Scientific and Technical Review, Issue 2, July 1993 (Conservation Bulletin 20 supplement)

(NB: page numbers are those of the original publication)

Works professional services for English Heritage

The availability and application of the services of qualified and experienced works professionals are vital to English Heritage's ability to fulfil its objectives for the conservation of the historic environment. These services are required as much for the indirect conservation of our national heritage through advice on grants and statutory work, as for the direct conservation of our own historic properties.

The works professions encompass a wide range of disciplines and subdivisions: architecture and building surveying, landscape management and design, building services and environmental engineering, civil, structural, and public health engineering, quantity surveying, and site and monument surveys. Many of the in-house professional staff are within the regional teams in the operational groups, particularly the historic buildings architects in Conservation Group and the design and works managers in Historic Properties, but the rarer, discipline-specific posts are grouped in the central Works Professional Services Division. This is done for flexibility and economy, to facilitate comparison of the lessons learned from working for both the Conservation and Historic Properties Groups of English Heritage, and to promote the benefits of multidisciplinary working.

The central Works Professional teams are closely associated with the teams providing scientific and conservation services which were described in the first *Scientific and Technical Review* (supplement to *Conserv Bull* **17**). This grouping, formerly known as Technical Services, was renamed Research and Professional Services (RPS) in April 1993 under a new Director, Roy Swanston. The new title embraces the dual tasks of the delivery of scientific, technical, and professional services to Historic Properties and Conservation Groups and the undertaking of research, development, and training on behalf of the whole of English Heritage for the benefit of conservation at large.

The research programme is derived from the experience of providing services to the other groups within English Heritage, from the experience of professional staff working within those groups, and by contact with other organisations and individuals in the field of historic conservation. Clearly, it is desirable to give priority to areas which are urgent, where problems are significant, and where real benefits are possible at acceptable cost. Research in partnership with other interested parties, government, academics, or industry is seen as essential and increases the available resources.

Monitoring dampness using infrared thermography: thermal image of the head of a window embrasure at Dover Castle, blue showing several concentrated points of dampness

The advisory and executive work of Works Professional Services is a major source of material for development work and is necessary to give a proper perspective to the evaluation and interpretation of data from other sources. Practical work provides a proving ground for the application of standards and the results of research. The programme of research and development is directed towards the provision of coordinated information: through publication, representation, lecturing, exhibitions, training, and the development of products with commercial potential.

The following articles offer a sample of the research and development work of the division. There are a number of common overlapping themes running through this work: understanding of what is being conserved, minimisation of loss through the normal effects of existence and use, the effects of alteration and of disaster, due consideration to the proper application of standards to historic monuments which were developed for new structures, and proper management as a means to better conservation.

Much of the development programme is concerned with building standards and control. The balance of risks against costs in the use of standards is relative, not absolute, but cannot be used in such a way for historic structures. No building is completely safe from most hazards, whether accident, flood, fire, or collapse. One which does not quite meet the current standard is not unsafe, just less safe, and can often be made as safe by the application of alternative strategies to meet the same objectives.

View of the Bishops Palace, Lincoln

The kitchen, Bishops Palace, Lincoln: the vault at the northwest corner before and after consolidation

The appropriate degree of relaxation is not simply a matter of how great the risk is, but also of evaluating the importance of the risk. The latter is not a task for the works professional alone. Their strategic task is to advance the art of the practical, so that it is closer to the ideal of maximum retention of historic fabric with minimum intervention and maximum reversibility, by developing effective new applications of existing materials and techniques, and identifying requirements for new ones.

Disaster planning is like insurance: not needed until it is, and then too late if it is not in place. Resources spent on disaster planning can be one of the most cost-effective means of conservation. Disaster planning is often a matter of balancing risks, not eliminating them. It is also a matter of balancing the actual damage which may result from preventing or mitigating disasters by physical means and the potential loss from disasters.

The Works Professional Services Division is committed to promoting best standards of practice in conservation in the belief that better practice saves the heritage, as well as saving money. Properly managed projects lead to decisions being taken in a systematic manner in accordance with predefined objectives for conservation. Systems developed for ensuring value for money on conservation projects at our properties should be applicable to heritage conservation generally and may have potential in the commercial sector.

We are as concerned with the standards met by our agents, as we are with our own staff. We have a series of forms of contract developed for conservation work and introduced last April a revised set of model term and single project commissions for works consultancies. We monitor the capabilities and performance of our own works consultants and contractors and those whose work we have contact with through our operations. We are concerned to improve the standard of documentation for conservation contracts to help manage the risks inherent in historic building projects to the advantage of all parties, including that of the building.

The closely knit, multi-professional group of Works Professional Services can make headway in all these vital areas and has it as part of its brief to take stock of what is needed in practical, professional terms in order to make the objectives of English Heritage more achievable and then to act in conjunction with colleagues in the other operational groups.

ALASDAIR GLASS

Coordinated project information and conservation works

'New works' seem always to have enjoyed clear and comprehensive guidance in the form of specification libraries and measurement guides, enabling specifications and bills of quantities to be produced to high standards with speed and efficiency.

Conservation works on the other hand appear to have come off second best in this respect, with specification libraries and measurement guides failing to give the adequate and detailed coverage that such works require – if indeed they give any at all. This has added to the problem of researching and deciding on appropriate methods and techniques of restoration with the equally time-consuming problem of how to specify, measure, and present this project information for prospective contractors to price.

Many architects decide to avoid the issue completely by adopting a prime cost or daywork form of contracting, with resultant poor cost control and likely higher cost implications. Fortunately, the majority do adopt contracting methods which require a proper and fully pre-planned approach, in many instances probably instigated by the cost-conscious client who has the foresight and experience to brief his consultants accordingly.

Project information on conservation works should be specified and measured in a form similar to that for 'new works'. The continual specifying and measuring of conservation works automatically leads to some consistency in approach developed over many projects (probably due largely to the *ad hoc* rehashing of previous specifications and bills of quantities), but variations in consistency within the industry are numerous with varying degrees of quality and comprehensiveness, reflecting the expertise and professionalism of the individuals concerned. The variable project information received inevitably confuses contractors who have to price the end product (incorporating subcontractors' costings), instilling an increasing lack of confidence and resulting in inflated cover prices, if a decision is made to tender at all.

In 1987–8 Coordinated Project Information (CPI) was introduced to the industry and its professionals, in an attempt to improve generally the standards of project information/documentation produced for the procurement of building works. It was conceived as a system of control and coordination for the three main sets of documents produced by the professional design team for use by the building team, ie specification, drawings, and bills of quantities.

Bolsover Castle, west face, an example in practice

Background to the CPI initiative

A Government report in 1978 first drew attention to the problems and failures arising from the inadequacies and inconsistencies between specifications, drawings, and bills of quantities. This was followed by a pilot study commissioned by the Property Services Agency (PSA) which recommended that a common framework should be used.

To act on this recommendation, a committee was established with the title ‘The Coordinating Committee for Project Information’ (CCPI). The CCPI’s overall objective to generally improve documentation, both in technical content and in the effective coordination between documents, culminated in the creation of a set of conventions published in five books: *Common arrangement of work sections for building works; Project specification: a code of procedure for building works; Production drawings: a code of procedure for building works; Bills of quantities: a code of procedure for building works;* and *Coordinated project information for building works, a guide with examples.*

The CPI system, developed and agreed by many representatives of the architectural, surveying, and engineering professions and the building industry, provides a practical solution to the many criticisms levelled at project documentation. The CPI proposals are probably the most important contribution ever made by the building industry as a whole to a common problem. They affect not only the form of the finished project documents, but also the procedures followed by the design team. Inevitably, there is a learning curve involved in deciding to adopt the system, but the advantages are substantial.

The common arrangement

The keystone of this coordinated approach is *The common arrangement of work sections for buildings works* (CAWS). Its purpose is to define an efficient and generally acceptable framework that is identical for specifications and bills of quantities. The main advantages that result from this are an easier distribution of information, a more effective reading together of documents, and a greater consistency of content and description.

CAWS is divided into worksections which are characterised either by the sources used or by the end result of the works. The worksections are arranged first by groups and then subgroups, providing a three-level presentation. Provision is made within this three-level classified grouping system for the insertion of further worksections in the future. Normally, levels one and three would be sufficient for use in specifications and bills of quantities. Each level three worksection identified by CAWS is given a description of its scope followed by a list of items to be included in the worksection and a list of related items which are contained in other worksections.

The three volumes on codes of procedure lay down guidelines for the coordination of these elements. The underlying theme is that specifications should always be the first source of information about type and quality of materials and methods of workmanship. It is therefore recommended that drawings and bills of quantities cross refer to the appropriate specification clauses, rather than include probably incomplete specification information.

This then leads to two imposed disciplines, in which the specification content is considered in the production drawing stage, giving coordination between the drawings, specifications, and bills of quantities and an improved quality of information, and during the post-contract stage, when the contractor has to read the specification, with a consequent improvement in the quality of the building work.

Bolsover Castle, interior of gallery, before and after consolidation

Conservation works and CAWS

With the number of people now involved with the production of project information, a consistent approach can only try to reduce the risk of misunderstanding and oversight. Better tendering may also be expected with contractors able to price work with greater confidence and less risk. During post-contract, contractors will be able to spend more time managing and controlling the work, less on chasing information, coping with disruptions, and preparing claims. But how have works of a conservation character been provided for under this concept and CAWS?

CAWS includes approximately 30 worksections divided up under work groups and subgroups. Work groups effectively replace the traditional approach of dividing information in specifications and bills of quantities into between 15 and 20 'trade'-orientated sections, originating from the use of particular building materials and the differing craft skills needed in the use of each material.

These work groups and subdivisions have been derived from the close observation of the current pattern of subcontracting in the industry. They vary widely in their scope and nature and reflect the large range of materials, products, specialists, and subcontractors which now exist. The primary factors influencing and defining their creation are responsibility for the design performance and the method of working, related to subcontract practice.

This new approach reveals the basic shortcomings of CPI in relation to conservation work, in that it has been drafted primarily in the interests and to the requirements of modem materials, techniques, and practices as related to 'new works'. However, to seek a different approach because of this would not be in the interests of conservation or the construction industry. It is therefore necessary that we adopt the framework created by this initiative and adapt it to suit our needs.

Looking more closely at CAWS, it appears that CPI intends works related to demolition/alteration/renovation to be kept separate from 'new works' under work group 'C'. All conservation related work would therefore be expected to be included under this group. Unfortunately, the framework for work group 'C' is narrow and insufficiently detailed, reflecting a lack of emphasis and appreciation of work falling within its defined framework.

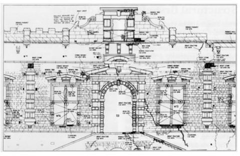
Amplification and integration

Although a complete rethink of work group 'C' may at first seem desirable, this can only be realised as a long-term aim with the eventual update/revision of the CPI documentation and the interrelated *Standard method of measurement of building works, seventh edition*. In the short term, too much diversification can only confuse this concept. Therefore, the existing CPI/CAWS framework must be used as the basis and any remodelling must be formed within that base framework with the minimum of interference. From research, and experience from a number of projects following the principles of the CPI system, a preliminary or guide framework was formed for workgroup 'C' (which can be renamed conservation/alteration/renovation to make the title more palatable).

This revised framework broadens what has been provided in the CAWS guide, yet still allows for further groups and sections to be added as necessary.

An example in practice

In December 1990 it was agreed that, together with other public organisations such as the PSA, English Heritage would phase in CPI practice to replace all previous practices. However, before making this mandatory on both internal staff and on all consultants, it was decided to undertake some further work to ensure its effectiveness in our work. This was done by undertaking a relatively straightforward project using CPI for specification, drawings, and bills, by giving seminars to staff responsible for implementing it, and by developing a library of standard specialist clauses specifically for conservation operations. The difficulties already identified came to the fore in carrying out the trial project: the consolidation of the Terrace Range at Bolsover Castle.



Bolsover Castle, base drawing, west elevation, marked up with keyword and specification clause numbers

With the Terrace Range, the base drawings were the drawn photogrammenic surveys for the exterior walls, where each stone was drawn to 1:50 scale. Being a relatively simple job of fabric consolidation, few overlays were required, and after identifying each and every operation and preparing the specification, the drawings were marked up with the keyword and specification clause number. This was satisfactory for individual operations, but it was found necessary to identify areas for varying degrees of repointing and surface treatment by coordinates in the margins, and an estimate average percentage of the linear total of jointing given relative to the clause. This enabled a firm measurement to be carried forward to the bills and lump sum figure or rate for the job given in the itemised tender.

Replacement of rotting cornice

By this means, we knew precisely what we were paying for, and it enabled a close monitoring of the cost to be maintained through the job.

At each site meeting, the degree of variation, if any, was agreed, and a duplicate set of drawings marked up and signed. It was then a comparatively simple job to transfer this information to the ‘as-built’ record drawings at the end of the job.

Some variations did occur and were either varying the original specification clause as a result of experience, such as the proportions of materials in the mixes, or the addition or (occasionally) subtraction of individual items which could not be ascertained from the initial inspection, but appeared on opening up. It succeeded as an exercise, as there was no dispute over conflicting instructions, no delay in providing instructions or clarifications, and the job was completed on time. Equally importantly, the cost was clearly monitored and controlled throughout.

Terrace Range after consolidation

The exercise at Bolsover clearly proved the worth of CPI, and in consequence it was resolved to apply the principles of CPI in the production of project information on all works operations.

Conclusion

The CPI initiative sets out a clear system of control and coordination that is worthy of implementation throughout the construction industry and, although it shows a number of shortcomings in relation to conservation works, by adoption and adaptation, in the long term it should be possible to influence some future amendment/redrafting of the work group to which these works relate.

CPI has only been explained briefly here, and the relevant books need to be read in detail to gain a full appreciation of the concept. From this system of control, we now need to develop a specification library and complementary measurement guide for conservation works to further aid the structuring and preparation of consistent, coordinated, and clear project specifications and bills of quantities. This is a sizable task, but one that may be furthered with English Heritage's commitment to research and development. Only when these have been achieved will the full benefits of a closer parity with 'new works' be enjoyed.

MARTIN CLAYTON and PAUL WOODFIELD

Structural first aid after a disaster

When a sudden disaster befalls an historic building, it is necessary to take rapid action to prevent further loss of historic fabric over and above that initially caused. Following an explosion, a fire, storm damage, flood, or some other calamity, the local emergency services, usually the Fire Brigade, will be involved. Whilst not wishing to detract from the undoubted bravery and skill of such people, it must be said that often they have no particular expertise in dealing with historic buildings, and they may not be aware of the significance of the historic elements of that building.

The immediate action by the emergency services will be to put out the fire or to declare an area safe after an explosion. There may then be a time when the people initially involved stand down for a short rest period, before they begin to think about making, as they see it, the structure safe. This 'making safe' often involves some demolition, sometimes major demolition. The sympathetic building professional, usually an architect or structural engineer, needs to be available during this stand-down period, because a much later arrival on site may well be too late.

Rapid response

It is therefore incumbent upon the professionals in the field of the conservation of historic buildings to provide a very rapid response to the disaster. Whilst it is not usually possible to have any input to the actions being taken by the emergency services, for example while a building is still on fire, sympathetic building professionals should be on site and ready to give advice as soon as the immediate hazards have been dealt with. Such rapid intervention needs to be handled very diplomatically, in order that the building professional should be seen as giving helpful advice, rather than as a busybody interfering in a situation that they know nothing about. The first keywords therefore must be rapid response and diplomacy.

Inspections

The initial inspection of a damaged building is important. It should always be done carefully, gaining as many vantage points as possible, with perhaps the use of a hydraulic platform if one can be made available. The Fire Brigade may have such a platform on site, and it will obviously be to advantage to make use of it, if possible. Inspections at such times will, of necessity, need to be done quickly: binoculars, a camera and/or a video camera, and a torch are useful.

Collapse of the spire in a storm threatened the stability of the nave

It may be possible, in the rest period following the immediate actions, to persuade the emergency services that demolitions can be safely deferred for a short period, but much will depend on the location of the building. Clearly, a busy city-centre situation will have to be treated very differently from a building standing in its own grounds and which is not putting passersby in immediate danger.

Fallen debris makes shoring and clearance works difficult

The building professionals involved in such rapid response following a disaster will need to be experienced and confident, as well as sympathetic to the historic building. There will be no time to retreat to the office to do calculations, and those who show a lack of confidence will, quite rightly, not be accepted as being in control of the situation. Thus, the next keywords are experience and confidence.

Actions

The historic building which has suffered a disaster will have elements in differing states of structural stability. There will be elements which are quite sound and which can remain without immediate action. There may well also be elements which are in an extremely dangerous condition, and the building professional, however sympathetic to the structure, must agree to their demolition. Finally, there will be elements between these two extremes.

Elements which have to be demolished should be recorded in the best way possible, bearing in mind the dangerous condition of the structure. Any demolition should be carried out with great care to ensure that falling debris does not cause further damage to other parts of the structure.

Walls which do not demand immediate demolition, but which appear unstable, should be shored. The decision on whether walls remain, are shored, or are demolished will be largely a matter of experience and should be made bearing in mind short-term changes, such as high winds and the ingress of moisture. Shoring can be constructed from tubular steel scaffolding or timber; the material used will depend on availability and on what is best for the situation.

Suspended floors need special attention, particularly where they have been fire damaged and reduced sections may exist, or where they have been damaged by explosions and fractures may have been created. Suspended floors may also be seriously overloaded with fallen debris, which may well be waterlogged after a fire. It will be necessary wherever possible to examine the floor from below, before the work to remove fallen debris commences. The additional weight of workmen, or the disturbance caused by the removal of debris may be sufficient to overload the floor to a point of collapse. Shoring the floor from below, assuming that shoring can be well founded, has inherent risks to people working below a grossly overloaded floor. However, with care this can often be done successfully. It should always be remembered that floors, even partially damaged floors, may well be providing useful lateral stability to walls.

The tops of walls may have become dislodged, resulting in a risk of masonry falling onto people below. Such loose masonry should be removed after recording, possibly utilising a platform hoist. Where there is risk of falling masonry, a protection fan may be used to advantage to provide protection and to delay removal until decisions can be made or recording carried out.

There may be a conflict of interests between removing debris quickly for safety reasons and leaving it undisturbed in order that it may be recorded properly; there is no easy

solution to this dilemma, but the structural engineer may be able to provide a shoring solution which satisfies both criteria safely.
While great care is needed to ensure that all necessary actions are taken, the professional should take care not to overreact, either by attempting to save dangerous elements, or, conversely, by giving permission for wholesale and possibly unnecessary demolitions. The next keyword is therefore care: care to save as much as possible and care in avoiding unnecessary risks.

Temporary shoring restraining a freestanding wall

Weatherproofing

Having made the building safe in the short term by a combination of demolition, shoring, and removal of debris, it will be advisable to consider some longer term weatherproofing of the remaining structure, so that, for example, the building can be allowed to dry out slowly after a fire and be protected from further damage from the elements. It may also be necessary to protect the building from unauthorised entry and from further damage due to vandalism and theft of historically important and valuable features. The last keyword is protection: from the elements and from vandalism.

Tall, unrestrained walls and weight of fallen debris are problems here (note freestanding cast-iron column)

Legal aspects

It is all too easy to forget the legal viewpoint in considering buildings damaged by disaster and when there are quite understandable pressures to deal with the situation quickly. The fact that a building has been suddenly damaged and may therefore be in a dangerous condition does not obviate the need for obtaining listed building or scheduled monument consent to demolish, except when there is an immediate danger to safety or health. Even then, notice must be given to the appropriate authority justifying such action. There will often be times when it will be necessary to obtain such consents very quickly and, whilst safety must override conservation, it is by no means necessary to discard all ideas of conservation on supposed safety grounds.

Further advice

The Conservation Engineering Branch of the Research and Professional Services Group of English Heritage has visited a considerable number of buildings which have suffered from some catastrophe and has been able to advise on ways of saving considerable elements which in other circumstances might have been demolished. A guidance note on this topic is under preparation.

Keywords

The highest priority for structural first aid following a disaster to an historic building is to get sympathetic building professionals onto the site as soon as possible. These people need to be in position to give sound, competent, and practical advice and to encourage others to take a positive attitude as an alternative to the more obvious solution of demolition.

The need for quick, but thorough, investigations prior to making decisions regarding shoring dangerous elements, demolition, or other actions cannot be overemphasised. Where demolition is unavoidable, such recording as can be done in safety should be carried out and the remains of the structure should be made weathertight and vandalproof as soon as possible.
The keywords for structural first aid must therefore be rapid response, diplomacy, experience, confidence, care, and protection.

IAN HUME

Learning to measure historic buildings

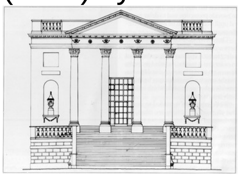
All professional disciplines involved in the care and conservation of historic buildings and monuments need to make use of measured survey drawings in plan and elevation of the structures. Quite often, especially in the earlier stage of their career, such professionals will also need to carry out some measurement themselves. While today the bulk of measured survey is provided through various specialist routes, it is nevertheless very valuable to have an understanding and some skilled knowledge of how a measured survey is put together.
To fulfil this need, the Survey Services Branch of RPS has been developing a measured survey school over the last few years, which is held in the grounds of Stowe School. Stowe itself is an excellent site for this exercise, as, apart from the house itself, the grounds have some 40 temples, follies, and other buildings spread around them, which present an ideal range of different survey problems.
Each year since 1987, up to 20 students have attended the course to learn something of measured surveying. They have been drawn from a range of disciplines, but have mostly been from architectural schools. For the last two years, however, we have had more students from conservation courses, as well as archaeologists and English Heritage staff.
The students are initially assessed to find out their previous experience of measured survey work. Then, they are put into small teams of four or five to carry out a survey. Typically, a facade of a small temple building might be chosen for the exercise. The students will be instructed in the methods of measurement directly on the facade by establishing grids, making measurements with tape and plumb-bob and offset, and then producing these as a drawing.

Stowe School: a classic elevation

Surveying the Queen’s Temple

A typical example is the survey of the Queen’s Temple. The Temple is a mid eighteenth-century structure of fine ashlar in the Palladian manner with classical detailing over a brick inner skin. It stands in opposition to the Temple of Friendship, overlooking the Elysian Fields.
Two scales were used to record both the detail of the Orders and the building as a whole. The survey was controlled by internal diagonal taping of each room and then fitted to an electronic distance measurement traverse. Radial observations were made to key detail points marked on a sketch plan. The plot of these coordinated positions was used to fix the geometry of the external plan of the building. Plans were prepared at basement level, involving the projection to plan of the vaulting, and at *piano nobile* level. As access to the roof was possible, elevations could be prepared by lowering tapes from the parapet and

then ‘booking’ tape measurement between datums fixed by levelling to record the heights of facade components.
Working at a larger scale, the details of the composite capitals and the unusual balustrade on the south elevation were measured onto annotated field drawings. Column entasis was measured by caliper and offset from a plumb line – still the most reliable method.
Constructing the section through the Temple proved to be a demanding task for students who were used to working in plan. The concept of using land-survey techniques was new to most students, as was the use of a traverse for control. For those who were familiar with archaeological recording, the measured drawing technique required for architectural survey was a big jump from the ‘part’ to the ‘whole’. To extend the value of the exercise to the students, the plan was also plotted out using the *AutoCAD* computer-aided drafting (CAD) system which we take on-site with us along with a plotter.



Stowe School, measured survey drawing of the south elevation

The course content

However, the course is much more than just an exercise in measurement, for our aim is not simply to train students in the matter of carrying out a survey, but to inform them of the important developments and range of techniques which can be used in measured survey nowadays. The aim is to give students a good grounding and understanding in assessing their own potential, and also to establish their own limitations when it comes to measured survey.
Despite the course being only a week, the students should take with them a feel for the type of work which they could undertake for themselves, in relation to the accuracy levels which they need to achieve. At the same time, they will know when they would be ‘out of their depth’ and realise the necessity of calling in specialist help.
To this end, we not only give a series of lectures, but also demonstrate more advanced technical methods of survey. The business of measured survey of historic buildings has been substantially transformed in recent years with the development of new technology. The photogrammetric methods of measurement in particular have revolutionised the way we survey. These are too complex to be carried out directly by students, but we take on site one of the latest generation of photogrammetric instruments – an Adams MPS Analytical Plotter – and demonstrate on the spot how a survey is produced through the photogrammetric plotter. We take the photography, we take the survey control dimensions, we carry out the plotting of one feature each year, and we give all the students the opportunity to use the instrument.

Measurement in the field

Measured survey work in this field has also been rapidly transformed in the last few years, principally by the common availability at reasonable cost nowadays of the electronic ‘total station’ theodolite. These instruments enable angles and distances to be recorded directly into a computer and this gives enormous benefits in terms of the ability to reach difficult areas of buildings. A third way in which measured survey has been transformed in recent years is with the arrival of CAD systems, again at reasonable cost.

Committing the survey results to paper

As well as these practical demonstrations, students are given a series of lectures during the week to cover the various methodologies involved. However, we also believe that it is important for students to understand the context in which surveys are required, and to this end a lecture is given on the role of measured surveys in relation to the conservation of historic buildings, focusing on the archival, interpretative, and works related aspects of the subject.

Using the experience

Clearly, in a short time it is not possible to train a person to be fully competent in any branch of measured surveying. Our purpose is to develop a rounded approach to the subject, where students will have a feeling for the methods of survey. At the same time, they will learn of the much wider range of possibilities available nowadays in measured survey work and also know when to call in specialist services, such as can be offered by the Survey Services Branch.

Students find that the preparation of measured drawings is a challenge to trust the eye and then construct and prove the geometry of the subject. In developing an awareness of this skill, students gain an understanding of the science of modern survey, as well as enjoying the art of both the architecture and architectural draughtsmanship. The 1993 Summer School takes place on 12–16 July 1993 at Stowe: for information on future courses, contact Bill Blake, RPS Survey Services, English Heritage, Room 504, Keysign House, 429 Oxford Street, London W1R 2HD; telephone 071-973 3515.

ROSS DALLAS and BILL BLAKE

Lightning protection for historic buildings

The purpose of this article is to provide an illustration of a practical and realistic solution to the protection of historic buildings from the effects of a lightning strike. British Standard 6651 (1990), *The protection of structures against lightning*, does not in the main differentiate between modern and historic buildings. It specifies the method of determining the need, the conditions to be met, and an approved means of installation, but it does not take into account the aesthetics of the building or the damage both visually and practically which could be caused by the installation itself.

The historic building of Ickworth Hall in Suffolk, owned by the National Trust, is used here as an example. The flanking wings of the building are relatively straightforward and the BS recommendations can within reason be met, but the central rotunda dominates the complex with the remainder of the buildings at a much lower level.

The rotunda comprises a three-storey circular building with a large domed roof, a lantern at its head, supported by walls which are not all in the same vertical plane. The elevation drawing shows the main changes in the vertical faces and the carved pediments which result in a tortuous route for any earthing down-conductor. To meet the existing BS would therefore result in the defacing of the building by down-conductors and their fixings. An alternative would be to set the building within an earthed metal cage, a short distance from the building itself. This would offer excellent protection against a lightning strike, but would be unthinkable aesthetically.

The objective therefore was to protect the rotunda should it be struck by lightning, by passing the discharge directly to earth, and to achieve this without damage to the structure or its appearance.

Method

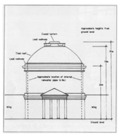
In many of the larger ornate historic buildings with considerable roof areas, such as Ickworth Hall, there are substantial internal rainwater downpipes. These pipes collect rainwater via gullies and pass it through the structure, within the building line, to soakaways. Therefore, this is a direct path to earth and furthermore the area at the foot of the pipe is normally damp and, in electrical terms, constitutes good conduction.

These downpipes are made from lead or lead-rich alloys and are generally of considerable wall thickness which adds to their stability. They do not normally run in a continuous vertical plane, but the large internal cross-sectional area creates a path which can be utilised by a suitable down-conductor. The use of the lead pipe as the main conductor may cause problems in terms of electrical continuity, and it is therefore advantageous to use a copper conductor within the pipe and bond it at the top and bottom to avoid flashover.

The areas above the rainwater pipes at Ickworth, ie the dome and the lantern, can be protected in accordance with the BS requirements with copper rods bonded to extraneous metal components of the building. A finial forming a direct connection to the earthing system would ideally be situated in the centre of the lantern which is the highest point in the structure. Although visible from ground level, the visual impact would be small and could be considered acceptable. The parapets at the top and bottom of the dome also need to be ringed with a horizontal conductor, not visible from ground level, and this in turn should be directly connected to the appropriate down-conductors.

The BS recommends that for a building of the height of the rotunda down-conductors should be spaced at 10m intervals. As the circumference at the lower parapet is in the order of 100m, it follows that ten conductors to the ground level are recommended. For this particular case and applicable to this type of structure, a total of four main down-conductors would be acceptable, with each passing through and bonded securely to the existing rainwater downpipes. The solution is not ideal and, considering the heavy load these conductors would take, the bonding to other metals in the rotunda has to be given special consideration. It is very important that all metal which may constitute an earth path in the vicinity of the lightning protection system is also bonded to the system itself in order that flashover is minimised.

Ickworth Hall: the rotunda presents problems for lightning down-conductors



Elevation of rotunda, showing the rainwater pipe routes which could be used for earthing inside the building

One of the internal rainwater downpipes

The earth rods are then located within a concrete pit complete with cover, giving access to the disconnection points for testing at the earth rod.

Testing

The testing as recommended in the BS calls for a maximum total resistance to earth of 10 ohms with the building conductors disconnected from the earth rods. This condition would also apply to the system of four conductors, with the exception that the total resistance to earth is reduced to 5 ohms. There might be a need to link the earth rods together to achieve this figure: if this is the case, this work would be carried out during the installation. In addition, it is necessary to ensure that continuity of a low earth path is maintained within the conductor rods, and this would be inspected and tested at the same time.

Conclusions

The method of using internal fixtures as a path to earth, rather than introducing external means, is not an easy or cheap option: it requires a considerable amount of 'bonding' of other potential earth paths, and the cost is likely to be higher than the system recommended by the BS.

The reduction in the number of down-conductors at the lower level of the rotunda does not in fact increase the voltage significantly, providing the resistance to earth can be reduced to 5 ohms. The resultant voltage is then only 7% above that calculated for ten down-conductors with a resistance to earth of 10 ohms. The resistivity of the soil is an important part of the method outlined and values for this would be recorded first.

A lightning strike is an act of God and many assumptions are made with regard to its behaviour and severity. The BS takes the view that the building needs to be protected regardless of the aesthetics; of course, from a conservation aspect, it is necessary to look a little further, whilst still taking account of the recommendations.

PETER MANN

Natural wall cappings

The significant protection offered by grass and other plants on wall tops has been consciously exploited in the past few years on a number of ancient monuments. Jervaulx Abbey is a particularly fine example, where the considerable amenity value of the flora flourishing on the walls was a stimulus towards developing a more sympathetic approach to consolidation *(Conserv Bull* **7**, 14). In this instance, plants were lifted off while consolidation took place and then a proportion replaced in pockets to stimulate further regeneration. Other approaches have been developed to suit particular circumstances. In some cases, a minimalist 'gardening' technique has been used, only removing woody growth and leaving the resultant vacant spaces to revegetate. At the other extreme, the hard capping has been thoroughly consolidated, soiled, and returfed leaving a green, but monotonous effect.

Soft capping can provide a durable insulating layer, modifying temperature extremes and the effects of frost and, in some instances, shedding off water from wall faces. At Bolingbroke Castle, the walls of Spilsby Sandstone have a natural tendency to erode from within, forming a fragile honeycomb which can collapse underfoot. The solution in this case was to hollow out the corework, add topsoil, and turf over to form a protective layer. Even where stone is more durable, the soft capping can still be useful in preventing the finer material from washing out of the core and the example of Tintagel shows the associated amenity and nature conservation benefits of a natural, florally rich capping. The trials described below were designed to test a selection of techniques for establishing both a durable and sympathetic capping.

Isles of Scilly

In 1992, an experiment was set up on the walls of the eighteenth-century Garrison on the Island of St Mary's to examine ways of providing a satisfactory protective capping without destroying its colourful and interesting flora.

The Isles of Scilly are extremely interesting botanically. The mild, virtually frost-free, oceanic climate allows species that are rare on the mainland to flourish, and the combination of thin soils, bare rock, and exposure to salt-laden winds favours maritime and heath species. The weed flora of the bulb fields is also notable, and many introduced 'exotic' species have become naturalised. Tourism, development, and changes in farming are all affecting this fascinating natural heritage, so that the plant communities present on the historic sites, including the Garrison Walls, assume greater importance.

Turf wall cappings at Chysauster (above) and at Tintagel (below), where the florally rich capping offers nature conservation benefits

The granite walls, which encircle the Garrison and run for approximately 1500m, vary between 1
and 2m high on the inner (landward) side and between 0.6 and 1.5m in width. The profiles of the tops vary from flat to concave and frequently slope towards the sea. Some sections have had soil added and have been reseeded, but generally there is very little soil present and some are quite bare. Soft cracked mortar is frequently exposed. This is easily penetrated by roots which seek the moisture held in the core of the wall. Where soil exists, it is coarsely sandy with high organic content and held together by the matted roots and rhizomes of the sparse vegetation. In these circumstances, the majority of the walls are exposed to the wind and rain and suffer from erosion which, in turn, is exacerbated by pedestrian use.

A preliminary botanical survey was carried out in March 1991 which showed this to be an important botanical site, supporting interesting communities which grow in dry conditions and a range of scarce or localised species. Accordingly, a more detailed survey was commissioned. This was carried out in August 1991. It confirmed the significance of the vegetation growing in the thin dry soils on the wall tops. It also demonstrated the damage caused where fresh soil had been added.

The typical flora includes maritime species such as thrift *(Armeria maritima),* scurvy-grasses (both *Cochlearia officinalis* and *C*. *danica),* sea fern-grass *(Desmazeria marinum),* buckshorn plantain *(Plantago coronopus),* sea rock spurrey *(Spergularia rupicola),* sea storksbill *(Erodium maritimum),* rock samphire *(Crithmum maritumum),* and the fern sea spleenwort *(Asplenium marinum) .* The more unusual species include the rare four-leaved all-seed *(Polycarpon tetraphyllum),* the autumn Lady's tresses orchid *(Spiranthes spiralis),* early meadow grass *(Poa infirma),* and wild parsley *(Petroselinum crispum).* A variety of annual and perennial clovers include burrowing clover *(Trifolium subterraneum),* rough clover *(T. scabrum),* western clover *(T. occidentale),* hares foot clover *(T. arvense),* suffocated clover *(T. suffocatum),* and fenugreek *(T omithopodioides)* in addition to the commoner species.

The problem was how to retain these generally rather specialised plants, whilst at the same time encouraging a more complete cover and a more durable turf. Many of the plants listed cannot compete with strong-growing grasses and require dry, infertile conditions. Analysis of soil from five locations showed high levels of magnesium and potassium which result from exposure to the sea. The highest pH values obtained from the samples were probably caused by old mortar. Generally, there is considerable variation in the composition and nutrient status of the soils which correlates with differences in the vegetation.

Sampling of the litter from the wall tops showed the presence of numerous seeds, suggesting that this could be used as a source for re-establishment.

It was clear that a basic requirement would be to add soil to the wall tops in order both to provide a growing medium and to create a convex profile to shed excessive moisture. The problem was what to use. Topsoil would be too fertile and, unless sterilised, would inevitably contain troublesome weeds. Peat-based composts would tend to be acid and the use of peat was undesirable on environmental grounds. After careful consideration, it was decided to use a proprietary material called 'DANU'. This is a by-product of the brewing industry, consisting of spent roasted barley grains and rape straw. It is available either as a 'growing medium' or as a 'soil conditioner'. The former had previously been used in the repair of erosion at King Charles's Castle on nearby Tresco. The latter material was chosen for Garrison Walls, because the nitrogen in it releases more slowly and over a longer period.

St Mary's Garrison Walls: saving specimen for replanting

Laying the DANU / ram mix

View along the trial plots: turf in foreground, protective fleece beyond

In order to raise the pH and increase the mineral content, the DANU was mixed with a gritty soil obtainable locally (known to the islanders as 'ram') in the ratio of two parts soil conditioner to one part soil. This produced a dark fibrous material somewhat similar in appearance and structure to the existing soil on the wall tops. Analysis of a sample indicated that the phosphorus and magnesium levels were acceptable, and the potassium, though high, was expected to fall rapidly. pH was rather low, but plant roots would quickly contact the mortar-rich wall surface.

It was decided to test three methods of establishing an acceptable vegetation cover, one using turf and the others using seed. The aim would be to obtain a stable grass turf into which the indigenous flora could be sown or planted to supplement natural colonisation. The grasses used had to be hard-wearing, salt-tolerant, and able to spread by rhizomes and tillering. At the same time, they would not be so aggressive as to dominate the sward or prevent invasion by desirable species. *Festuca rubra* was found to be an important grass on the walls and therefore a mixture of three cultivars of Red and Chewing's Fescues was selected: these were *Festuca rubra subsp rubra* 'Baruba', *F.r. subsp litoralis* 'Barcrown', and *F.r. subsp commutata* 'Bargreen'. Turf and seed of these were obtained from commercial sources in England.

The treatments were applied to plots of between 2 and 4m long at each of three locations, chosen to represent different aspects, degrees of exposure, and levels of pedestrian use. In each case, some of the existing vegetation was first removed, with as much adhering soil as possible, and placed to one side. The prepared soil mixture was then shovelled onto the wall top and spread to form a slightly convex profile.

The following treatments were then applied: 1) turfed, 2) sown lightly with seed mixture and then protected by covering with a polypropylene fleece to aid germination and reduce wind erosion, and 3) sown, as in 2, but then watered with 'Scanbinder' starch-based adhesive at 5g per square metre.

In each case, the 'rescued' plants were then replanted along the landward edge of the plot. The plots were laid out at the end of November 1992, and early establishment was excellent. This, however, is only the initial stage of the phased trial, the results of which will

only become apparent after several years. The next stage will be to scarify the surface of each plot and to over-sow it with seeds obtained by collecting the litter from wall-tops in other parts of the site. This may be done either by sweeping or by vacuum-cleaning.
The final result will not reproduce the existing vegetation communities, but we hope that it will enable all or most of the important species to survive within a capping that provides better protection for the wall fabric.

ANDY WIMBLE and JOHN THOMPSON