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Saving Structures

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Abstract

The analysis of historic structures is often carried out using similar methods to those employed for new construction, while recommendations for repair may be framed to comply with modern design codes. Both are often inappropriate. A scientific committee of ICOMOS has recently drafted a set of recommendations that point out the dangers to the historic fabric of adopting this kind of approach, while also describing more appropriate methods. This paper outlines the background to the drafting of these recommendations and reviews their main points.

Introduction

Some structural assessment is needed for any building that we buy, adapt, or refurbish, if only to check that it has withstood the ravages of time and possible mistreatment by previous occupiers. The process adopted may be little more than checking for possible signs of distress and then pointing a structural engineer at any that are found, with instructions to find a solution. If this seems to be a caricature of what actually happens there are many occasions when it is very close to this, and such a process fails to recognize both the contribution that the engineer can make to the conservation process and the skills needed of the conservation engineer. This is a problem that occurs at all levels of conservation from the Grade II-listed agricultural building to the structures in a World Heritage Site, and it has been tackled by the International Scientific Committee for the Analysis and Restoration of Structures of Architectural Heritage (ISCARSAH) in its recently completed *Recommendations for the Analysis, Conservation and Structural Restoration of Architectural Heritage*.[1]

ISCARSAH is a scientific committee of ICOMOS set up at the 1996 General Assembly in Sophia.[2] In spite of the handicap of its cumbersome name, the committee has drafted this series of recommendations that comprise both general principles and more specific guidelines. The

Principles were ratified by the ICOMOS General Assembly in 2003 and therefore now have the status of an ICOMOS charter, while the Guidelines provide more practical guidance for the practising conservation engineer.

The *Recommendations* recognize the differences between the task of designing the structure of a new building and that of advising on the conservation of a historic structure. In doing so they raise a number of issues: those of methodology, of ensuring the safety of historic structures, of the fee structure for conservation engineers, and of the relationship between the engineer and the other members of the conservation team. These all have implications for the organization of conservation projects. They are dealt with in some detail in the Guidelines, which not only describe the methodology but discuss methods of analysis for understanding and predicting the behaviour of historic structures that are different from the formal calculations adopted by design engineers. The Guidelines also consider the limits of present-day codes of practice as applied to historic structures. The purpose of this paper is to outline some of the main issues raised by the Guidelines, to discuss the implications for other members of the conservation team, and to consider what further developments might be undertaken.

The engineer's dilemma

The engineer's fundamental task is to ensure the long-term strength and stability of a structure: its safety. But while the design engineer specifies the form and construction of proposed new buildings, the conservation engineer has first to describe those of existing buildings. The techniques of analysis used by the former are applied to a virtual structure of known form and properties (if only known through the engineer's ability to specify them). The conservation engineer is applying methods of analysis to a structure whose form and properties are only known to the extent that they may be determined by surveying the building. They are therefore limited by the extent to which it is possible to investigate the structure, and so are of uncertain accuracy – but it is upon this uncertain model that any recommendations must be based.

If the engineer is sensitive to conservation issues (and one hopes that one has been employed who is), he or she will be aware that there is a conflict between the requirement to ensure the safety of a structure and the requirement to preserve historic character and that this involves striking a three-way balance. Opening up the structure can provide data that will enable its behaviour to be described with greater certainty. This will provide a greater guarantee of public safety and might also enable the engineer to devise less intrusive methods of repair. However, in itself it can involve loss of historic fabric. At present the extent to which opening up is required is a matter of engineering judgement, and the Guidelines discuss the need for a cost-benefit analysis to be made.

Methodology

The Guidelines describe the engineering methodology in terms of a medical analogy, because the stages in the process of understanding and making recommendations for the repair of a structure parallel those used by a physician in treating a patient. Both involve the observation of symptoms of distress, the carrying out of tests to obtain further information, the diagnosis of the causes of distress, and recommendations for treatment. One may take the analogy further. A structure might show signs of distress because of natural ageing processes, because of damage caused by external agencies, or because of abuse by its users: all paralleled in a human body.

Just as the physician might carry out an examination in several stages, so might the conservation engineer. Following an initial survey to gain an overview of the structure, more precise measurements will be taken. These might indicate a need for more specific tests, perhaps involving some opening up of the structure. These processes must be proportional to the nature of the problem: mindless measurement is a waste of time and money while, as with the human body, it is also pointless to kill the patient in an attempt to find out what is causing the trouble.

The first stage in the analysis is to survey the structure and describe the structural scheme (i.e. the system of members that carries loads to the ground). Physicians have the advantage that they are dealing with an anatomy common to all their patients, but this is far from true for the conservation engineer. Not only do historic buildings differ in kind and in their methods of construction, but even those that have a supposedly similar anatomy might have differences arising from the whim of their particular builder, the quality and availability of local building materials, and so on. One might even be dealing with buildings of relatively unknown anatomy, a situation that can occur in countries where there has been little study of historic construction methods. In such circumstances the only recourse is that taken by the medical student – the study of cadavers. Then the observation of buildings under demolition or the examination of derelict buildings in a state of semi-collapse can provide the data that the engineer needs.

Methods of analysis

Modern analytical methods used by design engineers require a complete description of a structure that might not be possible for the conservation engineer to acquire or supply. The design engineer describes a virtual structure whose properties will depend upon the control of standards of workmanship, often impossible to know for an existing building. Moreover, the precise composition of an existing wall or the relative stiffness of timber members might be unknown. The history of the structure might have involved the shifting of loads from one structural element to another to a degree that cannot be measured, while composite timber and brick structures present problems relating to the sharing of the loads between the various components.[3] This means that there can be more than one possible structural scheme and it is essential to bear this in mind and to devise appropriate means to deal with it. Thus, however detailed the survey, there will inevitably be some uncertainties in the eventual description of the structural scheme that will affect the accuracy of any analytical techniques. This means that modern methods of analysis need to be used with caution, and the *Recommendations* place considerable emphasis on the need for other methods of analysis: historical and quantitative analyses that are not available to the design engineer.

Historical analysis draws upon an understanding of the past behaviour of the structure, while qualitative analysis invites a comparison with similar structures. The assumption of the former is that clues to the present state of the building are to be found in its past behaviour, but this in turn involves being able to explain the present state of the building as the result of that behaviour. Engineers experienced in dealing with historic buildings will be aware that much of their effort goes into explaining the history of its construction. This is often a combination of the history of changes made to the building, their structural consequences, and possibly subsequent remedial measures to deal with those consequences. Perhaps, for example, a timber-frame building has been altered in plan and a brace has been removed to enable a passage to be created. The frame has then swayed over and remedial measures have been incorporated to check the movement. Such histories have consequences for the present behaviour of the structure and need to be explained.

The history of the building will account for any signs of distress that might be present. Whether signs of movement are of recent origin or long-standing, and whether they result from inherent weaknesses or ill-considered alterations, might well be more evident from a knowledge of the building's history than from present-day monitoring. At the same time there is the assumption that what has proved satisfactory in the past will continue to do so. Of course, the past behaviour of a structure is not always a reliable guide to its future performance, especially where brittle structures are working close to their stress limits or where there is some cyclic or repeated phenomenon that is progressively weakening the structure. There might be some continuing effect on the structure, perhaps continuing creep deflection of mortar that will result in changes in the load path over time, or repeated actions such as daily or seasonal temperature cycling or earthquakes, that have weakened the structure. Nevertheless, within these limits, close observation of the structure combined with an understanding of its history will show how the loads are being carried and will provide a measure of assurance of its safety.

Qualitative analysis assumes that similar structures exhibit similar behaviour and is the nearest that we have to the anatomical studies of the physician. While, like historical analysis, qualitative analysis is not a method generally accepted by building control, it would be foolish to rule it out as unacceptable and it can be a valuable guide. Studies of the behaviour of Gothic vaulting, for example, have demonstrated that certain crack patterns within the vaulting are an inevitable feature of their behaviour and present no danger (Figure 1).[4] It would therefore be foolish to monitor such cracks on the assumption that they indicate recent movement. One might also use historical precedent to indicate the safety of a structure that defies analysis. Price, for example, has provided a qualitative description of the forces acting on a cantilevered stone staircase (Figure 2).[5] In the United Kingdom the public regularly use such staircases, but engineers would have difficulty in analysing this kind of structure. Price has shown that the treads rely upon torsional restraint at the wall, but we are unlikely to be able to measure the properties of an eighteenth-century wall laid up in lime mortar that has been subjected to repeated loading over the centuries. At the same time no one would surely condemn all such stairs simply because we do not know how they

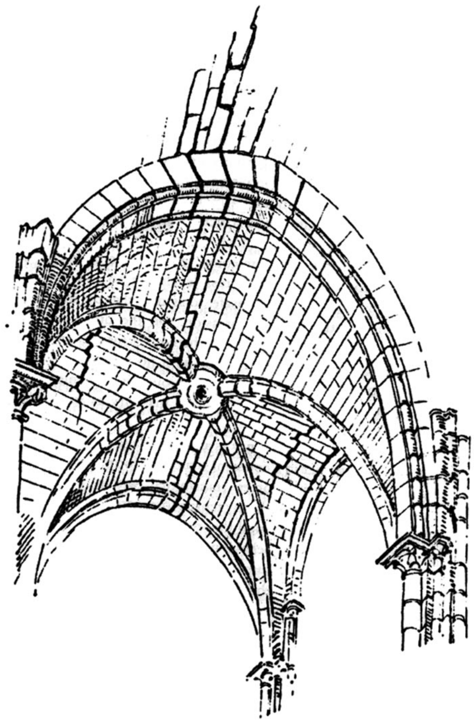

Figure 1 *Normal cracking in Gothic vaulting, recorded by Pol Abraham.*

are working, or even suggest that they should be taken down and rebuilt to known standards of workmanship.

But it is arguable that before such an approach can be widely accepted by regulatory bodies there needs to be more published data that can be referred to. What we require are more qualitative studies of the kind undertaken by Price that will provide a sounder footing for engineers in their explanations of historic structures. Like historical methods, qualitative methods are also not completely reliable. Structures that are within the same limits as others of the same type may be expected to behave in a similar way, but some caution is necessary when extrapolating beyond the limits of known structures. The ability to do this depends both on the number of similar structures observed and the judgement of the engineer.

Design engineers are more familiar with quantitative methods, but these too need to be used with caution. For example, finite element analysis is commonly used in the analysis of historic structures, but it has recently been called into question. Huerta has suggested that our ability to model the properties of the materials with the accuracy needed to

Figure 2 *Cantilever stair at Lytham Hall, by John Carr, 1758.*

obtain the results that are quoted defies common sense.[6] Computer programs designed with the analysis of steel or concrete in mind are sometimes used for the analysis of timber frames by engineers who seem to be unaware that there are significant differences. Mortice and tenon joints will simply not transmit the forces sometimes assigned to them by these routines and analysis may suggest the need to add steel fasteners where none existed in the past. This is essentially trying to make the structure conform to the analytical description when the correct approach should be to produce a numerical description consistent with the observed behaviour. It is an example of where historical analysis can be used to inform the numerical analysis. The key factor here is the observation of the structure, and indeed the building of which it is a part. The emphasis within the Guidelines is on the holistic nature of the fabric and the kind of understanding that needs to be brought to bear upon it. Quantitative methods need to be used in conjunction with historical and qualitative methods.

While the Guidelines are clear about these issues, they can only deal with them briefly and work is still needed to supply an explanation of the use of these techniques. More studies like those by Price are needed and it is sad to see those involved in the now developing field of the history of construction adopting modern methods of analysis so enthusiastically. While the reasons for this may be understood, it is not doing the service to conservation engineering that it could.[7] This is something that might be addressed by ISCARSAH through the formation of special interest groups.

The survey process

All conservators will agree on the importance of the survey stage in any conservation project, but what they might not recognize is the value of involving the engineer at this stage. If the engineer needs survey data, and if that is augmented by a knowledge of the building's history, then it surely follows that the engineering survey should be carried out in parallel with any archaeological survey. Thus it is distressing to see survey work carried out, sometimes by large teams on major historic buildings, without any engineering support. Understanding the history of a building should involve the engineer just as much as the archaeologist and the architectural historian, for several reasons. Events in the history of the building might have structural implications that the engineer will wish to be informed about. Some changes in the building might have structural explanations (i.e. there might be changes that have left structural traces that will be apparent to the engineer). Thus the engineer might be in a position to raise historical issues. The engineer might also have questions that are best answered by historical or archaeological investigations. All these factors imply the need for a dialogue to exist between the engineer and the historians or archaeologists involved in tracing the history of the building.[8]

A team of over a dozen members was assembled for the survey of the cathedral at Vitoria in Spain prior to its restoration, yet there was no engineer in this team. This was hardly because of parsimony since a large international conference was sponsored by this project.[9] It was simply that the contribution that a conservation engineer could make at this stage of the work had not been appreciated. Unless the engineer is involved from the beginning, there might be significant questions that are simply not asked during the archaeological investigations. Then the engineer will have to undertake his or her own investigation, or will have to do without the information and so make more conservative estimates of the behaviour of the building. The word 'conservative' used here in the engineering sense implies possibly more intrusive interventions to ensure structural safety.

In passing we might note that it is also possible that the structure itself is of historic significance. If there are aspects of the building that have some significance within the history of engineering design, then these are matters for the engineering historian, and something about which a conservation engineer might be better informed than the archaeologist or architectural historian. This does not necessarily mean that the engineer must be an engineering historian, but simply that he or she should have sufficient knowledge of engineering history to know when to seek specialist advice on a structure. This is something that has come about in recent times. About 40 years ago the medieval timber roofs of Norwich Cathedral were replaced with a modern concrete structure. Medieval carpentry has since been appreciated as something that has its own historic significance, so that if that kind of work were done today a quite different approach might be adopted. Instead of a complete replacement of an inadequate structure there have been cases where supplementary structures have been used that leave the original and historically significant (albeit now redundant) structure in place.

Diagnosis and treatment

In some ways the diagnosis and treatment processes can be more difficult for the engineer than for the physician. The latter, faced with certain symptoms, may have a number of possible causes in mind and could try a treatment for the most common, assuming it had no harmful side effects, moving on to other possibilities if that did not work. The engineer can seldom do that, as any treatment prescribed is often irreversible. On the principle that there is more than one way to skin any cat, where there is a need for repair or strengthening the engineer will be looking for those means that best retain the historic character of the building. It is therefore important that he or she understands the intentions of the conservation team and the aspects of the fabric that are considered to be historically important. But the possibility of there being more than one possible engineering solution also implies some dialogue with other members of the conservation team.

Just as with a human body, the object of the exercise is not to restore a historic structure to youthful vigour (the equivalent of trying to make it conform to modern codes of practice), but to put it into a satisfactory condition that ensures its continuing life, and respects the age and nature of its original construction. The intention must be to address the present state of the structure, to identify any cases of distress, and to provide some remedy. Work should not be undertaken beyond that and the intention is not to make the structure conform to present day codes. We should, instead, simply see our work as giving the structure a helping hand.

This is an issue that the Guidelines discuss in some detail. Modern codes are part of a regulatory system designed to ensure that buildings are safe and fit for their purpose. However, there can be a conflict of interest where the requirement to guarantee public safety is in conflict with the desire to preserve our historic fabric. An obvious problem with modern codes is that they might simply not deal with the kind of structures used in the past. Also, the methods of historic and qualitative analysis are not something that they recognize. The conservation engineer therefore needs some defence against them. Conservators will be aware of other aspects of historic buildings where this conflict of interest can occur, such as fire protection. It can occur in structures where there is a requirement to satisfy present-day standards, or simply to demonstrate that the structure does so, requiring excessively intrusive methods.

What is often not appreciated is that there is a fundamental mismatch between modern codes and historic buildings. Where it is not possible to define a precise structural scheme, the analytical techniques required to establish conformity with the codes have little value and might suggest a greater level of understanding of the structure than is actually possible. But the mismatch is more fundamental. Modern codes and design methods are part of a complete safety system where design loads, allowable stresses, and methods of analysis are interrelated and depend upon a statistical approach that requires *inter alia* a knowledge of the variability of the strengths of materials. That in itself is impossible for a historic building. Even if samples are taken to obtain some indication of material properties, their variability will remain unknown. Therefore any attempt to apply modern codes to a historic structure is a theoretical nonsense.

This issue has been dealt with in more detail in a paper currently being developed by one of the subgroups of ISCARSAH. Their argument is that recognition of the logical conflict between the present methods of design and historic buildings implies a much closer relationship between the conservation engineer and the rest of the team. The engineer's responsibilities are currently defined within the scope of the present regulatory system. If we are to operate outside that system, as seems inevitable, then it is questionable whether responsibility for this should be placed entirely upon the engineer. It should perhaps be shared with other members of the team, as judgements need to be made that concern the balance between the degree of intervention and the degree of confidence placed in the security of the structure. This is a significant issue in the management of conservation projects and one that needs to be debated more fully.

The inevitable uncertainties in the analysis of the building may mean that there are some difficulties in predicting the behaviour of the structure both during and after treatment. This implies the need for monitoring of the structure, especially during the execution of the work. The Guidelines stress both the need for planning such monitoring and that it should be appropriate for the work being undertaken.

The explanatory report

At the heart of the Guidelines, and a vital aspect of the methodology, is the need to produce an 'explanatory report'. The significance of this can be gauged from the fact that it is referred to no less than five times in the *Recommendations*. The essence of this is that it should provide a justification for any recommended actions as well as both an explanation and discussion of any alternative strategy. It is, of course, possible that the report would demonstrate the adequacy of the present structure and therefore recommend that no action be taken.

This was one of the first things to be considered by ISCARSAH, because of the dangers that members saw in two aspects of design engineering: the common practice of engineers' fees being a proportion of the cost of the work undertaken and the influence of codes of practice. The former means that, should the engineer recommend taking no action, there would be no fee, even though it might be the most desirable course for the preservation of historic fabric. Moreover, such a recommendation might have required a great deal of time and expense in investigative work. Separate payment for the explanatory report rather than a percentage payment would overcome this difficulty. It would also mean that the engineer could not justify a recommended course of action simply on the grounds that it was necessary to comply with a code. The recommendation would have to be explained in terms of the specific behaviour of the structure in question. Additionally, it would be quite inappropriate for the engineer to produce such a report on a 'take it or leave it' basis because, unlike in new design, there is not always the single goal of producing a safe structure that accommodates the architect's design. There might instead be a range of goals. There might, for example, be alternative future uses of a historic building or quite different ways of ensuring the safety of the structure, each with different implications for the historic fabric

Implications

The availability of these *Recommendations* has already had some effect. Rather dramatically, one member of ISCARSAH resigned from his advisory capacity on a project, pointing out that its management contravened a number of issues within the document. The result was a change of management and personnel on the project. The Guidelines have also been used as the basis for the drafting of a set of recommendations for the conservation of Angkor Monument,[10] and the implication is that they could be used in a similar way for other projects.

While in the main addressed to engineers, with the Guidelines presenting practical advice, the *Recommendations* have wider implications for other members of the conservation team and for the conservation process as a whole. The Guidelines refer to the need to form an appropriate team and a conservation engineer should be appointed at an early stage as part of that team – certainly early enough to be involved in the survey of the fabric. The contribution that the engineer can make to this phase of a project in helping to understand the history of the structure and in asking appropriate questions should already be clear from what has been said above. While employing an engineer at an early stage in the project might appear to be more expensive, adding to the members of the conservation team, it is likely that it will save money in the long run as well as benefiting the historic fabric. Of course it is difficult to prove this, and clients might be unwilling to make such an appointment. However, as the engineer will eventually need to gather data on the construction of the building to use as a basis of the structural assessment, it must surely make sense to the most reluctant client that this is most efficiently done as part of the archaeological examination. It is clearly going to be more economical then than having an engineer return to the building to obtain necessary data that was not gathered earlier.

The task is to preserve the historic value of the structure, so it is essential that the engineer understands what this means in terms of the physical characteristics to be preserved. If the engineer is involved from the beginning, he or she is more likely to understand the relative value of different parts of the building and hence be able to understand the judgements made about what is to be preserved and how. This is where collaboration is important, because if intervention is necessary on safety grounds it may well involve some loss of historic fabric. It is as well that the engineer understands and is sensitive to the historic value of that fabric in order to select methods that do least harm. Moreover, on the principle that there is nearly always more than one way to solve any problem, the engineer needs to appreciate the historic values that are being preserved to be able to devise appropriate engineering solutions that will be sensitive to those values. At the same time the conservator needs to be aware of the engineering limitations and this may require a dialogue between the two for each to understand the other.

The need for, and significance of, the explanatory report inevitably has implications for the way in which the engineer is engaged and paid for. The function of the engineer is not simply to provide design and details for strengthening work, but to provide an overall report on the condition and safety of the building to support any engineering recommendations. The engineer will be dependent upon survey data for this and we have already discussed the desirability of having engineering advice at the survey stage. If the engineering assessment is to draw upon historical and qualitative methods, then it will draw upon information obtained by the historian and archaeologist.

The *Recommendations* also have implications for the necessary experience and training of conservation engineers. The use of historical and qualitative analysis requires engineers with some knowledge of historic structures and the skills to interpret their behaviour. The need to present an explanatory report and to engage in dialogue with other members of the conservation team also implies the ability to communicate engineering ideas in a way that can be understood by those without engineering training.

Biography

David Yeomans BSc (Eng), PhD, AIWSc

David Yeomans is a Senior Research Fellow of the Liverpool School of Architecture and Secretary of the International Scientific Committee for the Analysis and Restoration of Structures of Architectural Heritage (ISCARSAH). He has taught both structural design and building conservation, and practises as an engineer specializing in the repair of historic timber structures. He is also the author of a number of books and papers on the history of structures.

Notes

1 *Recommendations for the Analysis, Conservation and Structural Restoration of Architectural Heritage* are available from ICOMOS-UK.

2 Under the chairmanship of Professor Giorgio Croci, Faculty of Engineering, La Sapienza, Rome.

3 See Yeomans, D., 'The Interaction of Timber and Brick Masonry in the Kathmandu Valley', *APT Bulletin,* Vol. 27, No. 1–2, 1996, pp. 74–81.

4 Heymen, J., *Arches, Vaults and Buttresses*, Variorum, Aldershot (1996).

5 Price, S., 'Cantilevered Staircases', *Architectural Research Quarterly*, Vol. 1 No. 3, Spring 1996, pp. 76–87.

6 Huerta, S., 'Mechanics of Masonry Vaults: The Equilibrium Approach', *Historical Construction*, Possibilities of Numerical and Experimental Techniques, Proceedings of the 3rd International Seminar, Guimarães, Portugal, University of Miño, 7–9 November 2001, pp. 47–69.

7 Yeomans, D., 'Modern Analysis and Historic Structures', *Proceedings of the First International Congress on Construction History*, Vol. I, Instituto Juan de Herera, Madrid, 2003, pp. 81–88.

8 A further advantage is the availability of the engineer to comment on the safety of archaeological excavations. At one meeting of ISCARSAH, the committee was taken to see work on a major monument and commented that it thought the archaeological excavations were dangerous. The response was that no funds had been allocated in the archaeological budget for engineering advice.

9 First European Congress of Restoration of Gothic Cathedrals, Diputacion Foral de Alava, Vitoria, May 1998.

10 *Recommendations for the Conservation and Restoration of Angkor Monument* are being drafted by a working group chaired by Professor Giorgio Croci.

Book Reviews

The Weathering of Natural Building Stones **by R. J. Schaffer,** Donhead Publishing, 2004 (facsimile of 1972/1932 edition).
208 pp. 244 × 172 mm. £33.00 hardback. ISBN 1-873394-69-1

If one book deserves to be on the shelf of all those involved in architectural conservation it is DSIR Building Research Special Report No. 18 *The Weathering of Natural Building Stones* by R. J. Schaffer, originally published in 1932 and commonly referred to merely as 'Schaffer'. As is pointed out by Dr Tim Yates in the 'Introduction' to the latest edition of this seminal text, it was written in response to concerns expressed by a number of organizations, including the Imperial War Graves Commission and the Royal Institute of British Architects, that pollution in the large towns was clearly affecting the stonework of the buildings but that, despite many investigations, no satisfactory solution had been found. Schaffer started his work at the Building Research Station in 1925 and over the next six years carried out the thorough literature survey which resulted in the publication of the report.

Although the book resulted from concerns about the apparent effect of pollution on stonework, the term 'weathering' is used by Schaffer in a much broader sense, covering all aspects of the failure of stone in man-made structures. Hence he covers natural weaknesses in stone, faulty workmanship, poor material selection, and the use of incompatible materials. What is quite amazing is that, even in buildings constructed today, failures due to machine dressing of stone are occurring, reactions between different stone types can still be found, and Portland cement mortars are still used with building stone. All these potential causes of stone decay were identified and discussed by Schaffer, his conclusions being available in print for over 70 years. I cannot recall ever having found a form of degradation in stonework that Schaffer had not identified and discussed in his book. This is its importance: it is as valid today as when it was written.

Certainly there have been advances in some areas of study. For example, when discussing the potential role of bacteria in the breakdown of stone, Schaffer concludes that 'the supposition that bacteria contribute significantly to the decay of stone in buildings must still remain a matter of conjecture'. However, this conclusion is based on what was known about bacteria in the 1920s. We now know that mineral–microbial interactions are an important aspect of weathering. What is important is that Schaffer raises the possibility that bacteria may be involved in the breakdown of stone and discusses the literature on the subject at some length.

Other topics discussed are still as controversial today as in 1932. When discussing 'preventative and remedial measures' he concludes that 'the bulk of evidence at present available indicates that the value of the application of stone preserving solutions is doubtful'. Many would still agree with his comments, others may well suggest that he was mistaken.

Although it is considered that the findings of the report are as valid today as they were when the book was originally written, caution must be exercised when considering those sections where remedial treatments are suggested. This is due to the fact that, just as in the case of bacteria, we now know a little more about the processes involved in the breakdown of stone. The section on plastic repairs, for example, is now out of date and there are many modern texts on the subject. Similarly the section on stone cleaning is out of date. The original 1932 version of the book merely contains a section within the main body of the text, which covers washing, steam cleaning, and the dangers of adding alkalis to the steam-cleaning process. However, the 1972 reprint, which has been used for the new edition, has a new Appendix II which covers the cleaning of the exterior of buildings using a range of methods which were used in the 1970s, as well as a section on surface coatings. It should be remembered that this addition to the original version is thirty years old and may now not be applicable, some of the techniques even being potentially damaging to stonework. More up-to-date texts on cleaning are available, such as Nicola Ashurst's *Cleaning Historic Buildings*, also published by Donhead.

Despite the period of time which has elapsed since this book was first written, it is now considered by many to be the 'bible' of stone conservation, its content being as valuable today as it was in 1932. Not only should it be within arm's reach of all those involved in conservation, it should be compulsory reading for every architect. This new edition is to be warmly welcomed.

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Stone Decay, Its Causes and Controls **edited by B. J. Smith and A. V. Turkington,** Donhead Publishing, 2004.

256 pp. 234 × 156 mm. £37.50 hardback. ISBN 1-873394-57-8

Despite Schaffer's studies on the degradation of stonework over 70 years ago, it is only in recent years that the importance of understanding 'how' and 'why' building stones weather in a certain manner has been appreciated. For example, English Heritage's present policy of 'like for like' stone replacement is the result of a much greater understanding of the reactions which can occur within stones and, more importantly, between different rock types. The appreciation that, unless there is an understanding of the changes which can occur within stone, cleaning, consolidation, and other treatments could actually do more harm than good, probably first came to the attention of the general conservation community with the work carried out at Glasgow University on the dangers inherent in cleaning sandstone buildings. Since that time more and more research has been carried out into the nature of the breakdown of stone. *Stone Decay, its causes and controls* is a welcome addition to the literature published in recent years on the subject. It is not, as its title may possibly suggest, a comprehensive text on the subject of the breakdown of stone, but a volume of selected papers from the Stone Weathering and Atmospheric Pollution Network (SWAPNET) conference, which formed part of Weathering 2000, a conference held in the Queen's University of Belfast in June 2000.

As the editors point out in their introduction, stone decay and conservation is a multidisciplinary field requiring interdisciplinary solutions. The value of this book is that, it being the result of a SWAPNET conference, one of the major disciplines contributing to the studies is that of geography, or more accurately geomorphology. As a result, aspects of the weathering of natural features are discussed. This is important since, when studying the weathering of stone in a building, it is only too easy to concentrate on the building and its location, forgetting that the stone would deteriorate even if it had not been used for construction. In addition, the potential uniformity of geological strata over a wide area allows for weathering studies to be undertaken using a much broader sample database than if a single building is being used. A paper describing a study of the effect of pollution on the rate of weathering of stone which was undertaken in Poland demonstrates this, the samples studied being from locations up to 180 kilometres apart. Such studies could clearly provide valuable background data when studying individual buildings within the overall area.

The nature of geography is such that it places the environment in both social and economic contexts. As a result, the volume contains two papers that discuss how individuals, having set their own research agendas, can possibly colour our views on weathering and durability. This human aspect of multidisciplinary studies is important since the background, training, experience, and overall approach of specialists ranging from conservators to engineers and from scientists to art historians, can be very different.

Although containing papers which are clearly influenced by the geographical background of the authors, there are also reports and discussions on research into the weathering of stone in man-made structures. These include studies on buildings in Belfast, Prague, Kraków, and the north-eastern United States. Studies of sandstone weathering in the last-mentioned paper had an advantage over many similar investigations, in that the length of time over which weathering had occurred is very accurately known, the study locations being tombstones. Weathering studies over a greater period of time are reported from Portugal, the subject of the investigation being megaliths dated at about 5500–6500 BP.

This book contains a range of papers which should be of interest to conservators, architects, and others involved in the maintenance of our historic built environment. Its slight geographical bias provides a balance to other recent publications such as *Natural Stone, Weathering Phenomena, Conservation Strategies and Case Studies*, published by the Geological Society, which tend to concentrate on detailed scientific studies of specific monuments. As with all such publications, the reader may not agree with the findings of the individual papers, or even the methods of research used. However, if the result is debate and a raised awareness of the problems of stone conservation, it has surely achieved its purpose.

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Palaces for the People/Prefabs in Post-War Britain **by Greg Stevenson,**
B.T. Batsford, 2003.
240 pp. 160 × 160 mm. £12.99 paperback. ISBN 0-7134-8823-9

This unusual little book – filled with evocative photography – combines scholarly research with everyday affairs in a fascinating story of prefabricated houses built under the Temporary Housing Programme of 1944–9.

Greg Stevenson is both architectural-heritage consultant and lecturer, and author of *The 1930s Home* and *Art Deco Ceramics*. His enthusiasm for the subject of prefabs comes across in *Palaces for the People*, which provides clear and authoritative commentary on construction, interiors, furnishings, and gardens.

At a time when we are looking again towards the creation of sustainable communities, the aspirations of young and old must be taken into account in proposals for new development. The role of temporary housing, whether in meeting the demands of a growing population or providing shelter for the homeless in our towns and cities, is perhaps ripe for discussion.

If ever there was a book to carry on the train or in the car, able to both inform and bring a smile to the face, this is it.

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