cleaning, including repointing and the redress of moisture ingress through the external masonry walling.

Phase 3

9. Following the commencement of work on site, to undertake site inspections in conjunction with the architects during the contract period of the external cleaning and repair works.

10. Additional liaison with the structural engineer with regard to structural matters affecting the external walls.
The inspections and trials described above were undertaken over the period November 1991 to January 1992.

Nature of the stones

Building 1 comprised abutting buildings three and four storeys in height. The architecture of each elevation was essentially plain walls broken up by the frequent and regular placement of windows. The repetitive facade design was similar in each phase of construction. The materials and surfaces to the bulk of the facades were robust. The exceptions were the small portion believed to be oldest part of Building 1. Figure 6.30 Detail of conditions present on a section of wall comprising sandstone (upper portion) and limestone (lower portion). Prior to cleaning it was necessary to remove loose pieces of sandstone ashlar and all the pointing as this masked the edges of most stones. Repainting was undertaken as necessary on completion of cleaning. and two carved panels depicting railway engines transported from original placement elsewhere. The external masonry was made up of a combination of limestone and sandstone with a limited use of bricks as arched window heads. Limestone was used for gutter cornices, copings, string courses, window sills and jambs, quoins and some limited areas of ashlar. The remainder of the ashlar was of sandstone. The surfaces of the limestone units were dressed. The sandstone ashlar units had split and rock-faced surfaces were laid in an irregularly coursed pattern.

The sandstone ashlar had weathered to a wide range of surface colours ranging from purple, olive green to buff, orange and tan. It was clear
that if such a wide range of colours could develop on one type of stone, its mineral constituents were highly mobile and would therefore be sensitive to a chemical cleaning operation. Three samples of sandstone and one of limestone were sent for specialist geological identification to obtain a fuller understanding of the constituents and characteristics that were causing the deterioration and soiling patterns observed. The findings are presented in the Appendix on p.225, below.

The limestone was confirmed as an oolitic limestone, one of the Bath stones. All three sandstone samples were confirmed as being a Pennant Grit from the Forest of Dean area. This stone was composed predominantly of grains of quartz (about 30 per cent by volume) and fine-grained sedimentary rock fragments with a minor proportion of feldspar. A little ferruginous clay matrix was present and dolomitic carbonate cement was locally abundant. These results confirmed that chemical cleaning of the sandstone would need to be undertaken with great caution.

Condition of the masonry surfaces

Limestone

On the whole, the limestone units were in weathered but good con
dition. The surfaces of most blocks were granulated. In areas of heaviest weathering, soft beds and pockets had weathered out and harder veins protruded from their more weathered background. Repairs scheduled for the limestone included stone replacement, indent repairs and mortar repaus.

On the weathered elevations of the building, the surfaces of the limestone blocks were very lightly soiled only. At lower levels, where adjacent buildings limited the full impact of the weather and on protected elevations, adherent soiling ranged from moderate to very thick. Joints between the limestone dressings were narrow and in many instances remained in good condition. It was important that the proposed cleaning did not disturb them.

There was a marked difference between the soiling and weathering of the limestone of the dressings and the limestone ashlar of sections of the earliest walling. It was clear at an early stage that the cleaning of the two types of surface needed to be approached differently. Bricks The impervious and highly vitrified nature of the blue bricks meant that these were in very good condition and only lightly soiled. In most instances, the black mortar in between was in weathered but acceptable condition. Sandstone The sandstone units were in a wide
variety of conditions. While the same type of stone had been used throughout, the sizes and shapes of blocks changed as coursing ranged from slightly to very irregularly coursed. Joint widths ranged from 1/2 in. to 1 1/2 in. Areas with a predominance of small stone units had joints of up to 2 in. width. In all areas, the original block mortar had been overpointed in a wide strap profile which covered the arrises and wide margins at the edges of every stone. Cutting out trials conducted on each elevation confirmed the strap pointing to be loosely attached and readily removable. This was necessary to enable localized repointing of the mortar behind and, in the first instance, to uncover the substantial widths of soiled stone covered by the repointing prior to cleaning. Soiling on the sandstone had collected most heavily on the individual stones which protruded most from the wall line and within all the stones in areas which were most frequently wetted. When viewed at long range, variations in the sandstone soiling were much less noticeable. At both close range and long distance, the different stone colours were distinctly visible. Areas of sandstone affected by run-off from limestone quoins and sills had experienced advanced surface granulation due to the gypsum run-off from above. Surfaces to these stones had weathered back and kept clean by the on-going salt crystallization damage. Elsewhere, the surfaces of stones which were face-bedded were experiencing delamination and detachment of their outer zones. Stones which had been correctly bedded demonstrated smaller-scale losses mainly to their perimeters and the selective loss of softer bands. All loosely adherent material needed to be removed by skilled masons using hand-held tools prior to cleaning.

Figure 6.31 On-site cleaning trial on sandstone ashlar. Loose pointing has been removed from within the area outlined.

On-site cleaning trials

A series of on-site cleaning trials was conducted in January 1992 on representative areas of masonry type and degrees of soiling. A mild, wet abrasive cleaning process was selected.

Water washing had been eliminated because of the relatively
low proportion of limestone surfaces present, the potential for water penetration through defective joints and the likelihood of efflorescence appearing on saturated sandstone. Medium and high pressure water processes were eliminated because of the differential hardness between sandstone and limestone surfaces, the vulnerability of joint material generally and the sensitivity of some of the weathered sandstone surfaces. Chemical cleaning was eliminated from consideration because of the incompatibility of cleaning processes required for sandstone and limestone (the acidic cleaner for sandstone strongly etches limestone), the high iron content of the stone and its observed sensitivity to an acidic environment (ability to change colour) and the sandstone's known poor response to chemical cleaning. The services of a specialist contractor experienced in wet abrasive cleaning were engaged to undertake the trials which were observed throughout by Adriel Consultancy. The trials investigated the effectiveness of fine and medium-fine manufactured grits at various flow rates and a range of pressures from 10 to 40 psi. Work distances of 12 to 18 in. were used. Both abrasives had angular grains, hardness 5-6 Mohs and density 2.8 kg/dm³. The fine abrasive was graded from 0.40 mm down, and the medium-fine from 1.0 mm down. The abrasives were J-Blast Finesse and J-Blast SC. Water for the cleaning was provided by a wet shroud head fitted to the nozzle. The wet head was removed at frequent intervals to rinse down the test area and the visor of the operative. There was continuous voice contact between the operative at the nozzle and the operative at the abrasive pot enabling instantaneous adjustment of air pressure and aggregate and water flow rates. Test areas included sandstone ashlar on three elevations with interspersed dressed limestone quoins and plinth. Areas of heavily soiled limestone ashlar were also included. The limestone of the dressings was found to be considerably softer than either the sandstone or limestone ashlar adjacent. It was necessary to use the fine abrasive at pressures up to 25 psi and a light to moderate flow rate to clean these surfaces. The work needed to be conducted at a slow pace to accommodate variations in surface weathering and the presence of soft beds and pockets present on each stone surface. When the method for cleaning the dressed limestone was transferred to the limestone ashlar, cleaning was achieved at an
exceedingly slow pace, even when the aggregate flow rate and pressure were increased. The medium-fine aggregate was then investigated and found to produce good results when used at pressures of up to 30 psi. Because of the multifaceted profile of the stone faces, the cleaning needed to involve at least six passes coming from different directions for all parts to be cleaned. The abrasive and water streams for the limestone ashlar needed to be kept off the limestone dressings, otherwise damage occurred. This was achieved by cleaning a margin of ashlar beyond the edge of the dressings, avoiding the need to bring the ashlar abrasive and water streams near to the dressings. The medium-fine aggregate was also found to be suitable for the sandstone ashlar. There, it could be used at a higher pressure of 45 psi. The sandstone trial areas included the cutting out of defective pointing and the dressing back of loose stone surface material. The visual effect of the cleaned limestone dressings was considered attractive, especially as the many subtle variations in surface colour and texture were retained. The impact of the removal of continuous, thick, encrusted soiling from the limestone ashlar was startling. Cleaning of the sandstone revealed its general grey-brown hue and the orange, brown, green and purple colours of the individual stones. The specification for the recommended cleaning procedures set out the
for each type of masonry.

The cleaning of the two carved train panels was considered separately from the remainder of the walling masonry. Close inspection of the surfaces showed much of the crispness of the finer detail to have been lost. The carvings had also had small-scale stone indent repairs under taken. Thick, encrusted soiling was found within the deep recesses.

Figure 6.32 South elevation of Building 1 on completion of masonry cleaning and repair. The sandstone surfaces have been greatly lightened by the cleaning, and streaking has been removed from the limestone of the carving. A conservation-oriented approach was recommended for the carved panels, undertaken by a stone conservator rather than the specialist cleaning contractor. It was fortunate that the site was in the part of the UK where the conservative cleaning and surface repair of carved limestone is a well-established practice. It was recommended that cleaning be undertaken by the use of nebulous water sprays to soften soiling and brushing with small, fine, compact, crinkle-wired phosphor bronze brushes or soft, natural bristle brushes, backed up if necessary by the use of plain clay poultices. The application of limewater to consolidate the friable limestone was recommended to be undertaken before, during and after the cleaning, as appropriate. Select mortar repairs were to be undertaken in a colour-matched, compatible aggregate: lime mortar. It was stressed that all missing detail was not to be reinstated, particularly if there was inadequate evidence of its original form. Mortar repairs were to be used to make good areas which would otherwise become sources of deterioration. The work was to be finished with the application of a lime: casein shelter coat. All these procedures of cleaning and repair which are widely practised by limestone conservators are known collectively as the Lime Method. Work on the external masonry was undertaken in 1992-93. APPENDIX TO CASE STUDY 4 STONE IDENTIFICATION AND ANALYSIS Report on
Specimens of stone from the BREL Building, Swindon

Francis G. Dimes, MSc, BSc, MIGeol, FGS (20th January 1991)

All specimens were examined by eye and with the aid of a X 10 lens and a binocular microscope. Simple physical and chemical tests also were undertaken. Following initial examination and a possible determination as to nature and provenance, all specimens were closely compared with material from known geological horizons and provenance. One specimen was submitted for a thin section to be prepared and for a photomicrograph to be taken, as well as a petrographic description.

Specimen 1 (limestone) may be described as a buff-coloured (very close to 10YR 8/2 [Munsell System] ‘very pale orange’ on the Rock Color Chart) highly calcareous stone displaying an oolitic structure,

with the ooliths showing a softer, outer somewhat powdery layer and

with the ‘kernel’ of the ooliths mostly missing, thus leaving the broken surfaces of the specimen with a dimpled look. Comminuted fossil matter

is irregularly present leading to an irregular grain appearance.

The general appearance, mineral content and overall texture and structure of the specimen are not inconsistent with the sample being an example of Bath Stone.

The lithology of specimen 1 suggested it was either Combe Down Stone, Odd Down Stone or Box Ground Stone (Corsham-Box area).

Specimen 2 may be described as a reddish-brown (close to 5R 4/2
'grayish red' on the Rock Color Chart) fairly fine and even-grained, the grains being subangular and mostly of the mineral quartz with scattered lighter-pink coloured grains, possibly feldspar, prominent. Occasional flakes of white mica (muscovite) may be seen particularly on freshly broken surfaces. The specimen was determined to be a sandstone and, from the angularity of the grains, the variety grit. The specimen was noted to be laminated, the laminations being in the plane of the maximum dimension, and also was somewhat friable, suggesting that the stone from which the sample was taken is a fissile sandstone/ grit.

The description of the specimen indicates characteristics which are not incompatible with material taken from the geological horizon known as the Pennant Grit. In an endeavour to secure the determination, specimen 2 was submitted for a thin section to be made and for a photomicrograph to be taken. The detailed petrographic description supported an identification of Pennant Grit. See petrographic report which follows.

Specimen 3 may be described as a mottled, mostly blue-grey (near to
N4 'medium dark gray' on the Rock Color Chart) with areas of brown

(near to 5YR 4/4 'moderate brown' laminated (representing original

bedding), with bedding planes, top and bottom a rusty colour (between

10YR 5/4 'moderate yellowish brown' and 10YR 4/2 'dark yellowish

brown') with white mica (muscovite) flakes lying flat on the bedding

planes in marked quantity. The bulk of the stone is of sub-angular grains

of quartz with subsidiary feldspar.

Apart from its colour, specimen 3 was determined to be the same as

specimen 2, Pennant Grit. The determination was considered suffi
ciently secure for a thin section not to be cut. CASE

STUDIES 227 Specimen 4 was found on examination to be of the same nature as specimens 2 and 3, and hence a determination of Pennant Grit is given. The Pennant Grit is a formation within the Coal Measures Series, Carboniferous in age. In South Wales, in the Forest of Dean, in Monmouth and in the Bristol coalfield area of Avon and Somerset, the Coal Measures Series is divided into an upper and lower series separated by a thick group of sandstones the Pennant Series or the Pennant Grit which in the main are massive 'blue-grey' or 'red', rusty weathering and parted at intervals by thick shale beds. Some of the beds may be very coarsely grained. In places, the rock may be fissile and closely laminated enough for it to be considered for use as a tilestone. Because the stone generally is tough and durable, particularly when massive, it has been widely used for building, for example in Bristol (the jail), Cardiff (in Park House, Park Place), Caerphilly Castle, South Wales generally, Portishead and elsewhere. From comparison with material of known provenance, gross appearance and mineral content, the submitted specimens visually match most closely samples from the Forest of Dean area, specimen 2 matching
particularly well with 'Red Forest of Dean Stone'. The petrography of a sample of delaminating sandstone from a building in Swindon Robin W. Sanderson, BSc Analytical methods Analysis has been effected by means of microscopical examination of a 30/1m thick section treated with sodium cobaltinitrite stain to differentiate between feldspar mineral phases, low magnification examination of the hand-specimen and by simple chemical tests. The sectioned sample was impregnated with coloured resin to show empty pore-space in the thin section. In the following description, colour terminology follows that of the Geological Society of America Rock Color Chart, 1970. Identification of the stone The sample is a medium-grained, feldspathic litharenite.

Mineral composition

The stone is composed predominantly of grains of quartz (c. 30 vol. %) and fine-grained sedimentary rock fragments, with a minor proportion of feldspar. A little detrital clay matrix is present and dolomitic carbonate cement is locally abundant.

Petrographical description: macroscopical features:

The fragmentary weathered sample is of slightly friable and roughly laminated nature, with a uniform colour between 'pale red' (5R 6/2) and 'grayish red' (5R 4/2), apart from rare, small, pale greenish, bleached spots less than 2 mm across. Viewed at low magnification, distinct pink and green grains are noticeable. An ovoid depression, c. 13 mm across, lined with ferruginous clay, apparently represents a mould of a pebble.

No reaction to the test for calcite was noted.
Petrographical description: microscopical features

The stone has a poorly sorted grain supported and moderately to strongly compacted detrital fabric. Very angular to subangular grains of low sphericity measure up to 640 μm, modal medium sand (lower) grade (250-350 μm). There is a slight indication of subparallel arrangement of elongate grains.

Monocrystalline quartz is only weakly strained, but strained poly crystalline quartz is common, as is chert. Some vein quartz is present. Lithic fragments include mainly fine-grained impure sandstones and mudstones, some of which are phyllitic and more or less chloritic. Haematite, or ferruginous mudstone is common. Rarer fine metamorphic types - quartz-garnet and quartz chlorite rocks are also present. Feldspars are moderately abundant with K-feldspar apparently dominant. Accessory minerals are rare but include muscovite and chlorite flakes and garnet grains.

Detrital grains show incomplete pellicles of ferruginous clay (mixed chlorite/illite) matrix. A pore-filling, partly replacive, medium crys talline dolomitic cement is locally abundant.
The sample exhibits weathering-induced secondary fracture-porosity, but little if any visible primary macroporosity. Comments assuming that the sample is a British stone, the macroscopical features suggest either one of Old Red Sandstone or a ferruginized Pennant Sandstone. The relatively low quartz content and high proportion of fine sedimentary rock grains are characteristic of the Pennant type of stone. These are usually of a grey or greenish tint, the red colouration being associated with the areas of haematite mineralization of the Forest of Dean and Bristol areas. The presence of pebbles is very unusual in Pennant sandstones. This page intentionally left blank.


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