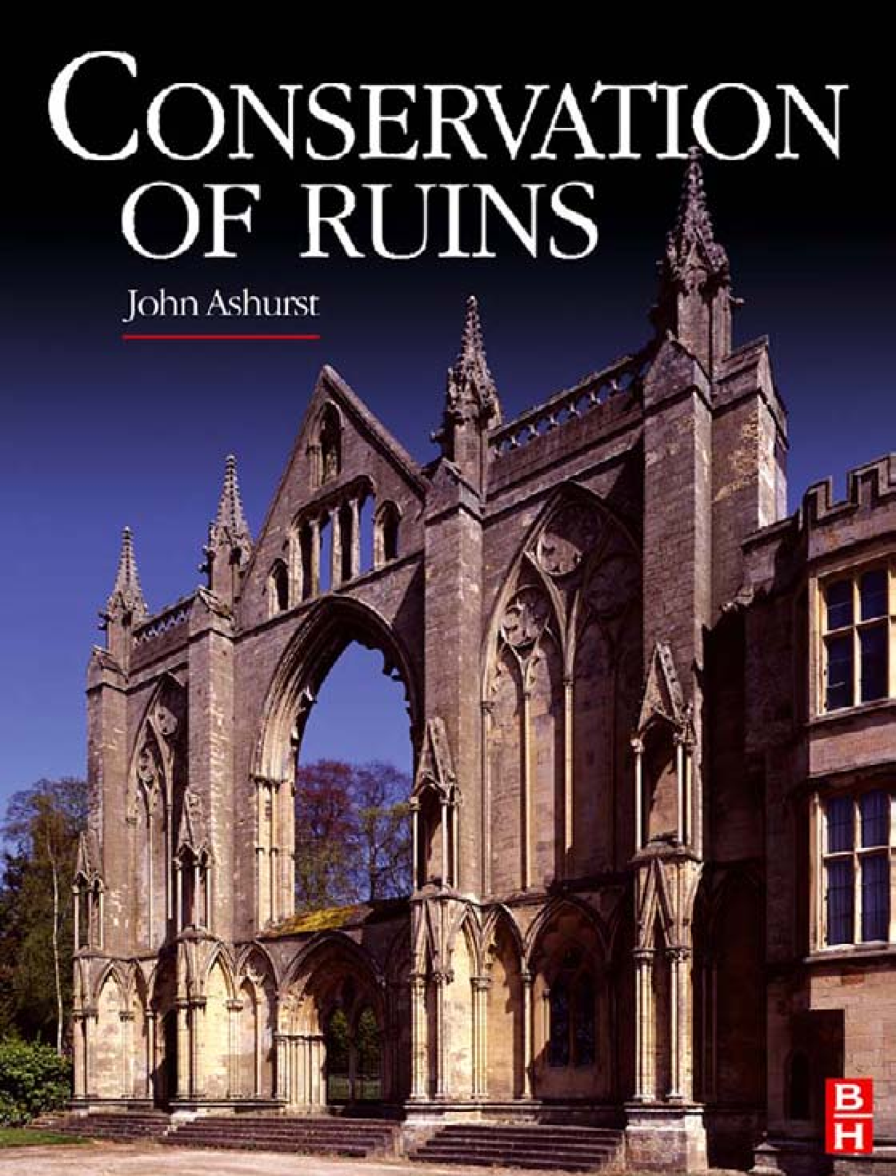
CONSERVATION OF RUINS

John Ashurst



Conservation of Ruins

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Knowlton Church and Rings are a good example of a Scheduled Ancient Monument in England. Located in the ancient landscape of Cranborne Chase and surrounded by barrow cemeteries and earthworks, the church is eleventh century but much altered in the fourteenth century. Remarkably, it stands within a well-preserved ceremonial Neolithic Henge monument of c. 2500 BC. Consolidation of flint core work, tamping and pointing, the use of rendered brick structural supports and bronze corbel bars are classic interventions of the Ancient Monuments Division of the Ministry of Public Building and Works (c. 1950). Scale by Sam the retriever.

CONSERVATION OF RUINS

Edited by John Ashurst

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Contents

I met a traveller from an antique land
Who said: Two vast and trunkless legs of stone
Stand in the desert. And near them on the sand
Half sunk, a shattered visage lies, whose frown
And wrinkled lip and sneer of cold command
Tell that its sculptor well those passions read
Which yet survive stamped on those lifeless things,
The hand that mock'd them and the heart that fed;
And on the pedestal these words appear:
'My name is Ozymandias, king of kings:
Look on my works ye mighty and despair!'
Nothing beside remains. Round the decay
Of that colossal wreck, boundless and bare,
The lone and level sands stretch far away.

(Percy Bysshe Shelley,
Ozymandias of Egypt, 1817)

Acknowledgements

My first and most important acknowledgement is to my contributor authors. Without them this would have been a much smaller and less interesting and useful book, and would have lost much of its authority and value. Without exception they are people with whom I have had the great pleasure to work or train with in a wide range of situations, times and sites, and all of whom have taught me something new about the fascinating, compelling and important subject of this book.

I count it a true privilege to know each one of them.

Graham Abrey • Jason Bolton • Colin Burns • Sara Ferraby • Chris How • Jukka Jokilehto • David Odgers • Gionata Rizzi • Asi Shalom • Margo Teasdale • Amanda White • Catherine Woolfitt

Particular and special thanks are due to Gillian Reading, who has worked tirelessly on the fabric of this book and has more than made up for my lack of IT skills.

My second acknowledgement is to all those who have contributed to my love and knowledge of historic buildings and especially those buildings with 'special needs' which have so much to teach us, the building ruins and their sites.

The list which follows is a dangerous one, because there will be omissions which I will later remember and regret. But I list them as well as I can without their titles but with my enduring thanks and appreciation.

The architects

Bill Adams • Alejandro Alva • Bernard Ashwell • T. A. Bailey • John Barnes • Corinne Bennett • Keith Blades • Patricia Brock • Eric Brown • Oran Campbell • Bob Chitham • Barry Clark • Raymond Connelly • Bill Cutting • Richard Davies • Maggie Davies • Patrick A. Faulkner • Bernard Feilden • John A. Fidler • Brian V. Field • Percy Flaxman • Reshat Gega • Emil Godfrey • Harry Gordon-Slade • Neil Hynde • David Heatt • John Kaye • John Knight • Derek Lindstrom • Graham Luckes • John Ludlow • Ingval Maxwell • Iain McCaig • Anna McPherson • Peter Miller • Neil Moffat • Dick Oram • Donovan Purcell • Norman Riley • Zygmund Skrobanski • Gail Sussman • Harold Yexley

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The building surveyors

Chris Wood • Elizabeth Vause

The engineers

Leonard W. Ashurst • Ian Hulme • Ralph Mills

The scientists

Lesley Arnold • John Beavis • Leo Biek • Mike Bowley • Brian L. Clarke • Tony Coote • Francis G. Dimes • Peter Ellis • Sophie Godfraind • Yosef Hatzor • David B. Honeyborne • Elaine Leary • Frank Matero • John Musty • Sara Pavia • John Pickering • Clifford A. Price • Barry Richardson • Brian Rideout • John Savory • Giorgio Torraca

The craft supervisors and craftspeople

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The conservators

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In Ireland

Chuck • John • Roger • Robert • Tadg

In Israel

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In most of the above categories

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The dogs

Sam • Meg • Bryony • Finch

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List of contributors

Professor John Ashurst is a chartered architect who has spent most of his professional life working on historic buildings. In the early part of his career he joined the Ancient Monuments Division of the Ministry of Public Buildings and Works and remained with the organisation through its several changes, culminating in privatisation as the Historic Buildings and Monuments Commission for England, better known as English Heritage. For the greater part of this period he was architect in charge of the Research and Technical Advisory Service and took particular interest in the conservation of ruins in the care of the state. For many years he has been actively involved in teaching and site training, and is author of numerous technical notes and books including, with Francis G. Dimes, *The Conservation of Building and Decorative Stone*, published by Butterworth-Heinemann. Since 1991 he has worked in private practice as a consultant on historic buildings and their sites and has had a particular interest and involvement in the historic sites of Israel. His other interests are eighteenth century history, theatre, film and the graphic arts.

Colin Burns is a master stonemason and served his apprenticeship on the Isle of Portland in Dorset, England. He has spent the last 35 years in the field of masonry conservation. The greater part of that time has been with the Directorate of Ancient Monuments and Historic Buildings, later English Heritage, where he worked with John Ashurst in the Research and Technical Advisory Service. He is a well-known and respected teacher of practical masonry conservation, particularly for his speciality in site training on the conservation of ruins. He has contributed to the conservation of ruins training programmes in Ireland, Albania and Israel. His varied interests include the practice and history of quarrying.

Graham Abrey is a chartered building surveyor accredited in conservation by the Royal Institute of Chartered Surveyors. He gained considerable practical experience in the repair of historic buildings as a supervisor and project manager for a UK stone masonry company. He obtained a Postgraduate Diploma in building conservation and subsequently worked as an independent consultant in the repair and conservation of masonry buildings before co-founding Ingram Consultancy Ltd in 1999. Graham uniquely combines an extensive knowledge of traditional building materials and repair techniques with essential professional project management and documentation skills. He has travelled widely in the Himalayan region and has a passionate interest in its cultures.

Jason Bolton has a background in architectural conservation science, heritage risk management, commercial diving and archaeology. He has recently completed doctoral research on the deterioration of coastal stone monuments, and has authored a wide range of books, technical studies, papers and articles since he began in private practice as an Architectural Conservation Consultant in 1997. Research interests include the weathering, decay, cleaning, repair and conservation of stone, brick and mortar masonry structures, the interaction of island and coastal environments and historic buildings and materials, medieval mortar technology, quarrying and sources of building materials, and the technology and design of Irish stone monuments.

Sara Ferraby is a chartered building surveyor with a background of project management in Historic Royal Palaces in England. She has considerable experience in conservation contract procedures and documentation, and of using these coupled with proper supervision and good communication to ensure the maintenance of high standards on site. This translation of conservation requirements into practice on site has given her a particular interest in the development of accredited practical conservation training. She is committed to the protection of the countryside and its wildlife, is interested in all equestrian pursuits and regularly competes at affiliated dressage with her Hanoverian horse Leonardo.

Chris How studied Civil Engineering with a Structural Engineering bias at West Ham College of London University. He carried out a variety of investigation and design works, which included bridge design in Cornwall, before migrating to Australia in 1970. Since 1973 he has lived and worked in the pioneer region of South-West Victoria, most of this time as a Consulting Engineer in his own practice. Chris is now semi-retired and is busy indulging a fascination for historic buildings and their problems, which stems from 3700 site tests around the area, and a large number of structural investigations on pioneer structures. He is a team player who enjoys the interaction with heritage architects, builders, conservationists and historians. He is a member of Australia ICOMOS, a member of the Institution of Civil Engineers, and the Institution of Engineers, Australia.

Dr Jukka Jokilehto was born in Finland, where he first worked as architect and city planner. In 1971, he attended the International Architectural Conservation Course at ICCROM in Rome, and was later made responsible for the Architectural Conservation Programme, reaching the position of Assistant to the Director General. Many of the world's conservation practitioners came to know him in this role and benefited from his guidance and enormous experience of international conservation. Retired in 1998, he has been Advisor to ICOMOS on the UNESCO World Heritage Convention. Internationally known as a lecturer, he has written on conservation theory and practice, including *A History of Architectural Conservation* (Butterworth, 1999), and is an accomplished violinist.

David Odgers graduated with a degree in chemistry, then spent several years working on the fringes of industry before becoming an apprentice conservator at Wells Cathedral under Professor Robert Baker, where he learned the value of the conservator becoming as knowledgeable about the object to be treated as any doctor should be about their patient. He later built on this experience to become one of the founder members of Nimbus Conservation in 1984 and from 1991 until 2005 Managing Director of the company, employing over 40 craftsmen and conservators. He was responsible for conservation works to many important historic buildings and monuments, including archaeological sites. He is now an independent consultant, an Accredited Conservator, well-known trainer in conservation subjects, and a keen cricketer.

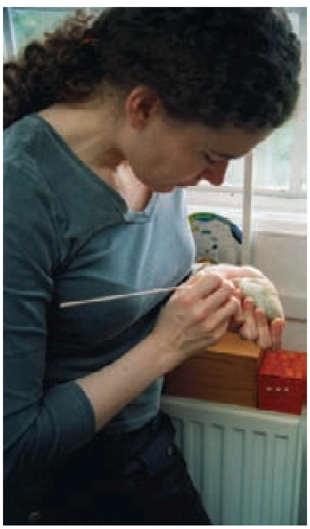
Gionata Rizzi graduated in architecture from the Polytechnic of Milan before specialising in building conservation at ICCROM and at the University of York, where he obtained an M.A. with a thesis on masonry ruins. Assistant to Sir Bernard Feilden in Rajasthan, he has been involved in many projects of architectural conservation in Italy, France, Spain and the Middle East. As a consultant to UNESCO, ICCROM and WMF he worked on various World Heritage Sites, including the *Templete Mudéjar* in Guadalupe (Spain), a project that won a Europa Nostra Prize. For the Getty Conservation Institute he developed a proposal for a shelter on a hieroglyphic stairway of a Maya pyramid. He is now working in Italy on Herculaneum, on the façade of Parma's Cathedral, and on the archaeological site of Piazza Armerina in Sicily. He has taught Architectural Conservation in Milan and Geneva, and is a guest lecturer at the University of Pennsylvania.

Asi Shalom is an archaeologist and site conservator. Asi was one of the founders of the Conservation Department in the Israel Antiquities Authority in 1989. He is a graduate in Conservation Studies of the School of Archaeology, Hebrew University, Jerusalem, and has also trained in Italy. He founded and has managed the Archaeology Conservation Center since 1995, and has participated in and led over 60 conservation projects throughout the country, such as Masada, Qumeran, the Spice Road Caravansaries, Mosiacs of Memphis, City of David – Jerusalem and various Classical and Biblical sites. Asi's many interests include early technologies, especially the culture and work of the Nabateans. He has developed and manages a successful olive farm in the north of the Negev and is author of a new manual for archaeologists, *Excavation and Conservation on Archaeological Sites*.

Margo Teasdale is a planner with a first degree in Canadian Studies and History and a masters in Environmental Studies from York University in Toronto. Her early professional life was spent with the Ontario Heritage Foundation, during which time her activities included key heritage sites such as Fort York and the Music Building in Toronto. She also prepared reports for the Canadian Pacific and Canadian National Rail on saving Ontario's railway stations. She subsequently worked for the Ontario Ministry of Culture and Communications on grant projects in the Toronto region. In England she obtained an M.Sc. in Historic Conservation at Oxford Brookes and Oxford Universities and a Diploma in Urban Planning. She has since worked as a conservation officer with Bath and North-East Somerset, and as a senior conservation officer with Hampshire County Council. Her lifelong interest is the protection of the natural environment and the effects of climate change.

Amanda White is a chartered building surveyor with a post-graduate diploma in the Conservation of Historic Buildings from the Architectural Association. Amanda joined English Heritage's Research and Standards Group in September 2004 from Historic Royal Palaces, where she worked as a Project Surveyor at Hampton Court Palace. Amanda assists the Chief Conservation Architect in setting, promoting and monitoring English Heritage's maintenance standards for the estate in its care. Her concern about the lack of craft skills in the heritage sector leads her to visit schools as a Construction Industry Training Board construction ambassador to stimulate interest in the national heritage and in training programmes. She is a keen traveller and enjoys walking and swimming.

Catherine Woolfitt is an archaeologist and architectural conservator, and co-founder and director of Ingram Consultancy Ltd, a practice dedicated to the conservation of historic buildings and ancient monuments. Since completion of her training at Queen's University in Canada in the fields of Classical Archaeology and Art Conservation, she has pursued her interest in history and specialised in the conservation of historic building fabric – survey, recording, analysis, repair and surface treatment. She has had a long-term involvement and maintains an ongoing interest in the history and archaeology of the Mediterranean region and of her ancestral home in North Wales. Catherine is a member of the Institute of Field Archaeologists and of the UK Institute of Conservation. Spare time is devoted to the conservation of her sixteenth century Somerset farmhouse and garden.



Rachel Sabino-Gunaratna is Assistant Conservator of Objects and Sculpture at The Museum of Fine Arts, Houston. Rachel has carried out internships at the Metropolian Museum of Art, J. Paul Getty Museum and Corning Museum of Glass and successfully managed a private practice in London. Her interests include gardening, bookbinding and enquine pursuits.

Gillian Reading runs her own administrative support company out of offices shared with Ingram Consultancy on the Fonthill Estate in Wiltshire. She has worked as personal assistant to John Ashurst, Catherine Woolfitt and Graham Abrey of Ingram Consultancy for the last three years and has a client base of 10–15 small to medium size businesses in the area. Gillian spends time away from her computer running or walking with her Jack Russell dog, Finch.

Foreword

The conservation literature contains many books on earthen architecture, stone and historic buildings. Few of them, if any, deal specifically with ruins, and this volume fills the gap admirably. Similarly, the conservation profession has many gifted people but there are few, if any, who are better qualified than John Ashurst to bring such a book into being.

One of my first encounters with John was at Tintern Abbey. Its immaculately maintained appearance contrasted markedly with photographs from the previous century, when it was covered with ivy, the archetypal romantic ruin. We were applying a range of biocides to control algae and lichen, seeing which worked best and lasted longest. I doubt whether it occurred to either of us to question what we were doing, or to set the evident need for maintenance into the wider context of conservation ethics and principles. Conservation then was largely a matter of finding the right material for the job.

This book reflects the changes that have taken place in the intervening years. It contains much practical advice, but it also maps out some of the wider context in which conservators now operate.

John's first book *Stone Preservation Experiments*, co-authored with Brian Clarke and published by the Building Research Establishment in 1972, marked a turning point in approaches to stone preservation. It was meticulously researched and recorded, but few people who read the preface went any further. The preface ended with the memorable words 'None of the treatments has had any overall beneficial effect in retarding decay on any of the sites'. Why read on? This volume, by contrast, will be quarried repeatedly by students and experienced practitioners alike. It provides, in the words of Gionata Rizzi's preface, a 'close encounter with ruins': an encounter that will inform and invigorate on every occasion.

Clifford Price
Professor of Archaeological Conservation
Institute of Archaeology, University College London

Figure credits

Figure	*Page number*	*Source/Credit*
Frontispiece	ii, xvi	John Ashurst
Jerash	xxiii	Gionata Rizzi
I.2	xxv-xxvii	John Ashurst
I.3	xxviii	Michael Williams
I.4	xxviii	Agence photographique Roger-Viollet
Short story	xxxii-xlii	John Ashurst
Pevensey	xxxix	John Ashurst
Kirby Hall	xxxix	Graham Abrey
Hatshepsut	xxxx	Asi Shalom
Parthenon	xxxx	Catherine Woolfitt
Tel Beit She'an	1	John Ashurst
Stoa of the Athenians	1	Catherine Woolfitt
Pompeii	2	Catherine Woolfitt
Herculaneum	2	Gionata Rizzi
2.0	10	John Ashurst
2.1	12	John Ashurst
2.2	13	Chris How
2.3	14	John Ashurst
2.4–2.7	14–17	Chris How
2.8–2.10	17–18	John Ashurst
2.11–2.22	20–24	Chris How
2.23	25	John Ashurst
2.24–62	26–43	Chris How
3.0	44	Graham Abrey
3.1–3.10	55	Graham Abrey
3.11	57	John Ashurst
3.12–3.14	62, 63, 67	Graham Abrey
3.15, 3.16	69, 72	Graham Abrey, based on drawings by WS Atkins
3.17	73	Graham Abrey
3.18	74	Graham Abrey and John Ashurst
3.19	75	Plowman Craven Associates
3.20	77	Graham Abrey and John Ashurst
4.0	82	Catherine Woolfitt
4.1–4.5	84–90	John Ashurst
4.6, 4.7, 4.8	91, 92	Colin Burns
4.9–4.17	92–100	John Ashurst
4.18–4.27	101–105	Colin Burns
4.28–4.35	106–110	John Ashurst
4.36–4.38	111–112	Colin Burns
4.39–4.43	112–116	John Ashurst
4.44, 4.45	117, 118	Colin Burns
4.46, 4.47	118, 119	John Ashurst
4.48, 4.49	120, 121	Colin Burns
4.50–4.69	122–139	John Ashurst
4.70	140	Asi Shalom
4.71–5.76	141–144	John Ashurst
5.0	146	
5.1	149	Graham Abrey

Figure	Page number	Source/Credit
5.2–5.4	151–153	Catherine Woolfitt
5.5	154	Asi Shalom
5.6, 5.7	155, 156	Catherine Woolfitt
5.8	157	John Ashurst
5.9–5.13	161–165	Catherine Woolfitt
5.14, 5.15	166, 167	Courtesy of Museum of London Archaeology Service
5.16, 5.17	169, 170	John Ashurst
5.18	172	Graham Abrey
5.19–5.23	173–180	Catherine Woolfitt
5.24, 5.25	181, 182	Orit Bortnik
5.26	182	John Ashurst
5.27, 5.28	183, 184	Courtesy of the Austrian Archaeological Institute
5.29, 5.30	185	John Ashurst
5.31	186–189	Catherine Woolfitt
6.0	194	Courtesy of The Blackburn Museum
6.1–6.8	196–203	John Ashurst
6.9	204	Colin Burns
6.10–6.12	205, 206	John Ashurst
6.13	210	Sara Ferraby and John Ashurst
7.0	212	John Ashurst
7.1–7.12	213–229	Jason Bolton
7.13	230	Courtesy of the Archaeological Diving Company
7.14, 7.15	231, 232	Jason Bolton
8.0	234	Colin Burns
8.1	236	John Ashurst and Colin Burns. Reproduced courtesy of Getty Conservation Institute
8.2–8.8	237–245	John Ashurst
9.0	246	Asi Shalom
9.1	250	John Ashurst
9.2	251	Amanda White (2005)
9.3a	252	John Ashurst
9.3b	252	Elisabeth Vause
9.4, 9.5	253, 254	John Ashurst
9.6, 9.7	256, 257	Helen Thomas (2005)
9.8	258	John Ashurst
9.9, 9.10	259	Peter Ranson
9.11	262	John Ashurst
10.0	264	John Ashurst
10.1–10.14	266–278	Catherine Woolfitt
10.15, 10.16	279, 280	INNPA
10.17–10.20	281–285	John Ashurst
10.21–10.24	286–289	Asi Shalom
10.25	289	John Ashurst
10.26	290	Catherine Woolfitt
10.27–10.30	291–293	John Ashurst
10.31–2.33	293–294	Asi Shalom
10.34–10.45	295–305	John Ashurst
11.0	306	John Ashurst
Appendix 1	309–311	John Ashurst, first appeared in *Mortars, Plasters and Renders in Conservation* (1983), J. Ashurst, Ecclesiastical Architects' and Surveyors' Association, London
Appendix 2	319–324	John Ashurst
Appendix 2	326–330	Information provided by Mann Williams acting as term consultants for CADW
A4.1	332	John Ashurst
A4.2–A4.4	335–336	Reproduced with permission of the Daughters of the Republic of Texas
A4.5, A4.6	337	Rachel Sabino-Gunaratna

Knowlton Church and Rings are a good example of a Scheduled Ancient Monument in England. Located in the ancient landscape of Cranborne Chase and surrounded by barrow cemeteries and earthworks, the church is eleventh century but much altered in the fourteenth century. Remarkably, it stands within a well-preserved ceremonial Neolithic Henge monument of c. 2500 BC. Consolidation of flint core work, tamping and pointing, the use of rendered brick structural supports and bronze corbel bars are classic interventions of the Ancient Monuments Division of the Ministry of Public Building and Works (c. 1950). Scale by Sam the retriever.

Preface

Gionata Rizzi

Rocks impregnable are not so stout, nor
Gates of steel so strong, but time decays.

(Shakespeare, Sonnet 65)

Ruins: buried cities brought to light by archaeologists in every part of the world; sacred temples dedicated to divinities that we have ceased to worship; towers, forts, strongholds, military defences made useless by the unremitting development of new weapons; industrial plants and factories no longer compatible with modern techniques of production and abandoned like the carcasses of huge old-fashioned cars; buildings that have been gnawed, mutilated and reduced to a state that bears no relation to their original purpose; buildings that have sometimes deteriorated to a point where their original form can hardly be recognised; buildings that only survive in the form of isolated fragments.

Ruins are everywhere. They form a considerable part of our architectural heritage and, actually, even of the World Heritage List: they are preserved as ruins, maintained as ruins and visited by a growing number of people who, in ruins, see values, significance and meaning – in spite of their condition.

In spite of their condition or *because* of their condition? Henry James[1] puts it clearly: '*It has often seemed to me … that the purest enjoyment of architecture was to be had among the ruins of great buildings*'. True, although the *enjoyment* he describes is probably not only architectural: the interest in archaeological ruins and the taste for architectural fragments go far beyond the historical and artistic importance the remains of a given building may have; as the ephemeral traces of the human activity on earth, ruins are actually among the most evocative icons of times past.

Indeed, the 'enjoyment of ruins' seems to thrive in contemporary sensitivity nourished, as it is, by many aspects of our mentality: the aesthetic pleasure in the patina of time, the romantic sensitivity for the work of man reconquered by nature, the positivist interest in architecture denuded of ornament and observable in its bare 'anatomy', the taste for the part wrenched from its context, for the unity turned into pieces, for the isolated fragment.

As a matter of fact, this fascination of contemporary culture for ruins appears to have its roots in at least two centuries of history of ideas. A crucial moment for the development of such sensitivity is perhaps to be seen in the great excitement that seized Europe when Winckelmann, before being murdered in 1769, began to reveal to Northern Europe the extraordinary discoveries of Pompeii and Herculaneum. It is difficult to imagine a historical moment when European culture could have reacted with greater interest to the discovery of a buried city: eighteenth century sensibility was by then ready to become excited at the romantic notion of the ruin, while neoclassical antiquarian taste was anxious to find in archaeological remains new material for its aesthetic. From the end of the eighteenth century, and for a period that was to last many years, an avalanche of writers, thinkers and artists descended upon Pompeii and Herculaneum: Goethe visited the excavations in 1787, Stendhal in 1817 ('*The strangest thing I have seen on my journey …; one feels transported into antiquity …*'); and subsequently Chateaubriand, Taine and Gautier. Thus, in a few decades, the aesthetics of the *bella ruina*, the literary sensibility for the 'pleasing decay', the poetry of ruins, received a strong impulse that would have a profound effect on the history of taste.

***

Ruins, however, do not only attract for romantic reasons. Actually, at the very same time as the romantic emotion primed by the discovery of Herculaneum, a completely different attitude inspired the scholars who saw in the archaeological excavation a chance to study classical antiquity *in the field*: remains to be observed, buildings to be measured, objects to be catalogued just as naturalists were doing, in those years, with the flora and fauna of tropical forests. Since then, endless drawings of ruins, in Europe, in Africa, in the Middle East, have been produced with the evident desire for scientific precision; drawings made in the same style as a treatise on anatomy – clear, precise, perfectly rendered in watercolours – where the interest in architecture is clearly higher than the pictorial taste for wear and tear.

These were the type of drawings that young French architects studying in Rome at the Villa Medici were asked to make as part of their training, and it is on that basis that they had to draw the hypothetical reconstruction of the buildings in their original state, in its *pristine form*: this work of *restitution*, this backward itinerary from the fragment to the whole, was to have a fundamental effect on the study of ancient architecture, a starting point and a testing bench for archaeological restoration, still in its infancy.

What in fact these scholars did was to use archaeological remains as 'anatomical specimens' of architecture.

Architecture, at least until the advent of the Modern Movement, never shows how it is built. There are certainly periods where the gap between the load-bearing structure and the architectural form is very thin, but even in the case of gothic cathedrals, where the gap is reduced to a minimum, the structural core is well hidden beneath layers of plaster and paint. Indeed, most of western architecture from the Renaissance to the nineteenth century is characterised by a kind of representation of the structural form: columns, pilasters, capitals, cornices and entablatures – all the elements of classical vocabulary – refer directly to the tectonics of a building and to its structural articulation; generally, however, these elements have nothing to do with what makes the building stand up. The Romans were maybe the first to 'hide', behind a decorative apparatus of stucco and marble, an independent structure made of concrete: since then, for much of the architecture that we admire, we can only attempt to guess at its anatomy.

Ruins are fascinating even for this: they reveal how they were built. Once the cloak of the finishes has been removed, ruins unmask their entrails: the materials of which they are built, the structural principles that determined their design and the techniques that made their construction possible. It is perhaps no accident that the architects of the Renaissance spent their time drawing ruins: while their notes and drawings seem to focus on proportion and mathematical ratios, one can bet they were paying great attention to building technique and that from the close observation of ruins they learned many lessons about the ancient structures.

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But what is, in fact, a ruin? An art historian, an archaeologist and an architect would probably answer in different ways, depending on the specific work that each specialist is required to carry out and on the cultural, technical and scientific approach of each discipline: a case study for a given period of history of architecture, an opportunity to analyse the relationship between the standing building and the stratigraphy of its surroundings, a challenge for consolidation and conservation. If, however, one wanted to conform to the evidence and formulate a definition that would be suitable for a dictionary, it would be tempting to answer 'a ruin is a building which, having lost substantial parts of its architectural form, has ceased to function as such'. Elementary, but full of implications: a building that has lost its natural defences (roof, windows, plaster, etc.), unarmed against the ravages of atmospheric agents and consequently more vulnerable to the destructive effects of time; a building that has stopped to fulfil its functions, to shelter human activities and which, in a sense, has begun its journey towards progressive decline and final disappearance – here, between architecture and nature, in a sort of no man's land, lies the ruin.

An entire book would not be enough to describe how ruins are created. There are different reasons underlying the formation of a ruin and different causes that trigger off the process. The medieval ruins scattered through the English countryside (Fountains, Rievaulx, Byland, etc.; they seem created on purpose to explain the term '*picturesque*') originated when, after the dissolution, the lead of the roofs was ripped off to be reused elsewhere; and, by the time conservation was taking its first conscious steps, they had already become celebrated landmarks.

In other cases, natural phenomena of extreme violence have condemned entire cities: Jerash, one of the most extraordinary urban structures of the Roman empire, with its famous circular forum, was shaken by an earthquake of such intensity that it never managed to recover and was abandoned soon afterwards. Ephesus, like many other cities in antiquity, was condemned by the silting up of rivers and ports, a less spectacular cause, but just as inexorable.

Added to these is the destruction caused by man during wartime, either in the course of military operations designed to destroy strategic objectives or with the deliberate aim of striking at the enemy through the mutilation of its cultural heritage. In general, these types of ruins are quickly repaired in the attempt to heal the injuries of a war: the bridge of Mostar, after its single arch of stone was shelled and reduced to just two macabre stumps, has been entirely reconstructed; sometimes, however, a monument hit by a bomb is voluntarily turned into a ruin and, as with Coventry cathedral, becomes a memorial.

Experience shows that a piece of architecture, left to itself, does not take long to begin its journey towards wear and tear: a few decades is all that is necessary for a leak to open up in a roof; a century of abandonment is enough to cause the initial collapse of the walls in a castle or to transform a monastery into an impenetrable tangle of brambles and rubble. After this it is simply a question of time before, as an eighteenth century writer[2] put it, '*nature takes its revenge and, through the assaults of vegetation, reconquers what man has built*'. But the way a ruin is formed – whether, little by little, it gradually silts up and is brought to light after centuries as a disinterred burial or, still above ground, is reduced to a bleached skeleton by the sun and rain – has a great influence on how it is perceived, used and eventually conserved.

Ruins that – thanks to their size and to the quality of their materials – never disappeared underground often became part of modern urban fabric. Either reused for new purposes or treated as quarries of building materials, these structures keep a function and mix with the architecture of the living city: the stones of the roman amphitheatre of Milan, dismantled in the sixth century, were used to build the foundation of the nearby church of San Lorenzo; in Lucca the amphitheatre lent its radial walls to the houses that grew on the tiers while the arena dissolved into the piazza; medieval Rome turned into houses the arches of the Teatro di Marcello; in Tarragona (Spain) the vaults of the hippodrome form part of the medieval city wall; Diocletian's palace has become the historic centre of Split; and so on, with endless examples.

Other ruins, instead, emerge from the archaeological digs after centuries of oblivion; when they are excavated they may risk to suffer the same fate as those Egyptian mummies which, brought to light after thousands of years, disintegrate in front of the eyes of the discoverers. But they are immediately recognised as monuments, treated as cultural objects, studied and conserved with due consideration for the historic, artistic and documentary value they bear.

An interesting case, in this respect, is represented by Pompeii and Herculaneum which, although considered almost a prototype of the archaeological remains, are actually an exception, for they have ceased to be buildings but, in a way, have never become ruins. As everyone knows, they were buried overnight during the eruption of the *Vesuvio*, Pompeii by showers of *lapilli* and Herculaneum by a river of boiling mud which filled every hollow space. What makes these sites special is that the wave of liquid sludge, an amalgam of water and volcanic ash, solidified as tuff and protected the buildings – with their finishes and their content – for centuries. As a result, the remains that archaeologists brought to light, especially in Herculaneum, are like fossils as they appear when one breaks open the stone that conceals them: pieces of architecture that emerged from the tuff like the imprisoned forms that Michelangelo imagined to liberate, stroke after stroke, from a marble block.

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Is it good to restore a ruin? The question is less rhetorical than it might seem at first sight. The fact that a ruin cannot be *restored*, in the sense of *taken back to its original state*, is obvious. To start with, there is a philological problem: with the exception of monuments built of large blocks of stone, which can be re-erected with great precision like a gigantic three-dimensional jigsaw puzzle, *the original state* is usually unknown. One can obviously make hypotheses on the grounds of solid archaeological evidence and careful stylistic comparisons, but they are hypotheses nonetheless. To reconstruct what has been lost based on these arguments may lead to the 'invention' of a monument that has never existed. And even when it was possible to determine with absolute certainty the original state of the building, the lack of original finishes, of original details, of original colours would give the reconstruction an artificial and unreal appearance. This is what has happened at Babylon, where the reconstructed portions resemble a film set more than a real ruin of a real city.

In reality, the problem is not solely the correspondence to the original form: even when philologically correct, the reconstruction of something that no longer exists is, to a certain extent, a fake. Or, if we want to stay away from any theoretical consideration, the problem is that the more a ruin is restored, the more it loses its authenticity; the more its evocative power is diluted, the more its archaeological truth is blurred.

Authenticity and archaeological truth: they appear to be among the most intrinsic values of ruins, but are the ruins we see really authentic? Not always. What one often fails to realise is that sites like Ephesus, the Parthenon or Pompeii have been restored for hundreds of years and have by now a long history as *historic monuments*. In that period of time, frescoes have been detached from the walls, stones have been replaced, columns have been re-erected, walls reconstructed. In Ephesus, more than a century of restoration work by the Austrian Archaeological Institute has shaped the excavated remains into the present site; the Parthenon is almost unrecognisable in the photos taken before the work of Balanos; in Herculaneum, 200 years of restoration have gradually transformed the ancient fabric into a mixture of authentic and reconstructed, where modern additions merge inexorably with the original buildings (a recent study demonstrates that nearly 50 per cent of what we see today was built between 1930 and 1950).

In fact, in an attempt to preserve them *as found*, to present them as ruins, many remains have been reshaped and retouched several times. Odd as it may sound, more ruins than we suspect are made-up ruins.

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If it is impossible to restore a ruin to its original shape; if, on the other hand, the romantic idea so well described by Gilpin – '*it's time alone which meliorates the ruin, which gives it the perfect beauty*' – cannot be put into practice for it leads to a growing and continuing process of deterioration; if authenticity is so easily lost by the attempt to restore the elements that made the building stable in an open environment; then we can only try to protect it against further decay and preserve it as it is. But this is precisely where the contradictions and ambiguities begin. In order to preserve a broken artefact *as it is*, one needs to provide it with new defences that never belonged to it and never existed; thus, to prevent an archaeological remain from disintegrating completely, one may have to put up shelters, to build buttresses, to reinstate a bit of masonry, to construct some sort of capping at the top of the walls; in other words, one has to make all those alterations, more or less visible, that can guarantee the survival of a ruin. Indeed, Viollet-le-Duc's much-criticised definition, according to which restoration would consist of turning a monument into a state in which it may have never existed, seems to be the fate which ruins are unable to avoid: a conserved ruin is always, in a way, an artifice.

We have reached the core of the problem: up to which point – it is the question that torments the practitioners who deal with ruins – is it legitimate to alter the original in order to preserve it? And to what extent must restoration work be visible and distinct from the original? Should the restored parts merge with the rest and become unrecognisable or should they strike the eye of the observer? And lastly, should the consolidated parts be made using ancient materials and techniques or with modern ones?

All these questions arise from the awareness that much of the value of ruins lies in the sense of transience they emanate. This is perhaps the main point of ambiguity: we want to preserve a ruin without obliterating the offences of time, we want to slow down decay to enjoy for longer their presence: what we actually want to do is to keep them suspended 'in the middle of the ford', no longer architecture and not yet nature. Maybe our real attempt when we work on these fragile fragments is to take them away from their temporal dimension: not without reason has the conservation of ruins been defined as a *respectful kidnapping*.

It is clear by now that conserving a ruin is a cultural activity. It is a cultural activity because it has to do with cultural objects and because it has to do with our sense of the time past. All cultural activity is controversial and as in all cultural activities there are no ready-made recipes. Trying to define what is a 'proper restoration' is probably vain: there is no such intervention that satisfies all the criteria of an abstract idea of 'conservation correctness', that is irreproachable both from a theoretical and a technical point of view: each site has a different story, each case calls for a specific approach. And, what is more, the same ruin can be treated in different ways.

Once again, Herculaneum is a telling example: the presence, along with masonry structures, of wall paintings, mosaics and stucco creates a problem that leads to a painful dilemma – is it better to put the entire archaeological area under a modern shelter, turning the site into a museum and losing for ever its outstanding urban value, or to detach and display elsewhere the decorative apparatus that cannot survive unprotected, denying the special quality that Herculaneum possesses and losing at once what the eruption miraculously preserved? Probably a less dramatic alternative can be found, but one which requires following the slippery path between excessive reconstruction and insufficient protection, which involves reconstructing more than is desirable and verging on falsification.

Even anastylosis, which one would think to be the least critical degree of intervention, raises many problems and much controversy. Apart from the correct interpretation of archaeological evidence, one can actually argue on the phase and the extent to which a monument should be restored if not on the worth of remounting scattered elements that lay for centuries on the ground. In addition to this, one can debate about the due level of respect of the original static behaviour of buildings and, in seismic areas, about the earthquake response the re-erected structure must have. An interesting case, to give but one example of the inherent uncertainties of anastylosis, is the Propylaeum of the temple of Artemis in Jerash. More than 90 per cent of the original pieces of the monumental entrance had survived and their position could be determined with accuracy; a more careful analysis, however, indicates that the entablature had been taken down in Roman times and that the pediment was possibly never positioned. Should one envisage to reconstruct what has never collapsed but was deliberately dismantled?

Indeed, in conserving a ruin, it is impossible to be neutral. Experience teaches that, no matter how cautiously the work is designed, a conserved ruin always bears the traces of the intervention carried out. So different is, for instance, the way to treat a ruin from country to country that, by looking at it, one can almost guess the nationality of the architects who did the work.

But if one cannot be neutral – as a musician cannot be neutral, though fully respectful of the score – one can at least try to be elegant and effective. To do so we need the best acquaintance with all the possible techniques of repair and stabilisation developed in years of activity all over the world. After that, we have to rely on a profound knowledge of the architectural body we set to conserve: of its form, of its history, of the history of past intervention; on a perfect insight of its structural behaviour, on a solid understanding of the materials it is built of and on a deep comprehension of the mechanisms of decay.

Only this 'close encounter' with the remains to be conserved can hopefully be of assistance in defining the most appropriate conservation strategy and to guide the battle against the silent work of time with the technical and intellectual elegance ruins deserve.

It's this close encounter with ruins that John Ashurst and his authors offer to us in this book.

Gionata Rizzi

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Introduction – continuity and truth

John Ashurst

The doors are locked for the last time and the gates padlocked. As months pass and no-one comes back, there are unmistakable signs of change. The mice grown bolder in the house and their feet and tails leave trails in the accumulating dust. Foxes and badgers become less wary about appearing on the unkempt lawn, and wasps feed unhindered on the fallen showers of plums.

Then there are visitors. By day they come and break out the fireplaces of marble and polished limestone and load them onto trucks for sale in London. The gadrooned urns go next from the balustrades and the lions of Istrian limestone from the gate piers.

By night they come with ladders and prise out the heavy cast lead gutters from behind the parapets and from the roof ridges. These mortal wounds are made in secret, and the high walls and great trees which gave the house its seclusion and privacy now conceal a crime and the making of its end.

Crime because the building is protected by law and may not be damaged or demolished without consent. But the law is for those who respect it.

The heavy rains of autumn find access through the open gutters and ridges and lie on the floor of the Chinese Chippendale bedroom. Pooling there for a time the water begins to penetrate more deeply into the house, and lies on the back of the rich plaster ceiling of the saloon, swelling the lath and softening the keys. Late in the wet winter the ceiling begins to sag and crack, and one of the plaster scallops of the Lyttelton family falls to the floor in a scatter of lime and cobweb and dust. The painted plaster panels of the wall, perhaps the work of Biagio Rebecca, are now decorated with black strands of mycelium …

In the gutters, the feet of the Baltic fir rafters and the plates on which they sit grow sodden. They might still be saved, but exchanges of letters and proposals and counter proposals take time and wood-rotting fungi are finding the wet and summer-warm roof space a congenial environment in which to grow. As negotiations enter their second year, the stair begins to collapse and a ridge to sag. When the first section of the roof falls in, the jackdaws in the cold chimney are the only witnesses.

Curiously, from the wilderness outside that was once a garden, the house looks remarkably intact, and almost unaltered except for dark water stains under the parapets and some broken glass. But already it is no longer a house, it has become a ruin.

(John Ashurst, *The Story of Pit Place*)

Figure I.1 *Massive Herodian masonry forming the revetment around the Temple Mount. Huge stones, sawn to size, were also used in the first (Solomon's) Temple, some over 7 m on face.*

Why should we want to conserve ruins as ruins? They have no practical use unless they are somehow repaired and restored to functional buildings again. And ruins have been adopted and adapted for new uses throughout history or have been restored to their original, or supposed original, form and appearance. These kinds of interventions are really better described as the conservation and/or restoration of historic buildings, rather than of ruins, on which subject an abundance of literature, philosophical, historical and technical, exists. For instance, Bernard Feilden's *Conservation of Historic Buildings*[1] not only remains a standard reference after nearly 25 years, but is still a hard act to follow. A book this wide ranging in its scope and so comprehensive in its detail is challenging to addition, even though there have been refinements and developments in the quarter century since its publication, most notably in recording, in investigative techniques and in conservation technologies. But the present book is concerned with a different subject, in spite of inevitable overlaps. In writing, now, about the conservation of ruins after nearly 40 years of working with them, I am far more conscious than I was once of the differences between the conservation of buildings and the conservation of ruins.

One of the great changes in the last few decades, in addition to the technology just described, is the considerable amount of interest shown by the building professions in conservation training, and the great number of degree courses and short courses which have been developed to provide for that interest. Only history will fully show how much the interest and the training have benefited our historic buildings and how they contributed to the quality of their survival. But thus far, on the conservation and treatment of ruins, I believe the impact of this interest has not been great. This may simply be a reflection of the relative importance most conservation personnel afford to ruins in comparison with whole historic buildings, and perhaps a vaguely held belief that looking after a broken building must be much the same but probably a lot simpler. Significantly, training of the professions has not been matched by skills training; and when skills are discussed, the focus is generally on the revival of traditional crafts, rather than on teaching practical conservation skills.

The conservation of ruins is, as Gionata Rizzi's preface has shown, a wholly illogical practice in some ways, and is at variance with what most of us are trained to do. Architects, surveyors and builders mend damaged buildings and make them useful again. A stonemason rightly takes pride in his or her ability to copy the moulded stone of a cornice and replace it. Not to do so, only to stitch and pin and treat the surface of a ravaged detail is, on the face of it, a curious and rather unsatisfactory pursuit. Yet in doing so, a physical unit of history has been secured; multiply it many times and an entire ruin, for all its scars and lack of essential elements, can still exist. But, to return to the original question, should we want it to? Often, we know that we want to, but we do not know why, a subject explored extensively and imaginatively by Lowenthal.[2] Whatever the complexity of the reasons, we need these physical links with our past, and for the most part need to believe that they are substantially 'authentic'. 'Unless we are able to look back we will not be able to move forward' is a piece of ancient Sumerian wisdom which has not outlived its relevance and which cultivates a respect for our past, and the past of others.

Whatever our understanding and perceptions of history, ruined buildings and their sites are somehow and somewhere woven into them. Unlike smaller artefacts, which are movable and may be protected, studied and enjoyed in museums, the ruin and its site are inseparable. Even those few ruins which have been small enough to move lose much of their value and meaning in the process. The site is the reason for the ruin's existence; it was the site that provided security or shelter, needed to the guarded, offered profitability and prosperity, or instilled awe or inspired by the beauty of its natural setting. The site and ruin may be thought of as unread, or partially read, books. The more respectfully they have been treated, the more information there will be to read. Carefully conserved, they will remain for future readers to reinterpret in the light of more knowledge and understanding. Carelessly or ignorantly handled the pages will be spoiled and confused; obliterated they will be more irretrievably lost than books burned in the Opernplatz in 1933[3] or at any other time when the deliberate destruction of information and ideas has been attempted.

The ruin and its site often remain under-appreciated and not sufficiently understood as sources of information, but once recognised as such the archaeological and conservation work which is carried out inevitably becomes more thoughtful and professional. Sometimes, even after decades or centuries of study, a site can still yield information and should never be considered as fully and finally read. The example of the Temple Mount in Jerusalem may be quoted in this context (Figure I.2). Few locations have attracted so much attention so continuously, and few have had such a long, complex and violent history. Even today, the systematic unravelling and recording of the building history of the Temple and its curtilage is made prodigiously difficult by physical, ideological and religious divisions. Throughout history there are examples of individuals, movements or cultures endeavouring to manipulate history through 'selective archaeology'. But archaeology is a science which must, above all, provide, through its technology, its techniques and its professionalism, a true record of what survives. The evidence so produced may well remain the subject of debate and maybe of disagreement, but it must be unadulterated. Tampering with the evidence for whatever reason, either archaeological or in the way standing ruins are conserved, is inexcusable. Archaeologists and conservators, of all people, must understand this, whatever external pressures may be applied to avoid or distort the facts.

One of Jerusalem's many epic moments in history was the major destruction in the first century AD (CE). Already damaged by zealot factions during the Jewish revolt against Rome, the city was besieged by Titus with the greater part of the occupying army of Judea, consisting of four legions with auxiliaries.[4] Following circumvallation of the upper city, the siege ended with the systematic demolition of much of the city and, especially and symbolically, of the Temple. This was the Temple raised by Herod the Great on the ruins of Solomon's Temple, which had commenced in 20 or 19 BC[5] (BCE), was still being built during the time of Jesus.[6] The completion of this rich and massive structure was not completed until around 50 AD (CE), only some 20 years before its destruction. Archaeology has uncovered many of the massive stones of the Temple and of other buildings on the Temple platform lying in the Herodian street[7]

Figure I.2 *Demolition material from the Temple and other buildings thrown down into the street below the western wall.*

(see Figure I.2), below the western wall and in other locations, a graphic record of the demolition work of Legio X Fretensis, complementing the historical record of the event.[8] But much that still needs to be known lies within the Temple Mount and, for complex reasons, out of reach. In such circumstances, and however frustratingly, it is important that what survives remains undisturbed and not investigated in any way other than openly, cooperatively and professionally, so that the information remains intact for others to read in the future.

The vexed issue of 'authenticity' recurs from time to time in the chapters of this book. 'Is it original?' the visitors ask of the historic site they have come to see. Why, generally, do we need to believe that what we keep is 'authentic' and not a copy, however well made? This philosophical issue does not need to be resolved (if it ever can be) before we engage in the physical activities of uncovering and conserving, provided we work on the assumption that we must not alter, or remove, or add to, unless we have no other option of securing and saving our subject. And if we do, we must make an accurate and honest record of what we have done and our reasons for doing so.

Authenticity in the case of a relatively 'new' ruin is interesting because the cause of its ruination is still within living memory and authenticity can therefore, for a time at least, be critically monitored. Nineteen-thirties images of the Church in the village of Oradour Sur Glane in the Haute-Vienne department of France have an air of timeless tranquillity; its devastated condition seen in Figure I.4 is not the result of a fire caused by an electrical fault or a lightning strike, but as an act of reprisal against local resistance by a Regiment of the Second Waffen-SS Panzer Division Das Reich on their route north to meet the Allied invasion of Normandy in 1944. Not just the church, into which the women and children had been driven, but the whole village was destroyed by fire, with most of its inhabitants and their visitors

Figure I.3 *The ruin of the Church at Oradour Sur Glane as it is today.*

Figure I.4 *The Church at Oradour Sur Glane. Photograph taken in November 1994.*

who happened to be present on 4 June. Even to a world inured to violence this event had, and has, such a peculiar horror that the need to commemorate that summer day by the preservation of the entire village as a ruin seemed imperative. There is a new Oradour Sur Glane close by now, and a commemorative centre to provide information (Centre de la Memoir, Oradour Sur Glane), but the buildings and streets remain as they were left, devastated and silent, and can still be visited by some who knew them whole. Figure I.3 shows the church as it is today, the smoke blackening washed away, the open wallheads consolidated and protected with roof tiles. The instruction in the streets is 'Silence', the message '*Souviens-toi*' ('Remember').

Other ruin sites witnessed other tragedies long outside living memory and likely to remain unknown, but a site such as Oradour, where much (although not all) is known about the event, has a particular poignancy and presents a particular challenge in terms of conservation. Here it is not the significance of the buildings that merits their retention, but the significance of an event. A memorial could record, but not recall with the same immediacy and power as the broken buildings. The buildings are likely to outlive the living witnesses who remain, but how long and how effectively they can record the original reason for their retention depends on how skilful and how sensitive the ordinary physical processes of maintenance and conservation continue to be. A restoration or reconstruction of destruction would be pointless. There are still those who can say 'no, it was not this way'. Authenticity may still be experienced in the ruins of Oradour, even with the softening of time, but how long their evocative power can remain has much to do with the quality of their conservation.

More familiar material than Oradour is the usual subject of this book, such as the conservation of fortifications, temples, abbeys and houses of architectural, historical and social significance surviving as ruins. The sites used as illustrations only represent a small proportion of the ruin types which can be found around the world, but the aim is to try to address principles and practices which can be applied to any site, however far its form and materials may be from those found in this book. For those who want to enjoy the diversity and splendour of the world's ruins there are books such as Rose Macauley's *The Pleasure of Ruins*,[9] or Charlotte Trumpler's *The Past from Above*.[10]

When the idea of this book, for me, was first conceived, I am not sure. But it had something to do with the loss of an old house of singular character which I knew well, hidden in a landscaped quarry of unusual beauty, adorned with relics of Henry VIII's Nonsuch Palace. Just as Henry's builders had made use of the stone of Merton Abbey, following its dissolution, to build Nonsuch, so Nonsuch, the 'non-pareil', was destroyed to pay the prodigious gambling debts of Barbara, Lady Castlemaine, and so, finally Pit Place, the house in the Epsom quarry, was destroyed by developers needing to turn a liability into a profit. All three buildings had, in their prime, a sense of permanence, but now survive as little more than archival records and some archaeology. All three stood, for a time, abandoned and prey to looting, and became ruinous in a relatively short space of time through commercial need, if not necessity. The rapid decline from splendour to ruin, described at the beginning of this introduction, is somehow always shocking, although parts of a building may be a long time dying.[11] However, and importantly, the process of decline can sometimes be interrupted. That act, or series of acts, of interruption or intervention is one of the subjects of this book. The conservation of ruins, as far as we can achieve it, should be about the continuity of truth. In practical terms, this is to say that the evidence of the past which the ruins represent should be so accurately and painstakingly observed and recorded, and so well protected and maintained that their true story will survive.

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Preliminary survey.

Short story

The demise, discovery, destruction and salvation of a ruin

John Ashurst and Asi Shalom

This story shows how one small building, part of an ancient settlement, was abandoned, neglected, and fell into a ruin state. This regression slowed as the building became buried, finally becoming largely stable until modern times, when it was uncovered as part of an archaeological project. Exposed and recorded, the site was left again and its regression continued rapidly. Poor quality interventions exacerbated its demise. Finally, intelligent conservation was carried out and the building was re-buried as the best means of ensuring its survival.

Preliminary survey

The preliminary survey must include not only remains showing above or just below the ground but also a wider analysis of the topography and climatic conditions in the area, such as changing heights, water movements and natural drainage, seasonal winds, naturally protected areas and a general assessment of rocks, soil and vegetation over the site. Topographical and climatic conditions and the accessibility of the site were critical factors affecting its first settlement. These conditions must be appreciated and understood as a critical part of the analysis of the site and the history of its development.

The illustration on the left indicates the location of a small building standing high on the hillside above disturbed ground indicative of a medium size settlement. There was a backdrop of ancient terraced hillsides and the distinctive profile of an old volcano. At the base of the hill slope is a shallow lake navigable only to shallow draft boats.

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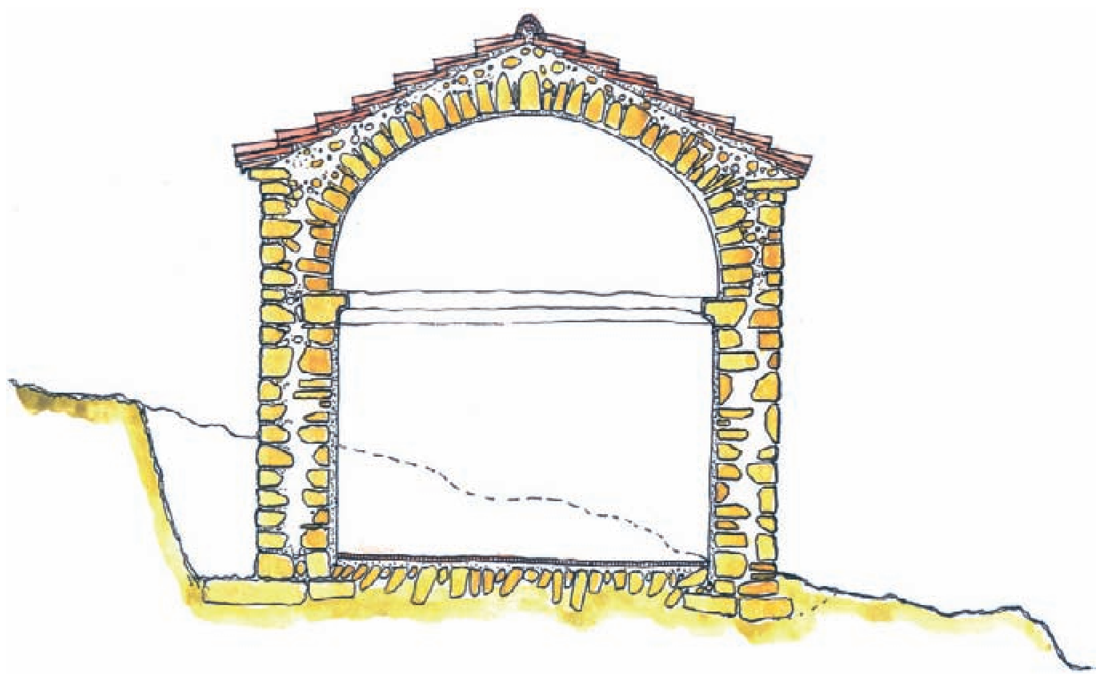
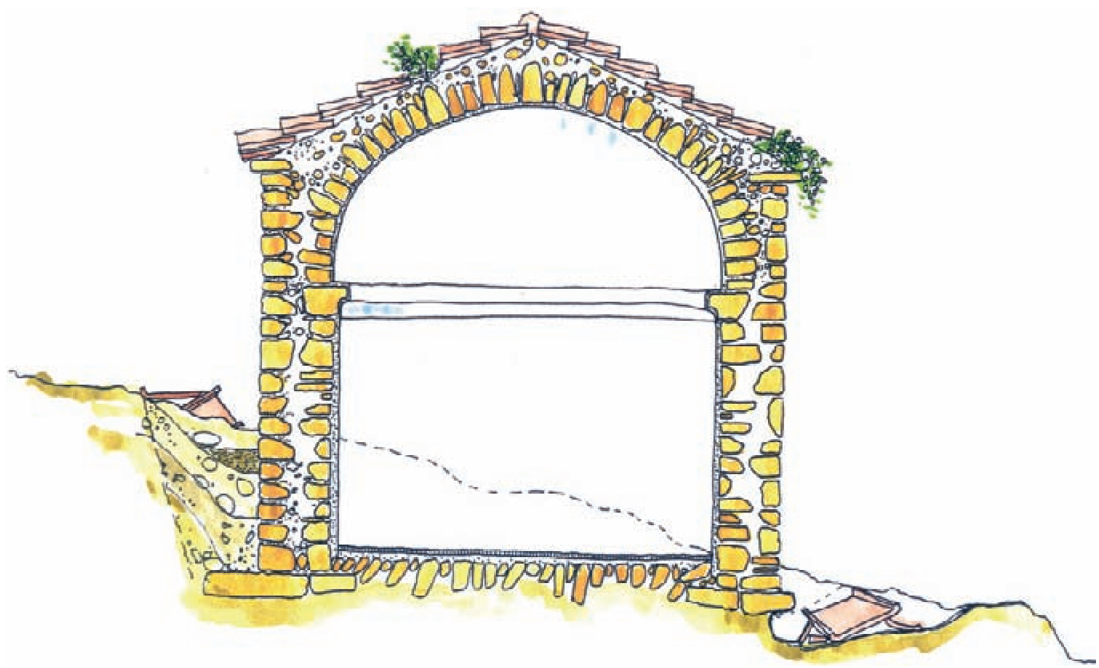
1 The complete building

A small cult temple was constructed high on the hillside above a small town located on the waters edge. It was constructed of the local limestone with composite walls 0.75 m thick. The internal space was covered with a stone vault capped with lightweight lime concrete and a pitched tiled roof. The internal surfaces were covered in plaster and richly painted. The floor was covered with limestone, ceramic and marble mosaic. The town and its temple were abandoned following a minor eruption of the nearby volcano and the silting up of the waterway which brought trade to the town.



2 Phase one deterioration

After a few years of disuse roof tiles become loose and fall. The weak fill of lime and tufa above the vault attracts soil forming plants, and their roots exploit fine cracks in the concrete and invade the joints of the vault. Externally, soil is gradually washed down against the upper retaining wall and is scoured from under the shallow foundation of the lower wall. Water begins to have access to the heart of the walls, moving between the tails of the stones and the core.



3 Phase two deterioration

Earth tremors cause the undermined low wall to lean forward and the unrestrained vault to crack along its length, causing many of the roof tiles to slide to the ground. This is followed by the collapse of the centre of the vault which allows large stones to fall, in places smashing the mosaic floor. Plaster at floor level becomes intermittently saturated, softens and loses its decorated surface. Water is able to pour through the open roof and settle over the floor area.

4 Phase three deterioration

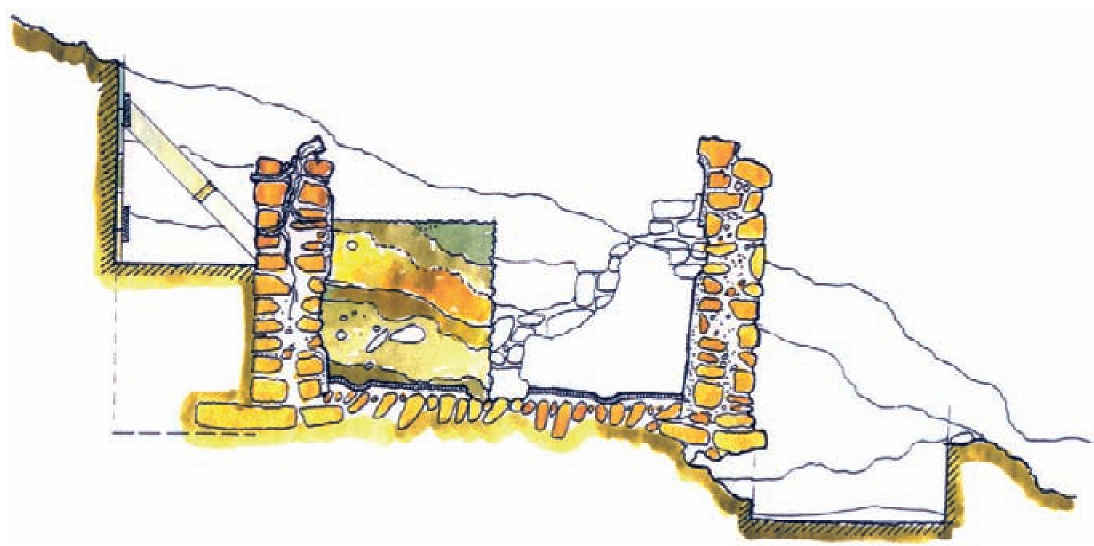
There is now a progressive loosening of the vault stones, which depend now only on the adhesive qualities of the mortar to remain in position. Further collapse of the weakened vault creates piles of stone and debris on the floor. Water now has free access to the decorated wall plaster. Accumulation of soil and stone washed down from the hill above bring about the collapse of the top courses of the upper wall, adding to the accumulation of stone within the building. Some of the fallen stone carries with it the decorative painted plaster frieze.

5 Phase four deterioration

There is now little more to fall. Accumulations of stone and soil create relatively stable conditions over the ruined temple. However, deep rooting trees and shrubs readily colonise the loose debris and, as they continue to grow, exploit the wall cores. Small mammals and reptiles occupy the site with its numerous natural cavities. This is the site in the condition found by the archaeological team. Priorities have to be established and time and cost estimates prepared for the work of uncovering and recording. A minimal budget is provided for temporary supports and partial back filling. The likelihood is that this small contingency sum will be spent during the excavation and nothing will be left for protection.

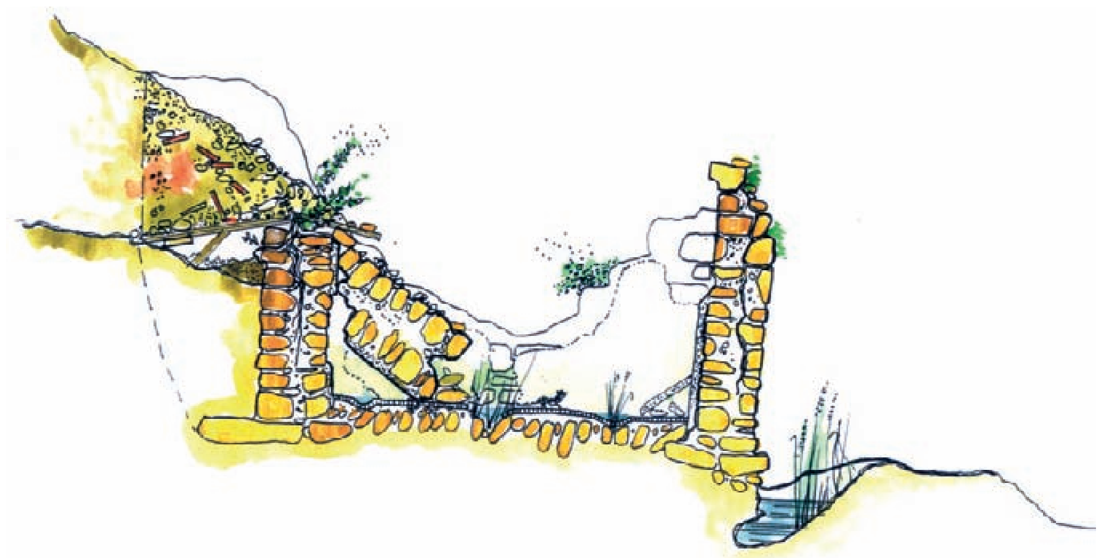
6 Archaeology as an informing force

The site is studied contextually and specifically, carefully recorded and systematically excavated. The stratification, construction, materials, artefacts and sequence of building and destruction become clear. After a period of further analysis reports are prepared and archived, perhaps suggesting a further season of excavation if funds are available. No money is left for any temporary protection, and it is confidently predicted that not much deterioration can take place in one year. The site is left in a dangerous condition and is regularly visited by souvenir hunters.



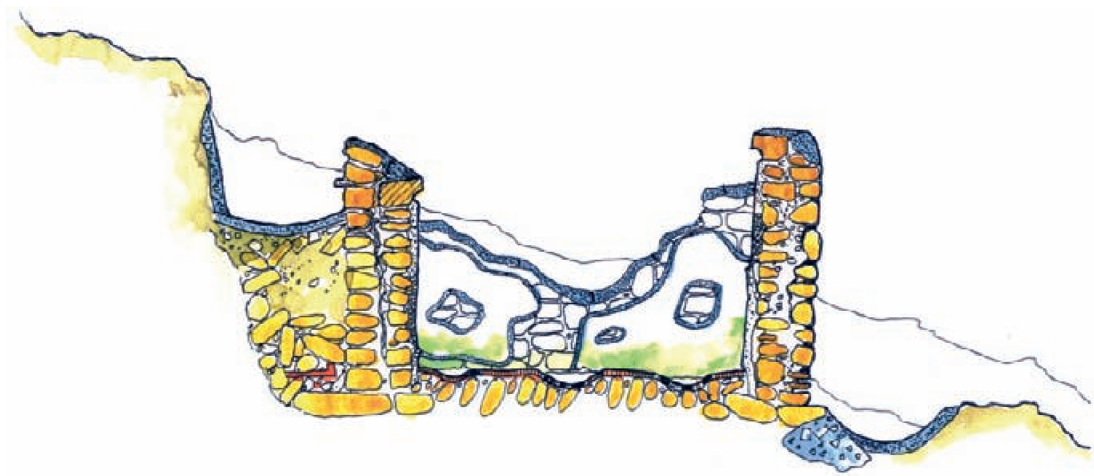
7 Archaeology as a destructive force

The site has provided all the information considered necessary for the historic record and is left abandoned. No money can be made available for further excavation and a period of neglect begins. Excavated material from the interior of the temple had provided a counterfort against the pressure of soil, loose rock and water moving down the hillside. Now the spoil has been removed, the rear wall collapses. Water ponds under the foot of the lower wall encouraging its subsidence. Water moving through the composite walls loosens the face work from its core. Water ponds on the mosaic floor and micro-organisms begin to colonise the painted plaster surfaces. Cut roots of vegetation growing on the wall begin to support new growth. Small mammals return to the site and begin to burrow into loose fill. The plaster is totally unprotected and detaches from the walls. Within a few years nothing significant will be left on the site for further study and re-appraisal.



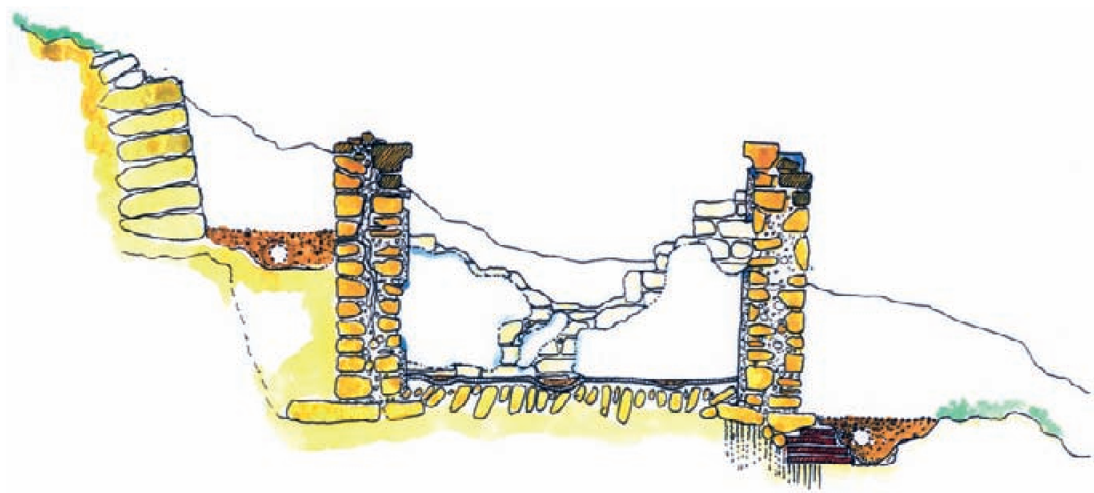
8 Ignorant repair as a destructive force

In an attempt to consolidate the excavated building and leave it open to view, the responsibility for the site passes to a maintenance team with no experience other than general building repair. The walls are capped with cement based mortar and open joints are packed with cement grout and mortar. Fallen stones are picked up and set back on the wall heads with no understanding of their original provenance. Cement mortar is also used to form fillets against broken plaster edges and to patch lacunae in the mosaic floor. The plaster edges are painted with water soluble adhesive. The lower wall is underpinned with stone and concrete block. Water still collects in all the low spots of the site. Drainage channels are formed along the base of the walls and are lined in cement mortar. This kind of work not only completely confuses the surviving evidence of the original building but plays a real part in encouraging its destruction with the use of totally incompatible and inappropriate materials.



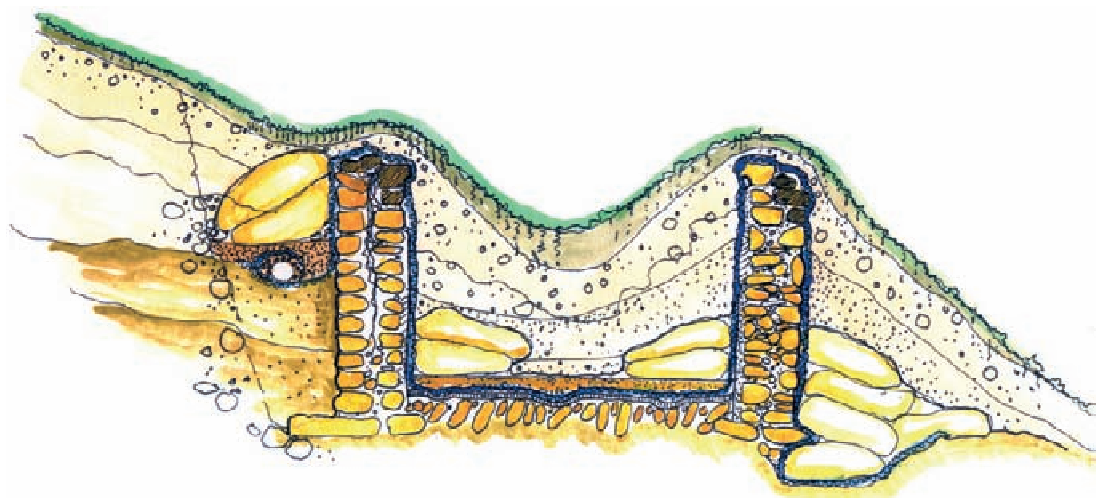
9 Correct conservation as a benign intervention

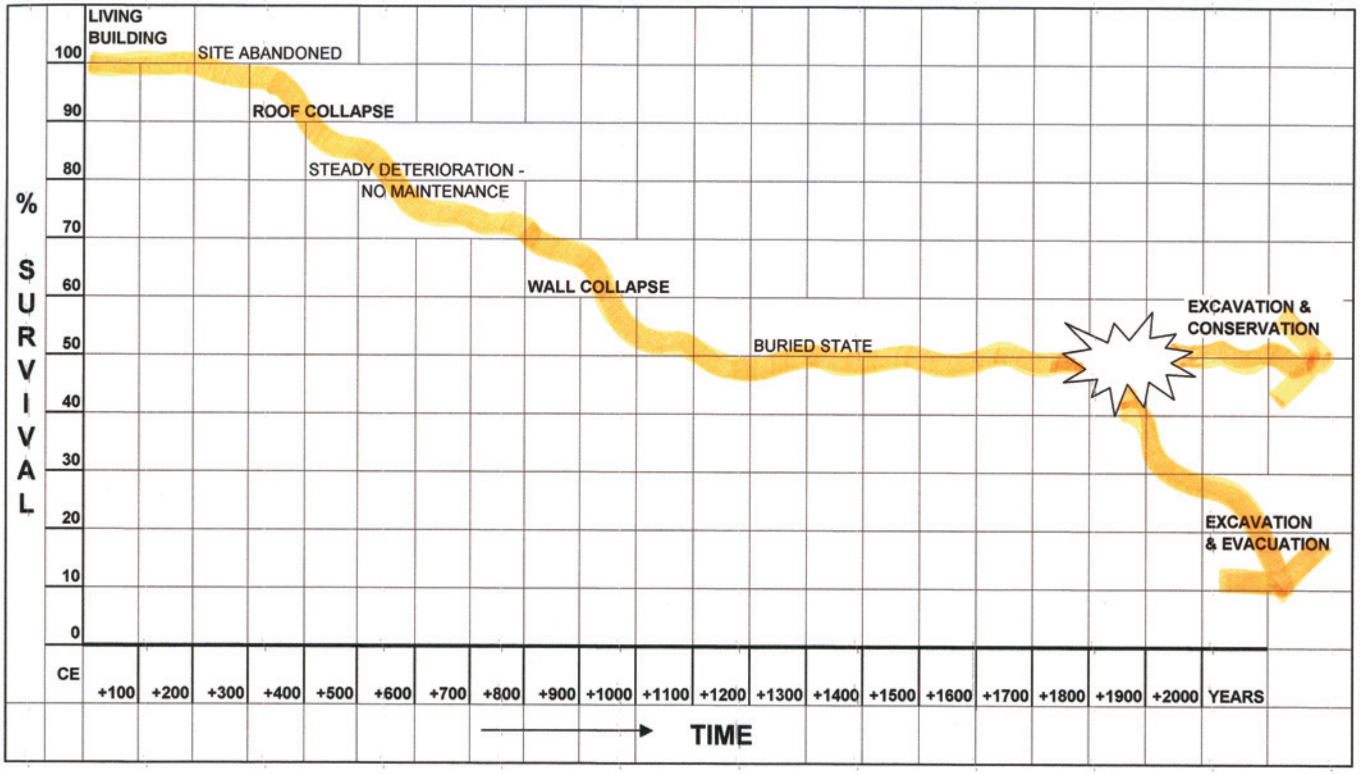
If the site is considered important enough to leave open, perhaps because it is part of a tourist route, good conservation practice can be used to protect the excavated building, always providing there are adequate funds to carry out conservation maintenance for the indefinite future. Alternatively, the site may need to be temporarily consolidated because the archaeological investigation is not complete. Loose stones remaining in situ can be wedged with stone pins and a weak, compatible lime mortar. Small roots can be removed and large, woody growths cut back as close as possible to the surface of the masonry. Open joints and wall caps can be consolidated with compatible lime mortar, often a putty lime with ceramic powder. Water collecting hollows in the mosaic floor can be covered with geo-textile membrane and levelled with sand. Walls which are leaning or have inadequate support can be buttressed with sand bags. Decisions need to be made about who carries out this work. The archaeologists may need to carry out immediate emergency support works. Full conservation work needs to be carried out by trained conservators.



10 Reburial

Where no funds are available for adequate conservation works and especially when the future of the site is uncertain, careful reburial after recording is often the wisest option, even when there is local opposition to the idea. Even reburial, however, will require some of the protective support and intervention of the kind which can be carried out by the archaeologists. The whole of the excavated area needs to be covered with generously lapped geo-textile membrane before returning the spoil to the site. Providing there is a generous covering of soil over the walls there is no reason why their outline should not be readable above the ground, and there may be significant benefits in being able to see the position of the building. In some situations temporary land drainage may be installed to divert water from sensitive areas as part of the reburial plan. This protection recreates the relatively stable conditions in which the ruined building survived for many centuries.





ARCHAEOLOGICAL INVESTIGATION - LINKED TO SURVIVAL OR EXTINCTION

Pevensey. The Roman Fort of Anderida (late C 300) was one of a line of forts along the south and east coasts of England set up to control Saxon activity at sea and prevent incursions on land, an enterprise which failed generally but spectacularly in this particular location, with the massacre of the defending garrison. The site was adopted and modified following the Norman conquest, Pevensey Castle being formed within the Roman curtain. In 1940, the site was again adopted and modified with the installation of concrete gun emplacements in anticipation of German invasion. All periods are legible and conserved.

Kirby Hall. The construction of Kirby Hall began in 1570 and may have been completed by 1575. Modifications and additions to part of the house were made in the 1630s. As a partial ruin it provides useful information on construction methods and materials of the time and on the alternations, but its real significance lies in its architectural importance to the Elizabethan period and the influence it had an later domestic architecture. Plans to re-floor and re-roof the whole of the house have been made from time to time but have been abandoned.

Hatshepsut. The terraced mortuary temple of Hatshepsut (Makare Hatshepsut 1503–1452 BC), located in the Theban hills, was known to Napoleon and partially explored during the 19th century. This spectacular site has been fully exposed for almost 100 years, since the work of the Egyptian Exploration Society in 1906–1909. The condition monitoring of a site of such antiquity and importance in terms of natural weathering and erosion and of visitor impact is critical to the quality of its ongoing survival and for future study.

Parthenon. The Parthenon is the most famous of the 5th century BC buildings on the Athenian Acropolis and retains its spectacular beauty and sense of power in spite of multiple phases of use and alteration, from church to mosque and, disastrously, to munitions store. Although there have been periods of substantial restoration in the 19th century the Parthenon remains a testament to the ingenuity, refinement, sophistication and skill of its creators, Pheidias the culptor and Iktinos and Kallikrates its architects. This site and its original context is of such importance that unpicking of 19th century interventions is seen as entirely justified.

Tel Beth-Shean is a mound covering some ten acres on a high hill at a strategic road junction in the Jordan Valley. An ancient city occupied from Late Neolithic times it was not conquered by the Israelites at the time of their first occupation of the land. When the Israelites were defeated on Mount Gilboa (circa. 1005 BCE) the Philistines brought the bodies of Saul and his sons to Beth-Shean and impaled them on the walls ("Your beauty, O Israel, is slain on your high places! How have the mighty fallen". Lament of David for Saul, King of Israel, and his sons, Second Book of Samuel). The Roman city is seen in the foreground.
(Photo John Ashurst)

The Stoa of the Athenians at Delphi was erected by the Athenians some time after 478 BC to house the trophies taken during their naval victories over the Persians. Tradition has included amongst these trophies the ropes used by the Persians to lash together their bridge of ships across the Hellespont. Seven monolithic Ionic columns, some original polygonal masonry and the stylobate into which the commemorative inscription was cut still survive.
(Photo Catherine Woolfitt)

There are many facets to the significance of ruin sites which are explored in the book. One of these is the association of sites with personalities and events of history, of which the above are examples.

Pompeii. Buried in a shower of ash as Vesuvius erupted (see Preface page xv). Some work of anastylosis has been carried out (see Chapter 5).

Herculaneum. Buried in boiling mud from the same eruption (see Preface, pages xv, xvi). Some modest protection in the form of tiled pentices has been provided (see Chapter 5).

Chapter 1

Conservation concepts

Jukka Jokilehto

One is often faced with the significance given to words used to define the approaches to the conservation of the built heritage. One such pair of words is: principles vs. theory of conservation–restoration. We could see these two concepts as complementary. A principle can be defined as: 'origin; primary element; fundamental truth; a general fact by virtue of which an instrument operates'. Theory, instead, would describe: 'a mental scheme of something, or of the method of doing it; a system of ideas held as an explanation of phenomena accepted as accounting for the known facts' (Oxford English Dictionary). *Conservation principles* are generally brief statements summarised in various conservation charters and recommendations (such as those of UNESCO and ICOMOS). *Conservation theory* instead can be seen as the description of the methodology that should be followed, starting with the identification of the heritage resource, the definition of its character, significance and condition, and the development of projects or programmes required for its appropriate conservation and eventual rehabilitation. This theory results from the evolution in the critical thought and experience in the conservation of different types of properties. While the main lines of the theory will be generally applicable, it is obvious that each property requires due attention, taking into account not only its individual character and condition, but also its physical and social–cultural context. In fact, in many cases, conservation of similar properties in differing circumstances may result in different solutions. It is therefore necessary to base any conservation approach on a coherent methodology, as described in the conservation theory.

Evolution of modern conservation thought

Modern conservation thought and the consequent theory result from the various developments that took place especially in the eighteenth and nineteenth centuries. This was seen particularly in the identification of values, and consequently the significance of heritage to society. On the basis of this development, F. W. Nietzsche (1844–1900) concluded that the relativity of cultural values is fundamentally dependent on human beings as members of society. Nietzsche stated that the former concept of absolute and universal values imposed by religion had been replaced by values that were the product of human culture. Hence, his famous: '*Gott ist tot*!' (i.e. God is dead!). The concept of '*Der Übermensch'* was referred by him to man in his being in the new reality and with his new obligations defined by and for the will to power. In this context, man is expected to take full responsibility for his own being, and found this in generating values. Values, in fact, become a product of society. Therefore, also the identification of heritage and its safeguarding fundamentally depends on the awareness of values and significance.

The approaches to conservation have evolved over the past two centuries or so, and there have been different schools of thought:

- All though this period, the ***traditional approach*** to existing building stock continued, involving repairs, changes as well as demolition, depending on the emerging requirements and the needs of the users. It also meant continuity in the use of traditional techniques and materials, rather than introducing modern industrial methods. However, with time, this approach has been increasingly 'corrupted' due to the impact of increasing 'globalisation' in society.

- From the end of the eighteenth century, there developed two lines of thought, both based on emerging heritage values but looking at the issues from different angles. One of these was the so-called ***stylistic restoration*** (i.e. restoration of stylistic integrity), later introducing a line called ***historic restoration*** (i.e. restoration based on historically certified evidence).
- The second line of thought emerged as a protest movement, an 'anti-scrape' approach, which then evolved into the modern ***conservation movement***, based on the recognition of the irreversibility of time, and the specificity of human activity subject to cultural values and social–economic context.
- From the 1880s, there emerged a third line of thought, taking note of the previous, and suggesting a compromise. This so-called ***philological restoration*** compared an ancient monument or historic structure to a manuscript. Modern restoration should respect the text inherited from the past, and any additions should be clearly readable. In the 1920s, this approach evolved into the so-called ***scientific restoration***, which emphasised the importance of scientific methods in restoration. With time, this approach tended to eliminate the cultural issue, stressing material evidence complemented with archival research. This approach has also stressed the pragmatic adherence to principles.
- Over the early decades of the twentieth century, there matured an approach that was spelled out in the aftermath of the Second World War. This approach could be called the ***modern conservation theory*** (or 'modern restoration theory'), which recognised the specificity of each heritage object, introducing a critical methodology based on sound judgement regarding its character and significance.
- Since the 1970s, there has been yet another line of thought and action, this time related to the social and natural environments. On the one hand, this has emphasised the ecological aspects in any exploitation or change in the natural environment. On the other hand, the approach has broadened the concept of cultural heritage to the built environment, also taking into account the human and social context. This has introduced the '**culturally and environmentally sustainable development**', which has become a major concern in the worldwide context today.

From stylistic restoration to modern conservation theory

In the nineteenth century, one of the leading figures in the development of 'restoration' principles was the French architect E. Viollet-le-Duc. His definition of restoration was the following:

> *The term Restoration and the thing itself are both modern. To restore a building is not to preserve it, to repair, or to rebuild it; it is to reinstate it in a condition of completeness which may never have existed at any given time.*

While his numerous followers and disciples have often caused more destruction than conservation, one of Viollet-le-Duc's merits should be seen in his attention to the development of restoration methodology. To him, restoration was a form of archaeology as well as being 'pure science'. Even though sometimes carried away on hypotheses, in most cases he correctly documented and recorded the structures before any restoration, analysing all available evidence. In the case of Carcassonne, he carried out a long archaeological analysis of the ruined fortification, before any work. His restoration of the defence walls was limited to completing the upper parts – previously dismantled by the people – and his intervention remains clearly readable with respect to previous construction phases.

In many cases, however, emphasis on stylistic unity led to complete reconstruction, which became a fashion in many countries of Europe and even outside. There thus developed a counterpoint, the 'conservation movement', which has generally been identified in the figure of John Ruskin, but which also had other protagonists in various countries. Ruskin emphasised life in historic buildings, claiming that 'Restoration' (i.e. actually reconstruction) would definitively abolish the spirit of time:

> *That which I have above insisted upon as the life of the whole, that spirit which is given only by the hand and eye of the workman, can never be recalled. Another spirit may be given by another time, and it is then a new building …*
>
> (Ruskin, *The Seven Lamps of Architecture*, 1849 vi: xviii)

His disciple, the socialist and arts and craftsman, William Morris, took Ruskin's message and stated words that have since become the trademark of the Society for the Protection of Ancient Buildings (SPAB) that he founded:

> *… to put Protection in the place of Restoration, to stave off decay by daily care, to prop a perilous wall or mend a leaky roof by such means as are obviously meant for support or covering, and show no pretence of other art, and otherwise to resist all tampering with either the fabric or ornament of the building as it stands; if it has become inconvenient for its present use, to raise another building rather than alter the old one; in fine to treat our ancient buildings as monuments of a bygone art, created by bygone manners, that modern art cannot meddle with without destroying.*
>
> (Morris, 1877)

These ideas were clearly reflected in the intentions of Camillo Boito (1836–1914) when he wrote a circular letter (in 1883) on behalf of the Italian Ministry addressed to the officers responsible for ancient monuments. He expressed the principle:

> *Historic buildings should be consolidated rather than repaired, repaired rather than restored, taking great pains to avoid any additions or renovations.*

He also demanded:

> *Modern work and new materials to be kept to the minimum and to differ from the historic, in harmony with artistic appearance … contributions of all historic periods to be respected; exception can be made and parts removed if these are manifestly of minor importance compared to forms that they cover.*

These principles became the first Italian charter on restoration, and many of the ideas were later integrated in another charter, written by Gustavo Giovannoni (1873–1947) after the international meeting in Athens in 1931 (published in 1932). Giovannoni emphasised the scientific character of restoration work, and maintained that historic phases should not be eliminated or falsified by additions that might mislead scholars. He stressed the importance of regular maintenance and appropriate use. The monuments should be kept in situ, and any alterations should be kept to the minimum, simple in form, and carefully documented. He also introduced training in restoration at the school of architecture, which was established in the 1920s.

The question of values had already been analysed by Alois Riegl, the chief conservator in the Austro-Hungarian Empire, in a study in 1903, where he distinguished between a ***memorial*** (*Gewollte Denkmal*) vs. ***historic building*** (*Ungewollte Denkmal*), one being built in order to remind people about something, the other instead being associated with historic values later on in its 'life'. Riegl identified two categories of values: ***memorial values*** (age value, historic value, intended memorial value) and ***present-day values*** (use value, art value, newness value, relative art value). Riegl also coined the concept of ***Kunstwollen***, which means that each period or each culture has its particular conditions, within which artistic production achieves its character. In this context, there is mutual influence between an artist and his society.

Riegl's thinking was well received in Italy, where his thought was continued, for example, by G. C. Argan (1909–94), who dealt especially with works of art, and introduced the concepts of 'conservative restoration' and 'artistic restoration'. In conservative restoration, priority would be given to consolidation of the material of the work of art and prevention of decay. The emphasis would be on maintaining the status quo of the object. In artistic restoration, instead, a series of operations would be undertaken, based on the historical–critical evaluation of the work of art. The aim in this case would be to re-establish the aesthetic qualities of the disturbed object. This could involve reintegration of losses (*lacunae*) and even the removal of parts that were not considered essential from the historic or artistic point of view. Obviously such interventions needed to be founded in critical judgement based on the quality and significance of the work concerned. In this regard, priority was often given to aesthetic demands of the work, but on the other hand each work had to be taken case by case.

Cesare Brandi, the first director of the Italian Central Institute of Restoration (Rome, 1938), wrote the fundamental text clarifying the modern theory of restoration (*Teoria del restauro*, 1963). He distinguished between the restoration of 'common, industrial products' (where the purpose was to put them back into use) and works of art. The restoration of the latter he defines as a methodology that depends chiefly on aesthetic and historic values:

> *Restoration consists of the methodological moment of the recognition of the work of art, in its physical consistency and in its twofold aesthetic and historical polarity, in view of its transmission to the future.*

The theory of Brandi emphasises restoration as methodology, based on a critical judgement. Brandi maintained that a ruined structure should be understood as a fragment of architecture. In line with Ruskin, Brandi also stressed the limits of any reintegration. He was against the so-called 'archaeological restoration', which would be simply based on some principles. Instead, he stressed the requirement of a thorough analysis and identification of the meaning of each element within the whole – just as in any other historic structure.

International framework for conservation policies

From the period following the Second World War, there has been increasing international collaboration in the protection and conservation of cultural and natural heritage. A milestone in this regard was the World Heritage Convention of UNESCO in 1972, which has since involved most countries of the world in the process of clarifying culturally and environmentally sustainable conservation policies and strategies. The World Heritage List, while being strictly limited to sites considered of outstanding universal value, has become a model which is having an increasing impact also in the rest of heritage. One of the most interesting features of this convention has in fact been the interaction between culture and nature, a parallel that may well benefit both in the long run. The convention encourages the development of effective and active measures to be taken for the protection, conservation and presentation of heritage integrated in the life of the community. It has also promoted debate on various fundamental issues in conservation, such as the concepts of authenticity and integrity, and, even more fundamentally, the convention has promoted the exploration of new types of heritage that risk being neglected and destroyed. As a result, the World Heritage List with its over 700 entries is gradually being enriched with an increasing variety of items, ranging from traditional rice fields to sacred mountains, or from historic railways to canal systems and pilgrimage routes. There is an increasing tendency to identify larger areas such as historic towns or cultural landscapes rather than single structures and monuments, which obviously will increase the variety of stakeholders responsible for their conservation and development.

In this international context, it will be increasingly important to identify the values and methods of intervention. In terms of values, we can see two basic categories:

- ***Cultural values***. Identity value and emotive value based on recognition; relative artistic and relative technical values based on evidence and research; and rarity value, which is more of an administrative nature, and based on statistics.
- ***Contemporary socio-economic values***. Economic value based on heritage as resource; functional value and usefulness of the property; educational value, tourism, social value, awareness, and the political value that often depends on the priorities of the ruling regime.

The ICOMOS Training Guidelines of 1993 emphasise that conservation works should only be entrusted to persons competent in these specialist activities. In fact, education and training in the conservation and restoration of the built heritage has become a recognised activity in society. According to the 1993 guidelines, such training should produce, from a range of professionals, conservationists who are able to cope with a great variety of tasks, such as 'reading, understanding and interpreting' historic structures and areas. Particular attention is given to communication between specialists and non-specialists, considering that the different sectors of society would be required to have informed participation in the conservation process. Conservationists should be able to make balanced judgements based on shared ethical principles, accepting responsibility for the long-term welfare of the heritage.

The same ICOMOS Training Guidelines define 'conservation' as follows:

> *The object of conservation is to prolong the life of cultural heritage and, if possible, to clarify the artistic and historical messages therein without the loss of authenticity and meaning. Conservation is a cultural, artistic, technical and craft activity based on humanistic and scientific studies and systematic research. Conservation must respect the cultural context.*
>
> (Par. 3)

As mentioned above, conservation is a process consisting of the identification, understanding, interpretation and presentation of heritage. It will necessarily include several phases:

- ***Survey*** (inspection and documentation of heritage, its historical setting, physical and cultural environment).
- ***Definition*** (a critical–historical definition and assessment of the significance of the heritage resource within its setting and regarding relevant cultural, social and economic considerations).
- ***Analysis*** (examination of the resource using scientific methods, the diagnosis of its physical consistency, material, structure, risks, vulnerability and spiritual significance).
- ***Strategy and implementation*** (short-term and long-term plans and programmes for the conservation and management of change; monitoring, regular inspections, cyclic maintenance and environmental control).

A necessary tool to acquire knowledge of cultural heritage in all the necessary aspects is provided by recording. Recording is an essential part of the conservation process, in order to get to know the place concerned and its physical condition, and subsequently to monitor any changes occurring over time. It is necessary for the management of a heritage site, programming maintenance and timely repair, as well as any time a new restoration or rehabilitation project is launched. Recording should be understood in the broad sense so as to meet all the requirements, from the inventory to research and site projects. It will thus include inspections, reports and graphic records, as well as scientific data on the condition and behaviour of the building within its social, cultural and environmental context. It is obvious that records should be properly deposited in safe places, possibly with a second copy in another location, and made available for relevant consultation and research regarding the site. Results should also be published (see: ICOMOS, *Principles for the Recording of Monuments, Groups of Buildings and Sites*, 1996). The survey phase is fundamental for the identification of the resource and its significance, and vital for the definition of what should be preserved and what are the limits of change. It includes detailed inspections and reports, and the relevant graphic documentation and scientific analyses. The task is to define the structural system, the historical phases of construction and change, the condition of the building and the causes of decay.

The test of authenticity

Sites that are inscribed on the World Heritage Lists are expected to pass the 'test of authenticity' in relation to design, material, workmanship or setting. This demand is not only relevant to the moment of nomination, but remains always valid in the process of conservation and eventual change. Authenticity means that an historic building should be seen as a true testimony of the culture or traditions that it represents. The Nara conference of 1994 indicated that while the word 'authentic' was not necessarily used in all languages, it was possible to find corresponding words to express the intent. The *Nara Document on Authenticity* has further emphasised that 'the diversity of cultures and heritage in our world is an irreplaceable source of spiritual and intellectual richness for all humankind' (Par. 5). Living cultures are subject to a continuous and dynamic process of change; the values and meanings that each culture produces need to be re-appropriated by each generation in order to become a tradition that can be handed over to the next. As a result of such cultural process, each moment on an historic timeline is characterised by its specificity, reflected in all that is conceived and built. Authenticity is expressed in the tangible and intangible aspects of a building, including historic changes and additions.

The Venice Charter invites us to safeguard historic structures 'no less as works of art than as historical evidence' (Art. 3). In relation to the ***artistic aspect***, it would refer to the building as a genuine result of the human creative process. This can be verified in the quality of design and execution, but requires critical comparison with similar works of the same culture. Authenticity in this sense is at the root of the definition of the outstanding universal value. Another aspect of authenticity refers to the historic structure in its quality as ***historic document***. Due attention is required to safeguard not only the quality and aesthetics of the surface, but also the material and structure, which document the workmanship and different phases of construction in the past.

The Venice Charter notes that the concept of monument 'applies not only to great works of art but also to more modest works of the past which have acquired cultural significance with the passing of time' (Art. 1).

Even if we may be able to build a replica of something that has been lost, the cultural meaning of the new work is different from the old. The Venice

Charter therefore recommends that any indispensable new work should be 'distinct from the architectural composition and must bear a contemporary stamp' (Art. 9).

Condition of integrity

The condition of integrity in relation to cultural sites should be understood in the relevant historic context describing the state that a particular place has acquired by the present time. Integrity can be referred to visual, structural and functional aspects of a place. It is particularly relevant in relation to cultural landscapes and historic areas, but even a ruin can have its historic integrity in its present state and its setting.

The ***visual integrity*** of a building or an area indicates what is visually relevant to its historically evolved condition in relation to its context. The identification of the visual integrity of an historic building should take into consideration not only its architectural character but also the impact of historic time. Building materials such as stone, brick and timber obtain patina of age as a result of the ageing process and weathering. Replacement, reintegration and other types of treatments of such surfaces require a sensitive eye and an understanding mind in order not to lose the historically established visual integrity of the place:

> *Replacements of missing parts must integrate harmoniously with the whole, but at the same time must be distinguishable from the original so that restoration does not falsify the artistic or historic evidence.*
>
> (Venice Charter, Art. 12)

The ***structural integrity*** refers to the mutual relationship that links the different elements of an historic structure or area. Any change to such balance should be carefully thought out, and based on a sound judgement of the values and priorities in each case. In an historic building, the question of structural integrity is particularly relevant when discussing consolidation and reinforcement. Nature is a laboratory that tends to reveal the faults and weaknesses of human constructions. It is therefore important to give due consideration to structural integrity, particularly in areas subject to seismic action. Experience has shown most traditional structures in seismic areas can resist earthquakes if in a good state of repair. Failure generally results from poor condition due to lack of proper maintenance. Even modern reinforcement in an historic building may turn out to be destructive if not carried out with full understanding of the behaviour of the existing structure. This leads us to stress the importance of follow-up and monitoring in order to learn from experience and improve for the future. This is also one of the reasons for 'reversibility'; one should be able to repeat a treatment when necessary.

Architecture is conceived in reference to a functional scheme, the basis for ***social–functional integrity***. Altering the function of or introducing new uses to historic buildings and areas may often cause conflicts. It is necessary, therefore, to establish limits on the modifications that such function might cause, and recognise the character of an historic building as the basis for rehabilitation. The notion of functional integrity is particularly relevant in relation to large sites and landscapes, where traditional functions may be challenged by the introduction of modern technology and new priorities. It is useful for an appropriate balance in the policies of development and conservation, with due regard to the character of traditional uses. Even museum use is a new function in an historic building, and often imposes radical changes, e.g. for requirements of safety and security.

The concept of integrity is equally relevant in relation to ruins or architectural remains. Archaeological sites are often inside the urban area of a city or in its immediate vicinity. Such areas are a major concern. For example, in Jerash, the lack of liaison between archaeological site managers and the community has resulted in an uncontrolled expansion of residential areas around the archaeological site. This has been the main reason why the site was deferred from being nominated to the World Heritage List of UNESCO. Sites whose existence has been revealed through urban archaeology in the middle of an already existing living city, such as Beirut, have been subject to major campaigns, but unfortunately too often with scarce results. The conflicts of public and private interests in the management and change of the territory are generally linked with high economic interests, where historic values may well be given much less attention than the construction of business centres. In suburban areas, the historic integrity of archaeological sites is subject to high risks due to frequent conflicts with the interests of developers on privately owned land.

Conservation of cultural heritage is increasingly seen in the context of parallel approaches that have emerged in the past decades, including the policy of human sustainable development as a complement to development based on economic factors. In fact, progress should take into account cultural, social, economic and functional resources and values, striking a balance in order to identify the most appropriate approach. Sustainable society should be based on a long-term vision and it should ensure continuity of renewal processes within the scope of social justice. The built and cultural heritage resources are a great potential, offering new alternatives and new strategies for the future. The preparation and setting up of appropriate strategies need to start from appropriate knowledge and understanding of the history and the resource potentials of an area, aiming at a balanced integration of all relevant issues within the planning process.

Further reading

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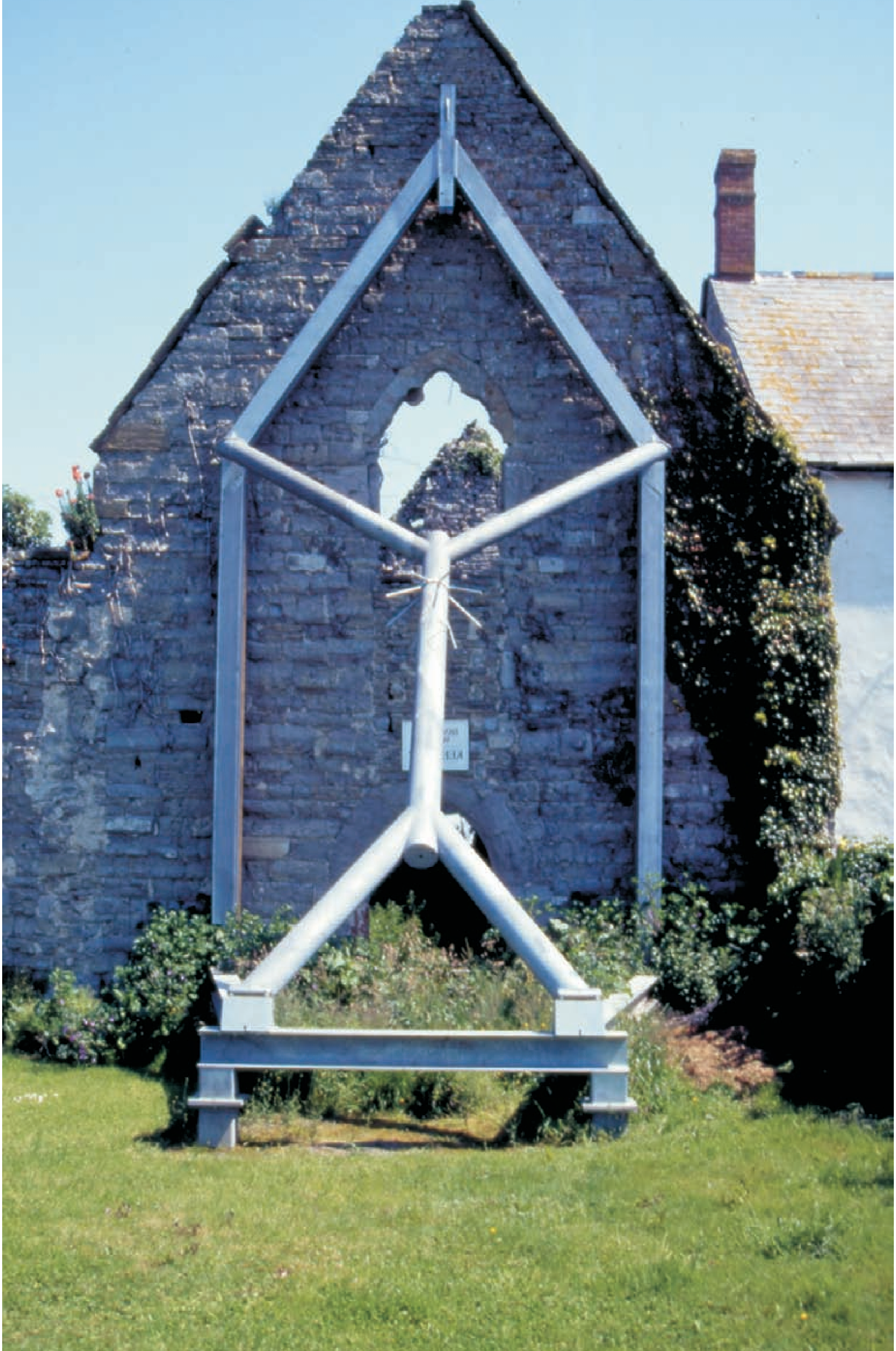

Chapter 2

Stability and survival

Chris How

Introduction

This chapter is not about hi-tech solutions or state-of-the-art analysis, but rather a call to recognise and respect the fundamentals governing the slide leading to deterioration and ruin. These are most easily recognised in the various causes of damage to standing buildings which if left unattended develop into future ruins the mechanical forces that set up the decline process, continue to operate and will accelerate and be exacerbated by the loss of essential elements such as roofs, floors and the buttresses of walls on ruins and standing buildings alike, and need to be identified and addressed wherever possible.

This chapter is also a warning to limit engineering interference, as far as possible, to measures consistent with the historical context and original construction methods. Not all old buildings are well conceived, and during investigations the quirks of individual builders surface on a regular basis. However, an honesty of approach to the remedial measures to be adopted, and staying within the historical context, is preferable to the creation of a new synthetic hybrid, and usually projects the most sympathetic resolution. This presupposes that a conservation engineer will not only have adequate structural experience, but will also be familiar with historical forms of construction, the nature and characteristics of traditional building materials, be able to identify the intervention measures likely to have been used for stabilising structures in the past, and will understand and work within the parameters of a clear conservation philosophy and policy. In fact, this is the essential definition of the 'conservation engineer'.

There is a real need to have such a 'conservation engineer' involved at an early stage of any investigation. Working within the team, he or she can help identify the original structural model, untangle the historical modifications, and identify the structural effectiveness of the structure as presented. The requirements for engineering information and archaeological reference both involve limited excavation early on, and often the question of foundation stability can be assessed during the digging of trial pits in the first phase of investigation.

Opposite page *Kilve Chantry. The Chantry at Kilve, Somerset, UK is a group of buildings of the 15th century needing further investigation but at substantial risk of deterioration and local collapse. The illustration shows an applied restraint to the lean of the gable wall as a means of retaining it in position in anticipation of later masonry consolidation.*

Why do structures fail?

The road leading to ruin is as much the cause of human failings as it is of nature. In a new country like Australia, where this chapter is being written, the gems of a fragile heritage have often been squandered by a deliberate policy of neglect and a refusal to spend a dollar which will not give an immediate return. Ironically, a small amount of timely maintenance would have added many thousands of dollars in value to assets that can frequently be seen reduced to ruins. The many grace and favour historic homesteads, often set in fine, landscaped gardens, are now receiving renewed interest, and sell for sums which recognise their true worth.

Human inactivity or misguided intervention, not, of course, unique to Australia, figure high on the list of reasons why failures occur. It is possible to summarise these reasons into two groups as follows:

Human causes

- Neglect
- Quarrying, or 'robbing' from ruins
- Fire
- Mistreatment of structural members
- Vandalism and war
- Design inadequacies.

Natural causes

- Rain and water action
- Ground movements

- Thermal stresses and frost
- Vegetation and root damage
- Rodent activity
- Wind erosion.

The two lists are subjective, and will vary between countries and locations. It is far more common to have a combination of elements involved rather than one individual cause. The sad thing about the first group is that, apart from education, there is little that can be done to change human behaviour.

Thus, leaving aside the human aspects, which have been discussed elsewhere, the effects of nature itself are now examined with appropriate engineering actions that can be taken to modify and ameliorate them, thereby ensuring a degree of stability to assist the long-term structural survival.

Planning for cyclic conditions

Stability is not found in nature, which runs its course in a series of cycles, and which we need to recognise and allow for in advance. These natural cycles affect our weather in the seasons of the year to a variable extent, but the years themselves run into a series of cycles of flood and drought, extremes of heat and extremes of cold. The records show that even today's changes in climate pattern have had their precedents in the historical past. Recognition of the cyclical nature of climate and its consequences on ruins and complete buildings alike is the first key to planning for stability. The forces of nature cannot be countered, as these are too major, but mitigation plans can be made and potentially exacerbating interventions can be avoided. It is common-sense policy to assess each site with the same care we would expect to give to that for a new structure, and so far as circumstances allow, to install appropriate control measures.

The role of rain and water

In almost all climates, by far the greatest single factor in distress to structures is water in one form or another. Figure 2.1 illustrates the role of water and the various ways it constitutes a degradation regime of its own in a simple gable wall end. It is good to remember that rain is usually a weak cocktail of acids, some due to fixation of atmospheric elements and others due to pollution in the atmosphere. Rain can fall with appreciable force due to wind action and act to scour out previously softened or weakened pockets of lime mortar. This phenomenon becomes more apparent on stone such as basalt than on an alkaline masonry, such as limestone or marble.

Of course, the building solution to these problems would be to provide a properly maintained roof, incorporating collection and discharge features,

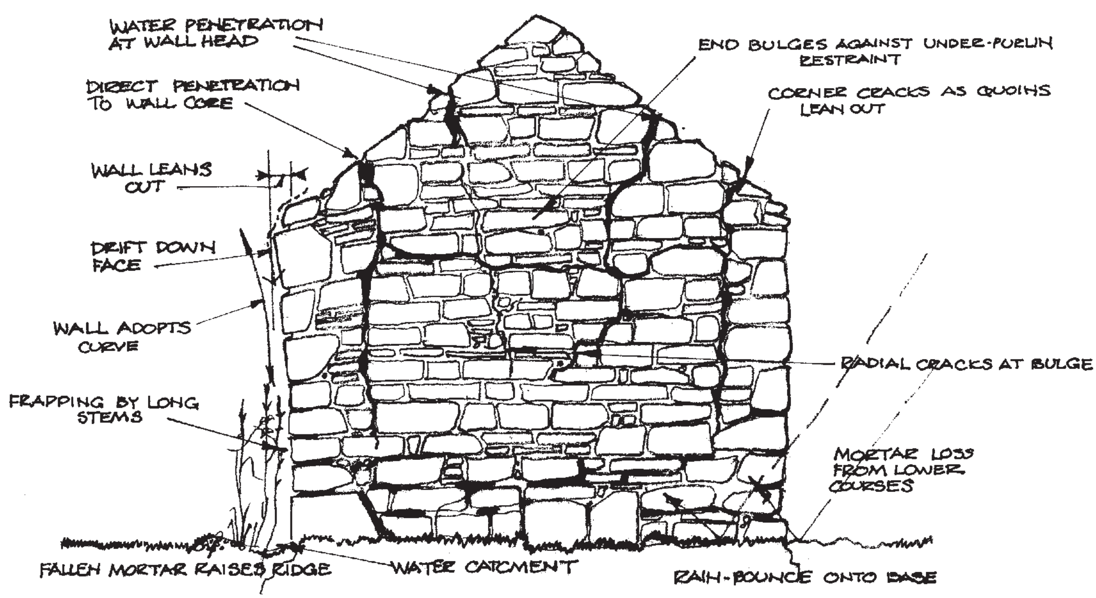

Figure 2.1 *Rain degradation regime: a typical case.*

which would protect the structure below. Many illustrations in this book show how rapidly the loss of adequate roofing leads to a ruin situation. The natural inclination of engineers is to encourage repair or re-installation of proper roofing, and thereby protect the structure from further ravage. Where this is not possible, or desirable for philosophical reasons, buildings with broken wall tops or of very high cultural value or high sensitivity, ruins are best conserved by provision of a free-standing modern roof. A simple example made from readily available materials is shown in Figure 2.2, but numerous alternative configurations are possible and can be adapted to suit local conditions (see Chapter 5).

Even in the case of well advanced deterioration, it is possible to intervene in saving structural ruins by a combination of techniques shown in Figure 2.3 but critical to their ongoing survival is control of water, not only the roof but raindrop bounce, standing water and drenched vegetation. A critical zone exists which extends up 450–500 mm above ground level around the wall perimeter. This is where the combined effects of direct rain, seepage, drift down the face, raindrop bounce, wind and often frapping from vegetation, all act together to denude the lower courses of mortar. Unfortunately, it is this zone which is most critical to the lateral stability of the wall as a whole, analogous to a bottom hinge. Left unattended for long enough this denuded zone causes a lean outward of the whole wall, and is often accompanied by a curl of the wall face as mortar is dissolved within the external faces of the bedding joints. These two effects combine to cause a lateral shift at the top of the wall, which when a roof exists, is then resisted by the wall plate attachment. Unless a capping course or top perimeter beam has been provided, the opposing forces initiate a crack at the top of the wall running into the wall core, which progressively loosens. Frequently this is accompanied by rain penetration at the eaves level as the geometry of the top of the wall distorts, and water trickles into the loosened core carrying particles lower down into the wall body, blocking the natural aeration of the core open-rubble work. Localised moisture build-up becomes evident internally, and eventually the build-up of pressure, acting on weakened bed joints, forces bulges to develop in the external face.

A typical reaction by engineers unfamiliar with historic construction is to grasp at underpinning as a solution to the problem. There are cases where this will be necessary, but normally addressing the repointing of the wall from below ground level, progressively

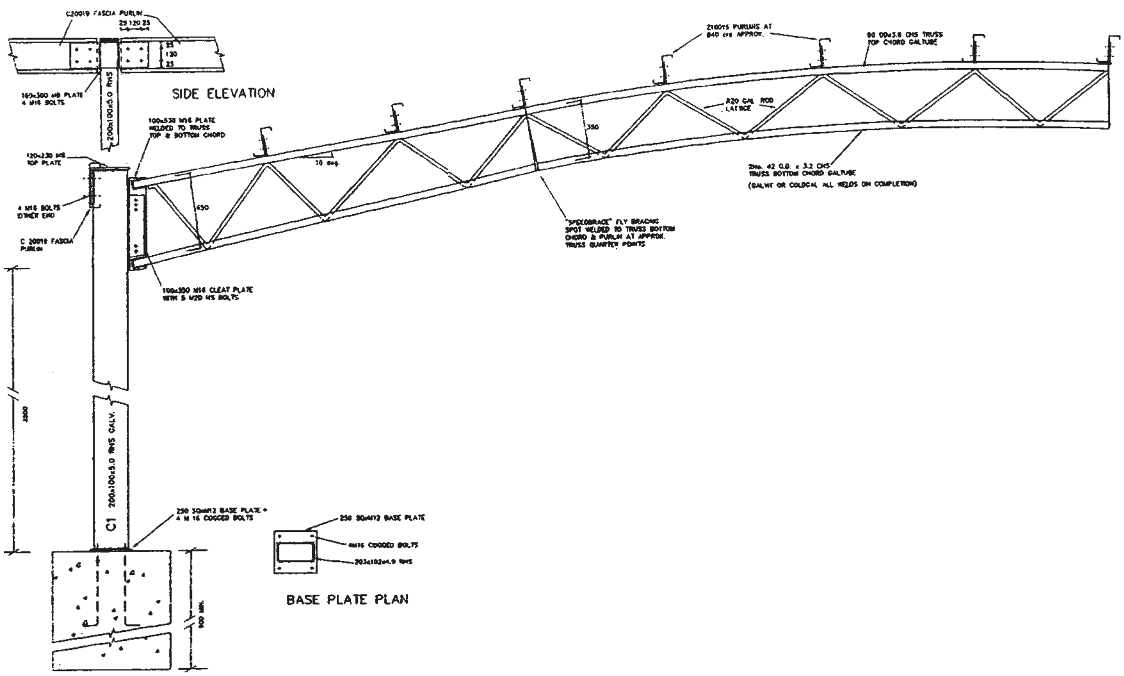

Figure 2.2 *Example of simple free-standing roof.*

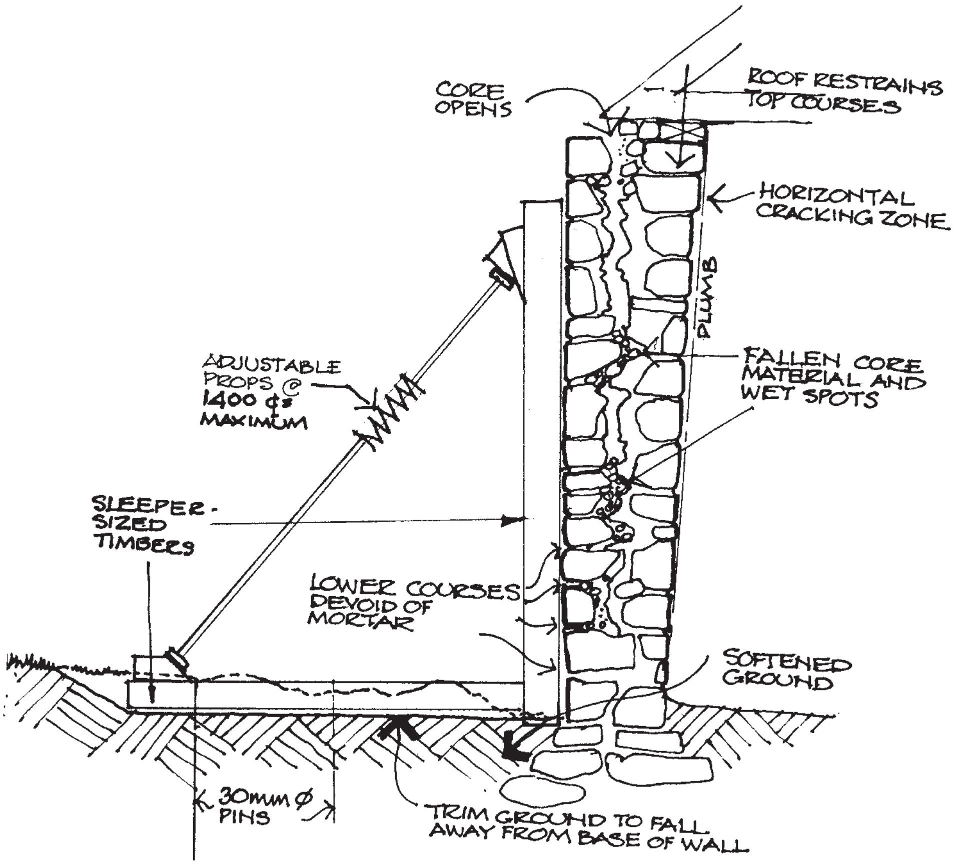

Figure 2.3 *Wall alignment by jacking.*

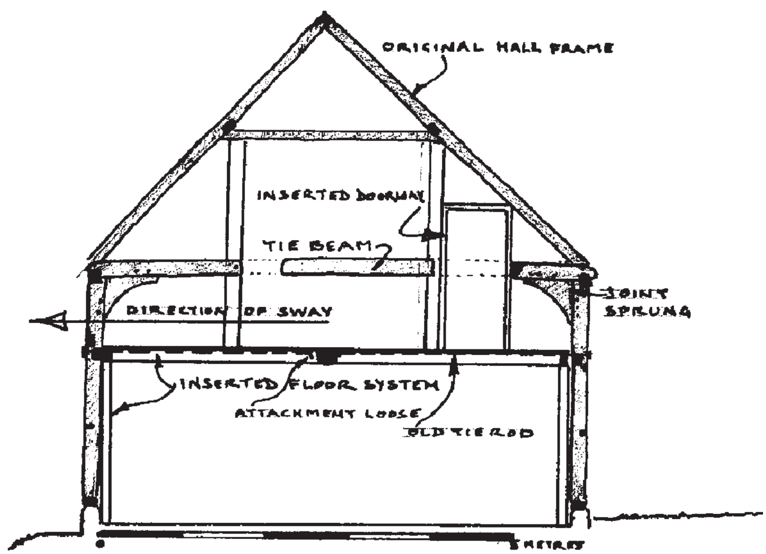

Figure 2.4 *Schematic of conservation principle on end gable wall.*

to the top of the wall, may be all that is necessary and is the correct solution. Where it is feasible and practical to do so, the wall can sometimes be levered back into place using adjustable props in the procedure shown in Figure 2.3. This may sometimes need to be accompanied by grouting of the core, as is described in Chapter 4. Small deformations evident in the realigned wall surface do not need to be corrected.

Identification

The above description of distress caused to the structure may be evidenced by the following phenomena (see Figure 2.1):

- Walls are out of plumb and leaning outward, a condition which can often be seen by eye alone
- There is an accompanying curl outward and concavity lessening towards the top
- Transverse walls show near vertical cracks, which widen towards the top
- Open or significantly degraded mortar joints often exist at the base of the wall
- Internal horizontal cracks develop near the top of the wall
- Internal damp spots may match external bulges
- If roofs are present, underpurlins or secondary timbers lodged onto the end walls often show corresponding cracks on the external face.

In addition to the roof question, which may not be appropriate for most care of ruins situations, certain fundamentals of approach require consideration for the site investigated. For instance:

- Ground should slope away from the base of walls for a minimum distance of 1.2 metres, to a fall of at least 50 mm
- On an upslope side, a cut-off drain or a graded swale should be provided, and be able to discharge away from the structure
- A clean surface of gravel or maintained turf should be provided to the graded margins
- In flood plain situations, some capacity for the rapid draining away of floodwater needs to be considered, in addition to provision for normal surface flows
- Pointing should permit free surface flow to cappings and vertical faces alike
- Hollow core grouting needs to be considered to back up cappings where necessary.

These recommendations clearly have archaeological implications which may make them difficult to implement but may also be ultimately useful in clarifying original contexts, facilitating legibility and enhancing presentation.

Remedial action

Wherever possible the desirable solution of roofing the ruin or structure should be given active consideration. In a reversible ruin situation, where a limited reconstruction is possible and constitutes a valid option, then the following checklist is useful:

- Correction of lean and curl to the wall by the adjustable prop method. Larger structures can be tackled in the same way, using major shores to the walls, from which jacking forces can be applied
- Where static analysis suggests resultant forces may result in minor tensional stresses, provision of a non-obtrusive ring beam, or substantial continuous top plate, should be considered
- Core grouting, in circumstances indicating partial core collapse, should follow the procedures given elsewhere with respect to first washing out sands and fines.

Ground movement

A vast amount of research has been carried out on the subject of soils, and a basic understanding of soils is key to understanding most of the phenomena encountered in the field.

From an engineering standpoint, soils are interesting as the foundation medium and are classified into two main groups:

- Non-cohesive or granular soils, such as sands and gravels, which are classified by grain size.
- Cohesive soils or clays, which are sticky and can be moulded. These are classified according to their swelling and shrinkage characteristics.

Apart from certain types of loess and some sediments, limited to arid zones, which can exhibit some strange features such as collapsing under load, granular soils are not overly concerning. Within the range of ruined structures likely to be encountered, problems such as bearing capacity will have been resolved long before.

Clays, on the other hand, are an ongoing source of problems as all clays move to a greater or lesser extent. This is because of their ability to store water within the cellular structure of the clay particles, categorising them into ‘highly reactive’, ‘medium reactive’ or ‘low reactive’ clays. The clay particles are microscopic platelets, which change shape and dimension as water is stored or lost. The usual analogy is that a dry clay platelet starts as a breakfast plate and changes to a soup bowl with the uptake of water, and this feature is responsible for the swelling and shrinking of a clay subgrade.

There is a variation in the extent to which various clays shrink and swell, dependent on the chemistry of the original parent rock. For example, clays derived from basalt sources are more reactive than from granitic sources, and the least reactive, for instance, are those derived from the earlier series of mudstones.

Water is lost from a clay subgrade due to evaporation to the surface, and to root action through the fine hair-like roots of major plants such as trees. It is necessary here to introduce the last contender in the soil types, namely silts. Silts are very small individual particles of the parent rock of spherical shape, but below the level of individual grain identification, and they behave differently to both clays and sands. Being very small they are carried to the top of the soil profile and normally form a band between the topsoil–humus layer and the clay below. There is an ongoing transfer of materials from the surface down to the clay layer by worm action, and as part of this process silt gets transferred downwards, resulting in a mixed band of silty clay sitting directly over the clay proper.

These upper profiles provide a blanket to the clay below, protecting and limiting the extent of evaporation, and hence shrinkage. Depending on the effectiveness of this blanket, the clay subgrade swells and shrinks to a greater or lesser degree, following the seasonal variation of wetting and drying in a lagging sequence caused by the time taken for water to store within the particles. The effect of both decreases with depth below the clay surface and hence founding deeper into the clay is preferred to shallower founding, as can be deduced from Figure 2.5.

It was well understood in antiquity, from an empirical basis, that founding should be on the firmest layer within the soil profile and hence finding poorly founded structures or ruins tends to be unusual, although these do occur.

It is important when investigating a new site, particularly if sited onto clays, to bear in mind the general geology of the area, the level of weathering and the location of the site within the local topography. Sites occupying hill sides or tops, apart from being closer to the underlying rock, will sit onto clays formed by *in situ* weathering (Figure 2.6), whereas those on valley floors would normally sit onto clays, which have shifted downhill under the combined influences of gravity, frost and water transport.

The tiny platelets comprising the clay particles are randomly organised within the parent rock and weathering *in situ* leaves the skeletal structure (including the microstructure) unaltered; hence the swelling and shrinking forces are randomised. Those clays shifted downhill become remoulded to some extent, and achieve a partial orientation as the platelets slide together. However, clays laid down by freshwater action are fully oriented as shown in Figure 2.7. This is the worst combination from a structural aspect, since all the platelets now lie in the horizontal plane, resulting in vertical swelling and shrinking being maximised. Ancient clays of saltwater deposit do not align as evenly as those laid down in freshwater lakes, as a result of ionic interaction.

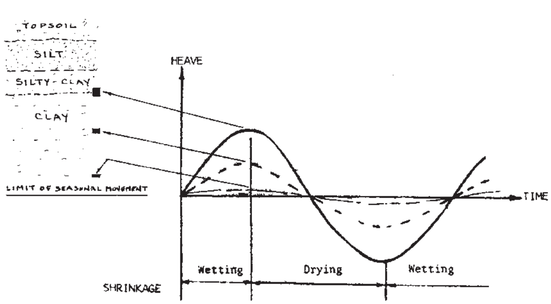

Figure 2.5 *Typical clay soil and seasonal vertical soil movements.*

Figure 2.6 *Deep in situ residual clay weathering showing residual basalt boulders.*

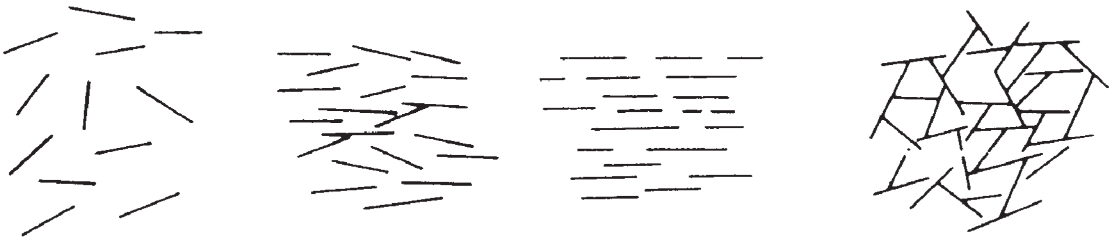

Figure 2.7 *Clay particle orientation.*

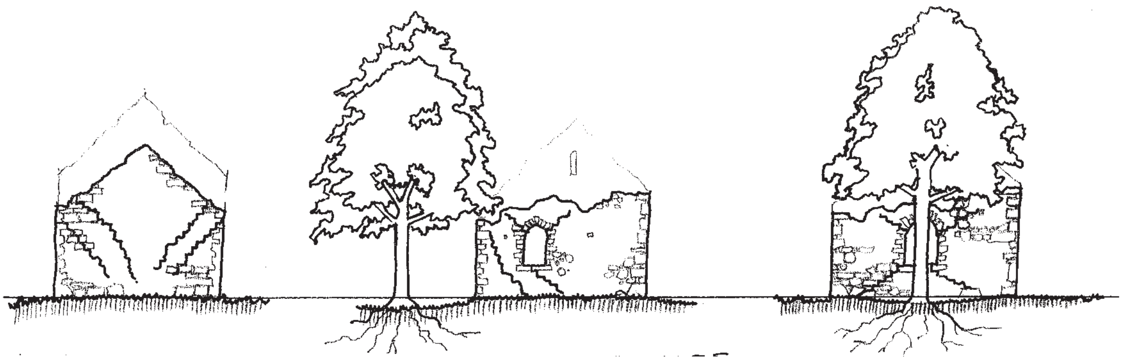

Figure 2.8 *Distress cracking on clay subgrades.*

It follows from all of the above that an adequate blanket of topsoil and silt should be maintained as far as possible.

Trees, however pose a major threat to stability of ruins and standing structures alike, and large, vigorous, deciduous trees particularly so. Figure 2.8 shows the dramatic ground movements, which can be caused by the introduction of a large elm tree.

Figures 2.9 and 2.10 both show a simplified relationship between vertical movement and the tree height-to-distance ratio. From these two examples a simple rule has been developed for new structures, that the closest they should be from a large tree is equivalent to its full mature height. Where a group of trees exist, or are intended, then this needs to be increased by 50 per cent, since the tree roots are in competition with each other and reach further in their search for moisture.

To avoid cyclic ground movement affecting ruins or structures founded onto clays, large trees should not be permitted close to them. Since the phenomenon exists in reverse also, the cutting down of a large tree nearby may cause heave developing over the next three or four years. Any clearing of trees on a clay subgrade should be carried out well in advance of other remedial or conservation work, or provision made for follow-up work during subsequent years. The potential conflict here between structural necessity (or advisability) and site ecology and presentation is obvious, and must be discussed and assessed by the conservation team.

Identification

A masonry structure protects the ground below from drying out and a reserve of moisture will have built up after a few years. During dry months, or particularly extended periods of drought, the loss of moisture to the atmosphere will cause a clay subgrade to shrink around the structure, which evidences itself first at the corners. This relative movement causes the corners to appear to drop, creating diagonal cracks radiating upward and outward from the mound edges.

Trees will cause a similar but unsymmetrical effect if located close to a corner, or may cause a central panel to drop if central to a wall. Typical cracking patterns associated with these three conditions are shown in Figure 2.8.

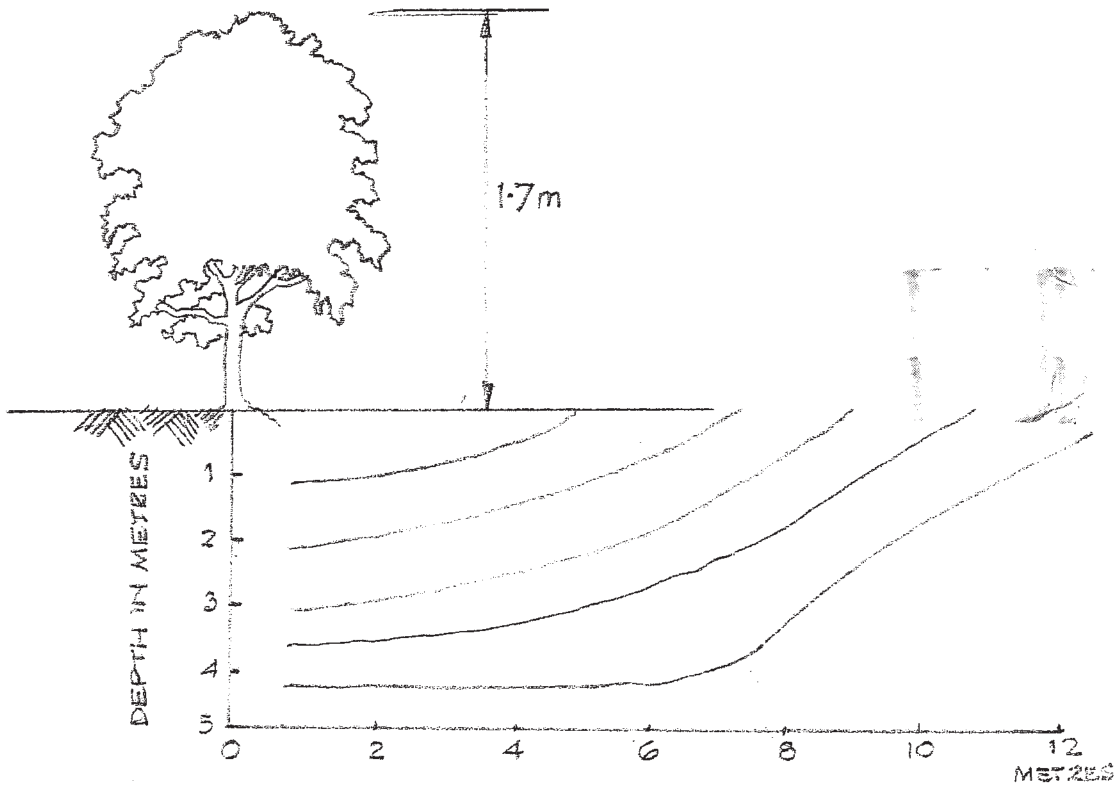

Figure 2.9 *Variation in settlement with distance.*

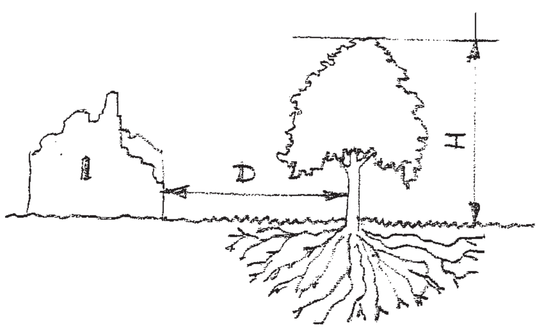

Figure 2.10 *Settlement versus distance/height ratio.*

Silts

Silts have a special characteristic of being dispersive in the presence of water, which, put simply, means that they undergo a sudden and drastic loss of strength. They also have a second characteristic of being susceptible to laitance when subjected to fairly minor vibration as water makes its way to the surface, this action being the prelude to the silt soil turning into a thick fluid resembling porridge. The mere presence of silt should ring alarm bells in regard to any form of construction. Silt normally is associated with clays in only thin bands, but in certain circumstances can be found in deeper pockets up to 600 mm deep, sitting above a clay subgrade.

Identification

Correct identification of silt is vital to determining a safe foundation depth, as what appears as hard as mudstone when desiccated can turn to a soupy consistency during wetter months when a high local water table persists. Most silts contain a proportion of clay particles, and a simple jar test gives a quick indicative result. To do this, a sample is placed into a small glass jar, which is then almost filled with water and shaken. The silt particles will settle within a few minutes, whereas the colloidal clay particles will stay in suspension for some hours. Unless the silt proportion, which usually is lighter in colour, is only a very small percentage, then deeper founding is necessary.

Remedial action

- Provide means of intercepting winter seepage flows by cut-off drains or swales if archaeologically appropriate
- Discharge downpipes well away from buildings or ruins on their downhill side
- Renew footings or underpin to safer strata if ruin is reversible.

Slumping

The folding of soil as it slumps down a hillside is a common feature in steep hilled country, and these folds are normally referred to as 'sheep tracks'. They are another example of the cyclic wetting up during periods of heavy rain, which, due to the added weight of water, can increase the density of the upper layers of soil by up to 60 per cent. As described above, the upper layers are composed of mainly permeable soils, whereas on clay or rock hillsides an impermeable interface lies below, which creates a slip surface. Slow draining of water causes the upper layers to increase in weight as water is absorbed, and further rain then acts to lubricate the slip surface.

When buildings are sited on the brow of slopes, any change to the drainage at the top of the slope will upset the status quo and can lead to an adverse effect.

Seismic effects

Most people are familiar with the concept of a shock wave emanating from an epicentre below ground being the source of a seismic event. For the purpose of considering the forces developed against structures, this shock wave can be considered as travelling at ground level, which, in effect, laterally displaces the ground and objects attached to the ground. These objects experience a momentary shift, or series of shifts, with intermediate replacements, in the direction of the wave propagation. It follows from this that anything which has an appreciable part of its mass above the ground surface, such as tall trees, columns or walls, will be at risk from its own dead weight. This is because inertia will try to retain the bulk of mass in its former position, whilst the base of the object is forced to displace due to the ground-level wave. Slender, flexible objects, such as tall reeds, saplings, etc. are at low risk, even if quite tall, as they are able to bend to accommodate the shock wave. Medium to tall trees do not fare so well, whereas rigid structures, such as most buildings, all suffer a degree of damage.

Because the shock wave passes across the structure in a continuous succession of increments, each element in a wall, say, will suffer compressive, then tensional, forces. A low-height, rubble-cored wall may appear to survive fairly well from the experience, and be seen to lose some outer masonry blocks. In fact, the whole core will have been rumbled by the passage of the wave, and much core mortar will have been detached or de-bonded with the core stones.

This basic mechanism was recognised by some ancient peoples who specialised in the construction of interlocking masonry able to absorb the alternating forces developed by the shock wave, and built without loose core material to be disturbed by it. The high seismic resistance of the Inca ruins and those at Rhodes, etc. show how very effective this type of masonry has proved to be.

Tall structures built of conventionally coursed masonry, and which lie parallel to the wave front, will sway due to inertia and are likely to topple. As the inertia of the above ground mass resists the inertia, a secondary shear zone is initiated, which due to primary stress distribution will occur above ground level. With a homogeneous material, the initial compression will spread at 45 degrees upwards, and a horizontal shear will be initiated since no further material exists to accept the compression. In simple terms, a column 1400 mm in diameter is likely to shear at about 1200–1600 mm above its base, and such shear will tend towards a joint where the resistance is least. Some concomitant stone damage will also occur, and this will be at a sloping shear plane on the leeward edges, but will be minor.

In active seismic areas, which experience only low-level tremors, such as south-eastern France, some ruins display timber beams built into masonry walls at regular vertical intervals, which are seismic attenuation devices. These are often mistaken for former lintels abandoned due to alterations. Further south in Europe, the Balkans, etc., these timbers occur in vernacular architecture, as full perimeter ties, rather like bond-beams in concrete masonry. The timber tie beams provide a tensional capacity, which the masonry lacks, and some minor flexural capacity. These features, coupled with the softer, fibrous nature of the timber, help to redistribute some of the ground wave stresses, and to absorb some of the shock by local bending and by dampening.

This same phenomenon helps to explain the Roman fascination for bands of brickwork within their masonry buildings.

Some minor tensional capability is available from the brick layers via the mortar bonding, and the frequently repeated layers, as for example in the Baths of Constantine in Arles shown in Figure 2.11, provide

Figure 2.11 *Baths of Constantine, Arles.*

a cumulative capability for tension between the layers. The different dynamic response of fired brick, as opposed to masonry, has a dampening effect also. As can be seen, the brick courses extend the full width of the walls.

In the low seismic areas of southern France, there are many examples in vernacular architecture of tapering walls or buttresses, with splayed quoins, which reduce the effects of minor tremors. These have often been added to with quite massive sloping buttresses, which taper towards their tops, and provide the same effect (Figure 2.12).

A similar add-on seismic buttress can be seen here provided to the seventeenth century church at Manosque, France (Figure 2.13). Notice the neat, but massive, buttress of extra large quoins which has been added to stabilise the fine limestone ashlar work of the façade, which shows signs of having been shaken and cracked by an earth tremor. The position of the crack and loose joints, just back from the corner, indicates that the shock wave passed from right to left. This is borne out by signs of light spalling to the ashlar faces of the two town gateways, which lie on the same axis of the wall shown. This is typical of light tremor damage and it shows how the masonry damage will accumulate on the lee side of the pressure wave, as the masonry rebounds, thereby realising tensional forces in the masonry. An examination of building complexes damaged by seismic activity will illustrate these principles.

Some experiments have been made of reinforcing re-erected ruined columns with steel rods through their centres. This has a potential for further worse damage to occur, than if solely pegged together in the classical manner. In the event of a seismic occurrence, grouting of the rods is likely to initiate a secondary shear plane starting from the centre of the rod group,

Figure 2.12 *Tapered corner designed to reduce the effects of minor earth tremors.*

Figure 2.13 *Massive added buttress to wall fractured during seismic activity, Manosque, France.*

and should therefore be avoided. As the magnitude of a future seismic event is unpredictable, a satisfactory model for analysis may not be possible, and it may be better policy to avoid this type of refinement. The probability of a lightning strike to the top of a reinforced column is a further factor to consider.

Lightning strikes

Any tall ruin will attract lightning, and the risk increases in open situations, where the ruin is at a relatively high elevation. Lightning produces between 10 and 100 kA in a period of less than one-hundredth of a second, and in a poor conductor has a significant heating effect. Trees hit by lightning, being poor conductors of electricity, sometimes split due to the tracking path being partly internal, where there is a reserve of moisture, and instant vaporisation into steam creates an explosive force. On occasions the heat generated will also set the tree afire. Hence, stainless steel reinforcing rods will heat up with a lightning strike, and if epoxy grouted in position, the heat generated will melt the epoxy. If the reinforcing rods are in a group then the current will flow through all rods, simultaneously generating a powerful magnetic field, which will pull the rods violently together through the melting epoxy. In a worst case scenario, this sudden force could split the top and bottom column sections longitudinally into several fragments. In a lesser case scenario, the discharge of current at the base is likely to track across the surface of the stone pedestal, and if marble, some electrolysis may occur with consequent surface damage.

Conductors should be external to the monument in question, and solid copper for preference, as any hollow formation will collapse inwards. In sandy soil the best earthing is a buried copper grid, but this may need to be quite extensive and may be impracticable in an archaeologically sensitive context.

Omission of a conductor will sooner or later lead to lightning causing some damage, as was caused by a strike in 2003 to a conical roof to Cesis Castle in Latvia (Figure 2.14), which had been replaced in the 1890s. Little damage has been caused in this case, as the vertical transmission of the electrical energy has dissipated into several of the sloping timber props. Although nominally dry, residual moisture in the timber has been vaporised from those parts of the timber retaining the most moisture, such as the central pith, and at the cross beam intersections.

Both of the props nearest the camera show the splintering effect caused by the sudden release of energy as moisture turns instantaneously to steam.

Figure 2.14 *Evidence of lightning strike, Cesis Castle, Latvia.*

Climatic effects

Wind, sun and frost contribute to degradation in different ways in different places, and modifications to avoid moisture traps, which invite frost damage, necessary in northern Europe, are less important in most parts of, say, Australia or North Africa. Temperature cycles of expansion and contraction rarely seem to affect massive constructions of masonry in lime mortar. There is a heat sink to the interior of the wall, and the lime mortar is relatively soft with a degree of elasticity. Over a large surface area this is usually sufficient to absorb the expansion forces. Cement mortar, on the other hand, is a whole order stronger, and thermal movements in cement mortar masonry can cause brittle cracking which, in brickwork, often leads to surface spalling. It is as well to remember that reinforced concrete is technically possible because of the similar coefficients of expansion of steel and concrete. Even in a relatively modest climatic range, such as Cornwall or Brittany, a 33-metre-long bridge deck will have a movement range of nearly 40 mm. Care needs to be taken, therefore, in introducing a dissimilar material, such as Portland cement concrete, into masonry ruins, particularly in situations where direct solar heating is likely. The natural flexibility of lime mortared

Figure 2.15 *Granite column showing temperature-related 'onion-peeling'.*

Figure 2.16 *Frost damage in saturation zone created by fallen rubble.*

masonry with its inherent advantages over modern materials needs to be respected.

Limestone masonry is quite forgiving of solar radiation. Igneous masonry, however, heats up rapidly in hot conditions, and due to poor conductivity within the stone, heat stresses set up in layers below the exposed surface. Basalt in particular, being dark in colour and a good insulator, frequently shows symptoms of defoliation ('onion-peeling'), and should there be a mortar deficiency in the surrounding joints, heat sink to the wall interior is lessened, increasing the surface effect. Since quoins often pinch-up as mortar loss occurs, the mechanical effect thus developed compounds the effect of the temperature stresses. Consequently, the sharp arrises of basalt quoins often spall off in west-facing buttresses. This is a further consequence of poor maintenance, particularly of repointing being left unattended.

The direct stresses due to temperature, which cause the typical onion-peeling of stone, occur at night when cooling causes the outside layers to shrink, whilst the interior of the stone is still hot. Thus, it is most pronounced in desert conditions, where the clear air allows rapid heat radiation loss after sundown. Granite columns sometimes found in Roman ruins can show a variation of this effect (Figure 2.15). Hot days followed by cold nights cause microfracture of the exterior layers, and condensation or rain running down the column penetrates the very small cracks, which can then freeze as temperatures plummet. This causes localised damage mainly around the column bases. Lesser damage occurs at the top of the columns where a small reservoir of water collects between the top of the column and the capital.

Sometimes it is possible to ameliorate the conditions around a site by judicious planting, giving an element of shade during the day, some shielding, and a small heat output after dark, effectively allowing the stone a longer time to transfer heat load to the outside layers.

Frost

The collection of water generally within the sedimentary stone masonry of standing ruins can lead to spalling of face stonework similar to the above, and this type of damage can be seen in Figure 2.16 of a seventeenth century chateau which was gutted during the French Revolution. Frost damage is limited

Figure 2.17 *Frost damage related to the creation of an eighteenth century terrace behind an existing bastidon wall.*

Figure 2.18 *Common frost damage caused by accumulation of soil.*

to the base of the tower walls where fallen rubble allowed the masonry to remain wet. This demonstrates the need for attention to detail to any exposed wall tops and to the removal of moisture traps.

To avoid this type of damage, filling behind retaining walls should not be done without first installing a free draining layer directly behind them. Figure 2.17 shows how the creation of a chateau terrace during the eighteenth century has left a clear outline of the step in terrace level behind the older bastidon wall, shown by the resultant frost damage. Figure 2.18 shows a combination of frost and salt damage to brickwork due to mounding soil behind a brick wall.

Similarly, attention needs to be given to ingress of moisture at the roof or capping level. Moisture penetration at the top, in most materials, permeates down towards ground level, and if not fully dried out, the bases of these structures become susceptible to frost damage.

This is particularly dangerous to ruins, due to the fact that loss of support is involved at ground level, and as the structure seeks to re-balance the forces acting from above, a point is reached where the applied stress is sufficient to shear the stone above. Cracks can be seen developing above the eroded levels of the Roman Theatre in Orange (Figures 2.19 and 2.20).

The Baltic tower (Figure 2.21) built by the Livonian Order has been successfully stabilised and protected from further damage, in spite of being 700 mm out of plumb, by provision of a non-intrusive roof and flashings. The openings have been kept through the flashings, retaining some of the realism of the historic apertures, and the use of boarding to close in the structure is not jarring to the sense of the ruin.

Figure 2.19 *Stress cracking of the Roman Theatre at Orange (1).*

Salt damage to brickwork

In Australia a fragile ecology has become unbalanced along some major river systems, raising salinity levels and increasing the extent of previous salt pan country. It is here that some of the worst 'salt damp'

Figure 2.20 *Stress cracking of the Roman Theatre at Orange (2).*

Figure 2.21 *Wall head protection of Baltic tower, Latvia.*

Figure 2.22 *De-icing salt damage, Old Arsenal, Riga.*

problems occur. Typically the lower courses of pioneer bricks in historic structures suffer almost complete collapse into powder as salt from groundwater is drawn by evaporation into the structure of the clay, which progressively eats away the faces of the bricks.

In Europe, however, especially in those countries with long cold winters, de-icing salt will cause the same effect when it is taken up as a saline solution during thaw, as seen in buildings surrounding the Old Arsenal in Riga (Figure 2.22).

Spreading salt to de-ice paths and steps around ruins and historic complexes needs to be done with great caution if there is any brickwork present.

Wind

Damage by wind alone is seen to its greatest effect on leeward surfaces, wherever sharp edges project into the wind stream. This is due to the downstream vortices induced immediately behind any sharp edge, and the vortex intensity relates to wind speed and the sharpness of the traversed edge. The vortices produced are of higher velocity than the stream itself, and are typically of the order of 1.5–2.0 times the generating wind speed.

Two other features need to be borne in mind with respect to vortex effect and Figure 2.23 helps to

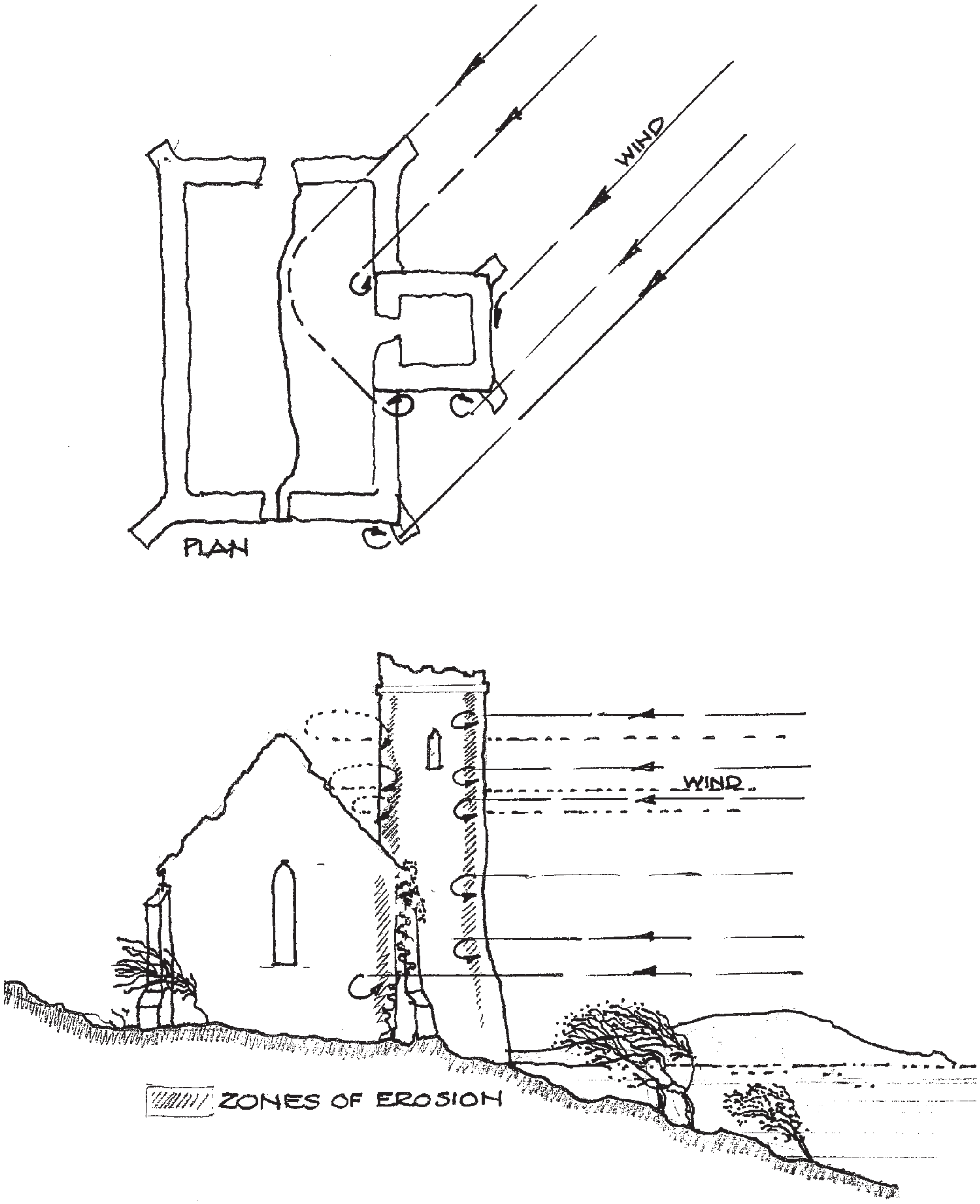

Figure 2.23 *Vortex scour and deflected wind.*

explain the phenomena. Firstly, it should be noted that downstream of the corner or edge, the standing vortex generated will establish, for a given wind speed and direction, a reversal in direction of flow at the downstream face of the masonry.

This causes suctional forces to develop against the leeward face, similar to the effect over an aircraft wing, for the short section close to the corner. The suctional forces drag any loose mortar free of the joints, and hence increase the chance of arris damage as noted above. It should also be noted that wind is never constant in either speed or direction for long, as it constantly veers and backs in short time cycles, reacting to major forces in the atmosphere. Hence the constantly changing effects of the vortices aggravate the extent of scouring on the downstream face. Friction with the ground decreases, causing wind speed to increase with height. Tall ruins, such as towers or ruined abbey naves, should have carefully rounded-off tops and shoulders where dressed for water shedding, etc. These rounded edges help maintain a laminar condition to the airstream, which restricts the development of vortices.

Judicious planting around very exposed sites will help to drop the wind speed and lift the airstream to some extent. This not only creates a more visitor friendly environment, but can also reduce weathering to the fabric.

The second effect, which can be recognised both in ruins and standing buildings alike, is that of wind channelling, such as shown in Figure 2.23. The effects of other walls, roofs or objects, if at a suitable angle to the wind stream, can divert part of the stream, effectively deflecting it against a leeward corner, which might otherwise be sheltered to some extent. Hence, certain parts of a structure can receive wear over a wider range of wind directions, and localised wind degradation will be more severe.

Figure 2.24 demonstrates the basic effects of wind vortex erosion in a high wind area, although little erosion occurs on the mine chimney, because the smooth profile restricts the development of vortices; the square base structure has noticeable corner erosion just where the vortices are generated.

Figure 2.25 shows localised erosion to a round chimney, where downstream vortices have impinged on the surface, these being spun off the adjacent edge of the engine house ruin in the foreground.

In certain very severe cases, as occur frequently in maritime situations, some thought should be given to providing wind-break fences within a complex of ruins. Obviously there is a visual trade-off involved here, but occasions will arise of frequently visited sites needing them. They are best made of vertical battens about 30–35 mm wide and spaced apart a clear distance of 40–45 mm. They need to be 1700–2100 mm above ground level, and the tops should not be capped with a rail, but left as protruding fingers. This type of fence has been tested in high-wind areas and works efficiently to 'kill' the

Figure 2.24 *Chimney base showing effects of wind vortex erosion.*

Figure 2.25 *Localised erosion related to downstream vortices.*

stream speed by the simple process of generating opposing vortices.

Allies of degradation

In spite of the beneficial advantages of selected planting given above, there is no doubt that nature is not neutral but active at all times in the general process of decay to ruins and structures alike. Plant roots, whether of climbers like ivy or ordinary tree roots, are active in lifting, breaking into masonry and increasing surface acidity (Figure 2.26). For all these reasons, the mature height rule given above for clays could be applied equally to maintaining a safe distance of trees away from masonry structures.

Birds and rodents provide active allies in the degradation process. Rats, being omnivorous, are active in any benign climate where a food source is available, and exploit any weakness in a ruin or building, such as hollow core work or soft backfill. They are also happy to cohabit with humans, unlike shy rabbits. They occasionally cause problems of settlement immediately below footings by leaving voids, usually in stables, shops, etc. They can leave pathways facilitating water penetration and later subsidence. These problems remain hidden when the building decays to ruin status, but continue to exist until changing circumstances lead to a collapse.

From a financial aspect, the damage caused by birds is much more important as their activities take place in the most inaccessible locations, and hence are more expensive to reach and rectify. In Australia, the strong beaks of cockatoos have no difficulty cutting body holes through 300 mm of soft sandstone in high, undisturbed locations such as church towers, and I have seen several examples. Even small birds such as starlings and jays cause damage too, as they exploit small openings and dislodge mortar.

Figure 2.26 *Tree root lift.*

Simple stratagems, such as plastic snakes placed in suitable locations, or cut-outs of black crows, can be employed to scare birds away from critical points. The ecology of ruin sites is discussed in Chapter 6.

Disasters

These tend to monopolise public thinking, almost to the exclusion of the vast number of highly successful designs from antiquity. Well-known cases are promoted by popular television and press in a superficial education process. It seems that most people are aware that the dome of the Santa Sophia collapsed after only 21 years, but few know that it was due to an earthquake. Very few realise that the modified dome has now stood for over 1400 years and withstood several earthquakes since.

Similarly the famous collapse of the nave at Beauvais is given undue prominence against, say, the technically brilliant, and aesthetically beautiful, strainer arch solution used for the Salisbury Cathedral spire support.

Earthquakes aside, the balance of structural forces was well understood and catered for in the past, and collapses occur usually through structural alterations. These are outside the intentions of the original design, and hence change the structural conditions, sometimes creating a new set of stresses. We can detect changes in the behavioural pattern of structures because they leave clues of how the new set of stresses are redistributing as the altered structures respond to different forces.

A background knowledge of the area, its history and geology is very important to an assessment of stability and its possibilities. In an area with a history of colonisation, there will be layers of historic changes, perhaps in the form of terraces, ditches and underground conduits, which can sometimes account for an unexpected reaction from a ruin or structure. Mine shafts and sealed adits, in mining areas, fall into this category, with some alarming consequences. These too leave their own sets of clues, and the search for evidence then extends well beyond the structure itself.

Human failings

Surprisingly, inadequate footings do not figure large in a listing of failures. Human intervention not in keeping with the original design affects the long-term stability of a structure and can initiate a process of decline. Fortunately the response of most antique structures is usually slow as they seek to readjust, and there will be an ongoing process of load-sharing to other members or sections of masonry. The altered behavioural pattern can then be identified by a subtle set of clues in cracks and earlier repairs. New introduced elements can also force a series of readjustments by the main structure, beyond the capacity of the original structure to cope. The introduction of extensive elements of reinforced concrete needs to be well thought out in advance, as they have very different responses and flexural qualities to traditional materials.

Mistreatment is possibly the greatest factor in weakening of structures and ruins, leading to degradation. Once a ruined building is seen as a material source, expediency and economic greed overcome any compunction or restraint. This has been the consistent story of history generally. From a structural standpoint, the most attractive spoils are also those providing key elements of support, such as quoins from corners or buttresses, arch and voussoir stones, roofing, etc. This makes it all the more important for governments to take the necessary steps to protect sites from plundering.

Fire

Few natural stones can cope with the high temperatures generated by fire. Volcanic ash, solidified by the pozzolano effect into a lightly cemented soft rock, is one of the few, and it can sustain heat with no significant change. Most other natural stone either cracks due to unequal heating expansion forces or may undergo chemical change should the temperature get high enough.

The big difficulty for the conservation engineer is that key structural elements such as lintels are often the most exposed during a fire, and frequently crack as a result. Cracked lintels frighten engineers, and the pragmatic solution for a reversible ruin would be to cut a new one from the same stone source. This is not always easy or possible. For ruins, where the stone will have obtained a patina of wear or algae discoloration, repair *in situ* is always possible, even if this requires that the real structural lintel must be concealed behind. Repair of fire-damaged masonry is covered elsewhere in the main text.

Timber can accept a degree of charring, but it is necessary to remember that timber exposed to a temperature of 180°C for any period of time suffers thermal degradation and, in extreme cases, total embrittlement. Even at lower temperatures, where cycling of temperatures has occurred, reduction in timber strength of over half is possible. The charring of timbers does not necessarily render them unsatisfactory, but a rough guide is that a two-hour fire usually results in a charring level of 20 mm, hence it is pointless attempting to conserve timbers less than 140 mm on the lesser axis. The retention of original timbers is frequently of great historic interest, as much can be gleaned from joint detailing, dimensions, saw signatures, etc. However, this is a process for individual selection and will require the expertise of a structural engineer experienced in this field, and alternate structural support must often be provided.

Vandalism and war

From a conservation aspect these two have much in parallel; however, fences and other barriers aimed against intruders intent on damage are unlikely to stop a determined, armed and trained force of soldiers. Ruins are often massive enough to withstand a medium level of blast, as it is quite difficult to collapse most ancient structures without a well-thought-out, and accurately placed and timed, deployment of explosives. It therefore comes down to protecting high-value ruins against normal gunfire and shrapnel, which will significantly disfigure any stonework. This is easiest accomplished with protective sandbagging. Because this will give the appearance of a strongpoint, or signals bunker, monuments should be clearly marked in bright colours and their presence advised to the enemy through the Red Cross, or other neutral authority, as has happened several times in past engagements.

Determined vandals are very difficult to stop, and see barriers as a challenge to their objective. Damage of this nature could be on the increase, and monitoring systems may be of more effect than direct protection.

Forces in balance

When a structure is assessed it is necessary to know if it is stable and, from a long-term perspective, whether the forces are in balance. The immediate static situation can be read from the clues left by cracks and previous repairs, but these do not give a clear picture as to whether there is a dynamic element present. Fresh cracks or spalling may infer recent movement, but this becomes a matter of opinion, and some quantitative evidence is needed if a prediction of further movement is required. On occasions the provision of funding for remedial works may depend solely on this criteria.

When a ruin structure is inspected for the first time it is important to fully record the situation photographically and by measurement of the cracks present. More sophisticated forms of monitoring may be recommended. It is good practice always to carry a crack gauge, and set up preliminary points which can be measured and recorded, marking these with an indelible pen so they can be easily found again. This process can be invaluable, as it removes the subjective element. Cracks seen in strong sunlight look very different on a dull day or in shadow. An absolute surety comes with a carefully recorded set of measurements, which cannot be disputed, and if a programme of measurements over specific intervals is available, then often a pattern to movement can be discerned.

Should an initial visit suggest that cracks are still opening then installation of the plastic window type tell-tale is worthwhile (Figure 2.27). These come ready graduated and are made to span across cracks, and the relative movement in two planes can be plotted directly as a trace.

Should major movements be involved, then modern survey equipment can be used for the same purpose over extensive areas. This usually involves the installation of permanent pins or marks, in liaison with the conservation team, and will be necessary for major structures. It is time-consuming, expensive and will normally involve years of monitoring, rather than months.

The seasonal movement of clays has been explained above, and a monitoring programme for ruins or structures sited onto clay subgrades will need to take account of seasonal changes and long-term climatic effects. For example, a crack measured during winter may be considerably wider by the next autumn, but will have partly closed up again by spring. For this reason an ongoing monitoring programme will usually be necessary.

Transfer of forces

The ultimate destination of all forces developed by a structure is to the ground. Just as we take all of our weight through our feet, so does a structure through its footings. The analogy can be taken further in that the load onto our toes is, for most of the time, greater than on our heels. Thus it is also for most walls, or even an individual column should it be receiving some other load. If there is a change in the distribution of foundation forces at ground level, this toe pressure will be the first affected. This regularly occurs due to softening of the ground at the base of a wall, or trenching in front, or loss of face mortar (Figure 2.28). The structural forces will attempt to redistribute load to compensate for the loss of support by increasing the toe compression, which often involves a forward rotation of the wall.

In Figure 2.28 it can be seen that the front wall separates as the wall leans forward, and tension cracks open in the return walls. This phenomenon increases the stress on the toe, as a consequence of which a significant vertical shear acts on the face of the structure, as demonstrated by the spectacular shear cracks on the buttress shown in Figure 2.29.

Figure 2.27 *Graduated tell-tale bridging a fracture.*

Figure 2.28 *Forward lean of wall with tension cracks showing in return wall.*

Figure 2.29 *Shear cracks in buttress of leaning wall base.*

Regrettably, this realisation fails to get home to large numbers of professionals, and it is not unusual to find excavations carried out at the toe of walls, with no regard to the tons of force from a cupola or vault at its top. It is important to realise that, in nearly all cases, the greatest vertical stress will be here at the toe and that there will be a corresponding horizontal component also. Even more common is the gross disregard given to discharge of roof water, which invariably happens just where it can do the greatest damage: at the toe of the wall. Some basic facts are worth recapping in this regard, if we look at some primary structural components.

The mechanism of structural components

Wall systems

All walls are subject to wind forces and they also experience, on a regular basis, additional stresses due to heating (often asymmetrical), shrinkage, unequal drying due to sun or wind, and the destructive action of frost. The mechanics of how a wall responds to these forces essentially classify walls into two groups:

- Free-standing walls, or
- Panel walls.

Thus, from a structural perspective, free-standing walls are vertical cantilevers from a base or foundation, which in turn redistributes forces to the ground. In this regard it is of no concern to us whether the wall is two metres long or 200 metres long, with respect to the structural mechanics. Of course, the wall length is a factor in expansion and affects wind pressure development, but otherwise does not figure in how the structure reacts.

For long-term stability a conservative height-to-thickness ratio is required, and since masonry in lime mortar is deemed to have zero tensional capability, then the wind and secondary forces become distributed and absorbed by the wall's mass.

Free-standing walls in well-known locations, such as Haddenham in Buckinghamshire, have a height-to-width ratio of less than 5:1, and have some ability to absorb temperature effects. For example, the Haddenham walls (Figure 2.30) are built of wichert, a chalk marl and straw mixture.

Panel walls are created by the insertion of piers or buttresses to a free-standing wall, or by a change in direction which accomplishes the same thing. Thus, an open-top garden wall becomes a panel supported on three sides with the insertion of buttresses. The piers or buttresses accept the greater part of the wind forces and transfer these to the ground. The top edge spans as a beam and transfers the top reactions to the buttresses and hence to the ground.

A panel supported on four sides is more efficient still, as the wall can then span in two directions: top to bottom and side to side. This is the normal case within a multi-storey structure, where the horizontal supports are provided either by the suspended floors or by the roof and ceiling diaphragms. Panel walls, being more efficient, are often thinner than free-standing walls. In ruin situations, the timber floors have often rotted out and what masonry remains is under-catered for with respect to the forces developed. Some ruins present opportunities for the introduction of a diaphragm, for example as was done in the Guildford Castle restoration (see Chapter 10), which provided a stiffened roof diaphragm inserted below the top of wall level. This is altogether a nice resolution as the one item provides weather protection, a stiffened diaphragm and creates useful visitor display space.

This type of resolution may not always be practical, and some other disguised support may become necessary. Highly visible visitor inspection platforms, for example, are immediately read as modern and necessary items, without any detraction from the ruin authenticity.

Figure 2.30 *Wichert wall at Haddenham, Buckinghamshire.*

A simple rule has been adopted in the past for some codes of practice, which is that a wall panel supported on four sides should not exceed 28 square metres. This is a useful guide in assessing wall slenderness for stability, but obviously will often need some further structural analysis, particularly if the wall is thicker than normal. Where massive ruins are concerned, such walls frequently have solid cores. In these cases the walls are able to develop an arching effect in response to wind loads, etc. Hence a wall that is two metres thick, spanning a horizontal distance of 14 metres, has a plan aspect ratio of 7, which is about the limit for development of arching. A degree of caution should be used as, even with walls of this thickness, the core construction plays a big part in the overall stability.

Before leaving this subject, mention should be made of various zigzag or serpentine walls, such as the garden walls at Bramfield Hall in Suffolk. These gain their stability from the part buttress or fin effect created by their plan outline, where part of the wall length is able to provide an opposing counterfort to the applied force, hence giving the wall greater overall stability.

Retaining walls

In monuments and sites these will invariably follow the thickness-to-height ratio of 1:3 or exceed it. The wall capability is enhanced if the face is laid back rather than being vertical. They are not designed to carry a water load, which if it occurs can triple the force acting on the back of the wall. Surface flows must not be diverted behind mass-retaining walls without provision being made for collection through a culvert discharge. Neither must the natural porosity of a wall be altered, for example by pressure grouting, without some provision for weepholes being made.

The effect of inadequate provision for drainage and discharge of water from behind a wall can be seen in the bailey of the ruined Baltic castle shown in Figure 2.31. The earth backfill collects water, which then exerts a much higher active pressure on the back of the wall, and maintains the mortar in a damp condition. The wall then fails through a combination of increased loading, weakened mortar and frost damage to mortar and masonry alike. The top of the wall is well protected by a capping, but continuous cappings in long lengths, particularly if composed of cement mortar, can experience expansion and temperature stresses large enough to lift the capping from off the masonry.

It is usually possible to insert weepholes at the base of a wall in unobtrusive positions, and to drill vertical holes from above to link with them which can be filled with drainage media. These must not be too small a diameter or they will quickly clog, or too far apart for the respective soil permeability to drain effectively.

Very occasionally, an arched retaining wall is found, often ashlar faced, and which functions on a similar principle to a dam. This does not mean that it will accept a water load, however, and the same precautions as above apply.

Figure 2.31 *Retaining wall failure under earth and water pressure.*

Corbels

These depend on a cantilever effect and must have adequate back weight in order not to topple. In working around corbels temporary propping should be provided, until a safe amount of masonry has been laid above their back projections and has had time to cure. The corbel projection with respect to depth is always very conservative, 1:1 or less, to avoid initiating a tensional stress in the stone (Figure 2.32).

Arches

The purest expression of structural efficiency is seen in Roman or Norman arches, and the transfer of forces at the cut faces of the arch ring voussoirs is even around the semicircle. All arches terminate with a horizontal thrust, but the semicircular form produces the least. Arches may terminate with either an inclined springing (as below) or a horizontal one, from off capitals or off sleeper pads. Greater care needs to be taken in supporting the arch weight if the springing is horizontal.

The Pont Julien, taken out of service in 2005 and built between 24 BC and 14 AD, demonstrates the enormous strength and longevity of the semicircular arch when built of dimensioned masonry (Figure 2.33).

After such a long period in service, loss of mortar and wear of the stones is having an effect, and the flood spillway arch keystone can be seen dropped in Figure 2.34. The arch remains safe, and it is the approaches and spandrel filling which have suffered most from regular flooding and earth tremors, causing spreading of the spandrel walls.

The opposite effect can be seen in Figures 2.35 and 2.36, where both arches are close to failure due to spreading at the springing points. In both cases shown the distortion is towards the springing offering the least lateral support. It can be readily seen that a flatter arch significantly increases the horizontal forces.

This brings in an important concept of flatter arches, which is that of containment within a mass of masonry. When a loss of lateral support develops, the residual horizontal thrust from the arch will cause the weakened outside panels to push outwards, resulting in cracks in the masonry above the arch, allowing moisture penetration, which hastens the process.

If there is adequate support from one side, but the other side is near a corner return, then a lurch to one side will result, as seen in Figure 2.37. Where the

Figure 2.32 *Corbel projections.*

Figure 2.34 *Dropped keystone at Pont Julien.*

Figure 2.35 *Arch close to failure due to spread at springing level.*

Figure 2.33 *Semicircular arches at Pont Julien.*

Figure 2.36 *Arch close to failure moving towards the area offering least lateral support.*

Figure 2.37 *Asymmetric movement of arch.*

horizontal thrust is balanced by a second span, or by a large mass of masonry containing the arch, this loss of shape cannot occur.

Very flat arches develop significant thrust at the springing points, even when lightly loaded, as seen in Figure 2.38. It can be seen that there is an asymmetrical displacement, towards the unsupported abutment, pushing some of the masonry from off its bed and allowing the arch to drop at the centre.

Relieving lintels and blind arches

Relieving lintels normally take the form of an arc situated above the real lintel, be it timber or masonry, and these are used to relieve the loading which would otherwise fall onto the lintel below. They are commonly mistaken for signs of a modified opening and can cause some pedantic, if erroneous, statements. For this reason, and because they vary in form, some examples are shown here.

The first is a dry-stone 'borie' (Figure 2.39), which has been dated as pre-Christian era and of a type which goes back to 3500 BC. Although it has a renewed timber lintel, the relieving arch above it is probably original.

Figure 2.38 *Thrust of flat arch.*

Relieving lintels are often of brick inserted into stone masonry. They do not always form so complete an arc as the ones shown in Figure 2.40, and often retain a decorative element.

They frequently conform to the general type shown in Figure 2.41. Just as with arches, adequate containment by masonry to each springing is necessary for the development of full structural potential.

Blind arches

Blind arches are a variation of the same, but have a more important structural function in that they actively distribute loadings towards specific points, where other members have been provided to cater for major loadings. Perhaps the best known of these are the blind arches around the Pantheon in Rome (Figure 2.42), dating from 80 AD, and which confirm the faith that Roman builders had in semicircular arches as a structural solution. These distribute the loads from the dome onto a series of major pilastered piers in the interior periphery, thereby enabling a series of side niches. Note also the small semicircular relieving lintel inserted above the window. One might call this a belt and braces approach, but since the building has stood since 80 AD, such criticism would be impertinent.

Figure 2.39 *Relieving arch in dry-stone borie.*

Cupolas and vaults

These are both forms of arch from a structural perspective, and are dependent on a balance of forces throughout the construction. A simple explanation of balance is that the resultant of the forces in play must pass through the middle third of the surface presented. As with arches, voussoir masonry can be

Figure 2.41 *Typical relieving arch above timber lintel.*

Figure 2.40 *Brick relieving arches in stone masonry.*

Figure 2.42 *Blind arches in the walls of the Pantheon.*

Figure 2.44 *Diagonal brick ribs in Roman vault.*

Figure 2.43 *Half cupola, Baths of Constantine.*

Figure 2.45 *Cracked vault related to wall movement.*

adjusted in size and shape to ensure the resulting forces comply with this rule.

The half cupola in Figure 2.43 forms an apse, which exerts an appreciable horizontal force onto the adjacent structure. This is the Caldarium apse of the Baths of Constantine, which takes its support from the massive arch which separates it from the Tepidarium. The remains of a springing for a second dome, visible top right, shows how the balance of forces would originally have been achieved. Nevertheless, the apse remains intact, and the deliberate use of brickwork ribs shows how the loading from the apse roof was directed onto the pillars between the windows.

The same method is used in a diagonal form in a first century Roman vault (Figure 2.44), and the inherent strength is achieved by a mix of brick ribs and regularly shaped limestone.

Rubble construction, however, with rounded stones of different size and shape, has none of these advantages and, when used in relatively thin elements, as in an arch, is reliant on the mortar to transfer forces evenly from stone to stone. When dealing with this type of construction, extensive support from below is necessary for safety reasons if the mortar is at all weakened.

Even with dimensioned masonry strengthened by ribs at regular intervals, if the end wall moves due to weathering, then the vault will crack in its weakest plane. This is what has happened in Figure 2.45, and the second bay has similarly cracked at the midpoint between ribs as the stresses are shared by the structure into the locations providing the least resistance.

Dissimilar materials and their consequences

Mass concrete

Pouring mass concrete gives rise to problems of support, shrinkage and heat output when it is used in large volumes. In new construction, one of the most common forms of site collapse is due to failure to adequately cater for wet concrete. This acts as a fluid of very high density, and when vibrated the wet concrete mobilises its full fluid effect and also transmits some of the vibration energy onto the boxing. Temporary support needs to be over-catered for in respect of the calculated forces, in order to avoid shift in alignment and displacement of timbers or wedges with load. Similarly, masonry walls used as front shuttering to wet concrete should be braced at close intervals and as a rule of thumb the pour height should never exceed 900 m.

It is best to avoid concrete as a backing medium if possible, but in those circumstances when it is used, allowance must be made for about 1 mm of shrinkage for every 2.5 m length of concrete. This may mean pouring concrete in short lengths between stop ends to avoid fracture or stress to more fragile masonry, and a limit of 4–6 m should be taken as a maximum. Heat output of large volumes of concrete, such as in bridge decks or dam construction, is an unlikely scenario with ruin conservation, but it is important to remember the relatively large heat output associated with the chemical reaction of curing concrete.

Reinforced concrete

When used in most structural elements, there is a balance of steel reinforcing within the cross-section. If long lengths are provided with reinforcement in one face only, as occurs often with top-course bond beams, then a small amount of curl will result as the concrete shrinks when curing. For this reason, the installation of top-course bond beams and cappings needs to be undertaken in short lengths to allow time for the concrete to shrink, or some balancing reinforcement added to the opposite face. A minimum period of five days should be allowed between pours. It is good practice to provide expansion or movement joints in situations like this, as they provide an extra degree of tolerance to shrinkage also.

Adequate concrete cover to the steel is very important, as the start of rust will lead to severe problems later. Consideration should be given to providing galvanised reinforcement in doubtful cases.

Figure 2.46 *Damage caused by rust growth.*

Rust growth in steel and iron

Rust growth is unfortunately a very common destructive agent in more recent structures, particularly amongst industrial ruins. It was a practice in Victorian times to attempt to strengthen some tall masonry structures, such as church towers, by the insertion of wrought iron or rolled steel straps embedded into the masonry. These were intended to function like a bond beam, but they have in fact been a source of endless trouble.

Rust growth occurs to steel and iron alike and exhibits as layers of rust similar to the leaves of an uncut book, as can be seen in Figure 2.46. Note how small bolts can burst open large blocks of concrete as they rust. The formation of the ferrous oxide layer increases the thickness of first one, then successive leaves. Where steel packers have been left in masonry courses they can lift many metres of building above, and it is not unusual to find a 20-mm vertical gap in the bedding joints, which when dug out reveals the presence of a strap or piece of steel plate.

These gaps then promote the ingress of moisture, leading to further direct damage due to stresses in the masonry, accompanied by increases in dampness. Examples of the lifting effect caused by a thin packer, and direct damage to an end gable, where the stub of a steel gantry beam has been left in place, are shown in Figures 2.47 and 2.48.

Wrought iron rusts in much the same manner as steel, and unfortunately iron cramps (or 'dogs') were used in the Middle Ages and by the Romans for joining stone panels and blocks together. Several blocks

Figure 2.47 *Jacking effect of thin steel packer.*

Figure 2.49 *Corrosion damage from Roman iron cramps.*

Figure 2.48 *Cracking due to corrosion of a steel gantry beam.*

Figure 2.50 *Corrosion damage from medieval iron cramps.*

on the weather side of the Roman triumphal arch (Figure 2.49) have been exploded by rust growth of concealed wrought iron cramps (more stable bronze cramps were often used, but caused damage of another kind, as they were extensively robbed, involving breaking open of the stone/arches).

The same effect is seen in the medieval tomb in Figure 2.50 at every joint, and as an additional consequence of the rust build-up, the increased stress applied to the thin Purbeck Marble has initiated a shear crack on the outside face of the stone end panel, which is about to spall off.

Both the Roman and medieval builders were aware of the problem and often used poured lead or fixed lead wrapping to the iron tines. This was not always adequate, and sometimes omitted.

The simple message is that iron or steel is not compatible with masonry, and should be removed wherever detected, and before damage becomes too severe. Where considered necessary, steel fixings in contact with masonry should be stainless steel (316L), and it should also be noted that galvanising will not survive long in a high alkaline environment such as occurs with most mortars.

Vitrified bricks

Heroic efforts are being made in Latvia to preserve the national heritage since it gained independence in 1991, but the absence of some materials, and the lack of choice with others, has caused problems. These have resulted in modern pressed, cellular bricks, fired to higher temperatures, being used in conservation work, to fit with the historical context of brickwork used in the late Livonian period.

Modern bricks in a restoration context bring two particular problems to the fore:

- Brick growth, caused as newly kilned bricks absorb moisture from the atmosphere
- Brittle fracture exacerbated by the cellular structure.

Just as it is necessary to provide expansion joints in concrete, so it is also with modern bricks in modern cement mortar, which suffer the double effect of brick growth and thermal expansion. Hence there is a danger of the cladding to the ruin core, seen in Figure 2.51, moving differentially to the core material of rubble and lime mortar.

The chimney in the background, which is part of the modern restoration, should be noted also, as a further example of frost damage.

Where there are substantial anchors to each end of a brick wall or panel, such as a junction with a tower or a large mass of core, the movement in the brick face will accumulate towards the centre. This can clearly be seen in Figure 2.52 at the arch and in the wall in the background.

In its initial phases brick growth tends to be limited to the face exposed to the atmosphere, and should this also be the one subject to maximum solar effect, then significant shear forces develop on the longitudinal axis. The cellular nature of the bricks used can be clearly seen as the whole brick face has sheared off in several instances. In such a severe winter climate, the voids, which collect water due to the impermeability of the cement mortar, will spall off later with frost action, as has occurred with the chimney already noted above.

These examples serve to reinforce the necessity of keeping to traditional methods and to like materials as far as is possible and practical.

Figure 2.51 *Problems with new vitrified brick, Latvia.*

Figure 2.52 *Brick growth, Latvia.*

Inappropriate interventions (or how to make things worse)

Masonry and embedded steel

It should be obvious from the above examples that any attempt to stabilise masonry by using steel cramps, straps or bolts has the potential to cause more damage than it prevents. There may be some disbelief that such techniques are still being applied, but some far-ranging examples are shown here.

Each buttress, to this mid-1500s building in Saxony (Figure 2.53) is different, showing forward lean to the front façade over a long period of time. This has increased the toe pressures to each pier, with a concomitant horizontal component acting on the bed joints, tending to open them. The solution has been to insert long steel straps.

The pier at the opposite end of the same building (Figure 2.54) shows how ineffective this solution is, as all three anchor stones have cracked and spalled, and the growth at a join has forced open the perpend joint, displacing the quoin.

A similar scenario is about to unfurl at this medieval Kloster (Figure 2.55), also in Saxony, a recently reversed ruin. Extensive restoration work by way of pressure grouting has been undertaken, which will be evident for a long time to come. The works have left in place iron strap ties to each of the buttress padstones, which will cause cracking later.

The Cornish jetty (see Figure 2.56), subject to violent storms, has been reinforced with steel straps, all of which have severely rusted and cracked the granite edge copings, in a classic counter-productive measure. The extent of rust growth can be gauged by the size of the cracks in these major stones. They are currently being replaced with stainless steel. Note how the lead embedding has not relieved the rust growth stresses.

Exposed steel and condensation

The relatively dry environment in the south of France is subject to large nocturnal temperature drops throughout the year. Lightly protected steel

Figure 2.53 *Forward lean of masonry façade in Saxony.*

Figure 2.54 *Long steel cramp failures showing cracked anchor stones.*

Figure 2.55 *Cramps left in place post-grouting, Saxony.*

Figure 2.56 *Granite cracking and steel straps, Cornwall.*

will not last long before corrosion sets in due to regular evening dew formation. It follows that exposed girding bands, such as those seen in a Gallo-Roman monument near St Remy, should be of non-corrosive metal (Figure 2.57). This is an area subject to minor earth tremors, and was possibly an expedient solution from the past. It begs the question of further expense to replace the bands when rusted through, and leaves significant local staining which is difficult to eradicate.

Figure 2.58, also showing a site in Provence, shows a steel beam insertion into finely crafted masonry, in which a small amount of rust growth has managed to crack three of the supporting pier stones. It is precisely because the seat cannot be painted that regular condensation will cause rust at the steel–masonry interface, and to the top surface also. The rust growth to both surfaces is increasing the direct pressure at the seat, and creating a couple forcing flexure into the beam. The two effects together are well demonstrated by the crack pattern to the pilaster cap. The leverage has then forced a shear spall to the face of the second pilaster stone, which has relieved the eccentric force, causing the increased pressure to centralise to the third stone down, which has split on the centre line.

Figure 2.57 *Iron girding bands, St Remy.*

Figure 2.58 *Cracked masonry related to corrosion of unmaintainable steel beam insertion, Provence.*

Figure 2.59 *Undermined wall and collapse.*

Figure 2.60 *Rock bolting at Chateau de Lacoste.*

Loss of support

One of the areas of most concern to the conservation engineer is the lack of appreciation of danger with which laymen and some professionals approach excavation close to walls, and the bland assumption that because things stand for a short time, long-term stability is assured. Figure 2.59 captures that moment when the collapse of an undermined wall has already occurred, but the suspension of disbelief holds strong with the handyman. Although the wall shown in Figure 2.60 is undermined on both sides, part has collapsed and a section of concrete facing has detached, the assumption still holds that a skim of concrete 60 mm thick will hold up a granite wall of some tonnes. In neither case did further damage occur, but it could easily have been otherwise, and in the latter case irreparable damage was done to hand-made bricks of high historic value. It is easy to be wise

Figure 2.61 *'Temporary' masonry support.*

after the event, and the magnificent work done by the French Centre des Monuments Nationaux is beyond criticism. Here, however, at the Chateau de Lacoste of the Marquis de Sade (Figure 2.60), the rock bolting seen in the picture is unlikely to work long term. There is a shear face visible in a relatively soft rock, and as work is currently in progress some direct support from firm rock at cutting level would be the best long-term solution.

The pillaging of monuments in southern France has been widespread for centuries, and the shear volume of conservation work to be undertaken is enormous. This expedient solution seen at Barbegal to the Eygalileres Aquaduct (Figure 2.61) can therefore be forgiven as public safety is still a primary consideration. The use of a masonry prop to an arch is of doubtful effect, however, and the time spent on it could have been directed to reinstatement of the missing voussoirs and minimal pressure grouting (see Chapter 4). The superior construction of this third century aquaduct has left it mainly intact, whereas the adjacent Caperon Aquaduct, which can be seen intruding into each side of the frame, has essentially collapsed.

Tensional bands or ties in brickwork

The aftermath of the Second World War has left a legacy of expedient solutions in much of eastern Europe, where occupation was continued by Soviet forces until recent times. The need to stabilise ruins until repairs or reconstruction could be effected led to many stopgap measures such as steel tie bands around a church stairwell in Riga Old Town (Figure 2.62).

Figure 2.62 *Steel tie bands, Riga Old Town.*

In each of the three bands shown in Figure 2.62, it can be seen that the tension in the bands has pulled in a course of bricks, shearing the mortar in the process, and leaving the remaining brickwork proud of the course held. To this has now been added the problem of rust growth after so many years since the war. The rust growth has increased the steel band thickness, and hence the tension, resulting in further tangential force developing, which increases the relative distress.

Conclusion

An understanding of the underlying processes, which govern deterioration, together with a knowledge of the inherent strengths which ruins exhibit, are fundamental to the conservation process. Small, subtle changes around a site can often assist in stabilising a ruin, slow its deterioration, and prolong its life. Adequate background knowledge, awareness of a site's history and of the various types of alterations likely to have been carried out in the past can shorten an investigation and save both time and money.

A conservation engineer, competent in more than just structural analysis, is an asset to any investigation, but needs to be called in early to be effective.

Engineers in the conservation field are a privileged group, who are given the opportunity to see and admire the work of those mainly unknown builders who have gone before. We have a duty to deal sensitively with their work with understanding, and recognising their original intents. If we treat their work with respect and a degree of humility, then we shall come to see that, even if we do not exactly stand on the shoulders of giants, we still owe them a huge debt.

Chapter 3

Condition surveys of masonry ruins

Graham Abrey

Overview

Understanding the condition of masonry ruins, and the scope and methods for repair and conservation, may at first glance seem similar to the approach taken for the conservation of historic buildings, but there are significant differences. These differences include:

- The behaviour of a masonry ruin is different to that of an intact building structure.
- Ruins seldom have a roof to protect the walls and interior fabric and are therefore subject to more intense weathering and decay mechanisms, which frequently promote more widespread and long-term patterns of decay, such as voided wall cores.
- Ruins are seldom given adequate inspection and maintenance. The consequent absence of a history and track record of inspection and repair documents can create uncertainty regarding the rate of ongoing decay and the success of past repair work. This often leads to inappropriate specification of future work.
- Ruins are often complex structures involving less familiar construction methods and materials that are often locally sourced. When combined with more intense patterns of weathering and decay, the solutions to long-term conservation can be less clear and heavily reliant on specialist knowledge and experience.

Bearing this in mind, how should a condition survey of masonry ruins be approached?

The success of a condition survey and future phases of conservation and repair are dependent on development of an analytical approach where the cause, pattern and extent of structural movement, weathering and decay are recorded, enabling proposals to be made based on sound experience. Where new or unfamiliar decay patterns are encountered, solutions should be tested using trials before full-scale implementation. A balanced approach should be developed which recognises the distinct properties of the original fabric; when solutions cannot be found, temporary repairs or protection can provide a way of delaying or slowing deterioration or loss until reliable methods have been developed.

The conservation and repair of ruins in the United Kingdom and elsewhere is facing a less certain future because the availability of funds in the short and long term is becoming increasingly limited. New methods of long-term conservation will need to be found and recent controversial work has included the reinstatement of roofs and wall plaster to ruined structures which once depended on these simple elements for durability.

This chapter will encourage an analytical approach by examining the various methods of undertaking condition surveys using illustrations of survey work to a range of ruins, including low-lying wall fragments, standing rubble walls and complete but roofless elevations.

Opposite page *St Lukes. Illustration from the Condition Report on the masonry facades of St Lukes Church, London (1727–1733), showing extensive settlement and structural intervention in the form of steel frame bracing, masonry repair and replacement and joint and fracture filling. The ruined church was fully adapted to a new use, and the external shell is now supported and protected, forming the home of the London Symphony Orchestra.*

Introduction

The intention is not to set down a prescriptive approach but to draw on the experience of the author in undertaking surveys to ruined structures. Architects and surveyors will create their own approach bearing in mind who will use the survey and always bearing in mind the conservator or crafts people who will be reading the schedule of work or drawings. Could they identify the location and scope of the defect easily? The scope and content of the final survey documents can be tailored to the end user. In many instances survey documents are prepared without considering who will need to use them. Clients, property managers and potential funders will not want to read the full details of the report but wish to obtain a comprehensive overview which includes cost and time implications and summarises future stages. Consents bodies, conservators, craftspeople and contractors will need to understand clearly the detail. For instance, if the condition survey is to be used as the basis for a future programme of work, then those who will be repairing or conserving individual elements are probably the most important.

This chapter is written primarily for the surveyor undertaking the ruin survey and the client intending to commission a survey by developing a survey brief.

The need for condition surveys

When funds available for the upkeep of ruins and monuments are becoming increasingly limited, it is particularly important to be clear about the contribution that condition surveys make to the long-term conservation of the site, and where they fall within the hierarchy of expenditure.

Condition surveys are a means of:

- Understanding the condition of the monument at a point in time
- Monitoring conditions over a period of time by review and analysis of past and present survey data
- Reviewing the success of past interventions such as adaptation and conservation and repair work
- Understanding the most cost-effective methods of conserving a monument in the medium and long term.

Condition surveys are the foundation of long-term conservation in its broadest terms. A history of condition surveys, starting with the archaeological excavation report and followed by the development of programmes of conservation and possibly adaptation, provides for essential understanding of success and failure. On this basis, future maintenance and care of the site can be progressively refined with the aim of minimising intervention and maximising cost-effectiveness.

Experience has shown that surveys are frequently commissioned without reference or access to a maintenance record; work is often needlessly or inappropriately carried out, resulting in unnecessary intervention to the historic fabric of the site and wasted resources.

Future sustainability of our historic sites is dependent on public support and interest. Many of our historic sites are under the guardianship of government agencies, local government authorities and non-government organisations (NGOs – charities, trusts, etc.) and unless they can demonstrate real public benefit the level of available funds will continue to diminish.

It is important that the aims and objectives of the condition survey are clearly understood and set down in the commissioning brief.

Stabilising or arresting accelerated decay of the site is of prime importance, but other objectives such as increasing legibility, visitor access and commercial opportunities (e.g. as a venue for public functions) may all be necessary and justifiable provided the physical conservation of the site remains of paramount importance. It is true that without fulfilling the public desire to visit the site or capitalise on the site's earning potential, the future may be uncertain, but a balance must be struck which tips in favour of the physical conservation of the fabric.

The special nature of masonry ruins

Ruins are very special places – they are fragmentary remains of an earlier culture, civilisation or way of life that, in most cases, no longer exists. They provide a window for the visitor to look through and to visualise how things had once been. They are often romantic places which appear impermanent and unspoilt by modern times. They can be a haven for wildlife, providing homes and sources of food for a variety of flora and fauna, often rare and of special scientific interest in their own right (Figure 3.1).

These perceptions and ideals of ruins as natural, unspoilt or romantic places within visitors' minds often create special challenges for the surveyor to leave intact (Figure 3.2). Most visitors like ruins to remain as ruins and do not wish them to appear clean and new, or obviously repaired in their appearance.

Ideally, the conservation strategy should seek to maintain the existing environment and natural balance, but there are occasions when intervention is necessary for the long-term well-being of the monument; when this occurs, programmes of work should be devised to leave a very light, almost imperceptible, footprint of repair on the site.

Figure 3.1 *Celtic settlement of Chysauster in Cornwall: sites can become home to a wide range of flora and fauna, increasing the diversity of interest and importance.*

Figure 3.2 *The Great Tower at Guildford Castle in Surrey: ruins are often romantic places which create special challenges for the surveyor to leave intact.*

Figure 3.3 *Soft wall capping has been found to be beneficial for the protection of standing wall remains, enhancing site ecology and providing a long-term, low-maintenance conservation solution.*

Recent review of the soft wall capping at sites within the United Kingdom[1] has generally found them to be beneficial (Figure 3.3). This is good news for the natural site ecology and will, it is hoped, provide a springboard for botanists and ecologists to become more frequently involved in the conservation of ruins and their sites (see Chapter 6).

The conservation and repair of masonry ruins occupies a very small and highly specialised sector of the construction industry with a limited number of projects completed annually, restricting the development and refinement of experience within the industry as a whole.

There is an increasing tendency to rebury archaeological ruins, since this is the most cost-effective way of preserving them. If we are to conserve ruins without reburial, we must consider how the remains can be protected in a cost-effective and sympathetic

Figure 3.4 *Mourneabbey, Cork, Republic of Ireland: the absence of protective roofs and wall plasters leaves ruined walls vulnerable to uncontrolled water ingress and invasive, destructive plant growth.*

way. The reinstatement of missing protective elements, such as roofs and wall plasters, should be considered as part of a long-term strategy.

What makes ruins uniquely vulnerable?

- Ruins usually lack protective elements such as roofs, wall plasters, harling coats, or even their original facings of stone or brick, allowing uncontrolled water ingress to the core of fabric (Figures 3.4–3.7).
- Exposure to the weather over prolonged periods without the benefit of protective elements often leads to decay characteristics which are either not seen in functioning buildings or are hidden and not easily identified. For example, alveolar weathering of stone is often associated with ancient structures where time and exposure to the effects of wind-driven sand or salts has created pockets of erosion in the masonry face (Figure 3.8). This pattern of decay is not normally associated with often younger functioning buildings and would not normally be within the experience of a designer or specifier of work to more modern buildings. Water ingress into a wall head over a prolonged period can create voids through the masonry core which have the potential to destabilise the wall and are frequently inconspicuous from visual inspection of the external wall face.
- Ruins frequently lack a maintenance record which permits monitoring and review of condition over the medium and long term.
- Ruins often lack sufficient funding and this funding often fluctuates with changes in political policy and public interest.
- Ruins can be situated in remote locations, which hinders access to the site and to high-level masonry elevations.
- Ruins may incorporate materials or construction techniques which are unusual and outside normal experience.
- The conservation and repair of ruins cannot consist of a single, isolated programme of work, but requires the same ongoing inspection and maintenance as any historic building; however, many projects are undertaken in isolation without any commitment to future funding or programmes of work. The surveyor must inform the guardians of a ruin about future site requirements, must seek to

Figure 3.5 *The West Front of the Priory Church, Newstead Abbey, Nottinghamshire: where protective roof coverings have been lost and cannot be reinstated, the ruin will often require more frequent monitoring and maintenance than protected elements.*

achieve long-term conservation objectives with limited funds, and should encourage guardians to look to the future by possibly setting up trust funds or endowments to finance future ongoing maintenance.

- Conservation and repair of ruins requires an understanding of specialist conservation techniques which may not be widely employed within the construction industry. It is often difficult to find suitably skilled personnel to undertake the work, particularly if such personnel are to be sourced locally, and it is difficult to establish proven track records of success. In some instances established conservation methods may not be appropriate, so the surveyor will need to form new ideas which should be centred on site-based investigation and testing, including mock-ups or exemplars where necessary.

Figure 3.6 *Newstead Abbey: the standing remains of the West Front of the Priory Church. The wall is now exposed on both the external and the internal elevations, increasing the potential for rainwater ingress and decay. Carefully considered and well-executed conservation work is required to reduce the maintenance burden, but maintenance and inspection levels of the masonry will always be comparable to, or exceed, those of a building with protective elements still in place.*

The influence of condition surveys on the well-being of the site

Condition surveys can be highly influential documents with a profound effect on the future of the site. It is therefore important that the appointment of the surveyor be carefully considered and based on a proven track record of relevant and successful experience. Selecting a professional practice of repute is insufficient; it is the individual who will be undertaking the survey, preparing the recommendations and specification that is essential, since this advice will directly influence future work (Figures 3.9 and 3.10; also see Chapter 5, Waterlow Park).

Survey should include review and discussion before final recommendations are formed – this is normally undertaken between co-workers, but in some instances wider review may be appropriate. Misplaced recommendations can and have frequently had a detrimental affect on masonry ruins, leading to accelerated decay and early failure of both original fabric and repairs.

Figure 3.7 *Waterlow Park in London: ruined seventeenth century viewing platform with brick piers, part of a formal garden landscape. Lack of maintenance to the structure and surrounding garden led to the partial collapse of the wall and loss of the wrought iron screen and decorative sculpture.*

Specifying appropriate conservation work

Policies of minimum intervention should be adopted wherever possible, but this approach should not be confused or advocated solely on the basis of idealistic principles, but must be tempered with sound practical experience. A balance must be struck and this needs to be guided by a developed understanding of how the ruin originally functioned within the natural environment as an intact building, and how this function has changed as the building has become a ruin. It is worth noting that in many cases the condition and rate of decay of a ruin stabilised when the remaining structure became naturally buried. Archaeological excavation and re-exposure of the ruin in an exposed climate will typically increase the levels of decay once again.

Historically, buildings were constructed as flexible structures using earth, lime or gypsum mortars in a composite construction which accommodated gradual movement. It is important that this flexibility be maintained or reinstated in any repair work. This can often be achieved by filling and deep tamping open joints with new earth, lime or gypsum mortars or by grouting voids within the wall with low-strength grouts based on hydraulic lime and bentonite. There is now a proven track record in using this approach – after all, buildings were historically repaired using materials that were locally sourced and closely matched the original materials.

Rigid repair solutions which advocate the use of stainless steel pins set in resin grouts, or reinforced concrete beams and buttresses are often problematic in the medium and long term since they create localised stiffness within the structure, resulting in pressure points which can cause cracking and displacement. These methods have often, in the past, been put forward as a 'minimal intervention' approach, and at first glance they may be more localised than grouting or repointing, but once installed they are very difficult to remove or reverse. If some form of localised strengthening is

Figure 3.8 *Alveolar weathering of White Mansfield sandstone. The age, weathering, and lack of maintenance and repair over the lifetime of a ruin are often associated with advanced patterns of decay.*

required this can be achieved using more sympathetic methods. Rigid stainless pins set in resin can be substituted by flexible wire stitches set in a hydraulic lime grout. Reinforced ordinary Portland cement concrete wall heads can be replaced, in certain circumstances, by reinforced hydraulic lime concrete. Hard mortar caps can be replaced with soft, organic wall caps.

Whenever considering recommendations as part of a condition survey it is important to base the advice on a thorough understanding of the functional design of the original building and the influence of decay upon the fabric. Recommendations must always be made with the long-term well-being of the site in mind.

Figure 3.9 *Waterlow Park: sixteenth and seventeenth century lower terrace garden walls after removal of invasive plant growth. The upper section of the wall had collapsed.*

The skill and experience of the 'surveyor'

The ideal surveyor of ruined structures would be an architect, building surveyor, craftsperson, archaeologist, materials analyst and ecologist all rolled into one. In reality, there are very few people who have all these skills. Many competent practitioners may possess detailed experience in possibly half of these fields, with some understanding of the other areas. In certain instances, the surveyor's skills will need to be supplemented by other consultants, such as ecologists, craftspeople and conservators.

A detailed understanding of building pathology, i.e. the causes and effects of building and materials decay, is essential. Condition survey is, in essence, an

Figure 3.10 *Waterlow Park: the lower terrace wall following conservation and repair. Condition survey had determined that the long-term survival of the wall was dependent on reinstating the missing wall head to shed rainwater and protect the brickwork below, but other significant benefits included improved legibility of the structure and enjoyment by the visiting public.*

investigation of failures caused by one or a number of mechanisms which may include: unresolved structural stresses, missing architectural elements, decay of materials caused by a number of environmental factors such as frost, thermal or moisture content functions, surface contamination, poor design, the use of past inappropriate materials or repair techniques in earlier repair work, or a change in the local environment.

Success of a condition survey is based on the development of an analytical understanding of the ruin and its site.

Required skills may include those of:

- Building surveyor – recording and analysis of decay patterns
- Archaeologist – to understand the significance and chronology of the site

- Historian – an understanding of social and political history
- Architectural historian – an understanding of style and detail
- Architect – understanding of architectural form and function but also how best to present and interpret, appreciate the monument and its site
- Structural engineer – understanding and interpretation of structural movement, distortion and cracking of the ruin
- Stonemason, plasterer, artisan
- Materials analyst.

The contractor as a consultant

Contractors are a valuable resource which should be used more widely during the survey process. Experienced contractors who specialise in the conservation and repair of historic buildings and ancient monuments can offer practical experience in the implementation and execution of repair work. Advice can be given on suitability and application of repair techniques, site access, programming and completion of the work, availability of resources, and cost budgets.

Early consultation with contractors during the survey process can bring efficiency and focus to a project by avoiding inappropriate selection of work methods or impractical programmes and costs.

The use of experienced contractors should not be seen as a challenge to the skill and experience of a surveyor but an added dimension which complements the surveyor's approach. Advice can be sought on a wide variety of subjects, including conservation and repair techniques, material selection, scope and implementation of work, feasibility of an approach, costs and programme. The contractor may, for instance, be a building conservator, an archaeologist, scaffolder or access supplier.

One of the most important and underused areas where a contractor can bring invaluable experience during the survey process is in site-based investigation. Visual inspection can frequently be enhanced by either non-invasive or invasive investigation. Even simple site investigation, such as removing later mortar repointing or a few facing stones, can provide a clearer understanding of the condition of the wall core, for example. Unless the wall core is in a sound condition there is little point carrying out superficial work to the external facings.

The contractor's involvement may be in several phases, starting with site investigation and moving on to trials to test ideas and feasibility of repair methods, for example grouting voids within a wall core or construction of soft wall cappings to protect exposed wall heads. Development of site trials into a sound and practical approach, demonstrated by an exemplar of work, will enable tendering contractors to see and understand exactly what is required.

Expenditure on commissioning a contractor as part of the consultancy team is normally cost-effective and frequently prevents delays on obtaining consent, tendering and commencing work on site. The contractor can be commissioned either as a subconsultant to the surveyor or as a direct commission to the client working under the direction of the surveyor.

Understanding the need for and availability of maintenance work

All structures need to be maintained. The long-term conservation of ruins is dependent on finding a balance between expensive conservation techniques which may be sacrificial, or offer limited short-term durability and long-term measures such as reinstating missing roofs or wall plasters.

Condition survey reports should not simply provide advice for the short term, but should consider the long-term future of the site. Even if the advice extends beyond the client brief it is important to at least plant the seed of an idea or commitment for the future with the guardians of the site to bring a realisation and prevent possible unproductive expenditure on short-term measures which may be of limited use.

Prerequisites for a condition survey

Removing plant growth

In all condition surveys, with the possible exception of a feasibility study, plant growth should be carefully removed as far as possible to reveal the condition of the underlying structure. Removing plant growth can, however, involve significant risk to the monument and to the personnel undertaking the task, so it should be cautiously undertaken with only surface growth removed. Plant growth within the wall should be left and only removed as part of the programme of conservation and repair. In some cases removal will result in localised collapse. Small-scale plant growth can often be removed by the surveyor undertaking the survey. More extensive growth should be removed in advance of the survey under the direction of

Figure 3.11 *Detail of masonry wall at Rushen Abbey on the Isle of Man. Invasive plant growth should only be removed from the monument under the supervision of the conservation architect or surveyor to avoid further damage.*

the surveyor (but see Chapters 4 and 6). Natural or intended soft wall cappings, other plant-based protective coverings and plants of special or scientific interest should be removed where possible, and reinstated once the condition survey has been completed. In some cases the advice of an ecologist should be sought and plants only removed under their supervision.

Access

The success and value of a survey often depends significantly on the type of access available. Good access will produce more reliable results than poor or limited access. Access to remote sites can present unique challenges. Access to high-level masonry can be difficult to achieve but without undertaking this work the benefits of the survey will be greatly reduced. How access is to be achieved should not be left to the surveyor who is tendering for the condition survey work. Methods and possibly the design of site access should be predetermined so that genuinely competitive tenders are received. Access can be one of the most expensive elements of a condition survey and differing proposals for access arrangements can distort the relative cost benefits of tender submission.

Site-based investigation

Site investigation is not normally a prerequisite to a condition survey but may follow an initial feasibility survey which has defined the need for investigation work, such as trial pits. Reference to archaeological excavation reports, where they are available, frequently provides valuable information which may reduce the need for further investigation work.

Documentary research

Recommendations for future repair and conservation work should avoid obscuring archaeological evidence wherever possible. The surveyor therefore needs a developed understanding of the architectural and archaeological significance of the structure so that informed decisions can be made. Review of past and current archaeological reports is an important part of the initial research process and may provide important information on the condition of the site at the point of excavation.

Reviewing extant survey reports

Where sites have been excavated some time ago, past phases of conservation and repair and maintenance work will usually have been undertaken and reference to this past work is invaluable. Reference to records of past survey and repair will help to understand the rate of ongoing deterioration, the success of past repair methods and any future requirements. However, it is a regrettable fact that post-excavation maintenance is sometimes minimal or non-existent, and that records may be sketchy or missing. In these situations experience in recognising past intervention becomes particularly important.

Elevation drawings and photographic records

Condition surveys can produce large volumes of data which are difficult to understand. Graphic presentation of survey information by annotating drawings or photographs is a good way to present a clear overview of the general condition. Presentation methods and formats of condition surveys are discussed in greater detail at the end of this chapter.

Survey limitations

It is important to understand what can be achieved by a condition survey and why it is carried out. Condition surveys cannot provide a totally accurate account of the condition and extent of repair work which is necessary. They should, however, be as comprehensive an assessment of condition and scope of repair as possible to reduce unknown or unanticipated future failures and expenditure.

Condition surveys rely overwhelmingly on visual inspection and analysis, and to a very limited extent on equipment and scientific analysis. This is why it is so important to commission a surveyor who has a proven and demonstrable track record of relevant experience.

Visual analysis is, of course, limited to surface evidence, but experience recognises and can often interpret superficial indicators such as fracturing and local areas of decay. As a survey progresses, the evidence often builds up in such a way that accurate predictions can be made.

Table 3.1 Typical accuracy of various survey methods

Survey type	*Level of accuracy (%)*	*Level of contingency (%)*
Ground level survey	50–70	30–50
Close inspection	70–90	10–30
Close inspection with site-based investigation	80–90	10–20

Ground-level surveys are severely limited by remoteness from the subject. Using binoculars or a field scope increases the detail which can be seen, but this remains two-dimensional. Two-dimensional images can severely limit perception and understanding. On a practical note, holding binoculars for a day is extremely fatiguing and progress can be slow.

Visual survey becomes much more useful with proximity to the subject. Seeing detail in three dimensions and being able to touch and feel surfaces increases understanding of the condition very significantly. Close inspection using access facilities such as scaffolding or aerial access platforms is always desirable and will enable a more accurate understanding of the condition of the buildings to be reached at an early stage in the project.

Table 3.1 illustrates the level of accuracy which may be anticipated with different survey types based on field experience. The level of accuracy increases with close inspection and site investigation. Where lower levels of accuracy are achieved, higher contingency sums should be allowed for the unknown.

Basic surveys

Ground-level surveys (basic or preliminary surveys)

A basic survey is a useful tool providing an overview of the condition of a site, normally as a preliminary stage in a wider programme of survey and investigation. Basic surveys are also frequently undertaken where work is carried out adjacent to a ruin, for example in the construction of a visitor centre, where it is necessary to record and monitor the condition of the ruin before and during construction. A basic survey is typically comparatively inexpensive to undertake and can limit expenditure in the early stages of a project, which may not proceed further.

Ground-level surveys are often used for a simple (limited) scope of work – for example, to understand the condition of a single section of a ruined structure and plan for a small package of conservation work. They can also be used where a monument is regularly maintained and the aim of the condition survey is one of monitoring past repair and conservation work. For masonry ruins a basic survey is not normally particularly useful because of the limited access from ground level. Budget constraints should not dictate the type of survey; a more appropriate type for ruins is typically a detailed condition survey, particularly where a programme of conservation and repair is planned.

Feasibility studies (options appraisal)

A feasibility study, also commonly described as an options appraisal, is a useful tool to explore various options for repair, adaptation or presentation of a site. An options appraisal may also be used to investigate the need for a more detailed condition survey, which may include phases of research and site-based investigation. The study would normally commence with a limited amount of background research to identify the broad history of the site; this may, for instance, include social history and architectural history. Feasibility studies are useful when considering ways of protecting a vulnerable site, or creating new visitor access or facilities.

Feasibility studies would normally be undertaken from ground level, but closer access can be specified in the client brief, dependent again on the project objectives.

Example of report content:

- Summary
- Client brief – it is always advisable to include the client brief within the report, since it places the report in context for future readers who may be unfamiliar with the project
- Historical background – based on research into the social and architectural history of the site
- Options appraisal – discussion of the various options for repair, alteration, reuse or presentation of the site
- Condition assessment – a broad assessment of condition usually based on ground-level inspection, identifying the general levels of decay rather than specific detail
- Conclusions – summarising conclusions which can be drawn from the appraisal
- Recommendations – recommendations for the way forward.

Optional work can frequently include:

- Budget costs
- Reports by other specialist subconsultants, such as ecology, paint research
- Preliminary or conceptual design work.

Property management surveys

Quadrennial and quinquennial surveys

Quadrennial or quinquennial surveys are undertaken on a four- or five-yearly cyclical basis, and are used to monitor condition and undertake maintenance and repair work on a planned and preventative basis. They may identify the need for a major programme of conservation work, but they should not be used to identify or quantify the full scope of defects and methods of repair which are necessary for programmes of conservation and repair. The format and content of quinquennial surveys are normally set out by the property owner, such as local and central government authorities and non-government organisations, who have a large portfolio of properties and sites in their care. Quinquennial survey reports normally identify key defects using a descriptive account rather than scheduling and quantifying individual defects. A quinquennial report also normally requires an assessment of the progress of decay or deterioration, the success of past repair work and a note of outstanding work by comparison with the previous survey report. A quinquennial survey regime is very useful for the long-term management of a site, since it allows property managers to accurately assess and monitor the decay of a site and the possible impact of visitors. They are, however, distinct from detailed condition surveys, since they do not go into as much detail and do not aim to schedule each and every defect. The report content is similar to a detailed condition survey but would normally exclude a schedule of defects.

Comprehensive surveys

Detailed surveys (building survey or fabric survey)

Detailed surveys are normally undertaken when the condition of a site is not well understood, for example where maintenance records do not exist, or

Table 3.2 Example of the content of a detailed condition survey report

1.0	**Report Summary**	
	1.1	Schedule of the Structures included in the Survey
	1.2	Description of the Structures
	1.3	Construction and Materials
	1.4	Inaccessible Parts
	1.5	Summary of General Condition
	1.6	Recommendations for Further Investigation
	1.7	Recommendations for Further Specialist Advice
2.0	**Description of Defects – Structures**	
	2.1	Masonry Walls
	2.2	Floors
	2.3	Surfaces Finishes
	2.4	Protective Structures/Coverings
	2.5	Past Repairs
3.0	**Description of Defects – The Site**	
	3.1	Landscape
	3.2	Invasive Plant Growth
	3.3	Site Drainage
	3.4	Visitor Impact
4.0	**Description of Defects – Services**	
	4.1	Electrical Supplies and Fixed Installations
	4.2	Fuel Supplies and Heating Installations
5.0	**Recommendations**	
	5.1	For Immediate Action
	5.2	For Completion within Two Years
	5.3	For Completion within Five Years
	5.4	For Completion within Ten Years
	5.5	Monitoring Work
	5.6	Adequacy of Routine Maintenance
	Appendices	
	1	Schedule of Defects
	2	Photographs
	3	Survey Drawings
	4	Preliminary Specifications

where they are vague or incomplete. Alternatively they are used where a comprehensive programme of conservation and repair is planned.

Detailed surveys are commonly referred to as *building surveys*, *building fabric condition surveys* or *fabric surveys*, and consist of a detailed visual inspection of all elements of building fabric and frequently its surrounding site. Comprehensive surveys can also be described as a 'stone-by-stone' inspection, indicating that a high level of detail is required. Since this type of survey is intended to be comprehensive in nature, it is normally based on close inspection using either scaffolding or aerial access platforms (mobile elevated work platforms). The survey document would normally include a descriptive account of the condition, the principal defects and their causes, and a detailed schedule or tabulated record of individual defects with recommendations for repair. The typical report content for a detailed building fabric survey is shown in Figure 3.2. This, of course, would be adapted to suit the monument and its site and the survey objectives. A more detailed account of the schedule of defects is included later in this chapter.

Detailed condition surveys will aim to provide a comprehensive understanding of the condition of the ruin, but they can also include further optional work, which may be deemed necessary to provide a comprehensive understanding and to meet client requirements.

Examples of optional work include:

- Tabulated record of all defects, including proposals for repair and conservation.
- Invasive site investigation involving removal of stones, mortar joints, etc.
- Non-destructive investigation, possibly including scanning to detect the presence of iron cramps, thermal imaging to map the pattern/path of water ingress, or ground penetrating radar used in some instances to detect subsurface voids, for example hypocaust systems.
- Camera survey and testing of drainage.
- Electrical testing of appliances, for example site lighting, etc.
- Material sampling, for example mortar analysis, petrographic analysis of stone types.
- Production of record drawings. Record drawings are a very useful resource to assist in understanding the condition of the monument, to aid interpretation, and to record the location and extent of defects.

Schedule of defects

A schedule of defects is simply a tabulated record of every individual defect identified by the survey (Figures 3.12 and 3.13). The record would normally contain the information shown in Table 3.3.

Site-based investigation

Site-based investigation can be very useful to establish methods of construction, to check, validate or clarify theories for causes of decay, or to investigate and establish archaeological evidence. Site investigation can either be invasive (for example, involve temporary removal of fabric such as the deconstruction of part of a wall head to reveal the condition of the wall core construction beneath) or non-invasive (such as thermal imaging to indicate the presence of voids within a wall). Invasive investigation is frequently discouraged in favour of non-invasive investigation but, in fact, carefully thought out invasive investigation undertaken by experienced personnel can produce much more relevant information and understanding, providing a valuable insight into the nature of any repair work which may be necessary. The scope of investigation work must, of course, be carefully controlled to minimise intervention. It is very important that any investigation work be accurately and comprehensively recorded and the record kept with the site maintenance file. It is frequently the case that phases of survey and investigation work are repeated time after time, without reference to earlier condition survey reports, leading to unnecessary work and loss of original fabric.

Structural surveys

There are occasions when structural assessment beyond the training and skill of the surveyor will be necessary. In these cases a structural engineer should be appointed as part of the condition survey brief to advise the surveyor and produce a supplementary report. The structural engineer, like the surveyor, should have a demonstrable track record of relevant skill and experience, since any repair should aim to maintain the qualities of the original construction, which are typically flexible structures, quite unlike modern rigid or semi-rigid structures (see Chapter 2).

The timing of a condition survey

Detailed condition surveys should be carried out at the earliest opportunity, either before project conception or at the start of the project design stage. Detailed condition surveys should not be left until a contractor has been appointed to carry out the programme of conservation and repair or when access scaffolding has been erected for the work. This is far too late and will bring increased risk of delay and cost increase while a contractor is waiting for the scope of work to be confirmed and access scaffold is erected. It is often argued that detailed surveys should be undertaken either by the designer (surveyor, architect or conservation consultant) once access scaffolding has been erected by the contractor or once the consultant has been appointed to carry out the conservation and repair work. This approach is fraught with danger and uncertainty. It is normally much more cost-effective to carry out a detailed condition survey as a preliminary task before tender documents are written and the contractor has been appointed.

Analytical approach

Condition survey of masonry ruins has the same foundations as condition surveys to any form of building or structure. That is, to gain an understanding of

SCHEDULE OF DEFECTS

St Luke's Church, Old Street, London EC1

Elevation: - South Elevation of the Porch | **Drawing No: - 360.56/ELV/03** | **Survey Issue/Revision: - A** | **Date: - 15 March 2002**

Item	Grid Ref	Defect and Location	Repair Type	Size (mm) / Quantity (m²) length x depth x height	Comments	Repair Priority	REV'
			MG				
55	A4	Widened/open lead caulked joint to the cornice	GR	1200 girth		1	A
56	A4	Open and failing mortar joints to the face of the cornice	GR + RP	4no. 1200 2no. 300		1	A
57	A4	Minor decay of an isolated ashlar stone next to a perpend joint above the oculus	MR	50 x 400		2	A
58	A4/5	Open and fractured mortar joints with minor displacement of the masonry; fracturing located on the ashlar masonry and oculus	GR	6Lm x <12mm	Masonry to be grouted using a hand pump following the guidance given on sketch IC/SLC/GR-01. Location of grouting holes to be agreed on site with conservation advisor	1	A
59	A5/6	Decay of mortar joints with displacement of ashlar	GR	4Lm	Masonry to be grouted using a hand pump following the guidance given on sketch IC/SLC/GR-01. Location of grouting holes to be agreed on site with conservation advisor	1	A
60	A6	Diagonal fracture in the ashlar masonry where movement and displacement have occurred	GR	400		1	A
61	A6	Minor spalling of perpend joint of door entablature	L	2no. 100 x 20		-	-
62	A6	Minor spalling to fascia of door entablature	MR	140 x 70		3	A
63	A6	Redundant fixings in ashlar with minor surface spalling	REM + MR	150 x 250 75 x 75 50 x 50		2	A
64	A6	Minor pinch spalling of ashlar masonry	L	100 x 100 50 x 50		-	-
65	A6	Redundant iron ring bolts in ashlar masonry	REM + MR	70 x 70 90 x 70		2	A
66	A4	Iron fixing in the head of the oculus	REM + MG	20 x 5		2	A
67	A4	Failing cement mortar filling to spalling along the rear arris of the oculus surround	MR	100 x 30 200 x 30		2	A

Ingram Consultancy

Figure 3.12 *St Luke's Church in London. An example of a tabulated 'schedule of defects' from a detailed condition survey. The schedule formed the basis for a phased programme of conservation work.*

SCHEDULE OF DEFECTS

Newstead Priory Church West Front

Elevation: - **North end and West face of the West Front**

Drawing No: - IC/22001/ELV/01

Survey Issue/Revision: - A
Date: - 12 June 2002

Item	Grid Ref	Architectural Description Defect and location	Repair type	Quantity (m², No. Lm)	Size (mm) length x depth x height	Comments	Repair Priority
		Façade Element: Pinnacles and Buttress Gablets					
		Grid Areas: A6/7 to J6/7					
		Architectural Description:					
		Rising from each of the four buttresses are pinnacles, hexagonal in plan, ornamented with crockets, gablets with trefoil blind tracery and grotesques. Figural masks form head stops at the terminus of the pinnacle corner ribs to the front face of the parapet. The buttresses are terminated by simple gablets with poppy head finials.					
		Defects and Locations:					
1	A6/7 to J6/7	**Pinnacles [soiling]:** Extensive organic growths of lichen, moss and other microflora conceal and disguise the condition of the masonry and mortar joints. Atmospheric soiling (black soil crusts) is not evident. Surfaces are likely to be fragile in areas where contour scaling has developed. Ongoing fracturing and detachment of crockets and weathered detail is evident	S CL	4no.	Approx. overall size of each pinnacle 1.3 x 1.3 x 1.7m	The pinnacles include the buttress gablets and figural masks down to the parapet string course to both front and back faces. Cleaning of the grotesques and figural masks is described as separate items. Note: some pinning and grouting of fractures may be required during the course of cleaning to stabilise failing detail	2
	A6/7 to J6/7	**Pinnacles [decay]:** the true condition of the pinnacles is masked by heavy organic growth and is unclear. Visual inspection indicates that fine fissures and fractures have developed on some of the ornamented detail, which has resulted in detachment and loss. Detachment of contour scales (3 to 5mm thick) and thinner papery scales is ongoing. Erosion of soft beds to the face of many of the gablets has resulted in the loss of detail, although a significant amount remains. The finials to many of the pinnacle gablets have been lost with the resulting 'shelf' encouraging water to pond and migrate into the stone. The apex stones of all four pinnacles are replacements with crude, simplified detail. Many of the mortar joints have been repointed with cement mortars. A corroding iron band projects from pinnacle P2 in the bed joint below the replacement apex stone.					
2		• Contour scaling and papery scales to flat masonry detail	TO + TE + RB	4no.	Approx. overall size of each pinnacle 1.3 x 1.3 x 1.7m		2
3		• Contour scaling and papery scales to ornamented detail	GR CS	4no.	Approx. overall size of each pinnacle 1.3 x 1.3 x 1.7m		2
4		• Fracturing of ornamented detail	ST + GR	20no.	200mm each	Provisional item	2
5		• Missing gablet apex stone and finial (incl. 1no. heavily decayed)	RPL CS	19no.	350 x 350 x 500	Provisional item	2
6		• Cement mortar joints	REM + RP	250Lm	-		2
7		• Corroding iron band	REM + PI	1no.	-		2
8		• Existing poorly carved replacement pinnacle apex stones	L	-	-		-
9	A6/7 to J6/7	**Grotesques [soiling]:** Extensive organic growth, as described for the pinnacles, is present on all grotesques and masks their true condition. Inspection indicates that many of the grotesques, whilst structurally stable at present, have numerous bands of erosion and surface fracturing along the natural stone bed. The surface detail to many grotesques is fragile with detachment of thin surface layers of stone and paper scales which threatens loss of remaining detail	GR CS + DMR + S CL	24no.	Approx. 700 x 500 x 300 each	Each pinnacle is hexagonal in plan with a grotesque projecting from each corner rib below each gablet. Grouting and consolidation of contour scaling and surface fractures will be required in advance and during cleaning to conserve detail	2
10	A6/7 to J6/7	**Grotesques [decay]:** Inspection of the heavily soiled surfaces indicates that whilst structurally stable at present, many of the grotesques have quite fragile surfaces with ongoing loss of detail through detachment of contour scales and thin papery scales. Ongoing erosion of soft beds is causing	GR CS + DMR (CONS)	24no.	Approx. 700 x 500 x 300 each	Allow Provisional Sum of 8 Hours for each grotesque for further conservation and repair following cleaning and consolidation of	2

Photograph and Drawing Details

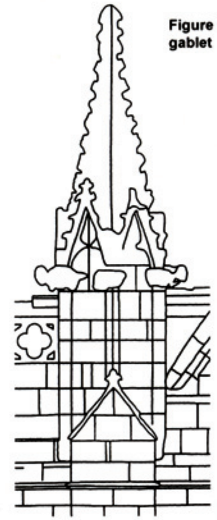

Figure 1: Pinnacle and buttress gablet

Figure 2: Detail of pinnacle ornament

Figure 3: View of pinnacle P1 looking north

Appendix 3 – page 3

Figure 3.13 *The West Front of the Priory Church at Newstead Abbey. For structures with complex decay mechanisms requiring a variety of conservations and repair solutions, tabulated schedules of defects can be illustrated with drawings and photographs to assist in conveying information and understanding.*

Table 3.3 Information contained in a schedule of defects record

Item	*The defect number to permit easy referencing*
Location or grid reference	Condition surveys can frequently identify hundreds or thousands of defects so it is important that the location of each individual defect can be easily found by future users of the condition survey report. See *Survey drawings*
Element and defect description	Describe briefly the architectural element, possibly its construction if this adds to the understanding of the decay character or the method by which it will be repaired and then a description of the defect and its cause. The description should be succinct and relevant. See *Report format*
Recommended repair	A schedule of defects should always include repair recommendations. It is easier to identify a repair approach at the time of a survey with an informed mind than at a later date when the report has been submitted and subsequent users are trying to identify a repair type
Size and quantity	The size of the defect, or the repair, and the quantity should always be included. Unfortunately, many surveys seem to lack this information, reducing their accuracy and worth, creating uncertainty in planning for subsequent work
Comments/additional information	It is always good to include this extra column for any information that may be relevant to the individual item
Photo reference	Include the reference number of photographic illustration
Repair priority	Include the priority – for example, immediate, within 2 years, within 5 years, within 10 years

the condition, the rate of decay and relative performance of the materials over time by a process of visual analysis. Additional analysis can be undertaken using a combination of techniques, such as laboratory testing and comparison of data from a series of condition survey reports, but condition assessment will largely be based on visual inspection of the building fabric on site.

An analytical approach leads to a comprehensive understanding of the monument, its condition and its conservation requirements.

The starting point is an understanding of the form and function of the monument. Ideally, this should include both architectural and social form and function, its construction, and its history of disuse and decay. Often, monuments are in a ruined condition and gaining an understanding of the original form and function is necessary to interpret their condition and establish the range of conservation measures that are appropriate. It is often the case that much of the original evidence has been lost or radically reduced by decay. Cross-referencing similar sites is often necessary.

Analysis of the structural condition of a ruined building requires a detailed understanding of its original complete form and how the loss of elements such as roofs, vaults, buttresses and towers has influenced its current state. Condition survey may determine that some reinstatement of collapsed or missing masonry is necessary to provide critical support, or wall head protection to ensure the sustainability of the monument.

An analytical approach will provide a detailed, considered awareness of the conservation and repair requirements. Within the report should always be a summary of the short-, medium- and long-term needs. If sacrificial treatments are to be used, the expected life of those treatments and the future requirements for inspection, monitoring and maintenance should be set out.

Approach to the survey of virgin sites

Sites that have not been subject to repair since the mid to late nineteenth century, before the advent of artificial Portland cement, are particularly special places, which are becoming increasingly rare in Western Europe. These sites could be described as ‘virgin sites’ because, although repair is commonly present, it is very likely to have been carried out using local materials and methods which closely match and are sympathetic to the original building fabric. It is a great privilege to work on these sites, where a great deal can be learnt for the benefit of the site, the conservation of masonry ruins in general, and the surveyor.

Condition survey of virgin sites will often require detailed site-based analysis to develop an intimate understanding of the original design, methods of construction and materials, and the type, purpose, methods and materials of subsequent repair work.

A controlled level of invasive investigation is frequently beneficial and would include removal of mortars for basic analysis on site and possibly more detailed analysis in a laboratory, removal of loose or displaced materials such as stones and plaster fragments for analysis and characterisation. Site-based analysis will frequently be supplemented by documentary research. It is important that the site be recorded sufficiently to record its special nature, but also to further contribute to the understanding of future conservation work.

Approach to previously repaired sites

There are a great number of sites where repair work has been carried out using cement-based mortars, grouts, concretes, resins and metal reinforcement. In some cases, these have been successful, or at least within the relatively short time period since the repairs have been carried out. There are, however, a significant number of sites where modern repair methods and material have had an adverse effect on the original fabric. It is important to establish as far as possible the site's repair history from documentary sources before starting the site-based survey. Past survey reports or documents from earlier phases of repair will provide a better understanding of where and when repair work has been undertaken than site inspection alone. With all condition survey work it is important to review the performance of past repair work and it is especially important to understand the impact of modern repair techniques. After all, modern repair materials and methods have a relatively short history of up to 150 years, whilst traditional materials and methods and repair work have a track record of centuries and in some cases millennia.

It is essential that the condition and performance of the original building fabric and later repair work be the basis for developing ideas and recommendations for future conservation work. It is essential to remember that the fabric is likely to have undergone many centuries of 'performance testing' with exposure to the environment, plundering and sometimes reuse. This is a significant test which should allow judgements to be made about the timescales and durability of the existing structure and new repair work. We have a comprehensive history of the durability of traditional materials (such as stone and lime), and we should therefore be confident that new repair work using lime, earth or gypsum mortars and local materials will last many centuries if correctly specified and carried out.

Understanding the significance of site archaeology

Conservation of the ruin is not confined to the preservation of the ruin or site as a whole, but also includes the conservation of its detail. During the course of the condition survey it is important to identify and understand the subtleties of detail and their contribution to the special interest of the site. Buildings' archaeology is an intrinsic part of condition survey of ruins and frequently condition survey will add to the archaeological understanding of the site.

Recommendations for conservation and repair should aim to preserve and enhance an understanding of a buildings' archaeology. At times difficult issues arise. Do you cover up or conceal detail from earlier phases or should you leave it exposed? Where restoration of detail is required, for example reinstatement of protective wall plasters, possibly essential for the long-term sustainable conservation of the site, what do you cover and what do you leave exposed? A balance must be struck based on a developed understanding of the site, its archaeology, architectural history, its significance and long-term conservation needs. In some cases it is preferable to cover up or protect vulnerable detail to ensure its long-term survival, where ongoing or new exposure to the environment will limit its future survival. The difficult question is how long will something survive if it is left exposed and will there be an unsustainable maintenance burden?

Developing an analytical approach

Before commencing the survey, prepare a checklist of the subject items to be covered in the survey. This will maintain a logical framework during the survey with helpful prompts to ensure that all items are covered. The scope of survey work can seem very complex and daunting, but by breaking the survey down into a series of logical elements or tasks it is possible to work progressively through manageable sections to develop a thorough and comprehensive analysis. It is surprising how a pattern of understanding develops when a series of observations link together the causes and effects of decay and the remedial action. Consider using identification marks or abbreviations in the survey notes to highlight significant or fundamental points which need further investigation during later stages of the condition survey or detailed discussion in the final report. For example, when carrying out the survey a series of questions need to be asked:

- What is the building? What is its date, function and type?
- How is it constructed?
- What are the materials?
- What is missing? For example, capping stones, roof, buttresses, etc.
- Which elements are significantly decayed?
- Are protective finishes missing, such as plaster or limewash?
- Are structural elements missing?
- Are weathering elements missing?
- What elements are significantly or dangerously decayed?
- What are the causes of decay?
- How have past repairs performed?
- What corrective action is necessary?
- What conservation and repair techniques are appropriate?
- What repair materials are required?

In general, the construction and architectural form need to be understood before analysing the type and causes of decay.

Decay is frequently caused by a combination of factors. Often, there is a primary or root cause and then several secondary causes or factors. For example, uncontrolled water ingress into a structure is considered a primary cause of decay since, without water, other decay mechanisms such as soluble salt crystallisation, freeze–thaw cycles or invasive plant growth would not occur. 'Controlled' water ingress, for example surface saturation in heavy rain, is normally acceptable provided the water can freely evaporate out of the structure during warmer, drier weather. Therefore, by addressing primary causes of decay many secondary mechanisms can be resolved or managed.

The next, often difficult, issue to resolve is how to record the scale or scope of the decay. For example, if salt-related decay is found in ten areas, should this be recorded as one item or ten separate items? This question can only really be answered by the person undertaking the survey and the approach will vary from one site to the next or even from one decay mechanism to another. In general, it is better to group the defects together within the written report under a summary of the zones and causes of decay, and to record the defects individually with the schedule of defects, so that future readers may see the scope and pattern of common defects and also be able to judge the rate of ongoing decay.

Adopting a methodical approach will provide certainty and confidence. A condition survey report should make a substantiated case for intervention where it is necessary.

Bite-sized chunks

With large surveys, for example a detailed survey of a complex of buildings, the survey should be carried out in 'bite-sized chunks'. The survey should commence with an overview of the whole site for familiarisation, but Phase 1 may be limited to a single building. Once this survey is complete and written up, the next building may be surveyed. Managing the survey process in this way prevents information overload, which easily occurs on large surveys due to the number and complexity of defects. Even large buildings such as ruined abbey churches or large bathhouse structures should be surveyed in manageable 'bite-sized chunks'. If subsequent surveys lead to revision of some initial ideas and proposals, these earlier surveys can then be amended. Requests to submit survey reports in several stages should be resisted, since later surveys and the development of understanding may influence views that have been expressed in earlier reports. The report should ideally be submitted as one homogeneous text or a series of volumes in one submission.

The ideal condition survey is carried out from access scaffolding, allowing sufficient time for consideration and revisiting the site before removing the scaffold. Survey carried out in conjunction with site investigation work will provide better understanding of the condition of the masonry core and other unseen areas. This will involve careful removal of mortar joints and isolated stones, and in some cases carrying out trial work such as grouting, to aid the understanding of the presence and distribution of voids within the wall and assess the potential success of grouting and consolidation work.

Access scaffolding

The accuracy of condition survey is greatly enhanced by close visual inspection. One of the easiest ways of achieving access at all levels across the ruin is to erect scaffolding (Figure 3.14). Scaffolding is very adaptable and can be constructed to accommodate unusual building forms. With suitable design it can overcome problems encountered with soft ground or obstacles at ground level which need to be bridged.

Figure 3.14 *Rushen Abbey on the Isle of Man. Access scaffolding should be considered as a means of providing close access for a condition survey. The closer the access, the greater degree of accuracy and certainty that can be achieved by condition survey.*

Scaffolding is a temporary structure which must be restrained to stop it moving, especially with wind load, and it must therefore be tied down for stability. Wherever possible, scaffolding should not be tied to the ruin using physical anchor ties which are drilled into the masonry nor ties that pass through openings and clamp to the structure. It is preferable that no loads be transferred onto the monument. Alternative methods for providing stability and restraint to temporary scaffoldings should be considered, such as buttressed scaffolds with Kentledge weight at their base or ground anchors to hold down the scaffold. Ground anchors are increasing in popularity since they can be permanently installed using stainless units that can be left in the ground and reused in the future, although they may have an impact on below-ground archaeology.

Scaffold is effective in providing close access and allows several people to work in one area at a time. The building elevations as a whole are slightly obscured by the scaffold framework, but this can be overcome with some agility by the surveyor, who at times may need to crouch or lie down on the scaffold to inspect items at platform level. Aerial access platforms do not obscure elevations in this way and can be easier to work with, but they frequently allow only a limited number of people to work in the platform. If drawings are to be produced as part of the survey these should ideally be completed before the scaffold is erected, since modern survey methods using theodolites and electronic distance measuring devices or rectified or stereo photography are much quicker to complete if the elevation is free of obstructions.

The use of scaffolding is normally limited not by the ground conditions or access around the ruin, but by the ability of the scaffold lorry to park in close proximity to the walls where scaffolding will be constructed. Scaffolding contractors are understandably reluctant to carry the equipment too far before it is erected. Vehicle access to the site is an important consideration and will undoubtedly be needed for later phases of conservation and repair, so temporary or permanent solutions may need to be put in place before survey work commences. On soft ground, temporary roads or trackways formed of purpose-made aluminium panels can be laid down and taken up on completion of the project. Where vehicle access is simply not possible, scaffolding equipment can be flown in using helicopters.

Aerial access platforms (mobile elevated work platforms or MEWPs)

Aerial access platforms are a convenient and usually cost-effective method of close access. Depending on the height of the ruin and the distance which needs to be bridged to reach the ruin (the outreach), machines can either be self-propelled or mounted on a lorry. Larger machines which achieve greater height and outreach are normally lorry mounted (Figure 3.15). Aerial access platforms, even small units which achieve a maximum height of 10 metres, are heavy in weight to counterbalance the load which is lifted. Mobile platforms therefore require a solid level ground (with no risk of subsurface voids) to operate from. It is important to anticipate the risk of voids in the ground surrounding the ruin and preliminary geomatic surveys using ground penetrating radar or resistivity are advisable if the make-up of the site is unclear. The route across the site must also be reasonably level and firm, otherwise a temporary roadway will be required.

The key advantage of aerial access platforms over scaffolding is their flexibility, especially the larger lorry-mounted machines. They can traverse obstructions in front of the ruin and even extend up over the ruin and drop down the other side to provide access across significant areas of vertical and horizontal elevations. They can even telescope down barrel vaults to inspect the underside of the vault, provided there is access for the platform and boom to safely enter. They avoid contact with the ruin but get close enough for the surveyor to touch the surface.

Surveys from aerial access platforms often demand greater discipline when adopting a methodical approach, due to the absence of scaffolding lifts, and horizontal reference points and close proximity to the building face, which can lead to disorientation. To avoid this, it is often useful to divide the building into horizontal bands following the lines of architectural mouldings, such as string courses, band courses, floor levels (defined by a line of windows), plinths, etc. It can be difficult and sometimes impossible to take this approach when dealing with plain masonry elevations, for example rubble walls without architectural detail. In these instances, orange string lines can be temporarily pinned into mortar joints across the elevation to provide horizontal reference lines to work to. When adopting this approach, set out the lines at two-metre spacing so that they approximate the position of scaffold levels for ease of reference for conservators who will need to locate the defects during a later programme of repair. In some cases it will be easier to survey a wall in vertical bands, but the survey data should be translated into horizontal bands in the office when the survey is written up. In this case orange string lines can simply be dropped down the wall face and retained in place by weights at the top and bottom (bricks or stones).

Ground level

Ground-level surveys provide limited access and therefore limited ability to identify defects or determine their causes. As far as possible, close inspection should be advocated.

Ladders and mobile access towers

Ladders are useful but limited, since they can only safely be used by two people, one person supporting the base of the ladder, and for a limited height. They should not be relied upon to provide detailed inspection above ground level but should only be used to supplement ground-level observations. Ladders are particularly problematic on ruin sites due to the nature of the surrounding ground, which is frequently uneven or soft, and the greater possibility of instability of the masonry at high level.

Mobile access towers can be useful for site-based investigation, but again their use is frequently limited by the ground conditions.

Tools and equipment

- *Clipboard*. A4 size for a note pad and checklist, and A3 size for the survey drawings. In wet weather clear plastic covers are needed to prevent damage and loss of valuable notes.
- *Hammer and a few sharp chisels*. Removing small sections of mortar for visual examination and

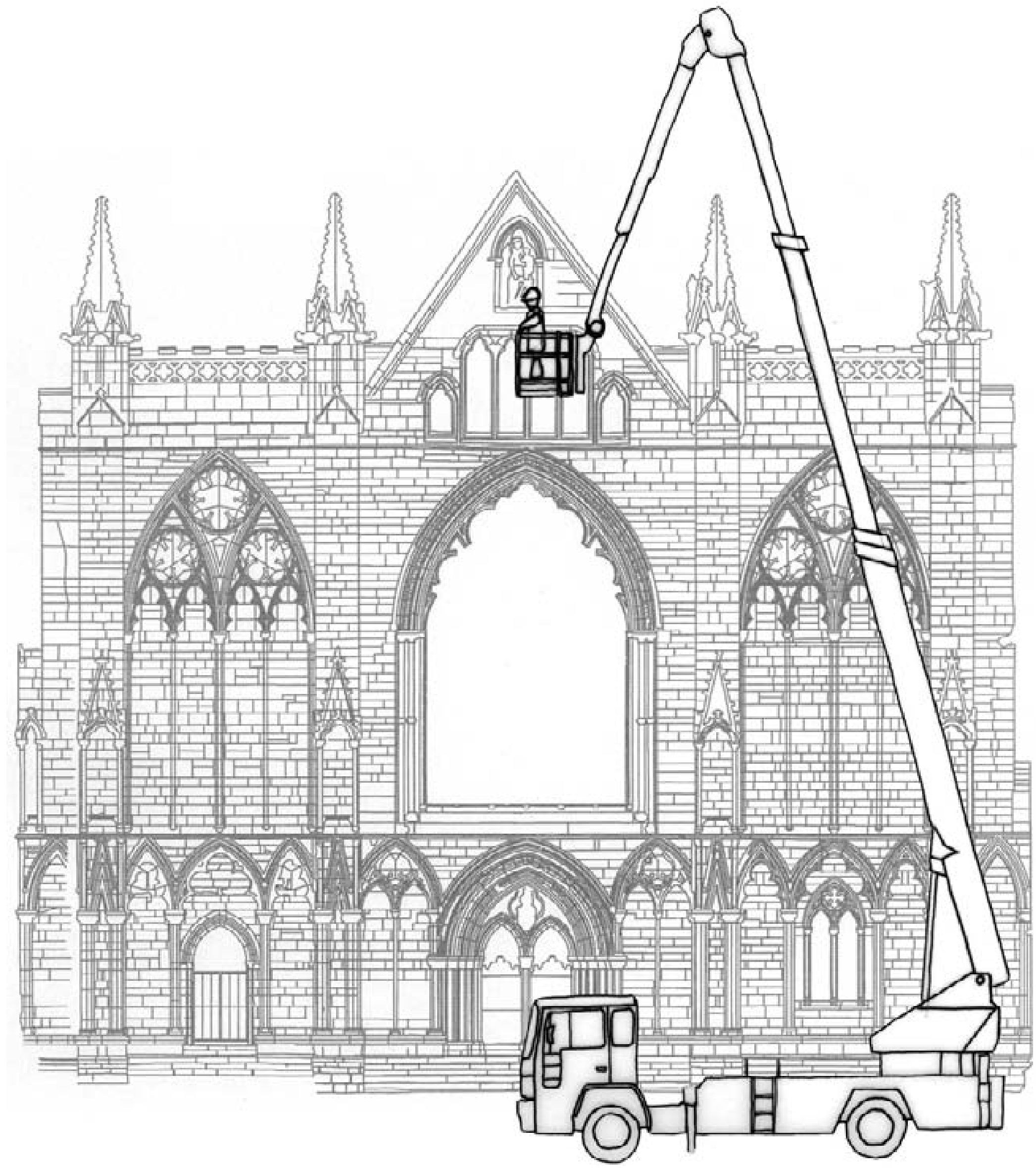

Figure 3.15 *Lorry-mounted aerial access platforms are frequently the most flexible means of providing access for close inspection. Large machines, which are more than adequate for the height of the monument, provide the additional ability to reach over obstructions in front of the monument and minimise the need to reposition the vehicle frequently during survey.*

possibly detailed analysis is often very useful in developing understanding of masonry conditions. Sharp chisels are also very useful to carefully scrape away surface soiling or decay to reveal the colour and composition of mortars. Care must be taken and only small quantities should be removed. Approval from statutory authorities should always be sought before removing anything from a protected site.

- *Hand-held* × *10 magnification lens* for site-based identification of materials to help build understanding, familiarity with different materials, especially mortar types, and for comparison of materials.

- A *knife or plasterers' small tool* is useful for carefully removing surface debris to investigate joints and voids.
- *Sample bags*. It is always advisable to carry a selection of sample bag sizes. They should be sealable and have space for writing a label so that provenance can be written directly onto the bag with a waterproof pen.
- *Tape measure*. A small three- or five-metre-long measuring tape is absolutely essential and a larger 30-metre tape desirable. A digital 'measuring tape' such as a Leica Disto is also extremely useful.
- A *torch* is essential for looking into dark corners and holes. Head torches are very handy, especially in poorly lit interiors, since they leave hands free to continue writing.
- *Camera*. Digital cameras are becoming increasingly popular and allow more efficient and flexible use of photographic illustrations with a report or survey drawings. A good-quality compact digital camera of at least five megapixels with a zoom lens from 28 to 100 mm is ideal. Digital SLR with a combination of wide-angle, zoom and telephoto lenses provides even greater opportunities for good-quality illustrations.
- A *small waterproof rucksack* to keep tools and survey information secure.
- *Walking boots or safety boots* are essential to protect ankles and provide support to feet and legs. They also reduce fatigue, which is a common problem when standing and surveying over consecutive days.
- *Sunglasses*. Not only desirable, but often essential, since they reduce fatigue and prevent eye strain on sunny days. Surveying light-coloured materials such as limestones, marbles and plaster on sunny days is particularly difficult without good-quality sunglasses.
- *Suitable clothing* for the particular site environment. Warm waterproof clothes for cold, wet climates. Long light clothing which is sun resistant for warm or hot climates and sunscreen. A wide-brimmed hat is absolutely essential in hot climates.
- *Lunch and drinks*. This may seem an unlikely equipment requirement but it is frequently forgotten and can save a significant amount of non-productive time if it is necessary to leave the site in search of sustenance. Always take a packed lunch with plenty of water and maybe a flask of hot coffee!
- *Personal protective equipment*. Depending on the condition of the site, a variety of personal protective equipment is essential. A comprehensive kitbag of safety equipment should always be taken on a survey, including as a minimum: safety helmet, high-visibility vest or safety jacket, safety boots, gloves, eye protection, eyewash, first aid kit, mobile telephone. For safety reasons it is important that site surveys should be undertaken by two people, especially at ruined sites or where access equipment is being used. Where sites are safe to allow surveys by a single person it is advisable to leave an itinerary with an office or home contact and to call in by telephone at regular intervals.

Methodology

It is good practice to develop and use a standard approach to condition survey. For example, carry out the inspection from left to right, working across the elevation in horizontal bands. Horizontal bands are ideally two metres high to match the standard height of access scaffolding, but this is frequently difficult to achieve when working from aerial access platforms or with ground-level access. In these instances use horizontal architectural lines, such as string courses, window sills and heads to define horizontal bands (see Figure 3.16). To assist with identifying the location of defects, vertical grid lines should be superimposed onto the elevation. Again, these can follow vertical architectural features such as columns, piers, buttresses or window and door openings. On long monolithic wall elevations which are devoid of architectural features, for example rubble stone walls, this is challenging and can only be practically achieved by dropping string lines down the façade at predetermined intervals, for example at two-metre centres.

When surveying wall heads the same approach should be used but the vertical face of the wall head should be inspected at the same time, at least to a one-metre zone to assess the condition. Decay of wall heads is seldom limited to the horizontal surface. It is important to survey the sky surface and both vertical faces. It is often useful to inspect the complete wall head with both vertical faces at an early stage, since this will build understanding of overall conditions and provide insight into decay patterns further down the wall face.

Survey of low-lying wall remains is undertaken in a similar way, working systematically along the wall, but the much lower vertical height can often be covered in one pass.

Survey of floors is undertaken following the same discipline of working from left to right and top to bottom. Start in the top left-hand corner and work in bands across the floor. Floors allow greater flexibility since you can superimpose a grid line across the floor using either orange string or survey ranging poles carefully laid onto the floor surface.

Survey drawings

Elevation and plan drawings are an invaluable asset in clearly conveying survey information. As a minimum they can clarify location by either identification of a defect marked on the drawing or by reference to a survey grid that has been superimposed onto the drawing. Annotation of defects onto drawings using shading and hatching also conveys the condition of the building and scope of work that may be required, and is useful in discussions with the client, other consultants or a consent-granting body that may not have first-hand experience of the condition of the site. In many instances it may not be possible to identify every individual defect on elevation drawings, since the large number would create an overly complex, possibly illegible, drawing. The use of survey grids is preferable, possibly combined with a separate drawing to show the principal decay patterns. Defect reference numbers can also be annotated onto the survey drawings, but again this frequently creates an overly complex or confused drawing. It is also worth considering the cost of annotating drawings. Survey grids are more cost-effective to produce than detailed annotated drawings and have been successfully used to direct conservators to defect locations to undertake repairs (Figures 3.16–3.18).

Where drawings are extant these should be made available to the surveyor before commencement of the survey so that they may be prepared in advance of the site inspection. If drawings do not exist, the preparation of simple sketch elevations that are not to scale can help to identify defect locations and orientate the reader of the condition survey report. The preparation of either accurate survey drawings or sketches should be encouraged as part of the condition survey brief.

Annotated survey drawings constitute a valuable addition to the property maintenance file and are a useful visual indicator of how the condition of a ruin has stabilised or deteriorated over time.

Rectified photographs

In the absence of line drawings, rectified photographs of the elevations of a ruin can be used to identify the location and scope of defects (Figure 3.19). In general, they are more useful to superimpose survey grids onto than for annotation of defects, since the level of detail in a photograph can prevent clear identification of individual repairs; they can, however, be used to indicate the general scope of recommendations, for example locations where repair to wall heads is required or where repointing or grouting of fractures is necessary. Aerial photographs can be used in place of site plans, especially where low-level wall remnants exist.

If rectified photographic elevations exist as well as line drawings, the surveyor will benefit from using both, since the photographs will provide a visual record of the appearance of the ruin at a point in time.

Where the production of survey drawings will form part of the client brief for a condition survey, it is also useful to consider commissioning rectified photography as part of the drawing production. Rectified or stereo photography can reduce the time needed on site to obtain survey data by reducing the need to take levels and survey targets across the ruin. Scaled line drawings are then produced by tracing over the rectified photographic image, which is imported into a computer-aided design package. Greater accuracy is achieved by specialist surveying companies using stereo images that are accurately traced over using a combination of specialist machines and software.

Three-dimensional scanners have also brought significant benefits to the production of scaled line drawings and are becoming increasingly accurate and capable of identifying points in space on a 10 mm × 10 mm grid. They can also provide three-dimensional models that illustrate distortion and lean in ruins and surrounding typography, which in the right circumstances can bring valuable clarity to the condition of the ruin in the local environment. These models can also be developed to aid presentation of the site to visitors.

Where digital data is produced this should always be supplied in a format that is commonly used, such as AutoCAD.dwg format or .dxf format.

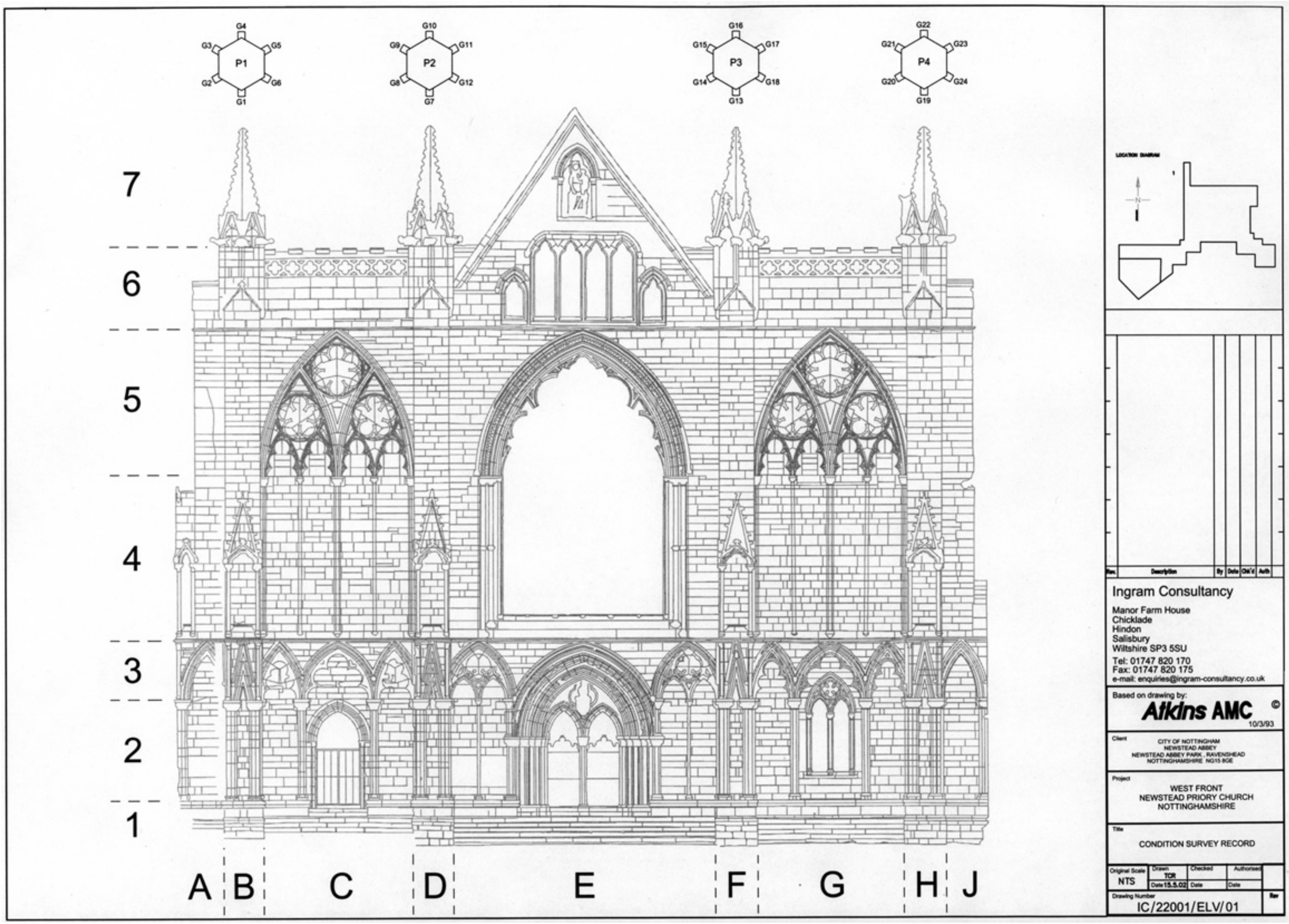

Figure 3.16 *Newstead Abbey West Front. An example of a condition survey drawing overlaid with grid lines to locate defects within a small, identifiable area. The plan layout of the finials has also been added to the drawing so that each grotesque sculpture can be numbered and referenced.*

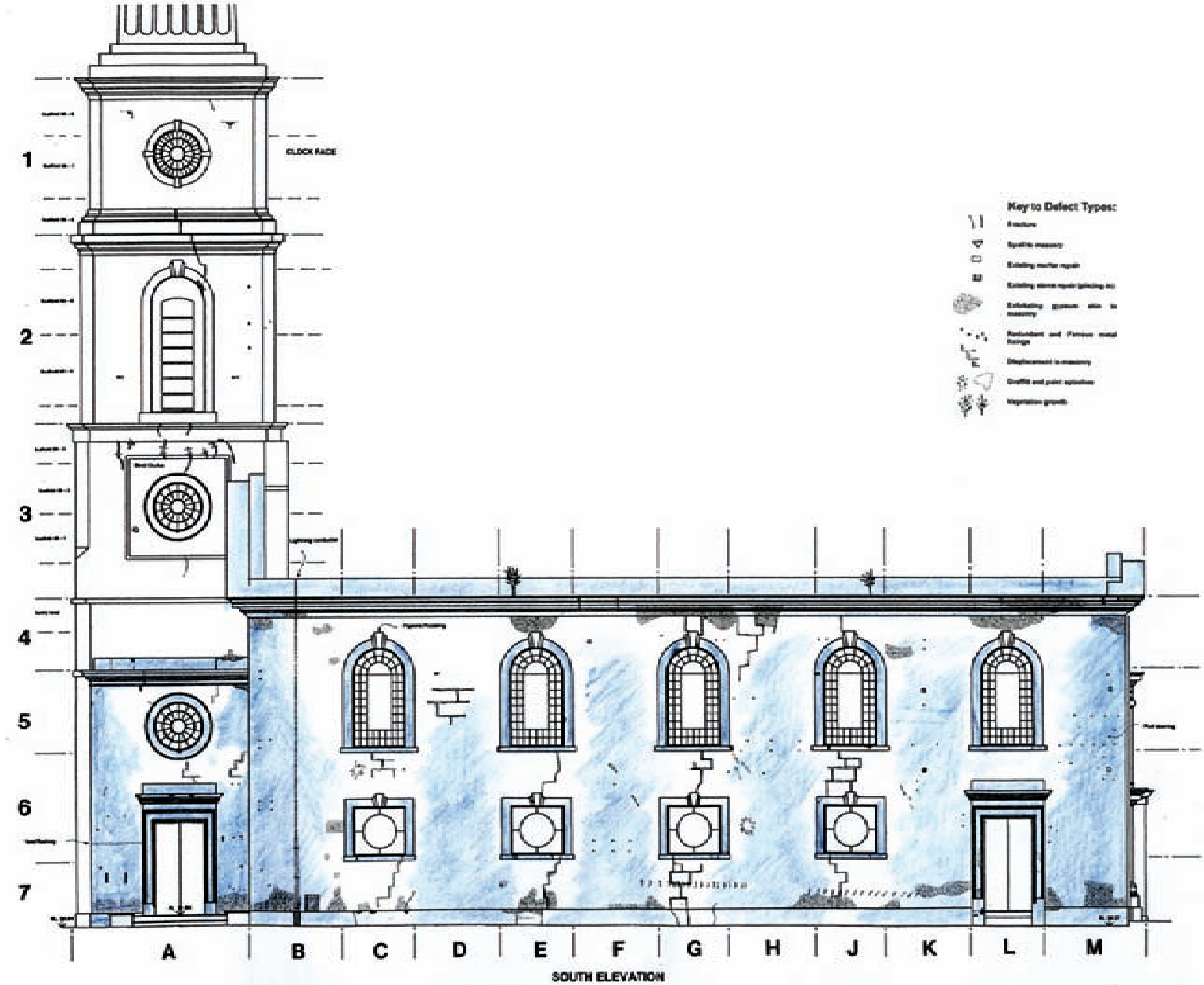

Figure 3.17 *St Luke's Church in London. A condition survey drawing with grid lines. In this example key defects have been annotated into the drawing to convey the scope of repair. Blue shading represents areas of stonework which are well bonded to the brick structure behind. Areas of white represent voids behind the stonework which require grouting. The tower was not included in the sway of masonry voids.*

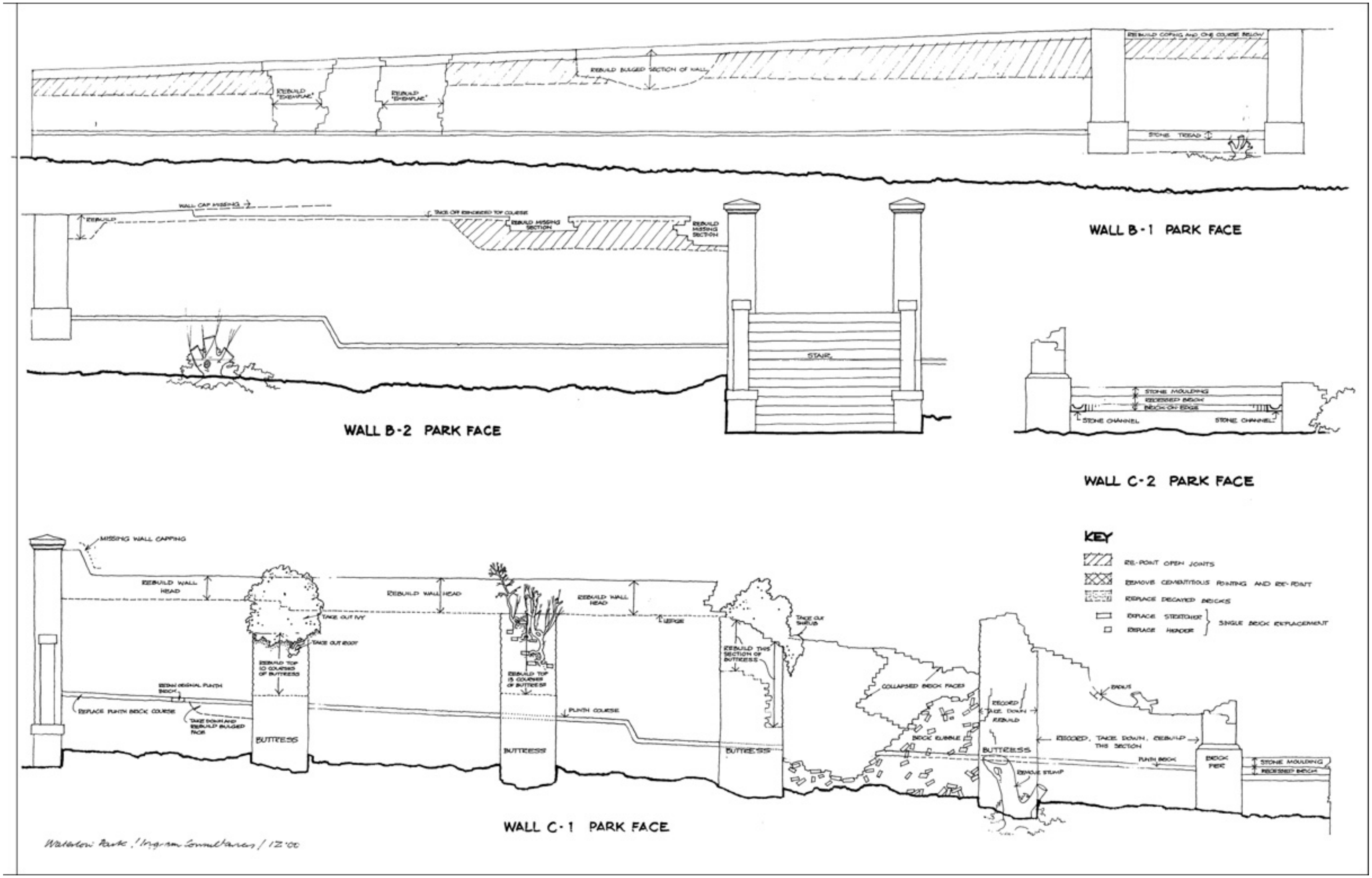

Figure 3.18 *Waterlow Park in London. Simple elevation drawings have been done by hand to assist in conveying the scope and nature of defects identified in the condition survey. The drawing was prepared based on basic site measurement and photographs.*

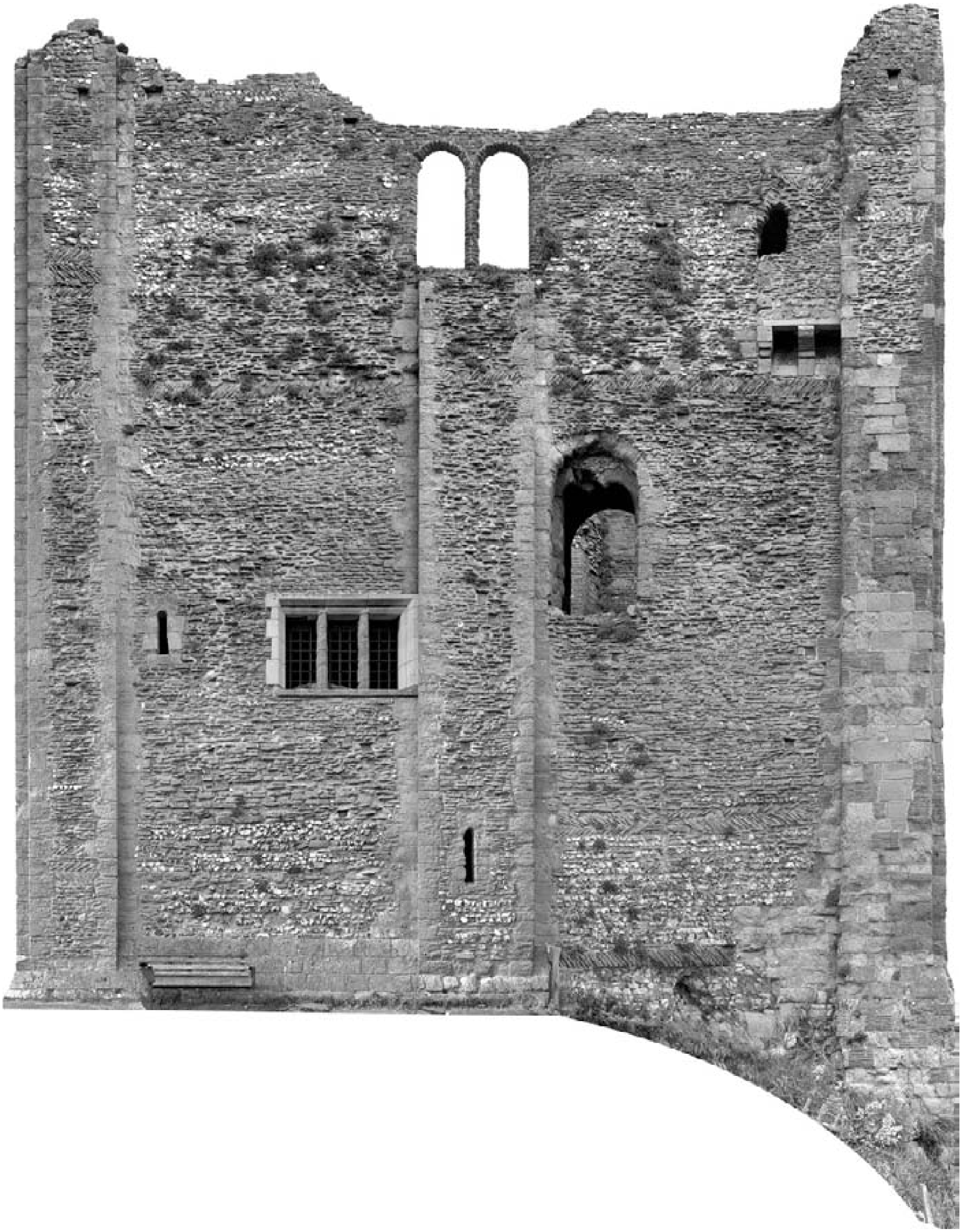

Figure 3.19 *Guildford Castle. Rectified photographs can be used in the absence of elevation drawings.*

The survey process

Survey preparation

- *Preliminary site visit*. It is always advisable to complete a brief site visit before commencing the survey. This is normally essential to cost survey work, but a preliminary visit is essential in understanding access requirements or restrictions, and the general approach to the survey.
- *Research*. Review of extant condition survey reports and archaeological papers and reports before commencing the survey provides background understanding. Archaeological excavation reports are particularly useful, since they frequently provide a baseline of condition to understand the rate of decay of the buildings.
- *Drawings*. Obtain drawings of the site in advance of the survey so that working drawings may be prepared for use on site.
- *Identify source and availability of materials*. It is not always possible to identify the construction materials before commencing the site survey but it can be useful, especially if the original materials are no longer available, since this may influence the approach to repair which is developed during the survey.
- *Prepare survey record sheets*. Record sheets used to record survey information should be prepared in advance, particularly tabulated record sheets for a schedule of defects.
- *Backup records*. Always take at least one spare set of record sheets, drawings and notebook.

Becoming familiar with the site

On arrival at the site, time should always be made available to understand its layout and complexities. Becoming familiar with the site may take anything from several hours to a few days, depending on the scale, during which time notes and photographs need to be taken while an understanding of the site is developed.

Report format (content)

When writing the report it is important to bear in mind who will read it.

The readership of a condition survey report can be very broad, so it is important that it be written as a comprehensive technical appraisal in a clear digestible form. Technical language may be used but this should be defined and explained so that the document may be understood by a less informed reader. It is advisable to use photographic and sketch illustrations to convey or illustrate information in a readily digestible form (Figure 3.20).

The report should be written using concise language. The subjects should be set out in short paragraphs, numbered for ease of reference. Headings and subheadings should be used to break up the text and permit speed reading and quick location of relevant information.

Example of a condition survey report text illustrating the use of short paragraphs with number referencing

Abstract – survey report

Granite walls

3.2.1 In general, the granite walls are in stable condition, but past repointing using cement-based mortars has promoted increased levels of decay by reducing the ability of water to evaporate out of the walls. It appears that the external elevations of the church and tower were repointed during the early 1930s by a local contractor. In many areas the repointing appears to be stable, but close inspection reveals perimeter detachment of the mortar from the granite with shrinkage and movement cracking. The complete repointing of all external granite masonry with a mortar based on hydraulic lime will be necessary to reduce long-term decay and permit the joints to 'breathe' (Photographs 11 and 12).

3.2.2 Some structural cracking has occurred, particularly around building corners, but reference to past condition survey reports suggests this is a long-standing defect. A structural engineer should be consulted to determine the cause of cracking and approve the scope of repair proposed here, as well as to advise whether any further measures are necessary. It is recommended that fracturing in the masonry walls be monitored to confirm if movement has stabilised.

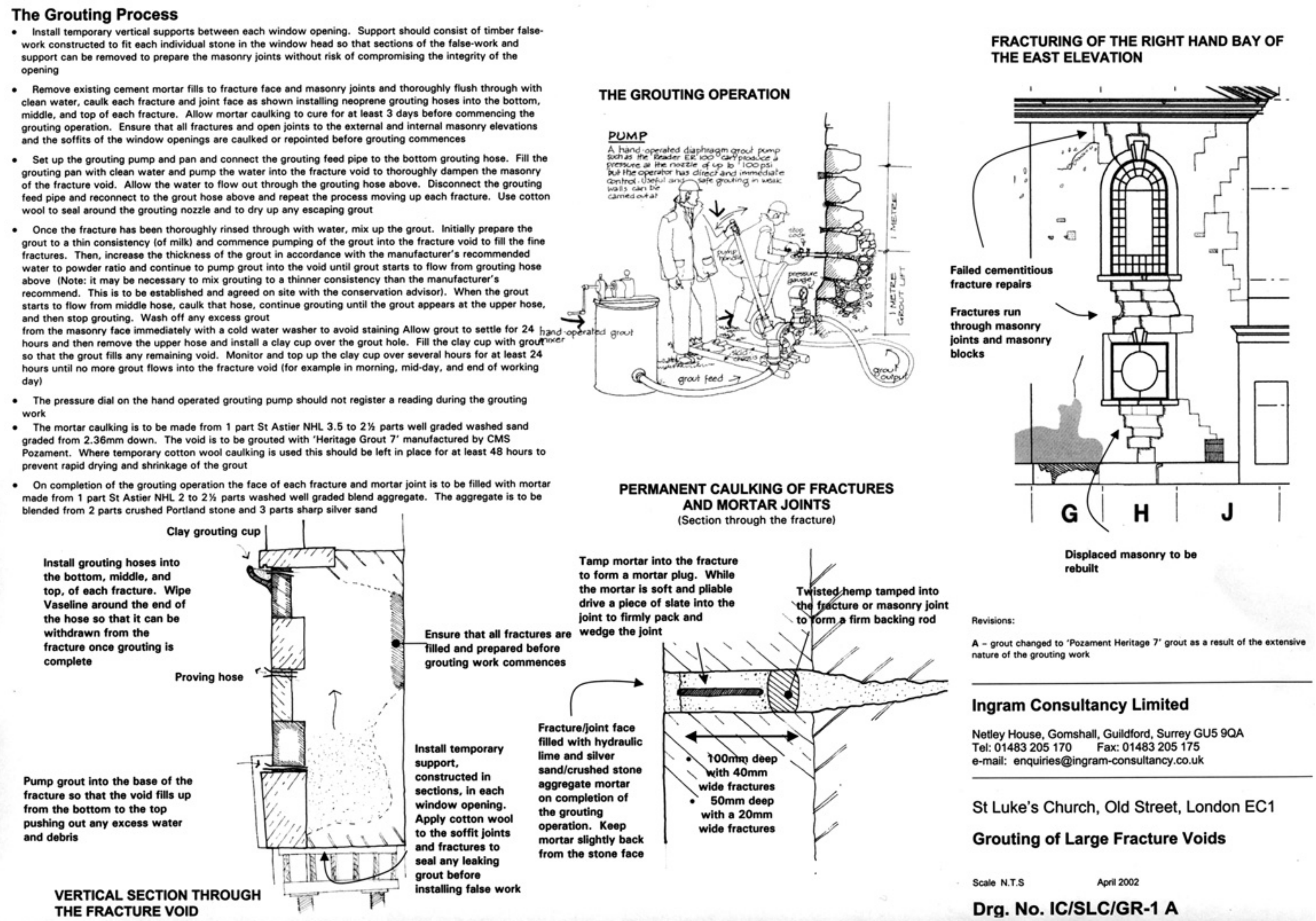

Figure 3.20 *Graphic illustrations greatly improve the ability to convey information in a survey report. It is advisable for the writer of a condition survey report to put himself or herself in the place of the reader – can the text be clearly understood?*

Formatting styles, such as variation of font types, styles or sizes, should be used to aid clarity and legibility. If the text appears less dense and is broken down into digestible pieces, this will help the reader to understand and assimilate the information. Illustrations can help to summarise information. Use of bullet points to emphasise or summarise key information or conclusions is also helpful.

Example of report text illustrating the use of formats and bold text titles to assist with speed reading

Abstract – Survey Report

PRE-CONTRACT WORK
The following items of work should be completed as a prerequisite to carrying out each phase, to ensure smooth and cost-effective management:

1. **Preparation of a Scaffold Design.** Scaffolding costs represent a significant part of the project costs and can vary considerably depending on the way in which scaffolds are constructed. For a contractor to accurately cost scaffolding provisions they must be fully informed of any restrictions that will be placed upon them when working on a site protected as a scheduled ancient monument. English Heritage normally requires scaffold structures to be free standing without relying on support or restraint from the scheduled monument. To ensure that each contractor prices a similar proposal and that pre-agreed scaffolding arrangements are followed, it is recommended that an experienced scaffold engineer be appointed to prepare a suitable design for inclusion in the tender document. Advanced preparation of the scaffold design will also minimise any risk of delays at the start of the project whilst scaffolding issues are resolved.

Survey documents which will be archived for the long term should be printed on archival quality paper. Drawings for archiving should be printed on polyester film. Digital copies of the report on popular and accessible file formats such as Adobe pdf should be provided.

Writing a survey or client brief

The survey brief should be a clear, logical and concise briefing document. It should set out the aim and objectives which are to be met by the survey. The type of survey and methods for undertaking the work should be broadly outlined with the intended access arrangements. Alternatively, the client might seek proposals for access arrangements from the surveyors tendering for the work, but this should be discouraged to prevent disparity between the tender submissions. In practice, it is far more effective if a decision has been made about the preferable methods and arrangements for accessing the site and work face in advance. This will avoid ambiguity in the fee tender submissions that are received and will permit comparison between the tender submissions.

It must be stressed that tenders should only be sought from practices or individuals which have a proven track record of experience. Speculative enquiries to companies of unknown experience will bring a high degree of risk to the client and will often be less cost- and time-effective.

Below is an illustration of the typical content of a client brief.

Example of typical content of a client brief

Client aim

- To understand in detail the condition of the ruined structures on the site and the need for maintenance and repair during the next 10 years.

Survey objectives

- Identify the need for emergency repairs to prevent risks to health and safety and to avoid significant loss to the building fabric in the immediate future.
- Identify the need for further repairs to minimise decay and prevent further loss of the building fabric during the next 5–10 years.
- Identify a long-term approach to sustainable conservation of the site over the next 20–50 years.
- Comment on the success of past repair and maintenance work, and make recommendations for any modification or change in approach.

- Provide a budget for each phase of recommended conservation and repair, and identify if there is any financial benefit in bringing forward future phases of work to form a single project.
- Prepare a specification for conservation and repair methods and materials to assist in obtaining statutory consent for future work.

The site

Provide a brief description of the site and its history, initially as a functioning building and subsequently as a ruin. The statutory listing or protection of the site should also be identified and a copy of the listing/scheduling document included.

Background information

Extant archaeological and condition survey reports should be listed and made available, together with drawings and rectified photographs. If a maintenance regime is in place, details should also be provided.

Survey method

The type of survey and access methods should be set out. For example, the survey is to be based on close visual inspection from access scaffolding, which will be installed by the client to each building elevation and made available for the surveyors use for a period of 6 weeks. If a scaffolding design has been prepared this should be sent to the surveyor for information.

It is difficult to determine the need for invasive or non-invasive investigation work in advance, but the client brief may request that a provisional sum be allowed. The cost value of the provisional sum should be stated in the brief.

The need for any laboratory-based analysis work should be identified, for example mortar disaggregation or microscopy. Again, the objectives of this work should be identified. If the need for specialist analysis is unclear, a provisional sum could be stated in the brief.

Survey scope

The scope of the survey work should be identified. This can normally be summarised in one or two brief paragraphs, followed by a list of building and site elements which are included. For example:

- 'Carry out a detailed condition survey of all standing masonry ruins within the site confines as defined on the enclosed drawing IC-22024-SPL-01-00. It is the intention of the survey to identify all visible defects to the masonry construction. The survey is to be based on a combination of detailed inspection from scaffolding towers and ground-level inspection in all remaining areas where scaffolding is not located. Where ground-level inspection is carried out it is anticipated that the surveyor will use the experience gained from areas of detailed inspection to reasonably predict the probable condition and scope of repair which can be anticipated.'

Access arrangements

If complex access arrangements are necessary, it is advisable to set these out in a separate section, with a description of the specific type in each location.

Appropriate skill and experience

A proven track record of experience should already have been established before the client brief has been sent to the tenderers, but it is advisable to request that the individuals who will undertake the work be identified in the tender submission and that a curriculum vitae be provided.

Programme

A programme for the work should be identified. This may include the start date, the period for completing the site-based survey and the date for submission of the completed report.

Survey reporting (deliverables)

The condition survey is to be presented as an A4 format bound document with colour photographic illustrations. The report should clearly and concisely summarise any identified defects using numbered paragraphs for ease of reference. The report should contain the following sections. The report recommendations should include a summary of costs for each recommended phase. Four copies of the bound report should be submitted together with one digital copy in Adobe pdf format. Photographic images should be provided as TIFF files to a 300 dpi resolution.

1.0 Report Summary
- 1.1 Schedule of the Structures included in the Survey
- 1.2 Description of the Structures
- 1.3 Construction and Materials
- 1.4 Inaccessible Parts
- 1.5 Summary of General Condition
- 1.6 Recommendations for Further Investigation
- 1.7 Recommendations for Further Specialist Advice

2.0 Description of Defects – Structures
- 2.1 Masonry Walls
- 2.2 Floors
- 2.3 Surfaces Finishes
- 2.4 Protective Structures/Coverings
- 2.5 Past Repairs

3.0 Description of Defects – The Site
- 3.1 Landscape
- 3.2 Invasive Plant Growth
- 3.3 Site Drainage
- 3.4 Visitor Impact

4.0 Recommendations
- 4.1 For Immediate Action
- 4.2 For Completion within Two Years
- 4.3 For Completion within Five Years
- 4.4 For Completion within Ten Years
- 4.5 Monitoring Work
- 4.6 Adequacy of Routine Maintenance

5.0 Schedule of Defects

6.0 Photographic Illustrations

7.0 Annotated Survey Drawings

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Chapter 4

Philosophy, technology and craft

John Ashurst and Colin Burns

We don't believe in 'restoration'. We have no cognisance of that word … If we had attempted to carry out 'restoration' instead of spending the few thousands per annum which we have spent, we should have spent hundreds of thousands and ruined the historic character of the monuments.

(Sir Frank Baines, Office of Works, 1921[1])

The living, historic building must be repaired to keep it habitable and secure, so that even when minimum works are carried out there are always aspects of restoration involved. The ruin is different; its partial destruction and the reasons for that destruction are part of its story, to be conserved. On an untouched site, the conservation team are 'first at the scene of the crime'. The exact way walls are found and the arrangement of fallen material are important to record and to preserve if the story is not to be altered for future generations. Even sites once consolidated can still, to the observant eye, contain evidence not previously noticed or understood, evidence which can be secured and made legible for the first time. The study and conservation of ruins is truly a specialised discipline and art.

In what is now the United Kingdom, an Act of Parliament in 1882 established, for the first time, some legal protection for its important ruins, described as 'ancient monuments'. Although these were initially primarily prehistoric monuments, the scope was soon to increase. Most importantly, the Act was the beginning of an Inspectorate of Ancient Monuments, whose duty was to report on the condition of monuments and to advise on the best methods of preserving them. An initially slow advance of awareness and concern was significantly changed with the appointment of Charles Peers as Inspector in 1910, 10 years after the death of the first Inspector, General Pitt-Rivers. A one-time architectural editor of the Victoria County Histories, he contributed much to the first inventory of the English Royal Commission on Historic Monuments, began a process of systematic recording and reporting, and established a specialist works division for the repair and maintenance of monuments under the architect Frank Baines. Most importantly, Peers was concerned with establishing specific common standards for the maintenance of monuments in State care. In particular:

… maintenance must avoid, as far as possible, anything which can be considered in the nature of restoration, to do nothing which could impair the archaeological interest of the monuments and to confine themselves rigorously to such works as may be necessary to ensure their stability, to accentuate their interest and to perpetuate their existence in the form in which they have come down to us.[2]

In legislative terms, a philosophy of 'preserve as found' had formally and officially arrived. True, it was not new and had been advocated since at least the middle of the nineteenth century. For instance, in 1856, Philip Hardwick, architect of the Euston Arch, reported to the Office of Works:

In repair of any old structure the first object to be gained is to arrest the progress of decay without altering in any way the character or features of the building. The restoration of an ancient fabric, without bearing in mind this rule, usually ends in its destruction as a work of interest and study. There is nothing that requires more judicious skill on the part of the architect than the treatment of a ruined building in this respect and in the first place I would recommend, at any rate, a partial removal of the ivy that has grown over the walls. The mischief that creepers do whose roots have the power of penetrating walls cannot be exaggerated … The walls should then be carefully examined, loose stones be

Opposite page *Glastonbury. The 12th century north portal of Glastonbury Abbey, UK, illustrates the survival of important sculptural detail in the context of a ruin and the particular care that is needed in recording, condition monitoring, and carrying out periodic treatment. The orders of the portal still have evidence of polychrome. Soluble salts (mainly chlorides and nitrates), are present in the joints, and there are fissured gypsum crusts on much of the detail. Periodic poulticing and reversible lime mortar repairs and crack fillings form the principal maintenance interventions.*

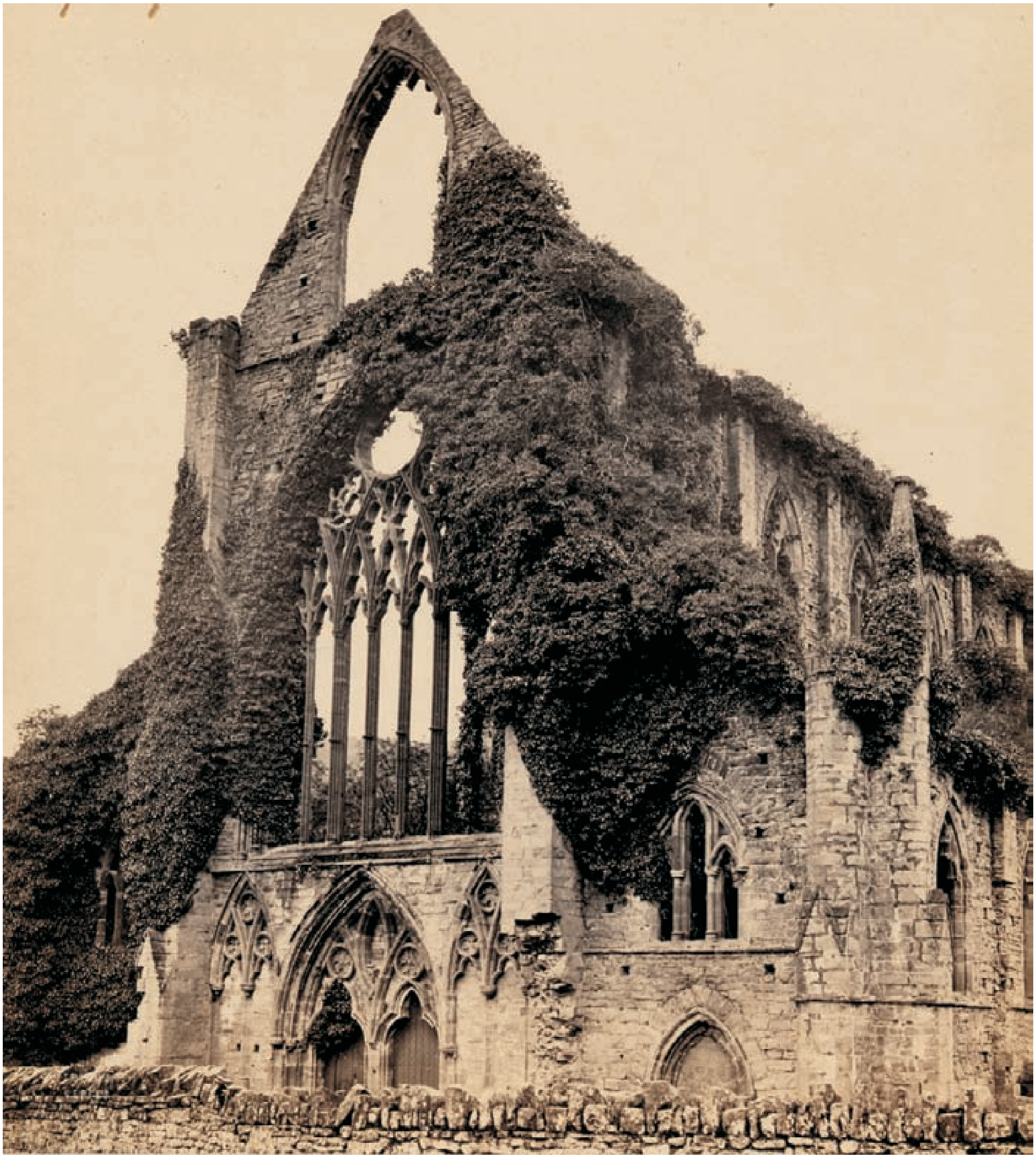

Figure 4.1 *The west front of Tintern Abbey c. 1860. This view is typical of the 'romantic ruin' which caught the imagination of Wordsworth and other poets. The heavy ivy mantles conceal the potentially disastrous development of several major structural problems, including the collapse of the south wall of the nave.*

fixed in their places and settlements stopped. Where the coping stones remain in situ they should be firmly secured, and when they are destroyed, as is generally the case, the upper stones should be set in their places where they are found and means taken to prevent water resting on the top of the wall and soaking into it. Wherever large apertures exist or where wrought masonry such as window heads etc. have fallen out, they may be restored to prevent further dilapidation, but, in general, it is not desirable to make any restoration of work which is

> *merely decayed and not likely soon to become loose, fall out or otherwise injure the rest of the fabric.*

One hundred and fifty years later, English Heritage still seek to follow the same guidelines.

But the pioneering work of the Office of Works was often the subject of considerable criticism and acrimony. Entrenched romantics, defenders of the 'ivy-mantled tower', resented the heavy hand of officialdom and, at least in some cases, believed that architects and stonemasons of the right calibre could devise solutions and produce results in a far more traditional and sympathetic way than an Office of Works engineer. Much of the opposition to the work being carried out at some of the first sites such as Tintern Abbey was based on a confidence bred of sound training and experience in the repair of traditional buildings. But the Office of Works' innovative use of concrete and steel to 'preserve as found' was, in many cases, the only way to retain broken structures in perilous conditions, and history has largely vindicated the action of its pioneer architects, engineers and masons. There is little doubt that without their ingenuity much of what survives today would have been lost; moreover, their achievements were remarkable in being largely undetectable on completion. Where criticism can sometimes be justly made is in matters of detail, and then only with the benefit of hindsight. We know, now, that masonry is not well served by deep-tamping and grouting in cement-based material and that concrete poured against the tails of ancient stones can create stress and damage to the fabric it was intended to save. In truth it can be said, however, that we have learnt more from the experience of the old Office of Works than they might have learned from us, three-quarters of a century later.

A study of the conservation of the Cistercian Abbey at Tintern, one of the earliest sites to benefit from major 'secret' structural intervention, is informative and illuminating of the determination of a fledgling government body to implement a philosophy of preservation without restoration, and of the ingenuity and imagination of the engineers and architects of the time.

Tintern Abbey is picturesquely set in the wooded Wye valley of South Wales, built over a period of some 50 years, commencing in 1269. Following dissolution in 1535 it was, as was usual, stripped of its lead roof covering shortly afterwards, thus beginning the slow process of decay and eventual collapse of its roof, vault and tower, and the mantling of its walls in ivy. The romantic appeal of Tintern was much enhanced by artists and writers of the eighteenth and nineteenth centuries, and it was this legacy which seemed, to critics of the Office of Works (and there were many) in the early twentieth century, to be so needlessly and carelessly degraded.

William Woodward wrote to the *Daily Express* in July 1921:

> *It is acknowledged that Tintern was the loveliest of our ruined abbeys, and so it is upon this particular ruin that the Office of Works has bestowed its benign influence. It has not been satisfied by the unnecessary stripping the walls of their ivy and wild roses, but it has introduced its favourite steel and concrete work as if it were complying with a London County Council Dangerous Structures Act.*

But the ivy canopies were not only concealing but contributing to the further demise of the ruined buildings. Frank Baines was very positive on the subject and is famously quoted as saying:

> *There is no more pernicious weed in the country than ivy. I once used to go about with a small saw, and whenever I saw ivy I cut its throat.*[3]

One of the first structural analysts of the substantial ruins of Tintern at the time of the First World War was William Harvey, whose studies of Tintern, Rievaulx, Westminster and St Paul's Cathedral were published by the Architectural Press in 1925,[4] advocating the essential practice of knowing the whole building to understand its movements and the reason for distortion and fracturing. Two major areas of concern were identified at Tintern, once the ivy was removed. The first was a progressive westward movement of the north chancel wall, towards the great arch of the missing tower and the overhanging broken end of the north arcade of the nave (Figure 4.2). Local repairs were not able to contain this westwards movement, as the north-west pier distorted and developed a pattern of fine stress cracks. The drift of its masonry piers in the chancel to the west could only be restrained by the installation of the reinforced wall head beams shown in Figure 4.3. The corbelled masonry of the nave arcade could only be supported by the installation of the steel ledgers shown in Figure 4.4b.

The second major potential collapse was of the south wall of the nave. There it was found that the head of the wall, at its centre point, had a lean to the north of just over half a metre. The instability of the wall was confirmed by cracking patterns. Two options to correct the problem were considered: either to replace temporary timber shoring on the

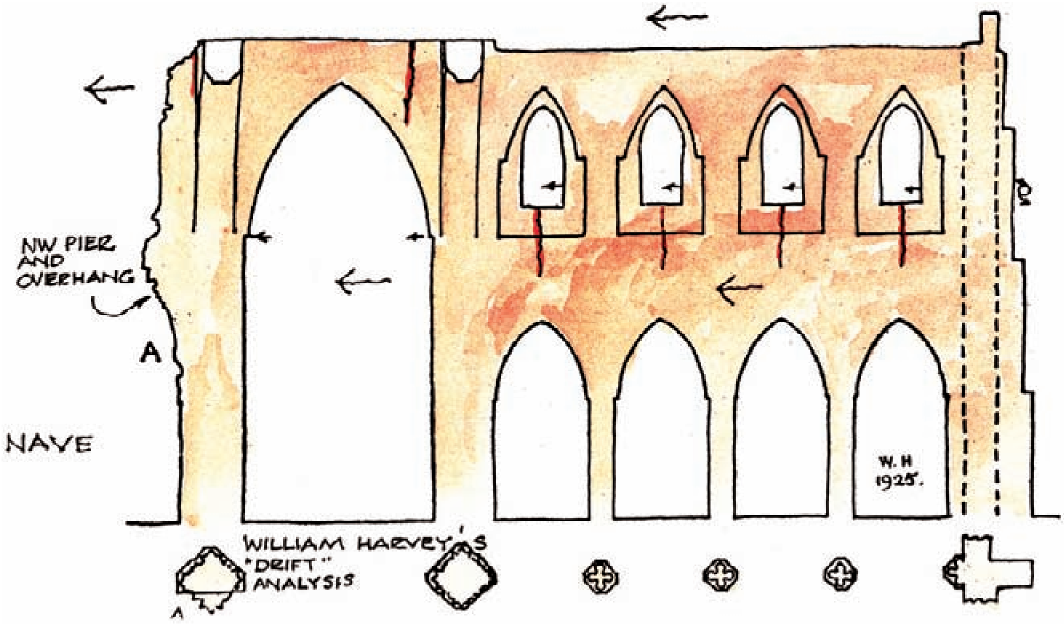

Figure 4.2 *William Harvey's drawing of the north chancel wall showing the drift of the masonry to the west.*

north side erected by the Office of Works, with masonry buttresses, or to devise a method of tying back the head of the walls. This second option was selected both for reasons of avoiding visual intrusion in the nave and through fears of possible settlement of massive buttresses which would exacerbate the problem.

The proposal to tie back the wall head was made distinctly more feasible by the presence of a south aisle which once had a single pitch roof. Replacement of this roof, whose line was clearly evident at east and west, would enable a system of reinforcement to be introduced. A lattice girder was installed to restrain the nave walls and bolted through the nave wall without attempting to correct the distortion. The lattice girder was finally covered with oak rafters and tilestones, leaving the soffit exposed. A secondary operation involved the substituting of the heavy timber shores with brick masonry supports to enable the shattered masonry of some of the piers to be strengthened by cutting out and inserting steel stanchions within the core of the nave piers; the steel was subsequently concealed by replacing original stones, or new stones where the originals had been shattered, and the brick supports removed.

These were the engineering works that so enraged William Woodward and others in the 1920s, but illustrate the ingenuity and care which were taken to transform a dangerous structure into a stable ruin. A certain pride developed based on the ability of architects, engineers and masons to execute major and minor works that were subsequently not easily detectable. Other major sites that received early structural attention and general masonry consolidation were the abbeys of Jedburgh, Furness, Rievaulx, Whitby, Byland and Netley, and the castles of Caernarvon, Kirkby Muxloe and Goodrich. It was on such illustrious sites as these that the 'Ancient Monuments' team of professionals and craftsmen cut their teeth and developed considerable expertise. Undoubtedly there was, and remained, a critical benefit in accumulative experience of the group and its continuity between and after the two world wars. While adverse criticism may be levelled, sometimes justly, against directly employed specialist works teams, there is little doubt that they have a distinct advantage over contractors in becoming familiar with their historic sites over many years and in knowing the techniques and standards required. In the absence of any such in-house team of expertise, the provision of adequate specialist training for architects, surveyors, archaeologists, engineers and craft technicians becomes even more important. This subject is addressed in Chapter 8. Based on review and study of the many pioneering works in monument consolidation, which were practical interpretations of

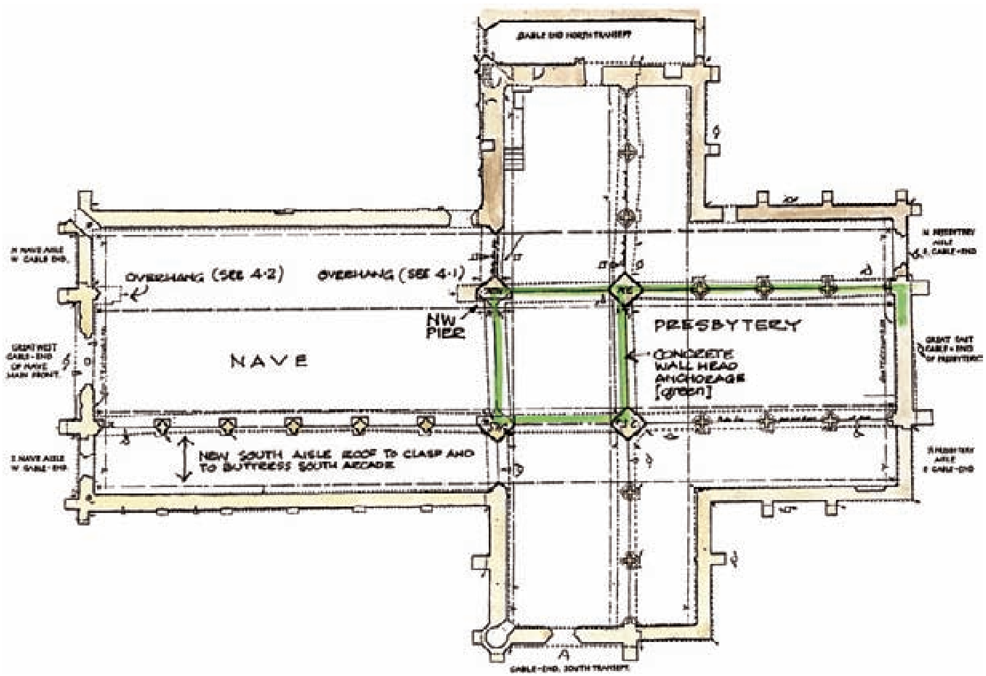

Figure 4.3a *William Harvey's elevation and plan showing the proposed installation of reinforced concrete wall head beam linked to a ring beam at the head of the tower.*

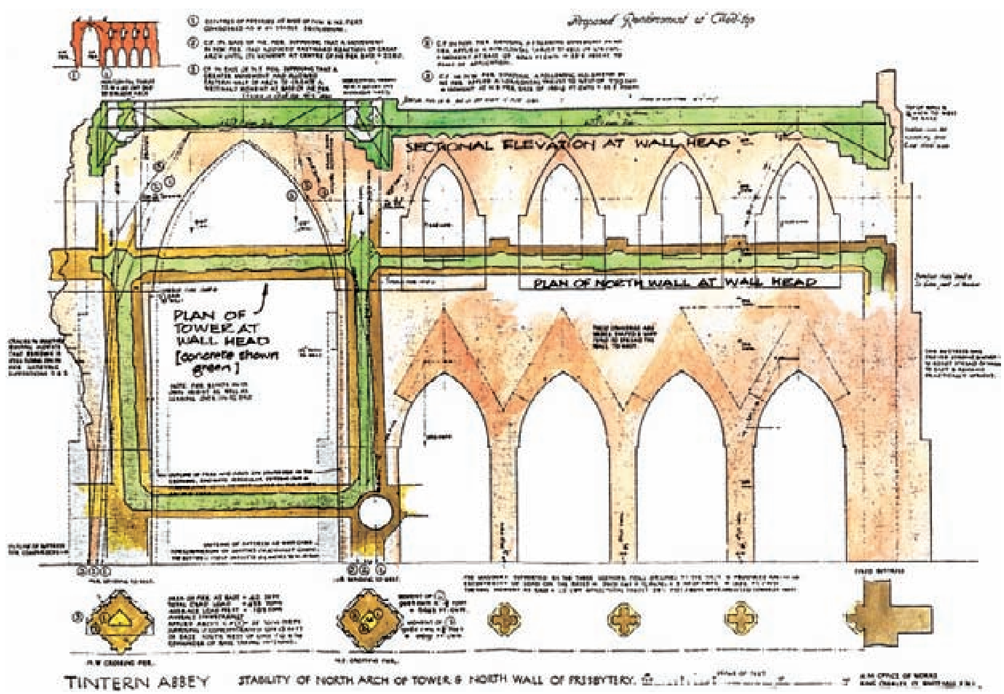

Figure 4.3b *Reinforcement of the corbelled masonry of the broken nave arcade.*

Figure 4.4a *Tintern Abbey - North west pier showing timber shoring under broken nave arcade. This overhanging masonry was repaired in the manner shown in Figure 4.4b.*

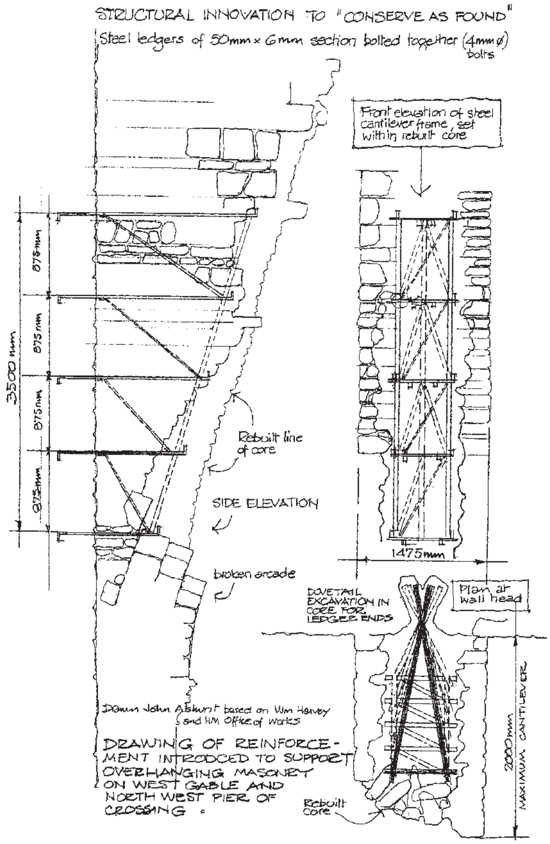

Figure 4.4b

conservation philosophy and which, at a major structural level, are illustrated in Figures 4.2–4.4, certain disciplines and methods have been developed in the approach to the ruin sites which can now be described.

Context and definitions

The most often repeated phrase in historic fabric conservation must be 'conserve as found with minimum intervention'.

'Conserving as found' is, of course, a philosophy whose implementation is governed, at least in part, by the nature and condition of the site, but it should influence every decision and remain as the ideal goal. In particular, essential conserving works should never introduce speculative restoration, or damage or alter evidence of the original buildings, or conceal the cause and character of their past deterioration and collapse.

'Minimum intervention' is the other familiar guiding principle for conservators of ruins, as for conservation of more complete historic buildings. Unfortunately, fundamental as the principle is, 'minimum intervention' cannot always mean doing very little, and a virtue should not be made of it where more serious intervention is actually needed. Largely worthless, low-key interventions are really only placebos, and may be illustrated by, for instance, the tamping and pointing of fractures without analysing the cause of fracturing, or installing an anchor within a crack or a bulging wall when what is needed is a programme of recording, taking down and rebuilding 'as found'.

Difficulties arise in two common ways. The first may be illustrated by a scholarly, theoretical demand that everything should be 'conserved as found, with minimum intervention', which is partly or largely ignorant of the materials or construction and the dynamics of an impending collapse. The second may be illustrated by an ignorance of any real belief in conservation principles, coupled with preconceived ideas of how standard building repair solutions will resolve the problem. The combination of both attitudes, which again is not uncommon, is inevitably damaging for the site where they meet.

Research into, and monitoring of, conditions found on ruin sites are often desirable and are sometimes essential. The benefit of a multi-disciplined team with continuity of experience is that information is collective and the risk of unnecessary duplication is avoided; but the individuality of ruin sites is such that there is always likely to be an element of investigation and treatment trial, most commonly in the design of mortars and often in the monitoring of fractures.

Structural archaeology

The informed, visual examination of any structure, but particularly an historic ruin, will usually enable some, and perhaps a great deal, of its building history to be deduced. This kind of examination was described by the late Patrick Faulkner as 'structural archaeology'.[5] The process is multi-disciplinary, and in the first stages architect, surveyor, engineer, archaeologist, historian and materials scientist may all be involved. In the later stages the 'conservation technicians', those who must unpick, clean, consolidate and stabilise, are always also involved; in fact, they are often the first to see anything not immediately exposed on the surfaces. This is one of the many reasons why their role is so important and so demanding of training. They are in a position both to reveal and illuminate or to destroy.

Structural archaeology is quite distinct from structural analysis, which is based on a study of the structural content and condition as described in Chapter 2; its evidence is final and incontrovertible, overriding even archival record. Typical features occurring and to be looked for in the ruined structure may be listed as follows:

- Straight vertical joints
- Toothed joints
- Random joints
- Straight horizontal joints
- Inserted openings
- Shadow lines indicative of the removal or decay of a feature
- Surface cavities such as putlog holes or lost fixings
- Assembly marks
- Changes in wall thickness
- Changes in construction type
- Changes in materials.

The last category may be immediately obvious but more often is rather subtle in character, especially in the case of mortar or plaster. Long exposure to, and experience of, the materials can become very important if evidence is not to be unwittingly destroyed. In some countries, especially, for instance, those which formed part of the Roman empire, mortar (used as lumps of aggregate), stone, brick and tile were extensively salvaged and reused. Areas of salvaged material may crop up randomly in post-Roman construction, indicative of periods of demolition and spasmodic delivery, and some may be recycled more than once.[6] Accurate survey plotting of properly identified materials is an important aspect of structural archaeology.

Temporary supports and protection

A condition survey, or even a more basic, preliminary survey, will identify parts of a building and its site which are at risk and which may present immediate dangers. In this category might be, for instance, seriously leaning walls, new or spreading fractures, bulging facework with open joints, displaced stones at high level or major landslips. Conditions of this kind often require immediate intervention both to support, contain and protect the ruin from further loss, and to protect visitors, legitimate or not, from injury and possible loss of life. Work of this kind will also be required on sites in poor condition which are unlikely to be consolidated and conserved for many years, and, within the context of a current conservation programme, areas which could be lost or cause injury to contract personnel.

In order to design and place such support and protective temporary structures, a thorough understanding of such ruined buildings and their condition is essential. A heavy-handed and ignorant approach could cause collapse of large areas of masonry and possible loss of life of those carrying out the works. Typical temporary support and protection works are illustrated in Figures 4.5–4.9.

On some sites, removal of vegetation is required in order to inspect the masonry and make some assessment of its condition. This operation requires more care and understanding than is generally appreciated, and should in any case be preceded by consideration of the ecological impact removal will entail (see Chapter 6).

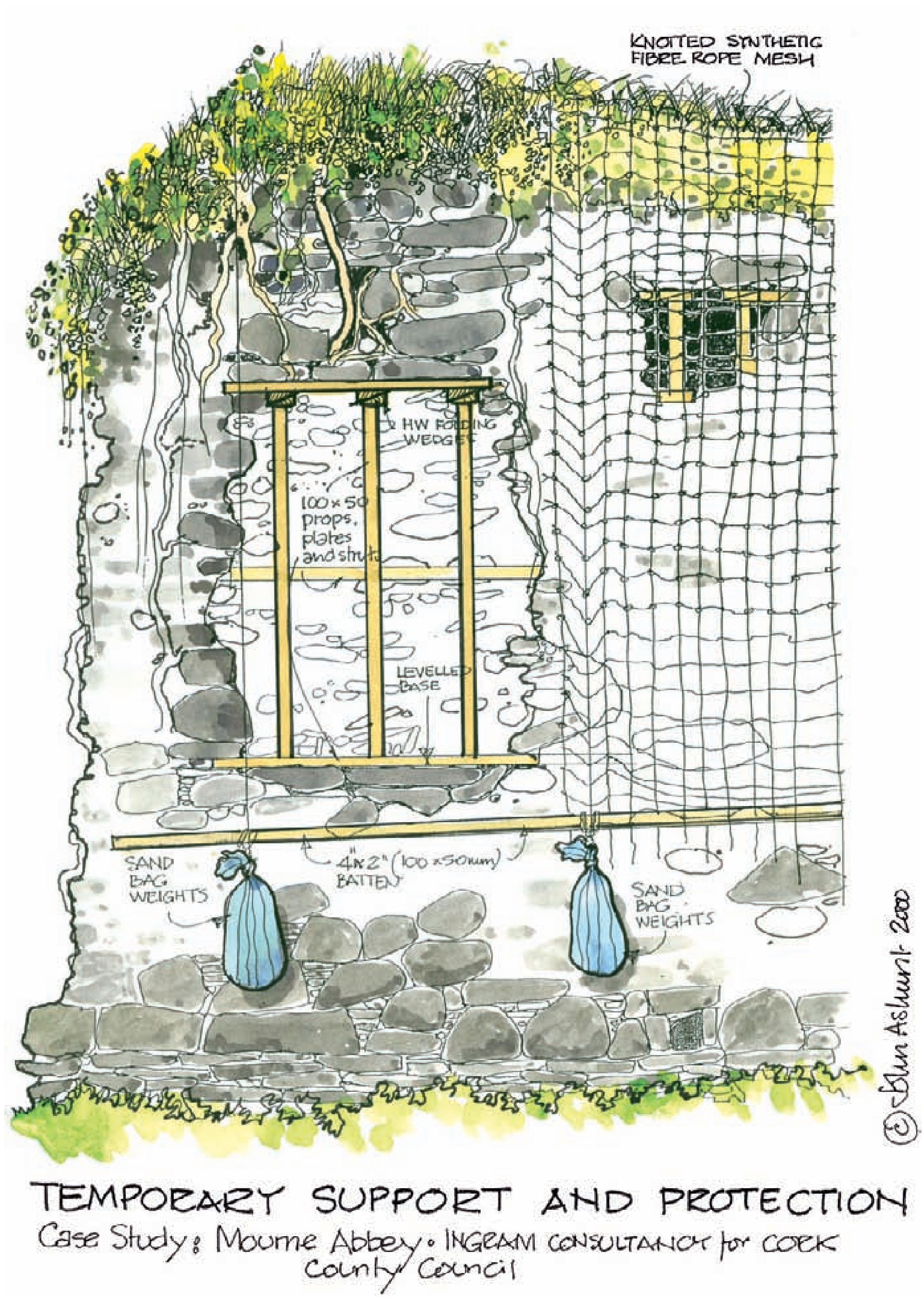

Figure 4.5 *Installation of temporary timber supports in the form of plates, props and wedges and synthetic rope net over vegetation and loose wall head, weighted with sand bags.*

Figure 4.6 *Small lancet window largely unconnected to its original masonry has been provided with corset plates bolted through the opening to provide temporary stability.*

Figure 4.7 *Leaning and fractured wall provided with simple temporary buttressing of concrete blocks, and ringed with security fencing. Myross Church, Ireland.*

Figure 4.8 *Temporary support of high leaning wall in the form of board facings and flying shores.*

Figure 4.9 *Temporary protection and insulation of masonry against rain and frost and temporary support works, County Cork, Ireland.*

Removal of the foliage and thin, easily accessible stems with shears can usually enable a condition assessment to be made of the masonry without trying to move heavy growth. Well-developed plants such as mature ivy (*Hedera helix*) are often found to be clasping and supporting unstable areas of masonry, so that premature or injudicious removal can result in local collapse and injury. Where trees have established themselves in the masonry, the usual approach is to cut them back to within 600 mm of the building face; however, consideration must always be given to effects that the release of the applied loading may have on the wall as the weight of the tree is removed. To avoid local collapses it may be necessary to install some temporary support to vulnerable areas before trees are cut.

A common practice in removing ivy is to cut out a metre section of the plant close to the ground to allow the plant to die on the wall and to poison the root by forming a frill girdle and applying a paste of ammonium sulphamate. There is no reason why this practice should not be followed unless a long period of time is going to elapse before clearance and consolidation of the wall can take place. If there are considerable delays, the dying plant may no longer be able to support unstable, overhanging masonry and may penetrate the structure at higher level in order to seek out the nutrients it has been denied at ground level, leading to further disruption, displacement and stress within the wall. In these situations the plant should not be cut at ground level until a work programme can proceed.

Wall tops (Figure 4.10)

Where walls still stand to their original height, the exposed and untouched wall tops of a ruin are often a rich source of information. Evidence of corbels or corbel tables, wall plates, tie beams, water outlets and even roof coverings may be present within a matrix of loose masonry and vegetation. Probably nowhere are structural archaeology and stability found in such an intimate and fragile relationship. Uninformed wall clearance and consolidation not only consign important information to oblivion, but can also conserve and present the surviving masonry in quite misleading ways.

Damaged wall tops, where significant amounts of masonry have fallen, are less likely to contain so much information, although some of the elements listed above may still be in the accumulations of stone and debris at the floor of the wall. Even in these circumstances, however, the same cautious, archaeological approach must be adopted during survey, site clearance and conservation processes. Broken wall heads may still be indicative of original, complete forms, such as crenellations, gables or towers.

Walls that have been reduced to low levels, standing only a metre or less above present ground levels, often appear to have very little evidence indeed of their original scale and form. Some sections may be missing altogether, or may only survive as foundation levels below the existing soil or sand. Careful recording, study and structural archaeology are still vital if the last pieces of information about the building are not to be obliterated or misrepresented by consolidation. In particular, evidence of door openings, buttresses, straight joints indicative of alterations or additions, plaster or tile fragments, changes in materials or construction methods may still survive and must be protected and made as legible as possible by the consolidation process. Maintaining the character of the masonry construction is vital; the size, shape and relationship of core to facework must reflect the ‘as found’ condition. Very-low-lying walls are particularly vulnerable, in some contexts, to flooding, frost damage, foot traffic, vegetation and stone robbing (Figure 4.11).

All categories of wall may, of course, have been partly or comprehensively conserved in the past. Pretreated sites of this kind can present particular problems, relating, for instance, to the use of cement-based mortar in joints and cappings, the modification of profiles to shed water and speculative (or accurate) areas of reconstruction. One of the most common problems is the deterioration of original work immediately below cement-rich wall cappings and the detachment of areas of facework pointed in cement-rich mortar (Figures 4.12–4.19). Only rarely do detailed records of such work survive even if they were ever made. The recording of past interventions, and of new ones, must become a part of the site’s archive, securely stored and easily retrieved. The ‘unpicking’ of previous work, where of poor or damaging quality, and reconsolidation of the original construction is a common requirement.

The approach and methods for consolidating previously untouched wall heads is suggested as follows. Where present, vegetation should be removed, as previously described. Where there is an intention to reinstate a ‘soft’ or natural capping to a wall head, the soil, root mats and small plants can be set aside and kept in suitable conditions for re-laying. Enough must be removed to a level where structural and archaeological assessments and recording can be carried out.

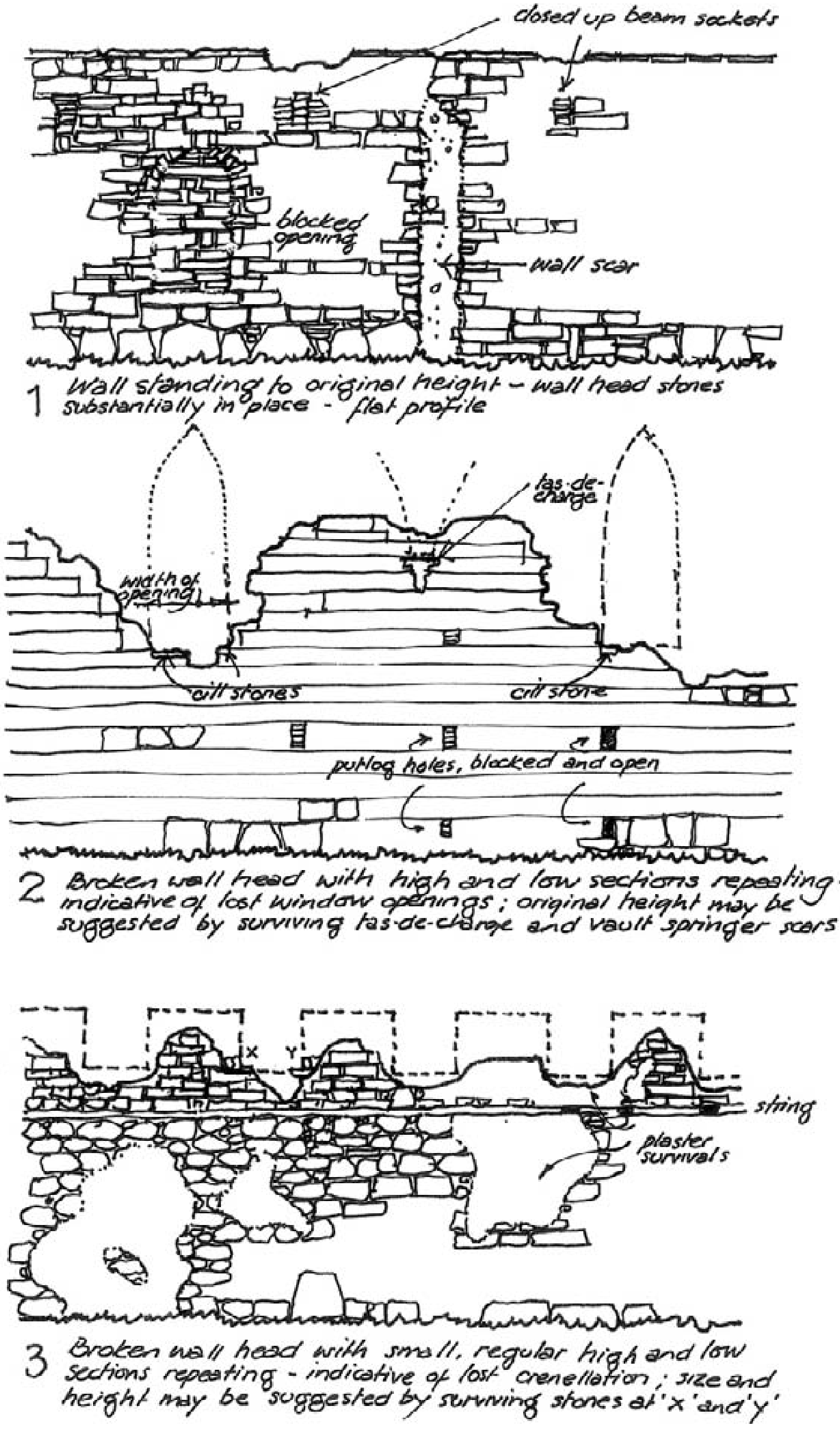

Figure 4.10a *Ruin profiles. Broken wall heads.*

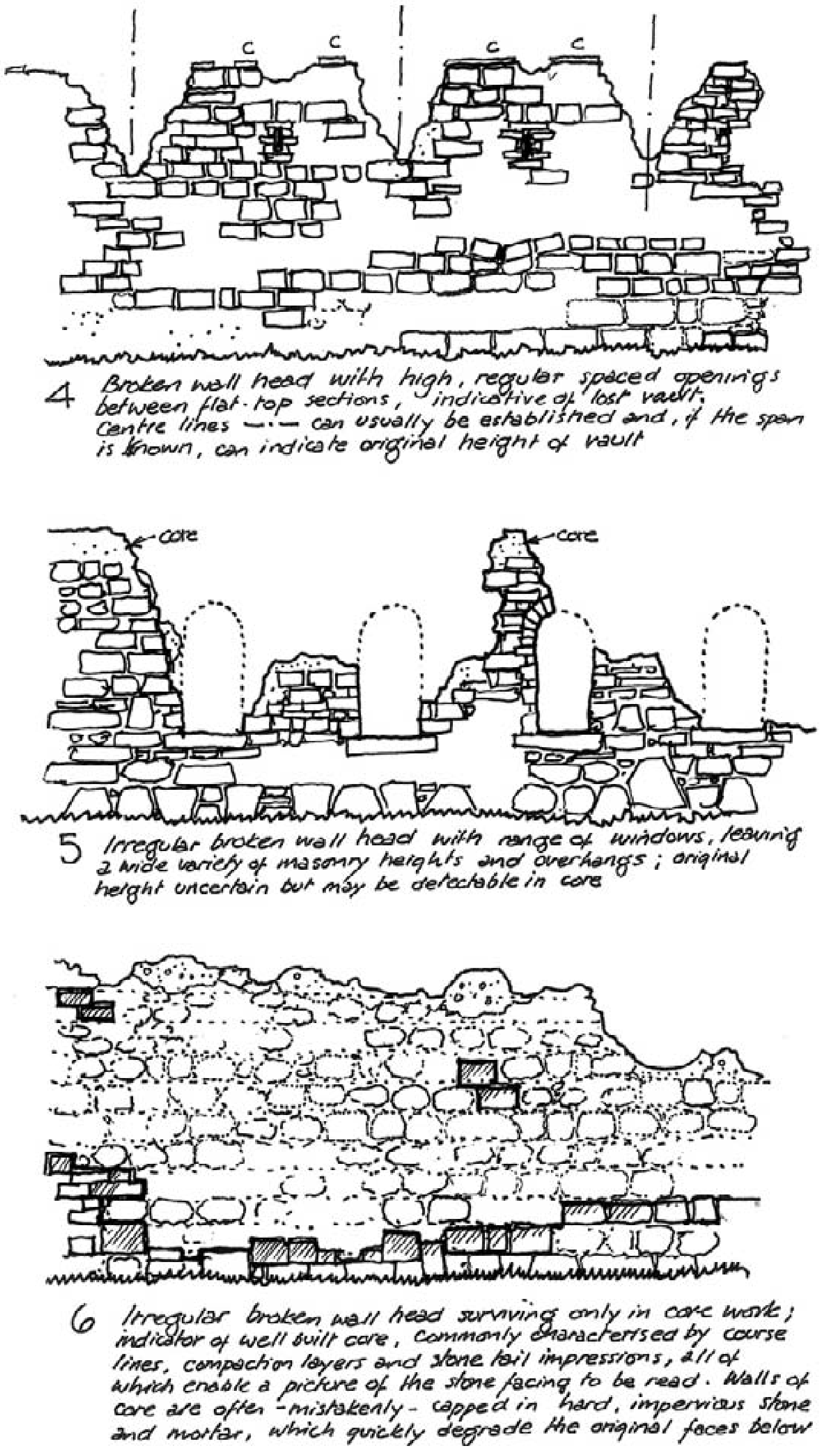

Figure 4.10b *Broken wall heads in masonry and core.*

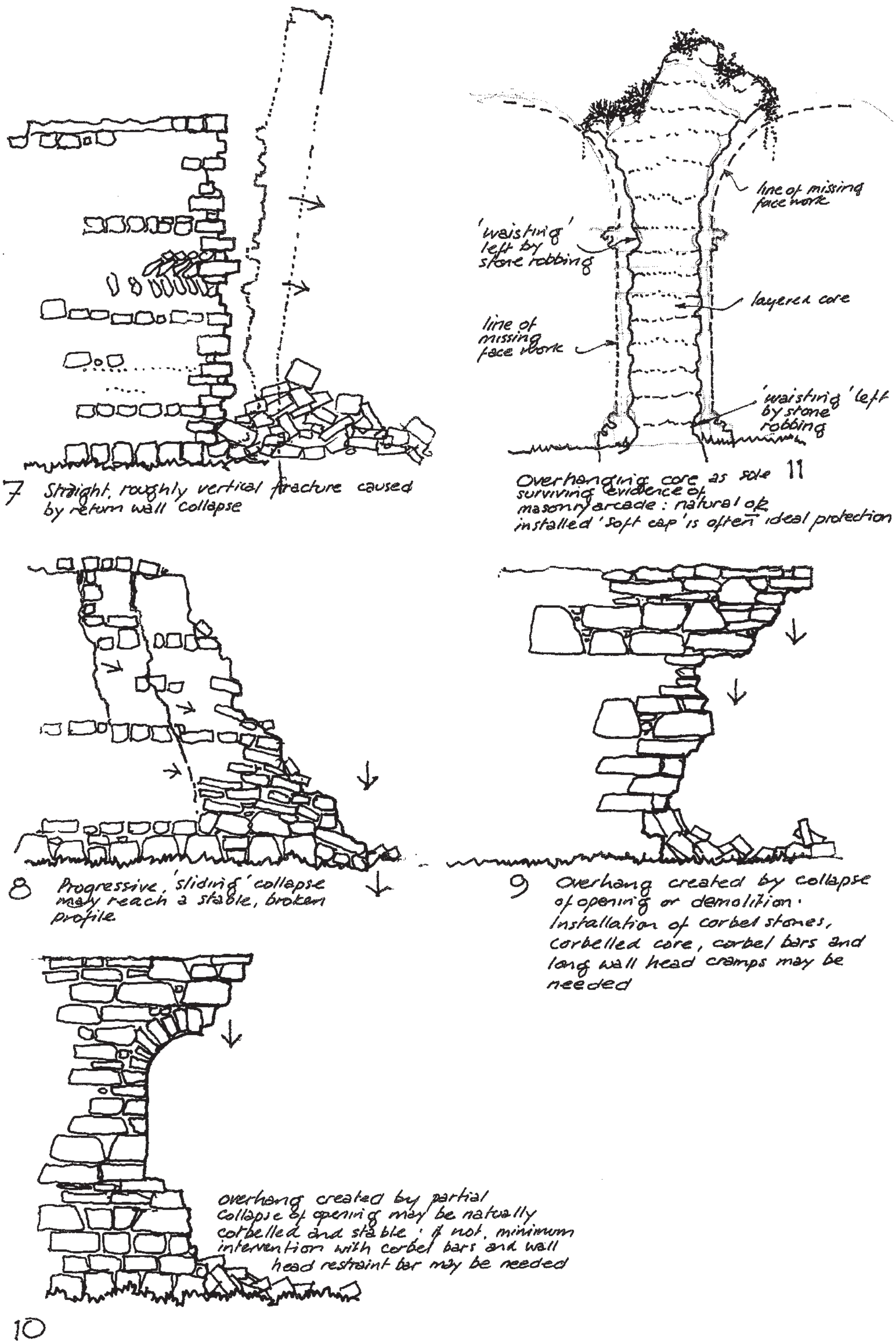

Figure 4.10c *End profiles and overhangs.*

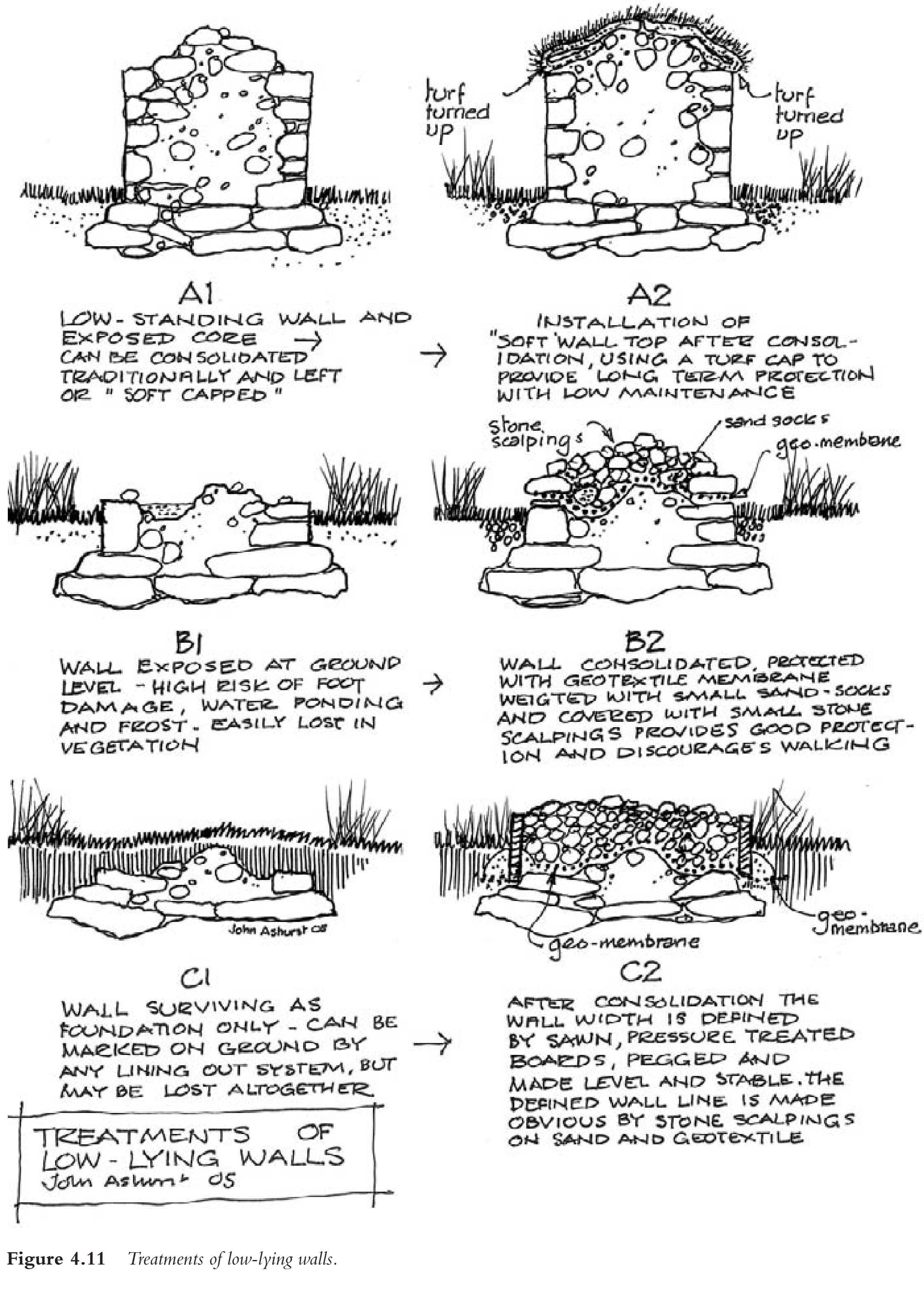

Figure 4.11 *Treatments of low-lying walls.*

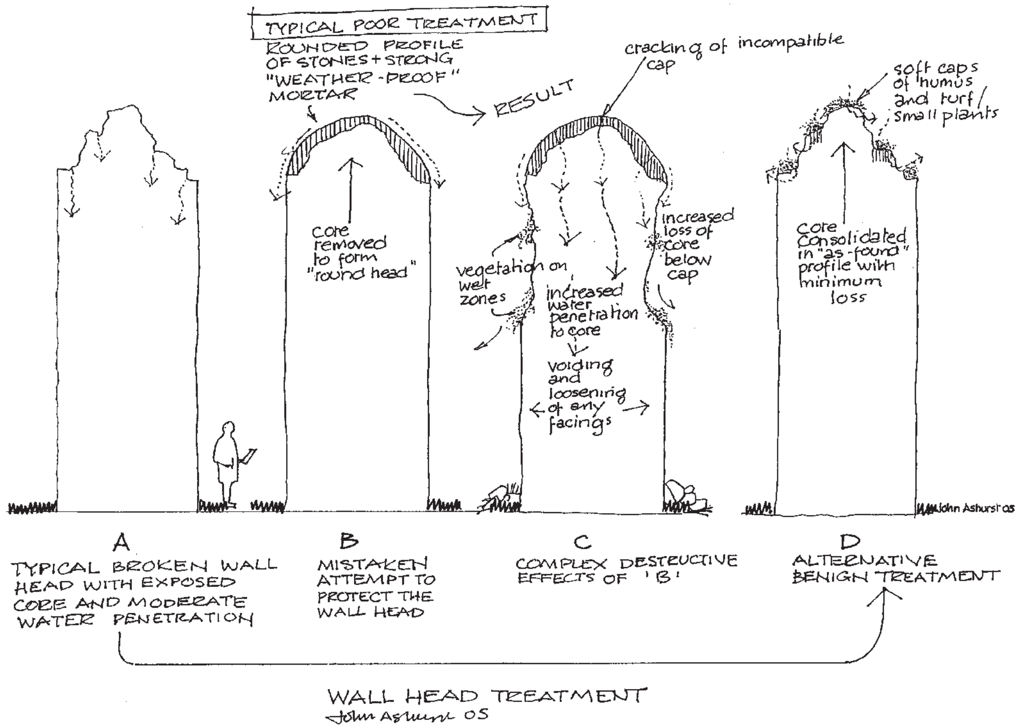

Figure 4.12 *Wall head treatment.*

Figure 4.13 *Cement-based mortar wall capping and wall profile combining to concentrate water run-off in one area with subsequent decay of wall face. Kenilworth Castle.*

Figure 4.14 *Early form of cement-based mortar and flint capping in large surface areas. These attempts to throw water off the wall head have the undesired side effect of taking water into the core through cross-cracking, where it remains trapped. Visually the core work is too far forward. Old Sarum.*

Figure 4.15 *Low-lying walls such as this are very vulnerable to frost damage in cold climates and to disruption by visitors anywhere. These walls are ideal candidates for soft capping, following consolidation. Note how hard capping has been placed over unconsolidated core with disastrous results as the capped zone lifts and cracks. Thornton Abbey.*

Figure 4.16 *Core facework, especially that exposed at wall heads, and even buried core are particularly susceptible to binder dissolution and migration in very wet conditions, especially at low temperatures (see Appendix). The design of replacement mortar for these conditions is clearly important. Non-hydraulic or weakly hydraulic mortars are too vulnerable and may never carbonate satisfactorily in persistently wet conditions. Moderately or even eminently hydraulic lime may be needed. But if the original material is too weak for such binders a weak mortar with soil and turf capping should be used. Face core work at Castle Acre Castle.*

Figure 4.17 *Most of this wall lies below original floor levels, with only a few stone facings showing above ground. The fragile core has been covered with geotextile membrane and sand, then set with unmortared limestone scalpings. The result is a free-draining protection which allows the wall line to be clearly read. Loose, large stones discourage visitors from walking on the walls and a more comfortable board walk is provided immediately adjacent to the wall. (see Figure 4.11, C2)*

Figure 4.18 *First stage clearance of ruinous wall head showing removal of vegetation and the stratification layers which confront a conservation technician.*

Figure 4.19 *Later stage of wall head clearance clearly showing the top courses of the wall and the twice-holed tilestones lying in the loose debris; this was the first evidence seen of the original roof covering. The conservation team needed to record, lift off, consolidate and reinstate as much as possible lying in its original position.*

Figure 4.20 *The planning frame is shown at the battered angle of the wall top connected to the scaffold tube. Temporary supports in the form of plate and props is shown bottom left.*

Recording should consist of photographs at all stages of progress and should make use of planning frames in preparation for consolidation.

Planning frames are used to record the positions of each stone forming the faces of the wall and the arrangement of exposed core, the aim being to enable the masonry to be put back in exactly the same positions as found. Carried out correctly, the consolidation work will not confuse interpretation of the structure in the future. The consolidation work will thus include any fractures, distortions or leaning and avoid the mistake of 'correcting' or 'restoring'.

The planning frames are shown in use in Figures 4.20 and 4.21. The outline and locations of each stone are drawn with indelible markers onto the plastic film, and each one is numbered. As the loose stones are lifted from the walls they are cleaned by a bristle brushing and identified by a number corresponding to the number in the planning frame. With the exception of its uppermost course, this number is marked on the top bed of the stone. The marking system should make use of waterproof markers or paint, all of which, except the top course, will be hidden within the wall when rebuilt. The top course can be marked on the bottom bed. The marking system enables the stones to be replaced in their original positions. When the loose, marked stones are taken down they are stacked neatly on the scaffold, ready for rebuilding. As the process of cleaning off, marking, lifting down and stacking proceeds, roots and soil within the walls are removed. Substantial roots are normally followed down into the wall by unpicking masonry until they no longer present a problem, but not all traces of root need to be removed. Fine roots can remain buried within the wall where, without light, they are unlikely to grow. The extent to which a wall head is taken down depends on a number of factors, including the size and arrangement of the masonry units, condition of the original mortars, extent of root invasion and displacement of masonry. As always, experience is essential to decision-making. The exposed wall head is prepared for resetting face stones and core by brushing down and, if available, removing small, loose material with an industrial vacuum cleaner, followed by washing with clean water. Rebuilding proceeds using a well-designed bedding mortar (see 'Mortar', p. 133). The position and alignment of each stone are checked with the planning frame and

Figure 4.21 *Planning frames shown in position for recording wall tops. The frames will need to be capable of repositioning in exactly the same position during the rebuilding process. Note, left, tilestone consolidated in the position found on the wall head.*

any profiles that were made during dismantling, until the work has been raised to its original position. There is a general acceptance that the finished wall head can be modified from the original 'as found' position to eliminate the risk of rainwater 'ponding', providing that this does not affect or alter any archaeological features that exist within the masonry (Figures 4.22–4.25). If, however, it is intended to reinstate root mats, soil and plants, the ponding issue is not as relevant. On occasion, new soil and seeds representative of the site's natural ecology are installed to provide a 'soft top' which acts as a benign sponge-like covering. The benefits of such a capping can be seen on many 'natural' sites. English Heritage found this of sufficient significance to carry out research into the beneficial effects of 'soft tops' as opposed to traditional hard cappings[7] (Figures 4.26–4.32).

Broken wall ends and core facework

Collapsed or destroyed sections of wall leave a variety of conditions requiring conservation treatment. In the common, composite wall the core filling is exposed and the facing stones that encase it are vulnerable to detachment. The original cause of damage can often be read in the broken profile: subsidence, stone robbing, loss of restraints or counterforts, failures of arches, lintels and buttresses, deliberate partial demolition, mining, artillery fire, high explosives, all leave particular signatures which, for the most part, should remain as legible after consolidation as before.

The term 'core facework' is often used to describe situations where the facing masonry has been robbed or lost and the core of the wall is now exposed as a 'face' (Figure 4.34). Broken composite wall ends always involve 'core facework', but the stone facings are often lost from large areas of wall extending back from the break, or quite independently of it. Stone robbing from the accessible lower courses and subsequent collapse of some of the upper courses is a common cause of loss. 'Core facework' is thus a very important element in masonry conservation.

Inspection of the exposed core, especially when the original facing was of coursed ashlar, will often

Figure 4.22

Figure 4.24

Figure 4.23

Figure 4.25

Consolidated walls showing reinstatement of all fractures, distortions and displacements as found. This work, carried out by the Cork County Council conservation technicians illustrates the highest standards of work which can be achieved in this field.

Figure 4.26 *Perfect protection for this roofless ruin is provided by a mature mat of turf and wild flowers. This natural covering can hardly be improved on, and if the masonry below is stable, should be left alone.*

Figure 4.27 *Another example of natural wall cover, this time on relatively weak, partly earthy core. The cover provides the ideal capping for any weak core which is not suitable as a weathering surface. Butrint, Albania*

Figure 4.28 *Walls built in clay mortar should not have cement or even lime-based mortar introduced as part of a consolidation process. Biodegradable net is used here to secure the loose wall heads after excavation, pegged with long plastic anchors deep into the core. In this wet area, grass and plants native to the site soon take over the wall tops again.*

Figure 4.29 *Following consolidation of this broken wall head, a layer of humus and turf is in the process of being laid to act as the new weathering surface; the variety of grass and the composition of the bedding material should follow specialist recommendations and the species should be natural to the area.*

Figure 4.30 *Rushen Abbey. The Chapter House cleared of brambles and deep roots.*

Figure 4.31 *The Chapter House vault consolidated and prepared with a hydraulic lime-based screed.*

Figure 4.32 *The Chapter House vault covered with humus and turf taken from the site.*

reveal the imprint of the 'tails' of the facings, which were rough-backed and unworked. In this type of walling, core was raised with the stone ashlars in regular heights so that even when the ashlars have been lost it is possible to read the course heights and even the individual block sizes (Figure 4.34–4.36). Other kinds of lost facing, such as Roman reticulate construction, may similarly be recorded in core. Impressions of facings are sometimes all that remains as evidence of their existence, and the preservation of the lime core becomes a matter of great importance. Any rebuilding needs to retain the appearance of the original, even when it is distinguished from it by some identifying characteristic (see 'Mortar'). The recreation of core of this type and its conservation are highly demanding of interpretative and practical skills.

The profiles of broken wall ends generally fall into three categories. The first is largely vertical, and may occur, for instance, at a straight joint or where a gable wall had been very inadequately bonded to the return walls. The second is ramped, or stepped back, often the pattern of progressive collapse, and sometimes achieving reasonable stability. The third is overhanging, a potentially dangerous situation commonly resulting from the collapse of a large window head, or a vault, leaving high-level masonry in a cantilevered position.

Undertaking the consolidation work of masonry in these reduced circumstances requires a proper understanding of the way stones can be corbelled out and counterbalanced in dry masonry. Mortar should never be relied on to achieve stability as a substitute for this understanding. In situations where balance cannot be reached, structural assistance can be provided by incorporating non-ferrous metals in the form of restraining cramps, dowels, corbel bars or column and plate supports (Figures 4.37–4.41).

Fractures

Fractures are part of the ruin's history. Their causes are many and varied, as discussed in Chapter 2, and are often indicative of the manner in which the building failed or was destroyed.

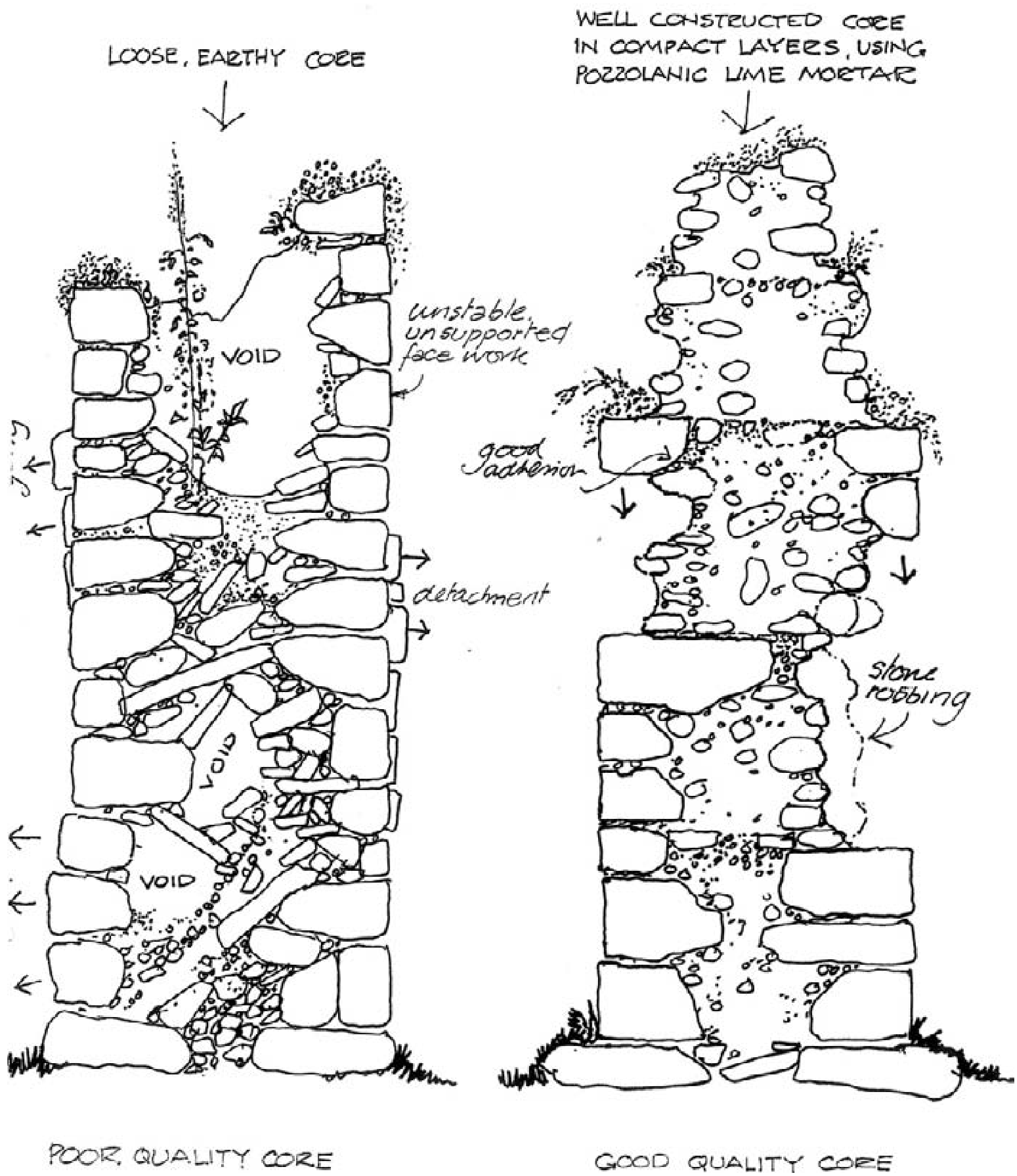

Figure 4.33 *Characteristics of different kinds of core in ruined contexts.*

Figure 4.34 *Almost all facework has been lost from his medieval composite wall. Only the core provides a record of the stone coursing and other features such as a column and vault springing line. Such core needs careful treatment; in particular, the wall heads must not be so consolidated that they become water-shedding. Either lime-mortared core or a 'soft top' of vegetation should be used. Waverley Abbey.*

Figure 4.35 *Detail of core showing the tail impressions of missing stones, with a few surviving ashlars bottom left. This evidence needs careful 'as found' consolidation to avoid losing or distorting the record. Clarendon Palace.*

Figure 4.36 *Consolidation work completed to a very high 'as found' standard with corbelled arch rings and corbelled out core. Complete stability has been achieved through the use of judicious masonry techniques and materials without any engineering device. Mourne Abbey.*

Figure 4.37 *Stainless steel torsion bars introduced at the springing line of a broken vault, anchored into the core with pattress plates, to prevent the vaults spreading, fracturing and failing. Sheriff Hutton Castle.*

Figure 4.38 *Consolidation of overhanging masonry with long restraining cramps set into core work at Byland Abbey.*

Figure 4.39 *View of overhanging high level masonry supported by restraining cramps at Nunney Castle.*

Figure 4.40 *Pattress plates and anchors used to tie back overhanging core work at Sheriff Hutton Castle.*

Some fractures are stable, and no further movement is likely to take place provided a maintenance plan is in place and is acted upon. Typically, some fractures are partly filled with debris. Live or suspect live fractures will usually require some form of monitoring in order to understand the causes of movement and to enable the correct mitigating procedures to be designed and installed. These may involve some underpinning, or underpinning and bridging areas of subsidence, and may sometimes require the insertion of wall-head beams or ring beams of tile or lime concrete (Figure 4.42). More commonly, large fractures such as those occurring a few metres from a wall end, with displacement on one side of the fracture, may require physical stitching across them; this is achieved by removing facework and core to form slots across the fracture at intervals. The slots are used to receive suitably shaped long stones, or non-ferrous metal bars with turned-down ends or stainless steel threaded bars set in resin dovetails, or lime concrete stitches. All stitches are intended to prevent further movement in the future. The type of stitch needs to be selected for particular conditions on site. For instance, if the core of a composite wall is found to be rather poor quality, it may be necessary to extend the stitch some distance either side of the fracture and to lock it well in two directions into the core (see Figure 4.43). If the core is well made and in good condition, the use of bars or even stones may be quite adequate. The installation of these stitches is followed by replacement of the facing stones in their original positions. Proprietary stitching systems incorporating a bar and a sock that are grouted *in situ* with a cementitious or

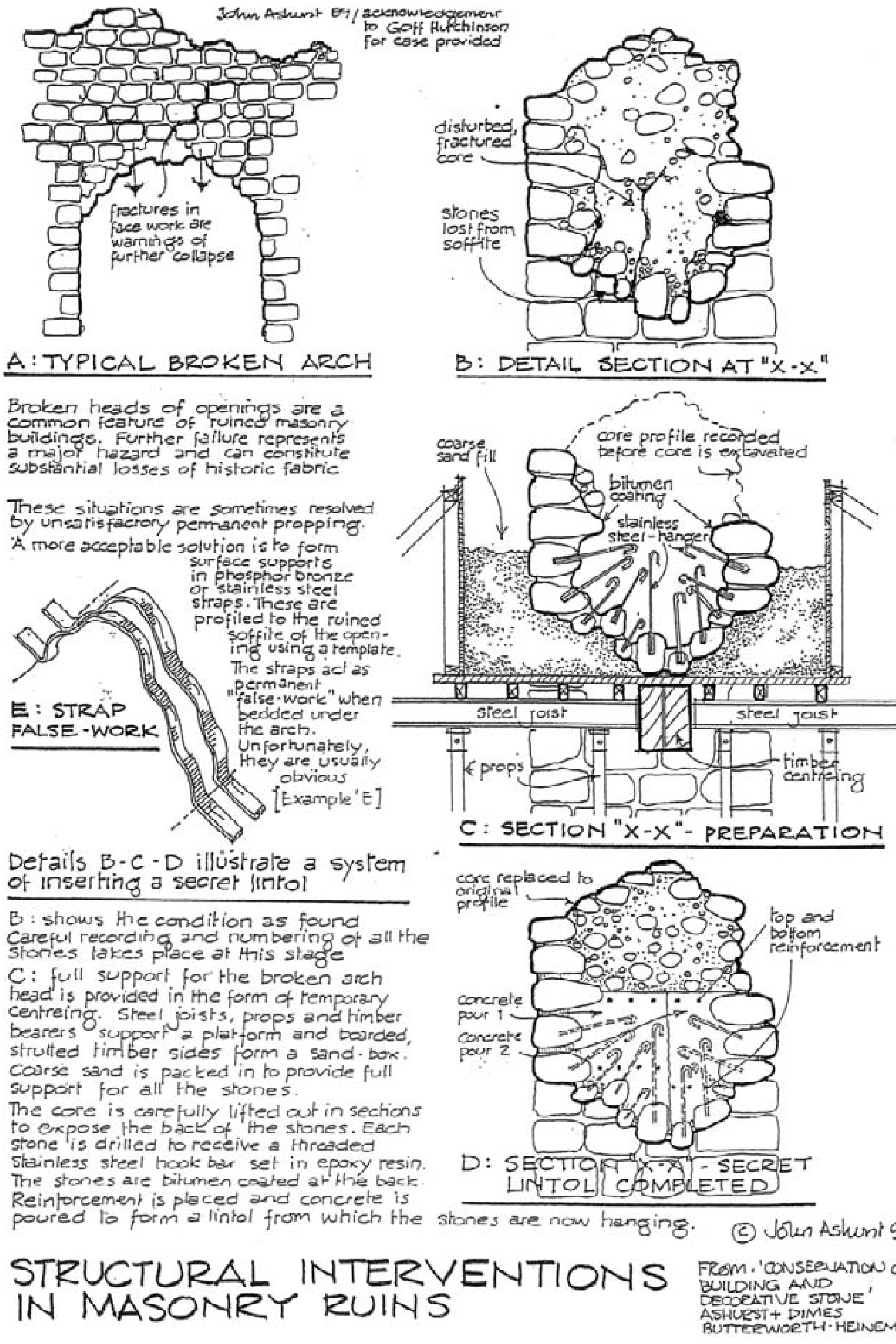

Figure 4.41 *Structural interventions in masonry ruins.*

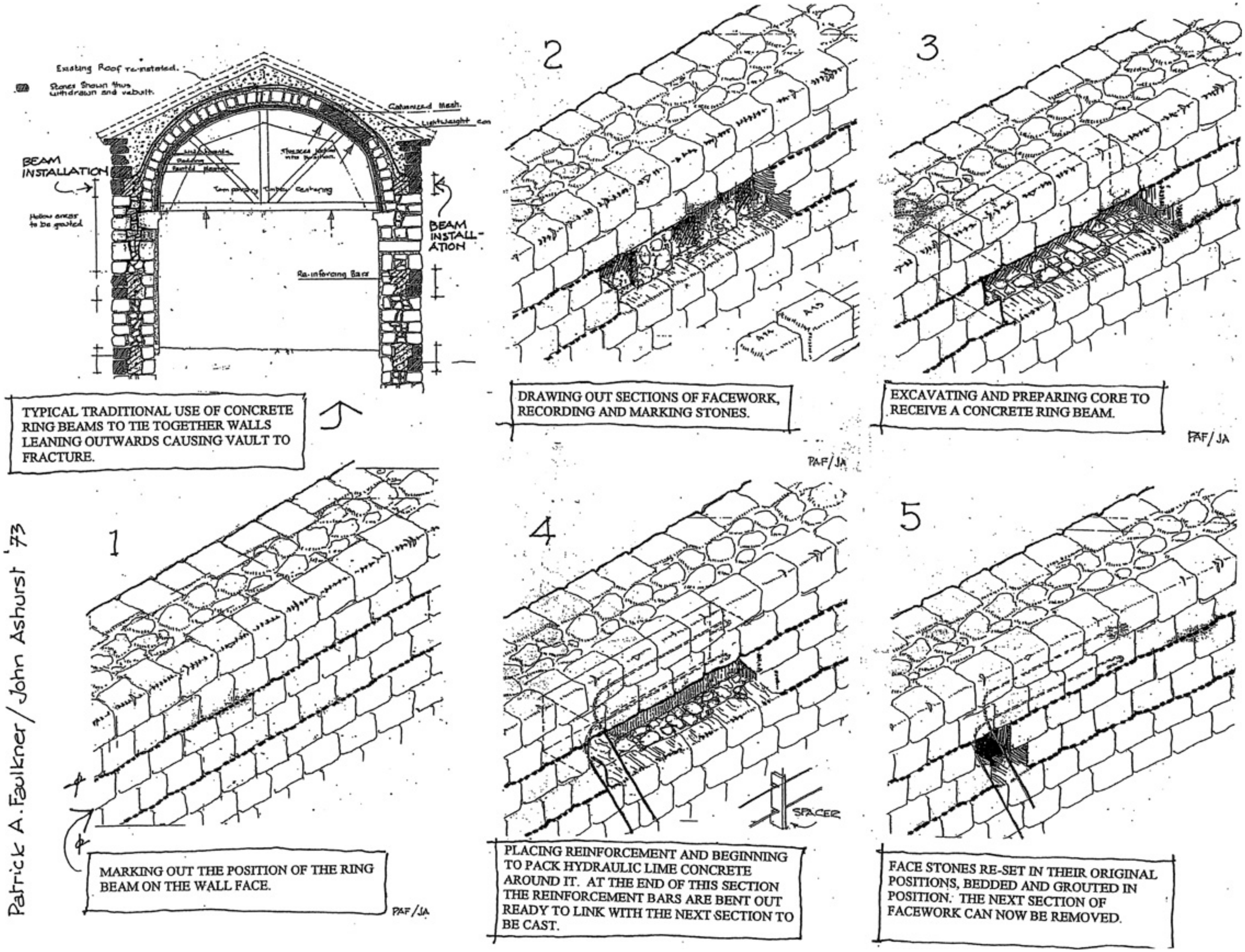

Figure 4.42 *Installation of ring beam.*

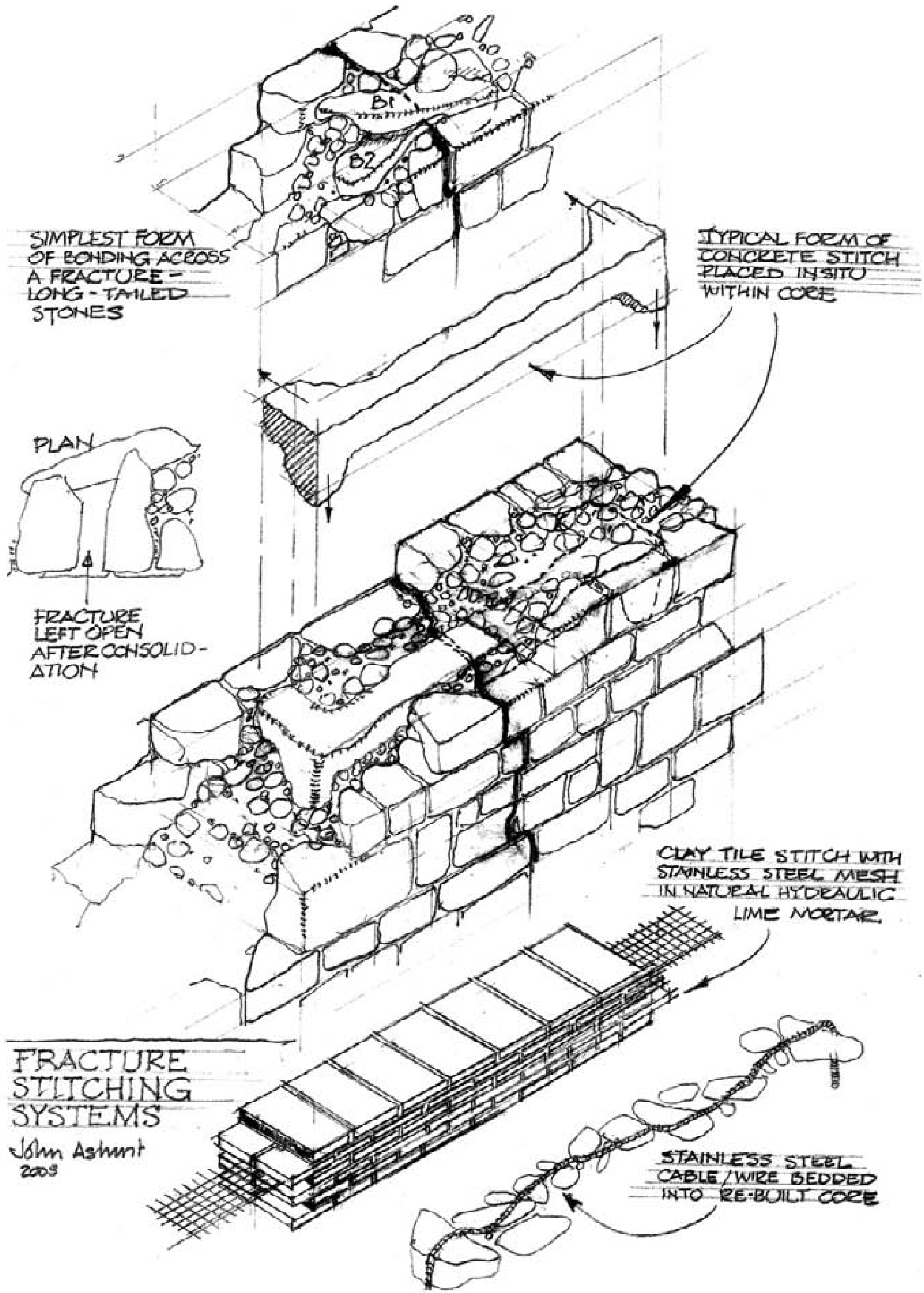

Figure 4.43 *Fracture stitching systems.*

Figure 4.44 *Distortion of this medieval arcade is due to multiple causes including loss of restraints and counter-forts during ruination. Most seriously, the low wall on the left of the picture below the twisted cluster of columns is badly fractured. Only the central shaft is making contact with the wall and the arch springing.*

resin grout to form a locking profile with the wall core are an ideal solution in certain wall conditions; however, when the wall core is poorly constructed their benefit can be questionable (Figures 4.44 and 4.45).

Whether the fracture is fine or wide, it is important to pack and tamp or grout them with lime mortar to prevent further degradation of the wall core by denying water access. Grout and mortar should be kept back from the face to a sufficient depth to create a shadow line within the old fracture, so that the overall appearance is unchanged after the weakness has been resolved within the core of the wall.

Voids in walls

Long-term exposure of wall heads, especially where fractures are present, can result in the creation of voids within the core of the wall. Such voids are not limited to ruins, but are particularly common in roofless structures and may house tenants such as bats, birds or snakes (see Chapter 6), who will require consideration before any remedial work is commenced. In the first decades of conservation work on ancient monuments in Britain, these voids were filled with cement grout (liquid mortar) introduced by a gravity feed system (Figures 4.46 and 4.47). The principles used were sound and the stability achieved in many cases undisputed, but unfortunately the choice of material sometimes contributed new problems without completely resolving the original ones. Unmodified cement grouts have poor mobility and create cold, impermeable zones within the lime-built construction where condensation can occur, encouraging frost damage in cold climates, and can deposit new soluble salts in the masonry.

In occupied buildings, the discomfort and inconvenience of water penetrating to the internal surfaces of walls is most likely to draw attention to the presence of channels and voids within the wall. In the ruined structure dark patches persisting around joints in the drying out period after heavy rain, water running from joints or out of exposed core and white patches of redeposited lime washed out of core are all common indicators of internal cavities. In serious cases of prolonged washing out, bulging

Figure 4.45 *Detail of base of column cluster seen in Figure 4.44 showing the distorted and fractured support wall. Temporary supports of the arcade are required to enable the wall to be recorded, taken down and rebuilt in hydraulic lime mortar. Stitching of such poor construction is inadvisable because of lack of adequate anchorage.*

Figure 4.46 *Traditional gravity grouting at Fountains Abbey showing the grout pan in its cradle on top of a scaffold. The grout solids are being stirred to keep them in suspension before releasing a plug which will allow the grout to rise from the bottom of the voided wall.*

Figure 4.47 *At the base of the wall this illustration shows grout emerging from one of the escape holes provided, confirming the rise of grout behind the face stones. The blocks here are shown levelled with oak pegs and the joints plugged, in the traditional way with tarred rope.*

of facework may be observed. The severity of such bulging may mean taking down and rebuilding the detached area, but if the situation is not too advanced it may still be resolved by grouting, and on occasion the combination of face pinning and grouting can be employed.

Attempts to correct the excessive movement of water in and out of the wall are, unfortunately, often in the form of pointing up cracks and joints with impervious, cement-based mortar. This practice commonly exacerbates the problem by failing to exclude water, because of the habit of the mortar to shrink and crack, and by inhibiting its evaporation and encouraging entrapment (see 'Mortar'). In the rectification of voided core problems, it is of paramount importance that such mortars are removed, unless such removal causes unacceptable damage to the structure.

Void patterns within walls are difficult to determine accurately by survey. The distribution system for invasive water within a thick wall core can be very complex. In spite of this, entry and exit points can be observed and should be recorded. A simple process of sounding the wall faces with a hammer will indicate some of the void locations close to the face, and the removal of a face stone in a suspect area will be even more informative. More sophisticated systems such as using gamma or X-ray or ultrasonic testing are sometimes advocated, but the time and cost and, especially, the potential benefits should be carefully considered against their true value. In all remedial works procedures the simplest means possible to achieve the required result should be selected.

In some situations voids may be apparent following the removal of degraded or inappropriate mortar pointing, especially at perpendicular joints. On occasion it is advisable to remove a number of face stones within an elevation, in order to get a better indication of the extent of voiding within a wall.

To further establish voids at greater depths and to determine their extent and direction, water can be fed into the wall using a hosepipe. Flushing with water in this manner has a number of benefits. It will escape the core from either face and indicates the bottoms of tracks or voids within the wall. These are marked as grout injection points. Loose dust and debris is flushed from the wall during this

Figure 4.48 *The simple diaphragm pump which has largely replaced gravity grouting of masonry walls.*

operation and the core is well wetted, ready for the grouting process.

The entire wall or walls are tested in this manner. Any large areas of masonry not showing signs of leaking during the process can be deep drilled through joints on a grid system of 0.5 m vertically, 1.0 m horizontally, and staggered in order to connect with long voids which will act as both grout injection and proving holes during the works.

All marked water escape points are fitted with plastic tubes set into the wall that are of a diameter to accept the grout injection nozzles. Repointing of the wall or walls can now take place and in doing so the plastic tubes are fixed into the masonry.

Grout is always introduced from the base of a wall, not from the top. This important practice is to avoid blocking through air locking and to prevent fine debris working down and closing up the voids. For this reason, it is sensible to plan repointing at open joints from the bottom upwards, so that the mortar can gain enough strength to contain the grout without leakage. In some circumstances the open joints can be plugged with foam backer rod or some alternative packing and repointed after grouting.

Introduction of grout is ideally carried out using a simple diaphragm pump which works by pushing and pulling the operating lever (Figures 4.48–4.49).

A pressure gauge is fitted to the pump and this, during pumping, should hardly register, as introduction of grout into the wall needs to allow for the grout to spread slowly and horizontally along the wall, rather than creating a vertical head of grout locally at the injection point and then allowing it to spread along the voids within the wall.

The lift heights for grouting will vary on buildings. Large granite ashlars with a fine joint system could be raised 1.5–2.0 m in one day. Alternatively, small stones in a weak mortar should not be raised above 0.5 m without the risk of hydrostatic pressure moving faces away from the core. Decisions on height of grout per day can only be taken on site and must be based on extensive previous experience.

If possible, each lift of grout introduced to a wall should be left for one day before resuming grouting. This is in order to give the grout time to dewater and stabilise before more grout is added to the wall. Grout continues in this manner until the head of the wall is reached. At this stage it is advisable to apply a head of grout to the upper proving holes, to compensate for the reduction in volume of grout due to de-watering within the voids. Quantities of grout

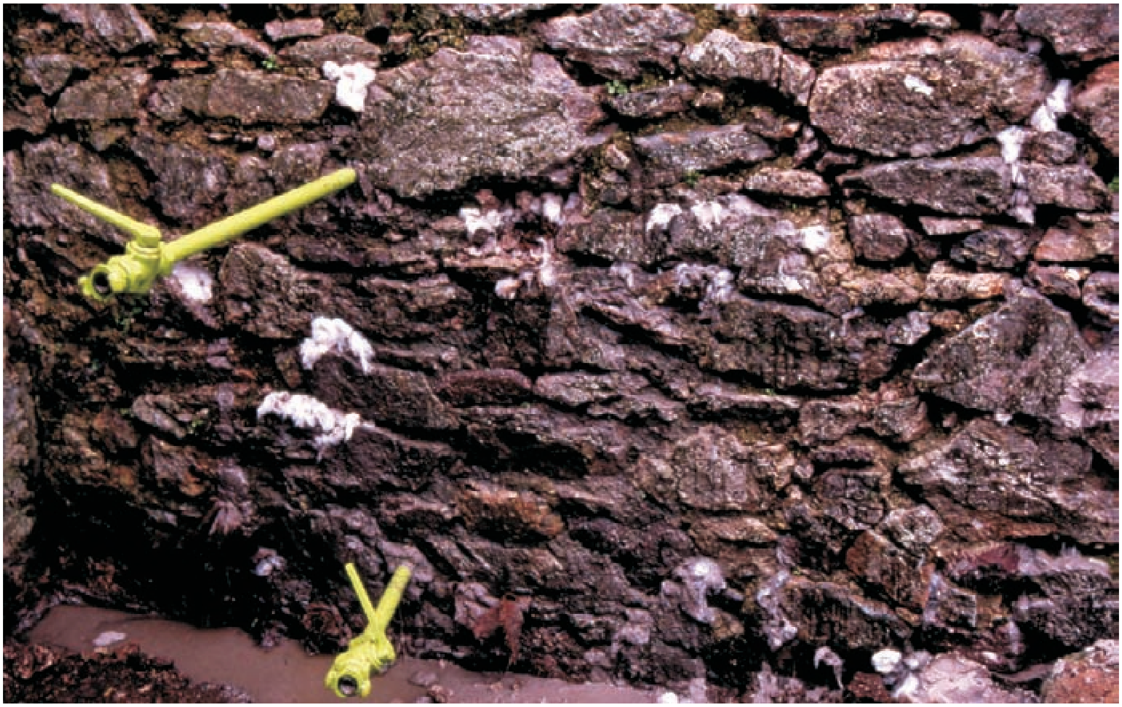

Figure 4.49 *Masonry wall showing grout nozzles installed. These can be simply coupled to the grout feed hose.*

taken up at each injection point should be recorded to provide an indication of the volumes filled.

On completion of grouting and after a period of three to four days, the plastic sleeves can be removed and the injection points can be deep tamped and pointed.

Stone replacement

Within the philosophical context already described it is unusual to find any substantial replacements of new stone. All stones, in whatever condition and especially any that have to be replaced, must be recorded and evaluated. All types need to be petrographically identified and provenanced as closely as possible, and archaeological evidence such as lifting tenons, quarry-working marks, tooling, identification marks and mortices must be recorded. When different types of stone have been used in construction, identification may indicate important changes in the history of the building or, for instance, the use of salvage material from other sites.[6] Where replacement is necessary, to support or protect historic material at risk, the rule of 'like with like' is generally thought to be appropriate. In many cases this can amount to no more than geological compatibility, because original sources of stone are often no longer available. Matching colour, grain size and texture are thought to be important in the repair of any masonry buildings, but in the conservation of old, weathered masonry the overriding objective must be to so modify the situation in the wall that its life expectancy is significantly increased.

Some general points on the selection of appropriate material may be made. The stone should be of the same type as the original, and of the same overall size and character, achieved through cutting and dressing techniques. Other characteristics are more problematical. Even when a replacement stone is near to identical with the original stone it will be different by reason of its unweathered state; its surface, at least, is going to be more resistant to weathering and decay agencies. Bedded and grouted into the old masonry, even in appropriate mortars, the new work is commonly much sounder than the old and may initially cause additional local stress to the fabric it is intended to assist. Admittedly, this is only likely to be the case when the old masonry is in very poor condition, but such situations are not unusual

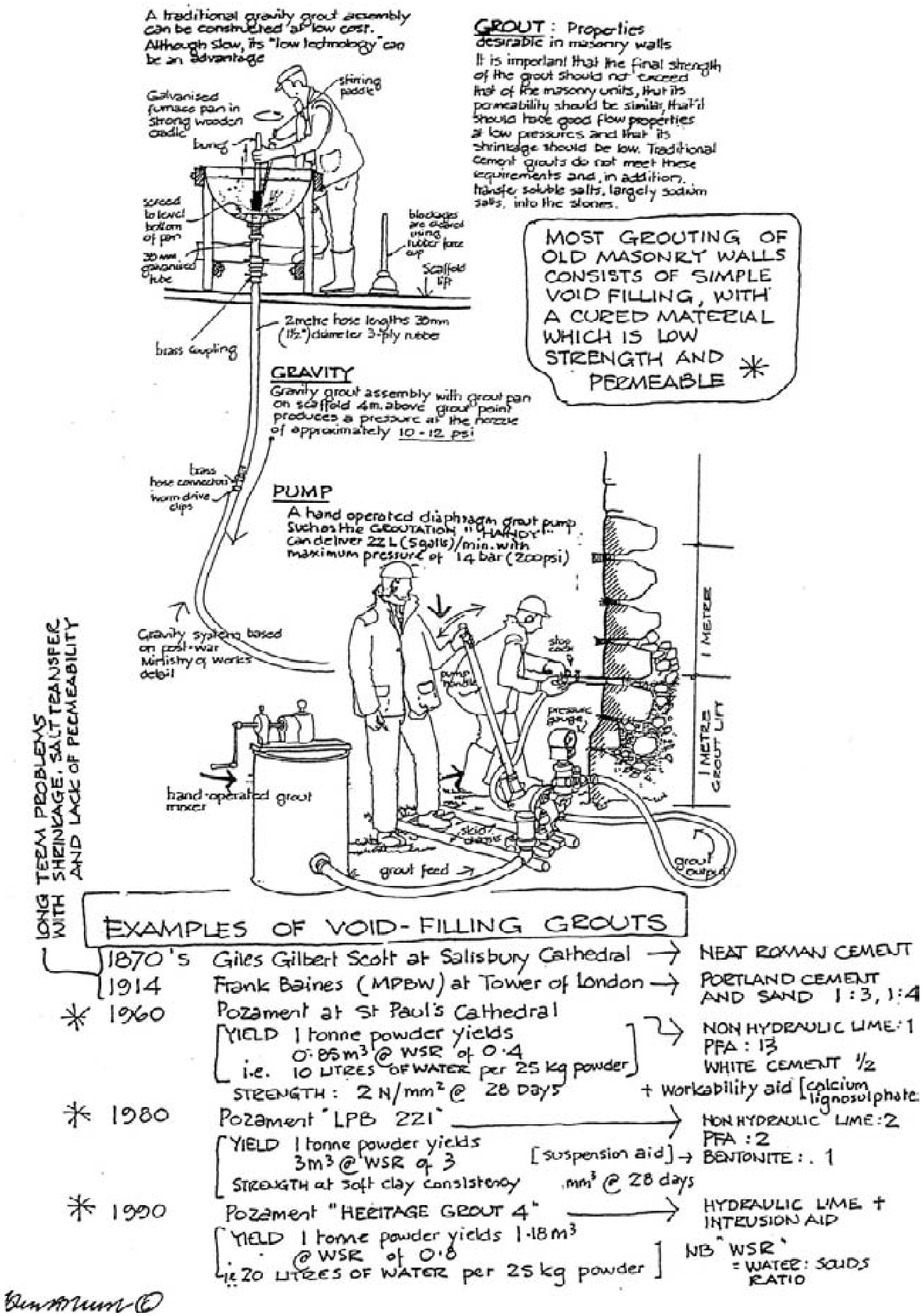

Figure 4.50 *Grouting masonry walls.*

in ruin conservation. With these concerns in mind, alternatives to stone replacement are sometimes specified, and these are described below.

The requirement for new stone is usually identified during the condition inspection and becomes incorporated in a schedule of repairs. Regardless of irregular arrises or damages, new stone should be scheduled giving large enough dimensions (length on face × depth on bed × height – $L \times B \times H$) to allow for dressing back to the final sizes required. In many countries new stone is now supplied four or six sides sawn as standard (Figure 4.51); such blocks would have been very expensive to produce in centuries past, when it is usual to find only the face and short-return dimensions worked square, with the back or tail of the stone irregular as quarried. Replacements should normally be 100 or 150 mm on bed, and sometimes longer, depending on their functions, but the face dimensions (L and H) should match those of the lost stone as closely as possible and, most importantly, should be set to the original face line on the building (Figures 4.52 and 4.53). In weathered and decayed masonry, this means that the new stone will project, often forming a ledge on the top bed and creating a shadow line under its bottom bed. In spite of this, there should be no deviation from this rule or the evidence of the original face line and its profiles will be lost, and the authors of future replacements denied essential information.

Projecting stones of this kind do not need conspicuous mortar frames, and especially not mortar fillets applied to the top bed as a 'weathering' (Figure 4.54). Mortar bedding and pointing should follow the weathered profile of the masonry, so that joints never increase in thickness over the original width and are not enlarged to fill out local damages. On the top bed, the stone may be given a very slight weathering and a pencil-rounded front arris to assist the discharge of water from the face (Figure 4.53). Stones should be set into well washed, cleaned cavities on a full bed of mortar (see 'Mortars'). The top bed joint should be filled with 'dry-pack' mortar (the bedding mortar with a low water ratio). This crumbly material can be firmly and tightly packed using a tamping iron, to within 20–30 mm of the face, and later pointed. Unless dry packing is used there will be a tendency for the top mortar bed to shrink, leaving the stone above unsupported.

Figure 4.51 *Uncomfortable machine cut replacement stone in an eighteenth century context of quarry-dressed stones.*

Figure 4.52 *This section of Roman cornice has been prepared from templates made from a complete stone found in excavation. It is set in the wall to fill a gap and to show the original architectural line and detail. Beth Shean Israel.*

Figure 4.53 *This replacement stone has been set in a damaged medieval entrance arch still used by vehicular traffic. The stone is the correct chamfered profile taken from the head of the arch and is placed in its correct line in the jamb. Although the new stone projects from the weathered masonry no mortar weatherings are used; instead the stone has a very slight fall on its top bed and a pencil-round arris. Providing the bedding mortar is deep and well packed this stone will shed water effectively. Guildford, Surrey, UK.*

Figure 4.54 *New sawn stones are rather more comfortable in a setting of squared ashlars but suffer from arrises which are too sharp and bedding which is out of line. There is also far too much mortar on the top bed, placed in an attempt to provide a weathering. This should be compared with 4.20. New mortar has an unnatural, flat face.*

Replacement stone should always be identifiable, and there is a tradition of incising the date of placement on new stone. In some situations stone replacement within ruins may be structurally necessary and a stylistic difference may be made to differentiate new from old. Examples of this approach are shown at Battle Abbey (Figure 4.55) and Furness Abbey (Figure 4.56). In both cases a structural solution has been provided with the 'correct' stone, but stone which has not been moulded to imitate the original, deliberately staying short of any accusation of restoration. It can be argued, in the case of the Furness illustration, that some ghosting of the vertical roll and hollow moulding would have been an aesthetic gain; certainly, the course lines of the blocks should have been carried through.

In cases where severely decayed masonry is in need of local replacement, an alternative to whole block indenting may be the use of tiles. The Society for the Protection of Ancient Buildings in England has for decades recommended the use of coursed clay tiles for philosophical reasons, in both hydraulic lime and cement and lime. The argument for this approach is that structural support can be introduced in a way that does not compromise the truth, even if the tile repairs were rendered, as they often were. An example of such a repair is shown in Figure 4.57, at Guildford Castle, carried out in 1914. A more elaborate example, including full arch rings, is shown used at Wolvesey Castle, Winchester (Figure 4.58).

There are, however, some situations where the use of tiles, clay or stone, may be the most suitable and successful replacement option, quite apart from the philosophical issues of honesty in repair. Tile slips may, for instance, be introduced with less loss of original material, in the repair of decayed vault ribs, performing perfectly well in compression within the arch thrust of which they will become a part. Or within a very weak, cavernously decayed context such as the poorly lithified limestone of Herod's Northern Palace at Masada, they may be almost

Figure 4.55 *Philosophy in place at Battle Abbey, Sussex. In the 1920s the left hand window head and masonry on each side were rebuilt. To distinguish the rebuild from the original, seen on right, the stones were roughly shaped voussoirs and jambs which recreate the scale and design of the original but remain permanently distinguishable from it. This illustrates a typical Society for the Protection of Ancient Buildings approach of the time.*

the only option, as described in Chapter 10.2. The importance of this technique is primarily in its compatibility with the ancient fabric. Porous, permeable tiles of clay or weathered stone set in porous, permeable mortars are receptive to water vapour movement and the passage of salts in solution; they do not create new crises for the beleaguered walls in which they are set and can, in later years, be replaced. Unlike new stone or brick they can be expected to perform in a truly sacrificial role for the benefit of the old work they are trying to sustain. In setting tiles into a cavity created by the removal of decay, bedding mortar is placed on the upper face of the top tile and the joint below is dry-packed with a tamping iron to ensure that the soft mortar is pushed up into the irregular roof of the cavity.

Stone repairs

The retention, rather than the replacement, of the stones or bricks in a ruin should be an obvious choice. Old techniques of repairing stones included the 'tinning' of open fractures by running in liquid cement, joining detached fragments with shellac or clasping elements such as mullions and tracery with copper tape. Minimum replacement is frequently coupled with techniques of filling small lacunae with mortar ('dental repairs'), or with small pieces of stone or tile within the boundaries of an old stone ('piecing-in'), or of drilling and stitching fractured stones. The design of appropriate mortar fills must follow the general principles set out under 'mortar specification for joints', but in the repair context it is even more crucial to have good water vapour permeability and moduli of elasticity in addition to good texture and good, stable colour in both wet and dry conditions. Dental repairs, like stone repairs, should always be sacrificial and records of their composition must be retained so that future repair material can be repeated or modified.

The technique of repair, preceded by photographic recording of the conditions, is to cut away the decay with small points or chisels, or even a spatula, scraping back to a sound surface and forming slight undercuts around the perimeter of the

Figure 4.56 *Philosophy in place at Furness Abbey. The missing outer orders of the arcade pier have been replaced in a similar red sandstone which provides the necessary structural support for the arch but which is visually rather unsuccessful. The new line of the pier face is too far forward, and has no articulation representing the base and cap. In addition, the course lines of the new stone do not run through to match the original coursing. Some shallow vertical channelling echoing the original roll and hollow moulding would have made it a much better intervention, whilst still remaining an obvious intervention.*

repair, to avoid feather-edging and to help to 'lock' the repair into the host material. Following preparation of the repair area it should be washed and sterilised, ideally by a small steam-pencil or by fine water sprays and a biocide. What is required is a firm surface, free of dust and debris and of micro-organisms. Before the repair is placed, a final stage of spray-wetting will be needed, especially in hot,

Figure 4.57 *Philosophy in place at Guildford Castle. The 1914 period clay tile replacements for decayed stones were once rendered. These repairs were and are unmistakable interventions, which is exactly what was intended.*

dry and/or windy conditions. Unless there is a reservoir of moisture in the repair zone, the stone or brick will draw too much water from the mortar when it is placed, with subsequent shrinkage. Drying shrinkage is the most common cause of failure in mortar repair, either due to this 'de-watering' by the background or to inadequate curing in the right conditions (see 'Mortar').

Following careful placing and packing of the mortar, which is either achieved in one layer (shallow repairs) or two or three, each layer being well compacted to the earlier one while it is still damp ('green'), wet packs of material such as cotton wool are placed over the repair and intermittent misting with water, usually from hand-held sprays, continued over three to seven days to ensure slow curing.

Fractures in individual stones often require a method of stitching. The use of adhesives alone is not particularly recommended, unless the repair is very small, and should never be used on interfaces

Figure 4.58 *Philosophy in place at Wolvesey Castle in Winchester. Missing stones of the arch have been replaced with clay tile rings; although an effective piece of consolidation the completeness of the tile ring could be misleading, suggesting that this might originally have been a tile arch.*

exceeding 10 mm^2 as they form barriers to water movement and can encourage local build-ups of salts. Stitching involves drilling across the fracture, blowing out the debris with a drinking straw or rubber 'puffer', flushing out with water and a suitably sized bottle brush, and grouting in a 'stitch', pre-cut and first fitted dry. Micro-stitching of this kind is best carried out with twisted strands of copper wire (two or three strands can be twisted together using a hand or power drill and then cut to size). Slightly larger stitching can be carried out using purpose-made ceramic pins or T-bars, which have the benefit of being highly compatible with porous stones or ceramic. Very fine stitching can be executed with carbon-fibre pins. In most cases, stitches can be satisfactorily grouted in hydraulic lime.

Mortar

Where ancient ruined masonry is mortared the mortar may be based on lime, soil or gypsum, or on some combination of these three. If a modern artificial cement is present, usually a type of Portland cement, in pre-1850 buildings, it belongs almost without exception to previous and inappropriate programmes of remedial work. Reference has already been made to some of the cement-generated problems experienced by conservators in the first half of the twentieth century. Most prominent among these are cracking of both joints and stones or bricks, lifting of consolidated wall heads, increased decay rates to stone, plaster, earth walls or mosaics caused by accelerated wetting and drying of salt contaminated water, and increased incidence of frost damage in cold, wet climates. Simply put, there is an inherent and fatal incompatibility between cement and lime-mortared construction, which no amount of theorising or modification will eliminate (Figures 4.59–4.62).

There is a significant body of material available on historic mortars and their replication.[8] In the context of ruined buildings which are to be conserved there is perhaps more justification for mortar study than might be the case with complete, roofed and protected buildings. The old mortar, whether in joints, exposed core work or applied as a plaster, is as much a part of the fabric as bricks and stones,

Figure 4.59 *Mature lime putty which has been aged for three years exhibiting the right consistency for use as mortar. Bryn Gilby's lime production, South Wales.*

Figure 4.60 *The volcanic crater of Santorini (Thera). The ash from this famous volcano has been important since classical times as a setting additive (pozzolana) for lime mortar and concrete.*

Figure 4.61 *This deposit of pozzolana near Tivoli shows the typical range of colours found in volcanic ash. This pozzolana has been used extensively since the Roman period. The most reactive material, mixed with lime and water was used very extensively for engineering works.*

and is equally at risk; moreover, mortar can contain important information about the technology and materials of the time of its composition and placement (Figure 4.62). A study of provenanced mortar samples is an important part of recording the history of a ruined building. The composite wall, already described, consisting of two masonry skins enclosing a core of stone and mortar, is the most common, traditional form of load-bearing wall, but variations in construction are very numerous and these variations have a profound effect on how walls behave when they are broken and exposed to the weather.

For instance, a wall in which the facings are bedded in good mortar and are well integrated into a soundly coursed and compacted core can withstand the trauma of partial destruction remarkably well. But if only the facings are set in good mortar and the core is of inferior material such as clay, then exposure through partial collapse or destruction will make the whole wall very vulnerable indeed. An important aspect of conserving composite walls with weak cores is that the facing joints must be very well maintained using an appropriate mortar to tamp and point where necessary; cement-based mortar must again be excluded altogether, as it will significantly inhibit the drying out of the wall following wet periods while allowing water in through movement and shrinkage gaps. Incorrect use of impervious mortar can bring out the rapid collapse of such construction.

Both clay- and gypsum-built masonry could be, and usually was, protected with lime-mortared facings or lime plaster. Without these original means of protection or a suitable replacement, walls will fail. No 'anti-restoration' philosophy should be used to deny essential protection to the walls of ruined structures, although it may, of course, sometimes dictate the use of a cover building (see Chapter 5) rather than replacement of plaster; but the risks to exposed cores must be understood by the decision-makers.

'Appropriate' mortars for ruined masonry are wide ranging in their detail, because of the tendency to use aggregates that are local to each site. Nevertheless, it is possible and important to make some general rules and classifications for mortars, plasters and grouts applicable almost anywhere. The steps to specification decision-making may be set out as follows:

- Make a visual inspection of the mortars on site; look for individual characteristics of colour, texture and weathering, and for differences; where

Figure 4.62 *Roman mortar at Pevensey, Sussex, England showing the use of artificial pozzolan in the form of powdered brick or tile blended with large brick aggregate and lime. This mortar is extremely durable and has survived a marine environment for 2000 years.*

Figure 4.63 *Exposed core of Hadrian's Wall with its wall head screed intact. Loss of face stones requires careful consolidation of materials not designed for weathering.*

possible, identify earlier interventions; look for and record areas of failure or apparent risk and areas of decaying stone or bricks.

- Take samples of unweathered mortar for record and analysis; this is much simpler matter from wall cores than from joints, but the aim is to remove samples that have not been significantly altered. Each sample should be kept in a sealable bag or jar clearly and indelibly labelled with the name of the site, the location of the site and a description of the mortar sample, preferably supported by a photographic reference and a record of the date and who took the sample.
- Design a mortar that will protect the masonry without creating new problems and that will be visually harmonious with the other mortars on site. This should take account of the original aggregates used and recorded from samples, but analysis should not be used as the basis of a new specification, which is for a mortar whose role is to perform alongside weathered and altered stones, bricks or earth. The condition of the old masonry must always be the first consideration, the role of the mortar the second and the exposure of the mortar the third.
- Prepare trial batches of mortars and look at them in the context of the site. Prepare method statements for the preparation of the remedial mortars using the site conditions to 'fine-tune' the way the mortar is treated and finished. When completed, these trials and the mortar specification should become a part of the permanent record of the site and are essential for future conservation and maintenance. Without such records no useful lessons can be learnt in the future.

Decisions need to be made on how new mortar should look. The traditional 'like with like' approach, although visually satisfying, may need some adjustment if the new work is to be distinguishable from the old. The last stage of well-executed joint filling is to tamp or wash the mortar face to match the weathered texture of old surviving mortar, or it may be profiled to match an original profile. This is skilled work which is to be encouraged. But some 'tagging' device, such as the inclusion of a distinguishing non-prejudicial addition to the aggregate, may be considered proper to enable replacement mortar to be distinguished in the future. Although there are precedents for a 'conservation house style' such as a particular kind of washed grit finish, this is far from satisfactory when used indiscriminately over a wide range of different sites, and a more discreet method of identification is recommended.

Critical to the success of mortar, mortar repair or plaster repair is the curing process. Whatever mortar is used it will almost certainly fail if it dries too quickly for a proper carbonation process to take place. The first essential is to make sure that the backing for mortar or plaster is made adequately damp. In practical terms this means that enough water will have been applied to the surface to avoid any significant suction on the new material. The surface should not glisten with water but it should refuse to take any more. Once the new mortar has been placed it needs to be screened, ideally with plastic film that retains humidity better than any open textured material. When working on scaffolds the construction of curing screens is a very useful way of maintaining the desirable conditions. These screens are typically 2 m high and 1 m wide, formed of 15 mm × 25 mm batten, and faced on one side with plastic film and on the other side with hessian (burlap). The hessian-faced side can be well wetted with sprays and placed close to the wall, allowing some ventilation. A series of screens can be joined together using a simple hook and eye system, and screens can be simply secured to scaffolding. If a plastic sheet is used alone it should be reinforced and fitted with reinforced eyelets to avoid tearing and to provide secure anchorage against wind lift. Screens are normally used as overnight protection but can be used during the working day by moving them to the back of the workspace to protect against sun or drying wind. During the day intermittent fine spraying of mortar surfaces is recommended to keep them in a slightly damp condition over a period of 7–10 days. Without this initial care a great deal of time and effort will be wasted, as the mortar will either shrink and crack or will carbonate rapidly on the surface, sealing mortar behind which will never gain adequate strength.

Replacement mortar materials

Placing new mortar into ancient walls is a serious responsibility. Failure to recognise and accept the responsibility through ignorance, insensibility or mistaken ideas related to cost-cutting is always paid for by the historic fabric. Decades of capping the broken and open wall heads of ruins, filling their joints and voids in cement-based mortar and grout have already caused too much damage. The research and field work on this subject have been carried out. The responsibility of the conservator is now to use

Table 4.1 Mortar type 'A' – lime putty and pozzolan

	Mix designation		
	A1	*A2*	*A3*
Mature lime putty	1.0	1.0	1
Aggregate – hard, angular	1.5	1.0	1.0
Aggregate – rough, porous	1.5	1.5	1.5
Aggregate – metakaolin	–		1/10
Aggregate – ceramic	–	1.0	
Aggregate – wood ash	1.0		

A1 = weakest; A3 = strongest

Table 4.2 Mortar type 'B' – hydraulic lime

	Mix designation		
	B1	*B2*	*B3*
NHL2	1.0	–	–
NHL3.5	–	1.0	–
NHL5	–	–	1
Aggregate – hard angular	1.5	1.0	1.0
Aggregate – rough porous	1.0	1.0	1.0
Aggregate – ceramic	–	–	0.5

B1 = weakest; B3 = strongest

materials that are wholly compatible with lime-, earth- or gypsum-based mortar and plaster, and which are ultimately sacrificial.

Non-hydraulic lime ('air lime') and hydraulic lime ('water lime') with pozzolans such as ceramic powder to promote set and react with available free lime are the usual binder materials for replacement mortars. Gypsum mortars are relatively rare outside those countries with hot, dry climates. Sand and other natural stone aggregates, including porous types, broken brick fragments, charcoal and slag, are common filler materials.

A comparison of hydraulic and non-hydraulic lime products and production is provided in Appendix 1. The range of conditions and exposures worldwide is almost limitless, so that it may seem rather ambitious to make recommendations on mortar mixes. Nevertheless, although combinations, adjustments and modifications may be infinite, certain parameters illustrated by typical mixes can be set with some confidence. Two mortar categories are proposed in Tables 4.1 and 4.2. The first, Type A, is based on a non-hydraulic lime in the form of putty, with a pozzolan additive to provide a weak hydraulic set. Three pozzolans are suggested, one wood ash and the other crushed ceramic tile or brick, and the third one a metakaolin. True pozzolan could also be included but variations in reactivity are so wide that to do so is not helpful. The purpose of adding pozzolan, following an ancient tradition which survives to the present day, is to provide a relatively weak hydraulic set. The weakest of these was often achieved by reaction of some of the lime in the kiln with the ash or slag from the fuel used in the combustion process. The second category, Type B, is based on natural hydraulic lime using the European standards to describe them as NHL2 (approximating 'feebly hydraulic'), NHL3.5 (approximating 'moderately hydraulic') and NHL5 (approximating 'eminently hydraulic'). In one case the addition of a pozzolan is suggested to react with some of the free lime present after the hydraulic set has taken place.

Description of mortar constituents

- *Lime putty*. This should be putty prepared from quicklime stored in an airtight tub or under water for a minimum of six months. Aged putties well in excess of one year old are particularly desirable for the weaker mixes. The putty must be in a stiff, plastic state when it is gauged, to avoid inaccuracies when batching. A stiff putty yields significantly more lime than the same volume of a loose, wet putty. As a guide for practice, a cut column of putty 50 mm × 50 mm and 150 mm high should be able to stand for five minutes without any appreciable lean or slump.
- *Aggregate – hard, angular*. This describes a clean, sharp grit-sand, well graded to suit the appearance of the mortar being matched.
- *Aggregate – rough, porous*. This describes aggregate with a pore structure that will assist carbonation of the mortar and improve its resistance to salt crystallisation and to freeze–thaw damage. Typically, this would be broken, graded limestone or brick, but could include particles of slag and other porous material.
- *Pozzolan – metakaolin*. This product may not be available in every country, but is a useful material. China clay fired at approximately 800°C produces material that will react rapidly with calcium hydroxide to provide a hydraulic set. Strength gains continue over quite a long period. Quantities in excess of one-tenth of the lime binder are not recommended.
- *Pozzolan – ceramic*. Following Roman tradition, this pozzolan is typically a low-fired brick or tile powder fired at relatively low temperatures

(*c.* 1000°C) ground to a fine powder (passing a 75-micron sieve). Grinding to provide fresh broken surfaces can be useful. Proportions are normally 1:1 with the binder.

- *Pozzolan – wood ash.* The weakest of the pozzolans is a difficult material to quantify, and like all additives must be subject to preliminary trials. The great advantage is that ash is universally available. Great care should be taken in using any other forms of fuel ash with unknown soluble salt contents and unknown reactivity.
- *Natural hydraulic limes – NHL2, NHL3.5 and NHL5.* Natural hydraulic limes are becoming increasingly available, with France being the current major supplier. The classification is important. In general, it is best to avoid a classification of NHL2, NHL3.5 or NHL5 suffixed with a 'Z', unless the Z additive is known. For historic work avoid any material simply classified as HL. All hydraulic lime mixes should be first blended dry and allowed to stand after being mixed with water. An NHL2 should be left for at least 24 hours after wet mixing; an NHL5 should be left for at least 12 hours. The wet mixes should be protected from rain and sun, and remixed before use.

The mortars in Tables 4.1 and 4.2 are arranged according to their strength; thus, the weakest mortar is A1 and the strongest is B3. The weakest mortar able to perform the intended function without creating new problems for historic fabric should always be selected.

Grout materials

Non-hydraulic lime ('air lime') and hydraulic limes ('water limes') in combination with pozzolans such as pulverised fuel ash (pfa) or fine powdered ceramic with suspension aids such as bentonite are the usual solids used in grouting. Although, in the past, cement was extensively and almost exclusively used, it should now be eliminated from grouts for historic masonry. Some mix proportions are shown in Figure 4.50.

Unmortared walls (Figures 4.64 and 4.65)

Many examples of unmortared masonry survive from a wide range of cultures, time and geographical distribution. These may be highly sophisticated or very primitive, but all required skill and experience

Figure 4.64 *Trei'r Ceiri. Unmortared, roughly split slate walls of iron age date in Wales. The sophistication of this masonry lies not in the dressing of the stones but in the way in which they are assembled, each stone acting as a structural component and sitting comfortably within the wall. Such walls could be packed with earth and turf to make them water and wind proof, but should never be mortared in any consolidation work.*

Figure 4.65 *Massive, unmortared stones as Cuzco illustrate some of the most accurately worked masonry seen anywhere, and virtually indestructible except through severe seismic activity, deliberate demolition or artillery fire.*

to construct, whether water-washed boulders at Tel Dan, irregularly split slate slabs at Trei'r Ceiri, carefully fitted polygonal stones at Cuzco (Figure 4.66) or the seamless ashlar of classical Greece. The principal threats to such construction, depending on location, are stone robbing, seismic movement, subsidence and acts of war. Not being mortar dependent at all, they are often extremely durable and stable. The contrast between dry-built and mortared construction is particularly interesting in wet, cold climates; there is little that water movement (aside from scouring at the wall base) can do to unmortared walls, and freezing presents few problems because of the free-draining nature of the construction. Some dry-built construction was packed with earth to keep out wind and rain, but these materials in such a context are non-structural and usually lost through time and weathering. Some were also plastered with clay, lime- or gypsum-based plasters.

The most important and perhaps obvious point to make in conservation work is that mortar and grout must never be introduced. Such interference with the natural wetting and drying rhythms in the wall will be damaging and may result in localised collapse, quite apart from falsifying the evidence. If locally bulging or leaning wall sections require help, they must be carefully recorded and marked before taking down and rebuilding using the planning frame. Iron cramps run in lead and bronze cramps were both used in dry-built ashlar. Occasionally, these need replacing in phosphor bronze or stainless steel, with preference given to bronze alloy where the installations are likely to be seen. If new stones are introduced into ashlar the work must carefully match the precision of the original; a slip-bed of lime putty or clay slurry will be needed to ease the block into position, but this has no mortar function and must not appear on the surface.

Earth walls

Earth walls have a very significant place in the history of building, and in many parts of the world earth traditions are still alive and the associated technologies are still well understood. Ironically, it is in those parts of the world where modern technology is most advanced and accessible that traditional construction such as earth is least understood and is often badly treated. Happily, there are some notable

Figure 4.66 *Masonry of water-washed boulders at Tel Dan, Northern Israel. Upper courses rebuilt.*

Figure 4.67 *The Medieval earth motte of Okehampton Castle, UK, showing earth slippage after heavy rain, exacerbated by burrowing rabbits. Turf repairs are appropriate, cutting into the mound and laying turfs as bonded blocks with staggered joints. Synthetic rope land mesh can be pegged across the repair until the grass is established.*

exceptions and there has been a revival of interests in use of earth for new constructions.

Continuity in earth building may be found in countries such as Afghanistan, Iran, Saudi Arabia, the Yemen, South America and the south-west USA, India, Africa and China, and it is from such areas that lessons on behaviour, repair and conservation of earth walls can be best learnt. Where suitable earth exists it has been used for construction, and for all building types. One of the most impressive early uses is in the form of the banks and ditches of the great Celtic oppida, although it may be argued that these are not 'walls' in the traditional sense. Nevertheless, earth has a longer history in defensive works than does any other material, absorbing impact and shock from modern artillery as effectively as it resisted missiles from Roman and medieval siege engines (Figure 4.67). Although mud-brick masonry could easily be breached by the swinging ram, earth and turf walls absorbed the shock very effectively. Earth 'ruins' include not only hill forts but a worldwide array of artillery forts from the seventeenth to the nineteenth centuries and the trench defences of two world wars (Figure 4.68).[9]

In more traditional usage, clay is the single most important constituent in earth walls, as an adhesive,

Figure 4.68 *The use of earth and turf on the late nineteenth century Fort Brockhurst, part of the Palmerston Defences of the Naval dockyards of Portsmouth. The meticulously trimmed profiles quickly become wilder in appearance as grass gains height and wild flowers become established. Repairs are made in block bonded grass sods.*

binding agent. Clay-poor earths need to be modified by the addition of clay from another source; earth very rich in clay and therefore prone to cracking needs to be balanced with a filler such as sharp sand, small angular stones and stress distributors such as chopped straw. The expansion and contraction of a well-balanced earth wall provides a useful degree of structural flexibility, but in general it must be remembered that earth walls are strong in compression and weak in tension. Construction methods include casting in moulds to produce bricks and blocks and ramming, with or without shuttering.[10]

The vulnerability of earth construction is at its greatest when damage and partial ruination have occurred (Figure 4.69). In wet climates such as northern Europe, earth walls can only survive when a water-resistant plinth and a water-shedding roof with a wide overhang and a slurry or plaster wall covering are maintained in good condition. Damage and neglect, especially at the wall head, quickly lead to disintegration and collapse. In drier climates, the disintegration process takes longer but may be exacerbated by wind-blown sand, and will inevitably and eventually take place without adequate protection. Unlike fired clay, capillary rise in walls of mud brick is low and the damage resulting from rising damp and deposition of soluble salts is relatively small.[11]

Excavated earth structures are often found in excellent condition, but rapid deterioration will follow exposure unless appropriate countermeasures are taken. Cover buildings (see Chapter 5) and screens to provide protection from direct rain and wind, and drainage channels to divert water away from earth walls are sometimes used, especially for important and extensive earth building complexes. More low-key protection can be provided by roof canopies for individual walls, but these must have wide (at least 600 mm) overhangs and catchments at the base of the wall to divert water run-off and avoid splash-back. Soft plasters or slurries of mud or stone dust and lime putty can be used to protect wall faces. Wall heads can be protected with soil-lime caps. A mix of clay-rich earth, natural hydraulic lime, sand and chopped straw or fibre (8:1:1) can be used as a structural repair, as capping slabs and even as plaster. The soil needs to be left under water for a few days before adding the other constituents.[10] These materials have good reversibility, especially mud, and are easily renewable. Where losses have caused, or threatened to cause, instability, as often occurs near wall bases subject to

Figure 4.69 *The use of a cement rich plaster applied to earth walls is seen here in dramatic failure mode. Cracking of the plaster occurred within 6 months and failure within one year. During its lifetime it held water against the ancient earth wall causing softening and significant losses for the first time in many centuries.*

water erosion and salt damage, earth walls are most suitably repaired by cutting out the degraded area and indenting new earth blocks. These blocks can be made by ramming a suitable earth mixture into wood moulds. Small quantities of hydraulic lime (e.g. 10 per cent by volume) can be added to help bind the block together, and chopped straw or synthetic fibre can be added to improve its mechanical properties. The mixture must be well compacted into the moulds and allowed to dry slowly. This curing period is best carried out under wet sheets of geotextile over a period of up to seven days, before de-moulding and being allowed to dry naturally, protected from rain and direct sun. Wall heads may also be capped with new modified earth blocks or plastered with earth or, as a temporary protective measure, covered with geotextile sacks half filled with sand. Rammed earth construction can be repaired in this way, as well as block construction. The homogeneous nature of rammed earth makes it difficult or impossible to repair with a rammed mix. In both forms of earth construction the blocks should harmonise in colour and texture, but can be easily identified as repairs.

Wood and metal

The conservation of wood- and metal-framed buildings is not discussed in this book, primarily because their conservation is a separate specialist subject, but also because the wood or metal 'ruin' normally requires re-roofing and recladding if it is to survive for any length of time. The dismantling, re-erection, renewal, replacement and restoration that are normally needed belong more to the field of historic building repair and conservation than to the conservation of ruins.

Wood and metal elements within ruins are in a rather different category and often form a small but integral and important part of their story. Wood often survives well in waterlogged conditions or in very dry conditions. Thus, the medieval oak and elm piling of the Byward Tower at the Tower of London (Figure 4.70) remained largely intact in the mud of the river Thames, and sections of Herod's timber scaffolding can still be seen in the walls of Masada and, at the same site, the date-palm lacing of Silva's earth and rock siege ramp. In between such

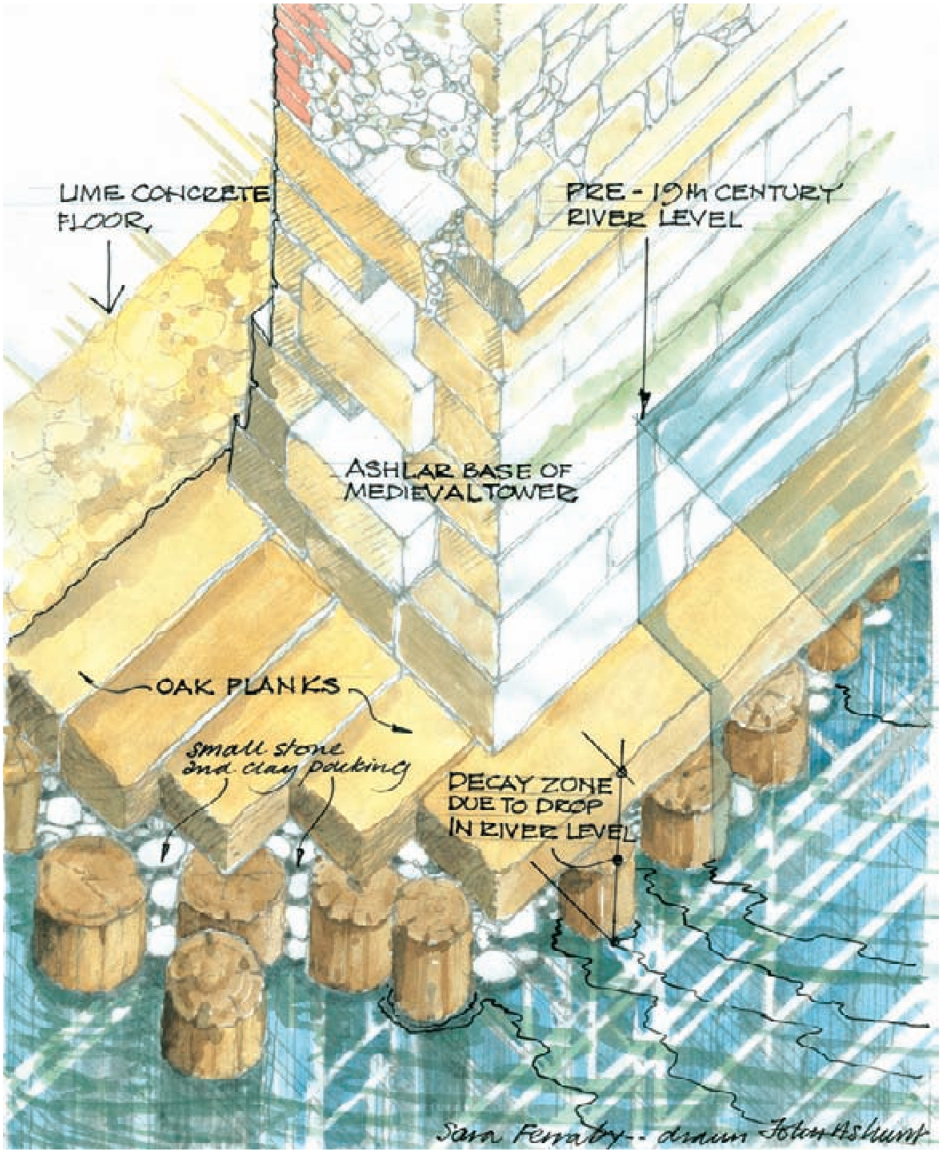

Figure 4.70 *Medieval timber piling, Byward Tower, Tower of London. Plants and pile-heads remained sound until the water level dropped, exposing the critical zone below the masonry to drying, wetting/drying cycles and decay. Settlement and facturing of the masonry followed, requiring dry-packed mortar to make the load bearing connection between piles and wall base. Casework: Sara Ferraby. Drawn by John Ashurst.*

extremes, without preservative treatment, wood does not normally do well in the ruin context. Fragments of beam ends, wall plates and lacings, door and window frames, panel fixings and even sculpture, such as the angel on Francis Bacon's sixteenth century gatehouse at Old Gorhambury, may last a few hundred years. The recording of these relatively fugitive elements is very important, and they may be consolidated *in situ*.

Wood elements such as lintels over door or window openings sometimes survive in a sound enough condition to provide dating information through dendrochronology or, more usually, in a form which is degraded by fungal and insect attack but which can be consolidated using, for instance, epoxy or acrylic resin, modified to suit each particular situation. Such treatment is ideally carried out after removing the wood from the masonry in which it is set, subsequently replacing it on lead spacers to allow air circulation. To achieve this, some first-stage hardening with brush-applied resin may be necessary. If the wood has an applied finish such as limewash, care has to be taken to protect the finish from staining. *In situ* flooding or grouting of surviving wood within the wall is an extremely hazardous operation and should normally be avoided because of the difficulties in controlling migration of the resin to surrounding materials.[11–14]

Metals often survive well in the form of wrought iron dog cramps, restraint fixings for facings, pintles, brackets and tie bars, and sometimes as sections of railings or even complete gates, and may need little treatment. In later buildings there may be survivals of cast iron beams which, in the present context, may be more vulnerable and may require effective cleaning and painting. Some classical sites have been seriously damaged by bronze cramps being dug out of masonry walls. Lead may be found in rainwater outlets through walls, in chases as flashings for lost roofs, as cover flashings on copings and cornices, as joggles or grouts around iron fixings, as glazing came and occasionally as sculptural elements.

Where corrosion of iron is taking place to the extent that stone is being damaged, the iron will need to be cleaned and stabilised where exposed or partly exposed. Typically, this involves rubbing down with silicon-carbide wool, washing and drying, and the use of a zinc-rich primer followed by a micaceous iron oxide before painting. Extensive damage to masonry from corroding iron cramps may indicate that the use of impressed current cathodic protection (ICCP) may be justified as a means of halting corrosion.[14]

Plaster

Plaster often survives in ruins, sometimes to the extent that it still has a protective role for the masonry, sometimes only as small coatings of gesso on architectural moulding, sometimes as the last indication of a decorative scheme, coloured or polished; its value in dating a structure or in indicating the original character of the building or a room within it is often considerable (Figure 4.71). Plaster bedding may sometimes be found for wall mosaics or other facings. The impressions of the lost finishes may be the only indication surviving of the original scheme.

Figure 4.71 *Polished Herodian plaster. Only a small percentage of plaster survives within a white cement frame which had been mistakenly used to hold the plaster in position. At the top of the picture only the cement frame survives.*

Figure 4.72 *Finished consolidation work on decorative fragments of eighteenth century plaster which involved the removal of cement mortar fillets and patches and the substitution of lime putty and ceramic fills. The plaster was cleaned of organic growth using a small hand-held steam gun and was treated with a shelter coat of lime, marble dust and casein.*

Figure 4.73 *Plaster survival in dry conditions. Multi coat plaster at Paestum. Plasters in these conditions can become detached through the activity of soluble salts migrating in the wall, especially after excavation. Detachments may need to be grouted with weak hydraulic lime and broken edges closed up with weak hydraulic lime mortar, carefully cured. Regular inspection of these important plasters is essential and replacement of protective mortar fillets may be needed from time to time.*

Accurate survey and recording is always important, and should not be delayed indefinitely, especially where there are signs of detachment. All plaster that was originally internal is at risk once a roof is lost, and even external plasters are in danger where broken edges have been created during the process of ruination. The most vulnerable plasters in the context of a ruin are those based on clay-earth (mud undercoats or full plasters) and those based on gypsum, especially in wet climates. Both are readily degraded in water and suffer surface softening and attrition followed by detachment, often soon after exposure if they are not protected by paint or limewash. Well-carbonated lime plasters, non-hydraulic as well as hydraulic, can have surprising tenacity and durability, and natural cement and artificial cement stuccos commonly only fail due to cracking, detachment and freezing of trapped water, although these failures may be exacerbated by a history of soluble salt crystallisation.

In the context of the ruin, conservation activity includes the installation of small roof covers attached to the wall to throw water clear of the plaster (Figure 4.74), removal of organic soil with biocide and small steam guns, removal of any impermeable cement-based mortar edge fillets or patches, flushing and grouting detachments and fractures, and installing lime mortar edge fillets and fills in lacunae (Figure 4.75). In some situations, because of the good tensile strength and flexibility of haired lime plaster, it is possible to carefully ease back a detaching plaster face onto a cleaned and lime slurried wall. Plaster grout specifications are provided in Appendix 1.3.

The replacement of areas of plaster, sometimes in the form of easily distinguishable undercoats, is sometimes advisable around a surviving ‘island’ of original plaster on the wall. These new plaster areas can help provide support and can act sacrificially (if properly designed, with good water vapour permeability) for the benefit of the old plaster. Weak surfaces can sometimes be consolidated with multiple applications of lime water and, where appropriate, protected with finely screened limewash, gauged with a small percentage of casein.

In common with other surfaces not originally designed for external weathering, internal plaster surfaces must be regularly monitored to keep track of their condition.

Floors

Solid floors exposed by the loss of roofs are challenged in the same way as wall heads and internal wall surfaces; they were not intended to be weathering surfaces. The most vulnerable are those of rammed earth, with or without a plaster finish. These are very quickly destroyed by rain and the root systems of plants, although evidence sometimes survives close to the protected base of walls or where the floor was covered with fallen debris. Floors of this kind, after recording, must be covered if they are to be retained in dry, ventilated conditions. Even when the floor finish is missing there may be layers of compacted material below, indicative of the original floor level and even of the missing finish type. Once recorded these compacted layers normally need to be protected by back-filling.

Lime, ash and gypsum composition floors can be almost as vulnerable.[14] Low-fired, ceramic tiles,

Figure 4.74 *Plaster survival in wet conditions. Decorative plaster at this level, seen at Hardwick Old Hall, is particularly susceptible to damage by water and colonisation by organic growth. In the absence of a roof, protection is provided by small, timber board projections of 300–450 mm, covered with lead. The upturn of the lead against the wall must be into a carefully formed wall chase, secured with stainless steel screws and washers. Maintenance is essential, including the use of thin lime washes.*

especially those which were subjected to heat as in oven floors, or to excessive wear, can also be easily destroyed and need to be provided with covers. Well-fired brick or tile and stone slabs or cobbles are the most durable finishes and may, with judicious pointing in hydraulic lime and sand, lifting and rebedding where necessary to avoid hollows where ponding can take place, weather well in exposed contexts. All floors need to be inspected regularly for signs of deterioration. One of the problems may be unusual levels of wear by numerous visitors. Rerouting may be necessary and some areas may need to be protected altogether from foot traffic even if exposed to view (see Chapter 9).[15]

Floors such as Roman or Byzantine mosaic, or medieval floor tiles, present particular problems in the context of ruins. They may have been damaged by fallen masonry, roof tiles or timber and may survive in localised areas with unsupported edges, becoming loose through exposure to weather. They are vulnerable to plant growth and organic soiling and salt deposits, and to hollows developing in the supporting base, leading to subsidence and water collection. They are, perhaps more than any other artefact on the ruin site, at risk from souvenir hunters. Unfortunately, many of these floors have been badly treated by uninformed custodians, and both mosaics and tiles have been grouted and even bedded in strong cement-based mortar to try to secure them. In cold, wet zones this treatment can have disastrous effects on clay floor tiles, and on ceramic and limestone tesserae, with the ancient fabric acting sacrificially to the mortar; similarly, in sites where soluble salts migrate to the floor surface, ceramic, limestone and marble will again suffer casualties while the mortar survives.[10]

Bedding, framing and grouting mortar must have good water vapour permeability. A mortar such as lime putty:sand:ceramic powder in the portions 1:3:1, or weak hydraulic lime (NHL2) and limestone aggregate (1:2.5) have the right kind of characteristics, but even weaker mortars may be suitable depending on circumstances. Surface protection such as geotextile and half-filled sandbags of geotextile and

Figure 4.75 *The conservation work required on Bacon's late sixteenth century entrance porch included mortar repairs, stainless steel and ceramic stitches to hold edge bedded columns together, conservation and replication of Roman marble, consolidation and surface treatment of a range of decorative stones and consolidation of heavily decayed wood sculpture.*

Figure 4.76 *An unusual reversible wall capping system seen on the so-called 'Temple of Saturn' in the Forum of Rome, which is designed to protect the archaeology of the wall head. This is a multi-layer lime-pozzolana plaster which is designed to provide a weathering surface but which can easily be broken off in the future without damage to the original substrate.*

sand covers may be needed on insecure sites, and on cold sites ventilated and insulated box covers are needed for the winter, a role once filled on some sites by layers of cut bracken. Organic 'blankets' of this traditional kind, although often effective against frost, can cause staining and invite investigation by humans and animals (see Chapter 5 for details on protective covers).

Some experimental work in flood-treating weak clay tiles and stamped and slip-filled medieval tiles has been carried out with catalysed silane consolidant. The areas of tile were first enclosed by a low upstand wall of lime mortar standing about 75 mm above the floor surface. The areas were cleaned, dried for some weeks under ventilated covers, and then surface warmed and dried with hot air before flooding and allowing the floor to absorb the low-viscosity consolidant, achieving enhanced resistance to freeze–thaw damage. While such a treatment cannot be described as reversible, it is not 'permanent' either, and may need retreatment, which can safely be renewed after a minimum period of one year.

Conservators on site

Walls and floors of ruined structures may themselves be fragile as in the case of earth construction, and are not infrequently associated with and intimately connected to fragile survival, such as plaster, paint, tile, mosaic, wood, metal and glass. Architectural moulding and sculpture can be added to this list. Although the *in situ* conservation of these important surfaces is properly the work of conservators specifically trained in their care, there is often a 'grey zone' in ruined buildings where fragmentary survivals are neglected or mistreated. Yet these survivals are often very important indeed to the understanding of the character and chronology of a site, and the 'conservation technicians' working on the stabilisation and conservation of the walls need to be able to recognise them and to protect them, until conservators can get to the site (see Figure 4.74).[10]

Summary

This chapter has shown the combination of technology and craft being used in the service of conservation and in the context of a philosophy of minimum intervention to achieve maximum retention of historic fabric. The objective is to be able to look at a ruin and know that it is an 'authentic survival' from its period or periods, with the 'non-authentic' parts, necessary for that survival, clearly defined. Amongst buildings, the ruin can be unique in this way because there is no practical reason or necessity to restore it, as Frank Baines was at pains to point out at the beginning.[1]

Who can carry out this work, and how such people can be found or trained, is the subject of another chapter.

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Open-sided shelters protecting the bath house at Beit She'an, Israel.

Chapter 5

Preventive conservation of ruins: reconstruction, reburial and enclosure

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Introduction

Attitudes to the protection of ruined monuments have altered radically over the past century, in the wake of the international conservation movement and international conservation charters, and with statutory protection of ancient monuments introduced in many countries. It has been common practice in many places to leave architectural remains on archaeological sites exposed with minimal or no intervention after excavation, once the valuable data and portable artefacts have been extracted. Experience has shown, however, that exposure without protection or intervention generally has disastrous consequences for building fabric and that the natural forces, which quickly set to work, are almost always destructive to some degree and in some form.

As a minimum, if other measures are deemed inappropriate or resources are limited, recently excavated ruins should be reburied, or back-filled, to use the term normally employed in an archaeological context. For a number of reasons, including limited resources in some cases, purpose-built shelters or enclosures, which would both provide protection and allow the ruins to be permanently on display, are generally reserved for the most important sites, of national and international significance. Such sites typically feature decorative architectural elements, such as mosaics, which can attract sufficient numbers of visitors for the site to be sustainable.

Ruins are diverse in materials, size, form and context. This chapter sets out methods and materials for protecting ruins of various types, from ruins standing to some height and masonry shells to low-lying walls, and their associated architectural detail and decoration, and outlines criteria for their use. Potential protective measures, including reconstruction, reburial, open shelters and permanent enclosure buildings, are described with examples drawn from historic and current practice. This chapter also touches on other crucial issues: condition survey, interpretation and presentation of sites, and conservation principles, particularly authenticity and significance.

The number of ruined sites formally recognised as being of international importance by inscription on UNESCO's list of World Heritage Sites grows annually. At a national level, archaeological excavations continue to reveal new sites, many with ruined structures, which require some form of protection, and often masonry consolidation if they are to be exposed to the weather. It is not an exaggeration to state that need far exceeds available resources for protection and maintenance of ruins, even in the most affluent nations. It has been reported, for instance, that the total budget currently required for protection and treatment of the ruins of Pompeii in Italy exceeds the present annual budget by a factor of 10.[1] Consequently, it is essential to define and apply the term 'preventive conservation' as broadly as possible. The concept of preventive conservation is well-known in objects conservation but little used in the context of ruins. Essentially, preventive conservation denotes an approach whose primary objective is to ensure the long-term physical survival of historic fabric; other objectives, relating, for example, to presentation and interpretation, are considered secondary. In general, preventive conservation entails modification of the ruin's environment by measures such as reburial and shelters, and the role of remedial work is minimised. However, reconstruction can modify the environment of a ruin, locally or on a larger scale, to secure the survival of vulnerable fabric. When used is special circumstances, to meet specific conservation-based objectives, reconstruction or reinstatement of missing elements has a role in preventive conservation. Proposals for any form of protection or intervention must be founded on respect for the essential values and integrity of a site and its structures, and seek to ensure that these are not compromised. In most cases, however, proposals that require permanent construction work on a large and multi-layered site will inevitably have some adverse impact. In these situations any negative aspects must carefully be weighed against the long-term benefits of a scheme.

The statutory framework

In England and Wales, ruins may fall within the classification of either a scheduled ancient monument or a listed building, or may be classed as both. There is considerable overlap between these two categories of statutory protection and both are very broadly defined. Virtually any alteration or addition to a scheduled ancient monument requires scheduled monument consent. Depending on the status of the ruin, either listed building consent or scheduled monument consent will be required for protective measures. If the ruin is both scheduled and listed, only scheduled monument consent will be required, to avoid duplication, and planning consent may also be required, depending on the nature of the work.[2] This statutory framework is, however, set to change. The government has indicated its intention to integrate the existing separate control systems and various forms of statutory designation.

At present in England, English Heritage implements controls over work to scheduled ancient monuments, on behalf of central government; local planning authorities administer control of work to listed buildings (listed building consent), and consult with English Heritage and other organisations, as required and especially on grade I and II* listed buildings. The principal general guidance documents are Planning Policy Guidance (PPG) 15, 'The Historic Environment', and PPG 16, 'Archaeology and Planning'. Underpinning these policies and other guidance documents issued periodically by English Heritage are various international charters.

The Venice Charter of 1964 was fundamental and set out the key definitions and principles to be applied in 'conservation' and 'restoration' of monuments. The definitions of terms such as restoration and reconstruction have evolved since then. Two of the most recent charters address the specific issues of authenticity and reconstruction: the Riga Charter of 2000 'On Authenticity and Historical Reconstruction in Relationship to Cultural Heritage' and the 'Nara Document on Authenticity' of 1994. It is worth setting out the definitions provided by English Heritage in 2001 in the 'English Heritage Policy Statement on Restoration, Reconstruction and Speculative Recreation of Archaeological Sites Including Ruins', which are adopted from the Burra Charter of 1999:

- Restoration – returning the existing fabric of a place to a known earlier state by removing accretions or by reassembling existing components without the introduction of new material.
- Reconstruction – returning a place to a known earlier state; distinguished from restoration by the introduction of new material into the fabric.
- Recreation – speculative creation of a presumed earlier state on the basis of surviving evidence from that place and other sites, and on deductions drawn from that evidence using new materials.

This English Heritage policy document includes the following important principles: that restoration and reconstruction should be approached with caution and never be carried out on a speculative basis, and that only minimum conservation work necessary for long-term survival should be done. These are key principles which guide the implementation of work to ruins in the UK and elsewhere. It should be noted, however, that it is almost impossible in practice to carry out 'restoration' work to a ruin, however minimal in scope, without introducing some new material. Reassembly of rubble and some types of ashlar masonry will, for example, necessarily entail introduction of new mortar. Most masonry conservation activities discussed in the other chapters of this book involve the introduction of new materials, mainly those based on lime. Usage and implicit definitions of the words restoration and reconstruction vary quite substantially in conservation literature and even more widely in the 'heritage' industry generally. Confusion and imprecision in the language of conservation and restoration is a problem, which sometimes hinders the progress of proposals for preventive conservation. It is not uncommon for proposals to be rejected on the basis of the use of the word reconstruction or restoration, when the same intervention couched in terms such as consolidation or reinstatement might find acceptance.

It is important to recognise that some of the issues surrounding protective measures, such as visual or aesthetic impact, can be subjective, and that the principles and policies set out in various charters and guidelines, like the terms reconstruction and restoration, can often be interpreted in more than one way. Consequently, opinions may diverge substantially when policies must be translated into firm proposals for protective measures and actual implementation of work on site. This is the case particularly in the context of proposals for reconstruction and enclosure, which can substantially alter the appearance of ruins and their settings.

Reconstruction

Should 'reconstruction' even be considered as 'preventive conservation'? This is potentially a divisive and controversial issue. To include it may risk abuse by zealous restorers, but to exclude it denies the legitimate role illustrated in the case work provided. The test, of course, must be a rigorous assessment of the motivation and justification for its use.

The success or failure of any scheme of reconstruction must be judged in its local, regional and national contexts. The kind of reconstruction work carried out by the Canadian federal government at the site of the town and Fortress of Louisbourg in Cape Breton, Nova Scotia, begun in the 1960s, which entailed complete rebuilding of a section of the eighteenth century French fortifications and settlement on the original ruined masonry remains, is alien in the British context, where there is a tradition of conservation and historic rejection of reconstruction and restoration. In Canada, however, this work was conceived as an act of preservation, motivated by a combination of cultural and socio-economic factors: the need to stimulate an economically depressed and isolated region of the country, where the impact of the collapse in the coal mining industry was sorely felt, and the growth of a national heritage preservation movement. The reconstruction is an interesting example of how federal government policy and intervention at several levels, including in this case the economy and tourism, can impact directly on a ruined heritage site. The subject of the Rand Royal Commission of 1959 was the economy, and in particular the coal industry, but its report extended to cultural resources and it concluded: 'That site [Louisbourg] marks a salient occasion in the transplantation of a civilization significant to the history of Canada; and to allow it to sink into ruin and obliteration would be a grave loss to the civilizing interests of this country.'[3] Based on extensive archival research in Canada, France and England, and on extensive archaeological investigation of the site, the reconstruction involved faithful replication of original eighteenth century structures, generally executed in the same materials and constructed on

Figure 5.1 *View of the reconstructed section of the Fortress of Louisbourg in Cape Breton, Nova Scotia, Canada (photograph: G. Abrey).*

the remains of the original masonry. The reconstruction attracts many visitors who would not otherwise visit the site, which is located in a remote part of Nova Scotia. In combination with the interpretive measures, which include costumed animation, characters in historic costume enacting scenarios and interiors furnished in the style of the period, it provides a vivid picture of life in the eighteenth century French settlement.

There is always scope for criticism of this approach in terms of authenticity and the scale of physical intervention, but in this case, where reconstruction relied on thorough research rather than speculation and the forms of many of the buildings, especially the public ones, could be established by a combination of archaeological investigation and documentary research, the benefits of reconstruction were considered to outweigh such concerns. The reconstruction has brought tangible educational benefits for visitors and extended the life of the site, beyond that of many excavated sites, where the nature of the low-lying masonry remains is such that they will not attract many visitors, other than those with a specialist or informed interest. If the impact of the Fortress Louisbourg reconstruction were measured against the various international charters, the assessment would vary depending on which one is applied. The charters differ in the strands of conservation philosophy, ethics or values that are emphasised. Judged by the terms of the Burra Charter and the English Heritage policy statement on restoration and reconstruction, the work at Louisbourg might be criticised as bordering on recreation. If considered by the terms of the Nara Document, with its emphasis on the cultural context of authenticity, the conclusion might be more favourable, allowing for factors specific to the Canadian context, such as the comparative scarcity of eighteenth century architecture standing above ground and the importance of the site as the strongest fort on the Atlantic coast of North America at that time.

Other recent examples of reconstruction discussed below are much more limited in scope and typically motivated by a combination of factors. An important point is that the aim of reconstruction can be, entirely or partly, to ensure the preservation of ruins, through not only physical interventions but also the wider benefits brought by these interventions, which can include raising the profile of a site in a positive way, increasing accessibility, and enhancing visitors' experience and understanding of sites and their history. The objectives in reconstruction can extend far beyond the physical preservation of ruins. Fortress Louisbourg is an extreme example in the sense that it is at one end of the spectrum of ruins reconstruction – complete rebuilding of entire structures, albeit of only a section of the site.

This extent of reconstruction is unusual on an archaeological site. More typical in the context of ancient sites is the re-erection of original masonry, with or without the introduction of new material to replace missing elements. This has long been practised on Mediterranean and Near Eastern sites and is generally referred to as *anastylosis*. Traditionally, masonry units which have fallen for whatever reason, earthquake, erosion or otherwise, are re-erected after excavation and recording. Well-known examples include the Treasury of the Athenians and other monuments at Delphi, in Greece, the Library of Celsus at Ephesus in Turkey and vertical elements of the Northern Palace at Masada, Israel (see Figure 5.27 – view of Ephesus). Columns are favourite subjects for this form of reconstruction since they deliver an immediate visual impact, their verticality defining space on sites where masonry remains are often otherwise low in height. The aim, in many cases, has been as much visual and interpretive as explicitly for the physical preservation of the ruined fabric of the site.

When to reconstruct or reinstate

It is difficult to specify precisely when reconstruction is appropriate, since any proposals for such work must be tailored to the particular conditions and needs of individual sites and contexts, but there are some general guiding principles. As a very general rule, the older the ruins, the more potential problems and complexities may be expected in attempting to carry out authentic reconstruction, or reinstatement of lost elements. The extent of documentation, drawings and written accounts to inform reconstruction work tapers off from the present through the past and into prehistory, where only physical evidence of structures and the material culture survives. For this reason and others, reconstruction of ancient ruins typically entails some degree of speculation and should only be carried out in special circumstances, to meet specific conservation-based objectives.

However, the age of a ruined monument is only one aspect of its significance. The historic significance of the ruined sites of the Second World War, which are comparatively recent, is undeniable. Oradour in France, site of a terrible massacre and destruction of an entire town, and the Cathedral of St Michael in Coventry, destroyed by bombing in 1940, and its counterpart, the Kaiser Wilhelm Gedachtniskirche in Berlin, are important examples

Figure 5.2 *Light well in the 'Throne Room' at the Minoan Palace of Knossos on Crete, early twentieth century reconstruction by Arthur Evans (photograph: C. Woolfitt).*

(see Figure I.3, Introduction chapter for a view of Oradour). In the case of these sites, reconstruction was considered inappropriate. Their significance lies in their ruined condition, which is meant to capture the moment of their destruction; they are to be left 'frozen in time' as reminders of the horrors of war. The ongoing challenge at these sites, as at any ruin which has lost its roof, is to ensure the preservation of the fabric and prevent deterioration with minimal intervention.

It is easy to find fault with early attempts at reconstruction of ancient ruins, but it must be acknowledged that much has been learned from past mistakes. The reconstruction of parts of the Bronze Age Minoan Palace of Knossos on Crete under the direction of Arthur Evans in the early twentieth century illustrates two principal issues, which have been addressed by later conservation charters: lack of authenticity and speculative work (Figure 5.2). Criticism of the Knossos reconstruction

Figure 5.3 *View of the reconstructed Stoa of Attalos in the Athenian Agora, Greece (photograph: C. Woolfitt).*

has focused on the use of materials alien to Minoan architecture (such as reinforced concrete) and the sometimes scant evidence for quite extensive reconstruction, including wall paintings. In the 1950s the American School of Classics at Athens carried out the complete reconstruction of the second century BC Stoa of Attalos at the site of the ancient Athenian Agora, building on the surviving foundations, and incorporating sections of the original, mainly at the south end.[4] The new stoa provides accommodation for the Agora museum and store, and for a conservation laboratory and offices for the Agora excavations (Figure 5.3). Although the new materials and design followed the original, as far as these could be determined from the archaeological remains and from nineteenth century photographs, there are some variations, for example in the modern terrazzo floor, which is quite different in character from the original, a section of which was preserved in the 1950s. Both the Knossos and Stoa of Attalos reconstructions might equally be described as recreations by the definitions of these terms set out above. The new stoa is a large structure and, inevitably, as the only complete classical building in the vicinity standing to a height of two storeys above ground level, it dominates the site of the Agora. It provides welcome shade in an otherwise exposed site during hot weather, but has nevertheless attracted criticism due to its impact on the original ruins and its scale and completeness in the context of the surrounding low-lying ruins.[5]

Dismantling and reconstruction of ancient ruins is sometimes necessary to rectify the failure of past interventions. Corrosion of ferrous fixings in ashlar masonry is a common problem and one that afflicted the ruined monuments on the Acropolis in Athens (Figure 5.4). The current, extensive programme of work on the Acropolis entails localised reconstruction – dismantling of ashlar masonry, removal of the ferrous fixings and other defective repairs installed in past reconstruction work – as well as some introduction of new stone to fill lacunae and replace missing blocks. The general approach and scale of reconstruction work contrasts markedly with the treatment of the Stoa of Attalos (Figure 5.3), although, in fairness, the two schemes of work are separated by several decades, during which period the international conservation movement grew. Sculpture is removed to a museum environment and replaced with replicas; the threat posed by the corrosive

Figure 5.4 *The Erechtheion on the Acropolis, Athens, Greece, one of the monuments subject to the ongoing programme of conservation work (photograph: C. Woolfitt).*

Athenian environment is considered too great to risk ongoing exposure of the remaining sculpture.

The Parthenon, in particular, is a good example of past reconstruction work and its unfortunate consequences. The partial destruction of the Parthenon by the famous explosion of 1687 created a ruin much less complete than the one currently on display; the long walls were largely destroyed, leaving mainly the west and east ends of the temple standing.[6] Prior to the explosion the structure had been adapted for use as a Christian church and a mosque. Nineteenth century work on the Acropolis included stripping away all evidence of accretions later than the fifth century BC. Work on the Parthenon extended into the first half of the twentieth century under the engineer Nikalaos Balanos, who published an account in *Les Monuments de L'Acropole: relèvement et conservation* (1938). This work has been criticised for a number of reasons, for the lack of accuracy and authenticity, since little effort was made to reinstate the marble blocks in their original positions, and for inappropriate materials – the iron fixings used, instead of iron set in lead as done originally. The later fixings subsequently oxidised, splitting and cracking the marble. UNESCO produced a report in 1970 addressing these problems and the threat from the corrosive urban environment, the result of which was the formation in the mid-1970s of a new committee to supervise the conservation and restoration of all monuments on the Acropolis site. Work on the Parthenon includes dismantling and reconstruction with detailed recording; stones are individually recorded, lifted and repositioned, the iron fixings removed and replaced with titanium substitutes. The Athena Nike and Erechtheion temples have received similar treatment. Recent assessment of the work on the Acropolis highlights the painstaking detail of the work, but also a tendency to focus on the fifth century remains to the exclusion of subsequent periods, a trend which began in the nineteenth century.[7]

The issue of authenticity can be complex when discussing ruins that have been subject to frequent rebuilding and repair in the past. As Mary Beard writes of the Colosseum:

> *It is a well-known axiom among archaeologists that the more famous a monument is … the more likely it is to have been restored, rebuilt, and more or less imaginatively,*

> *reconstructed. There is an inverse correlation, in other words, between fame and 'authenticity' in the strictest sense.*[8]

Recent examples from Israel illustrate the use of reconstruction on a small scale and with specific conservation-based objectives – to restore structural integrity and protect against erosion and loss. The Northern Palace at Masada, built by King Herod in the first century BC, is a remarkable feat of engineering; its structures on three terraces cling to steep precipices. On completion, lime plasters protected the earth and gypsum bedding mortars and undercoats against weather. Since excavation in the 1960s the site's vulnerability has been realised, and study and recording has revealed the sometimes precarious condition of the masonry, the causes of which included the proximity to the salt-laden Dead Sea, infrequent but torrential rainfall, and the nature of the rock formation on which the masonry was erected.[9] The decision was taken to reinstate sections of missing masonry to stabilise surviving fragmentary masonry remains. The broken vault of the bath house has been completed, both to protect what survived and to prevent further damage to the plaster lining of the bath, which had been damaged by stones thrown or fallen from the viewing platform above (see Chapter 10). Eroded and missing sections of the tholos (middle platform) have been repaired or reconstructed to protect the wall core. One factor in the decision to reconstruct was the inaccessibility of the site, which makes scaffolding very difficult and expensive, and prevents routine maintenance. The recent work at Masada is discussed further in Chapter 10.

Vandalism can be a problem at remote sites. An interesting example is the Nabataean site of Mamshit, in the Negev desert of Israel. Here a team of Italian conservators from the Centro di Conservazione Archeologica (CCA) carried out recording and conservation of the mosaic pavement in the west Byzantine church.[10] At the end of the work the mosaic was smashed overnight and much damage done to sections of detail. The decision was made to restore the mosaic, dislodged tesserae were retrieved and, using the records, which fortunately had been produced before conservation work had commenced, the damaged sections were reassembled remotely in Italy and sent back to the site for reinstatement (Figure 5.5).

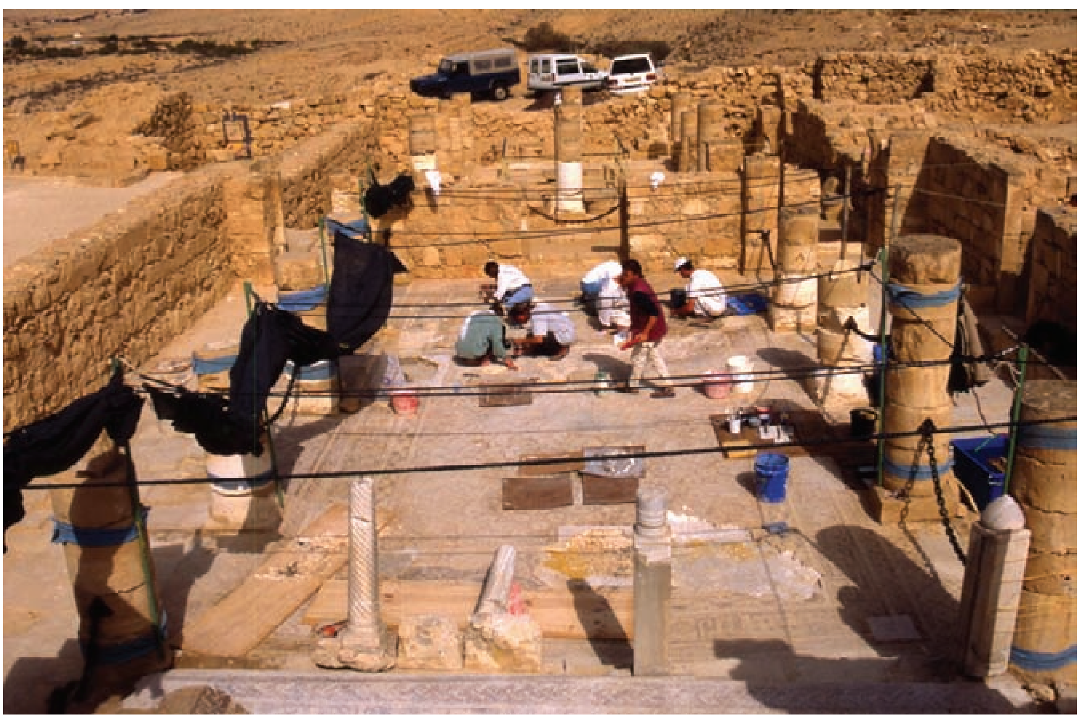

Figure 5.5 *Reinstatement of the vandalised mosaic pavement of the west Byzantine Church at Mamshit in Israel (photograph: Asi Shalom).*

Reconstruction of part of a ruined monument is sometimes carried out to permit or facilitate its particular use. Seats and steps in ancient Greek and Roman theatres are often reinstated, either partially or completely, to provide access for modern performances. This has occurred, for example, at the theatres of Epidaurus (Sanctuary of Asklepios, mainly in the 1950s and 1960s) and Athens (Odeion of Herodes Atticus) in Greece, and more recently at Caesarea and Beit She'an in Israel (Figure 5.6). In the case of Caesarea this involved very substantial reconstruction and introduction of new concrete elements to support upper levels of seats (Figure 5.7). One principle of reconstruction on archaeological sites is that new work should be visually distinguishable from the original. The pristine condition of new ashlar stonework often contrasts strongly with the weathered original, but this initial contrast may become less obvious with weathering. Seating in a different material would be more readily obvious as a modern insertion. A section of new seats at the amphitheatre of Beit Guvrin in Israel has, for example, been erected in timber on a metal frame.

In raising masonry walls the original work is sometimes differentiated from the new by a line applied to the face of the masonry joint forming this interface. Such markings can be aesthetically unsatisfactory, for example when carried out in a material such as black paint (Figure 5.8) over comparatively wide rubble masonry joints. A more aesthetically pleasing and durable alternative for use in rubble masonry is the incorporation of small stone or tile 'nails' incorporated or driven into the bedding mortar to delineate the new work from the original.

Although it is sometimes difficult to draw a hard line between the two types of ruin or ruin context – historic and archaeological – reconstruction of historic ruins is, in general, likely to be less complex and problematic. In some contexts, for example historic landscapes and gardens where ruined structures have fallen into disrepair and ruin, repair and reconstruction is the only viable option without losing important architectural elements within the historic landscape. The repair and localised reconstruction of the ruined garden walls (listed grade II) at Lauderdale House, Waterlow Park, Highgate, London, completed in

Figure 5.6 *Reconstructed section of the theatre of Beit She'an in Israel (photograph: C. Woolfitt).*

Figure 5.7 *New seats and supporting structure installed at the theatre of Caesarea in Israel (photograph: C. Woolfitt).*

2004, is an example of reconstruction in the context of a historic garden. The terraced brick walls were built as part of the landscaped gardens for the sixteenth century house and adapted and altered over subsequent centuries. Work to the ruined walls was part of a larger scheme to restore the historic landscape and enhance visitor use and awareness of the park; the Heritage Lottery Fund supported the scheme undertaken by the London Borough of Camden. The garden retaining walls had become so overgrown by plants that they were barely visible. Large sections of the walls had collapsed or been invaded by roots of woody species. Initial survey work included clearance of as much growth as possible, identification of brick dimensions and types to classify the walls and to produce new bricks, which were made by hand by Bulmer Brickworks, to match the physical and visual properties of the originals.[11] Accompanying this work was archaeological analysis of the original brick details, copings, mouldings at the base of the walls and evidence for original iron railings. These original details were recorded and drawn and formed the basis for reconstruction work (see Figures 3.9 and 3.10).

Re-roofing and reinstatement of internal structures

Re-roofing and reinstatement of internal floor structures are classed here under the heading 'Reconstruction', although in some respects they equally well fit under the heading of 'Protective enclosures and shelters'. Where a ruin comprises a masonry shell standing to sufficient height that the original roof and floor levels are legible, re-roofing and reinstatement of floors may be a viable option. Such measures bring a number of benefits, including protection of internal masonry and other features from weather, protection of wall heads (depending on the form of the roof), improved access to more parts of the structure for maintenance and associated interpretive benefits of defining internal spaces. Proposals must be based on buildings' archaeology – study and interpretation of the structure. Evidence for the

Figure 5.8 *At Masada in Israel a black line through masonry joints is used to delineate rebuilt masonry from the original (photograph: J. Ashurst).*

original roof level is typically in the form of masonry offsets or other features (cuttings) which provided support for a timber roof structure. Rainwater outlets through masonry walls are another form of evidence for roofs set behind parapet walls. Both offsets and sockets for timbers may be evidence for floor levels, as well as the level of openings in walls above ground level. It should be noted, however, that in ruined buildings of multiple phases of reuse and rebuilding or adaptation, the 'original' roof or floor levels may be unclear or the levels may have changed.

As a class of ancient monument, the tower is a form that lends itself to re-roofing and installation of new floors/stairs, provided, of course, that the condition of the masonry is adequate to support the roof and these interventions would bring other justifiable benefits. A programme of repair, conservation and investigation of the masonry of the Norman great tower of *c.* 1100 at Guildford Castle in 2003 led to the discovery of two early Norman construction phases and confirmation of the earliest roof level (see Chapter 10). Proposals were adapted to include the installation of a new roof and floor at principal (first floor) level. Evidence for the original roof level and crenellated parapet was found in the course of repair work; this included infilled embrasures, the line between the original parapet and the raised section of masonry above defined across large sections of all external elevations by a fine white line of plaster. Study of the masonry also revealed channels through one masonry wall for drainage of rainwater from the roof. The new roof was designed to make use of these channels, with large lead chutes projecting to throw rainwater clear of the building (see Figures 10.2 and 10.13 in Chapter 10 – view of new roof at Guildford Castle and view before installation of roof, with damp environment and abundant organic growth on internal walls).

The rationale for re-roofing at Guildford was based on two main premises: evidence for the earliest roof level and the benefits for the condition of the tower. The interior of Guildford's tower had suffered from abundant organic growth and a generally damp environment; the wall heads had been covered in a screed, formed with falls which directed rainwater into, rather than outside, the tower. The damp environment caused early decay of the oak viewing gallery and ground-level access stair, within 10 years of their installation in 1989, and created an unpleasant environment, exacerbated by nesting pigeons and their guano. The great tower closed to visitors in 1998 due to health and safety concerns. Re-roofing and a new floor offered the opportunity to improve the internal environment dramatically, to provide access to the entire principal floor level, including a garderobe chamber discovered in the course of work, and gave access to the upper sections of the walls above the level of the new roof for routine maintenance, mainly removal of plant growth from the wall head, since a number of harness points were installed, as well as fixings for a ladder. The design of the new roof and floor makes no attempt to recreate the Norman construction. The roof construction is of prefabricated softwood, covered with lead, and the soffit (ceiling) is boarded internally with ventilation gaps. The floor and access stair are of steel with oak boards and both are independent of the historic fabric.

More contemporary designs and materials are sometimes used for new roofs. At Rochester Castle a new tensile fabric roof has been installed over the forebuilding to the great tower. The glass roof installed over the ruined remains of the medieval Juval Castle (section of the ruin adjacent to the keep) in Alto Adige, in Italy, was designed to preserve the walls from further decay and to make the internal space available for various uses, such as sculpture exhibitions.[12] In a sense it is a shelter rather than a form of reconstruction, but is mentioned here as a contrast to the Guildford Castle re-roofing, where traditional material, lead, was employed for roof cover. The roof design at Juval Castle employs a minimal supporting structure of small section steel beams (I-beams) and tension rods. The roof structure is fixed to the masonry at only a few points and extends beyond the wall heads between 250 and 400 mm, with gaps between the often irregular profile of the walls and the new roof. The roof cover is of 16 mm laminated (toughened) safety glass and consequently the roof appears almost to float over the ruin.

Reconstruction/reinstatement – aspects of planning

The following aspects of conservation planning need to be addressed in the context of proposals for reconstructing all or a substantial section of a site, although their relevance will vary, depending on the nature of the site. These will also apply for other protective measures, reburial and sheltering or enclosure.

- *Defining significance*. The aspects of a site which constitute its significance need to be identified and explicitly stated. The need to establish significance is recognised in various guidance documents and charters. English Heritage's *Informed Conservation: Understanding historic buildings and their landscapes for conservation* (2001) by Kate Clark addresses this issue in detail.
- *Multi-phase sites*. Many ancient sites have developed and been adapted for different uses over centuries. The issue of which phase of construction or use to interpret can be an important consideration.
- *Justification/rationale*. The reasons for carrying out reconstruction work should be explicitly stated, and may be manifold, including any combination of the following (and others): condition of the fabric and need to prevent deterioration or vandalism, enabling ongoing maintenance of a ruin, significance, rectifying past interventions which are defective or promote decay, and a whole range of other factors such as socio-economic considerations, which will be unique to a site in its local and national context. Reconstruction should be

justifiable mainly on the basis of the long-term condition of the ruin, minimising risks to its fabric, and the benefits the proposed reconstruction brings for the physical remains. However, other issues, such as those of interpretation, presentation and access, often play a part and all factors must be considered together.

- *Research and understanding/interpreting a site*. This point is linked to the first one, of understanding and defining significance. Reconstruction cannot be carried out without a thorough understanding of the culture that produced the original monument or building. Reconstruction will almost invariably entail interpretation of the ruins, in some respect, and must be based on sound knowledge and understanding of the historical and/or archaeological evidence.
- *Recording and drawn/photographic survey work*. Recording of existing remains is essential, if this has not been carried out previously, and usually contributes substantially to understanding of a site and to developing project proposals. The record produced is important for a number of reasons, not least so that the extent of new work can be determined in future. The scope of work will depend very much on the nature of the ruin and its detail, as well as the extent of past records in the case of excavated sites, but should normally include a combination of written, drawn and photographic records. Most drawings, and a proportion of photographic records in the UK, are now produced digitally for ease of editing and of combining and overlaying different types of data. The following guidance documents on survey work are useful: *Understanding Historic Buildings: A guide to good recording practice* (English Heritage, 2006); *Metric Survey Specification for English Heritage* (2000); and *The Presentation of Historic Building Survey in CAID*, also by English Heritage.
- *Condition survey work* (see Chapter 3). Allied to recording and measured and photographic survey is condition survey work. Condition survey work must be recognised as a distinct activity and process, from measured, drawn or photographic survey, although the two can sometimes be carried out together, depending on the skills and experience of the surveyor. Condition survey normally employs the graphic representations produced by drawn/photographic survey work and may entail the addition of further data onto the digital files. Proposals for reconstruction or other protective measures must be based on sound understanding of the physical condition of the ruined fabric. It is essential that survey work be carried out by specialists who have detailed knowledge of the building techniques and materials originally employed, and the methods and materials currently available for implementing repair and conservation work.
- *Archaeological investigation/buildings archaeology*. Provision must be made for recording any archaeological features that might be uncovered in the process of reconstruction work. In England such recording is often a condition of scheduled monument consent. A scope of work and methodology should be produced in advance and recording may need to proceed in stages, both at the outset before work commences and in tandem with reconstruction work on site, where new features are uncovered.
- *Authenticity*. Are the form, materials and details of the original structures sufficiently established from the ruined remains and from any documentary evidence to provide a sound basis for an authentic reconstruction? Speculative reconstruction is to be avoided. It is possible, however, for the design of new structural elements, such as roofs and floors, to be blatantly contemporary, to avoid any confusion of the original with new.
- *Reversibility and minimal impact on original fabric*. The principles of reversibility and minimal intervention are fundamental in conservation. It should be possible to remove later insertions and sections of new work, and the extent of alteration to original fabric should be kept to the absolute minimum necessary to secure its stability. In practice, some types of work, such as the introduction of new structural elements, will necessitate some alteration of original fabric/masonry, either fixings or installation of foundations. When designing new structural elements, whether in the context of reconstruction or for sheltering or enclosure of sites, the intention should always be to minimise their impact.
- *Environmental impact*. There is a significant overlap in many cases between the cultural or built heritage and natural heritage sites. Ruins are often home to numerous species of plants and animals and form part of important natural environments. In many countries there is joint curation of natural and cultural environments, with organisations such as Parks Canada, National Parks Service in the USA, and the Israel Nature and National Parks Protection Authority (INNPPA). It is important that any proposals consider the impact on the environment as a whole (see Chapter 6).

- *Resources and sustainability*. The necessary resources will depend on the scope and nature of reconstruction proposed. Are the resources available to execute the work and to involve specialists from the various disciplines whose input will be essential? Have these resources been secured for the future? It is rare for any body, apart from central governments, to be able to commit the resources necessary over a sustained period for large-scale reconstruction work, for example of the extent and duration discussed above at the Fortress of Louisbourg.
- *Multi-disciplinary input*. It is essential that suitably experienced specialists be assembled to plan, oversee and execute the work. For a medium- to large-scale reconstruction the following disciplines are usually necessary: archaeologist, researcher (who may be an archaeologist or historian), architect/surveyor, engineer, craftspeople (masonry, joinery, blacksmiths), conservators, and possibly specialists in design, display and interpretation. All members of the team should be experienced in work on ruined sites, with knowledge of the relevant period of history/archaeology, of the building techniques employed in the original construction and of the materials appropriate to carry out the work on site. It is essential for success that these various specialists work together and in the case of work over long periods they should all be based at or near the site, at least for substantial blocks of time, so that decisions can be made jointly as work progresses.
- *Planning/project management*. Some group or individual must be responsible for overall coordination, assembling the necessary expertise, programming, budgets and practical execution of the work. In the context of the construction industry in the UK, a planning supervisor must be designated to be responsible for site health and safety.

Reconstruction/resinstatement – aspects of implementation (execution of site work)

- *Specification and selection of materials*. It is sometimes not entirely straightforward to apply simple conservation principles, couched in terms such as 'like for like' replacement or 'new materials to match originals'. These principles may need to be further defined or interpreted, to provide sufficient guidance in the selection and specification of materials. In the case of stone the issue of suitable replacement is relatively straightforward, provided the original source or type of stone is still available. Matching original bricks, at least in their visual and physical characteristics, is also often achievable. In the case of mortars and plasters, however, the matter is sometimes more complex. It is more realistic to seek a compatible material than what could be strictly termed a 'matching' material. Analysis and replication of historic mortars has received attention in recent years and the range of available lime binders has increased, with classification set out in the standard *BS EN-459 Building Lime* (2001, parts 1 and 2). In many cases it should be possible for a suitably experienced specialist in the conservation of ruins to identify the physical properties of the original mortars on the basis of visual analysis and simple tests, without recourse to chemical or other analyses, and to specify a visually and physically compatible mortar. In some instances, it may be necessary to use a mortar with different properties from the original, to meet certain performance requirements.
- *Implementation – quality of work*. No amount of planning or other professional work will compensate for poor-quality work on site. It is essential that those carrying out site work be trained and experienced in all aspects of the work, from the original construction methods and materials (so that they can detect any significant previously undetected features of the ruined fabric) to the particular techniques and materials to be employed in new work.
- *Recording during dismantling*. Techniques for masonry consolidation and dismantling are discussed elsewhere in this volume. It is essential that recording work accompany any dismantling and that appropriate labelling and cross-referencing to drawings or photographs be carried out so that masonry or other elements can be reinstated in their original positions.

Reconstruction – summary

It is difficult for the word reconstruction to shed its past associations with schemes of rebuilding work, which were sometimes speculative, and unsympathetic in scale and materials to the original ruin. This is unfortunate, for reconstruction (or reinstatement, if this term carries less negative connotations) has a role to play in preventive conservation, on a limited scale and in certain circumstances. Where ruins suffer accelerated rates of erosion and loss after exposure, reinstatement or restoration of missing elements, such as plaster, may be appropriate as a protective measure. Re-plastering has been used very successfully for the protection of rubble masonry at a number of important historic buildings in England, notably at the early churches of St Mary's at Iffley near Oxford and at Bosham in West Sussex. Where fabric is structurally unstable and has lost its integrity through degradation of constituent elements, whether corework or facework or both in the case of masonry, or where there is a risk of collapse and loss, reconstruction or reinstatement may be the best option.

Reburial

Reburial is the most basic, low-tech and, in general, the most effective protective measure, a practice commonly known in archaeology as back-filling. It is also the most cost-effective in the long term since, apart from the initial expense of the reburial process, it reduces the need for subsequent site maintenance. Where necessary, it will permit land to be returned to other uses, whilst protecting the buried remains. The feasibility of reburial will depend on a number of factors. It should be a relatively straightforward option for recently excavated sites, since in most cases the soil and other fill material removed in the process of excavation will be suitable for this purpose. In other circumstances, where ruined monuments stand to a considerable height, or have never been buried, it may not be possible. Partial reburial (leaving the upper sections of walls exposed) and reburial of selected elements (notably of mosaic pavements), has been carried out at a number of sites. An advantage of partial reburial is that the building's plan form remains legible. In current practice, reburial typically incorporates a membrane of geotextile over surfaces to be buried, often as a horizon marker to delineate the archaeological deposits from the fill materials. An intermediate layer of sand or other material is sometimes used and then the soil fill. However, recent evaluation of past reburials has highlighted problems with the use of geotextiles in the context of covering sensitive surfaces, such as mosaic pavements. Reburial should be the minimal measure anticipated as a post-excavation activity in planning the excavation of sites where ruined architectural remains are likely to be found. Reburial will not necessarily obviate the need for consolidation or treatment of remains. No preventive conservation measure is entirely maintenance free, and even reburied sites require monitoring and control of vegetation, to prevent damage by plants with potentially disruptive root systems.

The consequences of leaving ruined sites exposed without any protective measures or even minimal maintenance to remove invasive plants and their damaging root systems are depressingly familiar. The vulnerability of various materials and agents of deterioration are discussed further at the end of the chapter, but several illustrations (Figures 5.9–5.12)

Figure 5.9 *Section of ancient opus sectile pavement suffering gradual loss from visitor traffic and exposure; imprints of missing stones are visible (photograph: C. Woolfitt).*

Figure 5.10 *Wall plaster, lined out in imitation of ashlar, with detachment caused by the combined effects of vegetation and exposure to weather (photograph: C. Woolfitt).*

from ancient sites in the eastern Mediterranean are included here to highlight the problems.

When to rebury

Reburial may be the most appropriate protective measure in the following very general circumstances:

- When the resources necessary to implement other measures – either essential conservation, repair and maintenance necessary for long-term exposure or protection by cover building – are unavailable. This may be the case at sites of lesser interest or significance, where visitor numbers will be insufficient for the site to function as a visitor attraction.
- As a temporary measure while decisions can be made regarding more permanent solutions, such as protective shelters or enclosures.

Figure 5.11 *A neglected shelter and ancient site lacking maintenance, where vegetation grows uncontrolled (photograph: C. Woolfitt).*

Figure 5.12 *Exposed Byzantine mosaic pavement, with the pattern of water ponding and saturation reflected in the organic growth (photograph: C. Woolfitt).*

- When the ruined fabric, in general, is particularly vulnerable to exposure. Earthen ruins or masonry with earth as a principal component are, for example, particularly vulnerable, especially in more aggressive environments.
- Where sites are situated in isolated locations and inspection and maintenance is therefore difficult, or where there is a risk of vandalism, isolated sites tending to be easier targets.
- When particular vulnerable elements, such as mosaics, need to be selectively protected.
- When damage by frost is a primary concern, reburial is the only permanent measure (apart from enclosure with adequate environmental control) that will effectively protect surfaces, provided remains are reburied to an adequate depth. (Note: The agents of deterioration therefore need to be established in advance of any proposals. Condition survey work is discussed further at the end of this chapter and also in Chapter 3.)

The buried environment

Reburial generally provides a more stable environment than exposure to weather. Prior to excavation, soils or other fill materials are in intimate contact with building surfaces, which may consist of masonry, with finishes of plaster or paint, or of timber. Although problems can sometimes occur at the surface–fill interface, such as precipitation of hard and insoluble minerals through percolation of moisture and soluble material through soils, this close contact with the fill normally has a protective effect, provided conditions remain stable. Certainly for inorganic building materials, stone, ceramic, earth, lime mortars and plasters, the buried environment is more benign than the weather with its combined effects of daily and seasonal cycles, of wetting and drying, and heating and cooling. The surprisingly vibrant appearance of freshly excavated wall paintings and plaster of the Roman period, from both warmer and drier climates and wetter and colder ones, at sites across the former Roman empire is testament to the durability of these materials in a range of buried environments. Unfortunately, paint and plaster finishes are among the most vulnerable elements of a ruin once they are exposed. In the British climate, exposed surfaces of more vulnerable materials, plasters and paint, whether of earth or lime based, may need protection in the course of excavation. Past excavation reports of Roman sites in Britain have occasionally noted the red mud that results during unprotected excavation, where plasters containing crushed tile (*opus signinum*) survive. In such cases there is clearly a need for protection during excavation, as well as after.

For inorganic or porous building materials, the specific soil conditions, such as moisture levels and pH (acidity/alkalinity), are less critical than for organic materials. Organic materials, such as timber, behave quite differently and are much more sensitive to varying soil conditions. It is common, in the UK at least, to find only traces of timber structures during the course of excavations; timber elements of early structures are typically visible as discoloration in the soil. In certain conditions, however, timber can be well preserved. There are two general types of buried environment that favour timber preservation: (1) waterlogged or saturated deposits that typically consist of soils of low moisture permeability (such as clays) and low levels of oxygen, known as anaerobic or anoxic environments, and (2) arid conditions. The condition of waterlogged timbers presents a particular challenge in terms of conservation; the timbers must either be kept saturated or treated, to avoid drying out and collapse of the timber microstructure, the cell walls, which results in shrinkage and deformation of the timber. Treatment of waterlogged artefacts normally involves impregnation with polyethylene glycol (PEG) by immersion and subsequent freeze-drying.

Temporary protective measures during excavation

Exposure of building fabric by excavation alters the equilibrium that has been reached over centuries in the buried environment and can be traumatic for some materials, depending on environmental conditions. In some cases protective measures need to be taken during excavation, to avoid loss and deterioration. Moisture content at the surface of the structure will change quite rapidly with exposure depending on the nature of the material and the external environment. Drying occurs at the surface, and if this occurs too rapidly, damage can result to some materials, especially to mortars and plasters based on earth or weak lime binders. With drying, soluble salts are often mobilised and migrate to surfaces where they can cause either insoluble, hard deposits, in combination with remaining soil, or characteristic pitting and friability. The effects of soluble salts may not be evident until some time after excavation. Soluble salt damage occurred at the site of Masada in Israel after excavation and resulted in the subsequent decision to detach wall paintings from the masonry substrates and

Figure 5.13 *Detail of wall painting on the lower terrace at the Northern Palace, Masada in Israel, with pitting to the lower section from soluble salts (photograph: C. Woolfitt).*

mount them independently so that they were isolated from the source of salts (Figure 5.13).

Pre-excavation planning should anticipate the types of materials that might be uncovered and their potential vulnerability so that protective measures can be implemented at an early stage during excavation. In the case of decorative surfaces, such as wall paintings and earth plasters, it may be necessary to employ measures to slow rapid drying and associated problems of salt and insoluble deposits. These can include leaving a layer of protective soil on vulnerable surfaces after excavation to allow this to function as the drying zone into which potentially harmful salts can migrate. The advice of a conservator specialising in the conservation of archaeological remains *in situ* should be sought when vulnerable decorative surfaces are found. Treatments that might be appropriate for detached decoration (wall paintings, mosaics) in a museum context are often unsuitable for *in situ* treatment, due largely to the differences in environmental conditions. This is particularly true of long-term as opposed to temporary measures. The problem of applying materials and techniques applicable in a museum/objects context directly on a site is discussed further in the section below on 'Protective enclosures and shelters'.

The problem of excavating waterlogged timbers and the need to maintain their saturated condition is a familiar one in the UK. Measures to keep timbers damp on site include the use of plastic (polyethylene) covers and intermittent water spraying to ensure an adequate moisture content in both the soil matrix and the timbers themselves. Where existing groundwater levels are relatively high, as typically occurs on waterlogged sites, this is helpful in maintaining the required moisture levels.

The *in situ* conservation of remains of the Roman amphitheatre in London, within the basement of the Guildhall, is an interesting example of how ruins can be protected in the course of urban redevelopment and construction work, and creatively interpreted.[13] Remains of the amphitheatre walls, composed of Kentish ragstone and tile, were uncovered during excavations in 1988 and designated a scheduled ancient monument (Figure 5.14). Designs for the new structure, the Guildhall Art Gallery, were consequently modified and adapted to accommodate the Roman remains and to ensure their protection whilst two new basement levels were formed below the level of the amphitheatre. Considerable engineering work was required to support the Roman remains *in situ*, by underpinning and strategically locating the piles to support the new structure around the ancient remains.

The amphitheatre walls were protected in two phases during the long construction process. First, for the piling operation carried out from a suspended steel deck above the amphitheatre, the remains were boxed in with plywood, with a layer of thick polythene protecting the masonry surfaces and the void between the masonry and plywood box filled with expanding sprayed foam. In preparation for the second construction phase, of underpinning, the remains were boxed in with concrete block. Prior to commencing the second phase, the entire area was dried out and the environment within the plywood

Figure 5.14 *View of protected remains of the Roman amphitheatre in the course of redevelopment at the Guildhall, London (photograph courtesy of Museum of London Archaeology Service).*

enclosures monitored to prevent rapid drying, which might cause cracking.

The amphitheatre walls were underpinned using needles and a new concrete slab was formed beneath the remains, connected to the main floor slab. Once ambient relative humidity had stabilised to 50 per cent relative humidity, the masonry remains were uncovered gradually over a period of 15 weeks, with regular monitoring of masonry condition. No deterioration was observed and the remains are now displayed and interpreted. The display includes timber elements of the amphitheatre, which were removed from site for conservation and subsequently reinstated. Ruins displayed in such urban basement settings are often drab and uninspiring, but in this case considerable effort has been made to give an imaginative impression of the amphitheatre's original function and form, using dramatic lighting, projection and sound (Figure 5.15).

Materials which may be useful in the temporary protection of ruins against the weather during excavation or against physical damage in the course of construction work include:

- *Geotextiles*. Various types are available and may be used for various purposes, as barriers against soiling, as 'horizon markers' to separate archaeological deposits from added fill, or to contain cushioning/fill materials. Available under a range of trade names in the UK, such as Terram™ and Terralys™, these may be either of non-woven (needle-punched or heat-bonded) fibres or woven, and are composed of polymers such as polyethylene and polypropylene. Geotextiles are designed for civil engineering purposes, for example to retain particulates whilst allowing transmission of water within soils. Lapped joints between geotextiles can be sewn or heat bonded in the case of thermoplastic materials. Recent research has looked at geotextiles used extensively at the interface between excavated remains and backfilled soil and as membranes to facilitate future

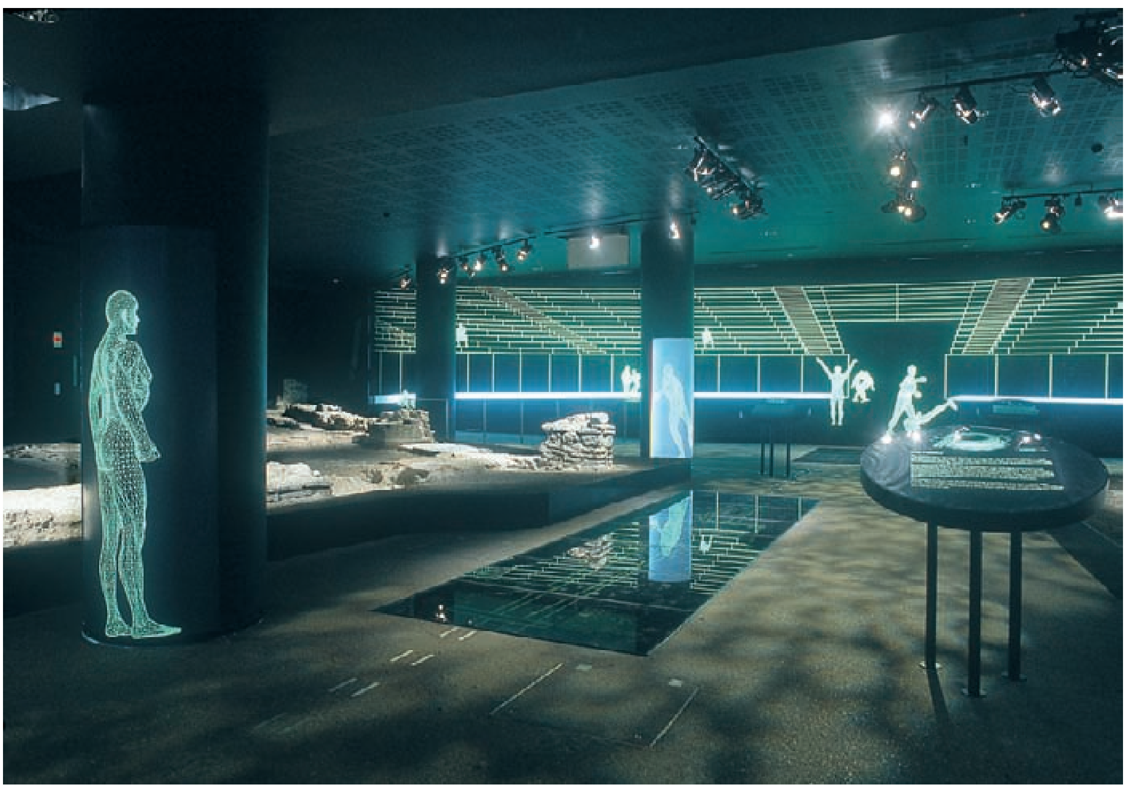

Figure 5.15 *The remains of the Roman amphitheatre in London displayed in the basement of the Guildhall (photograph courtesy of Museum of London Archaeology Service).*

excavation. In general, non-woven, needle-punched geotextiles have been found to have better water permeability characteristics. Examination of re-excavated sites has found damage from geotextiles adhering to architectural surfaces, through the precipitation of minerals at the surface–geotextile interface. Geotextiles should be permeable to water, depending on the intended use and proximity to vulnerable surfaces, but there are variations in water transmission characteristics depending on the geotextile type and properties, such as grade, mass per unit of area.

- *Plastic sheet and tarpaulins*. Waterproof covers (transparent, translucent or opaque), typically composed of polyethylene sheet, are available in various grades (heavier grades are better to avoid punctures and other damage), for walls and other architectural elements, which can be used alone or in conjunction with quilts or other materials. Prefabricated tarpaulins (also of polyethylene) are useful since they are prefabricated with eyelets and reinforced hems, making them easier to secure in position. Opaque covers may be preferable to cover surfaces that are exposed to light, to discourage organic growth, especially in damp conditions.
- *Padded or insulated quilts*. These may be useful for protection against frost if designed specifically for this purpose. Those designed and available for the curing of concrete may be appropriate. Industrial fabric suppliers can produce these to various materials and performance specifications, including the use of a range of synthetic or synthetic and natural fibre blends, with fill/wadding of synthetic (for example, polyester, acrylic, polypropylene, viscose) or natural fibres (wool, which is now used in insulating houses, offers good insulating properties).
- *Geo-mesh*. Synthetic (plastic) mesh of various sizes and types, such as those used in soil reinforcement; may be useful for securing covers.
- *Plywood sheet*. Various grades and thicknesses are available; marine grade plywood may be useful in waterlogged contexts.
- *Semi-rigid plastic 'corrugated' sheet*. An example is Corex™, which has twin walls and is available in various forms, varying in the degree of flexibility; useful for protecting surfaces where rigid plywood is awkward, due to the greater flexibility of plastic sheet and ease of cutting/forming to required shapes.
- *Foam and other synthetic packaging/cushioning materials*. Various foam products are commercially available in sheet, pellet or spray form. Sheets and laminates come in various forms, varying in thickness and flexibility; these are typically composed of polyethylene or polyurethane. Expanding spray foam, of the kind used for insulating buildings, which is normally of polyurethane, may be useful, but care must be taken to isolate surfaces before application. Bubble Wrap™ is a commercially available lightweight polyethylene packaging material, with cells filled with air, that can be useful for cushioning, as an alternative to heavier materials, when used in rolls, provided it is wrapped and protected from direct weathering.
- *Sand*. Normally used in bags for ease of removal. Natural fibre bags will deteriorate quite rapidly with exposure to weather and damp conditions. Synthetic fibre bags (such as nylon) should be used instead, although these will also degrade with lengthy exposure in an external environment.
- *Vermiculite/perlite*. These materials have been used recently in the context of protecting vulnerable surfaces, such as plaster detail, on archaeological sites.[14,15] They are naturally occurring minerals, which expand on heating to many times their original size, to form lightweight, highly absorbent particles. They are widely used in horticulture and the construction industry for their insulating properties.
- *Earth- and lime-based materials*. These are used as sacrificial or protective plasters, with various aggregates (sand, crushed brick and limestone) and fillers. They may be useful in protecting masonry, as well as decorative surfaces. Advice on appropriate applications and mixes should be sought from specialists in the *in situ* conservation of ruined structures and their finishes.

Reburied waterlogged sites: experience to date

There is comparatively little published information on the subject of the reburial of ruins in the UK. However, recent initiatives, principally by the Museum of London Archaeology Service (MoLAS), supported by English Heritage and the University of Bradford, have resulted in very useful review and publication of reburial methods and materials, particularly in the context of waterlogged sites.[16] There are a few waterlogged sites in the UK where ruins have been reburied with the intention of periodic excavation to monitor their condition. The Sweet Track, a section of the Neolithic trackway that crosses the Somerset Levels, is preserved in Shapwick Heath

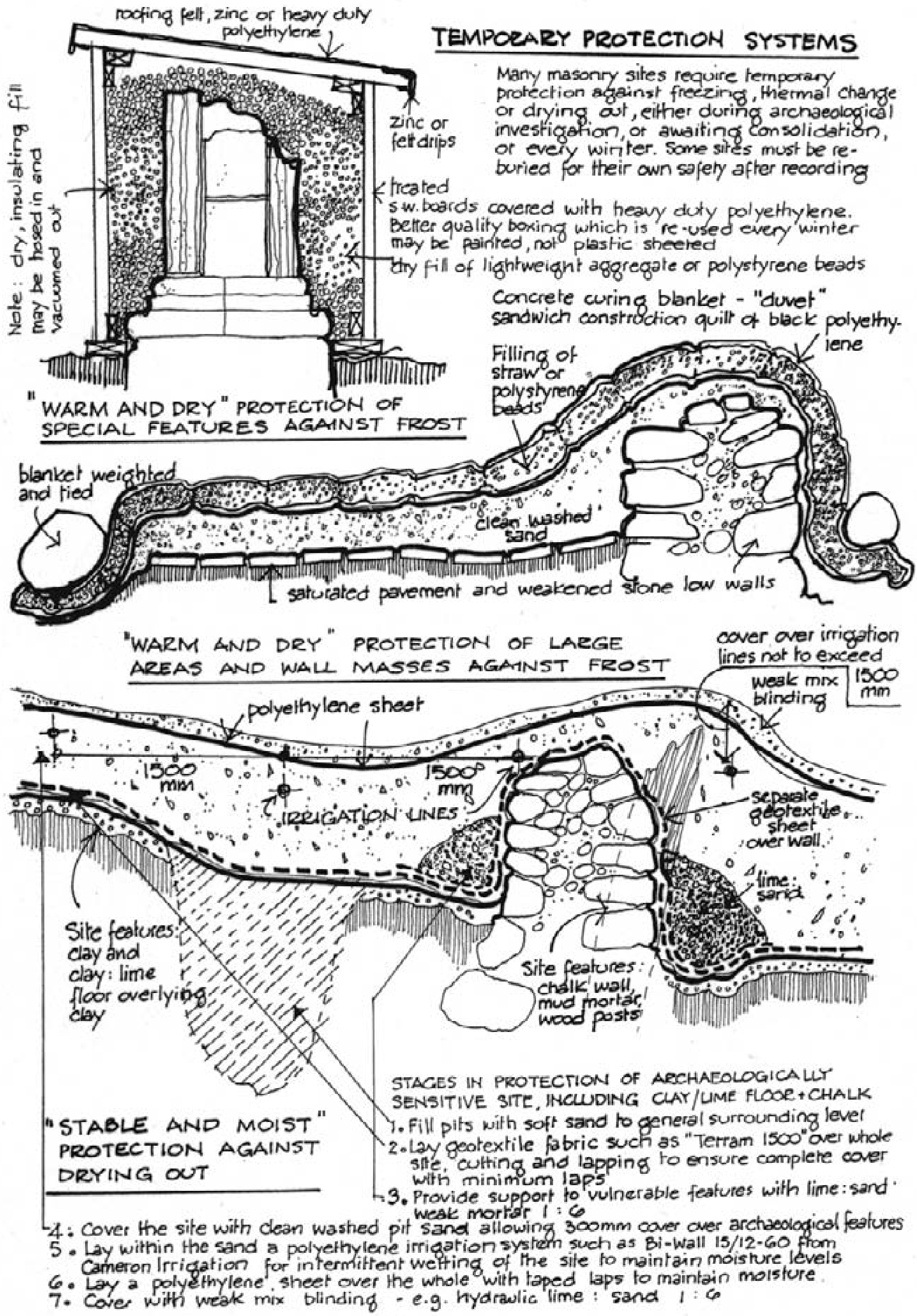

Figure 5.16 *Sketch of temporary protective measures for specific conditions (sketch by Prof. John Ashurst).*

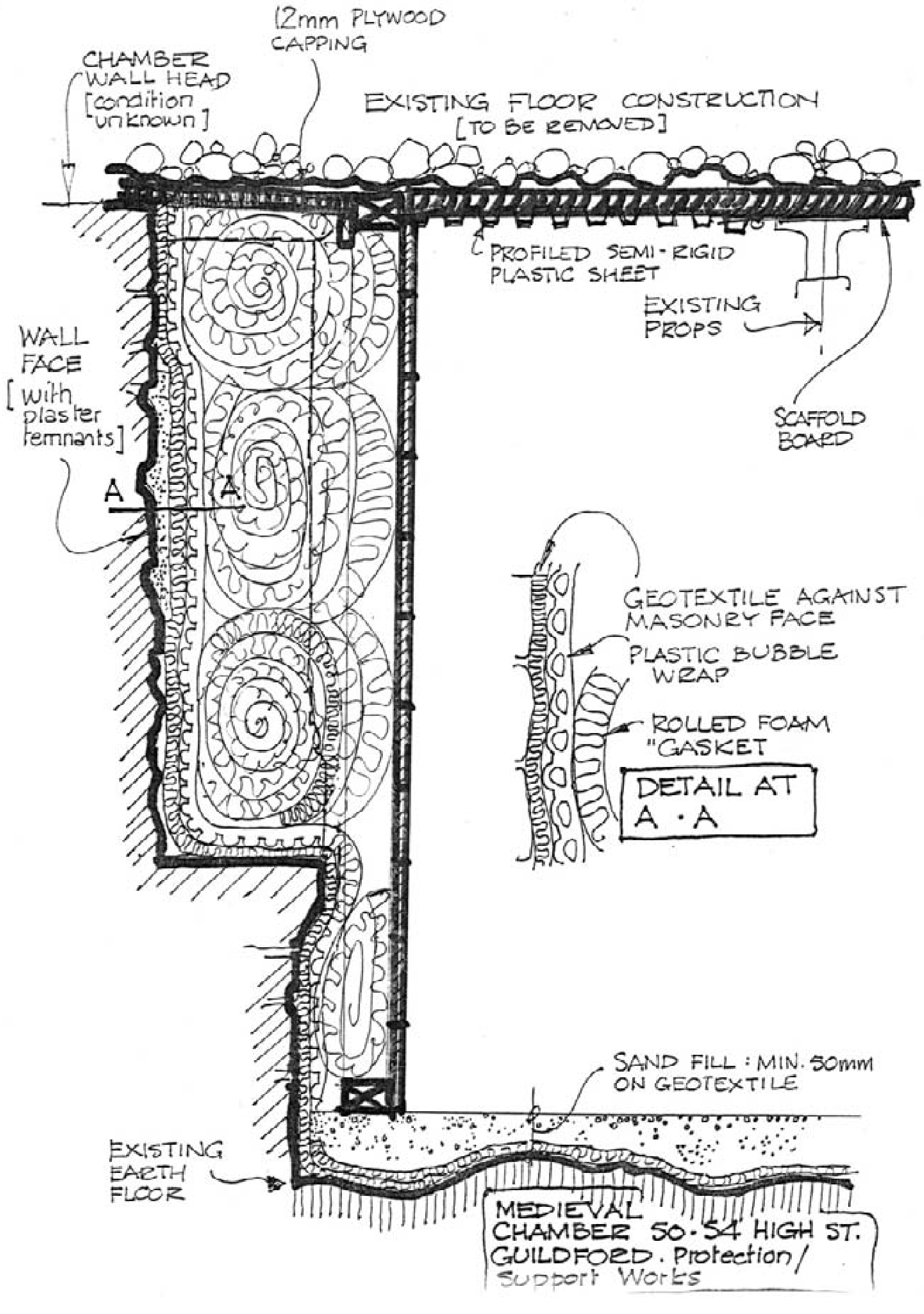

Figure 5.17 *Sketch of temporary protective measures for specific conditions (sketch by Prof. John Ashurst).*

Nature Reserve. Sustained efforts to maintain the saturated environment and ensure the stability of the reburied timbers have included the creation of a bund, pumping of water and control of vegetation. The trackway condition has also been monitored by re-excavation of small sections and detailed analysis of the timbers and of the buried environment.[17] Flag Fen near Peterborough is another early waterlogged site, but in this case a section of the Bronze Age timber causeway has been uncovered and protected under a cover building, with the moisture content of the timbers maintained by regular water spraying, the water containing silver ions to inhibit biological activity. Corfield comments that this is not considered a permanent solution and at some point in the future the site will be back-filled.[18]

The Rose Theatre, in Southwark, London, is one of the few sites in the UK that has been published, the process of its reburial described in detail and the site subject to ongoing monitoring.[18,19] Built towards the end of the sixteenth century, the Rose Theatre was discovered in 1989 during preliminary investigation of the site, in advance of redevelopment. Upon discovery of the theatre remains, a temporary roof was built to permit excavation and public viewing. The site attracted much public attention, not least from prominent actors, and the preservation of the site was eventually secured by negotiation with the developers. The agreed scheme involved retaining the remains *in situ* within the basement of the new structure on the site and redesigning the foundations to avoid damage to the theatre remains. Temporary protection in the course of archaeological excavation and investigation included maintaining the damp condition of the clay matrix in which the theatre remains were imbedded, with water sprays and covers to prevent drying out.

Initially, it was envisaged that covering the theatre remains, as described below, would be temporary, lasting only a few years, until later excavation and conservation could take place, but the site remains covered and under water. Once the decision to rebury the remains had been made, various materials were considered for use in this process. Selection criteria included that these be chemically inert to minimise their effect on the reburial environment and deposits. The reburial process, as described by Corfield, comprised the following:

- A cover of non-woven geotextile (Terram™), laid in sheets, with depressions below filled with sand to form a level surface. Joins between sheets were sealed with a weak 1:6 lime and sand mortar. Subsequent reassessment recommends that heat sealing ('heat welding') or sealing tape may have been better than mortar for use at these joints.
- A layer of clean Buckland silica sand, free of contaminants such as soluble salts, carbonates and iron oxide, was then applied to a minimum depth of 300 mm over the remains. The sand was pumped through a flexible hosepipe to minimise use of wheelbarrows.
- The sand was saturated with mains water, without any purification, and leaky horticultural hosepipe was laid at 1500-mm intervals for subsequent introduction of water; these pipes were in turn covered with an additional layer of approximately 12 mm of soft sand blinding.
- Plastic (polyethylene sheeting) covered the sand layers, and over this was laid a 50-mm weak concrete screed.
- Monitoring points were incorporated in the reburial strata so that the following could be checked: moisture content of soil and sand, water level (groundwater with contribution from leaky pipes), water quality (pH, redox potential, dissolved oxygen and temperature – as an indicator of biological or chemical activity).

As levels vary within the site, a pool of water has formed. Small sondages have been made to replace the soil moisture cells and to check the condition of the clay matrix and the timber, and these have been found to be stable. The criteria for selection of sand in the reburial process at the Rose Theatre were carefully considered and published separately.[20]

Parameters to be monitored in the context of waterlogged reburied sites include moisture content of the deposits and the quality of the water in the deposits. Research and evaluation of past reburial has found that relevant water quality parameters are: temperature, pH, dissolved oxygen content, redox potential and electrical conductivity.[21] The type and quantity of micro-organisms that can cause decomposition of timber is another variable. In general, on the basis of experience and ongoing monitoring at sites such as the Rose Theatre and the Sweet Track, it seems that reburial of waterlogged sites can be successful provided the conditions that favour preservation of the timber can be maintained.

Protection of decorative elements

Ruined remains incorporating significant decorative detail, such as decorative plasterwork, wall paintings and mosaic, tile or other pavements, are particularly

Figure 5.18 *View of the excavated Roman mosaic at Lopen in Somerset, prior to reburial (photograph: G. Abrey).*

vulnerable to weather and deterioration, and for this, and other reasons, tend to receive more attention than masonry ruins that have lost their decorative finishes. There is published experience of the reburial of mosaics, in particular, due to the efforts of the International Committee for the Conservation of Mosaics (ICCM), which hosts an international conference on a triennial basis and publishes the papers presented, and to joint initiatives of the Getty Conservation Institute and ICCROM, amongst other organisations, which have led to the very useful recent publication of a Special Issue on Site Reburial in the journal *The Conservation and Management of Archaeological Sites* (*CMAS*).[22] The MoLAS and *CMAS* volumes provide the most extensive accounts of experience of past reburials to date.

In the UK, the example of the Orpheus mosaic at Woodchester Roman villa is often cited. Uncovered in the late eighteenth century, the mosaic was subsequently reburied and uncovered at intervals subsequently, most recently in the 1970s, attracting large numbers of visitors. Decorative floors, such as mosaics, make relatively easy subjects for reburial, at least in terms of the practicality of physically covering the remains. This approach was adopted for the recently excavated Roman mosaic at Lopen in Somerset (Figure 5.18). In this instance, the mosaic was reburied after recording and consolidation of fragile edges. Reburial included the following: a cover of soil directly on the mosaic surface, a layer of Terram™ geotextile, more soil, strategically placed concrete slabs and finally a cover layer of soil, formed into a slight mound.[23] The same process was used for reburial at the Roman villa site at nearby Dinnington. At Chedworth, Roman villa mosaics not protected by the existing cover buildings have also been reburied. A cover layer of gravel has been used for protection against burrowing rodents and vegetation.[24]

Recent reassessment of the condition of reburied mosaics has provided useful information regarding suitable methods and materials. Standard practice has entailed the use of a geotextile or plastic (polythene) sheet as a barrier between the mosaic and the soil or fill. Recent experience has shown, however, that there are problems associated with the use of such membranes, particularly when they are impermeable to water vapour.[25] They can create problems at the mosaic–fill interface, by trapping moisture, with related microbial interactions, localised pH variations and the formation of mineral precipitates

Figure 5.19 *Section of mosaic pavement at Horvat Minim in Israel covered with geotextile, pozzolanic pellets and sand, which were found to be ineffective in protecting surfaces from vegetation (photograph: G. Abrey).*

on mosaic surfaces. If mosaics are not covered to sufficient depth, vegetation and root systems can also cause damage, even where geotextiles are used. Sand and clay pellets have also been used directly over mosaic surfaces in the past but neither is ideal for this purpose. Experience has shown that fill should be in intimate contact with the mosaic surface, in the way that soil provided protection prior to excavation. Fill of sand or clay pellets will have large pores and voids at the interface with the mosaic. Soil is preferable as a fill material in direct contact with a mosaic. If sand is to be used it should be free of contaminants which cause staining and of soluble salts. Any cover or fill material should be chemically inert and its pH compatible with the mosaic; the lime mortars used in mosaics are alkaline, so acidic fills should be avoided.

At the site of Horvat Minim (Khirbet al-Minya) in Israel, where Umayyad period mosaics of the eighth century AD were covered, from the mosaic surface to the top, with black plastic mesh, non-woven geotextile, volcanic pellets and then sand, recent uncovering and evaluation has found that substantial vegetation had grown after a period of only four years' reburial, causing damage to mosaics and detachment of the tessellatum (the surface layer containing the decorative image, composed of tesserae and lime).[26] This illustrates the need for routine inspection and maintenance of reburied sites to ensure vegetation cannot cause damage. It also illustrates the need to create a sufficiently deep protective layer so that any vegetation and root systems are confined to the upper surface of the protective cover, above the sensitive ancient surfaces.

Recent work at the Neolithic site of Çatalhöyök in Turkey involved the development of materials and techniques, including the use of mock-ups, for the temporary protection of freshly excavated earthen walls and murals.[14] This work by Matero and Moss illustrates an analytical approach to a particular form of deterioration in specific site conditions, with the use of materials analysis and trial tests/simulations to determine the best methods and materials for *in situ* protection. Ongoing excavation at Çatalhöyök, which was first excavated in the 1960s, has uncovered structures of mud brick with wall plaster, modelled reliefs and wall paintings. Past experience had shown that exposure to the environment by excavation was problematic for the earthen building materials. Rapid drying normally occurred very soon after exposure, with resulting cracking and breakdown of surfaces. The thickness of surface finishes, up to 100 layers, was another factor in deterioration. Some minimal pressure directly against surfaces helped keep them under compression and maintained the bond to the wall substrate during the drying period immediately after excavation. Efforts had been made to slow the drying process by erection of shelter structures during excavation and between seasons, but other flexible and easy-to-use methods were necessary to slow the drying rate of the plastered mud-brick-structures. Vermiculite and perlite, both materials of mineral origin, formed by heating and consequent expansion, were identified as suitable lightweight and non-abrasive fillers, for use at the drying interface. These materials were held in place against the wall face with the following system: a perforated rigid retaining 'wall', held in place by sandbags, and water-repellent (but moisture-permeable) geotextile, which contained the fill and extended up to the wall head and down, under the sandbags.

There is very little reliable information and guidance for the protection of decorated, plastered and painted wall surfaces prior to reburial. The use of fine synthetic polyester fabrics such as Holytex™ has been considered, along with sacrificial lime-based plasters, which have been tested at the Hippodrome at Caesarea as removable protective coatings in an exposed marine environment.[15,27] At Caesarea such plasters were found to prevent alteration of the original surfaces and to be removable without damage to the underlying plaster. This research included the use of various aggregate and fillers, including pozzolans and coloured fibres as visible markers to distinguish applied plaster layers. In the light of recent experience in the conservation of mosaics, it seems advisable to approach the use of geotextiles and other synthetic textiles in direct contact with any decorative surface very cautiously. The use of protective earth or weak lime (non-hydraulic or high calcium lime) plasters would, however, seem to be viable options as protective measures in preparation for reburial. Any system should be tested on a small area of the surface to be protected, to assess properties such as adhesion, ease of removal, any residual staining and other consequences.

Recent work at the ancient site of Zeugma in Turkey, founded in the fourth century BC, provides

Figure 5.20 *View of the Hippodrome at Caesarea in Israel, a site of recent testing of sacrificial lime plasters for protection of original plaster surfaces in a severely exposed marine environment (photograph: C. Woolfitt).*

an interesting example of reburial in unusual circumstances. Approximately one-third of the site was submerged in 2000 by construction of a hydroelectric dam and subsequent flooding, a controversial event, which has been widely reported. Emergency excavation in advance of attempts to commence *in situ* conservation measures had, unfortunately, resulted in the detachment of substantial quantities of mosaics and wall paintings in less than ideal conditions. Measures implemented to protect exceptionally fine mosaic pavements and other archaeological remains *in situ* included reburial, and have been published by Nardi and others who carried out the work.[28] Specific protective and preventive measures in the reburial process were: application of lime washes and hydraulic lime mortars to mosaic surfaces in preparation for reburial, necessary consolidation (as opposed to 'restoration' of structures) and barriers to protect buried remains against displacement by waves of water. The use of mortars to protect mosaic and wall painting surfaces is of particular interest, especially since comparatively little work of this kind has been reported. The lime mixture was composed of hydraulic lime (Lafarge), lime, brick powder and crushed stone in proportions of 0.5:0.5:1.5:0.5 or a 1:2 ratio of binder to aggregate/filler. It was applied to a thickness of 20 mm to wall paintings and 50 mm to mosaics. Hydraulic lime mixes will gain strength under water and it would be interesting to investigate in the future how difficult the removal of such a mix proves to be. The strength and adhesion of the mortar might be tempered by the intermediate layer of limewash, which was intended to facilitate future removal, and by the high proportion of fines (crushed brick and stone) in the mortar. Additional measures have been required to maintain protection of buried structures along the zone of the new shoreline at Zeugma, where erosion had occurred; these included depositing bags (biodegradable) filled with pebbles and gravel and sufficient cement to hold the aggregate in place.

Reburial systems in arid climates

The descriptions of reburial procedures and assessment at the World Heritage Site of Chaco Canyon in New Mexico by Ford and others in the *CMAS Special Issue on Site Reburial* are particularly detailed and provide useful information on the treatment of masonry incorporating timber members in an arid climate. The motivation for reburial and the methods adopted are summarised here in some detail, since they illustrate very well an analytical approach to finding a suitable methodology for the particular site conditions.[29] The ruined structures of Chaco Canyon belong to the ninth to twelfth centuries AD, stand to considerable height, and are built of stone bonded with earth mortar, with imbedded timber members and earth plasters. The rationale for partial reburial of selected structures included: the need to address visible and accelerated deterioration of the ruins; to prevent the loss of fabric and authenticity which has occurred through maintenance cycles; a desire to allow walls and structures to remain legible; and the need to equalise fill levels and pressures in adjacent rooms where one room was open to some height and the adjacent room infilled. In the case of one of the great houses, Chetro Ketl, the imbedded timber elements used for ceilings/floors and lintels to openings were of particular concern and the reburial system was designed to ensure their preservation and to maintain the timbers at a moisture content not exceeding 15 per cent by weight in the reburial environment to prevent rot by fungal growth and termites. Although the climate is generally dry, two sources of moisture were identified: snowmelt and rainwater. The reburial system needed to cope with periodic wetting of the fill and prevent water penetration into imbedded timbers. The special measures adopted to cope with precipitation were essentially:

- Forming compacted and graded/sloping surfaces incorporating a central drain which fed through buried PVC pipes to a drainage trench external to the structure.
- Inclusion of an impermeable geotextile membrane below the surface fill to prevent absorption of snowmelt water, which otherwise was found to penetrate to a depth of approximately 1 m.

The reburial sequence included the following:

1. A permeable geotextile horizon marker at the bottom, on top of any existing fill or archaeology.
2. Bulk fill of local soil (compacted every 300 mm with weighted drum roller and hand-held steel plate tamper; a skid loader and conveyor system was used to bring the fill material into the individual rooms).
3. Protruding surviving timbers were wrapped in geotextile (various types depending on context).
4. PVC drainage system.
5. Impermeable membrane (Tuff-Ply)™, with an erosion control membrane on top of this (Enkamat™ – nylon 3-D webbed matting).
6. Top layer of surface soil fill (200–500 mm deep).

The reburied area of Chetro Ketl remains closed to visitors but can be viewed from vantage points. Monitoring points were installed through the depth of the fill, at 300-mm intervals, during reburial so that moisture contents can be monitored on an ongoing basis. Subsequent evaluation of the reburial focused largely on the moisture content of the soil fill and of the buried timbers. One positive result of the reburial measures was a reduction in the erosion at the base of walls standing above ground level, apparently due to the combined effects of reduced moisture content of fill, the membrane and drainage system. Problems highlighted by evaluation included that some discontinuities in membranes occurred (punctures in membrane and incompletely sealed or poorly overlapped junctions) and were problematical, and also that soil moisture contents of 15 per cent by weight were insufficient to prevent deterioration of timber by fungi and termites.

Factors to consider in reburial

Depending on the complexities and scale of the ruins to be reburied, it may be necessary to assemble a multi-disciplinary team, including potentially the disciplines of geology, soil science, civil engineering and landscape architecture. Primary issues and variables to be considered in any proposals for reburial, especially for sites that have always been exposed or have been exposed for some time, include the following:

- *Condition survey and options appraisal*. Condition survey and appraisal is essential to determine the nature of the constituent elements of the fabric, their vulnerability to various agents of decay, and patterns of deterioration which have developed and may be anticipated in future, depending on how the site environment is altered. The issue of condition survey is discussed further at the end of this chapter and in Chapter 3.
- *Landscape design, height and morphology of remains and stability of reburial*. The height and form of ruins will determine to a considerable extent the final form of the reburied site/monument. Methods of reburial should anticipate the final appearance of the reburied site and how ruined remains can be interpreted. Drainage of the site needs to be considered, with levels planned to avoid water traps and areas of ponding, in larger schemes of reburial. Reinforcement of soil infill may be necessary in some cases, for example where slopes are formed. Final finishing with topsoil, seeding or planting should also be considered, where appropriate.
- *Reburial or cover material*. In practice the best fill material is often that which was removed in the process of excavation. Any fill should be stable and chemically similar to the original burial material. Extremes of pH should be avoided as this affects dissolution and redeposition of mineral processes. If sand is used it should be free of staining iron oxides, calcareous or other material which could be dissolved and redeposited on surfaces.[20,30] The soil matrix of the ruined remains and reburial medium should be of similar porosity and permeability to minimise the risk of mineral deposits forming at interfaces between the ruined remains and the fill, and to ensure uniform drainage of water. Ideally, the buried environment should differ as little as possible from the environment of the ruin prior to exposure. This is particularly important for waterlogged ruins. The following properties should be compatible: soil characteristics and typology, such as particle sizes (relative proportions of sand, silt and clay) and pore structure, groundwater levels and moisture content, pH and redox potential.[31]
- *Reburial process*. Experience has shown that, in general, fill materials should be in intimate contact with surfaces, to avoid problems at the interface with architectural surfaces. Fills need to be compacted. A layer of topsoil which supports manageable plant growth has a protective function in preventing weathering and erosion of the cover layer. This may be difficult to achieve in drier climates, where the level of clay in soil could be a positive factor, possibly enhancing cohesion and improving protection.
- *Depth of cover*. Cover must be sufficient to create a protective zone over the buried surfaces, to buffer against changes in temperature and moisture content and to ensure vegetation remains in the upper surface layer, posing no threat to buried remains. The depth of cover required will depend on the particular site, materials to be protected and the agents of deterioration, which pose a threat, whether these consist of vegetation, weather, thermal or moisture changes, animals, or humans.
- *Maintenance*. Sites must be monitored and the frequency of routine inspections will depend on the nature of the site and the system of cover. All reburied sites need some maintenance to control vegetation. Where sites are reburied entirely and to adequate depth, and where land is suitable for pasture, introduction of grazing animals, sheep, cattle or goats, may be an environmentally friendly way of controlling vegetation.

Protective enclosures and shelters

The terms protective enclosure and shelter are used here to describe structures that provide, respectively, complete enclosure or partial cover, the latter typically in the form of a roof, open to varying extent at the sides. These may be of a temporary nature, constructed to provide shelter in the short term, for example during excavation or whilst proposals for more permanent protection can be developed. More frequently they are permanent structures. The idea of such protective structures is not new; a number of sites in England were protected in this way in the nineteenth century, prominent examples including the Roman villas of Bignor in West Sussex and Chedworth in Gloucestershire, where structures were built for the protection of exposed mosaics. As a class of monument, in England at least, the Roman villa tends to receive protection of this form more often than others, due in large part to the significant and vulnerable architectural detail, such as mosaics and decorative or painted plaster, which often survives.

Early enclosure buildings such as those at Chedworth and Bignor are in traditional style and materials and, in general, have the appearance of agricultural buildings. Those at Chedworth are built upon the existing Roman walls and have timber-clad walls and stone-covered roofs. At Bignor they are in the form of rubble stone buildings with thatched roofs. The Chedworth cover buildings protect mosaics and other remains of rooms, mainly in one wing of the villa, and openings in the south walls, either doors or windows, provide access for viewing the remains. The nineteenth century Bignor shelters were comparatively small in scale, designed to enclose individual rooms and mosaics. The current, more recent display building incorporates some of these

Figure 5.21 *View of nineteenth century enclosure buildings over the remains of a wing of the Roman villa at Chedworth (photograph: C. Woolfitt).*

pre-existing enclosures and provides access to a larger area of the Roman villa, permitting visitor circulation.

Current design of such protective structures tends to make use of modern construction materials and technology, incorporating, for example, textile membrane covers (under tension), translucent or transparent polymeric (plastic – polycarbonate or acrylic) cover for roofs and cladding to walls, and lightweight steel or aluminium frames for the main structure. Space frames, or three-dimensional frames with characteristic lattice-like structures, are increasingly adopted since they can span large areas, requiring relatively few central supports, be prefabricated off site, and erected in a comparatively short time. Probably the most famous examples of the space frame in England are the geodesic domes built to house the Eden Project in Cornwall. Covers to such structures are typically of plastic sheet (Perspex or other transparent or translucent plastics) or of synthetic textiles, under tension, which are normally translucent to some extent and coated with polymers for enhanced water repellency – to be 'self-cleaning'.

In current practice shelter designs tend to be consciously modern, functional and distinct from the ruins they cover; with some exceptions, they tend not to relate or make reference to the ruin and its construction, design or materials. The use of traditional masonry construction for shelters is, in general, avoided. The principal reasons are apparently: the expense and slow rate of construction, compared to modern methods, the risk of confusing new masonry with existing, and the lack of transparency and light of solid masonry structures, in comparison to the translucent or transparent effects that are possible with other construction methods and materials.

Past experience of protective structures

Understanding of the effects of enclosing ruined structures has evolved through revisiting historic shelters erected over the past hundred years and more. In the process it has been possible to identify and rectify some problems with past approaches. On the other hand, some problems persist, such as the perennial one in wetter climates of groundwater

Figure 5.22 *View of wall paintings at the Northern Palace at Masada in their display cases.*

causing organic growth and associated problems on decorative surfaces. It is clear that a holistic approach is necessary in shelter design and that the entire environment of the ruin must be understood so that the new environment created within the structure and its impact on the fabric can be anticipated. Recent research has emphasized the importance of environmental factors, that these need to be understood, and that modelling can assist in producing designs for shelters and enclosures.[32]

Recent review of protective structures built in Sicily in the mid-twentieth century by Stanley-Price and Jokilehto has highlighted a number of attitudes and practices that have evolved since that date through experience of problems encountered at these sites and others.[33] At The Roman Villa del Casale at Piazza Armerina the protective structure was erected in 1957–60 with walkways installed on top of the original walls, for viewing the mosaic pavements. This consisted of a lightweight steel frame clad in transparent plastic sheeting. The focus was clearly on the mosaics, to the exclusion of the masonry elements of the site. A principal disadvantage has been the environmental impact – the 'greenhouse effect' – as well as the need for regular renewal of the cladding. At the site of Gela mud brick masonry was encased in glass panels (one metre square) fixed flush to the surface, and held in place with aluminium fixings drilled through the face. Problems here have included the visual impact, both of the reflective surfaces and the disfiguring moisture and organic growth, the development of an undesirable microclimate behind the glass, and the failure of the aluminium fixings, with openings appearing between glass panels. Finally, at the theatre of Heraclea Minoa plastic (Plexiglas) covers were installed over the seats, replicating their forms, and requiring some alteration and cutting of original stone to fix these. Again, the problem of a microclimate below the plastic developed, as well as deterioration of the plastic itself.

The wall paintings of the Northern Palace at Masada provide another illustration of the problem of using glass in proximity to ruined surfaces, without ventilation. At Masada the frescoes have been detached and remounted on new support layers and metal frames; they are now displayed behind unventilated glass cases. The use of museum-based display techniques, materials and treatments in the context of an exposed archaeological site presents problems. The wall paintings at Masada exposed to the heat of the sun for the longest period have suffered the worst; these exhibit localised cracking and detachment of the painted surface layer from the new supports. In summary, these examples from Sicily and Israel illustrate the following points:

- Proposals should be based on a holistic view of the site and individual elements should not be sacrificed or ignored for the benefit of others. A balance must be struck in presenting those aspects of the site perceived to be of most general interest and protection of the site as an integrated whole.
- Protective glass or plastic surfaces must not be placed in close proximity to original surfaces where microclimates can develop. Lack of ventilation exacerbates the problem. Even when these materials are used over larger areas this can be a problem if there is inadequate ventilation (greenhouse effect). One problem is visual; such glass and plastic surfaces, especially in close range to building surfaces, tend to be obscured with dust, organic growth or condensation. They tend to trap moisture and create differential thermal and moisture levels (internal/external).
- Alteration and damage to original masonry, for example by fixings to accommodate new structures, should be avoided as far as possible.
- Detachment of original decorative finishes (such as mosaic pavements and wall paintings) should be avoided as far as possible. Where such elements are detached, displaying them *in situ*, without adequate protection from the sun and weather, using techniques such as glass display cases in an external environment, is problematic.

Shelters built in the latter half of the twentieth century, particularly those over large ruined sites, have tended to be industrial in nature and appearance. The shelter at the Bronze Age site of Akrotiri, on the Greek island of Santorini, consisting of a Dexion frame, which is soon to be superseded (construction of a new enclosure is in progress at present), is an example of this. At Akrotiri the shelter extends over the entire excavated area of the site and the structural remains stand to more than one storey, so that the shelter is necessarily large. The new structure is intended to be more environmentally friendly than the one it replaces, with roofs designed to be less conspicuous in the landscape. Shelters which rely on concrete construction, such as the 1960s concrete framed shelter over the Early Bronze Age House of Tiles at Lerna in Greece, also tend to be industrial in appearance. At least the architecture of the cover buildings, in such cases, is purely functional and does not compete with the archaeological remains for attention.

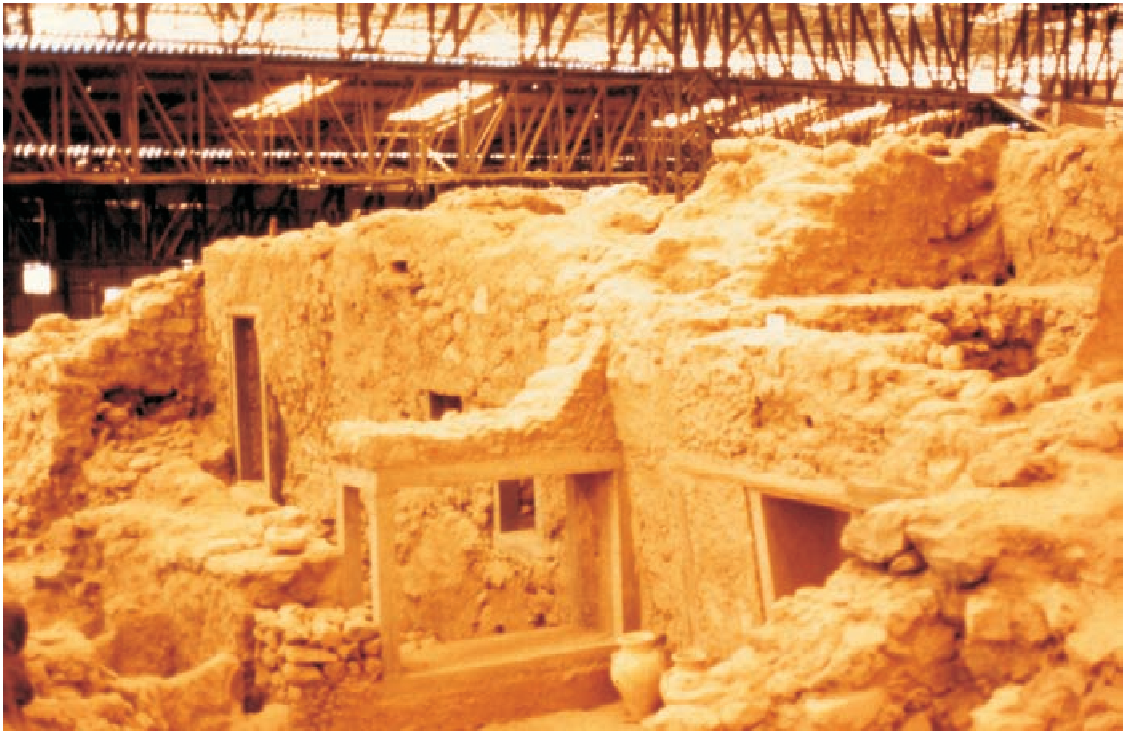

Figure 5.23 *View of the Bronze Age site of Akrotiri on the Greek island of Santorini in 1987; a new protective enclosure building is under construction (photograph: C. Woolfitt).*

Proposals to shelter the important mosaic of the Byzantine synagogue at Ein Gedi in Israel, with its inscription relating to the production of perfume, were debated before the current tent-like structure was built in the mid-1990s. It consists of metal posts and cables securing a tensile fabric cover, which extends down to provide additional protection at the sides. As for any substantial structure of this kind, concrete foundations anchors were required and some archaeology was sacrificed. In contrast with the form of the Ein Gedi Shelter is that over the Bronze Age gate of Tel Dan in Israel, whose arched form diverts water away from the vulnerable mud brick structure. It consists of a metal space frame covered with plastic sheet. The Israel Antiquities Authority erected the structure in the 1990s and carried out limited consolidation and support for the mud brick at the same time.

The cover building over an entire residential block (*insula)* at the ancient city of Ephesus in Turkey provides a good illustration of the application of contemporary structural design to the problem of protecting ruined remains over a very large area. There are extensive and remarkably intact and complete remains of wall paintings, mosaics and decorative stone (*opus sectile*) pavements. Designed and constructed under the aegis of the Austrian Archaeological Institute, the shelter was completed at the end of 1999.[34] The shelter is remarkable not only for its scale – it covers a massive area of approximately 4000 m^2 – but also as one of the few examples where an account of the design has been published. Previous shelters over the site, built in the 1980s, were deemed unsuitable for various reasons and a new design developed. The new shelter was engineered to meet specific environmental requirements and the internal environment modelled by computer simulation, taking into account variables of temperature, air exchange/air flow, relative humidity, condensation and light.

The stepped roof profile of the new shelter follows the topography of the site and the terraces of the original structures. The support structure is a lightweight steel frame, with a tensioned fabric roof cover and polycarbonate cover for the sides, which are louvred for ventilation. The overall visual effect internally is light and there is no need for artificial light (see Figures 5.27 and 5.28). The outlines of the ruined buildings remain legible to some extent from the exterior. The materials and design were selected

Figure 5.24 *View of the tent-like shelter over the site of the Byzantine synagogue at Ein Gedi in Israel (photograph: Orit Bortnik).*

for maximum surface reflectance to minimise solar gain and prevent increase of the internal temperature. The roof cover (PTFE–fibreglass membrane) is translucent but also reflects solar radiation. The sides are enclosed and covered with polycarbonate (Lexan™) 'louvres' for ventilation. The louvres are opaque on the south side of the building, which receives most sun, and transparent elsewhere. The Ephesus shelter, in effect, creates an *in situ* museum where visitors can comfortably circulate and view the architectural remains, complete with mosaic pavements and wall paintings.

At Cleeve Abbey, a site in the care of English Heritage, a tent-like cover has recently been erected to protect an important medieval tile pavement. The structure consists of a simple metal frame covered with a translucent tension membrane cover, with openings that can be closed in the same way as those of a large tent. The cover structure, which is reminiscent of a marquee, unavoidably has a visual impact in the context of the medieval building in front of which it stands, but has the advantage of being comparatively easily dismantled.

Another recent and interesting example in England is the enclosure building over the west range of the Roman town house in Dorchester in Dorset, which combines contemporary and traditional elements. Here the design of the cover building, and the roof profiles, give some impression of the volume and form of the Roman building. The projecting eaves help prevent solar gain through the glass elevations. Purbeck stones used for the roof cover have been formed to replicate the Roman originals found during excavation. The plate glass that encloses the elevations is fixed to the structure's tubular metal frame with ventilation gaps between the frame and glass, and hinging of some panels for additional ventilation when required.

Although none of the protective structures mentioned so far feature active environmental control

Figure 5.25 *Detail of anchor for the Ein Gedi shelter shown in Figure 5.24 (photograph: Orit Bortnik).*

Figure 5.26 *Protective shelter at Tel Dan in Israel (photograph: J. Ashurst).*

Figure 5.27 *View of the new enclosure of an ancient city block of Ephesus, with the reconstructed façade of the Library of Celsus nearby (photograph courtesy of the Austrian Archaeological Institute).*

measures, to regulate temperature or humidity, the design and selection of materials will affect the internal environment of enclosed structures, in what might be termed a 'passive' way. Materials which reflect solar radiation, for example, reduce solar gain and moderate internal temperature gain so that the interior is somewhat cooler than the exterior during hot weather. Gaps between materials which form the walls, either as louvres or in plates in the examples noted above, likewise provide 'passive' ventilation. In effect, however, the environment within such buildings will not differ substantially from the external environment. Consequently, any environmental conditions, such as frost or damp with related organic growth, which might be damaging, will not necessarily be eliminated within such enclosure buildings.

A common problem for ruins enclosed within shelters is rising damp and associated organic growth and soluble salt migration. Groundwater is drawn through the fabric to drying surfaces, wall faces and floors, and signs of moisture movement, often with associated deterioration, manifest themselves, which can be particularly disfiguring and potentially damaging for decorative surfaces such as plaster and mosaics. Surfaces typically appear green or dark (black) from organic growth, which can include fungi, commonly known as moulds. Wetting and drying and salt crystallisation can adversely affect stone, lime plaster and brick, resulting in friable and weakened surfaces. Figures 5.32 and 5.33 illustrate this situation. In this case Roman remains have been protected under an ad hoc shelter, intended to be temporary, at a site where groundwater levels and other environmental factors contribute to ongoing decay of masonry surfaces.

The enclosure building over the remains of the north wing of Fishbourne Roman Palace in West Sussex was built in parallel with the later stages of excavations in the late 1960s.[35] Problems with groundwater and the condition of the mosaics prompted lifting and relaying of some mosaics at that early stage; others were lifted and relaid subsequently on impervious membranes in the 1980s. Current modernisation of the 1960s structure, of timber, aluminium and glass, is being carried out as part of a wider programme of upgrading of interpretation facilities at the site, supported by the Heritage Lottery Fund. Work to the enclosure building includes improvements to lighting and internal

Figure 5.28 *Interior of the new enclosure at Ephesus, with translucent roof and wall cover (photograph courtesy of the Austrian Archaeological Institute).*

walkways, and the installation of double glazing and an external colonnade to reduce solar gain through the south elevation.

The example of Fishbourne illustrates the general point that, where high groundwater levels are a particular problem, construction of an enclosure building will not in itself resolve this situation. Experience at other sites of a similar type in England, at Chedworth, Bignor and Brading Roman villas, proves the same point. Staining and organic growth are visible on some mosaic pavements and wall surfaces at Chedworth Roman villa, and monitoring of external and internal conditions is ongoing.[36] At Brading Roman villa on the Isle of Wight groundwater levels, coupled with heavy rainfall, resulted in flooding of the site twice in the 1990s and progressive deterioration of the mosaics occurred under a corrugated iron cover building. Extensive survey and recording work, including the use of ground penetrating radar, led to the decision to install a drainage trench to prevent

Figure 5.29 *View of the tent-like shelter structure over tile pavement at Cleeve Abbey (photograph: J. Ashurst).*

Figure 5.30 *Internal view within the shelter at Cleeve Abbey (photograph: J. Ashurst).*

Figure 5.31 *The recent protective building over the west range of the Roman Town House in Dorchester (photograph: C. Woolfitt).*

Figure 5.32 *Temporary shelter over Roman remains situated in a natural depression in the landscape (photograph: C. Woolfitt).*

Figure 5.33 *Detail of typical condition of masonry remains within the shelter shown in Figure 5.32, with damp conditions, deteriorating and friable surfaces supporting organic growth (photograph: C. Woolfitt).*

recurrence of flooding and alteration to the cover building's rainwater disposal system, as well as to phased conservation work.[37] However, a new enclosure building and interpretation centre has since been built at Brading, with the support of the Heritage Lottery Fund; the building is mainly of timber, with a 'green' roof. The visual impact of the Brading cover building is more 'architectural' than, for example, that of the recent cover building at Ephesus, and the artificially lit interior at Brading contrasts with the naturally lit interiors created where translucent covers, for example of tensile membranes, are used. An aim of the design at Brading was, however, to avoid the thermal fluctuations caused by natural light.

Design briefs, environmental and other considerations

A design brief or performance specification for architects, structural engineers and others who will be responsible for the final design of the structure is essential, to guide the design process and achieve the objectives established by initial site assessment and survey. This should set out the significance, context, essential history and archaeology of the site in summary form, with reference to more detailed documentation. The brief should relate the essential values and significance of the site and stress how these must underpin the shelter or enclosure design. It should set out which elements of the site are vulnerable and the particular environmental factors that play a key role in the deterioration of the site as a whole and in its various constituent parts.

The planning process can be broken down into several parts and there may be more, depending on the nature of the site:

1. *Condition assessment and survey*. Survey and investigation of the nature of the ruined fabric. This subject is addressed in detail in Chapter 3.
2. *Environmental assessment and investigation*. Collection of data regarding all aspects of the site's environment. Condition survey and environmental

Figure 5.34 *General view of the south elevation of the enclosure building at Fishbourne Roman Palace, in the process of modernisation and upgrading (photograph: C. Woolfitt).*

assessment are often carried out in tandem. Monitoring may be necessary and may include some or all of the factors outlined below. To obtain a complete picture of an environment, monitoring should take place over a long period and durations of more than a year are typical so that seasonal variations can be determined. The large amounts of data gathered require interpretation and study to yield meaningful results that can be used to inform conservation proposals. Translating the results of monitoring into practical measures is perhaps the most challenging aspect of the process.

3 *Options appraisal*. Appraisal of potential/preventive measures, where the full range of options is to be considered: reburial, remedial work (whether reinstatement or consolidation), or protective structures. The impact of each on the ruin must be anticipated in advance.

4 *Building function*. As well as functioning to protect sites, large structures must also sometimes accommodate large numbers of visitors and function in some cases as a visitor centre and kind of site museum. Interpretation, access and circulation of visitors need to be considered.

Although environmental control and monitoring are not addressed in detail in this chapter, the following environmental factors are important in the context of designing protective enclosures and shelters:

- *Rainfall*. Both annual averages and seasonal variations need to be considered. Whilst rainfall in arid or desert climates is rare, it can have catastrophic consequences, since it often occurs without warning and in large quantities. Rainwater management and disposal and potential impact on masonry remains are considerations. Some materials are

Figure 5.35 *Detail within the enclosure building at Fishbourne, with groundwater ponding on the mosaic surface and causing staining (photograph: C. Woolfitt).*

inherently more vulnerable to the action of rainwater and wetting and drying cycles than others. Earth mortars and plasters are, for example, more vulnerable than those based on lime, with high-calcium lime mortars in turn more vulnerable than hydraulic limes.

- *Rainwater management.* Condition survey should include study of the pattern of rainwater run-off: the way rainwater is shed from the ruin, saturation points and collection/ponding areas and vulnerability of these, and potential for improvement by protective measures. Understanding of existing patterns of rainwater run-off may help guide design of a shelter or other protective measures.
- *Temperature.* Thermal fluctuations need to be considered. Both air temperatures and surface temperatures may be significant, depending on the nature of the remains and the site. Extremes of temperature can be problematic, causing, for example, localised greenhouse effects in enclosed, unventilated environments subject to direct sun and frost damage to porous materials, with characteristic shattering and spalling of surfaces, in conditions of high moisture content and low temperature. Internal environments can, in theory, be controlled by heating and ventilation systems, but the practicalities of introducing such systems with radiators, fans and associated pipes and other fittings may be prohibitive, not least in terms of cost. This is sometimes achievable for ruins in the context of urban redevelopments, which are contained within new buildings and in rare cases isolated from the ground.
- *Wind.* This relates to the provision of ventilation and, at exposed sites, can contribute to erosion of surfaces. Wind loading is obviously an important consideration in the design of shelters at exposed sites.

- *Light*. The source of light needs to be considered. In general, it is easier to design shelters that make use of natural light. The popularity of membrane covers for shelters is due in part to their ability to transmit some light, obviating the need to introduce artificial light. The orientation of any proposed building relative to incident sunlight may be an important consideration.
- *Ventilation*. Lack of ventilation within an enclosed structure can result in undesirable effects, especially in combination with transparent covers, which transmit direct sunlight.
- *Relative humidity* is a function of temperature and moisture content in the air. Unless environmental controls are introduced, the internal relative humidity of a protective enclosure normally closely follows that of the exterior. In situations where enclosed ruined remains have elevated moisture contents, however, the internal relative humidity could potentially be higher. In certain conditions (at dew point) condensation will occur, with adverse effects on surfaces in some cases.
- *Local flora and fauna*. The nature of any flora and fauna that have colonised the ruins, and their impact. Burrowing animals, which could potentially pose a problem in the UK, include rats, badgers, moles, rabbits and foxes.[38] Birds may nest on ruins and their droppings (guano) cause soiling and contamination of surfaces, as well as containing seeds that can grow on ruins. Feral pigeons are typically a problem in urban areas, where ruins standing to some height provide ideal nesting and perching places. They pose a health hazard to people in addition to other problems, and enclosure of ruins colonised by pigeons will require measures to exclude their access; openings may need to be screened.
- *Site topography, geology and hydrology*. The nature of the local geology, composition of soil and underlying strata is important in understanding how water is absorbed into the building fabric, particularly at sites where groundwater levels are high and rising damp plays a significant role in deterioration.
- *Salts*. These may be present as part of original fabric or introduced from the local environment, by rising damp or carried by wind and rain. Sulphate skins or crust will often develop on the surfaces of limestones and lime mortar in polluted environments, through the conversion of calcium carbonate to calcium sulphate. Sulphates are common in the surfaces of other materials as contamination or soiling deposited in polluted environments.

Other factors to be considered are:

- *Visual impact*. The impact of a new structure on the site must be considered. It is impossible for a new structure in a ruined context to have no visual impact. As far as possible, however, the new structure should be subservient to the ruin.
- *Security*. Is there a risk of vandalism and can the structure be made secure against intruders?
- *Reversibility* is always desirable, but is rarely completely achievable when erecting large structures over ruined sites, where foundations, however minimal, are a necessity.
- *Wide consultation and publication*. This will ensure that those who have an interest in the site, at whatever level, as local residents or as specialists in the field, can contribute or at least be informed of the process of developing schemes for sites. Information can be made widely available on the Internet. A good example is the current proposal to build shelters over the Hagar Qim and Mnajdra Temples on Malta, details of which have been made available online.[39]
- *Materials and design of proposed structure*. As discussed briefly above, selection of materials and design has an influence on the internal environment.
- *Foundations for structure*. The issue of minimising impact on the ruined structures and archaeological deposits has been addressed above.
- *Vulnerability of original ruins*. Survey and assessment of fabric is covered in more detail in Chapter 3, but this point is repeated here to reinforce the importance of understanding the materials which comprise the ruined fabric. An understanding of the vulnerability of the ruin as a whole and of its constituent parts is essential. It is often sufficient to characterise materials such as stone and mortar by visual examination and comparison to reference samples, although recourse to analysis (petrographic/microscopical or chemical) may be necessary.
- *Cost and sustainability*. Budgets for schemes to protect sites are often very limited. Design should aim for maximum cost-effectiveness and durability, although some elements, such as roof covers, may have a shorter life and require renewal.
- *Evaluation*. Ongoing evaluation of performance and condition is important for understanding the effectiveness of protective structures in varying conditions. Recent research by the Getty Conservation Institute has emphasised this point and entailed some practical testing of the efficacy of an experimental hexashelter, using control samples located both inside and outside the shelter.[40]

- *Organic growth*. The potential for organic growth, on a micro and macro scale within the shelter, should be considered. Enclosure or shelter of a ruin will not necessarily prevent the growth of either. Provided the essentials for such growth (water, light, suitable food/growing medium) are present, organic growth is likely to persist and will, in some cases, need to be managed.

Ruins sheltered within other buildings

In the context of urban site redevelopment, the enclosure and *in situ* conservation of ruins within other buildings has sometimes been unavoidable. The following is a small selection of examples:

- An early and prominent example is the Roman bath complex in Bath, where the Great Bath is the focal point of the nineteenth century redevelopment.
- The London amphitheatre within the Guildhall Art Gallery, discussed above under 'Reburial'.
- Sections of the Roman city walls in the City of London.
- 50–54 High Street, Guildford – remains of an early medieval chamber, now located in the basement of a bookshop.
- The fourteenth century Charnel House at Spitalfields, London.
- Billingsgate Roman Bath House in London.

Environmental problems in these contexts often relate to high groundwater levels, high moisture content in the ruins, and associated problems of mobilisation of soluble salts and organic growth on surfaces. Other problems are visual and interpretive. It is often difficult to provide an adequate setting for ruins due to constraints of space and construction within a new building superimposed over the ruins. Views of the ruins are often obscured by new structures, making it difficult to appreciate their plan and form.

Survey work and appraisal of protective options

Although the subject of survey and options appraisal has been left to the end of the chapter, it should be one of the first steps in the development of any proposals for preventive conservation. Survey and site assessment are the essential foundations of any scheme for medium- to long-term protective measures, without which the whole edifice of the planned intervention is likely to founder.[41] There are inherent and subtle distinctions between condition survey work in the context of protective measures of the kind discussed in this chapter and survey of ruins generally, as addressed in Chapter 3. Both address the condition of the fabric, but survey for the purposes of protective measures must be, in some respects, wider in scope. It must extend to an appraisal of potential protective options, anticipating the physical impact each optional approach would have on the ruined fabric.

Inadequate or incomplete survey work leading to ill-advised schemes of preventive or other conservation work will manifest itself eventually, often in later, unforeseen need for additional maintenance or repair work and associated costs. Although survey may highlight as many potential risks and problems as benefits of a proposed scheme of preventive conservation, at least these can then be addressed, and maintenance and monitoring regimes designed to cope with anticipated problems.

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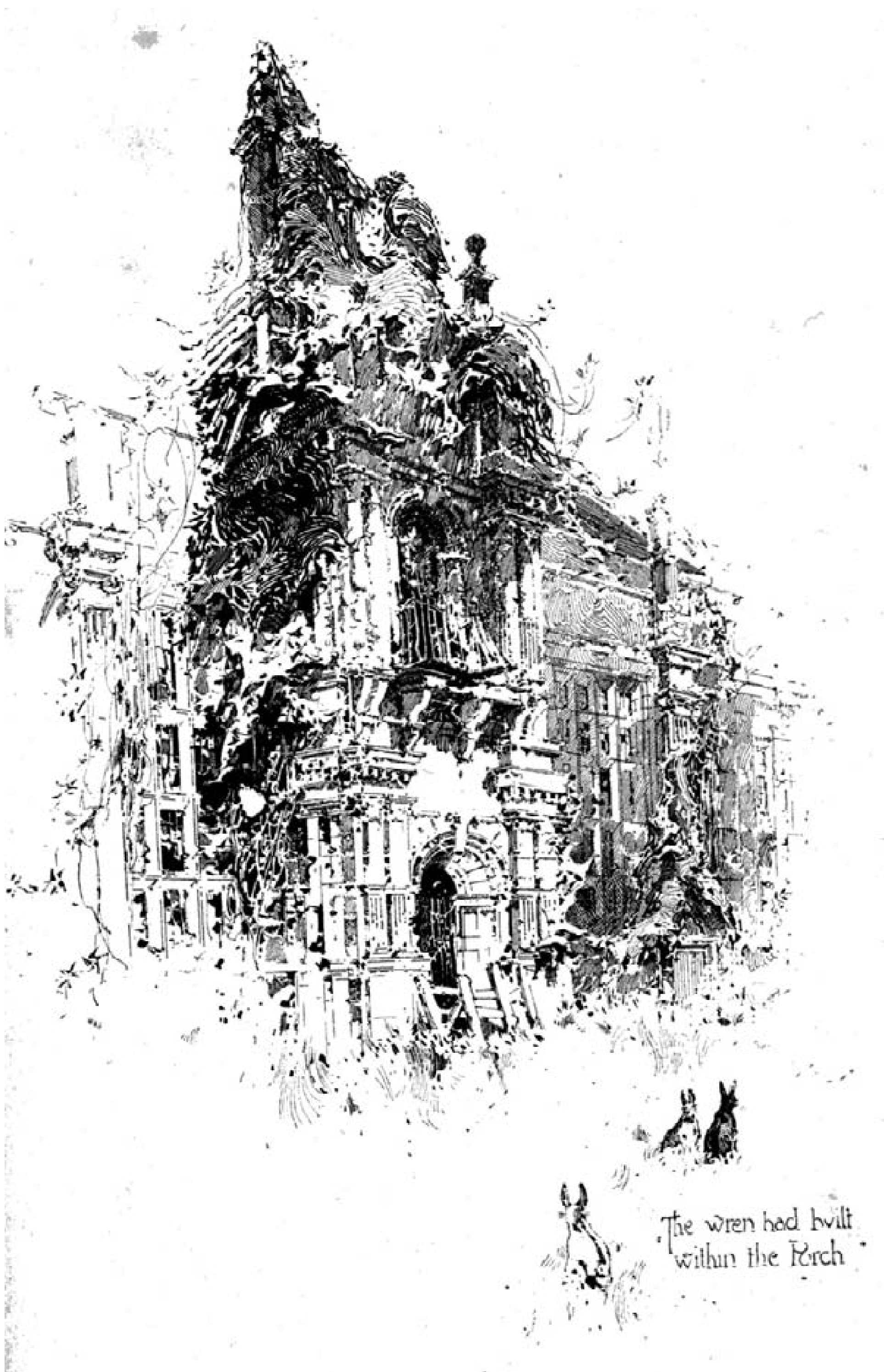


Herbert Railton's (1857–1910) illustration of Thomas Hood's 'The Haunted House' (Lawrence and Buller, 1896) captures almost better than any photograph the reversion of a building in a ruinous condition to a natural site (reproduced with permission from Blackburn Museum).

Chapter 6

The ecology of ruin sites

Sara Ferraby

… and thorns shall come up in its fortified towers, nettles and thistles in its fortified cities; it shall also be a haunt of jackals and an abode of ostriches and the desert creatures shall meet with the wolves, the long-haired goat also shall cry to its kind; … the night monster shall settle there and shall find for herself a resting place. The tree snake shall make its nest and lay eggs there and it will hatch and gather them under its protection … the hawks shall be gathered there, every one with its kind…

(Isaiah 34, v. 13–15, *c.* 700 BC)

'Ecology' is invented to convey the idea of the study of animals and plants in relation to their habit and habitats … we take, then, this word from the Greek ('oikos' – home and 'logos' – science) to mean 'the study of the household of nature'.

(Paul Colinvaux, *Introduction to Ecology*, John Wiley, USA/Canada, 1973)

Introduction

Unchallenged, the natural world soon asserts control over the works of humankind. No longer buildings, not yet wholly a natural landscape, ruins provide a specialised environment which plays host to a wide range of flora and fauna. In most cases this is a straightforward matter of the local populations moving back in, processes familiar to all who have observed a neglected demolition site, but in others the particular combinations of stones, bricks and mortar and the ways in which masonry may decay and collapse attract plants and other wildlife not previously indigenous to the locality.

Ruins which are remote and have little contact with visitors and little or no maintenance revert surprisingly quickly to a natural and untamed state, and may become sites with a diverse ecology of considerable interest. In the processes of survey, recording, excavating, stabilising and conserving, it is easy to ignore the importance of the site's natural assets and to overlook the need to protect its natural environment. In the early decades of interest in the conservation of ruins, one of the greatest problems was the extensive ground and wall cover, and a practice of total clearance of vegetation was established with the object of providing a formal, park-like setting for the ruin in its place. In the UK, considerable research and site trials were directed towards achieving long-term control of organic growth on historic walls (Figure 6.1), an objective which is now seen to be very much at odds with the interest in ruin site ecology.

Any practical and professional approach must consider an action plan for the analysis of the site's ecology, its structural stability, masonry consolidation, fabric conservation and long-term management of the complete site, without affecting its ecology and inherent 'romantic' quality. To this end it is necessary to identify the professional skills required and to engage suitably experienced professional advisers, skilled craftsmen and operatives to work in collaboration to achieve the desired outcomes of the conservation project and promote the longevity of the site as found and the continuity of its natural life.

Detailed survey, investigations, site trials and the installation of exemplars are necessary means by which all aspects of the site are fully understood, risk mitigated and the most appropriate repair conservation methods specified. Such understanding will be further developed through discussion and debate with all individuals involved in a design team, contractor team and through consultation with the appropriate statutory authorities, local groups and amenity societies, where these exist.

Figure 6.1 *Biocide trials at Tintern Abbey in 1972, carried out by the Ancient Monuments Division and the Building Research Station. The objective was to compare different treatments against untreated controls, to identify the most effective and persistent materials to keep wall tops free of organic growth.*

Ecology and making safe

Ruins are 'unsafe' places. Even following full consolidation they usually retain some potentially dangerous elements, but in the case of virgin or long neglected sites the hazards may be considerable and not always easy to identify, especially where there is extensive vegetation cover and large areas of fallen masonry. Endeavouring to make the site safe for the initial surveys which need to be carried out is fraught with challenges, but is a very important preliminary to detailed investigation work. The measures involved are likely to include setting up secure perimeter fencing around the site with warning signage and alarms, access controls, temporary propping and netting, and sometimes limited areas of access scaffolding. In most cases this work will need to be carried out in consultation with relevant statutory authorities and can form part of a preliminary site set-up and 'enabling works' programme. These works should be factored into the early cost exercises.

Although no works or close examination other than these preliminary ones should be carried out at these early stages, the conservation team, including its ecologist, should have the opportunity to visit the site as soon as possible and make first-stage assessments.

The first danger to the ruin and its site is often at the preliminary site investigation stage. For example, because thick surface growth may obscure the wall surfaces, severely inhibiting any extensive condition survey or graphic record-making, it is often deemed necessary to remove major plant growth, including that which is well anchored into the masonry. This well-intentioned but ill-informed site clearance can have catastrophic consequences in terms of safety, loss of historic fabric and the ecology of the site. Dangers to masonry of overzealous root removal have been described in Chapter 4. The dangers to species of flora and fauna are emphasised here and in the following chapter on submerged ruins. The aesthetic loss in creating a sterile environment is also considerable. For all

Figure 6.2 *Pevensey Castle and the Marsh; wetlands habitat. The design of conservation works need to be planned in such a way that the natural life of the site is respected and impacts on it are minimised.*

these reasons, virgin or neglected sites must always be the subject of a biological survey to identify all species and to see how they interrelate and integrate with the ruined buildings and the site.

The biological survey

The illustrations of a small selection of diverse sites (Figures 6.2–6.4) serve to emphasise, if emphasis is needed, how important the natural environment is to the character of the ruin site, quite apart from its importance as a habitat for largely hidden species of wildlife. The ecologist is therefore to be welcomed as the newest and essential member of the traditional 'conservation team'. While the primary concern remains the conservation of the fabric and the archaeology of the ruin and its site, this must never exclude the recognition and care of the natural heritage which has been established across its boundaries.

There are inevitable conflicts of interest at times when elements such as leaning walls, decaying tree stumps in masonry and voids in walls which provide ideal habitats for species of flora or fauna constitute threats to stability. Excavation by mammals such as rabbits, foxes or badgers (a protected species in the UK) may add to the dangers and are always potentially destructive to archaeology.

The biological survey needs to identify and assess the significance of the species present on the site, and to make recommendations on what can safely be removed and what needs to be retained and protected. The survey obviously needs to be carried out by a suitably qualified experienced individual (the ecologist), who should remain as an advisory member of the conservation team throughout a programme of works and the specification of maintenance regimes. In this way, through regular consultation, there should develop sound and practical implementation of proposals for holistic conservation of the site.

In practical terms the biological survey will provide detailed information on all species identified on site, and on prior inhabitation; it is essential to the preparation of contract documentation and information for conservation works and for long-term management of the site.

Effective planning and programming, the basis of the ecological assessment, will mitigate risk of delay once work has commenced on site. Stoppages and delays will be minimised as far as possible by the identification of certain species at survey stage. For instance, respect of breeding seasons will avoid having

Figure 6.3 *Biodiversity at Butrint, Albania. A balance has to be found between the lush flora, the natural habitat and/or food of insects, snails and reptiles, and the survey, recording and conservation of the ruins.*

to make special provisions to encourage species to return to the site on completion of works.

Early meeting on site between the ecologist and architect or surveyor will focus on the nature of masonry and other materials present, and samples of stones, mortar and soil may be taken, for instance, to determine pH conditions affecting the selection of the site by particular species of flora.

A well-colonised site may take up to 80 years to develop. Thus, as with historic fabric, once this is lost or destroyed it is impossible to recreate. Recording of all species and roost sites and sampling of species should also be carried out. Such sampling may ensure that colonies are maintained and traditional local species are cultivated and reintroduced to the site. It should be established, as part of the survey, what damage is being caused to vulnerable masonry and what structural damage is attributed to uncontrolled growth. Protections should be applied to vulnerable carvings, mouldings and details at immediate risk of collapse or loss.

Further specialist advice should also be provided where specific unknown species are found, so that the correct approach to their protection and prolongation is followed. An environmental impact assessment should be produced to identify the impact of proposed repair works on the natural habitats and species, and to determine the extent and effect of removal of, for instance, old trunks or ivy canopies from rubble walling and the disturbance of roost sites. The biological survey will set out the significance and provenance of each species and the risks of undertaking works on their future.

The biological survey will sometimes extend beyond the 'natural state' of the ruin itself to adjacent and associated gardens, park or woodland. Any major proposals such as the reculturing of historic planting schemes and the removal of inappropriate species will also need to be the subject of environmental impact assessment.

Treatment of flora

Historic sites with ruins are often of particular ecological interest, because heavily weathered stones and mortars and the common exposures of large areas of lime-rich core provide particularly suitable

Figure 6.4 *Early spring flowers at Beth Shean, Israel, thriving on previously excavated ground, are important to the biodiversity of the site and need monitoring and protection.*

environments for a wide variety of plants (Figures 6.5 and 6.6). The archaeology of the stones may have an unusual bearing on plant colonies when, for instance, siliceous stones are transported to sites in limestone regions and become host to lichens and other plants not native to the region. Similarly, sandstone copings on brick or limestone walls may support species distinctly different from each other. Walls, generally, are not hospitable to many plants because of the lack of soil and water, sometimes coupled with extreme exposures, but these unpromising conditions sometimes lead to the development of a specialised flora which can withstand long periods without water and extremes of temperature. Vertical surfaces, in particular, may sometimes support particularly interesting plants.

Weathered surfaces, wall tops, ledges and soft joints provide an ideal environment for a variety of vegetation, mosses and lichens. Different species will occur in each wall zone according to local climatic

Figure 6.5 *Plants thriving on the lime core and sloping surfaces of collapsed walls at Butrint, Albania. On such an extensive site, zones such as these may be left in their 'natural' condition without loss or detriment to the monument.*

Figure 6.6 *Wall cover at Jervaulx Abbey, UK, including wild roses, is an undeniable asset to the site, but needs to be controlled to allow adequate stabilisation and masonry maintenance to be carried out.*

conditions and microclimate, water run-off, sunlight, pore structures, alkalinity and acidity. The mild, wet climate is a major factor for the rich diversity of wildlife found on UK sites, but this situation may well alter with climate changes, with fewer colonies inhabiting sites and perhaps some species dying out, so it is even more important that the existing flora is recorded and retained.

Many types of plants are prevalent in masonry walls of traditional construction as their root stems penetrate through the soft mortar seeking the voids within the core and the nutrients inherent in the alkaline or acidic conditions of the masonry substrate. Changes in patterns of colonization occurred from the late 1800s following the introduction of Portland cement to the construction industry, which resulted in fewer soft, lime-rich mortars. Hence, virgin ruin sites often provide ideal environments for a variety of lime-loving traditional species of plants, ferns, mosses and lichens. Flora reflects local conditions and species with a variety of garden, aquatic, wetland and marine species occurring according to the location of the site and method of seed dispersal.

Woody growth and roots affect the stability of the structure and must be assessed prior to removal. Assessment should consider the importance and significance of the growth, its maturity and age, as well as considering the impact of its removal upon the structure. Removal of woody specimens may cause the collapse and loss of historic fabric where embedded in the structure or where roots are earth-bound; removal could cause settlement or dislocation of masonry walls. Assessment may require localised 'opening up' to determine the extent of root growth, supporting openings and shoring of overhangs, either as a temporary measure during investigations and repair and as a permanent management solution using anchors, ties and grout–stitch–pin consolidation techniques (see Chapter 4).

The common sight of ivy-clad ruins presents a problem in assessing condition of the stonework beneath and, by removal of luxuriant cover, the character of the ruin will be jeopardised. It is necessary to remove the damaging major woody stems where possible by cutting back to the main trunk and removing the minor stems carefully by hand. Larger roots should be left *in situ* where their removal would cause too much damage. Common ivy and other climbers and creepers which can cause damage to soft masonry should be carefully removed or controlled. However, it is likely that these heavy ivy mantles can also provide protection for the vulnerable masonry from accelerated weathering, processes of decay and frost damage, as well as wildlife habitats, so some retention should be considered as part of the biological assessment and long-term management of the site.

Pesticides and herbicides should only be used as a last resort for removing plants and only after specialist advice is sought. Due to the tough stems of some plants, such as rhododendron and buddleia, chemical treatments are often used, as manual removal could cause more damage to the masonry fabric. Chemical control methods should only be undertaken following biological survey and, once the species are known, should be restricted to use on species of little botanical interest or which are likely to cause damage. The use of pesticides should be controlled and appropriate measures taken for the control of run-off or errant spray so that it does not come into contact with other species or watercourses.

Nature can sometimes be harnessed to protect ancient sites. For instance, a more benign form of the Roman use of quickset thorn hedges in defensive ditches can be utilised in a 'natural ruin' to increase security, with brambles, blackthorn and nettles being introduced to provide 'soft' security of remote sites. Mature planting of this kind can be very effective against illegal access and vandalism, as opposed to having harsh 'hard' security measures surrounding the site, such as perimeter fencing, warning notices and steel gates.

Treatment of fauna*

The biological survey, thoroughly carried out, will reveal a great deal of information about the current and past occupancies of a ruin site from occurrences

* There is an increasing awareness of the importance of the environment to wildlife fauna as effects of climate change are becoming more widely known. For instance, the plight of polar bears and seals associated with the loss of sea ice as the northern ice cover retreats is well publicised and of national concern, but there are many other threats to the planet's animals and not only those which were, or are, being hunted to extinction, but those for whom there is simply no more room. 'The bigger the animals, the more conflicts there are with humans over territory. There are just too many people,' the Israeli INNP has said of the limited return of leopards of the Judean desert. Visitors and leopards are not often in direct contact, but the visitors scare away natural food sources such as ibex and rabbits. Although there are few ruin sites in polar bear territory and many in the leopards', the point is that successful survival is always a delicate balance and there are always competitive elements, even when the context is shrunk, as now, to the microcosm of the single site. Here, too, complex societies, almost unnoticed, can experience crises or face local extinction through ignorant intervention. Ed.

and patterns of guano, droppings, skeletal remains, excavations from burrows, shed skins, hair and feathers. The presence of protected species will almost certainly restrict works at certain periods and exclusion from some zones of the site, requiring careful planning. For instance, English Nature recommends a buffer zone between the entrance to badger sets and building activities, suggesting that light machinery should not be used closer than 20 metres to the entrances and that heavy machinery should only be used at distances exceeding 30 metres. The intrusion of the conservation team's work and manner in which it is carried out should not be allowed to put any protected species at risk. Survival of species can either be threatened or enhanced by informed and careful treatment.

In the UK, all birds are protected during the nesting season. English Nature encourages vegetation management outside the bird breeding season (February to July), and woodland and shrubland management between October and February. The avoidance of nesting and roosting periods often presents a conflict with repair needs since these generally fall in summer, when conditions are favourable to conservation works using traditional materials such as lime putty-based mortar. However, such works can also be managed in winter periods, with appropriate solutions such as heating and double sheeting to scaffolds, hessian protections and the like, and care of newly placed mortars to ensure they are not significantly affected by cold and damp conditions.

It is also possible that, following consultation with the relevant Statutory Nature Conservation Organisations (SNCOs), some minor non-disruptive survey works or enabling works and site set-up can be undertaken during these periods if they are of no detriment or risk to the wildlife.

Information from the biological survey is vital in the preparation and discussion of applications for statutory consents and relevant nature conservation consents. In general, statutory bodies are fully aware of the implications of delay to project works and will advise the best method of resolving delays caused by the presence or unexpected appearance of certain species on site and assist with the appropriate removal or control techniques. They will also advise, in collaboration with the project ecologist and design team, on habitat creation and risk control whilst maintaining the site in a natural but managed state.

Without the commissioning of a biological survey, the discovery of the presence of bats is a common cause for delays in conservation work. In the UK there are 16 species and all are protected, as are their roost sites, and works must be halted as soon as they are identified; works should also be avoided during the roosting and breeding season, which generally occurs during May to September. Once bats are identified it is necessary to halt any works and to consult a specialist organisation or SNCO such as English Nature (EN), so that their presence can be recorded by an officer of EN and they can be temporarily removed from the site during the works if necessary. Once works are complete, they can be reintroduced onto the site as long as the conditions are maintained for their inhabitation (Figure 6.7).

In fact, conditions can often be enhanced by the project works, by the provision of nesting boxes for birds of prey, such as owls, bat boxes and unobstructed flight paths as part of the works contract and exclusion of the public from certain vulnerable areas of the site.

Another situation which sometimes needs to be addressed and resolved is the presence on site of burrowing animals such as moles, rabbits and badgers (Figure 6.9). These creatures create voids underground in the development of their habitats, and these indiscriminately excavated voids can cause the undermining, settlement and partial collapse of masonry walls and destruction of earthworks. Selective soil grouting of rabbit warrens in earthworks, once the population has moved out, is a stabilising conservation technique which is sometimes useful and appropriate. Badgers are a protected species under the provisions of the Wildlife Act 1981 and the Protection of Badgers Act, but these burrowing animals can be humanely controlled under the guidance of the SNCO. Their existence should be encouraged as they are rare and beautiful creatures which are now under the added threat of culling due to a disputed risk of their transmitting tuberculosis to cattle. Conditions can generally be improved via the works for the animals and fauna, and built into the ongoing management policy for the site.

Voided walls and weathered surfaces provide ideal basking places and refuges for a variety of animals, insects and reptiles. Their presence on site will be identified in the biological survey and if possible the deep-tamping and filling of voids to masonry walls should be minimised or avoided to ensure these habitats are maintained. At the very least the voids should be inspected as far as possible prior to filling or consolidation to ensure that the animals are not trapped within. A high concentration of guano from bats and birds can be of detriment to the building fabric as the acid content can accelerate decay and deterioration of the masonry surfaces. This can be mitigated by the

Figure 6.7 *The late fifteenth/early sixteenth century brick precinct wall of a monastery, with its moat, now generally dry but seasonally wet, showing settlement fractures with brick underpins, mortar deterioration and luxuriant ivy growth. The wall is host to bats and masonry bees, sometimes to owls, and frogs, slow worms and newts are sometime inhabitants of the moat. The Conservation Management Plan includes recommendations for the management and maintenance of the site which must embrace and balance the preservation needs of the historic fabric and the needs of the natural inhabitants and their environment.*

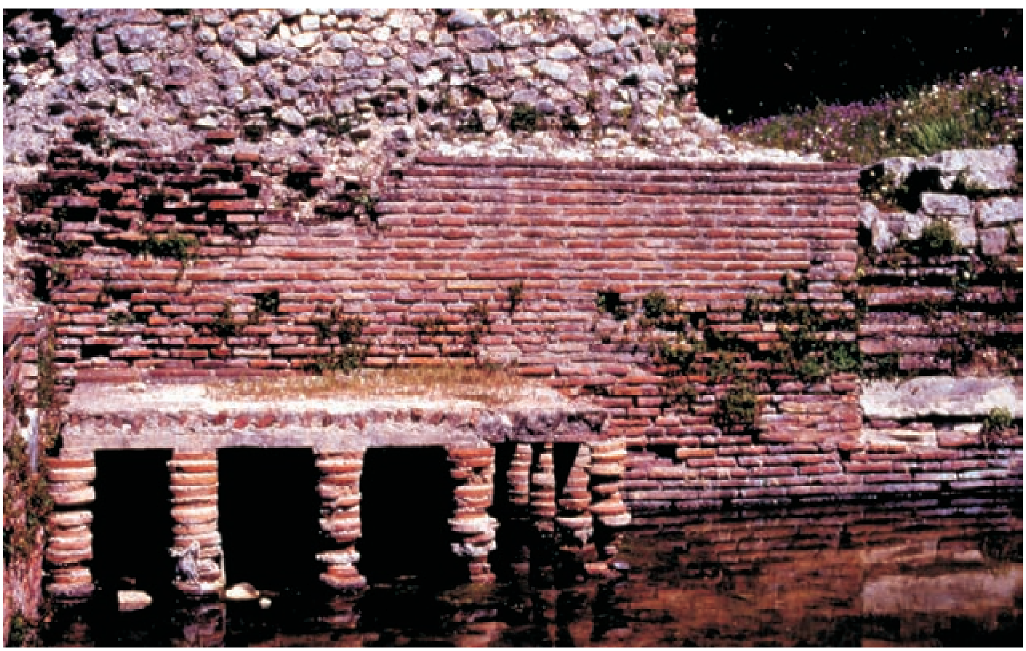


Figure 6.8 *Flooded area of hypocaust, Butrint, now home to terrapins, requires draining if soluble salt damage to pilae is to be addressed. Alternative flooded zones with less sensitive fabric can be used for relocation.*

Figure 6.9 *Underground engineering works by one of the UK's protected species, the badger, can become a problem for buildings and earthworks.*

introduction of timber guards or baffles to protect the masonry under the areas of congregation and by the provision of fine mesh to mouldings and carvings to prevent damage.

As part of the habitat creation and long-term ecological management of the site, provisions can be introduced such as piles of dead and decaying wood; composting and bare soil provide habitats and refuges for a variety of species.

Treatment of wall tops

Wall tops often support coarse grasses, mosses and woody weed growth, mainly of local species which have formed an organic mat over the years. Traditionally, it was common to remove all traces of this natural 'soft capping' and replace it with a hard capping of mortar following consolidation and repair of the masonry to parapet walls and sky-facing surfaces (Figure 6.10).

A more modern approach following the survey and prior to the masonry repairs is to carefully take up any existing natural growth covering the wall tops, to expose the condition of the wall below, extent of root growth and damage to the substrate. The precise locations of any planting should be recorded and the turf or planting should be retained on site in appropriate conditions to keep it alive, for later re-instatement.

The masonry from where the turf or planting is removed should be carefully recorded with photography and photogrammetry, if funds allow, in addition to sketches and textual descriptions. Any stone falls should be recorded and retained on site for replacement during the repair works, and any loose or unstable masonry should be taken down to sound masonry and the wall top rebuilt. Damaging main root sections should be cut out and removed where possible or poisoned and left *in situ* to avoid major disturbance to the structure (see Chapter 4).

Following consolidation and rebuilding of the original profiles, the ecologist should be able to make recommendations on installing soft capping of

Figure 6.10 *Wall tops at Tintern Abbey showing formation of grass and bryophytes in the foreground and biocide-treated surfaces beyond.*

the wall tops, including existing 'natural', local and contrived species. The contrived species are those which are newly introduced to the site but may be types which previously flourished. It is prudent to take seed samples from any existing specimens when they are removed prior to repair works and are intended to be reinstated within the wall top. This ensures that the seeds can be germinated either off site or in suitable conditions on site and existing species can be cultivated for these and other locations.

Following consolidation and surface repair, the wall tops can be covered with a separating membrane of geotextile to prevent the migration of fines from the soil layer, which in turn is covered with turf or the salvage root mat if possible. The turf will contain the

Figure 6.11 *Site clearance and maintenance by grazing-1. Goats were brought onto the site of Fort Southwick above Portsmouth on the Portsdown Hill to reduce the thick cover of brambles and buddleia growing above the precipitous walls of the dry moat.*

Figure 6.12 *Site clearance and maintenance by grazing-2. Sheep grazing the site of Henry II's palace of Clarendon above Salisbury, were introduced to exercise some control of low level vegetation growing on and over low lying, partly excavated masonry remains on the site.*

new seedlings, seeds and any salvaged species retained on site for replanting.

Procurement options

At planning stage, an appraisal of all feasible options will have to be considered according to phasing of the works in terms of priority, limitations of the site and funding available. All options for phasing the works will have to be costed so that the best approach can be undertaken within the given constraints of cost, quality and time, and to ensure that the ecological impact has been adequately considered and assessed in undertaking the options appraisal.

So that expensive preliminaries and site costs are not incurred when site activity is limited by decision-making, exploratory trials and during breeding seasons, it may be possible that several minor works or direct works packages can be set up to undertake the necessary enabling works. Enabling works packages could include provision or improvement of site access roads to enable contractors' vehicles to get to the site, direct procurement of site accommodation and safety elements such as temporary supports. Some of the initial site clearance could be carried out, if properly supervised, under a minor works contract to reduce main contractor overheads and avoid taking valuable funds away from the repair works.

Minor works contracts could also be used for the procurement of site trials and exemplars, undertaken by a suitably skilled conservation contractor and in reducing the length of the main contract period. Trials and exemplars, such as for tamping, pointing and soft capping, are also needed well in advance of the tender to develop and fine-tune the specification, and provide valuable quality, cost and programme information.

Competitive bids for the main contract should only be invited from suitably skilled craftsmen and contractors with previous experience in similar sites and of building ruins. Unless these are known from previous projects or trusted word of mouth, references and examples of work should be sought and, if necessary, interviews should be conducted with short-listed companies at which the site foreman should be in attendance so the contractor can demonstrate the ability to undertake the works (see Chapter 8).

Pre-tender site visits should be arranged, accompanied, so that the contractor is aware of the complexities of the site, which may be considerable. Because everything is seen and questions can be asked, these visits significantly reduce the risk of the contractor misunderstanding the scope and quality of works required. In the context of this chapter it is essential that the contracting team is fully aware of the ecological sensitivity of the site and understands the reasons for respecting it and its implications.

Risk can be further mitigated by the careful and complete preparation of preliminaries and contract documentation illustrating the site constraints, restrictions and implications of the work on the surrounding landscape and ecological system. A 'tight', well-defined specification and drawings will ensure that the work is carried out correctly and in the first instance is priced correctly so there are no surprises on site; any unknowns can be included as provisional sums items. Any time periods for attendances by members of the design team and statutory authorities should also be built in for programming and pricing purposes.

The importance of effective site supervision by a competent site foreman, who fully understands the requirements of the specification, the complexities of the site and its constraints, and is knowledgeable enough to stop work if new factors are discovered, cannot be overemphasised. The contractor and foreman must be able to work in full cooperation with the professional team and other contractors on site, including liaison with directly procured contractors.

According to the duration of the contract, regular site progress meetings should be held with the contractor and the design team, including the ecologist, where appropriate and necessary. Regular site visits by the lead consultant should also be undertaken to review progress and approve samples and trials, and to instruct the contractor.

The Conservation Management Plan

A Conservation Management Plan should include a detailed description of the site and its significance, assess all issues relevant to its conservation and longevity, and provide a plan for the prioritisation and implementation of these issues. In particular, in the context of this chapter, the plan and any revision to it must consider the biodiversity of the site and its wildlife, as well as the historic fabric; specifically, it must consider how best to protect and enhance these assets, and the ability to which they can sustain change in the future.

It is important that all stakeholders have an input into the contents of the plan as well as the local community. This includes all those professionals and craftspeople involved in the conservation project, statutory authorities, amenity societies, and local residents and 'friends' groups.

The plan is intended to include a survey of the site and its architectural, archaeological and historical significance, the characteristics of the natural environment, any original planting schemes, detail regarding its statutory listing and controls, site restrictions, financial information, and recommendations for the management and maintenance of the site. This will include information on restrictions upon works, such as those due to breeding patterns, and the ongoing monitoring and inspection and how this should best be implemented. The plan should also incorporate the findings and recommendations of the biological survey and assessment, detailing all species identified on the site and the requirements for their ongoing conservation and protection.

The ecology of the site must be incorporated into management considerations within the plan, including procedures for the encouragement of biodiversity and habitat creation, as well as ensuring that existing species are recorded, monitored, retained and preserved. This should also link into local and national policies for ecological control and conservation, and the recommendations of any local Biodiversity Action Plans.

Visitor access

Priorities of the management plan will include the conservation of the cultural heritage, habitat creation and maintenance of existing species and habitats, as well as health, safety and security measures to ensure that visitors to the site enjoy a safe, accessible and secure environment in which to enjoy both its built and natural assets.

There can be a conflict between the longevity and protection of the site and its assets and allowing access by the public (see Chapter 9). With visitors come the inevitable clutter of car parks, cafes, shops, ticket kiosks, litter bins and wayfinding signage, which affects the character and aesthetic of the site and its vistas. However, these sites represent national history and heritage, and there is an obligation to promote them as an educational tool for all members of the community; visitors also provide vital revenue to ensure their ongoing care. To this end, a balance must be struck between the needs of the visitors and those of the site. The site should always remain the priority and it should not be compromised by the visitors' needs or the need for commercial gain.

Following the provisions of the Disability Discrimination Act (DDA), there is also a responsibility placed on the owners of any property to improve access for all, including wheelchair access. There is perceived conflict between the historic and natural environment in implementing the requirements of the DDA, especially in terms of implementing physical changes to enable access. This comprises sufficiently wide openings, ramps, lifts and other such facilities to enable unaided access to the site by wheelchair users and those with physical disabilities. However, there is a test of reasonableness to be applied to this, and the protection of the buildings and their natural setting must remain the priority. This 'conflict' is often mitigated by the provision of web-based virtual reality tours and information sites accessible via heritage centres or tourist information offices that are not required to be on the site itself.

Ongoing management

This outline approach ensures that a detailed record is maintained of the species existing on the site prior to works and also immediately following completion of the works, especially where reintroduction of traditional local species has been implemented on the basis of site findings and local environment and climate. As part of the longer-term management of the site it is essential that this biological survey is a live document updated at regular intervals, such as the quinquennial inspections. This means that ongoing investigation and survey should be carried out in order to maintain a record of all species as a natural conservation record in accordance with the site's Conservation (Management) Plan.

The ongoing management of the site will be a process informed by the ecological survey findings and recommendations. The elements will be included within the Conservation Plan and will include security, structural survey, health and safety issues, ongoing survey and condition inspection to promote the longevity of the site and its ecology. It is not necessarily the case that wildlife will thrive where the site is totally abandoned, so a management procedure is very necessary to ensure the long-term future of the site. Management policy will also comprise site security, access for the public, accessibility, and wayfinding and interpretative signage. Quinquennial fabric condition surveys should be undertaken with findings costed, prioritised and fed back into the maintenance and repair programmes.

In terms of ongoing management and survey of the natural heritage, it is important that inspections are carried out regularly and a vegetation control system is built into the regular maintenance routine, with damaging vegetation removed or selectively controlled. Individual species should be checked for continued breeding and use of the site. This is especially informative and important following the disruption of major repair works, as some species may not return and their numbers must be calculated. Also, where traditional local species have been reintroduced to sites, it is important to record population levels to monitor the success of the project and the ongoing significance of the site as a whole, as well as a benchmark for future projects and national statistics.

But it is important that the ruin site becomes largely self-sufficient. The need for ongoing funding for surveys and inspections following repair works will not be welcomed by clients and funding bodies. The self-sufficient but managed site conserves and promotes its ecology, and establishes and controls access to the site by the public.

An economic and effective management resource may well be the local community groups, volunteers, friends groups and local residents. They may be trained, under strict supervision and by example, to undertake regular inspection, monitoring and restricted control of vegetation and site management following exemplars of the level and extent of any works. While the integrity of the historic and natural heritage must not be jeopardised or compromised by this approach, it can encourage people to take responsibility through a sense of ownership and involvement. Local groups can provide an enormous security benefit and any unusual activities, patterns of loss or other problems can be reported promptly.

Summary

Ruin sites often provide ideal habitats for a diverse wildlife. The presence of many different species is a useful indicator of climate and conditions, and sites which have been largely undisturbed for decades or centuries can provide valuable historical information on past changes. Rare species of flora and fauna may be present, some of which may be protected by law. Ecology helps to identify and understand the natural environment of the ruin, which enhances its cultural and aesthetic value, and helps to plan for its future.

Any approach to conserving the ruin should anticipate and resolve potential conflict between stabilising and conserving the buildings and preserving their natural environment. Understanding and appreciating the value of both before any work plan is finalised and implemented will go a long way to avoiding damaging interventions to either.

The biological survey, carried out by the ecologist, is an essential tool for developing a plan of work in just the same way as structural, archaeological and condition surveys; it should therefore be carried out as part of an integrated approach, and its recommendations incorporated within the works and linked to the current and long-term management of the site.

A word of warning seems appropriate at a time (and there will always be such times) when strained budgets are causing managers to look for all possible savings on maintaining the heritage of ruins. Chapter 9 makes reference to policies described, euphemistically, as ‘managed decline’ and ‘benign neglect’. The growing awareness of an interest in the natural environment can sometimes be exploited by those who need to justify budget cuts on essential maintenance to historic fabric. Such misplaced ideas and abuses masquerading as a ‘return to nature’ should always be challenged. In conclusion, the approach to conserving a ruin and its site must be holistic, encompassing an understanding in its ecological as well as its archaeological, architectural and historical significance. By adopting this approach it is possible for the built and natural heritage to be managed in conjunction, so that the site and its inhabitants can be sustained in harmony.

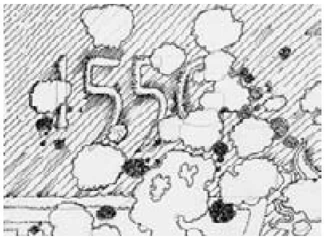
Further reading

Darlington, A. (1981). *Ecology of Walls*, Heinemann Educational Books, London.

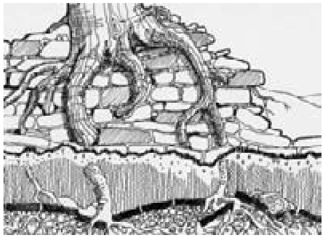
Gilbert, O. (1992). *Rooted in Stone – The Natural Flore of Urban Walls*, Department of Landscape Architecture, Sheffield University, English Nature.

Meech, H. (ed.) (2001). *Wildlife and Buildings, Technical Guidance for Architects, Builders, Building Managers and Other*. National Trust.

Figure 6.13 The ruin site: typical examples of conflicts of interest to be resolved.

Examples	*Description*	*Building conservation*	*Ecological conservation*
SURFACE GROWTH 	Superficial damage by certain species of crustose lichen is caused by acid secretions and growth of cells within stone pores. Some algae and fungi also secrete organic acids, especially oxalic acid. Thin surface scaling, surface bleaching, blistering and erosion pits can occur as a result on limestones, marble and calcareous sandstones, but can also attack silica and cause etching of granite. These conditions cause damage to shallow tooled surfaces, surfaces with small-scale detail and low relief, incised letters, masons marks, polished finishes and plaster. Churchyards and ruin sites often provide ideal habitats.	If damage is taking place to important detail the careful and selective removal of algae, fungi or lichen becomes necessary, using a combination of steam pencil, gentle mechanical processes and biocides. If surfaces are not threatened but joints need to be filled or repairs carried out extreme care needs to be taken to avoid wet lime contact with growth which is to be retained. Any biocide treatment needs to be carefully controlled to avoid run-off onto areas outside the treatment zone and any contamination of water courses. There are cost implications involved in this conservation approach.	Crustose (crust forming), foliose (leafy) and fructose (shrubby) lichens are interesting, attractive and ancient species commonly found on old masonry structures, the most important habitat for saxicolous lichens. Some species are unusual. They are important pollution monitors and useful indicators of the acidity/alkalinity of the substrate. Some can be of considerable age and are objects of scientific study. Species need specialist identification to determine significance and inform approach. Care should be taken to protect them and preserve their habitats, avoiding unnecessary cleaning.
WALL COVER 	Ruin walls provide demanding conditions creating a specialised flora, some rooted in soil at the wall base and some growing on the wall faces and wall heads. Woody weeds such as ivy, buddleia, red valerian and wall flower can cause varying amounts of disruption of masonry, cracking and loosening mortar and jacking and displacing stones and bricks, especially at wall head level and at broken wall ends. Luxuriant canopies of growth and voids within the wall provide habitats for a wide range of wildlife.	The careful removal of wall cover is necessary to ascertain condition, to record the masonry and to schedule repair and conservation works. The subsequent, programmed removal of ivy and other invasive, woody plants is needed to carry out consolidation of the ruin. Even if soft wall capping is adopted it is usually necessary to carefully record and remove mats of vegetation for later reinstallation. Voids within the wall need to be grouted or packed with mortar and open joints to be deep-tamped and pointed.	Wall flora is a distinctive and attractive feature of ruin sites, regionally diverse and indicative of different masonry types, exposures and pollution levels. The recording and preservation of wall colonising species is an important aspect of the site's value and conservation. Wall flora is important to insects such as bees and butterflies. Disruption and removal of dense foliage, often untouched for years, catastrophically disturbs the wildlife it supports and may inhibit or preclude future growth; some insects, reptiles and small mammals may leave the site altogether.

TREES



Many sites were taken over by woodland before becoming subjects of national interest. During centuries of neglect some trees grew on standing or collapsed sections of masonry and their roots moved down to break up floors of lime, tile or mosaic and seek out old water courses. Architectural features within the wall were often obscured or broken up; the effects of wind on high trees further weakened the walls on which they stood and falling trees can demolish substantial sections of masonry.

Major structural and archaeological damage can be caused by mature tree roots growing on or near walls. Above ground the tree has often become integral with the masonry fabric so that its removal is impossible without destroying the wall. Cutting back the tree to the wall face is the only way to prevent further growth and destruction by penetration and leverage, after which it must be maintained in its reduced condition. Growth control methods on mature trees on archaeologically sensitive areas such as pollarding are necessary to reduce root growth and are part of the ongoing site management.

The loss of woodland, especially ancient woodland, is always to be resisted, and if essential for archaeology or consolidation must be limited in scale and scope, exclude some particular species and be planned for the right time of year to cause minimum disruption to wildlife. Even limited removal is potentially damaging by modifying habitats and the landscape value of the site. Methods such as pollarding to reduce root growth may be acceptable.

SPECIAL HABITATS

Previously excavated areas such as foundation trenches and raised mounds or banks are attractive to burrowing animals such as rabbits, foxes and badgers. Burrows and sets can be well established and extensive and can undermine foundations, causing instability and even structural failure. Damage can also be caused to vulnerable plaster or mosaic floors, to burials and to archaeological stratification. Piles of fallen masonry can provide excellent habitats for a range of insects and reptiles; overgrown water courses with collapsed masonry provide ideal soft-bank conditions for voles and other aquatic and amphibian life; long undisturbed and overgrown areas may be well established zones occupied by slow worms or snakes, frogs, toads and newts.

Avoidance of subsurface damage to archaeology is often a major concern, as is any undermining of fragile walls above ground. The extent of underground voids caused by burrowing animals is difficult to ascertain; vacated sets and burrows may need to be filled by soil grouting. Site clearance under archaeological supervision to provide access to walls and floor levels and to record, salvage and identify fallen material is standard practice. Fallen, overgrown masonry on water courses such as medieval drains, wharfs and bridges require similar highly invasive practices to properly record, reinstate and consolidate.

Conditions of dereliction often support a rich bio-diversity of plants and wildlife. Existing habitats, especially for protected species, need to be preserved. Intrusive conservation works can disrupt established habitats and the site may be vacated to the detriment of the species; where protected and rare species are involved such as the Great Crested Newt this is a serious matter. The disturbance of habitats and breeding zones protected by law, especially during breeding seasons may constitute a criminal offence, as does the injuring or killing of reptiles and/or amphibians. It is important to understand, respect and preserve the conditions in which these creatures can thrive, such as food sources and living conditions. Specialist ecological advice must always be sought before any proposed works are put in hand.

Resolution of conflicts begins with statements of significance and bringing together the condition survey of the building fabric, describing structure and materials, and the Biological survey, providing a species list for the flora and fauna of the site.

Ferraby/Ashurst

The extensive ruins of Caesarea are located on the western edge of modern Israel and lie partly under the coastal waters of the Mediterranean sea. Herod's city lies over an earlier Phoenician port, traditionally founded by Straton. Underwater survey has formed a significant element of the investigation and recording of the site over many years. Survey and excavation are carried by the centre for Maritime Studies, University of Haifa.

Chapter 7

Submerged ruins

Jason Bolton

Introduction

> *Nel tempo, e con l'acqua, tutto muta. (In time and with water, everything changes.)*
>
> (Leonardo da Vinci)

One of the results of the historic use of the coast and rivers for the exploitation of natural resources, trade and communications has been the development of towns, villages, individual buildings, monuments, structures and complexes along the coastlines of the world. This pattern of historic settlement of coastal regions is seen internationally and reflected in modern population distributions – 50 per cent of the population of the industrialised world lives within one kilometre of the coast.[1] This legacy of archaeological monuments and historic buildings in close proximity to the coast ranges from the earliest tombs and ritual complexes to the wealth of medieval towns, fortifications and ecclesiastical settlements, through to the increasing diversity of post-medieval and twentieth century cultural heritage. The coast is not an immovable or constant boundary, and changes shape over a wide range of timespans. The tides rise and fall daily, storm events can cause sudden dramatic alteration, and over longer periods the processes of erosion and deposition cause shorelines to change shape and position. This has led to the phenomenon of historic harbours becoming landlocked, and other buildings and structures gradually sinking beneath the waves. The encroachment of the sea on the land and the inundation and submergence of historic buildings poses a host of new challenging conservation issues.

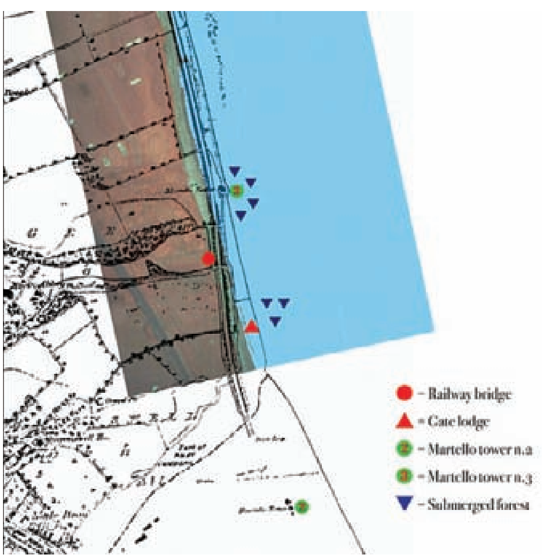


Figure 7.1 *Map c. 1843 overlain with digital aerial photo c. 1999 of Bray, on the soft glacial tills of the east coast of Ireland, showing extent of coastal loss (aerial photo courtesy of Gearoid O'Riain, Compass Infomatics).*

Considering the conservation of a submerged or submerging ruin is a complex task. The sea presents an aggressive, powerful environment, a salt-rich solution populated by a wide range of complex biological organisms seeking surfaces to colonise. And the sea is mobile, moving both landward and seaward, undermining, burying, abrading and corrading. There is no established 'best practice', no specialised generic techniques to draw on and very little previous work to draw comparison with. Instead, there are a range of issues which must be considered in addition to those familiar to architectural conservation, and a range of assessment, recording, monitoring and repair techniques which must be moulded, shaped and adapted to address site-specific needs.

Evaluation of the marine environment

Nature of the coast

One of the first challenges is to understand the processes of coastline change and what we mean by 'the coast' itself. The coast is most often defined as the place where the land meets the sea. However, the identification of where the sea stops and the land begins is a matter of some debate. The debate becomes increasingly complex in coastal systems such as coastal plains, mudflats, mangrove swamps and salt marshes, where the extent of the inter-tidal and the immediately supra-tidal is not clear. Common mapping practice is to use the edge of vegetation cover as the coastline, as it often indicates the furthest extent of high water. Historically, the mean high tide mark has been used as a convenient boundary to mark the coastline. However, the high tide mark is not an immovable datum point. The line fluctuates with the daily and annual cycle of tides, and over longer time-frames as the shoreline itself undergoes change through processes of erosion and accretion, and with changes in land and sea levels. Although in popular terminology the term coastline is frequently used, in practice the coast has width and depth as well as length, and in recent years it has become more common internationally to refer to a 'coastal zone'.

There are no clearly defined and universally accepted boundaries to the coastal zone. The many governments, institutions and other bodies involved with research and management of the world's coastlines operate on a wide variety of scales, using different boundaries for different purposes. Increasingly, definitions of the coastal zone are moving away from a spatial definition, to a broad description in line with Carter's[2] definition of the coast as 'that space in which terrestrial environments influence marine (or lacustrine) environments and vice versa'. Many definitions of the coastal zone do not contain physical limits and purposely leave the parameters open. Where the land is relatively flat, the coastal zone may extend some distance landward, and where the sea meets a cliff face or other steep surface, the coastal zone may be confined to a relatively narrow band. Within this broad

Figure 7.2 *This railway at Bray, Co. Wicklow on the eroding east coast of Ireland, was abandoned c. 1917, but stretches underwater for more than 2 km, with submerged traces of two martello towers, a gate lodge, fishermans cottages and a submerged forest over 6000 years old.*

definition, it is possible to break the coastal zone into a number of generic units, the parameters of which may vary from site to site, and each of which poses particular challenges to monuments:

- *The sub-littoral or sub-tidal area* – extending from the mean low spring tide water mark seaward
- *The littoral or inter-tidal area* – extending from the mean low spring tide water mark to the mean high spring tide water mark
- *The supra-littoral area (spray zone) and adjoining coastal land* – extending landward from the mean high spring tide water mark.

A ruined monument may be entirely, partially or occasionally submerged, depending on its location within each of these zones. These zones may also move either landward or seaward due to both natural and anthropogenic factors, and consequently a ruined structure may 'pass' from one zone to the next during a process of emergence or submergence. The key characteristic of these zones is the amount of available sea water which can impact on a building surface. Coasts are defined in a number of different ways for different purposes, but at the simplest level are either aggrading (advancing seaward), stable (no current significant change) or eroding where the shoreline is retreating.

Coastal erosion – causes and processes

Coastal erosion can be defined as the landward movement of a shoreline resulting from a loss of sedimentary or rocky substrate from the inter-tidal and foreshore zones. The process can be damaging to monuments in a number of ways – commonly undermining the foundations of a building, and allowing the direct impact of wave, spray and the marine environment on building surfaces as a prelude to inundation. Coastal erosion is the result of a combination of a number of factors, including changes in relative sea level, the intensity of wave action, tidal amplitude, the frequency of storm events, patterns and alterations to sediment distribution along the coastline, and the composition of the shoreline. Coastal erosion can be reduced or accelerated by natural and artificial changes to sediment distribution, such as alterations resulting from land reclamation works and mineral/aggregate extraction. The process of coastal erosion tends to arise from a combination of causal factors, and the relative importance of these factors changes according to local variables.

The rate and severity of coastal erosion is also controlled by the nature of the shoreline – most commonly divided into 'soft' (sandy dunes, glacial till) and 'hard' (rocky sea cliffs, man-made sea walls, etc.). The shoreline type is a key factor in estimating susceptibility to coastal erosion and consequent risk to a monument. However, at the small scale applicable to the consideration of levels of current and possible future deterioration of a coastal monument, large-scale surveys can underestimate the amount of damage occurring at small scale and need to be critically evaluated in assessing potential risk to a site. Published large-scale studies of coastal erosion tend to break the coastline up into coastal cells, rating each in terms of shoreline type and use, risk factors and an average rate of loss. At the small scale applicable to a coastal monument, greater variation is apparent. Local factors such as the durability of the monument itself influence erosion. The construction of hard coastal protection works has often led to accelerated rates of erosion at the edge of these works,[3] and this same phenomenon can be seen at some coastal sites where a durable stone masonry structure focuses the effects of coastal erosion at the edges or other vulnerable point.

All shorelines are subject to change, and even a seemingly robust rocky sea cliff is undergoing minor erosive processes such as sub-aerial scarp recession, weathering along mineralised joints, abrasion and corrasion (particularly adjacent to cobble/gravel beaches), notching and undercutting on platform/cliff junctions, and exploitation of sedimentary bedding and areas of structural weaknesses which lead to retreat of the cliff face. Low cliffs composed of soft sediments can experience gradual attrition leading to recession rates of 0.5–1.0 metres per annum, as well as sudden dramatic losses associated with storms. Historical shoreline changes on coastlines composed of soft sediments show that the pattern is not one of simple continual retreat, but of alternating periods of erosion, collapse, sediment build-up and then erosion again. Sandy shorelines are often in a continual state of flux, which can be extremely damaging to buildings located close to the inter-tidal zone.

Changes in sea level and potential impact of current climate change models for coastal heritage

Coastal buildings are also affected by changes in sea level. The level at which the sea stands relative to the land around the world's coastline is determined by a number of factors. Global mean sea level is ultimately determined (after Beniston and Tol[4]) by:

- The amount of water in the ocean
- The temperature of that water

- The volume of water stored in the Antarctic and Greenland ice sheets
- The volume of water stored in non-polar glaciers
- The volume of water stored in natural and artificial inland catchments, lakes and reservoirs.

Global mean sea level is affected by the balance of evaporation and precipitation produced by the hydrological cycle, the effects of gravity within the earth–moon–sun system, winds, atmospheric pressure fluctuations, and also on the extent and configuration of the crustal depressions which contain the worlds oceans.[3] Sea level is not constant, and fluctuates over a range of timescales, from diurnal oscillation with the tides to fluctuations over geological time through tectonic and eustatic movements (or a combination of the two). Tidal fluctuations also vary in direction, duration, height and speed due to local factors such as coastline morphology, bathymetry and weather conditions. Despite the natural fluctuations in sea level outlined above, mean sea level has historically been used as a constant datum, and is still used in practice to the present day.

There is currently worldwide concern about the possible impacts of predicted models of climate change and resultant sea-level rise resulting from increasing concentrations of greenhouse gases and other processes (commonly known as global warming). Increasingly, climate change scenarios are being used to postulate the impacts arising from possible increases in global mean sea level, and the possibility of increased incidences of storms and flooding, leading to potential impacts on ecosystems and human coastal infrastructure. Current studies on climate change[4] tend to concentrate on ascertaining the rate at which mean sea level may rise, estimated at between 14 and 80 cm, with a mid-range estimate of about 0.5 m, and increased levels in the frequency and severity of precipitation and storm events. However, it is the resultant changes in tidal amplitude, especially ascending levels of the highest tides, that may be of most relevance to the built heritage along the coastline. The maximum extent of the tides must also be considered in the understanding of the possible impacts of increased levels of storminess predicted for the twenty-first century. Storm surges caused by winds and atmospheric pressure changes can result in a temporary rise in sea level of up to several metres on a lee shore, and the production of significantly high-energy waves can result in dramatic loss to land and to buildings. The scenarios take a broad global and continental scope; however, local impacts of global warming are difficult to predict with any certainty, and both regional and local changes could differ substantially from the global mean value. The impact of climate change on coastlines is unlikely to be uniform, and influencing factors include shoreline type, topography and local variables. However, certain coastal types such as tidal deltas, low-lying coastal plains, beaches, islands (including barrier islands), coastal wetlands and estuaries may face greater risk due to their physical characteristics.

At the small scale of survey relevant to the consideration of ruined monuments, consideration of the shoreline type and consequent susceptibility to shoreline alteration may be a much more important indicator of risk than a rise in sea level *per se*. Inundation alone does not necessarily lead to significant deterioration of monuments on the coast. Many sites such as harbours and coastal fortifications were intended to be partially immersed. It is the factors associated with sea-level rise that have the potential to cause damage to ruined monuments – increased wave and storm activity, increased coastal erosion, and changes in climate and weathering parameters. And these associated factors may be controlled by local variables such as shoreline type, local and regional longshore and offshore sediment transportation processes, fetch and exposure to wave energy.

Techniques of recording and monitoring

The scope of assessment

The initial task is to determine the necessary level of scale(s) of recording that are necessary to understand the condition of the ruined structure and the level of intervention required to conserve it. There are four broad scales of evaluation:

1 *Coastline assessment*. Geomorphological study identifying the shoreline type, tidal range, degree of exposure of the coast to wave and storm action, local sediment transport patterns, and an assessment of historical and current coastal erosion and sea-level change.
2 *Assessment of the shoreline or seabed immediately associated with the ruin*. Type, nature and durability of the substrate, coastal erosion or depositional environment.
3 *General assessment of the building*. Survey of the extent of the building, noting design, materials, condition, range, type and level of colonisation by marine organisms, and identifying areas of vulnerability.

4 *Detailed assessment of areas of vulnerability*. For example, detailed assessments of local undermining, wall movement and other structural issues, areas of severe stone deterioration, etc.

The initial coastal assessment should comprise a desktop review of relevant literature, cartography, aerial photography, and previous coastal environmental and erosion studies (where available). However, much of the existing literature base is composed of wide-scale studies for coastal management purposes and while providing a good overview of coastal processes in an area, are generally not applicable to the relatively small scale of survey required for the conservation of a ruined monument. For the majority of sites, useful information is unlikely to already exist and must be gathered through site-specific research, survey, analysis and evaluation.

The assessment of a small section of coast, or coastal cell, is vital to understand the coastal processes that have led to the submergence of the ruin, and will have a strong bearing on the feasibility of practical conservation measures. The durability of the substrate and its resistance to erosion and undermining is often the prime determinant of the longevity of a submerging building.

This task becomes much more challenging than similar assessment and evaluation requirements on terrestrial sites. Though the ruin may require the same amount of investigative work, obtaining the necessary information can be a complex and hazardous undertaking. Working conditions associated with submerged and partially submerged ruins require thorough planning and adaptation to changing site conditions. In the inter-tidal area, the ruin may only be accessible for a few hours per day. For some sites only exposed on certain low spring tides, these may only be dry for a few hours per year.

Practical on-site assessment

On-site assessment comprises three main areas: a geomorphological study of the coastal cell, an inter-tidal survey of the ruin and an underwater survey of the ruin.

The *geomorphological assessment* should ascertain the nature, type, present condition and vulnerabilities of a defined section of coastline, and should ideally be done twice – once in the spring and once in the autumn for comparison. Different types of coastline require different evaluation techniques, as many of the decay forms are specific to different coastal types. For example, evidence of a wave-cut escarpment at the toe of a dune or embryo dunes could suggest either recent storm damage or a lull in continuing erosion. Glacial till cliffs require different questions to be asked, as different types of slippage, vegetation cover or the position and nature of the toe of the cliff could indicate one or a combination of drainage, storm or continual erosion problems.

The *inter-tidal survey* generally uses standard land-based techniques with some adjustments for the wet conditions and the limited amount of time available between tides. Midsummer is the best survey season as both low tide periods can be worked; however, continuous working in the inter-tidal area is not

Table 7.1 Typical large-scale problems found for some coastal cell types

Coast type	*Description*	*Typical problems*
Sand dunes	Accumulations of wind-blown sand, usually as a series of ridges	Vegetation damage Storm damage Blow-out
Sand cliff	Cliffs of sand/gravel, either glacial deposits or overgrown relic dunes	Storm damage Continuous erosion
Glacial till cliffs	An incohesive conglomerate normally formed of sand, gravel and boulders ‘floating’ in a poorly bound clay matrix, normally deposited by glacial action	Drainage problem Storm attack Recent slip Continuous erosion
Storm beach	Gravel/shingle ridge or barrier which protects the backshore from storm attack	Ridge active from wave activity Storm damage Wash-over by sea
Buildings	Monuments, seawalls, rock revetments, timber/rock groynes, etc.	Wave reflection and longshore drift leading to beach lowering and undermining

possible. Winter offers the poorest working conditions with few daylight hours, cold and wet conditions, but may return more valuable information as the monument can be assessed before, during and after a storm event. The main constraint is the condition of the foreshore. Deep layers of thick, sticky mud may impede movement, access for a hoist may not be possible, equipment must usually be brought on site and erected each day, and special safety considerations and measures may need to be undertaken. Careful planning can maximise the time available on site; however, inter-tidal surveying is usually merely awkward rather than difficult. A greater amount of recording tends to be carried out in the upper reaches of the tide due to the greater window of time available. However, this can be compensated for by allowing an overlap with the underwater survey.

Underwater survey is a specialised activity, with many site-specific limitations including wave activity, tidal movements, water temperature and through-water visibility. Underwater visibility is normally the most important factor in determining the quality and accuracy of underwater survey, and is a factor that can change dramatically from day to day and hour to hour. Underwater visibility may range from nil to greater than 20 metres depending on water depth, water quality, light penetration, time of year, tidal conditions, turbidity, marine growth and especially the amount of particulate matter suspended in the water. The working time of a diver is limited by depth and pressure and the availability of air (though this can be extended by use of surface demand diving). The working conditions may be challenging, but underwater survey is normally essential to determine the condition of the monument and to plan an effective conservation strategy.

The purpose of underwater surveying for the conservation of a monument is to record a sufficient amount of accurate, quality information to determine the condition of the structure, and to plan and specify necessary repairs. The type of survey is normally a combination of on-site visual assessment, survey drawing (generally a two-dimensional plan with supporting descriptions and measurements) and photographic survey. A video record of the site can also provide additional contextual information as supplementary information. Basic low-tech survey techniques can achieve a high level of accuracy on underwater sites. Many of the techniques[5] and specialised underwater surveying software were developed for recording shipwrecks, but are equally applicable to the complex, almost organic shapes characteristic of ruined structures.

Photography is one of the most useful underwater recording techniques, though commonly limited by poor visibility, low light levels and the refractive index of water (1.33). It is usually necessary to use wide-angle lenses (with consequent distortion) ranging from 15 to 20 mm in all but the clearest water. Low light levels can be treated with artificial light sources, and poor visibility can be compensated by choosing an optimum dive time and good diving techniques to prevent disturbing sediments on the seabed or on the monument. Underwater visibility is unlikely to allow an entire structure or large sections of it to be photographed. As ruined structures tend to present large flat areas of masonry surface, photomosaics of overlapping photographs can be very effective. A photomosaic can be quickly created using a photo-tower with 50 per cent overlap between shots (obtaining a scale), and after digital matching and correction can provide a high, cost-effective degree of detail to complement and corroborate the drawn survey.

There are a wide range of geophysical and remote sensing equipment and techniques available which are commonly used for mapping and interpreting submerged archaeological resources. The quality and accuracy of the information returned are continuously improving, and can be very valuable in interpreting the nature of the seabed and the extent and/or distribution of submerged structures. However, the majority of these techniques are currently of limited use for the consideration of the conservation of these ruins. The exceptions are remotely operated vehicles (ROVs), which allow for long periods of visual (video and still photography) monitoring and limited sampling. Other specialised applications include the use of underwater metal detectors to locate iron cramps and other fittings.

Decay diagnosis of a submerging monument

Evaluating risk to submerged masonry structures

The evaluation of deterioration and risk to a submerged ruin is a combination of established architectural decay diagnostic techniques,[6,7] natural stone weathering and coastal erosion and geomorphological studies,[8,9] supported by standard drawn, photographic and video recording techniques. Established laboratory techniques can also be used to address particular issues. Petrography is particularly valuable in evaluating stone and mortars, while some techniques such as electron microscopy (SEM) tend to be limited by the presence of abundant marine salts and marine organisms characteristic of submerged stone and masonry.

The buildings, complexes and sites recorded in the archaeological record are composed of a variety of building materials such as stone, earth, timber and other organic materials, and man-made materials such as mortars and burnt clay products. Timber and other organic materials can survive in good condition in submerged, boggy and other waterlogged sites, and submerged ruins may incorporate a certain amount of timber (e.g. structural members, piles, etc.). Metals, especially iron, can also be found performing both decorative and functional requirements. The deterioration of waterlogged wood[10,11] and the corrosion of metals[12,13] in marine environments is a well-researched area. The majority of submerged ruins are likely to be composed of more robust materials, such as stone.

Stone monuments present a particularly interesting field of study as they tend to be good survivors, with different architectonic forms often from overlapping historical periods used for a variety of social and cultural purposes. The term 'stone' covers a group of materials of highly variable strength, durability and appearance. Yet, throughout history and continuing to the present day, stone has been chosen as a high-quality, durability material intended often for important and prestigious constructions. The deterioration of a stone building can be considered as a combination of environmental conditions, building failures and stone failures – most notably the surface alteration of stones.

The deterioration of a submerged or partially submerged ruin is often due to a combination of many factors, including mechanical wave erosion, daily wet–dry tidal cycling, salt weathering, bioerosion and other biological influences, frost and related mechanisms, and alterations in beach levels and shoreline morphology. The stone and mortar surfaces comprising the monument are also susceptible to a wide range of decay processes, normally determined by evaluation of visual indicators of decay forms supported by laboratory analyses. Submerging ruins present further complexities as the upper (dry) sections of the structure may show similar decay forms to comparable buildings inland, while submerging sections may show radically different forms due to underwater processes of stone decay and deterioration, varying significantly from processes encountered in urban and unpolluted inland environments. Pointing, bedding and rendering lime mortars common to historic buildings are particularly susceptible to dissolution and survive poorly in marine contexts. Dry joints may range from local cavities to substantial loss, leading to subsidence and/or partial collapse of sections of masonry wall. Dry joints are common at the base of the wall, where sand and other particulate matter are concentrated as water-borne abrasives. Incipient dry joints may also be exploited by a wide range of marine organisms which tend to enlarge the voids. It should be noted that in a marine context a dry joint may extend >1 metre in depth into the wall core. The wall core itself may also contain a substantial amount of voids through dissolution and may require substantial grouting.

The structure and individual materials of a submerging monument may then be susceptible to a wide range of terrestrial and marine-specific decay forms and processes. In addition to the alteration and deterioration of submerging stone surfaces[14] and mortars, marine-specific decay forms may include undermining, wave action, abrasion and corrasion, colonisation by marine organisms and the action of marine salts.

Undermining

The undermining and collapse of built structures located on the coast is brought about predominantly by coastal processes acting upon the underlying geology, rather than primarily on the fabric of the monument. For example, the east coast of Ireland features long stretches of sandy cliffs which experience constant loss of material through wind erosion and wave erosion at every high tide period. The base of the sandy cliffs is often fronted by a highly mobile cobble beach, causing mechanical erosion through abrasion to the toe of the cliffs combining with wave action, sub-aerial processes and storm events, resulting in sudden failures of sections of the cliff face. The level of erosion is stabilised by the redeposition of this material during tidal movements. However, longshore sediment transport processes ultimately remove this material offshore, resulting in further collapses. As the protective head of collapsed detritus is gradually removed offshore by local sediment transport processes, the cycle of erosion is renewed. The process of erosion and deposition results in both the encroachment of the sea onto the land and fluctuating beach levels. There can therefore be both vertical and horizontal alterations to the character of a beach area. Changes to the morphology of the shoreline result in a number of destructive processes threatening monuments,

Figure 7.3 *Ballinaskelligs Castle, a medieval tower house now situated on a very vulnerable narrow sandy isthmus on the south-east coast of Ireland.*

Figure 7.4 *Erosion is now beginning to undermine the corners of the tower, with the cobble beach corrading the cills of the principal historic stone entranceway.*

including undermining, abrasion and corrasion, and the exposure of previously buried areas to daily wet–dry cycling through tidal movements. The process of undermining commonly leads to the exposure of the shallow foundations typical of historic buildings and the formation of structural cracks, which tend to develop rapidly and lead to the partial collapse of sections of the monument.

Wave action, abrasion and corrasion

The degree of exposure, severity and type of wave action is an important factor in assessing a coastal monument. Almost all shore erosion can be explained by the action of different types of waves. Gravity acts as the main force to bring sea water to equilibrium. Waves are generated by either periodic (e.g. the sun and the moon influence tides) or non-periodic (wind) disturbances of the water surface. Wave development is dependent on three factors: wind speed, wind duration and the distance over which the wind travels (the fetch). Ocean coastlines will therefore normally experience waves of much higher energy than a small sea, channel or sheltered bay. Storm waves tend to be steep, short-lived and irregular; however, once these waves move away from the storm area they naturally sort into swell waves of regular height, length and period, which lose little energy before reaching the coast. Once nearing the shore and shallow water, the waves may then experience a series of transformations governed by the reducing water depth (which causes waves to become steeper as they approach the shore, with narrow crests and flatter troughs) and depth contours (leading to variations in the height of breaking waves and currents). Eventually, the water is so shallow the waves over-steepen and break, resulting in a swash and backwash of sea water, which results in changes in the beach profile.

Evaluation of shore morphology and the type of wave action impacting in the vicinity of a submerged or submerging ruin allows the informed consideration of the potential seasonal or longer-term changes and pressures, and a better understanding of the processes of deterioration. Wave action will abrade a masonry surface both by direct impact and by abrasion from sand particles suspended in the water, commonly leading to the rounding and polishing of the surface of the stone units, and removal of mortar from the joints which disrupts the wall fabric, leading

Figure 7.5 *Subsidence of the corner of this 19th century granite harbour due to extensive dry jointing and undermining.*

Figure 7.6 *Vertical zonation showing transition from marine to terrestrial species.*

to settlement and collapse. At the base of the wall, the masonry may show significant rounding and etching by the corrasion of gravel, cobbles and boulders acting against the base of the structure by wave action. This generally occurs in a narrow band extending from the base of the wall to a height of 100–300 mm. Underwater inspection of the base of a submerged ruin will often show one elevation experiencing significantly greater rates and severity of deterioration – normally aligned with the prevailing winds and open fetch of the sea. Grooves can also develop in certain areas according to the topography of the building surface and the seabed in the immediate area.

Further stresses are also caused by wave quarrying – believed by many researchers[8] to be the dominant form of erosive mechanism on many rock coasts. Submerged ruins can be considered artificial rock coasts and are subject to many of the same processes of deterioration as coastal rocky cliffs. Quarrying occurs in a narrow band extending just below the still water level up the wave crest, causing shock pressures of the breaking wave, water hammer and air compression in joints. Masonry blocks can be dislodged as a result of the pockets of air trapped along joint, stone bedding planes and other vulnerable areas as waves break against the building. The process is cyclical as each wave brings sudden pressure and sudden release, and becomes a particularly effective erosive technique when sand particles are contained in the water, forming a highly abrasive solution. These processes are most damaging during the winter months when wave strength is highest, and most damaging when the wave front or bore is parallel with the building elevation, reducing the amount of wave energy that is deflected along the building elevation if the wave strikes at an angle.

Figure 7.7 *Submerged masonry surfaces can be obscured by extensive marine growth (e.g. the jewel anenome (Corynactis viridis) which may have other heritage values. Courtesy of Rebecca Morris.*

Marine biological organisms

Biological colonisation is a constant feature of historic buildings and archaeological monuments,[15] and there is growing research and debate on the impacts (harmful and beneficial) of lichen development on stone surfaces, soft organic capping to wall tops, and the realm of interactions and competing values between natural and built heritage. Biological species, both flora and fauna, exploit building surfaces in a similar manner to other rocky habitats. The mitigation of harmful biological colonisation on building surfaces, such as ivy development and bioerosion, is an established area of architectural conservation. However, marine organisms introduce a new world of complex species competing for habitat in the littoral and sub-littoral areas. A number of factors determine the nature, significance and rate (if this can be established) of marine bioerosional activity. Marine species are distributed in both the vertical and horizontal planes, and the distribution of different species is controlled by the availability of moisture (local tidal characteristics determine periods of inundation and exposure to dessication) and waves, surge and tidal currents. In general, the width of each organic zone increases with increasing wave energy, with wide bands of marine organisms found on exposed shores and an abrupt distinct transition between marine and terrestrial habitats in sheltered sites, where the influence of spray and wave action is greatly reduced. Other factors include salinity levels, pollutants levels, temperature and degree of exposure to sunlight.

Submerged sites may feature a complex environment of floral and faunal species, and the banding and distribution of marine organisms in the vicinity of a submerged ruin provides valuable information about the level and severity of exposure. Exposed littoral building surfaces are typically dominated by communities of common mussel (*Mytilus edulis*) and barnacles (*Semibalenus balaniodes*, *Chthamalus* spp.) with limpets (*Patella* spp.) throughout. On exposed submerged building surfaces, kelp normally dominates, with an understorey of foliose red or brown seaweeds forming a dense bed below the main kelp zone. Fucoids also occur in distinct horizontal bands, and a wide stretch of fucoids and seaweeds exposed during low tide indicates potential for

Figure 7.8 *The remains of McSwyne's Castle, Donegal, located on a narrow eroding isthmus on the Atlantic north-west coast of Ireland.*

Figure 7.9 *Erosion of the sandstone bedrock beneath McSwynes Castle by wave action and corrasion by the boulder/cobble beach element leading to partial collapse of the outer face of masonry.*

Figure 7.10 *The inter-tidal area below Carrigaholt Castle, Clare on the west coast of Ireland showing a highly mobile erosive cobble beach. The sub-surface remains of a now-lost gabled house can be seen in the cliff edge, now within 3 metres of the tower.*

significant wave action and/or tidal currents. Local anomalies can also be identified by biological colonisation. The replacement of kelp with robust animal species such as cushion sponges, colonial ascidians, bryozoans, anenomes, barnacles and calcareous tubeworms indicates an area of surge or other strong water movement. The range and type of marine organisms found on submerged and partially submerged ruins can then be used as a relatively accurate indicator map of environmental conditions. However, the presence and activity of these marine organisms can also have direct and indirect impacts on submerged masonry.

The effectiveness and zonation of erosive marine organisms varies according to the nature and durability of the brick or stone masonry substrate. Softer limestones and siliclastic rocks such as mudstones, siltstones and some sandstones may be very vulnerable to both dissolution and boring organisms. The most significant organisms are marine bacteria, microflora (e.g. marine and terrestrial algae, lichens) and grazers (which may include a wide range of species including chitons and gastropods – limpets and periwinkles – echinoids, crabs, starfish and grazing fish such as wrasse which mechanically rasp the stone surface). Boring and burrowing organisms such as crabs and lobsters are very common in submerged open joints, and conger eels of >2 metres in length can be found colonising the base of harbour walls and submerged ruins where conditions permit.

A wide variety of green, red and brown algae can be encountered in marine environments, from Chlorophyta (green algae) in the littoral zone, Rhodophyta (red algae) in the lower littoral and sub-littoral zones, and cyanophyta appearing as a blue–green slime in the upper littoral and supra-littoral zones. Algae are physically attached to a building surface and, like their terrestrial counterparts, have associated metabolic processes which can alter a stone surface. Some marine algae, such as endolithic cyanophyta, and other microfloral species, such as fungi and lichens, are also effective rock borers. Algal development is inhibited by grazers, although these may also cause a certain amount of disruption (including the formation of grooves under certain conditions) as they mechanically rasp the masonry surface to remove the microflora. Lichens tend to dominate the supra-littoral zones in northern waters, showing a zonation pattern determined by immersion/exposure periods. The width/height of lichen bands also increases with increasing exposure, with grey lichens (*Ramalina* spp.) above yellow lichens (*Xanthoria* spp.) at the top of the zone to black lichen (*Verrucaria maura*) at the base.

Figure 7.11 *Erosion tends to become focused at the edges of coastal protection works and other masonry surfaces. Here the protective bawn wall of Carrigaholt Castle, recently repaired, is again under threat as erosion tunnels around behind the wall.*

Boring and burrowing marine organisms may include certain barnacles, polychaete worms, gastropods, echinoids (sea urchins), bivalve molluscs and sponges, and may excavate for inhabitation, reproduction, anchorage or nutrition, and some grazing organisms use a chemical 'trail' to return to a particular location after nightly foraging. These organisms may have both direct and indirect impacts on stone masonry. Boring species excavate rocky substrates such as stone masonry and mortar joints both mechanically and chemically, and the size of the bore varies with the size of the organism, from 1 to 10+ mm in diameter. Boring directly removes a section of the stone surface in a specialised form of honeycomb weathering, and contributes to the retreat of the stone surface by providing a greater surface area for other physical and chemical processes. Burrowers tend to excavate softer sediments and excavate at the base of the wall or may enlarge an already opened mortar joint. They contribute to the undermining of submerged masonry and can penetrate deeply into the wall where a joint has been opened.

Assessing the rate of marine bioerosion is very difficult, and is affected by population density, the local environment, the characteristics of the building stone and mortar, and the range of species (algal, grazers, borers, etc.) to be considered, balanced with the repeatability and accuracy of the chosen survey method. It should also be noted that some marine organisms may provide a protective function, protecting the underlying masonry from wave action and physico-chemical attack in the littoral and sub-littoral zones. For example, hand-fired brick found in the submerged village of Rosslare Fort in south-east Ireland were found to retain surface features such as grass marks beneath a shelter coat of red algae, despite 70 years exposure in a high-energy littoral zone, experiencing daily tidal wet–dry cycles, wave action and abrasion by water-borne sand. A dense organic coating such as the presence of marine algae may act as a buffer to incoming waves, and may also retain moisture on the building surface and reduce the severity of daily wet–dry cycling in littoral zones.

Marine salts

I observed … that salt exuded from the soil to such an extent as even to injure the pyramids.

(Herodotus)

The formation, transport and crystallisation of salts in rocks and other porous building materials has been widely recognised as one of the primary causes of the deterioration of historical architecture, archaeological monuments and archaeological objects.[16–20] Salts are soft, light minerals which are highly susceptible to dissolution and recrystallisation. They dissolve in water, move in solution and crystallise when water evaporation takes place. All circulating waters are slightly alkaline (pH 7.5–8.4)[21] salt solutions, and may contain Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+, CO_3^{2-}, SO_4^{2-}, NO_3^- and Cl^-. Salts may not always be the original cause of deterioration, but their presence in conjunction with water and/or moisture may significantly increase the deterioration rate of a stone. Charola[22] records that the presence of water and/or moisture in the porous material is as important as the type of salt and the nature, texture, porosity and interior surface of the material; and that salts significantly impact on the weathering of stone, with scaling and granular disintegration being ubiquitous to all stone types.

Salts have been investigated due to their contribution to the deterioration of a wide range of stone types used for the construction of stone monuments. The occurrence, origins, mechanism and effects of salts on stone monuments have been a recurring theme in conferences and research forums for some time,[23–26] considering the process of damage, individual case studies and occasional conservation treatments. Marine aerosol includes a range of particles termed according to their physical characteristics, such as film drops, jet drops, sea water drops, brine drops, hydroscopic salt drops, sea-salt nuclei and sea-salt particles. These drops are formed from bubbles bursting in the whitecaps of waves, where a large amount of air and water are mixed. Marine aerosol salts are derived from the emission of these minute airborne drops of sea water creating sea-salt particles by evaporation (mainly Na^+, Cl^-, Mg^{2+}, SO_4^{2-}). Sodium chloride (NaCl), the most common salt in oceans, can be carried up to 200 miles inland, settling on the ground and on building surfaces.[17] Marine salt-originated damage has been noted by numerous authors to European cities on the coasts of the Mediterranean, the North Sea and the Atlantic coast. Galán *et al*.[27] stated (primarily in the context of limestone and marble building stone) that the degradation of built heritage of the Mediterranean region could be attributed (in order of importance) to the following factors:

1 Marine spray activity.
2 Industrial and urban pollution (at a local level).
3 Other factors (such as saline rising damp and percolating waters).

The three main sources of marine salts in the context of submerging ruins are sea flooding, rising damp (both sea water and brine) and marine aerosol (sea spray). Additional sources of marine salts in a coastal monument may include building stone quarried from the shoreline, the use of unwashed beach sands as a mortar aggregate and even the use of sea water to mix the mortar. Changing atmospheric composition, rainfall, temperature and storm events will have an impact on stone deterioration in general,[28] but may have a significant impact on the severity of marine-related salt damage. Unpolluted coastal areas with high levels of precipitation may not exhibit high levels of salt-related weathering, as the salts are leached from the stonework before they can accumulate to harmful levels.[14] The degree of damage caused by marine aerosols is generally considered to be severe;[29,30] they are formed when sea-salt particles (Na^+, Cl^-, Mg^{2+}, SO_4^{2-}) are left through evaporation on the surface of a building or monument, where they accumulate and penetrate the pore network of building stone and the mortars of the joints and the wall core.

A monument on the shoreline experiences daily changes in environment due to the movement of the tides – leading to a daily cycle of wetting and drying episodes, increased periods of wetness of stone surfaces and the presence of marine salts. Greater levels of salt-related deterioration may then be present. However, in regions of high precipitation, the continual washing effect of rainwater will help in leaching the salts from the masonry. Submerged masonry should then be considered as potentially heavily salt loaded; the amount and depth of penetration of salts will be dependent on the type and nature of the stone involved. If the stone remains submerged, the surface should remain in equilibrium. However, if the stone is being recovered, for example the recovery of a carved stone surface for conservation, the stone must remain immersed in sea water until proper desalination can be undertaken by a conservator. If the stone is too large for storage tanks, water-soaked absorbent materials such as hessian drenched with water at shore intervals can be used as an emergency measure during transport to a conservation laboratory. Desalination is normally undertaken using continuously running or changes of fresh, distilled or deionised water until all salts have been removed – normally confirmed using a conductivity meter.[11]

More robust stone types[15] may require much less intervention.

Risk mapping of a submerged monument

A range of conservation issues may then impact on a submerging ruin. The type, rate and severity of the decay forms can normally be sorted into vertical and horizontal zones corresponding with submerged, inter-tidal and spray zones on the shoreline. Mapping the risks and vulnerabilities in these different zones is the most effective way of understanding the decay processes (by mapping decay forms) and planning a conservation strategy. Table 7.2 outlines some of the impacts to be found.

Protection and conservation

Protection and conservation of a submerging or submerged ruin encompasses a wide range of site-specific measures comprising protection of the coastline (see Table 7.3), protection and repair of the monument (which could include repointing, reinstatement of

Table 7.2 Typical macro-scale decay processes acting on historic stone masonry at different zones of the shore

Area	*Type of impact*	*Intensity of damage*
U/W	Wave action Corrasion and abrasion Biological colonisation (marine sub-littoral) Coastal erosion leading to undermining of structures Fluctuating beach levels leading to undermining of structures Daily wet–dry cycling	Low to moderate
I/T	Wave and surf abrasion Corrasion Sea spray (at low tide periods) Increased periods of wetness Biological colonisation (marine littoral) Erosion of shoreline leading to undermining of structures Wave and surf abrasion	Moderate to severe
HW	Corrasion Sea spray Increased periods of wetness Biological colonisation (terrestrial and marine supra-littoral)	Moderate to severe
5M	Sea spray Biological colonisation (terrestrial)	Low

Table 7.3 A wide range of coastal protection and management options are available to consolidate and protect the shoreline associated with a submerging ruin

Zone	*Techniques*	
Submerged	Seaweed planting Breakwaters	Sand-bypassing
Inter-tidal to submerged	Groynes Beach nourishment Beach drainage	Artificial headland Mudflat restoration Silt redistribution
Upper shore to inter-tidal	Beach ridge restructuring Wave barrier fencing Dune recontouring Sand stabilisation Artificial dune ridge building Marram grass planting	Sand trap fencing Grass seeding Seawalls and revetments Toe protection Cliff stabilisation Land use restrictions

rebuilding of sections of collapsed masonry, etc.), and ongoing monitoring and maintenance requirements. Much can be learnt from the experiences and knowledge base of nature conservation,[31] which has already developed useful tools for the conservation of vulnerable heritage-rich coasts. Unfortunately, many of the principles of nature conservation, such as managed retreat, are not applicable to architectural conservation, and many of the coastal protection options may significantly detract from the character of the monument. Critical evaluation of the available information and innovative solutions drawing on a mixture of disciplines are likely to become the accepted norm for the conservation of submerging ruins.

Case Study: Medieval waterfront building, Drogheda, Ireland

This monument appears as the remains of a medieval waterfront merchant's residence fronting onto the tidal section of the river Boyne on the east coast of Ireland. The structure had continued in use in different forms and had a modern overburden of brick masonry and an iron roof structure, with later annexes in both stone masonry and reinforced concrete. The main waterside façade of the building retained a number of archaeological features including a water-door and two garderobe chutes (toilets) which were designed to be flushed by tidal action.

The original sections of the building showed relatively few decay forms. Biological colonisation was limited by poor water quality and confined to a few fucoid and crustacean species in the littoral and sublittoral areas. The base of the wall was disrupted and the waterside of the building showed a few missing masonry units, dry jointing and a few dislodged stones. The doorway and garderobes were largely intact. The interior face of the monument was in poor condition and required stabilisation. The site had been archaeologically excavated and the below-ground structures were to be preserved *in situ*.

The conservation strategy for the building was to consolidate the ruin as a standing archaeological monument for display and appreciation as a public feature within a new development. Repairs were planned on

Figure 7.12 *Medieval waterfront merchant's house at Drogheda on the east coast of Ireland, showing a range of conservation issues, including modern overburden, later repairs, missing and dislodged masonry, and difficulties in interpreting the character of the archaeological monument.*

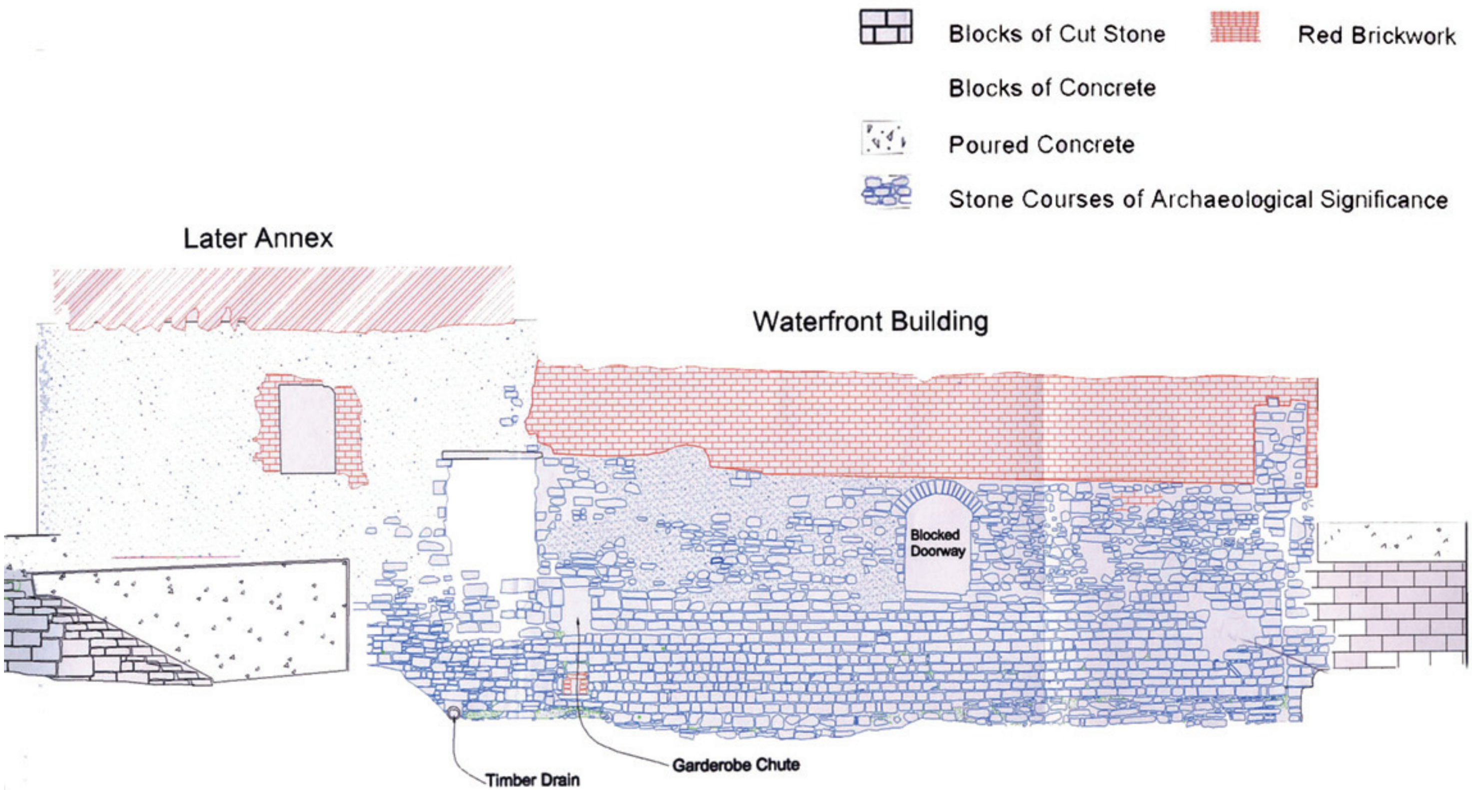


Figure 7.13 *Interpretative survey drawing showing stone courses and features of archaeological significance, used as a guide to plan and specify conservation works. Drawing courtesy of the Archaeological Diving Company.*

Figure 7.14 *Rosslare Fort at the mouth of Wexford Harbour submerged c. 1927, containing the remains of a quadrangle of brick and timber houses, a lifeboat station, a martello tower and an earthen star-shaped fort.*

a 'minimum intervention' basis to stabilise vulnerable sections of masonry, and to allow the still functioning tidally flushed garderobe chutes and the water-door to be visible to the public. The original mortar was analysed, and a new series of mortars were designed using local sands and different binders to cope with submerged areas, inter-tidal areas, general pointing and wall capping. The work encompassed:

- *Securing the character of the monument.* Controlled removal of some of the later annexes, the brick masonry overburden, removal of later repairs in brick and concrete, and recovery of fallen limestone masonry for reuse during conservation works.
- *General conservation works.* Stabilisation of vulnerable sections of the wall, pointing and reinstatement of limestone masonry wall face where collapsed to interior. Analysis of original mortars.
- *Submerged conservation works.* Comprised reinstatement of fallen limestone masonry at the base and submerged sections of the monument, and repointing with separate designed mixes for submerged, inter-tidal and 'dry' areas.

Case Study: Carrigaholt Castle, Co. Clare

The monument consists of a mid-fifteenth century four-storey tower house with a later bawn wall to seaward. The tower stands on the shoreline at the mouth of the river Shannon on the east coast of Ireland. The tower retains a number of features including an internal spiral staircase, murder hole, crennelations, lime-based wall finishes, dressed stone doorway and a range of window types. Traces of a large four-storey house attached to the south of the tower are indicated by protruding roof tiles and door openings.

The shoreline consists of a 5 m cliff face (3.5 m high siltstone bedrock below 1.5 m soft glacial till). The rocky cliff is friable and deteriorating rapidly, worsened by drainage run-off from the surrounding agricultural pastureland. Corrasion is caused by water-rolled limestone cobbles, substantially more durable than the siltstone cliffs. Cliff recession is funnelled into the formation of shallow caves leading to collapses of sections of the cliff. The foundations of a four-storey gabled building and associated archaeological deposits are exposed in the eroding cliff face, now standing <3 m from the base of the castle. The tower itself is in good condition, showing only minor decay forms such as biological colonisation, graffiti and some stone decay.

The main threat to the castle is from coastal erosion, and this is not a new phenomenon for the site with historical references that '*Lord Clare trained his dragoons in front of the castle, on a lawn, long since eroded by the waters of the Shannon*'. The castle is also constructed on rocky bedrock, a substrate normally considered stable by coastal erosion studies. This site is also not an isolated example, but one of an increasing number of medieval coastal castles such as McSwynes, Castlecove and Ballinaskeligs which are now submerging, and a wide range of ecclesiastical sites and other monuments. There is no simple generic solution. 'Hard' coastal defences such as sea walls and rock armour often have the knock-on effect of accelerating erosion at the margins and are not permanent solutions. The process of submergence may

Figure 7.15 *Castlecove Castle on the shores of the Ring of Kerry in south-west Ireland. Though protected from the brunt of Atlantic storms, high tides reach the base of the castle. Increased storminess and rising sea levels may have profound implications for similar coastal ruins.*

leave some of these monuments relatively intact. Others such as Rosslare Fort will see entire settlements disrupted in situations where conservation is not a feasible option, and in some cases it may be necessary to do nothing, and simply to preserve the monument by record and commemorate it in some way. The challenge for the future is to preserve what we can, as best we can, with the resources currently available.

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Training. Training exercises with John Ludlow's conservation technician team in County Cork, Ireland show, top, the use of the planning frame in marking out stone sizes and positions before taking down and rebuilding and, bottom, the use of profile frames in recording twists and distortions in the wall to enable the consolidated work to be built back in exactly the same positions.

Chapter 8

Implementing conservation works on ruins

Sara Ferraby and David Odgers

> *Those responsible for the treatment of an ancient building, realising that the contemplative work demands qualifications beyond their knowledge, will doubtless seek advice from an architect. It may be thought, having done this, their only remaining duties are to procure the necessary funds, and to enter into a building contract so that for a fixed sum the recommendation may be carried into effect.*
>
> *Yet, as can be seen in many an ancient building which has been dealt with under these conditions, such a course does not necessarily secure a building from harm.*
>
> (The Repair of Ancient Buildings, A. R. Powys, 1929)

Almost a century after Powys wrote his seminal book, ancient buildings, including those surviving as ruins, are still often damaged or degraded in the process of implementing conservation work. The truth is that the conservation of ancient fabric, and especially the conservation of ruins, is quite outside the usual professional experience of architects, engineers, surveyors, building craftspeople and archaeologists. They may often believe that they are competent but can deceive themselves and those for whom they provide services. Most seriously, they will unwittingly play a destructive role in the history of the subject they may have set out to protect.

All this is nothing new, as a review of Powys's work will demonstrate, but there have been changes. Significant numbers of planners, architects and surveyors now have first or second degrees in building conservation subjects, and work in or as specialist practices. Specialist conservators, museum or university trained, may still not be numerous but are no longer difficult to find in the fields of stone, ceramics, wood, metals and glass. Developments in technology and in the understanding of traditional materials science have made resources available to investigate, analyse and record which, even half a century ago, would have been difficult to imagine.

Against this background of welcome change and development, it is sometimes hard to believe that historic fabric, perhaps especially in the form of ruined buildings, still faces substantial risks at the time of implementing works.

Directly employed specialists – the 'conservation technicians'

> *We believe the directly employed labour force has an important role to play in the repair and maintenance of our monuments. It contributes a highly skilled and experienced cadre which provides not only the core of specialised skills required for the often delicate work to our own monuments but also a reference and training source for craftsmen in the private sector. It is also useful in providing a training ground for apprentices (about 10% of the force) and technical supervisors whose work is crucial, both to the properties in care programme and to control of conservation work in the private sector which may be funded by English Heritage.*
>
> (English Heritage Corporate Plan, 1988–1992)

These acknowledgements by the principal heritage organisations in the UK of the responsibilities, duties and declaration of policies and intentions had changed little since 1911, and thus represented almost a hundred years of continuity. These initiatives and models were based, primarily, on a recognition of the value of the 'in-house' team (Figure 8.1) and the benefits to historic sites of a continuity of experience or, as an alternative, on the value of a contractor genuinely dedicated to the conservation of historic fabric training and maintaining a specialist workforce. A typical structure for an in-house workforce based on the 'ancient monuments model', with descriptions of responsibilities, is shown in Figures 8.1 and 8.2.

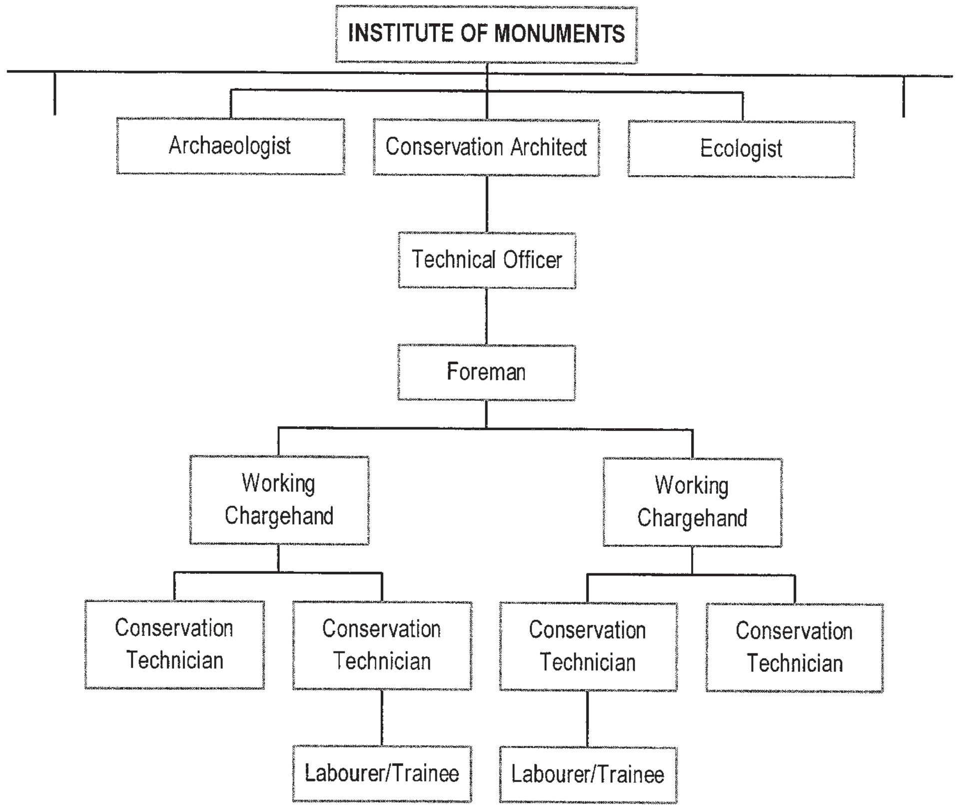

Figure 8.1 *Organisational Model. John Ashurst and Colin Burns. Reproduced by permission, the Getty Conservation Institute.*

In the early 1980s, concerns relating to the reduction in numbers of English Heritage's directly employed specialist staff and decline in work standards led to two major reviews specifically targeting ruin sites in the care of the government. The conclusion of both reviews was a confirmation of decline in resources and standards, and a recommendation that a training programme should be set up to provide the additional skills required for professional, craft and trade personnel to properly care for ruins and their sites.

English Heritage's first formal programme of training was launched in 1993 in a specifically designed facility located in one of its 'properties in care', a late nineteenth century artillery fort, Fort Brockhurst, in Hampshire. Here, for the first time, masonry 'ruins' were constructed to recreate many of the conditions found in historic sites and many of the problems encountered in their repair. Significantly, these had to be built by and under the supervision of the principal tutor, Colin Burns, who had many years of experience of real conditions on ruin sites. Thus, many common problems such as broken wall tops and wall ends, fractures, detaching facework and voided core were accurately simulated and enabled trainees to be given practical instruction in remedial works without risks to historic fabric. These 'ruinettes' became a key teaching tool in the training programmes developed at Fort Brockhurst.

The directly employed labour force of English Heritage was finally phased out after a life of some 80 years and its place taken by a privatised workforce who, after a period of five years, had to compete with other contractors to carry out works on historic ruined sites. This break in continuity rather reinforced than made redundant the need for a training centre, as many contractors with experience in the repair of historic buildings found themselves, for the first time, confronted with new problems in the form of ruined structures.

Partly due to organisational changes and new priorities the Fort Brockhurst centre closed after five years, although it remained active throughout this time. English Heritage re-established a new base

Conservation Architect	• Is reponsible to the Institute of Monuments for all works on Historic Monument sites and will make monthly and annual reports on situations and progress. • Contributes to planning and policy meetings with the Institute of Monuments. • Organises and coordinates the activities of works teams and contractors and professional consultants. • Carries out surveys of sites with consultants and is responsible for prioritising works programmes based on identified needs. • Participates in the interviewing and selection of staff for the Historic Monuments Conservation team. • Is responsible for the welfare and ongoing training of the Historic Monuments team, working with consultants as necessary. • Is responsible for ensuring that complete records are made of all work at all stages and that the records are adequately distributed. • Is responsible at local, national an international levels for communicating and promoting the work of the conservation team through presentation and publication.
Technical Officer	• Has direct responsibility to the Conservation Architect for the implementation of all the works to the required standard. • Has responsibility under the Conservation Architect for recruitment and training. • Will make annual reports on all site works and forecasts. • Will make monthly reports of activities and progress on all sites. • Will make, keep and circulate records of all site meetings. • Will be responsible for letting and management of all contracts relating to site works.
Foreman	• Has direct responsibility to the Technical Officer for the correct and safe management and execution of all works. • Will assist the Technical Officer in programming consolidation works and site maintenance. • Will be responsible for requesting and maintaining plant, equipment and materials for the works. • Will oversee the works and be responsible for the improvement and maintenance of good standards. • Will maintain a daily works diary.
Working Chargehand	• Has direct responsibility to the Foreman for the smooth running of the works. • Is responsible for site safety and welfare. • Will work to instructions issued by the Foreman. • Will be responsible for the training of conservation technicians, especially of new entrants. • Will provide ongoing training in specialised activities.
Conservation Technician	• Will take instructions from the Working Chargehand. • Will carry out basic consolidation of historic monuments and specialised activities as required under senior supervision and direction.
Labourer	• Will be responsible for mixing and transporting mortars to work stations. • Will work generally to support the Conservation Technician's activities on the site. • Will maintain the work site in a clean, tidy and safe condition.

Figure 8.2 *Job Descriptions. The organisational model as indicated in Figure 8.1 is flexible and adaptable to recession or growth. The middle and higher management levels shown create a slightly 'top-heavy' situation and in early stages of development either the Technical Officer or the Foreman posts could be omitted. As additional works units (Conservation Technician and Working Chargehand) are added, from six to ten units in number, the full management structure will be needed, especially as historic sites are geographically widespread.*

Figure 8.3 *'Ruinette' at West Dean College, Sussex, England, designed by John Ashurst and Colin Burns and built by Gerry Williams and his team. The ruinette incorporates many of the conditions found in the field, such as unstable and voided core work, detaching faces, cracked vaults and overhangs. Practitioners can gain experience in consolidation work without risk to historic fabric.*

for training by agreement with Dr David Leigh and the Trustees of the Edward James Foundation at West Dean College. This is some 50 miles east of Fort Brockhurst, where an old dairy building was converted into a training centre and new facilities including new 'ruinettes' were constructed (Figure 8.3).

The West Dean College inheritance of the English Heritage programme included the training staff from Fort Brockhurst, the two principal tutors forming an essential link through their careers with the old ancient monuments organisation and other specialist tutors in structural engineering, metals, ecology, paints and architectural surfaces.

The tutors developed programmes in ruin consolidation with specialists in other countries, including the training of a directly employed labour force to work on the largely untouched ruin sites in different locations. Notable amongst these are Cork in Ireland, under the direction of John Ludlow; the pioneer training of a similar group in Butrint in Albania, funded by the Getty Conservation Institute, working with Reshat Gega; and in Israel, the development of a team of conservators based at Masada with Asi Shalom (Figures 8.4–8.7).

The first of these two programmes was based on the tradition of ancient monuments training in the UK. The work in Israel, initially for the Israeli Nature and National Parks Authority, was more archaeologically orientated. The instigator, Asi Shalom, went on to publish a manual to encourage and inform archaeological excavators in essential procedures to record and protect sites in advance of consolidation works carried out by the architectural/archaeological conservators. All these training programmes, including a parallel one set up by Historic Scotland for its own directly employed labour force, are site orientated and relate primarily to those who carry out work on ruin sites.

Specialist contractors

It might be thought that conservation work on ruins was a simple variation on the conservation on any historic building, but there are important practical and ethical differences which need to be grasped by all the professions involved. From a practical point of view, it is often the case that the fabric being conserved was never intended as a weathering surface and there are also greater challenges ethically in trying to ensure that preservation and presentation do not become mutually exclusive.

Whether directly employed staff or specialist contractors are involved, good communication and an honest appraisal of the role of each contributor to the project are at the heart of any successful project. Depending on the ownership of the site, the source of funding and the vagaries of the client, there are going to be a number of professionals involved; it should never be forgotten that the contractor needs to be one of those professionals. Often, they are the last appointment made, but this should not preclude them from being fully briefed and included in any decisions that relate to the project. Often, in the planning and implementation of any works it is useful to include the contractor at initial concept and design stage, as they can have much to contribute from their knowledge and experience acquired on other projects, not least in terms of access, enabling works, phasing and programming. It is unfortunate that they are usually only brought in at the 'final' stages of a project once the specification and scope of works have been agreed rather than to input knowledge into the trials and investigations stage.

Once a decision has been taken to implement works on any ruin site it is beholden on the client to ensure that their appointed professionals have both the technical knowledge and experience required to oversee the project. All too frequently, this may not be the case and these professionals rely on the contractor to provide the expertise. This rarely results in a fruitful relationship and it is therefore essential that there is someone appointed to the client team who understands all aspects of the work.

Unless the relevant skills are available 'in-house' the client will need to appoint a consultant team to deliver the project, depending on the size, scope and value of the works. These consultants will generally include a project manager, architect and/or building surveyor also acting as contract administrator, quantity surveyor and structural engineer. On larger and more complex projects this team may also comprise an ecologist, services engineer and even a historic interiors specialist, amongst others.

The appointment of the specialist consultant team is as important as that of the contractor and should be as scrupulous. The process of appointment should include references and prior knowledge, site reference visits and interviews to ensure that the professionals are suitably knowledgeable and experienced. Often, client organisations secure the resources of these professionals via formal framework contracts whereby rates are agreed against certain services. This has the benefit of ensuring that there is a long-term relationship developed between the client and the consultant, and the consultants become more familiar with the buildings and properties in their care and their repair considerations. The team should be able to collaborate to achieve the desired outcomes of the project and to communicate effectively with the contractor before and during the works to achieve best quality.

A 'tight', well-defined and detailed specification and tender package will ensure that the work is carried out correctly and in the first instance is priced correctly so there are no surprises on site; any unknowns can be included as provisional sums items. Any restrictions, site constraints and time periods for attendances by members of the design team and statutory authorities should also be built in for programming and pricing purposes.

The tender documents are almost always assumed to be the crucial administrative tool that drives the project; this should indeed be the case, but only if it is a well-informed and clearly written document that conveys the full scope of the intended works. One of the main problems with conservation works on standing buildings (ruins or otherwise) is that, until full access is obtained, it is impossible to be precise about the extent of the works. This is sometimes used as an excuse to provide a tender that is woefully short of information and thus requires the contractor to take all financial risks; a project built upon such stony ground can never be a success.

It is essential therefore that the methodology is established prior to tender; this means undertaking small-scale trials and exemplars to reduce the unknowns and therefore risk, as far as practicable and possible, in terms of time, cost and quality. The importance of this part of the project cannot be underestimated. It need not be an expensive undertaking but it has big benefits to the project, enabling a detailed specification to be written and also allowing potential contractors to see what needs to be achieved in terms of quality of workmanship. In addition, it allows the client to be realistic in their perception of what they can expect at the end of a project and it will ensure a more accurate assessment of cost and programme.

Once the specification is written and drawings produced, tender documentation can be drawn up. The specification must be a clear and concise document that identifies quantities and establishes a transparent way of measuring variations. Trials should have helped significantly towards establishing those quantities but there may still be elements that cannot be measured. In such cases it is not the contractor that

Figure 8.4 *Site training with Asi Shalom's conservator team on the Byzantine Church at Masada. Stabilisation of weak surfaces and consolidation of wall heads.*

Figure 8.5 *Site training on the 'Venetian' House, Butrint, Albania. First-stage site recording and assessment.*

should be expected to estimate but rather the client's representative (usually a quantity surveyor or project manager), who establishes parameters for dealing with such imprecision. This may be by allowing for an hourly rate for the works or by allocating a provisional sum which may or may not be expended during the contract.

Tenders for a main contract should be invited from suitably skilled craftsmen and contractors with previous experience in similar sites and of historic buildings. Unless these are well known from previous projects or trusted word of mouth, references and examples of work must be sought and, if necessary, interviews should be conducted with short-listed companies. The site foreman should be in attendance at this interview so the contractor can properly demonstrate his ability to undertake the works. Pre-tender site visits should be arranged, accompanied, so that the contractor is aware of the complexities of the site. Although some authorities restrict this open tendering where all contractors are in attendance, the benefits are such that risk can be reduced from the contractor fully understanding the scope of works and questions can be asked on site and communicated to all on the tender list.

The choice of contractors who are to be invited to tender is a very crucial part of the process. Work on any historic structure requires a contractor to display a variety of skills, a depth of experience and a sound technical knowledge, as well as less tangible criteria like approach and attitude. Work on ruins tends to be less commonplace than work on roofed historic buildings and it is therefore even more crucial that these requirements are fulfilled. Regulations may exist that require a certain number of tenderers, but this number should be guided by the more important consideration of a known and proven ability to carry out the work. It is not appropriate for contractors who do not have the right experience to be included on the tender list merely to make up the required numbers. If they end up submitting the lowest tender the client or his representative is usually bound to accept this, so the project is set to fail from the outset with obvious risk to the historic fabric.

This is the general failing of many public sector organisations and local authorities which are bound by strict procurement procedures for the appointment of contractors. These procedures include government procedures such as Official Journal of the European Union (OJEU) publication, financial checks, security vetting, knowledge of previous works undertaken for the organisation or other local authorities and on the basis of approved contractors lists. Quality and skill are compromised by the need to appoint on the basis of lowest cost. These procedures are archaic and have no consideration for the conservation of the historic fabric. Tender lists often comprise contractors from an 'approved list' who have little or no experience of work on historic buildings and have been entered on the list because of success on previous general construction projects and refurbishments using modern materials and construction techniques, and because of their financial standing. There is a clear risk to historic buildings as there will be little understanding of traditional materials and methods of construction and, for instance, cement will creep into the specification, especially if the professionals involved are lacking in experience and knowledge.

Although most tender preliminaries state that the contract will not be let on least cost alone, it is often what happens and least cost seldom represents best quality. The only way quality can be assured and risk mitigated is by the carefully compiled tender list. Tenderers should be of similar size, experience and skill, so that the tender will be truly a fair exercise and tender prices will reflect this relationship; only then will the tender evaluation process be truly one of quality judged on the basis of cost, time and quality.

There is also a need for the enlightened technical officers from local authorities and public organisations to educate those in authority who are able to make decisions on procurement methods, in order that these old-fashioned approaches to tendering building works are made more flexible. This requires such measures as single tender or negotiated tender to specialist firms for certain works where specific skills or experience are required. This is preferable to inviting tenders from the specialist firm with a number of others selected solely to make up the numbers but without the relevant experience for the works in hand. This creates a difficult situation as the desired tenderer will seldom be successful or lowest tenderers, so there will be a period of negotiation with the decision-makers to approve the appointment at a higher level in order to justify public spend and increased contract sum.

Another problem affecting the quality of the tender and the work itself is the lack of sufficient professional and technical knowledge amongst client in-house teams. This translates into poorly prepared documentation or insufficient brief to the consultant team, which in turn makes for problems once the works are on site as the specification will not consider all the client's requirements. This risk will be transferred into additional cost once the project is on site and omissions are identified.

Figure 8.6 *The distorted and failing arch of a medieval flying buttress has been temporarily shuttered to its distorted profile. For it to perform satisfactorily the curvature of the arch needs to be restored but instead a muddled hybrid, partly distorted, partly 'corrected' has been created resulting in a confused assembly of new and old stones.*

Figure 8.7 *New stones are simply square blocks sawn six sides with a straight chamfer cut on two faces. Because there is no masonry involved the blocks still exhibit lash marks from the saw and a parody of tooling has been applied to the faces, even though there is no evidence of tooling on the original stones; the blocks form wedge-shaped joints and the blocks do not even line up. Some joints are imperfectly filled, and lime stains the surface of the stones.*

Lack of experience, confidence, team organisation, masonry skills, supervision and the absence of any trials or exemplars have damaging, long term impacts on historic sites; ideally, it should not be possible for work of this quality to be carried out on a national historic monument. This situation is never the fault of one individual but of a system which permits it to happen and which may not even recognise the damage it has done.

In order to ensure the correct choice of contractor, a certain amount of flexibility may be appropriate, even perhaps in deciding that one contractor does not have the ability to carry out all the work and therefore that named subcontractors would be required. It is the role of the client or their representative to interpret the requirements of the project and to ensure a flexible approach is adopted.

Selection of a contractor for the tender list cannot be done by simply issuing a pre-qualification questionnaire asking probing questions on relevant skills and experience, programming and resourcing. It needs to be a far more inclusive process and should normally involve a discussion or interview of potential contractors prior to short-listing. This ensures that the relevant experience is discussed. All of the client team should be involved, and the contractor should be asked to give their view on the nature of the works and encouraged to discuss practical and ethical issues. This then establishes at an early stage the spirit of good communication and mutual trust which has to play such an important part in the project as a whole. The proposed site manager should also be invited to attend the interview as well as any pre-contract meetings, as it will provide a forum to ensure that they fully understand the complexities of the contract.

Crucially also the contractor needs to demonstrate an understanding and experience of the special requirements for the conservation of ruins. It is not necessary that all of their site personnel should have hands-on experience of all the techniques required, but it is imperative that there are craftsmen and conservators on the team who have carried out these tasks and are able to train and educate others during the project. It is also crucial that all the team have experience in the use of traditional materials to be used, such as lime putty and hydraulic lime mortars, and that the contractor is honest about their experience and is willing to bring attention to any areas where they lack experience. This weakness can then be addressed, perhaps by the involvement of a subcontractor.

The pre-tender interview also gives an opportunity to convey how the project would be organised from the client's point of view and to establish how the contractor would propose to manage the project. It is not always sufficient that CVs of key personnel should be presented. The client needs to be completely confident that the project director will be fully engaged in the project, and that the site manager and senior craftsmen have the experience and vision to understand the complexities of the project, including historic context.

In addition to the necessary skills and experience, the use of correct materials underpins any work on ruins. The fact that the ruin has come to its current state may be due to inappropriate materials used in the original construction or, more often, poor subsequent maintenance and repair. Any material is only as good as the person using it, so that training in the use of the material is essential. Theory and technical background are useful, but it is practical experience that is most important. This can be taught in a formal environment to a certain extent, but is only fully learnt by using the material repeatedly in a real situation. Only through site experience can the nature and working characteristics of any material be fully understood and a confident versatility in its use be acquired.

Another factor in mitigating risk is effective site supervision from a competent site foreman, who fully understands the requirements of the specification, the complexities of the site, site constraints, and is knowledgeable enough to stop work if new elements are discovered on site and to consult the architect/project manager immediately. The contractor and foreman must be able to work with the professional team and other contractors on site, including liaison with directly procured contractors.

This site knowledge is where apprenticeship schemes can benefit as long as cheap resources are not used to fund conservation works and delays are not experienced due to lengthy training periods. Obviously, the importance of any historic building is such that it should not be used as a playground for inexperienced craftsmen to develop their skills. The very best way is for a contractor to ensure that a team of people on site are organised so that a less experienced individual works alongside somebody with the requisite skills – an informal, site-based, short-term apprenticeship. The use of lime mortars, for instance, is not overly complex and the necessary skills can be developed quite quickly as long as the trainee has the correct attitude to want to learn and the desire to apply what they have learnt.

The successful implementation of works is not a matter for one individual or for a contractor, but instead it is a pooling of professional knowledge and skills through mutual respect between everybody involved.

A major problem in all public organisations is the inherent lack of desire to make a decision; this is the limiting factor in the improvement to existing tender procedures. Individuals do not feel sufficiently empowered to change problems that are contributing to the flaws in many conservation projects.

A lack of decision-making results in a lack of action and/or loss of the historic fabric by this inaction.

Thus, it is essential that the professionals involved are suitably experienced and can convey the full scope of works in the tender documentation. Trials may be undertaken prior to tender to establish the basic methodology and provide guidance for the tender process. It must also be established that the contractors on the tender list are suitably trained and experienced in works on historic buildings. The specification must be clear and concise to avoid risk and to ensure greater cost certainty.

In order to ensure as far as practicable the (client) requirements of time, cost and quality in any project works to historic buildings and sites, a stringent pre-tender process must be developed. In the preliminary stages trials and exemplars can be undertaken in order that more information is available on methodology, standards of workmanship, and level and scope of repair. As well as providing vital information on methods and quality, which will be fed into the technical specification, it also provides essential information on costs and timescales for each element of the work, which gives greater client certainty with regard to budget and programme, as well as aesthetics and quality.

Trials and exemplars will also be necessary as part of the statutory approvals process, during which conservation officers and EH Inspectors will want to inspect trials relating to the proposed works such as cleaning trials, mortar samples, replacement stones and scope of repair. This information will feed into the tender process and will ensure that the specification is sufficiently detailed and as 'tight' as possible to ensure that there is greater cost certainty at tender stage, and bids are therefore realistic and accurate. This will also mean that provisional sums are not relied upon for unknown elements and all risk is not transferred to the contractor, with the resultant hike in tender prices for vagueness and unknown items.

Another element of ensuring best quality is by allowing suitable timescales for tender periods. So often tenders are invited late into the client programme, so tender periods are reduced to achieve the desired contract start and completion deadlines. There is inherent risk in shortened tender periods as tendering contractors and their subcontractors will not have adequate time in order to read through and fully understand the requirements of the specification and undertake site visits to ascertain a best estimate for the works. Tender periods should be gauged according to the complexity of the contract, quantity of tender documentation and specialist nature of the works involved, so that the contractor can be offered a sufficient period of time to prepare the tender return and supplementary information required by the tender. This will ensure as far as possible that the tenders returned are realistic and accurate rather than rushed, and priced accordingly to cover this risk and assumptions made. In addition, a shorter tender period will result in a general lack of understanding that will become apparent once works are on site. This in turn may result in a higher percentage of professional fees being invoked by the requirement for additional attendances on site.

The tender list should be compiled from contractors who are sufficiently experienced and knowledgeable in the requirements of the project. Contractors should be of similar experience and size so that it is indeed a fair process. Contractor selection should be on the basis of references, site visits, prior knowledge, questionnaires and interviews. This may seem like a rigorous process, but it is necessary to ensure best quality and reduced risk of damage to the building by lack of knowledge and supervision. At pre-contract stage it is important that the CVs of all those involved are submitted with the tender and these personnel attend all relevant meetings, including the selection for tender list. This should include the site foreman, who should be a competent person suitably experienced in the requirements of the project and of running sites of similar values and scope. This foreman should be fully conversant with the specification and should be able to communicate this to all site personnel as necessary, as well as any variations as the contract progresses. The foreman should be in attendance at all progress meetings to discuss any variations or logistical issues arising.

Conclusion

> *Our principal and inter-related policy aims for the properties in our care are: to conserve the fabric of the properties to the highest standard … to maintain, enhance and promulgate knowledge in its (English Heritage's) conservation works and to set standards for others.*
>
> (English Heritage Corporate Plan, 1988–1992, Item 3.1)

A mission statement of this kind, from a key heritage organisation, underlines the fundamental principles relating to the training, implementation and management of conservation works to historic buildings and sites. As discussed within the chapter, by creation of specialist in-house teams, careful selection of contractors, site supervision, ongoing training, and

Figure 8.8 *With no common language, communication on site is the only kind of communication. Colin Burns and Mohammed exchange tobacco, Masada, Israel.*

development of professionals and site personnel, standards can be set for conservation works of the highest quality to be undertaken on historic sites. But the achievement and maintenance of these standards require expenditure of money and time, not once but constantly. Without the recognition that specifically designed training is essential for all personnel involved, from labourer to director, and that all personnel have an understanding of their responsibilities to the historic fabric, successful conservation will remain elusive, sometimes fatally so for ruins.

Unwelcome Visitors. Abandoned and neglected sites are always at risk from unwelcome visitors who, in ignorance, show no respect or enjoyment of the ruins. Vandalism in the form of graffiti, dislodging of stones and removal of material from the site is a common experience. Photograph Asi Shalom.

Chapter 9

Interpretation and display of ruins and sites

Amanda White

This chapter explores the impacts of (human) visitors on ruined sites. It also examines the presentation (display) and interpretation of these sites. Although the main focus is on English practice at historic ruined sites the principles have a wider resonance.

Tourism and conservation: conflict or harmony?

Tourism of all kinds, whether mass tourism for pleasure, business or conference tourism, is one of the world's largest industries and is perhaps its largest growth industry. Tourism is likely to be here to stay and its sheer scale and associated gross expenditure are of considerable economic importance at national and local levels.

Tourist numbers are increasing year on year and ever more remote parts of the world, some with particularly fragile and vulnerable remains, are becoming accessible to large numbers of visitors for the first time. As visitor opportunities increase, so do the complexity and variety of threats to visited sites. The challenge posed to those responsible for the protection of sites and to those with a vested interest in their care is to develop collaborative management strategies to make the most of their potential and to anticipate and plan to minimise risks.

Long-term strategies must be sustainable. For instance, visitor numbers must not be permitted to exceed sustainable levels; profits generated from entrance fees and retail opportunities must be reinvested; fabric, flora and fauna must be protected and cared for, and educational opportunities raised.

Sustainable tourism

Ruined buildings and structures are unique, irreplaceable resources. All face multiple threats to their continuing existence and, if their historic value and integrity are not to diminish with the passing of time, long-term sustainable visitor management strategies are required. Strategies must maximise the positive benefits that visitors can bring to sites and mitigate, as far as practicably possible, negative aspects.

Our heritage of ruins represents a huge legacy of information, craftsmanship, design, energy and materials, and this must be protected against depreciation if the labours of our ancestors and the benefits we derive from sites are to be preserved. Those charged with the care of ruined sites must recognise and take account of environmental, social and economic factors when making decisions, and must consider the impacts of these factors on the sites and demonstrate accountability for the consequences of their decisions.

The type and number of people visiting a ruined monument should somehow be compatible with its character and needs if a sustainable balance between tourism and conservation is to be realised. All sites, whatever their type, have a finite capacity to absorb visitors. Unfortunately, though saturation is undesirable for both visitors and sites, the tourist market is highly lucrative and the approach to tourism is too often demand-orientated rather than supply-led. A supply-led (inward-looking) approach is based on the desired number of visitors who can comfortably be absorbed by a site and is always going to be preferable to an outward-looking approach, which only considers what visitors would like or can be persuaded to like. A 'comfortable' rather than absolute capacity of sites to absorb visitors should be the basis for everything else, such as the marketing policy, visitor facilities and interpretation of the site.

When considering the capacity of sites to receive visitors, their 'sense of place' and the impact of visitors upon them must be the principal considerations. They should be used intelligently to develop responsible proposals if visitor type and numbers are to be matched with the resource and if future tourism objectives are to be secured.

Visitors to ruined monuments are to be welcomed and encouraged, but excessive numbers and unwelcome visitor types can have undesirable, sometimes irreversible, effects on their long-term preservation.

Visitor numbers

Ruins may be categorised as attracting many, few or no visitors. Sites visited by the very few or by no visitors at all are usually neglected, and are generally found in particularly remote, often inhospitable, locations. Monuments can range from little more than piles of stones to the substantial remains of what were once large and complex buildings or groups of buildings. The rather inaccessible isolated desert and jungle sites of parts of the Middle East and South America respectively are examples of rarely visited sites. They are perhaps only of interest to national bodies and the most determined of scholars, unofficial archaeologists and/or looters.

Sites receiving modest numbers of visitors are often secluded though relatively more accessible, or they may have limited visual appeal, or be located in unattractive urban settings. There is commonly little to see beyond the ruined fabric and they are frequently unstaffed and free to enter. Visitors are generally drawn from home markets, with most living within an hour's travelling distance.

At the other extreme, well-visited sites include iconic, internationally renowned and well-publicised 'must see' monuments such as the Colosseum, Italy, the great Pyramids of Egypt and Stonehenge, England. They are located on principal tourist routes, can command substantial entrance fees, and are often supported by a wealth of visitor facilities and interpretation.

Visitor type

As regards type, visitors may simply be considered as desirable or undesirable. Desirable visitors comprise curiosity seekers who perhaps know very little of a site, its past occupants or associated events but are interested to learn and/or experience more; those with a serious interest in studying the physical fabric, flora and/or fauna of a site; those who value a site's 'sense of place' and are keen to experience it; those with little or no interest in a site beyond the prestige that comes with attending a function or event; and those who visit a site purely to take advantage of its associated facilities. The latter, if they appreciate a ruin resource at all, perhaps value it merely as a pleasant backdrop to a drink, meal or retail opportunity.

Undesirable visitors include looters and 'unofficial archaeologists', especially those equipped with metal detectors, who want nothing more than to take from monuments for personal gain, and vandals who want to damage and disfigure as an aspect of general antisocial behaviour or even for making political statements.

Visitor impact

Visitors can impact both positively and negatively on ruined sites and their environments, and the scale and severity of impacts will vary according to the type and number of visitors. The benefits and risks to neglected, seldom visited sites are both moderate. Whilst physical impact is generally negligible, such sites are often infrequently, if at all, inspected or maintained and, as such, can deteriorate unnoticed. Neglected sites have no capacity to generate income and there is little, if any, desire or capital to invest in them.

Sites of low visitor appeal are commonly unstaffed and free to enter. The benefits to the fabric of such ruins are low as there is no or little income-generating potential and the risks to the monument can be very great; poorly visited sites can attract the unwelcome attention of vandals, looters and 'unofficial archaeologists'. The actions of such visitors can go unchecked for lengthy periods between inspection cycles. The knock-on effect is that a lack of care can encourage further abuse, as subsequent visitors think it acceptable to follow suit by, for example, adding to existing graffiti or by taking small archaeological fragments as souvenirs.

Well-visited ruin sites can offer substantial scope in terms of their use and thus have huge income-generating potential. Sites can have a wide variety of uses, including exhibition; education and training; retail, catering and other commercial uses; worship and/or ritual; functions and events; storage; workshops and grazing purposes. Heavily or intensely visited sites can result in unacceptable deterioration and/or damage to vulnerable surfaces, environments and habitats. Wear and tear from visitors must not be permitted to erode the integrity of sites: a sustainable level and complexity of use must be observed whereby the risk to fabric, especially to primary fabric, and protected flora and fauna is minimal. While the benefit to fabric can be high, this must be balanced against the very high risks that large numbers of visitors pose as they challenge and test ruined sites to their limits.

Exploitation of ruins

More and more site operators are seeking to maximise the income-generating and educational potential of ruined sites in order to secure their long-term viability. There can be great scope to improve day visitor business and to exploit other commercial opportunities such as weddings, parties, corporate functions and seminars at many sites. As operators seek out new markets and try to improve their existing market share, sites are increasingly being developed to provide an array of tempting services and facilities. Though business and financial successes must not be the key objectives, investment in sites can bring economic success and provide opportunities for reinvestment which might otherwise not be possible. Whilst a degree of investment is welcome it must always be carefully balanced with non-commercial objectives.

Presentation of ruins

It perhaps goes without saying that the appeal of sites and the expectations of visitors are inextricably linked, and the presentation of physical fabric is, for most, the greatest draw. Due to their inherent defining nature, that of incompleteness, ruined sites (and their settings), particularly those where substantial parts have been lost or are masked by fallen masonry and shrouded in vegetation, can be confusing to understand. The development of sites can be difficult to determine with any certainty. This is particularly the case where documentary evidence is lacking and where similar materials, workmanship and/or architectural styles have been used for different phases of work; where buildings evolved in a complex or protracted manner; or where ancient fabric was reworked during construction, alteration or improvement.

So how are ruins to be understood by those that care to confront them? There are two ways: the study of tangible fabric and by reference to written records. Some 'tidying up' can often assist a visitor's understanding by revealing more of what remains, but it can be damaging to fabric, upset a site's delicately balanced ecosystem and, at worst, add to confusion by posing more questions than it answers. Insofar as written records are concerned, these can sometimes be fragmentary, if not lost altogether. Our earliest ruined monuments, those erected before written accounts, are usually the most difficult to understand.

Those responsible for the preservation of ruins have, therefore, another fundamental objective. In addition to the securing of fabric they must try to make ruins intelligible to visitors. As our understanding of ruined structures can only ever be partial, their physical display will always be problematic. Intelligibility is the prerequisite and a piecemeal approach must be avoided if sites are to be presented in a meaningful and holistic manner.

The objective of presenting a site, ruined or otherwise, must be to portray it in its correct and full documentary and historic context insofar as it is understood and possible to do so. Presentation policies must therefore be site specific and take account of, respect and achieve a balance between all values (emotional, symbolic, cultural, environmental and use – past and future) attached to or inherent in fabric, and clearly define its messages if visitors are to understand, learn from and enjoy these sites.

In the UK we have a long history of preserving and displaying ruins, and various approaches have been followed. Historically, methods typically came and went with fashion and as such we come now to a rich inheritance of variably treated ruin sites' fabric. Some approaches have proved more successful than others in preserving and rendering fabric intelligible to visitors and much has been learnt. Whilst some ideas would be considered unethical if adopted at virgin sites today, others currently being debated are perhaps little, if any, better in terms of the potential for loss.

The objective of physical presentation must, in addition to being authentic in all respects (design, materials, workmanship and so on), be determined by the particular nature of a site and its individual setting. These are the most important considerations for those who manage sites and they should always be the guiding factor.

Picturesque display

The picturesque display of ruined structures, whilst no longer common, is perhaps the oldest method of presenting ruins. Ruined monuments, much appreciated for their time-worn and weathered surfaces, were quite deliberately arranged in their settings during the eighteenth and nineteenth centuries. The objective was to create a series of pictures from multiple viewing points, a contrivance which could often be far from natural. Natural features were often rearranged to enhance the overall effect of a scheme; hills were raised or levelled and streams and lakes created as required. In some cases artificial ruins were constructed as 'eye-catchers' and focal points. There was little regard for the preservation of ruins; they were merely playthings and no doubt many suffered from selective demolition to 'improve' the romance of their silhouette.

Figure 9.1 *Roche Abbey, Yorkshire in the 1970s showing the use of closely mown grass as a context for the ruins, 'conserved as found'. This became the presentation house style of the Office of Works and its successors for many decades (photograph: J. Ashurst).*

Whilst the picturesque landscaped gardens of Stowe, Buckinghamshire and Stourhead, Wiltshire typify the fashion of the day, the ruins of Fountains Abbey in Yorkshire dominate what is arguably the most important eighteenth century water garden to survive in England. Though the garden is still much as it was conceived, it is today presented in a tidied up fashion. Jervaulx Abbey, Fountain's close neighbour, is one of only a handful of ruins to retain the picturesque qualities for which it was admired. A thick natural grass thatch and an abundance of wildflowers cover its ruined walls, and seemingly untamed trees, plants and grasses soften its setting and give the impression of walls rising from the land as if they were one (Figure 9.2).

Restoration: presentation by wholeness

The presentation of wholeness by restoration – that is, the alteration of a building or part of a building 'which has decayed, been lost or damaged or is thought to have been inappropriately repaired or altered in the past, the objective of which is to make it conform again to its design or appearance at a previous date'[1] – is a long-established means of displaying ruins. Though the approach fell from favour in the late nineteenth century, it is again becoming popular as a means of presentation.

As ruined walls inevitably and exponentially deteriorate with time, the restoration of ruined monuments for beneficial reuse is a much more logical and perhaps understandable objective than that of conserving them 'as found'. However, as 'The accuracy of any restoration depends on the extent to which the original design or appearance at a previous date is known, or can be established',[1] restoration must be carefully considered if it is not to detract from, impact upon or confuse a structure's wholeness and message.

Though each case for restoration must be assessed on its own merits, it should perhaps only ever be followed where monuments are complete enough to allow authentic restoration without unacceptable loss or distortion of evidence or conjecture. It should always be avoided where a ruin's aesthetic values are reinforced by the scenic value of its existing state and its setting, particularly where they have been a significant source of artistic inspiration.

Restoration can provide a clear and informative message to visitors and can afford other positive benefits, such as providing greater or improved access, improved or new views and an appreciation of original spatial qualities. But it can also be problematic, not least selecting the moment in a monument's history when restoration should take place. Ruined monuments are typically restored to their defining

Figure 9.2 *A thick carpet of wild flowers and grasses cap the ruined walls of Jervaulx Abbey (Yorkshire) in a striking picturesque display.*

period but, even if this is clear, this can lead to great debate and disagreement between even the most eminent of scholars.[2]

Restoration always carries the risk of inaccurate interpretation and can, even when accurately and carefully carried out, unavoidably confuse original and contemporary 'reproduced' material. It also carries the associated consequential risk of significant irreversible archaeological loss or distortion and structural damage which sadly comes with any work on an historic structure.

Anastylosis

Anastylosis is the name given to the process of rebuilding the remains of collapsed structures in their original positions and it is common practice in parts of the world prone to devastating earthquakes or having suffered conflict (Figures 9.4 and 9.5). Elsewhere, anastylosis is always difficult to justify, but a strong case can sometimes be made for partial rebuilding at sites catering for a broad, often international, audience of mixed visitor type. Here the re-erection of minimal fabric, a few well chosen significant features, should normally suffice to provide visitors, particularly those not able or prepared to make the concerted effort required for an understanding, with an appreciation of their original spatial qualities, form and purpose.

Reconstruction

Reconstruction, or the 're-establishment of what occurred or what existed in the past, on the basis of documentary or physical evidence',[1] can only be justified as a means of presenting ruins if undertaken on the basis of thorough research of the original. Like anastylosis, reconstruction is today most commonly associated with monuments ruined as a result of conflict or natural disaster. In reconstruction, ruined monuments are reconstructed to their prior existing form and detail in their original location so that they might fulfil their pre-existing function.

Reconstruction was common in the closing decades of the nineteenth and early years of the twentieth centuries (and is now experiencing something of a renaissance). Lost parts of buildings were typically reconstructed, sometimes completely for domestic rehabilitation. More commonly, low stone walls were typically constructed on original stone footings and finished using different techniques to distinguish between different building phases. Muchelney Abbey in Somerset was one of many ruined guardianship sites to be treated in this way; low walls containing some original material were constructed on medieval remains, twelfth century remains were finished with level tops and later material was rough-racked (Figure 9.3).

Reconstruction can be successful if the strength of evidence is good and if appropriately carried out. At Muchelney, the twentieth century treatment of ruined walls oversimplifies the development of the buildings, which is now known to have been protracted and complex and, to compound matters, they are no longer considered accurate. The earlier picturesque treatment of ruined walls at Jervaulx has perhaps been more successful, as carved, moulded and other displaced worked stones were merely stacked along the lines of pre-existing walls close to where they were discovered. Though the practice was unscientific by modern standards, the randomly stacked dry-stone walls clearly indicate the past location of missing walls whilst making no pretence to be anything other than what they are – randomly piled stones.

Figure 9.3 *(a) An example of 'rough racking', a favoured treatment by the Ministry of Works (UK) in the first half of the twentieth century for broken wall ends and heads, used selectively at Muchelney Abbey to denote post twelfth century work.*

Special cases for reconstruction can sometimes be made on safety grounds. Whilst low, ruinous walls can readily define the plan of a site they can, especially where particularly low, be trip hazards and, where taller, hide considerable and hazardous drops. It is not acceptable to ignore such risks to visitor safety and the raising of ruined walls, based on sound archaeological research and interpreted in a distinguishing manner, can be more aesthetically pleasing than the erection of a more conventional physical barrier.

Conservation 'as found': ruins 'as evidence'

Conserving ruins 'as found' is, at face value, a profoundly illogical pursuit. Buildings and structures survive by being kept complete – that is, because they are not ruins. Even so, ruins are important to us, and there is a long history of valuing, conserving, presenting and enjoying them.

The 'conserve as found' approach was common in the UK from the early twentieth century and was championed by the Office of Works and its successors for a period of approximately 70 years. During this time many hundreds of very large and complex virgin sites were conserved using what were then largely experimental conservation techniques. The approach was principally concerned with structural matters and archaeology, and sought to 'freeze' masonry at a point in time in its 'as found' condition by revealing as much original fabric as possible (see Chapter 4). Ruined fabric was 'retrieved' by the removal of later additions, fallen masonry and 'damaging' vegetation, and a standard range of consolidation techniques was used to arrest decay. Monuments were set off by closely mown grass and formal paths so that their primary 'evidence' might be displayed to maximum effect. Though the approach resulted in a high degree of similarity between sites and an attendant sad air of civic, almost clinical, austerity, it has been highly influential elsewhere in the world and continues to shape contemporary attitudes (Figure 9.1).

Deliberate ruination

An approach of deliberate or planned ruination of sites was sometimes adopted during the mid-twentieth century, where buildings were deemed to have come to the end of their viable lives and where their cultural values were thought insufficient to justify the expense of maintenance and reuse. In a period

Figure 9.3 *(b) The use of different forms of masonry consolidation and capping at Muchelney Abbey to distinguish between building phases of construction illustrating another early house style of presentation (see page 251).*

Figure 9.4 *The excavated site at Beth Shean, Israel showing limestone columns lying on the basalt-paved shopping street, as they have been since the town was largely destroyed by earthquake (photograph: J. Ashurst).*

Figure 9.5 *Anastylosis at Beth Shean, with re-erected columns recovered from their fallen positions in the street below (but see comments in Chapter 1, page 23, on Tall elements repaired with reinforcing rods set in resin).*

during which houses were being 'lost' at a rate of one every two and a half days, an alternative approach was to record them, then to divest them of their roofs, services, woodwork and other perishable contents in a misguided bid to reduce maintenance costs. The objectives were to remove all material liable to decay and to leave masonry walls and their openings intact, and to weather newly exposed wall tops and voids (such as beam sockets) as required. Following a serious fire at Witley Court, Worcestershire, in 1937, surviving parts of the former Edwardian Mansion, having survived calls for demolition in the 1960s, were treated in this manner.

Conservation 'as found': 'verdant' ruins

Whilst much vegetation is still routinely removed from ruined walls and their settings are neatly manicured and vigorously weeded, there is a growing view that many plants may be benign, rather than destructive, and that some might even be protective. This view, combined with an increased understanding and valuing of wider ecological issues and a greater appreciation of a ruin's 'sense of place', has led to a growing interest in the 'verdant' or green approach to presentation.

A verdant approach manages all facets of a ruined site and is still quite rare. It involves the absolute minimum of fabric conservation, sufficient to make the monument safe and to slow its rate of deterioration, and the divesting of destructive woody growth only. Its principal objective is to preserve, if not enhance, the natural and fragile ecology of a monument and its surroundings. The pioneering approach was successfully followed at Wigmore Castle, Herefordshire, during the early 1990s following its acquisition by the state and has generated much interest.

The approach is still relatively embryonic but lessons are already being learned. At Wigmore, the removal of dense, formerly protective vegetation to facilitate essential conservation works is, in some places, having a deleterious effect on masonry; areas of previously stable but hidden mudstone are deteriorating, some stones at an alarming rate. On the positive side, the approach, in striking a balance between the ruined fabric and nature, retains the spirit and challenges of the site for those who care to appreciate them. It is significantly less theatrical than the picturesque approach but offers, in common with it, a charm and sense of continuity that is sometimes missing at traditionally presented sites.

Managed decline

Perhaps the most controversial and somewhat sinister approach to presenting ruined structures is that of managed decline, a course of action that allows a ruin to safely follow its natural path to destruction. This option involves archaeological recording, monitoring, control of vegetation, making safe by the progressive removal of areas of fabric liable to collapse or likely to fail and fall in a fragmentary way with lethal potential.

Whether a 'letting go and making safe' policy should ever take precedence over the preservation of ancient fabric is a delicate point. The adoption of such a policy, however necessary for economic reasons, has such serious ultimate consequences in terms of cultural loss that it should only be determined at national level. Its message, were it to be adopted or sanctioned by a state body, would be far reaching and would not go unheeded by those who perceive present levels of preservation to be unjustified.

Benign neglect

Benign neglect falls somewhere between planned ruination and managed decline insofar as roofed buildings are 'allowed' to decline in a managed way. They are not helped along their way as in planned ruination but the end result is much the same – that of irretrievable loss. The Defence Estates (the MOD) have recently adopted such an approach, in agreement with English Heritage, at selected bomb stores at RAF Scampton.

Replication

Replication offers perhaps the greatest hope for the long-term survival of our most fragile ruins, which perhaps would benefit from not being visited at all. Shackleton's Hut in Antarctica and Easter Island are two sites that would undoubtedly be better unvisited than be destroyed by tourist development. The use of facsimiles is rare but includes replica sculptures in Florence and reproduction caves in Altimara, Spain and in Lascaux, France.

Interpretation of messages

As their once completed forms cannot be experienced, ruined structures and their true significance can perhaps never be properly understood. Interpretation, whether in the form of official guides and the like or by the transmission of stories, can aid the understanding of tangible remains.

Ruined (and non-ruined) historic fabric is physical history and provides, by its very being, actual links to the past. Ruined fabric is what remains of our ancestors' past endeavours, and gives clues to the lives once lived and to events that took place in and around them. Whilst their study can do much to illuminate history, ruined monuments have great educational potential; lessons in history, art and architecture, societal and cultural development and conflict can be explored. But it is not possible to present the whole story of a ruin solely by reference to the physical remains.

The interpretation of stories provides a means of conveying more of a monument's past. It can take many forms, including: simple printed leaflets; lavishly produced illustrated guides and histories; plans showing phased development and models, tactile or otherwise; graphic panels; exhibitions of related artefacts; knowledgeable guides with a command of multiple languages; audio tours; virtual reality and interactive television; costumed interpreters, re-enactments of historic events and *son et lumière* (dramatised spoken history accompanied by spectacular lighting effects).

The history of a monument is always best explained at its site and the provision of interpretation is an important aspect of managing tourism. Of course, it must be based upon thorough scholarly and accurate research and, if it is to be successful, it must inform visitors of something worthwhile and add to their understanding and enjoyment of sites. Though the level and sophistication of interpretation will depend on the breadth of a site's appeal and its popularity, at a minimum it should explain a building's pre-ruinous state and the cause of its ruination. Sites of broad appeal, certainly those of international interest, require particularly careful handling and demand considerable resources if all visitors are to understand their significance and experience all that they have to offer.

Successful modern approaches to interpretation encompass all phases of a monument's history and include details of its most recent, post-ruinous past, the objective being to provide visitors with the fullest understanding of a monument's story. This is a departure from the more traditional, quite selective approach in the UK, which focused on a particular time in the life of the pre-ruined building (typically its earliest, defining or grandest phase).

Interpretation is often undeveloped and under-resourced, so that visitors are poorly informed or, at worst, manipulated in a particular direction so that the complex nature and messages of a site are missed. Visitors who remain uninformed are often understandably disappointed with their experience, and may be frustrated and develop negative attitudes to the site and its continuing survival, especially those who have travelled long distances and paid entrance fees.

The same may be the case where interpretation is overdone. Assailing the visitor with audio-visual facilities of all kinds can be intrusive to those whose main interests are archaeological or historical, and to those who visit sites principally to enjoy and appreciate their spirit, sense of place and tranquillity. Clever 'living' interpretation is perhaps interpretation at its most extreme – glamorised and neatly packaged history for mass consumption. The problem of such packaging is that, if too heavy-handed, it can become the dominant resource, relegating the site to a pleasant backdrop and destroying its integrity, insulating the visitor from any real sense of the past.

The educational value of many ruined sites is huge, and their interpretation and presentation must be recognised as a responsibility of the custodian to the visitor rather than a means of drawing greater numbers of visitors to a series of 'attractions', which is too often the trigger for providing or improving interpretation.

Visitor services: expectancies and impacts

In a highly competitive market where visitor expectations are high, the provision of a wide range of visitor services is almost a prerequisite. The extent and scope of services is determined by visitor numbers and type, the ability and appropriateness of a site to accommodate them, the willingness and ability of a monument owner or guardian to invest in them, and ultimately of visitors to pay for them.

Access

Access to the location and around ruined sites are quite different matters but can be addressed together here. Whilst entry to and access around ruined sites should ideally mirror the original in order that visitors might better appreciate them, access has often been much altered since ruination. Though visitors may originally have approached sites along routes designed for defence or formal drives or landscaped parks, ruins, having been divorced from their surroundings or encroached upon by subsequent development, are often approached rather abruptly and illogically. This is commonly the case for many sites in state guardianship, where boundaries were often tightly drawn around monuments.

Though little can often be done to overcome losses, original approaches can sometimes be successfully restored and this should always be the aim where possible. Similarly, where gatehouses, successive courtyards and so forth have disappeared it is also important that visitors understand and follow the original progression around monuments if they are to be properly understood and their context maintained.

The disappearance of perishable elements, such as wooden bridges, floors and stairs, can cause both practical and intellectual problems. The provision of such items, particularly bridges over moats and ditches, is often essential for access and to aid intelligibility. Where restored, construction should ideally be unmistakably modern in design, but of materials sympathetic with what may originally have been used (Figure 9.6).

Local access to sites from further afield can be more problematic. Remotely located sites such as Dunstanburgh Castle (Figure 9.11) can be difficult to reach except by the most able and determined. This can benefit fragile sites by protecting them from heavy traffic, but as conservation awareness and, in turn, financial support increase with accessibility, limited access can have negative impacts too.

Where there is a need to introduce roads or paths, the aim must always be to guide visitors to and around sites by the most sustainable and least interventive and intrusive means. Focal points and pinch points such as gateways and popular routes are particularly sensitive to wear, and due account must be taken of them if the integrity of sites is not to be diminished through direct erosion.

Access can be altered or modified to benefit the site by removing pressure from key points or by reducing them to manageable levels. This is achieved either by altering the pattern of use by re-routing visitors or by improving the wearing quality of surfaces. Paths at Hadrian's Wall had, for years, followed the line of the wall, and heavy use by walkers had begun to expose and erode its foundations. The redirection of paths away from sensitive areas has

Figure 9.6 *One of two sympathetic, though distinctly modern, oak bridges constructed at Helmsley Castle in Yorkshire. With much timber fabric having long since perished, the use of oak goes some way to redress the masonry: timber balance.*

significantly improved the preservation and setting of the monument.

Facilities and infrastructure

Sites attract visitors and economic opportunities are created by the demand for facilities and infrastructure to cater for them. Visitor facilities are increasingly a prerequisite at popular ruined sites and the rise in tourism can put services for visitors in conflict with the care of sites if not sensitively handled. Where consideration is being given to their provision, they must be appropriate to, and influenced by, their surroundings in terms of design, scale, material and location. New buildings should be soundly constructed and designed for a long life, and be capable of alteration or extension as necessary to cater for future needs. Standards of design should be high and materials should be sustainable, durable and selected to enhance, though not necessarily match or be finished in replication of the originals.

Facilities should be located in areas of least fragility and archaeological disturbance kept to an absolute minimum. They should complement rather than detract from monuments and should age well and weather comfortably in their settings. The proximity of facilities to historic fabric can be offensive and excessive; poorly planned, badly designed or insensitively located facilities have a seriously adverse impact on the significance of features, ecological characteristics and an enjoyment of the site (Figure 9.8).

Where facilities are to be inserted within a monument, new work must respect the significance and sensitive nature of fabric and installations must be carried out in an appropriate and compatible manner if fabric loss and the risk of problems occurring at the interface of the old and new are to be avoided. It is important that account be taken of past and intended future use, minimal intervention and reversibility.

The use of uniform or generic corporate facilities are often best avoided, no matter how attractive they might seem in terms of cost. Though the relatively ephemeral nature of such accommodation can be positive, implying a transitory nature, new buildings must be unique or at least distinctive if they are to play their part in the attractiveness of sites; contemporary good design will, after all, be the heritage of tomorrow. On a cautious note, fanciful,

Figure 9.7 *Helmsley Castle's new visitor centre was sensitively designed and sited and makes a positive contribution to the historic site.*

Figure 9.8 *The proximity of services, such as portable toilets, to historic fabric can have a seriously adverse effect on enjoyment of a site.*

self-conscious buildings can lead to quite unhappy results.

Servicing sites

Power and lighting along with signage and, in some cases, security measures can be necessary at ruined sites. Each has a job to do, but each can detract from the character of a monument if poorly or inappropriately designed. It goes without saying that, as for any intervention, the most successful schemes are those which have least interventive and visual impact on fabric.

Power

Whilst most ruined monuments require very little in the way of electric power beyond perhaps some basic lighting, modern legislative requirements can be onerous and difficult to meet where visitor facilities are provided.

Many ruin sites, particularly those in isolated locations, have no modern power supply (having been heated by coal or perhaps gas during their pre-ruinous phase) and some have no service provision of any kind whatsoever. Where mains servicing is required but is prohibitive for reasons of archaeological sensitivity or cost, imaginative responses are needed if today's mandatory standards for human comfort (minimum temperatures, etc.) and energy efficiency levels are to be met (Figures 9.9 and 9.10).

When servicing sites, careful thought must be given to the location of plant and service routes. Modern services, having an expected life of 20 or so years, are transitory when compared to historic fabric, so reversibility and minimal intervention must dictate the nature of the installation if the special character of sites is to be preserved; no scars should be left as and when renewed or replaced, and holes and chases for pipes, cables and ducts, fixings and plant bases must be kept to an absolute minimum.

Service installations can contribute to preventive conservation by increasing the beneficial use of sites, but can also have a detrimental effect on historic fabric both in terms of physical damage and the deleterious effect on surfaces, which can result, for instance, with a sudden change in internal environment. This can be common where ruined monuments are reconstructed or restored, and the impacts

Figure 9.9 *Eight photovoltaic panels are sensitively and reversibly sited on top of the remains of the fourteenth century tower and provide general power to a small shop and ticket office. The panels replaced a noisy generator, are fully reversible, and meet government initiatives and green tourism initiatives.*

Figure 9.10 *Crichton Castle (Midlothian, Scotland) is the first Historic Scotland site to be powered by the sustainable technology shown above (Figure 9.9).*

and benefits of such actions must always be carefully thought through.

Lighting

Good lighting can be welcoming and can also enhance security. Ruined spaces in particular need to be imaginatively and sensitively lit if the beholder is to appreciate something of their former qualities, more so where such spaces have multi-functional use.

The discreet and careful positioning of lighting can illuminate parts of a ruined structure that are no longer accessible and/or would otherwise be difficult to appreciate without doing harm. Elsewhere, imaginative lighting can add interest and intrigue. In terms of effectiveness in internal spaces, schemes which attract the eye by echoing the effect of sunlight (or moonlight) are most successful. Externally, low-level up-lighters can have a dramatic effect on a building by accentuating the light and shade of architectural detail and its scale. The careful use of light can also be used to 'hide' less favourable or fragile areas by focusing attention elsewhere, and can also be used to highlight trip and other hazards. Whether floodlighting or special lighting effects (such as *son et lumière*) are appropriate at ruined sites for anything other than temporary, special events is always debatable.

Signage

Whilst lighting may not be necessary, appropriate or possible at many ruin sites, signage in its various forms, way-finding and interpretative, is often a prerequisite.

At a minimum, the way to a ruined monument should be adequately signed from the road (in the UK, 'brown signs' denote monuments of significant interest) and from footpaths, as necessary, by finger-posts. At the entrance to sites there should be signs advising contact details in the event of an accident or emergency, or to alert custodians to vandalism, etc., and giving brief details of the monument's pre-ruinous form and the cause of its ruination, plus a brief statement about safety. Where payment for entry is required, it is also good practice to display the price(s) of admission and, for larger or complex sites, a sign displaying an aerial view and a 'you are here' indicator can also be justified.

Signs, both wayfinding and educational, can enormously enhance visitor experience, but only if well thought out in terms of their design, size, scope, number and location, and if they are well maintained.

Signs should be of an appropriate height so that they can be read by all, be consistent in terms of symbolisation and the naming of parts (with guide books and the like), and should be appropriately designed and located. Inappropriately located or designed signage can easily detract from the aesthetic qualities of a site, and a desire for uniformity (as is the current policy for English Heritage sites) can have both positive and negative affects; uniform signage can provide quality assurances but, on the downside, can restrict or undermine the ability of individual sites to promote themselves as successfully as might otherwise be the case.

Security

Human interference at ruin sites has always been a major agent of destruction, often far greater than the natural agents of climate and vegetation. Historically, the deliberate levelling and quarrying of sites was the principal cause of loss, but today they are commonly protected by law. However, vandalism in the form of graffiti, the gratuitous destruction of objects and looting are modern threats often associated with tourism activities. Some measure of security is often necessary, and the denser the population, the greater the risk and the greater the requirement.

Casual acts of antisocial behaviour are more often than not a consequence of ignorance and stupidity but, when deliberately committed for reasons of political or social unrest or when associated with organised crime, can be extremely destructive.

The continuous erosion of some sites is certain if measures are not taken to protect them from casual treasure hunters and opportunist vandals. Security of monuments and their associated services generally take the form of lighting or fencing, but whatever form is employed the means must be appropriate, fit for the purpose, and carefully designed and located so as not to impact unduly on a site's significance.

Legislative requirements: health and safety and disabled access

The ownership of ruins entails many legal responsibilities, the most common being related to matters of health, safety and accessibility. In the UK, legislation governing both is largely non-prescriptive; standards are set and an owner or managing authority must assess what is 'safe', 'suitable' or 'reasonable' for any given circumstance. There are no hard and fast rules; for access issues it is a matter of reasonableness and for health and safety matters it is one of risk management.

The impact of making safe and providing access on the presentation and display of a ruin site can be great. In terms of health and safety, the greater the risk, the greater the impact. In particularly serious circumstances, for example where there is a likely risk of fatality, access to parts of a site may need to be restricted or the site may have to be closed until such time as the risk has been remedied.

A risk assessment which seeks to identify all known and reasonable anticipated risks identifies works required on health and safety grounds. Whilst common sense should always prevail, owners, anxious to avoid potential legal claims,[3] are often precipitate in installing safety measures. The challenge lies in identifying ways of overcoming risks to visitors that do not erode the enjoyment of the very thing they have come to see. The unnecessary use of the ultimate irreversible action, that of making safe by taking down, should of course always be the last option.

Safety and access are thorny issues and often related at ruinous sites. Parapet walks, precipitous paths and steep banks, descaling stone and live plaster are all potentially dangerous. Floor surfaces may be uneven and dangerous to even the most able of visitors. Whilst a quick-fix option might be to install regulation height handrails, dress off historic stone surfaces or to relay an uneven floor or cover it up, the appropriateness of such actions – in particular, what will be gained and at what cost to both the monument and observer – must always be carefully thought through. In the end, the procedures required to make 'dangerous' sites 'safe' may be quite inappropriate. The first duty of the custodian is security and survival, including the character, of historic fabric, not the safety of visitors. Clearly, the safety of visitors must never be ignored, and security fences and 'Danger – keep out' signs are sometimes the only responsible answer.

Access for disabled visitors can be particularly difficult at ruined sites and imaginative ways must often be developed to overcome them. Many ruined structures, particularly castles and fortified houses which were designed to keep unwanted visitors at bay, can prove particularly demanding. In the UK, access provision is tested on the grounds of reasonableness and the alteration of physical fabric is only one means of providing it. For instance, a tower on a steep defensive mound can only be reached by a steep ramp of such an incline that it becomes impracticable for wheelchairs to negotiate, and a steeply inclined ramp of considerable length or a chair lift can seriously compromise the integrity of a site. Alternative forms of access, such as improvements in intellectual access (written interpretation and so forth), can be an acceptable, alternative option.

Access to and around ruins presents the greatest access problems. Access, particularly to remote sites where there is no vehicular access (e.g. Dunstanburgh Castle, England, Figure 9.11), can be difficult at the best of times and it may not be reasonable in such cases to provide access for all. Whether or not access improvements are required is a question of reasonableness and, as this is as yet unchallenged in the courts, a pragmatic approach must be to consider improvements in light of a site's significance. If a ruined monument is of such archaeological or historic significance and/or is marketed as a 'must see', then it is reasonable to assume that large numbers of visitors will travel from afar to see it and that it would be reasonable to cater for disabled visitors accordingly. If disabled visitors are prevented from visiting such sites discrimination will be suffered.

In terms of facilities for the disabled, current English law provides that they must be at least equal to those provided for non-disabled visitors; discrimination arises if this is not the case. Where, for example, parking and/or toilets are provided for able-bodied visitors, then accessible parking and toilets must be provided for disabled visitors. If there are no facilities whatsoever, there is no discrimination.

Maintenance

Maintaining a ruin site in a safe manner is one of the most important responsibilities of an owner when visitors are to be admitted. However, whilst all property is required by law to be maintained to ensure the health and safety of occupants and visitors, it is stressed again that the principal aim of maintaining ruined sites must always be to preserve them, as far as practicable, in their 'as found' condition to protect their significance, integrity and setting. Maintenance for health and safety reasons, for presentational purposes or so that they can continue to fulfil their function as a visitor attraction must always be secondary.

The complexity and intensity of use of ruin sites impacts greatly upon the nature, frequency and timing of maintenance. Infrequently visited sites run the risk of neglect, whilst heavily visited sites or parts of sites can suffer unacceptable deterioration and damage by attrition. The usage of sites must never be such that wear and tear from visitors is allowed to erode the fabric, ecology or character of monuments or their settings. Visitor management and maintenance must be

Figure 9.11 *A significant part of the attraction of some ruin sites is their remoteness and inaccessibility. In these cases it may not be desirable or reasonable to create intrusive access facilities. Dunstanburgh Castle, England.*

an integral part of a site's long-term management plan and must follow a coordinated and coherent approach if the risk of otherwise avoidable deterioration, loss or, at worst, collapse is to be avoided.

Ruins have no indefinite life. However much attention is lavished upon them, erosion by natural agencies cannot be prevented but steps can be taken to slow the rate of deterioration. Legally, a failure to maintain sites appropriately can result, in the UK where monuments are listed, in a repairs notice being served or compulsory purchase.

The importance of maintenance as a preventive measure in slowing deterioration is essential, and even routine activities must be properly planned and prioritised. Many regimes are repetitive and interventionist, and over-maintenance can, where it leads to the loss of fabric, for example in the case of excessive repointing, be just as destructive as a lack of maintenance. Maintenance activities have an undeniable psychological effect on visitors. Neglected sites or those perceived as such give an impression that the site is of no particular importance and this can lead to antisocial behaviour. Where sites suffer deliberate misuse or vandalism, prompt maintenance is essential and must always be a priority.

Other visitor types: domestic animals and livestock

Though this chapter has been concerned with the impact of human visitors on sites, it is worth saying a few words about the damage that can be caused by domestic animals and livestock at ruin sites (see also Chapter 6).

Some sites are particularly vulnerable to the impact of domestic animals and livestock and, where this occurs, it generally results from the ignorance of owners. Irresponsible dog owners who allow their charges to run freely and foul sites can severely reduce the enjoyment of sites by others. Where they are allowed to foul, a serious health threat is posed and owners are in breach of the Dogs (Fouling of Land) Act 1996. This Act, where it is enforced, can prove a double-edged sword: the Iron Age hillfort of Old Sarum in Wiltshire has been particularly popular with dog owners since nearby Salisbury Borough Council began rigorously enforcing the Act in the adjacent city and its parks. Though the excreta of horses and other animals does not pose the same health hazards as that of dogs, it can be unpleasant for visitors all the same and owners must be encouraged to take due responsibility.

Livestock grazing can have both positive and negative impacts on the long-term preservation of ruins. Grazing, where it maintains the visibility of monuments and deters root-penetrating vegetation such as scrub and bracken growth, can assist the long-term survival of sites (see Chapter 6). However, it can be detrimental. For instance, stocking levels and livestock type require careful management and the location of livestock focal points such as troughs needs careful thought if monuments are not to be eroded to bare earth. Erosion or poaching occurs where the grazing of a site is above the sustainable level for the type of vegetation or soil. The problem is greater at focal points and increases during wet periods and during the winter months.

Summary

There is a long history of valuing and caring for ruins. Whatever the cause of ruination, they evoke strong feelings in contemporary society and we value them for many reasons. Whether it is their sense of place, their tangible link to the past or the secrets and stories that they hold, we recognise their special importance and we want to visit them.

The sensitive and appropriate use of sites must be the best way to preserve sites, and innovative, collaborative and sustainable strategies have to be developed for their long-term management. Conservation and tourism are in some ways mutually exclusive and must be reconcilable. There is no doubt that tourism depends largely on a pleasant and attractive environment, and that funds generated from site entrance fees can greatly assist conservation activities. Tourism is a growing industry and should be welcomed and harnessed for good; our heritage of ruins needs visitors to ensure its long-term viability. Conservation and tourism are inextricably linked; without visitors the need for those who care for ruins will diminish, and the sites will deteriorate inexorably and will eventually be lost to all but architectural historians and buildings archaeologists. A balance between the two must be found. Only when harmony between them is achieved will the future of our ruin monuments be secure.

Notes and references

1. BS 7913 (1998). *British Standard Guide to the Principles of the Conservation of Historic Buildings*, p. 3.
2. The alternative interpretation of the ruined space known as the Tudor Great Hall at Mont Orgueil Castle, Jersey, offered by Dr Warwick Rodwell and Professor Colin Platt, is a recent case in point and material to reinstatement proposals.
3. In England owners (or guardians) are liable for injuries to visitors under the Occupiers' Liability Act 1984. A breach or failure to fulfil statutory and legal liabilities can have substantial consequences, particularly where matters of safety are concerned, and may result in civil or criminal actions being taken.

Chapter 10

Case studies

Case Study 1: Guildford Castle, UK

Catherine Woolfitt, John Ashurst and Graham Abrey

The conservation of the tower keep of Guildford Castle in Surrey illustrates how archaeological investigation can inform repair and conservation work on a ruin, and conversely how conservation work can aid the archaeological interpretation of an ancient monument. The tower is the most prominent survival of Guildford's Norman castle, standing to a height 15 metres above its motte platform (Figure 10.1). Like other Norman great towers, Guildford Castle's tower is of massive composite wall construction, with walls 3 m thick, on average, at ground level. The tower is almost square in plan, approximately 14.5 m by 13 m. The date of the tower has never been firmly established. The earliest written references belong to the reign of Henry II, but the early twelfth century has traditionally been cited. Prior to commencement of survey and study the original internal arrangement of the tower was uncertain. It was clear that there had been a large principal chamber raised above ground level, over a smaller ground (or basement) level space. This principal (first floor) chamber had a large entrance in the west elevation and three large windows, one in each of the other three elevations. In contrast, the ground-level space below had only two very narrow, small window openings and a small entrance and, as at other towers of this date, apparently functioned as some sort of service or storage room. It had generally been assumed that there was an additional (second) floor level due to the presence of a mural chamber in the south-east corner and the continuation of a spiral stair in the north-west, but substantial rebuilding at the top of the tower over the centuries, including the introduction of brick windows in the sixteenth century, had obscured or destroyed much of the earlier construction.

In 1998 Guildford Borough Council, which owns and operates Guildford Castle's tower keep as a visitor attraction, was forced to close the tower to the public due to concern for visitor health and safety and for the condition of the tower itself. New access stairs, both internal and external, had been constructed less than 10 years previously, in 1989, with an internal viewing gallery at principal (first floor) level, but the oak timbers of these structures had begun to decay due to the damp internal environment. The tower had been without a roof since the seventeenth century. The condition of the interior of the ruined shell of the tower was generally poor. In addition to the decay of the timber stair and gallery, damp had promoted abundant plant growth on the walls and micro-organic (slippery mould) growth on the new stone floor at the base of the tower (see Figure 10.2). Feral pigeons had colonised the many ledges and chambers of the tower's interior and their guano contributed to the unhealthy environment.

Some elements of past repair work had exacerbated rather than ameliorated the condition of the tower. Work to the wall heads had entailed forming screeds that were either flat, allowing water to penetrate through to the wall core, or had a slight fall to the interior rather than to the exterior, which channelled rainwater down the internal wall faces. By 1998, when the tower closed, the internal wall surfaces were virtually obscured by plant growth at high level. The chalk quoins used internally had decayed at a greater rate than the Bargate stone used for most of the internal facework and were recessed in profile, relative to adjacent rubble masonry. The Bargate stone ashlars of openings had also suffered and losses had occurred, notably on the main west door, where large lenses of stone had detached and fractures were visible.

Opposite page *Theatre of Marcellus. Medieval Rome adopted and adapted the arches of the Theatre of Marcellus as housing (see Preface page xv). The illustration shows work of gentle cleaning and surface filling of the blackened travertine in progress.*

Figure 10.1 *View of Guildford Castle's tower keep from the south-west, with the slope of the motte visible in the foreground.*

The external masonry face was relatively free of organic growth, compared to the internal face. However, localised growth of problem plants with invasive root systems had occurred externally in spite of a programme of masonry repair work carried out at the same time that the new access stairs and gallery were installed. Buddleia and other species had taken hold in several locations at high level, and their root systems had penetrated the rubble masonry construction. Although some repointing had been carried out, plants had managed to gain footholds on masonry surfaces, in open joints and crevices between stone and mortar. Some past repair work had employed inappropriate, cement-based or cement-gauged mortars, particularly on the few sections of surviving medieval ashlar stonework on the east elevation pilaster buttresses.

Guildford Borough Council commissioned a condition survey of the tower, which was carried out in 1999, with a view to applying for scheduled monument consent for repair and conservation of the tower so that it could be reopened to the public. Due to its position on the east side of a high and inaccessible motte, access was limited and the survey was limited to ground-level examination, with whatever additional access could be gained internally from the spiral stair in the north-west corner and the viewing cage at wall-head level. Consequently, access to

Figure 10.2 *The internal south-east corner of the tower at wall-head level, illustrating the extent of plant colonisation and screeds sloping into the tower.*

internal elevations was better, although hindered by organic growth, than access to external elevations, which was from ground level only. The option of using a cherry-picker (aerial access platform) was explored but the slopes of the motte were too steep; only one elevation (the east) would have been accessible by this method. Consequently, for the purposes of initial survey, to produce recommendations for work and to tender the work, survey was based on ground-level access only. Allowance was made, however, in the tender documents and in budget costs for additional, more detailed survey work and for archaeological assessment from full access scaffolding.

Condition survey

The decay of Hythe Beds stone

The condition of Hythe Beds stone within the masonry was found to vary considerably, depending to some extent on the original source of the stone. In general, the Hythe Beds used for the buttresses and quoins, which is largely replacement stone of the mid-twentieth century, was in much worse condition than the Bargate used for the rubble masonry. The Bargate rubble stones were generally more durable, with a much higher fossil shell and pebble content. They exhibited very little surface decay. The Hythe Beds ashlar stones of the buttresses and quoins were fine to medium grained without visible fossil or pebble content. These stones exhibited considerable surface decay and it appeared that the binder/cementing medium (which in the case of Hythe Beds is calcium carbonate) of the stone has been attacked. The surfaces were friable to the touch, with large lenses of stone (often in excess of 20 mm in depth) detaching. Decay at the perimeter of Hythe Beds stones resulted in the opening of cracks at the stone–mortar interface, increasing the uptake of rainwater into the masonry joints. The erosion of the Hythe Beds surfaces on the buttresses is ongoing and stones replaced in 1989, including the stone inscribed with that date, had decayed perceptibly by 1999, evidence of a very rapid rate of decay and poor durability.

Decay of Hythe Beds stone of the south-east corner buttress was found to be extensive and there was an essential need for some stone replacement. The tile repairs carried out in 1914 had proved to be more durable than the adjacent Hythe Beds stones and stood proud of the ashlars (see Figure 4.57). Other Hythe Beds stones around the tile repairs had been replaced in post-1914 repair programmes. The stone of the central buttresses on the west and east elevations was also badly affected.

Saturation of masonry and soiling

The saturation of masonry was more readily visible from the interior of the tower, where a profusion of plant life grew on the walls, especially at higher level. Externally, plants could be seen growing from the masonry face in a few places, notably on flat projections such as window sills and at wall-head level. Permeability was a key factor in both decay and water retention, which had weakened the chalk and the Bargate ashlar as well as supporting a range of microflora. A pattern of dark discoloration on the external east wall of the castle had been visible for many years throughout all seasons of the year and was believed to be due to the migration of moisture, and possibly iron oxides in the stone.

Some dark soiling was visible on the external masonry face, most notably on the east elevation. This dark soiling, resulting from the deposition of atmospheric pollutants, was also visible in patches on the other elevations. A principal problem relating to all the surviving ancient masonry was that it was forced to act sacrificially to the more robust restoration and refacing work. This was true particularly of the calcareous sandstone ashlars surviving in the pilaster buttresses and dressings to openings and of the internal chalk quoins. The situation was most critical where areas of this shelly Bargate had been bedded up to weakened stone in rather impermeable cement-gauged mortar. Rainwater, which permeated to the core of the thick wall, found the easiest exit route through old, permeable stones and lime mortar.

Masonry joints

The mortar joints of the medieval rubble masonry were generally slightly recessed from the faces of the stones. Joints in sections of repointed masonry were more full and the character of masonry in these areas, especially at high level, was difficult to define. It was uncertain at the outset how much of the existing rubble facework was original and how much had been refaced. Careful and close-range study of masonry in the course of repair work would later demonstrate that most of the existing rubble masonry, excluding that at wall-head level, was medieval but this was not clear initially from ground-level survey.

Repointing carried out subsequent to rectified photography in 1989 was, in many cases, quite poorly finished and applied wet, with brush marks visible on joint faces. A few holes made by masonry bees containing insect casings were noted on the west elevation, but their overall impact on the pointing was insignificant. The main problem stemmed from the use of cement-gauged mortar in the joints which, coupled with the dense, shelly Bargate, created a rather impermeable external skin.

Wall tops

The original form of wall head was uncertain at the outset, although it was thought, on the basis of comparison with great towers of similar date, that the most likely form was a crenellated parapet. The wall tops had been covered with what appeared to be a cement, lime and sand-based screed, which exhibited cracks, permitting water to enter the wall head underneath. The screeds had not been designed to shed rainwater to the exterior of the tower. The screeds were either laid more or less level or with a slight fall to the interior of the tower. Elimination of this water catchment zone was identified as a priority.

Previous repairs

Ground-level survey indicated that the external façade had been extensively rebuilt and repaired, but precisely how much of the masonry façade was medieval and how much later restoration work remained uncertain. The façade had been extensively repointed in the course of numerous phases of past repair work, which obscured the nature of the medieval facework (see Figure 10.3).

Historical research by Dr Mary Alexander of Guildford Museum had identified the intervals of repair work listed in Table 10.1.[1]

Condition of the internal masonry

The exposure of the wall heads and internal elevations to the weather since the seventeenth century had led to saturation of the masonry, and the internal masonry surfaces were covered in organic growth ranging from algae to large plants. The plant growth was particularly abundant at high level and beneath window sills, where concentrations of water down the wall face.

The environment at ground level (below the 'principal floor') was continuously damp, even in the summer. The exposed and damp conditions had led to extensive decay of the susceptible building stones. Hythe Beds had been used for most openings, principally for facing the main entrance passage, and chalk for the quoins forming the internal corners and for the blind arcade of the chapel. Both Hythe Beds and chalk were suffering ongoing decay. The main entrance internally was in very poor condition, with extensive fractures through quoins. The fractured sections had detached substantially so that the stones sounded hollow when tapped and large spalls had detached in the past few years. The chalk surfaces were powdery and small flakes and spalls had detached over the entire surface of the stone, indicative of frost damage.

Rubble construction of this period was typically plastered and although no plastered medieval surfaces were visible on the exterior of the keep, it was presumed (and later confirmed in the course of conservation and archaeological study – see Figures 10.4 and 10.5) that the external walls had been finished with lime-based plaster.[2] The internal masonry surfaces were certainly plastered. Remnants of plaster and paint survived internally, most notably in the antechamber and main chamber of what is traditionally identified as the chapel, both on the vault and the blind arcade.[3]

Repair and conservation work

The scope of repair work defined by survey and which formed the basis for tendering included the following elements:

- *Consolidation of the wall tops*. To eliminate water penetration to wall cores and shed water to the outside faces, in the traditional 'ancient monuments' way. This involved resetting core work in hydraulic lime-based mortar to profiles which clearly indicate the broken nature of the wall tops (before these were 'rationalised' in nineteenth and twentieth century repair programmes) channelling all water away from the internal space (see Figure 10.6).
- *Replastering*. Partial replastering was recommended for a number of reasons: to act as a protective and ultimately sacrificial layer over decaying stone; to reduce the substantial water uptake into the walls, thus reducing moisture movement-related decay and inhibiting the development of organic growth; to equalise the water absorption between sound and decayed surfaces; and to enhance the appearance and increase the legibility of the masonry and its repairs. Replastering was to follow the contours of facework, allowing masonry features, such as courses of herringbone, to read as far as possible (Figure 10.7). External work was in hydraulic lime NHL2 whilst internal work, at principal floor level only, was based on a high-calcium (putty) lime binder.
- *Cleaning*. Associated with replastering was cleaning work. Plants and organic growth of various kinds, as well as the black soiling deposits, had to be removed in advance of plastering to ensure adhesion and sound bonding of the new plaster.
- *Repointing*. There was a need for localised repointing and deep tamping to both ashlar and rubble work, to remove past repointing in inappropriate hard cement or cement-gauged mortars and other defective work. New plaster had to be applied to a sound substrate and any detached or hollow pointing was to be removed and renewed prior to replastering.
- *Limited replacement of ashlar stones*. Since so little medieval ashlar work survived, replacement was to be limited to ashlar stonework introduced in later phases of repair, which had decayed at a rapid rate.

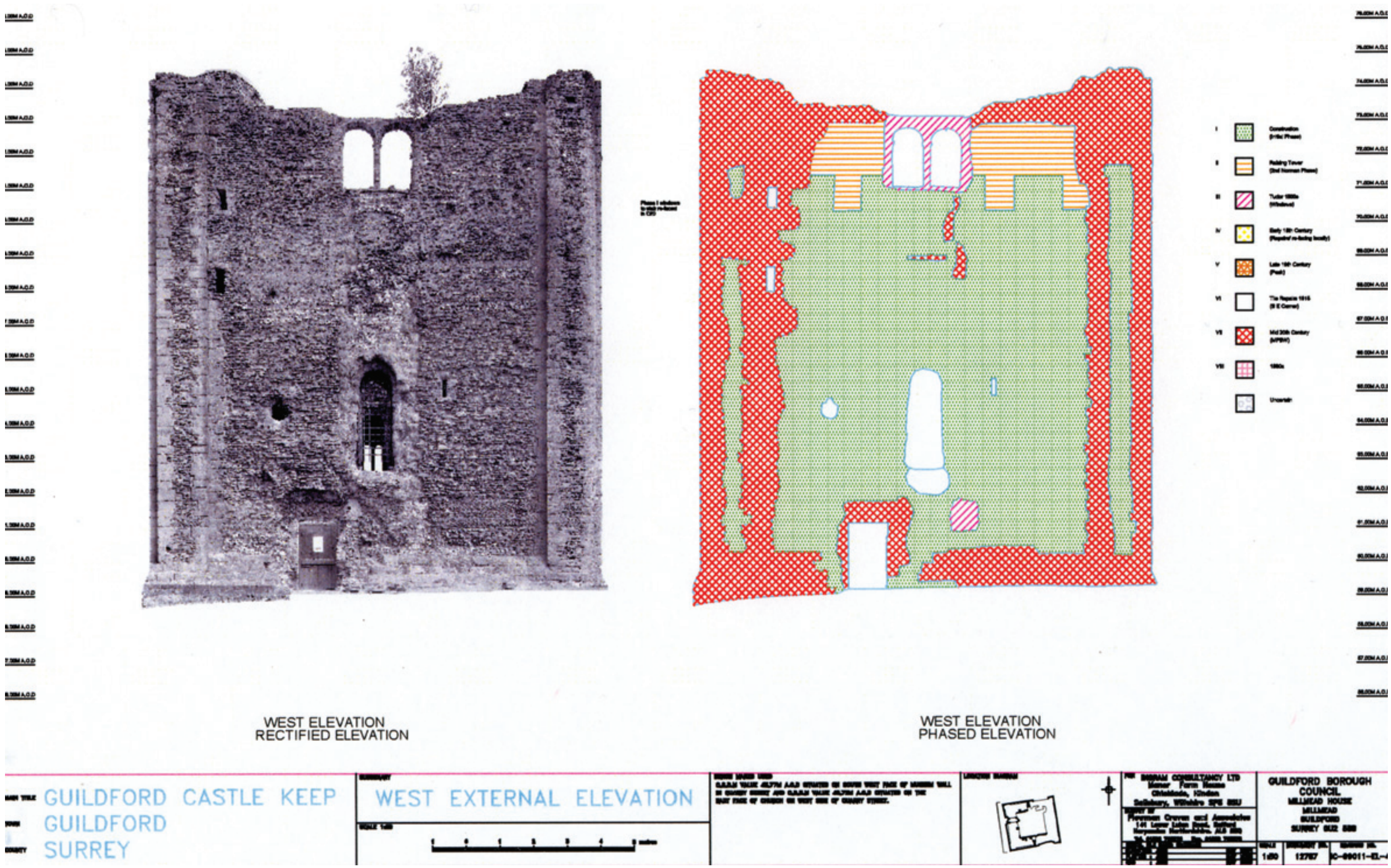

Figure 10.3 *Rectified photomosaic of the west elevation of the castle, annotated to show phases of construction and later alteration.*

Table 10.1 Intervals of repair work, Guildford Castle

1830s	Restoration and refacing of the lower part of the east external wall and other repair work
1880s	Major restoration, especially at wall-head level, under the direction of the borough surveyor, when Guildford Borough acquired the site and laid out the gardens surrounding the castle, which are still visible today
1914	Extensive SPAB style tile repairs to the external south-east corner of the keep (corner buttresses of the south and east elevations)
1940s to 1950s	Replacement of quoins on the pilaster buttresses on the north, south and west elevations. The entire plinth of the west wall and most of the plinth on the north and south walls was replaced
1989	Work included repointing, some stone replacement and formation of the screeds to the wall heads. Chalk was replaced with Portland stone

Figure 10.4 *Blocked embrasure on the west elevation in the course of excavating fill to expose the plastered vertical face of the merlon.*

Limited rebuilding was carried out where masonry was displaced by roots of woody plant species.

- *Repair of medieval stonework*. Pinning and grouting of ashlar masonry forming openings which exhibited spalls and fractures.
- *Construction of new internal perimeter gallery and ticket/custodian's office* at ground level inside the tower.
- *Site trials*. All aspects of the work were subject to trials to ensure satisfactory methods and materials. For example, replastering trials included preparation of mortar samples for approval of mortar composition, as well as application of panels of plaster to confirm colour, texture and finish.

Figure 10.5 *Detail of Norman plaster (in Figure 10.5) applied to the merlon in the tower's first phase of construction.*

Figure 10.6 *Existing flat screeds were removed and core work constructed to shed water off the wall heads and indicate their broken form prior to 'rationalisation' in the nineteenth and twentieth centuries.*

Figure 10.7 *Plastering trials were carried out to establish the mortar mix and final appearance and finish.*

An essential part of the site work was archaeological recording, which was a condition of scheduled monument consent.[4] Before erection of scaffolding, all masonry elevations were subject to rectified photography and photomosaics of the elevations produced (Figure 10.3). Measured survey was carried out to permit production of plans at each level. Scaffolding was designed to be completely independent of the monument and was secured by ground anchors rather than the usual masonry anchors. Once scaffold access was available the elevations were resurveyed at close range. At the same time, cleaning and cutting out of defective pointing began. Removal of later pointing soon revealed significant archaeological features, which would substantially alter the scope of work to the tower. Vertical features had been noted during recording of the west elevation and close range inspection confirmed that these were the lines of a crenellated parapet (Figure 10.9). The line of the parapet survived best on the west and south elevations, where it was clearly defined by a thin white layer of limewashed plaster applied over the horizontal and vertical faces of the embrasures. The line was legible on the north and east, but was less intact. The discovery of the limewashed plaster was particularly significant since so little evidence of the original treatment of external surfaces of Norman buildings has survived. The decision was taken to interpret the line of the crenellated parapet in plaster on the external elevations (Figure 10.14).

Archaeological investigation soon uncovered other evidence for the form of the tower in its earliest phase. Masonry offsets on the internal west and east elevations had always been visible, but there was uncertainty about their function, whether they originally supported a floor or a roof. In the course of study and work on the east elevation, four large channels were identified, just above the height of the masonry offset, which had functioned as drainage channels for a roof; they extended through the thickness of the wall and one contained the remnants of a lead chute (Figure 10.10). A further important discovery was the uncovering of a garderobe chute in the chamber at principal floor level, in the north-east corner. Prior to this, the chamber in the south-east corner had been interpreted as the garderobe, which had reinforced the notion of a tower consisting originally of two floors raised above ground level. Once this notion was dispelled, by the discovery of the garderobe and the evidence of the crenellated parapet and the roof drainage

Figure 10.8 *None of the Norman window mullions survived and one was reinstated in the south window to support the remaining voussoirs and interpret the early window detail.*

Figure 10.9 *Detail of line of crenellated parapet on south elevation, with Bargate rubble construction of merlon on the right and infill of embrasure in flint on the left.*

outlets, the earliest form of the tower could be interpreted: a single large chamber raised above ground level, over a basement, with a roof set behind (and probably screened from ground level by) a crenellated parapet. The survival of plaster on the upper surfaces of the parapet and the nature of the infill, with mortar and masonry matching that of the parapet itself, indicates the tower was raised at a relatively early (Norman) stage. It seems, in the absence of evidence to the contrary and on the basis of recent discoveries of the same arrangement at other early Norman towers, such as the White Tower of London and Castle Hedingham, that the tower walls were raised without the addition of a second floor, with dummy windows, apparently for the visual effect externally rather than to provide additional space internally.[5]

Together, the evidence for the early form of the tower was sufficient to form the basis for a proposal to construct a new roof at the same level as the original, using the same roof drainage outlets. Proposals were supported by archaeological evidence, not speculative assumptions about the original construction. The construction of a new roof would bring substantial benefits for the condition and sustainability of the tower in the long term. Principal among these was the protection the roof would provide for the castle interior, by excluding rainwater and preventing organic growth from recurring. The internal environment would be considerably improved for visitors as well. Pigeons could be excluded by metal mesh applied over openings. Acceptance of the proposal to re-roof the tower led to rethinking of the provision for access at first floor level. In lieu of the gallery previously envisioned, a design was developed for a complete floor (at first floor level) to stand independently of the tower masonry, on a concrete raft in the base of the tower. Introduction of a new roof and floor would define the original spaces and assist with interpretation of the tower, in particular of the principal chamber, which is thought to have functioned as an audience or presence chamber for the new Norman rulers to receive and impress vassals.

Figure 10.10 *Detail of channel for drainage of original roof through east elevation. View of external face which has been unblocked.*

The new floor is a free-standing platform with steel stanchions and main frame and oak boards. The roof frame is of softwood and has a slatted board soffit and lead cover. There was no attempt to mimic the original Norman roof and floor construction, since their exact forms were not determined. English Heritage provided grant aid for the programme of conservation. The successful conclusion of the work was due to the dedication of all members of the project team:

- The Client – Guildford Borough Council Leisure Services (Jim Miles, Head of Section and Lance Boswell, Clerk of Works)
- Statutory Consent (English Heritage) Judith Roebuck (Inspector of Ancient Monuments) and Robert Williams (Architect)
- Conservation Advisors and Buildings Archaeology – Ingram Consultancy (Prof. John Ashurst, Catherine Woolfitt and Graham Abrey)
- Metric Survey and Photographic Recording – Plowman Craven and Associates
- Main Contractor – Nimbus Conservation (Project Manager Manjit Phull, Site Manager Martin O'Connor and a team of conservators whose skill and sensitivity to the significance of the fabric ensured that important archaeological features were detected in the course of work)
- Structural Engineers – EJC Design Partnership (John Hamer)
- Historical Research – Dr Mary Alexander (Assistant Curator, Guildford Museum)
- Planning Supervisor/Project Manager – Madlin & Madison (William Woellwarth).

An interesting debate arose over the Norman window in the south wall. The once plastered embrasures and barrel vault of the window terminated on the outer face with a screen consisting of an apron upstand below a two-light opening and a rubble-filled

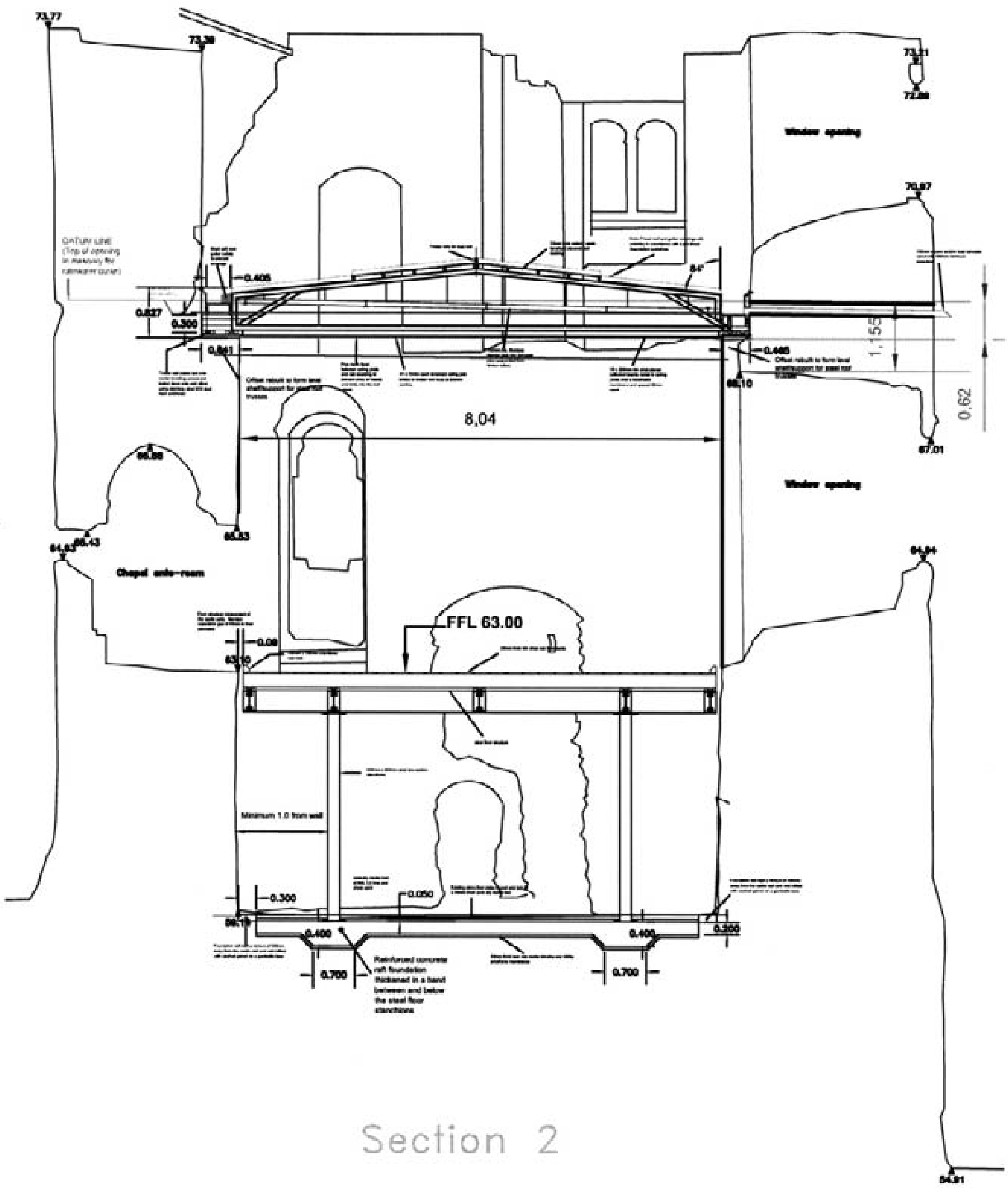

Figure 10.11 *Section through the tower showing design for new roof and floor.*

tympanum. At some time in the nineteenth century the single column supporting a rectangular abacus and the springing of the two semicircular headed lights fell. It appears in early nineteenth century illustrations, although not in great detail. The type of column is, however, plainly a circular column with a cushion cap.

The absence of this support was creating a problem for the tympanum, which exhibited stepped cracks and would be the next feature to be lost if left unaided. The usual rule of 'minimal intervention' suggested the use of an anchor installed through a new abacus to support the twin arches and the tympanum by hanging them from the corework

Figure 10.12 *View of new lead covered roof, looking north-west.*

above. A proprietary anchor which could be placed and grouted *in situ* was proposed.

The proposal was contested on the grounds of uncertainty about the integrity of the corework above. If the core could not provide the necessary anchorage the masonry at the face could be significantly weakened close to the south face to no beneficial effect. An alternative proposal was to reinstate a load-bearing column and abacus to return to the original structural arrangement. This solution was finally adopted, although not with unanimous support, because of the perceived 'restoration' involved. In spite of this, the structural problem has been simply resolved and the opening made visually intelligible to visitors. No attempt to detail the column, its capital or its abacus was made beyond cutting the basic profiles and it could not be mistaken at any time for original work. Architecturally, the work has been generally acknowledged as a substantial gain (Figure 10.8).

These major additions to the scope of work entailed an extension of the project timescale and obviously additional costs, but the benefits have been substantial. The site reopened in 2004 with considerable public interest. Visitors can now view previously inaccessible areas of the tower, including the various mural chambers, and can appreciate the original visual impact of the Norman presence chamber. The tower can now be maintained at high level, which was previously impossible without

Figure 10.13 *Internal view of plastered principal floor level with boarded soffit of new roof, prior to construction of new floor at level of base of new plaster.*

erection of access scaffold. Anchor points for safety harnesses and ladder have been installed, which can be accessed from roof level for removal of any invasive organic growth that might colonise the wall heads.

Notes and references

1. Alexander, M. (2004). *Aspects of the Early History of Guildford and Its Castle*. Thesis for Doctor of Philosophy, Dept of Archaeology and School of History, University of Reading, April.
2. Fernie, E. (2002). *The Architecture of Norman England*, p. 279. Oxford University Press. He summarises current understanding of Norman treatment of building surfaces:

   Unpalatable as it may be to modern taste, with its attachment to the ideal of truth to materials and appreciation of the texture and colour of stone, most of the surfaces in Norman buildings were painted, not only the interiors or the portals on the exterior, but every aspect. The evidence for this is scattered and sparse but undeniable … There is no reason to think that this applied only to churches, as even the name of the White Tower, although it is a late medieval one, suggests. Painted mortar joints could in theory be seen as a wish to even up courses of different sizes, but the way in which the lines are painted is on the whole much less regular than the real mortar joints. The painting must rather be due to a view that a building was not considered finished until the masonry had been hidden.

3. Howard, H. (1998). *Guildford Castle: Scientific examination of traces of paint remaining in the antechamber of the medieval chapel*. Conservation of Wall Painting Department, Courtauld Institute of Art, December (unpublished report).
4. See Woolfitt, C. (2005). *Guildford Castle Tower Keep: Analysis and Assessment of the Great Tower*. Prepared for Guildford Borough Council (Ingram Consultancy Project 99011), July (unpublished report).
5. Parnell, G. (1998). The White Tower, the Tower of London. *Country Life*, **192**(28), 86–89. For evidence at Hedingham, see Dixon, P. and Marshall, P. (2003). The Great Tower at Hedingham Castle: a reassessment. In *Anglo Norman Castles* (R. Liddiard, ed.), pp. 297–306. Boydell Press, Suffolk.

Figure 10.14 *View of tower from south-west after completion of conservation work. (Compare with the same view in Figure 10.1.)*

Case Study 2: Masada, Israel

John Ashurst, Asi Shalom and Catherine Woolfitt

Masada is located in Israel on the border between the Judean desert and the Dead Sea Valley. The name is thought to be an Aramaic form of *hamesad*, a fortress.[1] No name could better describe the almost impregnable flat-topped dolomite mountain standing over 400 metres above the Dead Sea (Figure 10.15). The top of the mountain measures 600 m north to south and 300 m east to west at its longest and widest points. Natural access is limited to a winding path on the east, the Snake Path, and from a gypsum outcrop, the 'white rock', on the west, linked by a spur of rock to the side of Masada, a geological phenomenon which played a major role in the history of the fortress.

The almost sheer sides of the mountain are characterised by vertical fissuring, evidence of stress release as the rock was pushed upwards in geological time. Although there is a tendency for surface rock on the sides of the mountain to slide downwards on the west and to topple over on the east, the stone itself is immensely durable. Unfortunately, another rock was used for much of the masonry on the mountain top; this is a poorly lithified limestone of recent geological age with poor durability. The rocks of the mountain also provide materials for mortar and plaster. Clay, gypsum and lime can all be won locally, and were exploited in ways which showed a good understanding of weathering characteristics and technology. Big section timber had to be imported from the north, but smaller sizes from olive and cypress trees were available closer to the site. Everything else had to be brought overland or on the surface of the Dead Sea.

Figure 10.15 *Aerial view of Masada from the north, with Herod's Northern Palace showing in the foreground. Silvas siege ramp can be seen on the right.*

Fortifications may have been raised on top of the mountain by Hasmoneans (153–152 BC – BCE), but it is with the name of Herod that Masada is primarily and most famously linked as builder. In 40 BC (BCE) he had taken his family there in flight from the Parthians and left them in the care of his brother and a garrison of 800 men. No doubt further impressed after this experience with the natural strength of Masada and the prodigious water-holding capacity of its great cisterns cut out of the mountain, Herod, according to Josephus,[2] furnished the fortress as a personal refuge from the uncertain moods of his Jewish people and from the antipathy of Cleopatra of Egypt. This period, from between 37 and 31 BC (BCE) until the death of Herod, saw the most lavish development of the site with fortifications, improved water collection and enlargement of cisterns, immense store houses, gardens, pools and palaces; and in particular the construction of the spectacular three-tiered Northern Palace located at the extreme north tip of the plateau (Figure 10.16).

A Roman garrison was taken by surprise in 66 AD (CE) by Jewish zealots; the best known of these, Eleazar, was master of Masada until the fall of Jerusalem in 70 AD, Flavius Silva and Legio X Fretensis with his prisoners of war marched south to take the last major centre of rebellion by conquest in 73 AD (CE). The well-known history of the siege, in the spring of 74 AD (CE), has left a number of physical marks on the site, the most notable of which is the siege ramp on the west (Figure 10.17), raised on the spur of rock referred to above by the Jewish prisoners until it was high enough to bring up the siege tower and ram to break the casemate wall. At this point lots were drawn by the zealot garrison to appoint executioners for themselves to deny final victory to the Romans, and to avoid the inevitable killing and enslavement which would follow surrender. When the wall was finally reached and the Roman assault succeeded in entering the fortress, only the bodies of the garrison were found amongst the plentiful

Figure 10.16 *Aerial detail view of the Northern Palace showing the three tiers, defensive wall at top and storehouses beyond.*

supplies they had laid out, and a sole witness to the event who had been hiding near the Northern Palace.[2]

Little is known about the subsequent occupation of Masada, but it was home to a Byzantine community who built a church on the site, the ruins of which still survive. The site was reidentified in the early nineteenth century. Limited exploratory excavations were carried out in the 1850s and the first professional survey work in 1932. Scholarly studies of the 1950s were followed by the detailed excavation and recording of 1963–64 and 1964–65 directed by Yadin.

Conservation of the Northern Palace

After 2000 years the Northern Palace, sometimes described as the Hanging Palace, is both remarkably legible and tantalisingly elusive. Fire, seismic activity, weathering and even archaeology have taken a serious toll, but the desert climate has, on the whole, worked in favour of survival, so that, for instance, excavators could expose jewel-like coloured plaster on the lower terrace of the Palace (see Chapter 5). Similarly, one of the remarkable experiences of Masada is to look out at the largely intact Roman siege works of camps and circumvallation on the mountain itself.

The aerial view of the palace (Figure 10.16) shows the great complex of buildings clustered at the northern end of the rock. Prominent at the upper level are the great store rooms, where grain, oil and wine could be kept in quantity. Not only the necessities but the luxuries of life were planned for by Herod. To the north of the storage area is a great wall still largely intact and covered with white plaster, which defines and protects the palace precinct beyond, forming a kind of promontory fort, as this wall is defensible and, in spite of an impressive approach stair, has only a narrow entrance with a guard room located at the east end.

The three levels of the Palace had three distinct functions. The upper level provided living accommodation around the three sides of a courtyard. The north side of the courtyard was extended in the form of a semicircular balcony, probably planted as a garden. The view from this point is spectacular, with views north, east and west, across the desert and the Dead Sea to the hills of present-day Jordan. This is personal and private accommodation in the Roman style, with black and white mosaic pavements and polished plaster.

Figure 10.17 *The middle terrace northern wall, showing at its base the coloured plasters of the triclinium on the lower terrace. The fragile condition of both rock and stones can be seen.*

The middle level was reached by a stair, shown by Ehud Netzer in his reconstruction on the west side, the main climb being within a stair tower. The precipitous sides of the mountain on the east and west are indicative of the enormous logistical problems associated with any construction near to the edge of the plateau. An extraordinary, circular building ('the Tholos') occupied the greater part of the terrace. Whether a library or simply a place to sit and enjoy the shade and whatever cool air could blow through the open colonnade will remain a matter of speculation. Certainly, it was a place to impress and entertain. A large part of this terrace is on made-up ground, requiring the construction of retaining walls.

A further stair on the east side led down to the lower terrace, the natural area of the rock shelf extended artificially and daringly, retained by great revetment walls. The lower terrace is the most splendid of all, containing a square structure with a central dining room and peristyle through which, again, spectacular views could be enjoyed. The use of plaster at this level is ingenious and sophisticated.

On the south wall a plaster surface is raised against the rock wall. Plaster fluting is used to enrich the columns and pilasters. The column capitals are carved in stone and were painted and gilded, and the supporting walls of the peristyle were decorated with richly coloured plaster imitating decorative stones such as porphyry and calcite. On the east side, adjacent to the south wall, a steep stair leads down to a small private bath house, perhaps the most secluded place on the mountain. Here are found a caldarium with remains of a hypocaust and mosaic floor, a furnace room, a tepidarium and a frigidarium. Above the frigidarium is a small cistern lined with ash plaster. Perhaps the most interesting survival at this level is the frigidarium, a pool reached by a series of plastered steps and covered with a plastered vault. It is in this remote corner that the remains of three people were found at the time of Yadin's excavation, a man with scale armour, a woman with braided hair intact and a child. Perhaps, inevitably, these three are associated by tradition with the mass suicide of the zealots.

Conservation work

The organisation and training of a team of conservators directly employed by the Israel National Parks Authority was established at an early stage and advised and directed by Asi Shalom, an archaeologist and conservator who had observed first hand over many years and in many countries the destructive potential of archaeology, and who would later write a manual of conservation for archaeologists[3] so that historic fabric and evidence would not be sacrificed in pursuit of knowledge.

The training period involved visits from a number of specialists from abroad, including an architect and archaeologist/conservator from the UK, with the object of pooling experience and developing a programme and suitable techniques for the conditions found at Masada. Training walls were built, and lime and earth technology taught by example and practice. Before any of the fragile historic surfaces were touched, the team had to establish a familiarity with the materials and the environmental conditions of Masada, directed by Shalom.

Categories of problems were identified and conservative approaches developed to try to protect and extend the life of what had survived. Plans were also developed with the Parks Authority for future schemes to enhance the visitor experience by allowing them to see more and by explaining in better detail the history and events which had taken place.

Stone conservation

The most obvious problem of the Northern Palace was the dramatic deterioration of the weak limestone which had been used for ashlar work and which, without exception, had once been plastered. Large areas of this stone form the walls of the great middle terrace platform supporting the Tholos and the revetments of the middle and lower terrace (Figure 10.18). Protected by their lime plaster, these stones remained secure, but loss of plaster meant that the stones were subjected to the combined effects of salt crystallisation damage and the scouring of wind-blown sand. Great, cavernous holes developed within the gypsum-mortared boundaries of the stones, a spectacular kind of alveolar weathering which could only end in the loss of entire walls. This situation posed the most serious threat in terms of major potential losses of buildings. A second, safety issue was also involved, and public access to the lower terrace would need to be limited or curtailed altogether unless a solution could be found.

The usual procedure of cutting out and replacing badly decayed stones with new stones was clearly impracticable in large walls which had become something like a fragile egg crate. The rigid grid of the 'crate' was formed by the joints and the stone adjacent to the joints; the voids were the centres of the stone blocks. Mortar filling alone was also impracticable because of the large volume of material each fill would require and the problems of curing such a volume without the development of shrinkage. A solution was therefore devised based on the use of stone tiles, bedded in lime mortar. The principle consisted of cutting a level base at the bottom of each cavity and raising a stack of tiles with mortared joints within the cavity until its roof was supported. This process provided, within each stone, a structural support system which left the Herodian coursing in place (Figure 10.19).

To ensure the tight packing of the cavity and that full contact was made from top to bottom through the tile stack, the uppermost tile was mortared on its top bed and wedged up into position so that the irregular top of the cavity was well filled with soft mortar. The joint below this tile was dry-packed with mortar using a tamping iron to maintain this critical contact. Slowly cured, the mortared tile stack restored the structural integrity of each stone and provided protection against further erosion by weathering agencies.

Compatibility of the tile stacks with the weakened Herodian masonry was clearly of the utmost

Figure 10.18 *The northern wall of the caldarium showing the fragile, egg crate-like form of the weathered stones (top centre) where they are not protected by plaster (bottom right).*

importance, since fillings which were of superior strength and durability would place additional stresses on the historic work and accelerate its decay. The material for the tiles was therefore selected from salvaged stones of the same age and condition which had fallen from the mountain and lay at various levels below, many of them damaged and all of uncertain exact provenance. These stones were sawn into tiles of 40–50 mm thicknesses. Mortar was based on a mature lime putty with sand and limestone aggregate and a ceramic pozzolan. Water ratios were kept as low as practicable and the repairs placed into well-wetted cavities before commencing the curing process of feeding them with mist sprays of water behind protective sun screens over periods of 10–14 days. Wet drapes of geotextile fabric were kept in place overnight when the mountain began to give back the heat of the day.

Figure 10.19 *Repair of the cavernously decayed stones of the Northern Palace was carried out using "tiles" cut from salvage, weathered stone bedded in pozzolanic lime mortar. Each stone was repaired individually. Joints were packed with mortar and stone in the final stages. The split faces of the tiles blend comfortably with the rough, weathered texture of the surviving masonry and are quickly coloured by the mud washing over the mountain during rainfall. Repaired stones are always easily identifiable at a 2 metre range.*

The visual impact of considerable numbers of tile stacks within the walls was another potentially controversial issue. Sawn faces were tried but were too intrusively regular, so the tiles were split instead and even worked with masonry chisels when in place to provide more natural-looking faces. Washes of mud from the mountain were applied to soften the initial appearance of the tile stacks, a task which the mountain subsequently took over itself as the few heavy annual rainstorms flooded off the plateau top. Textures and colours were very quickly in complete harmony with the appearance of the weathered Herodian walls (Figure 10.19).

The Tholos platform

Nowhere were the soft stone walls of greater concern than the great circular platform which once supported the Tholos on the middle terrace (Figure 10.20). The outer wall of the terrace still retained its stone copings but was severely reduced in load-bearing and retaining capacity by the weathering agencies already described. Significant losses could have occurred at any time, with falls of masonry damaging the lower terrace. Although some of the surviving stones could be repaired using the tile stack system, there were large areas where the stones were too seriously deteriorated even for this approach, and other areas where the stone facing was missing altogether. Without fairly substantial replacement the risk, at least, of the outer edge of the platform falling was clear.

A decision was finally made to replace the missing stones with cast stones. There were three reasons for this decision: new limestone was considered to be too aggressive visually and in terms of comparative durability; the use of new limestone was considered to be too close to condoning a policy of restoration; and the use of new limestone ashlars would require too exact a geometry to work in with the irregularities of the surviving Tholos plan. 'Stones' were cast in wood moulds based on a moderately hydraulic natural lime (NHL3.5), sand and porous aggregate to provide a block of adequate compressive and flexural strengths with good water vapour permeability. Stone sizes were taken from the tail impressions of the missing stones, and the bedding mortar was lime putty-based with ceramic pozzolan. To provide the essential stability for a high wall in such a precarious location, stainless steel dog cramps and restraint

Figure 10.20 *Early prototype of stone tile in lime mortar with a close texture to match stones in better condition. Thin mud washes are already blending the repair into the background.*

fixings of butterfly pattern were introduced (Figure 10.22). All cast block surfaces were finally plastered in a mud-coloured lime putty plaster to match the ubiquitous undercoat plasters of Masada.

Building and decorative plaster

The importance of plaster on the buildings of Masada can hardly be overemphasised both as a building and as a decorative finish. Although now weathered and stained by 2000 years of sand abrasion and mud washing, so many areas of plaster survive that it is not difficult to see how Herod's palaces on the mountain appeared from a distance to be built of marble, shining in the sun.[2]

As described above, the loss of plaster from exposed areas of stone, some of them raised on the top of precipitous cliffs, was, and is, a serious matter, leaving poorly durable stone at the mercy of weathering. But the loss of the plaster itself is to be regretted and therefore avoided by the use of conservative methods wherever possible; this especially applied to decorative, modelled work or the coloured plaster described in Chapter 5. The consolidation of plaster facings has been an important part of the conservation team's activity at Masada from the beginning, on areas of built up rubble and as linings to walls, cisterns, columns and stairs.

The most common conservation problem is the reattachment of areas of plaster surviving as 'islands' on natural rock or on worked stone faces. The problem can be exacerbated where these 'islands' have been given cement-based mortar frames to try to hold them in place (see Chapter 4, 'Mortar'). One of the difficulties with detaching sheets of plaster is that debris falls between the wall face and the plaster back, creating a wedging effect, so that simply pushing the plaster back onto a wet mortar slurry is not possible without causing it to fracture. Sometimes the debris can be extracted from the detached side with a vacuum cleaner, or some openings have to be made in and below the collection zone from the face and the debris washed out. In other cases it is only possible to re-adhere the plaster as it is found in its distorted profile by flushing and slowly grouting the void, a process accompanied by some risk and requiring temporary supports.

Almost every condition of plaster problem can be found on site at Masada, and there had to be development of a range of techniques and approaches by the conservation team. In addition to weathering attrition and physical damage, the ever-present reservoirs of soluble salts blown in from the Dead Sea accumulated everywhere and presented great problems. Even the washing out of cavities behind detachments and grouting with lime and ceramic

Figure 10.21 *Work proceeding from a suspended scaffold placing cast blocks back on the line of missing stones.*

powder would activate salt reservoirs and reconnect the back of the plaster with new supplies of salt from the rock, in the manner of a desalinating poultice.

The composition of plaster fills, supports and grout needed, therefore, to be designed with all these conditions and hazards in mind. Thus, a finished material with poor capillarity and good water vapour permeability, provided by a good pore structure, and good modulus of elasticity was essential. Careful control of shrinkage (see Chapter 4) by assiduous curing procedures was paramount to success. Without this, shrinkage would encourage micro-cracking and evaporation zones within which salt crystallisation would be encouraged. Success was very much based on the refinement of the conservation materials and on the building up of the conservator's skills, which became considerable. Any failures were carefully recorded and analysed. Conservation disciplines and understanding were developed over many months on the site, and could have been achieved in no shorter way.

Herod's private bath house: the frigidarium

Insights into the character and taste of Herod are numerous on the site of Masada, but nowhere more

Figure 10.22 *Assemblage of cast stones with stainless steel dowels and restraint fixings. The conservators are checking the final position of the face line.*

than in the ruins of his Northern Palace and perhaps, within the palace, nowhere more than on the lower terrace with its private bath house. The splendour of the palace in such a remote corner which seems to hang in space cannot fail to make an impression on the visitor, especially at those times when few others are present.

The small bath house reached by a staircase leading down from the lower terrace in its south-east corner was designed and constructed with some ingenuity. The building literally perches on the edge of a cliff and accommodates a disrobing room, caldarium, tepidarium, frigidarium and furnace room, all on a small, intimate scale. In spite of damage and significant losses, enough evidence of each space survived to be able to record and reconstruct, as a paper exercise, the whole of the complex, as Ehud Netzer had demonstrated.[4]

There was, and remains, no public access down to the bath house for reasons of visitor safety, and because the surfaces of floors and walls were dangerously fragile and vulnerable to damage. The vaulted space which may have been a disrobing room retained a low section of its eastern wall but the north-east corner had fallen away. The tepidarium retained significant amounts of plaster, both undercoats with plasterers' handprints in evidence and fine white finishes, and fragments of its white mosaic floor. The caldarium had bases of the hypocaust pilae still in place, a small section of its floor and a niche with white mosaic, but its eastern wall, like the eastern wall of the adjacent furnace room, had long ago fallen into the abyss below.

The frigidarium was the most complete of the rooms, consisting of a deep, rock-cut pool reached by seven plastered steps and approximately half of its vaulted roof (Figure 10.26). The water-holding plaster was still impressive, showing the same ingenuity that was used in the collection gutters, cistern and pool linings elsewhere on the mountain, and on which the impregnability of Masada depended (Figure 10.25). Such plasters, typically, have a base of clay packing with small stones to close up fissures and irregularities in the rock face, undercoats of lime plaster very rich in wood ash and charcoal, and a finish of fine, white lime plaster with a very close, almost polished surface. The water-holding capacity of these plasters is remarkable and was recently (2004) applied to the repaired and

Figure 10.23 *Detail of cast block fixing showing stainless steel dog cramps grouted in hydraulic lime and the dovetail fixing method back into the core of the rock. The fill between rock and cast rocks is a weak hydraulic lime and stone aggregate.*

part-reconstructed Herodian dam above Caesarea with great success (Figure 10.27). In the frigidarium, water marks at various levels were still much in evidence, testimony to the efficiency of the plaster over many decades. There survived at least two repairs neatly applied over areas where the rock profile presumably came too close to the surface and likely to be contemporary with the original construction. Above the broken vault was a small ash-plaster lined water system with floor channels and a square outlet which must originally have been fitted with a wooden plug; through this outlet water collected in the cistern could be allowed to fall into the pool below.

In the 1990s, fresh rock falls from the mountain, perhaps exacerbated by unauthorised visitors climbing above the bath house, were beginning to damage the plaster threshold and steps; even more seriously, the broken edge of the frigidarium vault was becoming increasingly fragile and further losses were imminent (Figure 10.28). Once again, the message of the need for continuing monitoring, maintenance and protection following archaeological examination was clear to read.

Figure 10.24 *During the progress of the facing work the surviving original stones can be seen in the foreground. Adjacent to them are two stones which have been repaired with split tile and lime mortar. Beyond the repairs can be seen three of the cast lime blocks with a roughened texture. The consolidated Tholos wall is now a mixture of original stone faces, repaired original stones and new cast stones where the facing was missing. Every part of the original face was secured and saved.*

Figure 10.25 *Herodian plaster lining to the artificial gutters running around the mountain to collect water and deliver it into rock-cut cisterns.*

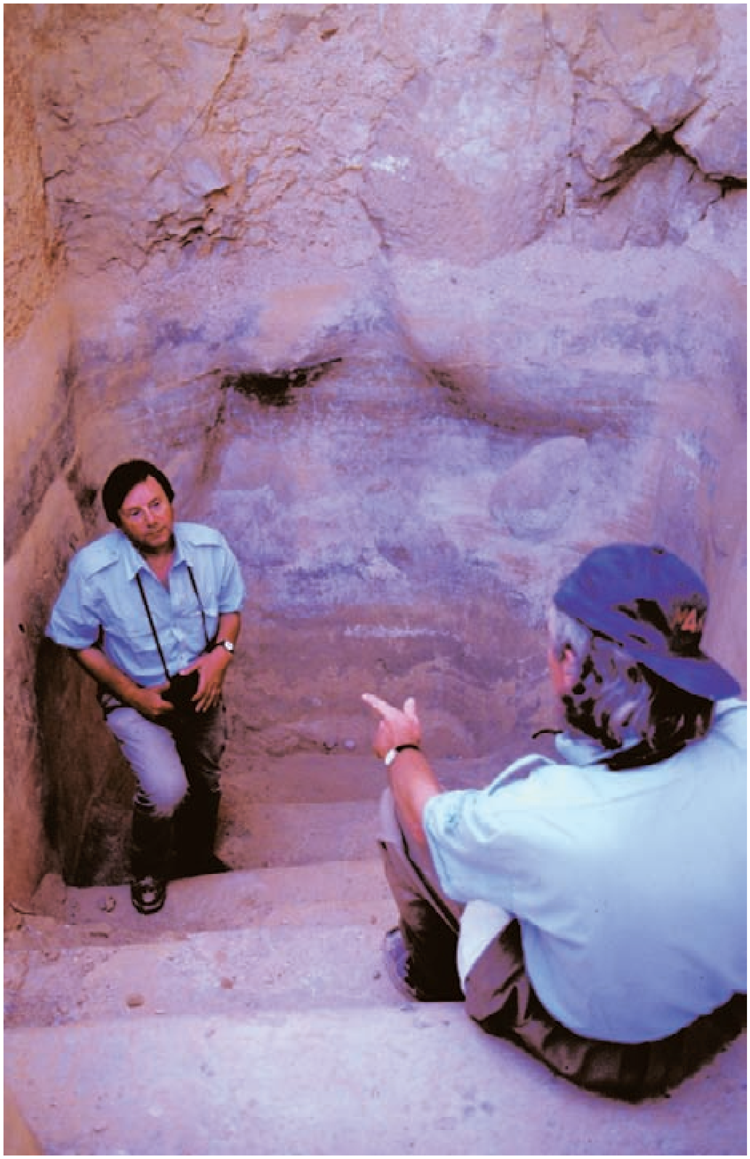

Figure 10.26 *The authors seen in the plastered frigidarium. The steps and the walls still retain much of the original polished plaster in excellent condition, still capable of holding water.*

The bath house is first made familiar to visitors through the site guide and through the audio-visual instructions in the new visitor centre. Although the bath is located at the extremity of their tour and requires the expenditure of some energy to be reached, there is an understandable fascination on the part of visitors to see the place where the three bodies were found, in the bottom of the frigidarium, with their possible link to the suicide of the zealots. The quest is frustrated, currently, by a lack of access, which encourages trespass, but this may be overcome if plans to recreate the full floor area of the lower terrace are implemented; from an extended floor it would be possible to look down into the bath house and see its layout without needing to go down into its vulnerable plaster spaces (Figure 10.29).

In the short term it became urgent to protect the plaster profiles of the frigidarium from further rock falls and to prevent the loss of more of the broken edge of its roof vault and consequent loss of the

Figure 10.27 *Detail of new water-holding plaster applied by Kimi Maman to the restored Herodian dam above Caesarea. The plaster copies that of the Roman period.*

Figure 10.28 *Detail of the broken and freshly damaged edge of the frigidarium vault, showing its extreme fragility.*

Figure 10.29 *View from the lower terrace of the small bathhouse complex during reinstatement of the vault.*

cistern above. Both possibilities were of immediate concern in 1997.

The action plan agreed by the Israel Nature and Parks Authority consultant, Asi Shalom, and the UK team was to put back the missing section of the broken vault over the bath to overcome all the threats in one structurally sound, visually harmonious way. The eastwards thrust of the new section of vault required a counterfort which would be provided by putting back corework on the east wall of the frigidarium to increase its height and weight, and by raising, in the same way, the height of the buttressing cross wall between the furnace and the caldarium, shown as hatched areas in Figure 10.30.

Once installed and cured, and the new corework raised in salvaged material and hydraulic lime (NHL2) mortar, the process of installing the missing section of vault could proceed.

The pool space was carefully cleaned to remove all loose debris and covered with geotextile fabric and synthetic fibre sandbags to prevent any impact damage to the plastered steps and walls. A scaffold frame on base boards could then be raised to provide a working platform below the springing line of the vault. From this base point vertical measurements were taken from the springing base line to establish the slightly distorted intrados line of the vault. The profiles obtained in this way were then translated onto 18-mm plywood formers, joined horizontally by 75 mm × 50 mm softwood framing, braced and screwed together to make a strong rigid base on which to construct the new vault. The last stage (Figure 10.32) was to screw-fix three sheets of 6-mm ply over the formers to create a rigid shell on which the stones would be set. The third sheet of plywood was introduced to allow for a plaster thickness on the surface of the vault.

The falsework was too heavy and unwieldy to slide into position and was obstructed anyway by the layout of the vault entrance, and thus was finally assembled and raised within the vault space, the last positioning being achieved with the use of wedges (Figure 10.33).

The new voussoirs from the vault were cut from salvaged stone and packed in NHL2 hydraulic lime mortar. The finished vault is shown in Figure 10.34.

Summary

The techniques used in the consolidation activities were developed by a team sharing experiences and

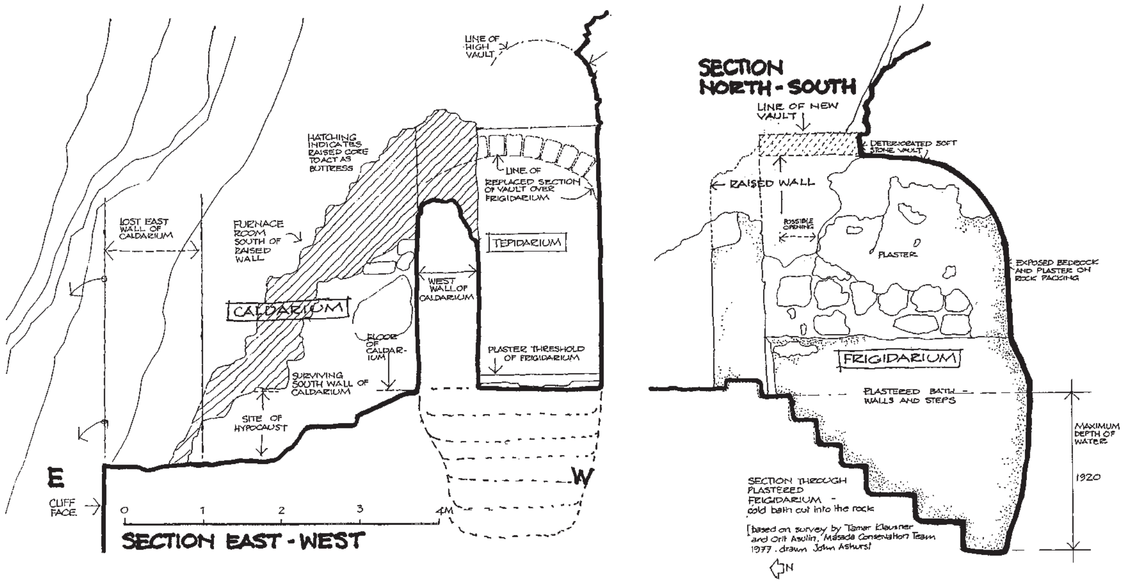

Figure 10.30 *Sections through the frigidarium.*

Figure 10.31 *Completed form work seen against the raised eastern wall of the frigidarium.*

Figure 10.32 *Fixing the plywood sheathing to the vault former.*

Figure 10.33 *Completed formwork raised up into position under the old work.*

Figure 10.34 *Completed vault showing the caldarium and the edge of a precipice beyond.*

working on site in 'real' conditions. Undoubtedly, the familiarity of the Israeli members of the team with their environment and their local materials gained over a number of years was fundamental to success, and paralleled that experienced by Colin Burns and John Ashurst with John Ludlow's conservation technicians in Ireland. The combination of this local experience and expertise combined with sympathetic team members from 'outside' creates a powerful resource in which there can be no room for the 'prima donna', because the achievements are recognisably and demonstrably collective.

A useful aspect of the conservation work on a remote site is the furtherance of an 'appropriate technology'. The advance of technology has, of course, benefited conservation in many ways, especially in recording systems and non-invasive investigative techniques, but in many locations and situations the technology of the twenty-first century is neither available nor affordable. In these situations improvisation, ingenuity, hand and eye skills, and minds trained to think logically, analytically and sometimes innovatively are what is needed. And always, essentially, a knowledge of the importance of the site, a respect for its status and unflagging enthusiasm.

Masada became a World Heritage site in 2002, a worthy recognition of its historic significance, but also of the great efforts of those who had protected and cared for it through many difficult years, not least the indefatigable Eitan Campbell, the site's manager. Visitors today have a greatly improved experience on 10 years ago, and will see and learn even more as conservation plans are developed. The new status in no way diminishes the need to carefully watch and maintain the historic fabric of Herod's and other buildings on the mountain, and to seek to set standards for other sites and other conservators.

Notes and references

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Case Study 3: Gosport Railway Terminal, UK

Margo Teasdale

Lay down your rails, ye nations near and far
Yoke your full trains to Steam's triumphant car;
Link town to town; unite in iron bands
The long estranged and oft-embattled lands …
Blessings on science and her handmaid steam!
They make utopia only half a dream.
(Charles Mackay, *Railways*, 1946)

These cathedrals of the new humanity are the meeting points of nations, the centre where all converges, the nucleus of the huge stars whose iron rays stretch out to the ends of the earth.

(Theophile Gautier, in Jean Dethier, *All Stations*, London, 1981[1])

Railway heritage

The railway architecture surviving from the nineteenth century in England and abroad stands as testimony to an age which believed in slow, steady progress towards a better future for all. The railway stations have been aptly compared to cathedrals, symbolic of the new technology of the industrial revolution and the steam age. The designs created for them, by the leading architects and engineers of the day, combined innovative modern techniques and revived traditional styles to reassure the travelling public and appease the cynics who spoke against the railway's destruction of the countryside. From the grandeur of the large British city stations like St Pancras with their breathtaking iron and glass train-sheds to the small country wayside stations, the variety of styles and designs that emerged have become highly valued where they have survived with their colonnades, canopies, iron columns, turrets and platforms. The *Building News* of 1875 declared that:

Railway termini and hotels are to the nineteenth century what monasteries and cathedrals were to the thirteenth. They are truly the only representative buildings we possess.

As railway mania spread, station designers across the world took their lead from the innovations made in the construction of the British railway network. British architects and engineers carried their knowledge of railway construction to North America and through Asia, Africa and Australia. The international phenomenon of railway building has many links still worthy of exploration through the individuals and the companies involved and the designs they employed in station architecture and engineering.

As railway networks all over the world have been gradually, and sometimes radically, reduced by the withdrawal of successive government support for passenger and freight transport, so too has their built infrastructure. Since the 1960s, 4000 stations went out of use in Britain. Many have been reused but many have been demolished, leaving gaping holes in the landscape and many bereft over their loss. The wave of destruction which followed the demolition of the great portico of Euston station in 1962 caused conservationists to comment that, since its establishment in 1947, British Rail had acquired for itself an all too deserved reputation as the 'biggest corporate vandal' and iconoclast Britain has seen since the Tudor dissolution of the monasteries.[2] In the United States the premier New York station of the Pennsylvania Central Railway Company was demolished. In 1975 Toronto's Union Station was threatened with demolition, causing a conservation movement to unify and lobby the Ontario Legislature for stronger protection and its successful retention.

By the mid-1980s over 600 stations were listed as Buildings of Special Architectural or Historic Interest under the Town and Country Planning Act in England. The Act protects railway stations from demolition and unsympathetic alterations. As the criteria for listing favoured the oldest stations and engineering structures, the sites selected for listing represented the origins of the early railway network built by the many Victorian railway companies and their now world-renowned architects and engineers. To celebrate and recognise this rich railway heritage, the British Railways Board commissioned Biddle and Nock to assemble the landmark illustrated guide to the listed stations and their architectural history. One of the stations included in *The Railway Heritage of Britain* was the Gosport Railway Station, listed in 1975, and built by the London and South Western Railway.[3] As one of the first generation of classical station designs, it was among Sir William Tite's best works, surviving now as a roofless, railway ruin with a social history worthy of celebration in its own right and testimony to the community that cherishes it. Gosport Railway terminal is, in many ways, the story of Gosport; architecturally, the ruin is a reminder of its one-time status and clientele.

Gosport peninsula is strategically located on the south central coast of England across the water from the historic dockyard at Portsmouth, on the Solent waterway. With Portsmouth it became the centre for elaborate defensive fortifications, built mainly from the seventeenth century. The construction of the Royal Naval Hospital at Haslar was completed by 1762. By the end of the eighteenth century Gosport was a strongly walled naval town. In 1828 the whole Victually Department for the Navy was transferred to the north-east of the town while the gunpowder and armaments depot developed to the north at Priddy's Hard. The town grew around the select resort and place of residence of naval officers at Alverstoke.

Proposals for a railway to link London with Southampton were confirmed by an Act of Parliament by 1834. The decision to locate the railway terminal at Gosport was partly as a result of difficulties in gaining local support and reluctance to breach the fortifications at Portsmouth. Gosport's ramparts were close to the town centre and the siting of Royal Clarence Yard made the locating of a railway terminal there convenient for the town and the Admiralty. Once the links with Portsmouth were secured with approval for a floating bridge link to Portsmouth in 1838, the London and Southampton Railway (LSR) secured the site for the terminal opposite the gates where the main turnpike road entered the town through the fortifications. At the same time, the LSR became the London and South Western Railway (LSWR). The first branch railway in Hampshire from Bishopstoke (later called Eastleigh) to Gosport was opened up in 1841. Gosport then became a destination, along with Bournemouth, the Isle of Wight, Devon and north Cornwall, on the 'holiday line'. The line developed as a year-round service to the south coast, and became known for its associations with Queen Victoria at Windsor, Eton Riverside and Gosport, and with troop movements during both World Wars. The South Western was also renowned for technical innovations in locomotive design and the use of automatic signalling with semaphore arms activated by low-pressure compressed air.[3]

Station plans

The architect, engineers and builders of the LSWR were some of the best-known names of the period. Sir William Tite was a prolific Victorian architect, best known for the rebuilding of the Royal Exchange in London, which was well under way by the time Gosport was designed. Tite's reputation as a station designer was established, as one of his best railway termini had been constructed at Southampton by 1840. Thomas Brassey, well known for associations with Sir Morton Peto and Edward Betts, who built the early Grand Trunk Railway in Canada, was contracted to oversee the construction of the line. Brassey subconstracted the building of the station to the local builder David Nicolson. The station was built at a cost of £10 980, compared to the £1250 spent on other stations at Fareham and Botley.[4] All the skills and experience of the architect and the contractors would be needed to meet the stringent requirements of the Board of Ordnance who, by rights granted in the enabling Act of 1839, had control over the siting, height and architectural form of the station to ensure that effective use of the fortifications near the station was preserved. Unusually for a station, the intent of the Board of Ordnance was to have it constructed as a defensible site that could be used by the Royal Engineers, if the need arose, to protect the Gosport Lines.[5]

Tite's drawings for the Gosport terminal submitted to the Board of Ordnance in 1840, for approval, were in the neoclassical style, showing a 14-bay Tuscan and Doric colonnade, in Portland stone, terminating in large pavilions with rusticated arched openings and parapets with miniature segmental pediments. The designs had to be modified for the Ordnance by removing the upper floor to make a single storey to provide an open line of fire, by erecting costly iron railings on brick bases on the elevation facing the ramparts, and extra high parapets, broad gutters and a lead flat roof over the colonnade for the use of troops on all four sides of the building. Fortunately, the elegance of Tite's designs was not altered to any degree that reduced the grand architectural impact the building would make when it was built. The station followed a linear plan common to the first generation purpose-built railways, aligned along the departure and goods platforms with access controlled to departures through the booking hall and waiting room. The original roof of the station was impressive, with heavy oak trusses spanning the track bed over both the goods and passenger platforms. The long, hipped roof frame was finished in slate and a rooflight the length of the ridge provided an elegant roofline (Figure 10.35). A flat lead roof covered the colonnade.

Other influences on station plans and additional problems for the Board of Ordnance were created when Prince Albert asked the Garrison Commander to build a private station for the royal family within the secure site of Royal Clarence Yard. The royal family needed to travel in private for fleet reviews and to board their yacht to Osborne House on the Isle of Wight. The construction of the Royal Victoria Station was agreed and the railway line from Gosport

Figure 10.35 *Sir William Tite's Gosport Railway Terminal.*

terminal was extended 600 feet through a new brick tunnel cut through the brick and clay defensive ramparts. The long history of Queen Victoria's arrivals and departures from Gosport ended with her death at Osborne House in 1901, when she was brought to Royal Clarence Yard to begin her last journey to London's Waterloo Station.

The station plan was designed to accommodate the passenger platform on the south side and the goods platform on the north side under one large roof span. Provision for separate departure and arrival platforms was never made. A separate goods shed was built to the west of the goods platform that could house up to 10 wagons. Three tracks ran into the station from the west with a pair of turntables at each end for manoeuvring the trains for their return journey. A stationmaster's house stood at the east end of the station and gardens were laid out to the south-west. The station yard developed to the north with shunting roads built to move coal, a two-road engine shed, weighbridge, signal box, cattle dock and horse stables.[6] The station yard would have been a riot of sounds, smells and activities as parcels, supplies of coal, fish, goods and Devon cattle for the navy arrived.

Adapting the station to meet technical, social and economic changes began very early after it was constructed and continued through the decades it was operational. The story of the conditions and events that underline the station's history has been told with much enthusiasm by local and railway historians, supported by a rich archive of old photographs, plans and maps. Soon after beginning operations, the openings for the trains had to be modified using cast iron columns where they met the platforms, as they were too close to the rail carriages.

World War II and the closure of operations

An important event occurred a century after its opening on the night of 10 March 1941, which was to have a dramatic impact on the station and mark the beginning of its demise. During one of the many air raids on Portsmouth during World War II, an incendiary bomb lodged in the station roof and set the timber framing on fire. Local accounts tell of brave acts to remove the loaded wagons in the yard and frightened horses from the stables, but there was no ladder long enough to reach the roof.[7] The fire

Figure 10.36 *Hillspan roof installed after the original timber roof was destroyed by enemy action in 1941.*

destroyed the offices and booking hall in the terminal, and business had to be conducted from buildings constructed at the west end of the passenger platform. A metal Hillspan roof was erected, leaving the passenger platform exposed to the weather (Figure 10.36).

After the war the strategic importance of the station for naval supplies and the movement of troops and hospital trains to Haslar declined. Passengers travelling to London preferred to leave from Portsmouth or used local trams and buses. Freight service continued until 1969 as the short-sighted Beeching Plan took effect in cutting all unessential rail traffic. The track was quickly removed, along with the steel-framed roof and all movable equipment. Within a short period of time the station took on the appearance of a ruin. The vegetation that quickly took over the site grew over the elegant colonnade and gave it a Piranesian character when it was photographed for the National Railway Museum archive (Figure 10.37).

Recognition and conservation

By 1974 Hampshire County and Gosport Borough Councils, with admirable foresight, had acquired the old railway track bed and the station ruins in a bold decision at a time when the qualities of industrial buildings and archaeological sites were not fully appreciated (Figure 10.38). Industrial sites were still associated with the often harsh conditions of the workers and only recently had industrial sites been considered important to save for a more balanced understanding of the past. Aside from some textile mills in the north and remnants of Cornish tin mining, few eighteenth or nineteenth century industrial buildings have survived the bombings of World War II, and the clearances and redevelopments that followed in England, as ruined structures. The reuse of industrial buildings is now common practice and socially desirable, as the work of SAVE Britain's Heritage has so aptly illustrated.

Figure 10.37 *Post Beeching Plan dereliction: the Terminal as a ruin.*

In 1975 Gosport terminal was listed as a building of Special Historic Architectural or Historic Interest and protected from demolition in English law. The County Architect of Hampshire County Council stated at the time that 'wholesale renovation on the scale which would be required could hardly be defended as conservation and the more satisfactory solution might be to preserve the ruins as they stood in an area of carefully designed landscaping'.[8] Plans to remove charred timber, demolish dilapidated sheds, consolidate and protect the brick wall tops, retain stucco, stabilise chimneys, repair decaying boundary walls, clean and treat rusting iron, and remove vegetation were carried out over the next few decades. The Gosport Railway Society demonstrated their avid support by volunteering with site clean-up, vegetation removal, and giving tours before health and safety requirements made visits difficult. In 1995 the iron railings to the station entrance were repaired and sections reproduced, where they had crossed the track bed (Figures 10.39–10.41). The elegant detail of the Victorian

Figure 10.38 *First sign of recognition of significance; acquisition of the Terminal ruins and track beds by Hampshire County and Gosport Borough Councils.*

Figure 10.39 *Cement stucco used to replicate rusticated masonry is particularly vulnerable to the ruined condition of the building and needs careful maintenance.*

Figure 10.40 *The tuscan order was used by Sir William Tite for the entrance colonnade, worked in portland stone, with scholarly detailing.*

Figure 10.41 *The quality and elegance of the Terminal buildings are a hallmark of the work of classical school architect Sir William Tite (1798-1873) and an important factor in the recognition of their significance.*

postal box, which is protected by listing and stands outside the iron railings, was restored after 23 coats of paint were removed (Figure 10.42). By this time the goods yards had been sold and redeveloped for housing.

Several proposals for reusing the station were made and even included a scheme for indoor bowling, but none were successful (Figures 10.43 and 10.44). Surprisingly late, an assessment of the historic value of the station was commissioned for the first time in 2003, to use site history to interpret the extant fabric of the structures. The report concluded that, collectively, all the remaining structural elements of the site were of national significance and that more recording and archaeological investigations of the station gardens were needed (Figures 10.42–10.44). A companion ecological survey was also commissioned and badger sets were discovered in the stationmaster's garden area of the site, which was to be given due consideration in any development proposals (see Chapter 6).

A 'new life for Gosport Railway Station'[9]

Gosport Terminal has been recognised and saved as a ruin by national legislation, by the foresight and intervention of the county at a crucial time in response to local planning, and by considerable community interest and pressure. To date, the station environment has been successfully safeguarded through planning initiatives respecting the need to incorporate the site and any development proposals for it within the grain of the St George's Barracks Conservation Area (Figure 10.45).

The future development of the Gosport Terminal site is again in question, as it is now on the property market with a development brief agreed by the owners and English Heritage which encourages a creative reuse scheme and some adjacent development, respectful of the historic significance of the site (Figure 10.44). With plans to develop the proposed South Hampshire Rapid Transit tram system turned down by the Labour government, it appears the former railway lines in the Gosport peninsula will not be reused in any way to alleviate the traffic congestion in the area. Given local interest in the station, there is considerable scope for presenting and interpreting the history of the site. Significantly, the interpretation is generally considered by some to be best carried out through the retention of the terminal as a ruin, its aura of authenticity remaining

Figure 10.42 *Restored railings and post box 1995.*

Figure 10.43 *The track bed space stimulated several proposals for re-roofing the Terminal for new uses.*

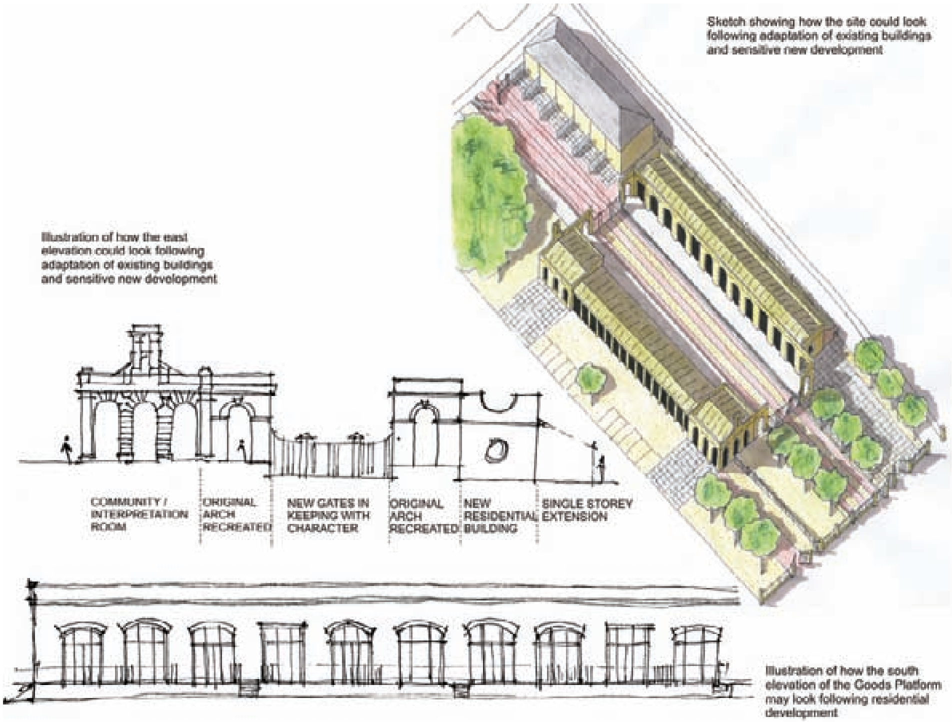

Figure 10.44 *Consideration of development briefs 2005. A proposal for adaptive re-use, including re-creation of elements of Sir William Tite's design. Proposals to retain the Terminal as a ruin have considerable local support.*

Figure 10.45 *The new 170 metre high Spinnaker Tower commemorating the area's great naval traditions, seen from the ruin of the Gosport Terminal, commemorating the importance of the railway era.*

undiluted by adaptive reuse and its story ready to be told. Clearly, however, there is also considerable scope for reusing and restoring the exterior of the booking hall, at least in part, for community use by a suitable investor with an interest in and commitment to historic preservation.

The future looks promising as the station is in an area experiencing much regeneration. The historic naval docklands at Portsmouth used to stage the 200th anniversary of the British victory at the Battle of Trafalgar, in 2005, and Royal Clarence Yard are being restored and redeveloped with private and public sector investments. The new 170-metre-high Spinnaker Tower overlooks the historic naval ports of Portsmouth and Gosport, and commemorates the great naval traditions of the area in its design (Figure 10.48). Similarly, as long as the community continues to value its elegant railway ruin, Gosport Terminal will be a reminder of and a memorial to the romance of its industrial, royal and military past.

Notes and references

1. Excerpts from Richards, J. and MacKenzie, J. M. (1986). *The Railway Station: A Social History*, pp. 3 and 17. Oxford University Press, Oxford.
2. Binney, M. and Pearce, D. (1986). Quoted in *The Railway Station: A Social History*, p. 36.
3. Biddle, G. and Nock, O. S. (1983). *The Railway Heritage of Britain: 150 Years of Railway Architecture and Engineering*, p. 203. Michael Joseph.
4. Oppitz, L. (2003). *Lost Railways of Hampshire*, p. 86. Countryside Books, Newbury, Berkshire.
5. Eley, P. The Battle of Gosport Railway Station 1840–1841; www.discoverycentres.co.uk.
6. Keat, P. (1996). You are not putting a hole in my wall. Gosport Railway Society, p. 19.
7. Keat, P. (1996). You are not putting a hole in my wall. Gosport Railway Society, p. 24.
8. Hampshire County Council (1974). Report on Listed Buildings Owned by Hampshire County Council.
9. Taylor, A. (2005). Promise of New Life for Gosport Railway Station; www.hants.gov.uk, 9 November.

Quarry at Thassos. The voracious Roman hunger for marble to adorn their cities of travertine, tufa, tuff and brick resulted in a great expansion of quarrying throughout the empire. Tasio marble, Marmor thasium, from the island of Thassos in the northern Aegean may be found in the Pantheon, the Forum of Nerva and the pyramid of Cestius. The almost blue–white marble is seen here sparkling in the sun, the old quarry workings plainly visible, the quarry floor now partly submerged beneath the sea. Here was the birthplace of numerous ancient buildings, some surviving, some now ruins, others returned to the land or the water. The quarry itself is now a ruin of spectacular beauty, a site to be preserved, a memorial to industry, to commerce, and to men and women who wanted to live in buildings fit for Gods.

Epilogue

John Ashurst

> *The planning process in essence is about bringing the right people and organisations together with the correct information. Identifying the individuals and organisations to participate in the process is, therefore, critical to success in making good decisions about a site.*
>
> (Jeanne Marie Teutonico and Gaetano Palumbo, *Management Planning for Archaeological Sites*, GCI, Los Angeles, 2000 – Proceedings of an international workshop, Corinth, Greece, May 2000)

This book has identified a wide range of threats to historic ruins and their sites, and has discussed and illustrated ways in which these risks can be confronted and reduced by properly informed survey, recording, protection, conservation and presentation.

There is, however, an additional threat to the quality of survival which is implied by Gaetano Palumbo in the extract above, from the Corinth Workshop. The planning and management processes must be the responsibility of the 'right people'. Who, then, are the 'wrong people'?

On the historic site the 'wrong' man or woman can soon be identified by their lack of genuine interest and respect for the skills and experience of their colleagues. At more senior management levels within a heritage protection organisation, and even more at national, political levels, the identification becomes more difficult. Of course, the manager or politician needs a more diverse range of skills and abilities and has more complex responsibilities than the site conservator. But if they have nothing of the interest and commitment of a good conservator to the heritage site they will almost certainly be dangerous for it. More seriously, they may be dangerous for many sites and perhaps to the future of their country's heritage.

National policies are telling. For instance, more than one country has created a government department whose responsibilities include interests as diverse as culture and sport. There is something disturbingly miscellaneous about grouping heritage, the arts and sport together as a leisure industry, and when budget restrictions begin, as they always do, heritage is the first to suffer.

Perhaps there is little that can be said here about the politicians, except to ask that they expect and get the best from their senior civil servants, and that they in turn listen to their directors. But the directors and their managers with heritage responsibilities must be knowledgeable and enthusiastic about their charges, and in some way be able to demonstrate their fitness and competence for the post. Managers who find it expedient to pay lip service to the heritage but cannot demonstrate a personal interest and a will to protect their sites and their specialist staff are as easy to identify as poor site conservators, although they are more difficult to move.

When charters have been drawn up, policies formulated and budgets agreed, ruins and their sites are in the hands of individuals who may be using public funds. The right people are those who know the value of their sites and the privilege of their position, and are prepared to take their custodial duties seriously. Without them, the heritage of ruins, amongst other historic buildings and sites, will pay.

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Appendix 1

Materials and techniques

John Ashurst and Colin Burns

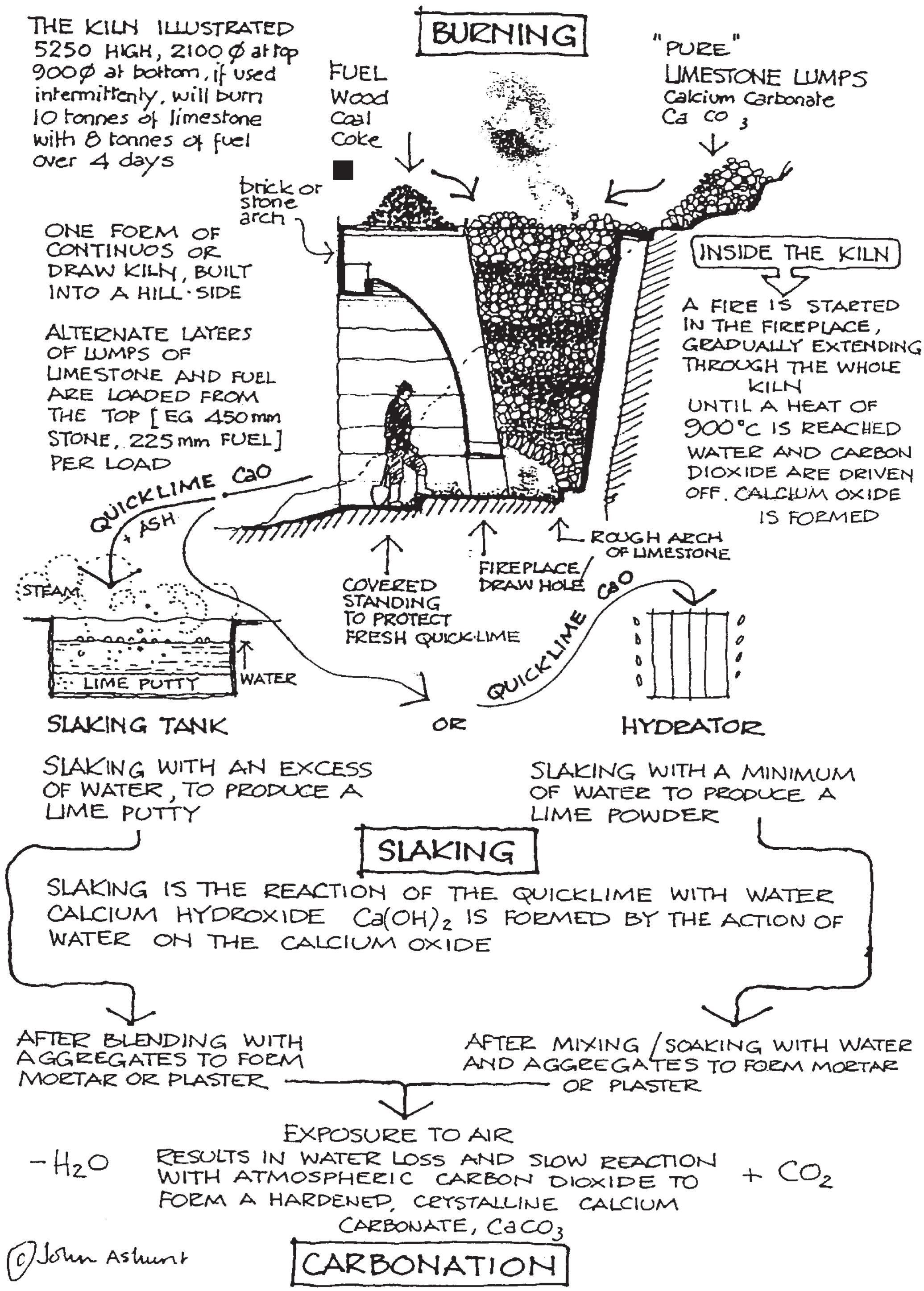
(These figures first appeared in *Mortars, Plasters and Renders in Conservation*, Ashurst, John, Ecclesiastical Architects and Surveyor Association, 2003)

1.1
- Traditional lime production; the processing of limestone, marble, coral or shell to produce non-hydraulic lime, usually as lime putty.
- Traditional lime production; the processing of limestone with clay 'impurities' to produce hydraulic lime, usually as a powder (but see text of Chapter 4).

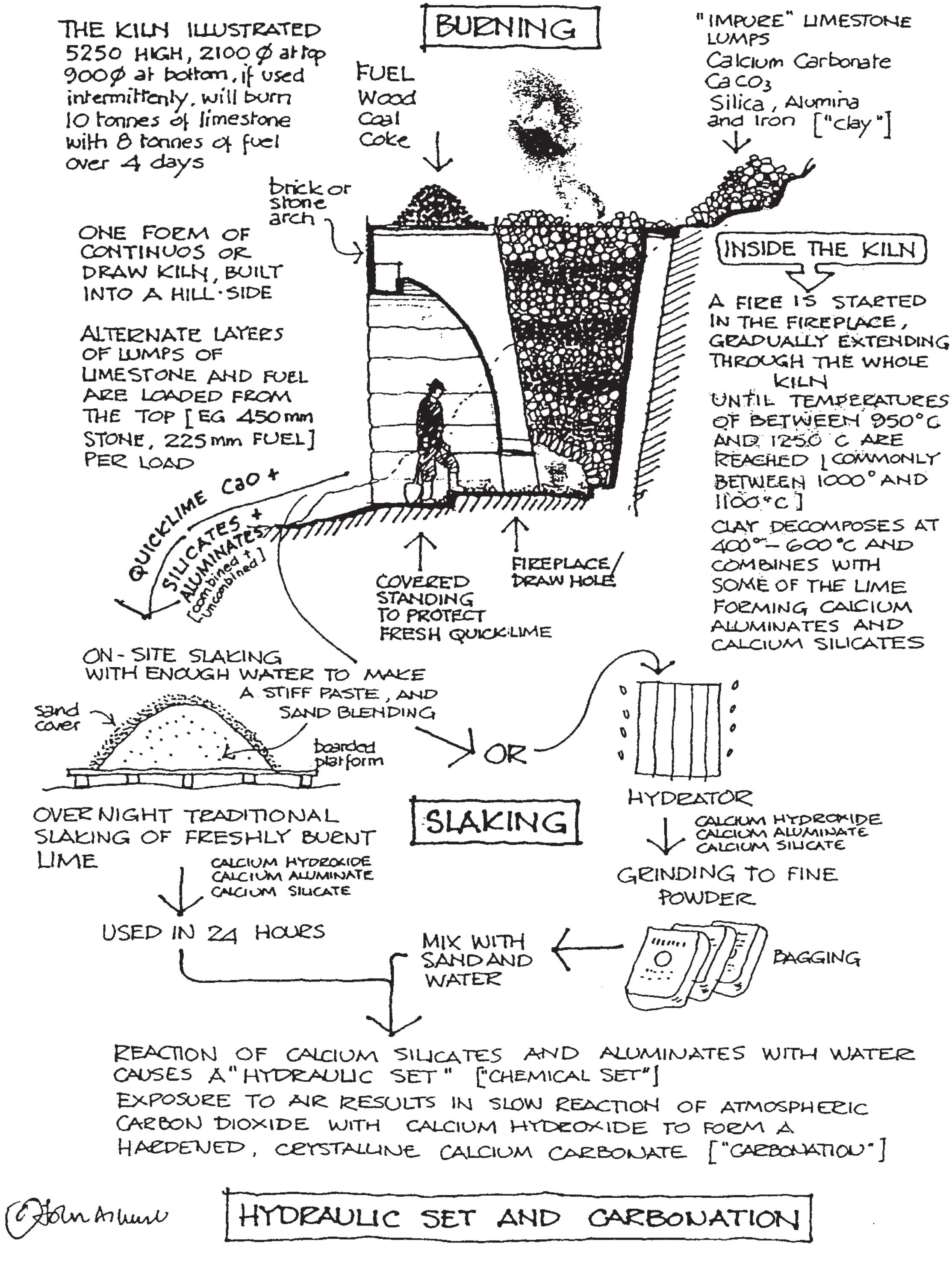
1.2 Lime mortar and plaster in ruin sites; problems related to carbonation and solubility.

1.3 Tools for joint and core treatment; cutting out, pointing, clearing out and deep tamping.
Techniques for cutting out, filling and finishing joints (see descriptions in Chapter 4).

1.1 Traditional lime production



Lime cycle: Non hydraulic lime



Lime cycle: Hydraulic lime

1.2 Lime mortar and plaster in ruin sites

Most frequent observations by the early custodians of those ruin buildings thought to be worthy of preservation focused on the damage caused by invasive woody plants such as ivy (see Chapters 4 and 6) and the problems of mortar, especially of core exposed on wall heads and broken wall ends. Early 20th century specifications almost invariably saw Portland cement as a key component in capping broken walls to enable them to resist rain and frost and in grouts to fill voids in wall core. The specifiers were concerned at the evidence they saw of old mortar softening and spalling and washing out of wall cores, and needed to find an answer. Unfortunately, although several good hydraulic limes were available to them, and although they recognised the need to avoid the use of cement in pointing ancient masonry, they chose cement mortar, or cement gauged lime mortar, as the answer (see Chapter 4).

Part of the problem was the saturated condition of many of the walls being consolidated for the first time, and the time it took for lime mortar, even their blue lias hydraulic lime mortar, to develop strength in such conditions. The problem remains familiar today and relates primarily to the issue of carbonation. The lower the hydraulicity of the lime used, the more critical the carbonation process becomes and the more vulnerable will the ruin be to weathering agencies. Carbonation describes the conversion of calcium hydroxide (slaked lime) to calcium carbonate. Both un-carbonated lime and carbonated lime in the form of calcite are soluble in water, calcite more sparingly so. The solubility of these materials in water increases with low temperatures, so that ruins in cold, wet environments are particularly susceptible; it does not necessarily follow that mortars in ruinous structures in hot, dry climates are immune from the problem, especially when clay and gypsum mortars are concerned.

Examples of binder solubility problems in ruins (see Chapter 4)

- Some of the binder is dissolved from core mortar exposed on broken wall heads and ends, reducing the ability of the mortar to resist cycles of wetting-drying, freeze-thaw, and salt crystallisation.
- Water penetrating the core forms channels and voids within the wall allowing water entry and retention and creating instability, especially if the core is of poor quality.
- Water penetrating the interface between the tail ends of facings and core weakens the mortar and reduces the ability of a composite wall to perform as an integral whole. Facings may detach and fall.
- As part of the above processes some of the dissolved binder migrates into the pores of the stones and onto wall surfaces where it is re-deposited in the form of hard, calcite skins. In the case of sandstone facings, this process can play a part in encouraging decay, manifesting itself in the form of dramatically rounded arisses with flaking, powdery stone surfaces.
- Washing out of joints at wall bases due to downward migration of water in the core and/or to splash zones, causes the wall to lean and distort (see Chapter 2).
- Newly excavated masonry in sound condition can begin to deteriorate rapidly as mortar from which the binder has been leached begins to dry out and is subject to migration and crystallisation of soluble salts and to washing.
- Unprotected plaster detaches and crumbles as water gains access to the wall interface, softening the body of the plaster, washing out some of the binder and causing it to fall.

Obstacles to carbonation of lime mortars and plasters (of particular significance to remedial works on ruins)

For carbonation to take place, air and water need to be present. In the absence of air contact, for instance, calcium hydroxide in the form of lime putty will remain soft indefinitely, as is well known. But air contact may be denied, or at least significantly reduced, in other ways, as follows:

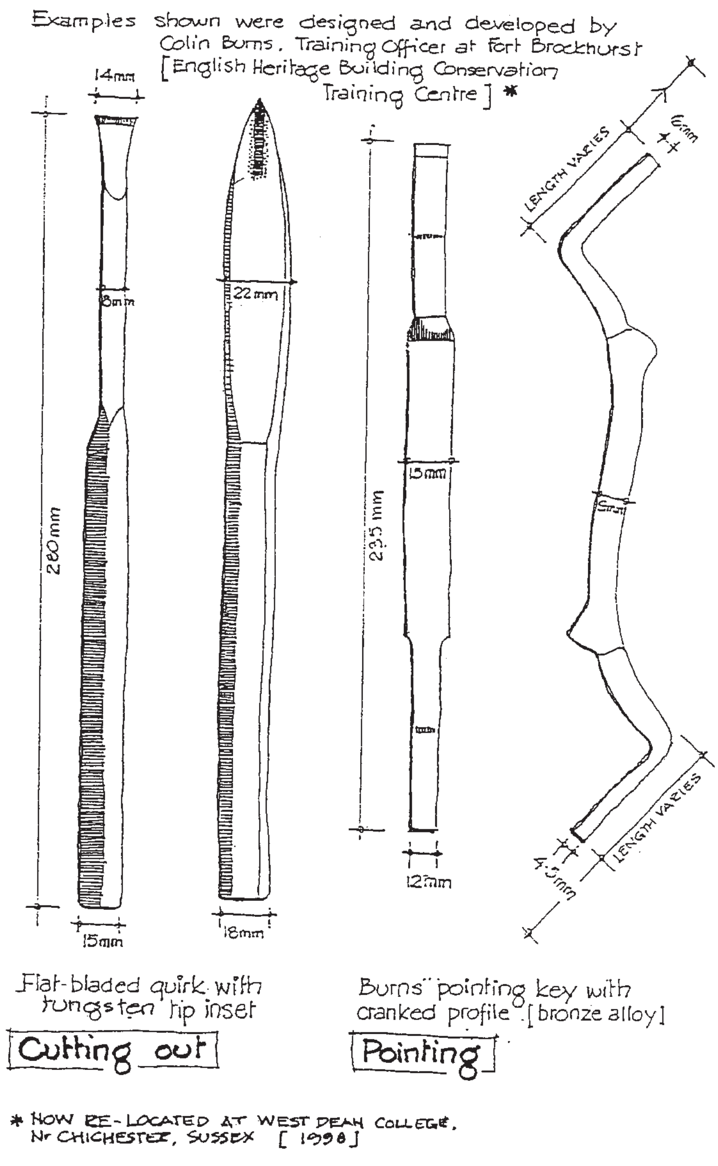
- Successful, rapid carbonation of the surface of mortar joints at wall faces may severely inhibit progressive carbonation of mortar deep in the wall core behind, especially if the masonry consists of dense, rather impermeable stones and the mortar aggregate is of similar material.
- Walls which have been saturated for long periods of time, or even wall heads which have been exposed to a long, wet summer may so severely delay the carbonation of new mortar used in the consolidation of wall heads or joints that it is easily destroyed by frost and/or heavy rain as winter advances.
- Voided, composite walls which have been extensively irrigated and grouted may severely delay the carbonation of new jointing material or plaster applied to the wall surfaces, so that they fail during the first winter's exposure.

- Insufficient water will also seriously inhibit the carbonation of new mortar and plaster. This situation most commonly arises through rapid loss of water to dry masonry (inadequate pre-wetting), or as the result of exposure to strong, drying winds or sun, or simply because a rather dry mix with a low water:lime ratio has been used.

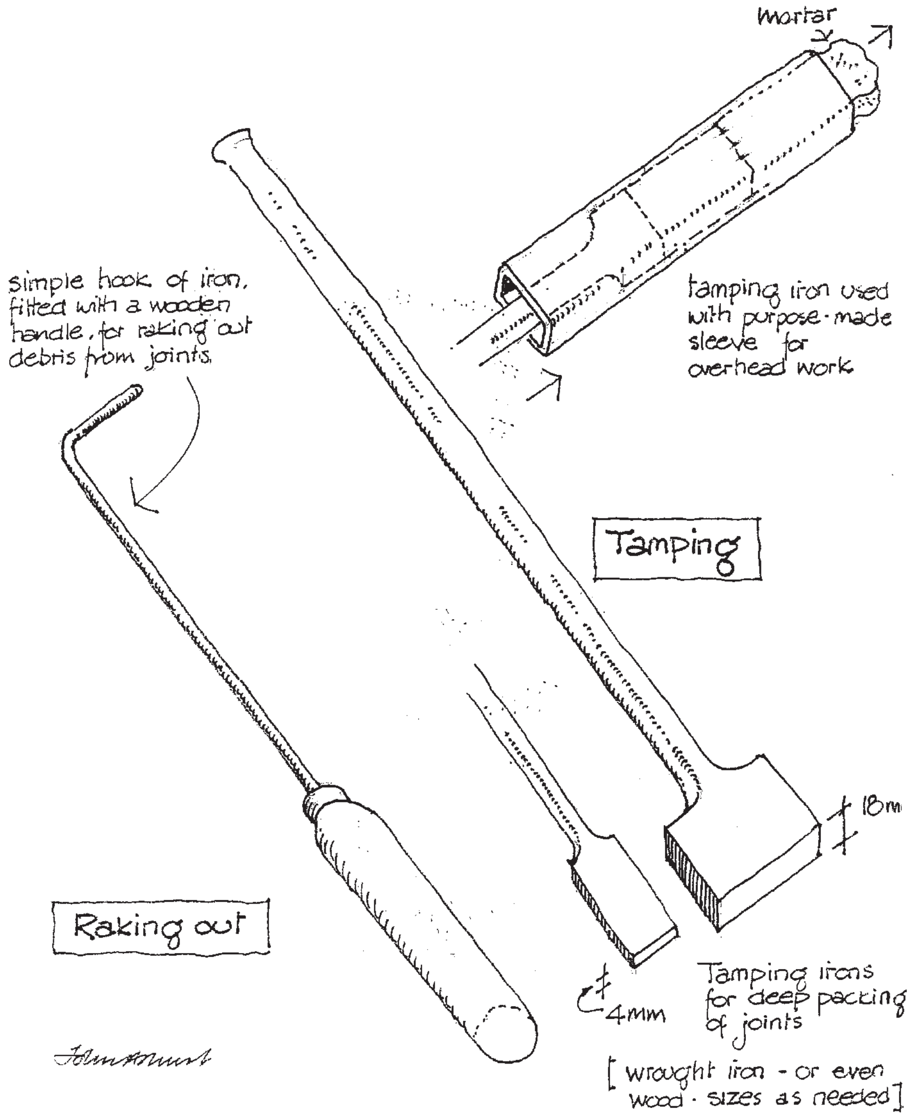
Response to carbonation and solubility problems

The use of natural hydraulic limes is advocated for a number of reasons (see Chapter 4) including the reduction of reliance on carbonation alone to provide the necessary resistance to wet weather and wet ground conditions. But there is "free" or "available" lime even in hydraulic lime-based mortars and plasters which needs to carbonate significantly, or it remains susceptible to water. The use of porous aggregates, of pozzolans and of careful water management in preparation and curing stages are imperative to ensure the good long term performance of mortar and plaster in vulnerable ruin contexts (see descriptions of mortar mixes in Chapter 4).

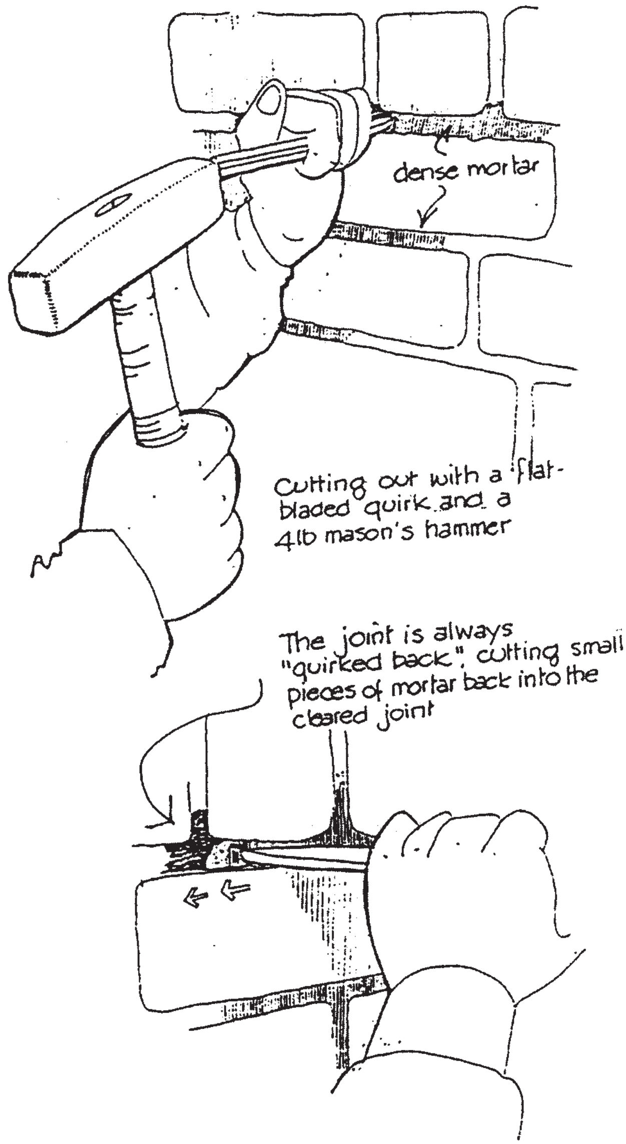
1.3 Tools for joint and core treatment



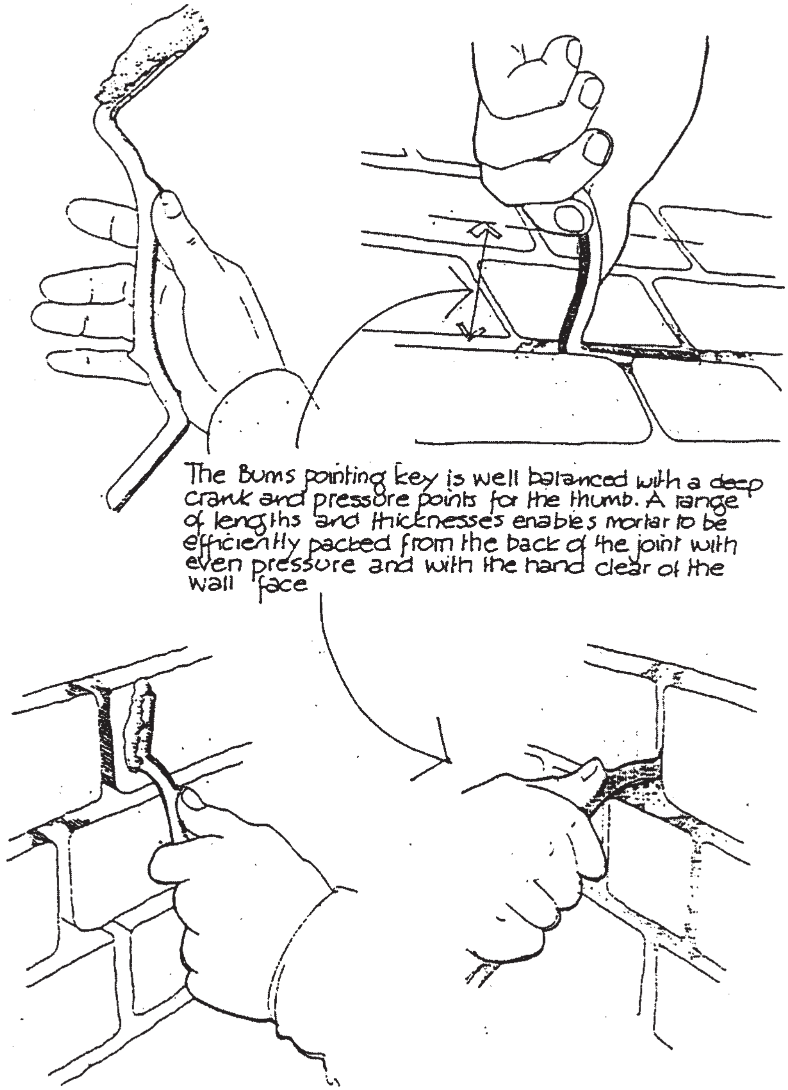
Tools for joints



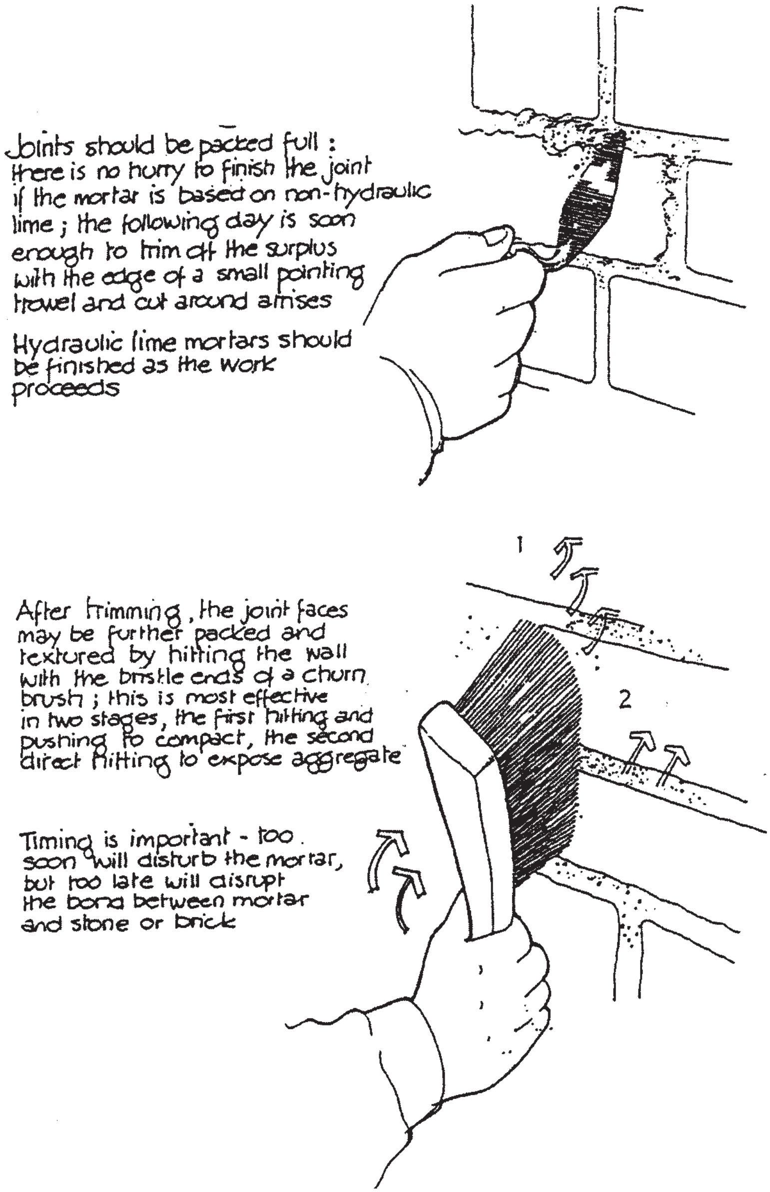
Tools for joints



Joint techniques: cutting out



Joint techniques: filling



Joint techniques: finishing

Appendix 2

Structural interventions

John Ashurst and Colin Burns
Jon Avent

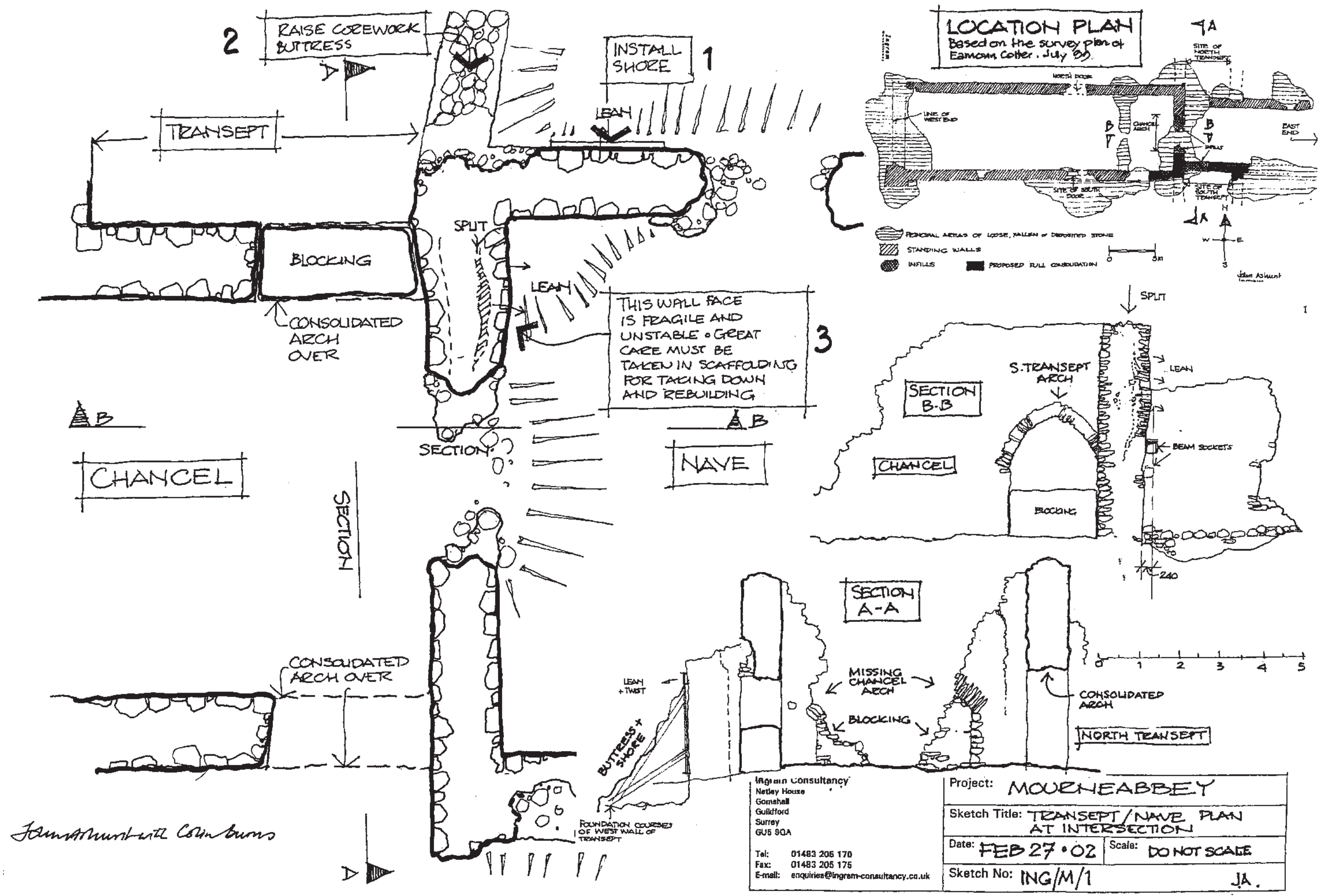
2.1 The use of temporary supports to hold a leaning wall in position before consolidation, Mourneabbey, Ireland. Consolidation of these walls is illustrated in Chapter 4.

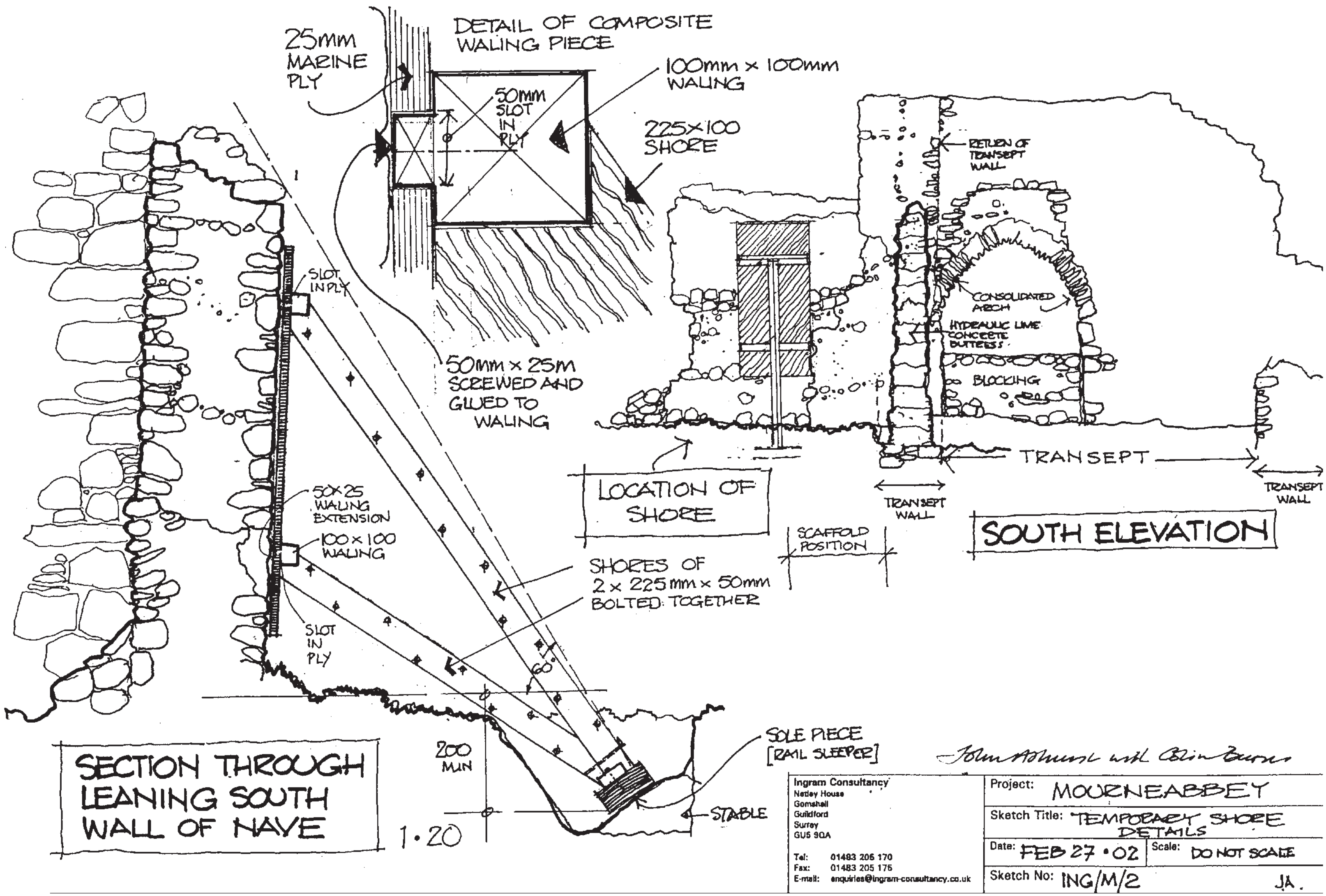
2.2a
2.2b A proposal to raise corework on the line of a missing wall to provide a permanent reinforced hydraulic lime-based concrete buttress.

2.3 Overhanging masonry, typical of some broken walls and often at high level, sometimes requires the introduction of cantilever restraint bars. Where possible, corework is corbelled out beneath the overhang to provide optional or additional support, but its character must be carefully matched to 'natural' exposures of core.

2.4 Re-alignment of leaning wall at Cymer Abbey.

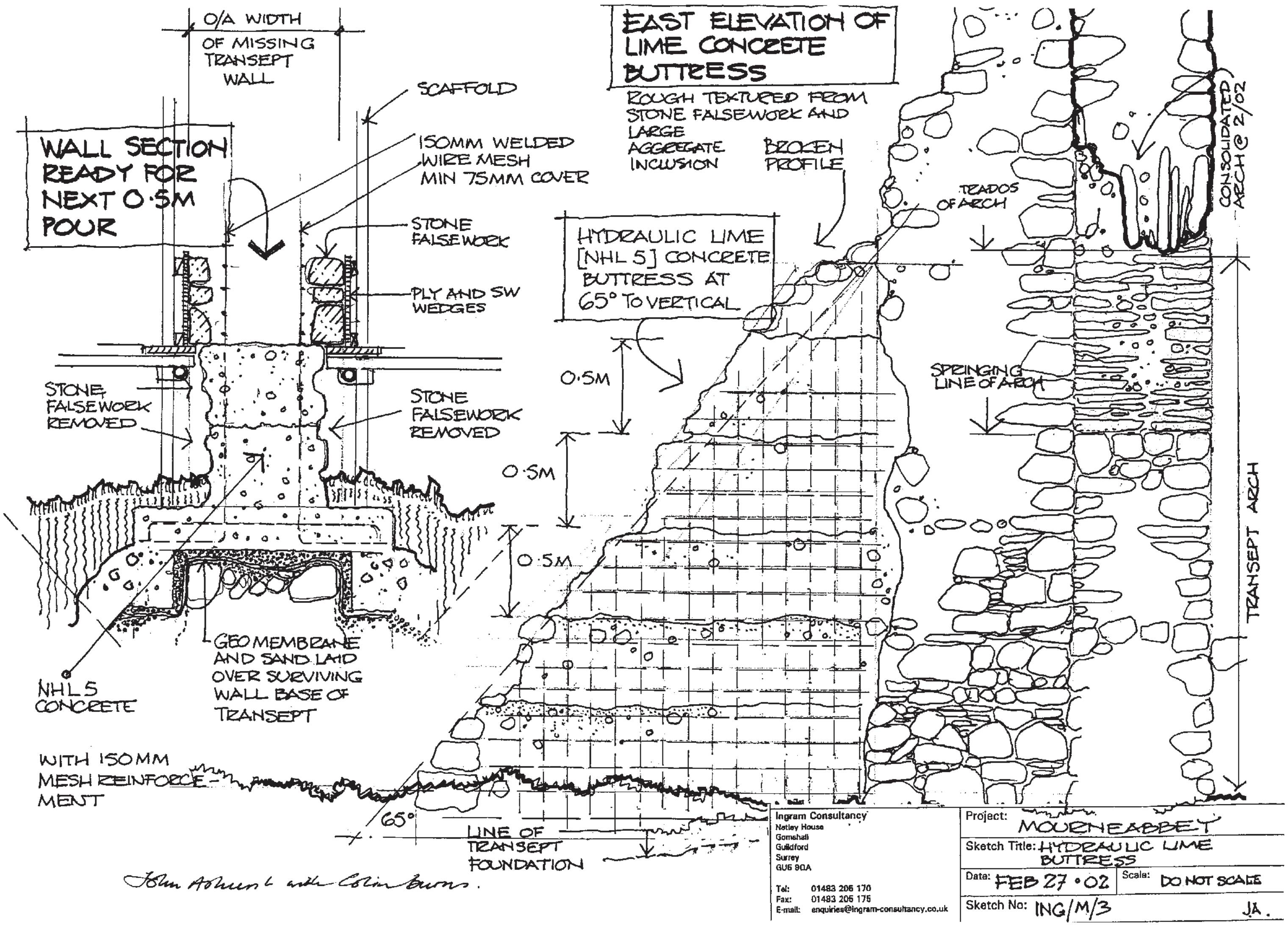
2.1 Temporary supports



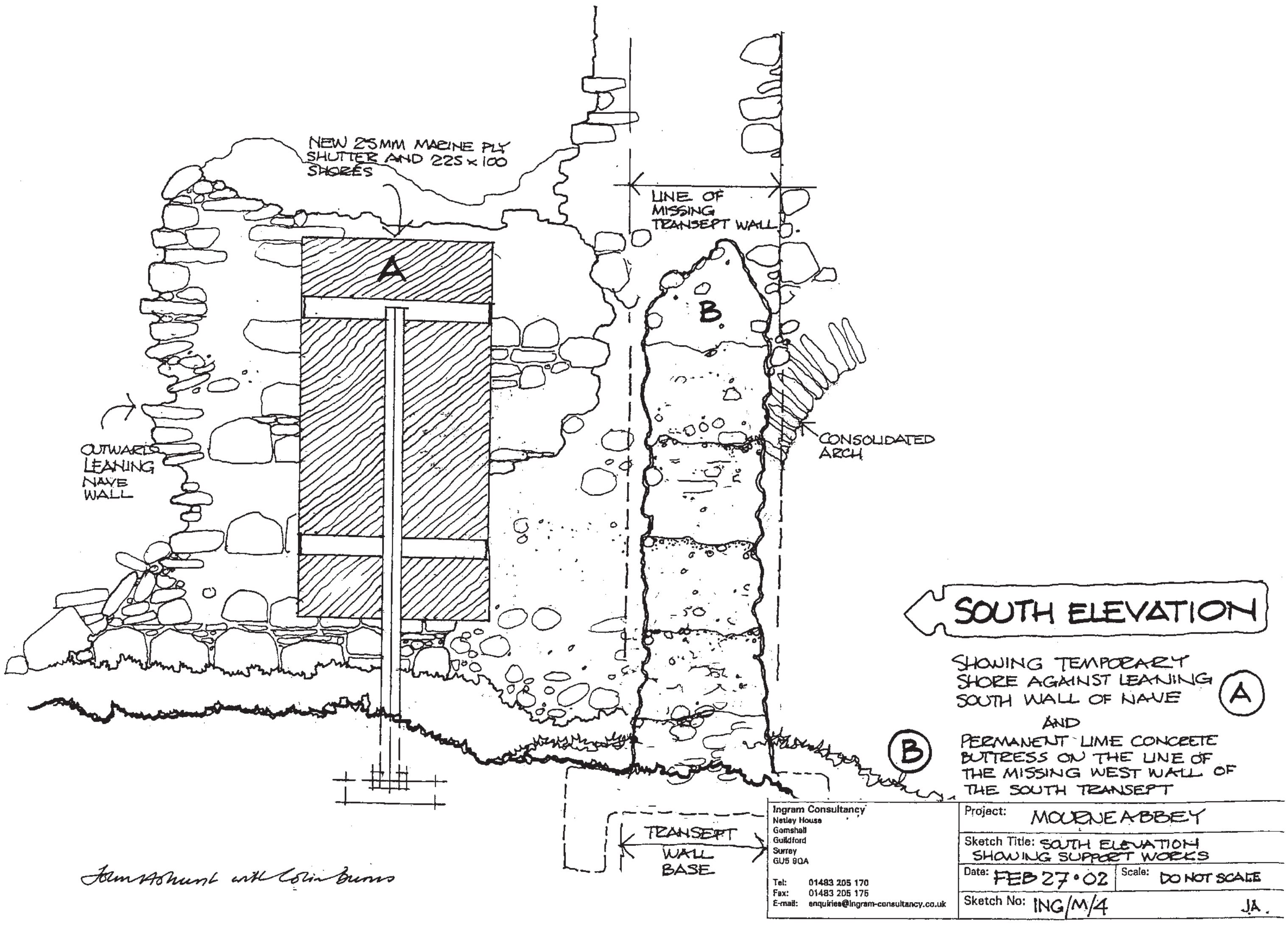


DETAIL OF COMPOSITE WALING PIECE
25mm MARINE PLY
100mm × 100mm WALING
50mm SLOT IN PLY
225×100 SHORE
50mm × 25m SCREWED AND GLUED TO WALING
SLOT IN PLY
50×25 WALING EXTENSION
100×100 WALING
SLOT IN PLY
SHORES OF 2 × 225mm × 50mm BOLTED TOGETHER
60°
200 MIN
SOLE PIECE [RAIL SLEEPER]
STABLE
SECTION THROUGH LEANING SOUTH WALL OF NAVE
1·20
RETURN OF TRANSEPT WALL
CONSOLIDATED ARCH
HYDRAULIC LIME CONCRETE BUTTRESS
BLOCKING
TRANSEPT
TRANSEPT WALL
TRANSEPT WALL
LOCATION OF SHORE
SCAFFOLD POSITION
SOUTH ELEVATION
Ingram Consultancy
Netley House
Gomshall
Guildford
Surrey
GU5 9QA
Tel: 01483 205 170
Fax: 01483 205 175
E-mail: enquiries@ingram-consultancy.co.uk
Project: MOURNEABBEY
Sketch Title: TEMPORARY SHORE DETAILS
Date: FEB 27 ·02
Scale: DO NOT SCALE
Sketch No: ING/M/2
JA.

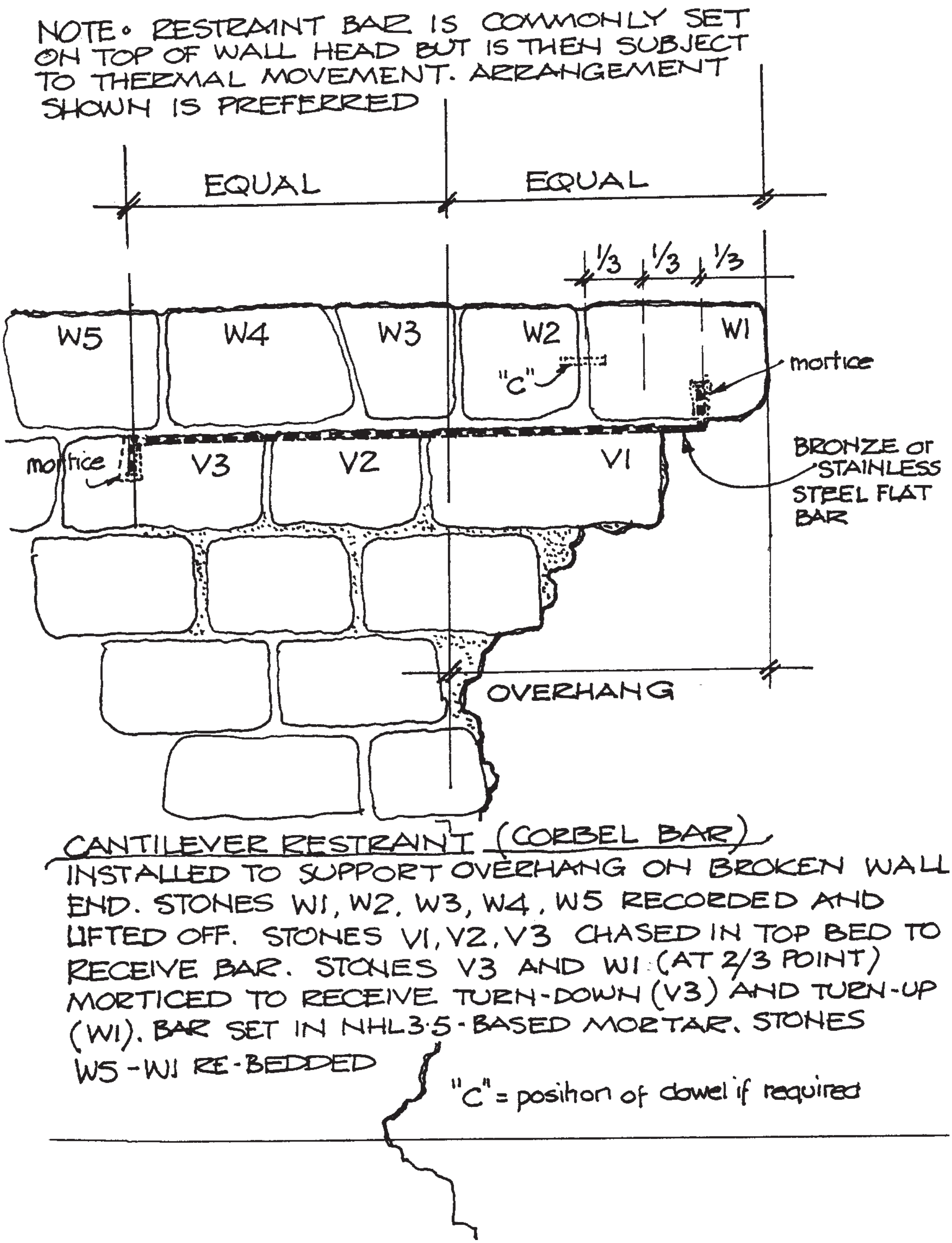
2.2a Permanent supports



2.2b


NEW 25MM MARINE PLY SHUTTER AND 225 x 100 SHORES
LINE OF MISSING TRANSEPT WALL
A
B
OUTWARDS LEANING NAVE WALL
CONSOLIDATED ARCH
SOUTH ELEVATION
SHOWING TEMPORARY SHORE AGAINST LEANING SOUTH WALL OF NAVE (A)
AND
PERMANENT LIME CONCRETE BUTTRESS ON THE LINE OF THE MISSING WEST WALL OF THE SOUTH TRANSEPT (B)
TRANSEPT WALL BASE
Ingram Consultancy
Netley House
Gomshall
Guildford
Surrey
GU5 9QA
Tel: 01483 205 170
Fax: 01483 205 175
E-mail: enquiries@ingram-consultancy.co.uk
Project: MOURNE ABBEY
Sketch Title: SOUTH ELEVATION SHOWING SUPPORT WORKS
Date: FEB 27 • 02
Scale: DO NOT SCALE
Sketch No: ING/M/4
JA.

2.3 Cantilever support



2.4 Re-alignment of leaning wall (Cymer Abbey, Wales)

Jon Avent, BSc Ceng MI Struct E of Mann Williams, Civil Structural Engineers was asked by CADW, the Heritage Organisation of Wales, to investigate the history and ongoing movement to an arcade wall in the ruin of Cymer Abbey, Dolgellau.

His report and conclusions, reproduced here by kind permission of CADW, led to the implementation of the recommendation to jack the leaning wall back into a near vertical alignment. This work was successfully completed in 2005. Stitching of the wall was carried out with Cintec anchors. The assistance of John Brooks of Cintec in identifying this project is gratefully acknowledged.

Cymer Abbey, Dolgellau (structural report), reproduced with permission

CYMER ABBEY, DOLGELLAU
STRUCTURAL REPORT

INSPECTION

Cymer Abbey is situated in a remote area at the head of the Mawddach estuary. It is one of seventy five Cistercian houses founded throughout Wales and England. It is ranked as one of the smallest and poorest, despite it being located on an important thoroughfare during the middle ages. Founded at the end of the 12th century by a colony of monks from Abbey Cwmhir, this site was among those that suffered quite severely during the various Welsh wars. This fact may have been partly responsible for the financial difficulties it encountered which, among other things, appear to have prevented the abbey church from being completed.

Evidence suggests that the small, plain, rectangular church was originally intended as the nave of a much grander building scheme that was apparently abandoned. Following the Dissolution in 1537, Cymer was left to deteriorate for nearly 400 years, and all that survives is part of the north arcade illustrated in the photographs opposite and below, and the east end gable, where three lancet windows outline the austerity of the Cistercian rule.

The end elevation of the wall is shown in the photograph opposite and illustrates the significant movement present at the east end of the arcade wall.

CYMER ABBEY, DOLGELLAU
STRUCTURAL REPORT

The annotated photograph opposite is an assessment of the approximate centre of gravity (centroid) of the east end of the arcade wall.

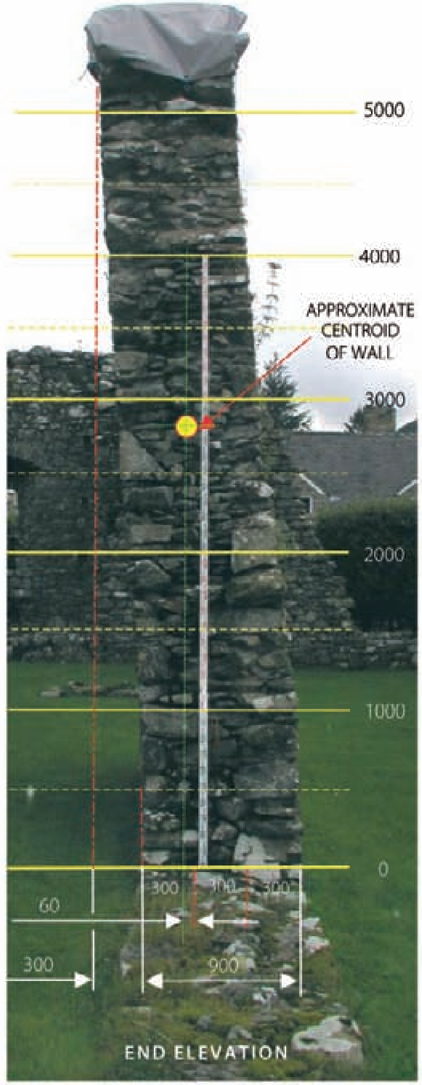
The wall is approximately 900mm thick and 5.7m high. Assuming uniform construction over the full height of the wall the centroid is shown to be approximately 60mm outside of the mid third of the wall. To ensure stability the centroid should be within the mid third of the base thickness.

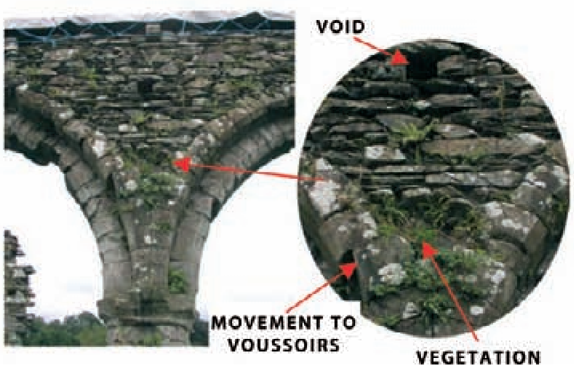
With the centroid in this position the wall has marginal stability. The consequences of this configuration is elevated compression stresses on the south side of the wall, and potential for tensile stresses to develop on the north side.

Monitoring records prepared by Stirling Surveys Limited from December 2001 have concluded that '.......... *there would seem to be a clear indication of increased deflection of the structure over this period*'

A radar survey of the wall has identified a small number of voids. Although these are undesirable they are not considered excessive.

The radar survey also concluded that the wall was extensively saturated. This is not unexpected in view of the exposed nature of the site and wall, and confirms its vulnerability to scouring and frost action.





On the north side of the arcade the movement is encouraging the mortar joints to open. Vegetation is also becoming established as illustrated in the photograph. Movement of voussoirs is also present, and voids were noted. These are all issues which will contribute to ongoing deterioration of the wall.

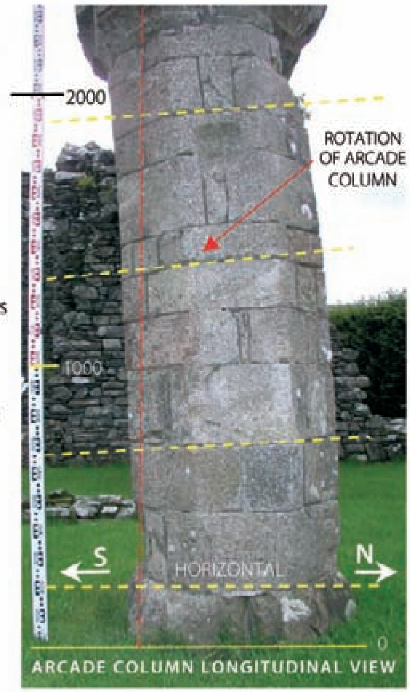
CYMER ABBEY, DOLGELLAU
STRUCTURAL REPORT

Visual appraisal of the movement in the arcade columns is illustrated in the photograph opposite. Datum lines illustrate movement at bedjoint positions.

At the base of the arcade column the bedjoint remains reasonably level suggesting a stable foundation.

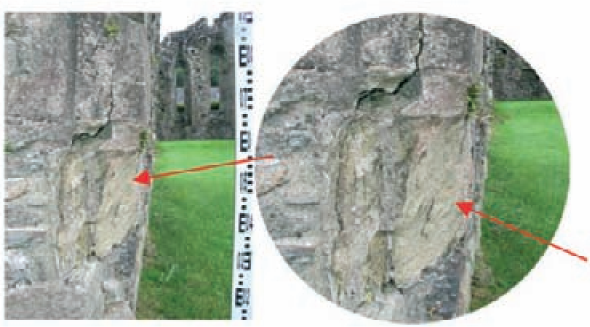
Rotation occurs at subsequent bedjoints above this level, indicating movement is related to superstructure failures or weaknesses.

Differential climatic effects on the north and south sides of the wall will also contribute to deterioration. The north side remaining wetter, and more susceptible to frost damage, and the south side generally drier.



ARCADE COLUMN LONGITUDINAL VIEW

The combination of rotation of the arcade column and the rigidity of the base plinth at ground level is causing elevated compression stresses, which have resulted in local failure. The photograph below illustrates the compression failures, which are occurring on the south side of the columns at low level.



COMPRESSION FAILURE OF FACE OF DRESSED STONE TO ARCADE COLUMN

CONCLUSION

The east end of the arcade wall has historical movement, which has taken its centre of gravity outside of the mid-third position of the base. For dead weight stability the centre of gravity should be contained within the mid-third of the wall thickness.

With the centre of gravity outside of the mid third there is a significant increase in the compression stresses applied to the face of the wall which is aiming to resist the movement. This is demonstrated by the local stonework compression failures that are occurring.

Visual appraisal of the base of the wall shows the bed joint(s) near to ground level as being reasonably level suggesting that the movement is primarily superstructure *(above ground stonework)* related.

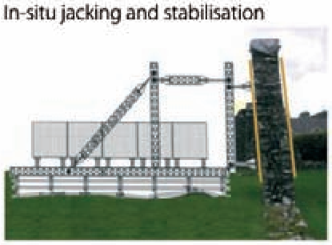
Geophysical investigations have revealed high saturation levels within the wall. Reduction and control of saturation is an essential aspect of any remedial works. This is most effectively achieved by provision of effective capping to the wall head and the use of appropriate lime mortars to wall facework.

In view of the ongoing movement identified by the structural monitoring it is concluded that the arcade wall stability is of sufficient concern for the site to remain closed to public access.

CYMER ABBEY, DOLGELLAU
STRUCTURAL REPORT

RECOMMENDATIONS

The following remedial measures have been considered.

	Option	Comments
1	Do Nothing	The least intrusive option, but will require public access restrictions to remain, and ongoing movement will eventually lead to collapse.
2	Take down and Rebuild	The most intrusive option, but will enable the wall to be rebuilt in a stable configuration, and enable public access to be reinstated.
3	Buttress 	Provision of a traditional buttress on south side, or 'restraining buttress' on north side of arcade. In conjunction with provision of core consolidation ties and some local stonework repairs the arcade would remain in its current configuration. The buttress could be formed in modern materials such as stainless steel (or possibly structural glass) to ensure a clear distinction between new and historical fabric.
4	In-situ jacking and stabilisation 	The arcade would be carefully jacked back into a more vertical configuration and stabilised by use of core consolidation anchors and isolated masonry repairs.

Options 1 and 2 are considered the least favored solutions. Option 1 effectively leaves the structure to inevitable collapse, while option 2 is considered unacceptably intrusive.

Options 3 and 4 each have their own merits, and further discussions would be appropriate prior to considering the development of a specification.

Our preference would be for option 4.
The technique has been recently used successfully on a scheduled ancient monument, and has the advantage of retaining the largest proportion of the original structure in-situ.
On completion of the works there is minimal evidence of works having been implemented.

In view of the ongoing movement identified by the structural monitoring it is recommended that the site remains closed to public access. It is also suggested that consideration is given to the provision of temporary support / bracing to the east end of the arcade wall pending a decision on remedial works.

It is also recommended that the protective tarpaulin remains on the head of the wall to minimise water ingress, and vegetation growth on the face of the wall is controlled.

Appendix 3

Implementation of work – personnel selection

Tadg Buckley

The selection of personnel with good potential as 'conservation technicians' to work on historic sites with ruined buildings where no specific craft skills training is necessarily required is difficult in the extreme, and requires good insight and extensive site experience on the part of the interviewer. The successful conservation team developed and trained by Cork County Council in Ireland was asked what guidelines they would give on selecting new trainees.

Tadg Buckley, Foreman of the Cork team, provided the following answers to John Ashurst:

Q: What indications might be discerned, from the application, of the suitability of the candidate?

A: Pre-interview, dissect beefed-up CVs, study the small print, look for continuity in the person through their work record and/or their involvement in sport, etc., hobbies. In particular, the mature candidate will have shown initiative.

Q: What indicators of suitability might you pick up at interview?

A: At interview, look to the person who can be passionate about their particular hobby or previous work experience. If asked correctly they will be only too willing to elaborate. Worthy of note: any person who gives of their time voluntarily to organisations, etc. Look for enthusiasm, openness, awareness of the natural environment, attitude – respect or lack of it for same. Look for perception of honesty and possible sense of values.

Beware of other agendas, like 'I cannot wait to build stone walls', test their reaction with 'you may be unlikely to benefit from promotion due to small staffing numbers'. Note their attitude towards authority, their acceptance of it.

Would you yourself be comfortable working in close proximity with this person or would you feel him best suited to your nasty neighbour. Beware of the overbearing person, he will always be that way.

Q: What probationary period would you consider suitable for a new candidate you believe to show promise?

A: The probationary period could be 12 months or less if proper cultivation of the new employee is correctly applied. Philosophy and conservation ethos and best practice are clearly identified – enthusiasm, or lack of it, will soon be apparent to all. Beware of detractors of this philosophy challenging accepted conservation best-practice guidelines rather than questioning with a view to learning.

Q: How suitable is the 'loner' for this kind of activity?

A: By its very nature the job dictates the 'loner' aspects. Each of us has our comfort zone within the team's environs and can develop on our own with firm tutoring and observation. The obvious loner will fail at interview.

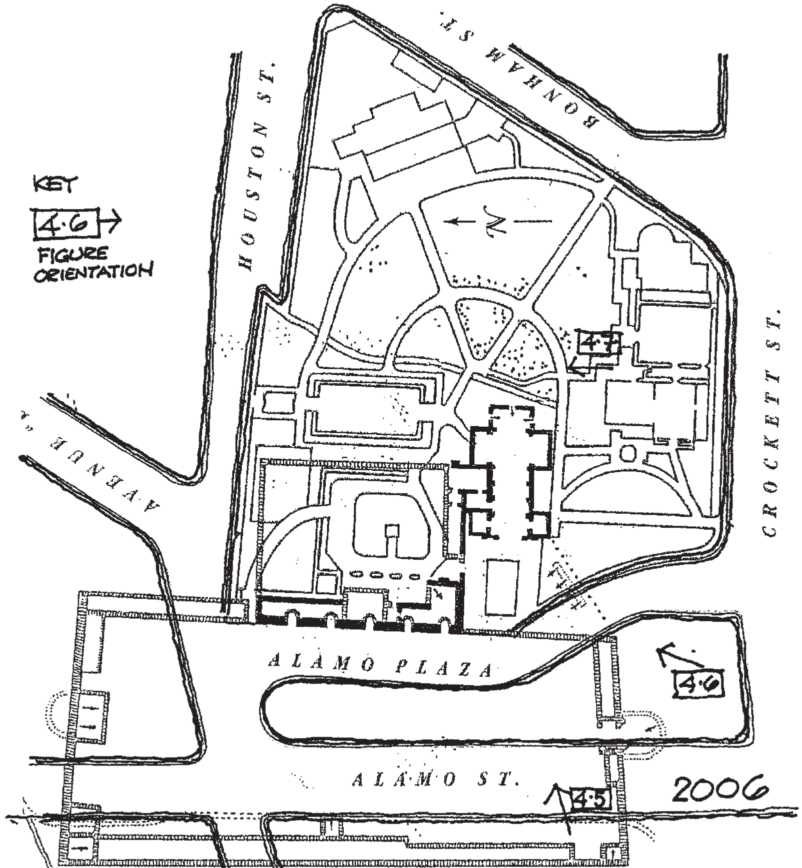
Q: What signs will you look for in the probationary period that the candidate is going to succeed or, alternatively, is having difficulties?

A: If symptoms of dissent appear and interest is waning on the team, then management have messed up. If your own team has a clear agenda, uncomplicated planning, proper coordination of all site business, and the knowledge that they and their work is of huge importance, then there is no place for the idle mind.

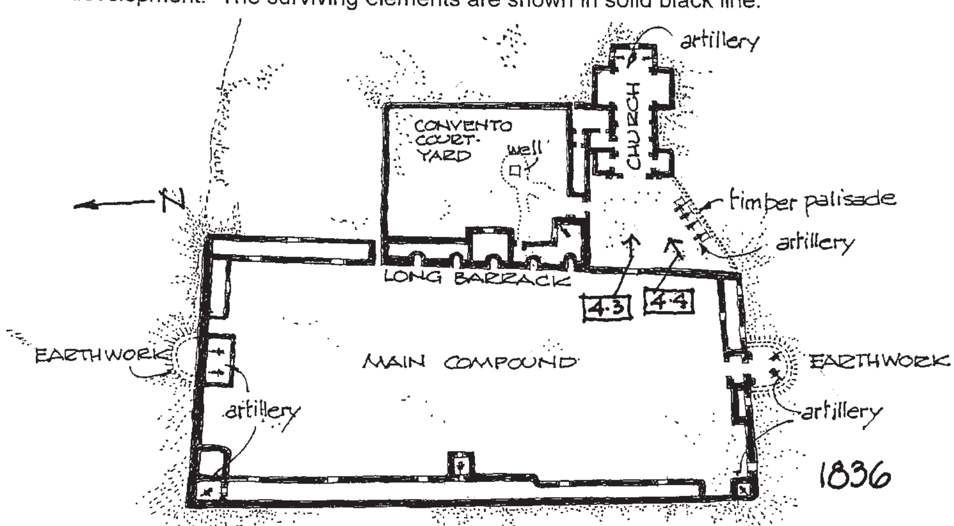
Observe the little things they manifest and/or keep a tight rein on the philosophical direction at all times, yet allow natural talent and enthusiasm to express itself, to harness that enthusiasm and steer it in the right direction. Show openness to new thinking and new ideas. Embrace consensus yet hold the reins. Impart a sense of values and importance. Understand that we are purely custodians of what we are charged with, we are travellers in time. Lack of knowledge can never be a fault – encourage the unsure and build confidence. Clarify always the understood philosophy, read the reaction to it, build on the weaknesses, look for and promote a good work ethic; this may have to be constantly followed through with some individuals otherwise standards will fall and conservation will suffer.

Postscript

The above comments, interpretations and assessments were garnered from non-academic, non-professional sources – just the experiences and observations from the school of life.



The Alamo Compound seen in the context of today's street layout and park development. The surviving elements are shown in solid black line.



The layout of the Alamo Compound during the siege of 1836 based on the DRT publication. "The Alamo Past and Present".

Figure A4.1 *The Alamo: 1836 and 2006.*

Appendix 4

Visitors Perceptions (The Alamo, San Antonio, Texas)

Bruce Winders

I was introduced to the Alamo as an interesting study for this book by the conservator/restorer Rachel Sabino-Gunaratna, practising in the UK but herself a Texan, born in Spain. Through her kind direction and that of her uncle, the architect Charles John of San Antonio, I made contact with Elaine Parker of the Daughters of the Republic of Texas (DRT) and Dr Bruce Winders, historian and curator at the Alamo.

The focus of interest lay in the international recognition of the Alamo through books and films (especially the latter), and the image of a desert mission-cum-fortress garrisoned by a small group of Texans in 1836 against the army of General Antonio Lopez de Santa Anna. The fall of the fort after a 13-day siege and the death of such well-known figures as James Bowie, David Crockett and William B. Travis are implanted in every movie-goer's mind, as must be the Texan army's battle-cry of 'Remember the Alamo!' at the battle of San Jacinto some seven weeks later.

But how does this imagery survive a visit to the Alamo site today, located now in downtown San Antonio amongst the noise and bustle of a modern city? More than 2.5 million visitors each year come to see the 'old mission'. How does 'authenticity' come into the experience, and can anything 'real' survive? These and other questions relating to the visitor experience were very courteously answered by Dr Winders as follows.

Q: What is the importance and significance of the Alamo site to the state, the nation and internationally? What survives from the principal period of significance? Who is responsible for the care, preservation and presentation of the site, and since when? Who are the 'stakeholders'? Who makes the policy?

A: The Alamo is recognized as a symbol of the continual fight for freedom. Although there are other interpretations of the Alamo's meaning, the courageous stand against overwhelming odds places the 1836 battle in a context that visitors worldwide understand and appreciate.

The Alamo began its existence as Mission San Antonio de Valero. Construction on the mission compound commenced in 1724 and continued until Spanish officials secularised the site in 1793. Only two buildings remain from the original mission compound, the church and the old convento or Long Barrack.

The State of Texas owns the Alamo. However, in 1905, the Legislature granted the Daughters of the Republic of Texas guardianship of the site with two stipulations: (1) that the site be maintained as a 'sacred memorial to the men who immolated themselves upon that hallowed ground' and (2) that they accept financial responsibility for the site without any monetary assistance from the state.

The stakeholders are the State of Texas, the Daughters of the Republic of Texas, and the public.

Policy for the Alamo is set by the Daughters of the Republic of Texas, through a DRT administrative group called the Alamo Committee, who report to the DRT's board of management. The DRT, however, employs a professional staff that conducts programming and the day-to-day operations of the site.

Q: What is it that attracts visitors to the Alamo? What do they come to see, experience, learn? Do many of them know?

A: Alamo visitors can be divided into two basic groups: the curious and the reverent. The Alamo's prominent location in downtown San Antonio makes it easy for visitors to reach. These are people usually who have heard of the Alamo and take the opportunity to see what is here. The reverent are people to whom the Alamo is an important event in their lives (historical, popular culture or both) and come here much as pilgrims do to other shrines.

Visitors expect to have a meaningful experience when they come to the Alamo. For some, it is to learn why it is important to 'Remember the Alamo!' For others, it is just enough to be on the actual site of the epic battle.

Many visitors have either no idea what happened at the Alamo or ideas that were shaped by movies and other forms of popular culture. Our philosophy is that commemoration cannot take place without education. To that end, we attempt to present a meaningful and current historical interpretation of the Texas Revolution and the Battle of the Alamo.

Q: What value is placed by visitors on authenticity of the site and its setting? Does it matter what is original, what is restored, what is reconstructed, what is speculative? Are differences between these categories made clear? How much does it matter?

A: Visitors hope to find the Alamo much as it was in 1836, an image reinforced by movies. Many are confused and disappointed to find it in an urban setting. An important part of our interpretation is to explain why that expectation cannot be met. Once visitors learn about the historic evolution of the site, though, they express a deeper appreciation for having an expanded vision of the Alamo.

Q: How important to visitor numbers are the visitor facilities? Not just car parking, restaurants and washrooms, but interpretative displays, off-site reconstructions and models, bookshops and educational facilities?

A: These are very important to the visitors because so much about the site has changed since 1836. It is an important way for visitors to make the mental adjustment between what they want or expect to find and what is actually here.

Q: How important is the siting and design of new visitor facility buildings and services perceived to be? Who controls planning and development of the historic site?

A: A new visitor centre would be helpful but it is not especially practical. One reason is that the Alamo does not charge admission and therefore does not have one central location through which the public enters. Thus, a visitor centre would not serve the traditional purpose of orienting visitors before they actually visit the site. A major obstacle is the fact the church building (which to many people is the Alamo) faces a plaza that is owned by the City of San Antonio. Although the plaza is the logical place for a visitor centre, one will never be built there.

Planning and development for the Alamo is done by the Daughters of the Republic of Texas in consultation with the Texas Historical Association.

Q: At what stage is the economic benefit of large visitor numbers seen to be outweighed by physical damage to the site, or even by loss of 'quality of experience'. What mitigating measures can be or have been taken to protect the site from the adverse effects of too many visitors?

A: Nearly three million visitors come to the Alamo each year. On one hand, such a large visitorship is needed as more than 90 per cent of the site's operating budget is raised through gift shop sales. However, on high traffic days, it is easy to conclude that the large crowds negatively affect the experience of visiting the Alamo. Unobtrusive barriers (stanchions and chains) are used to discourage direct contact with sensitive surfaces such as historic walls.

I also asked Rachel Sabino-Gunaratna who has known the Alamo site over many years and who is also familiar with much of the context of this book to provide her comments on the visitor experience.

The urban backdrop, together with the numerous amendments and modifications to the immediate setting of the Alamo, is indeed a far cry from the site of the 1830s (Figure A4.2). Only a committed visitor, with a great deal of reliance on available maps and models, would be able to discern original fabric from subsequent interventions. This is not, of course, the fault of the present custodians of the site but a simple matter of history. A number of major developments have taken place, which make the presentation and interpretation of the site so problematical. Firstly, as stated by Dr Winders, almost the entire mission compound lies under what is now

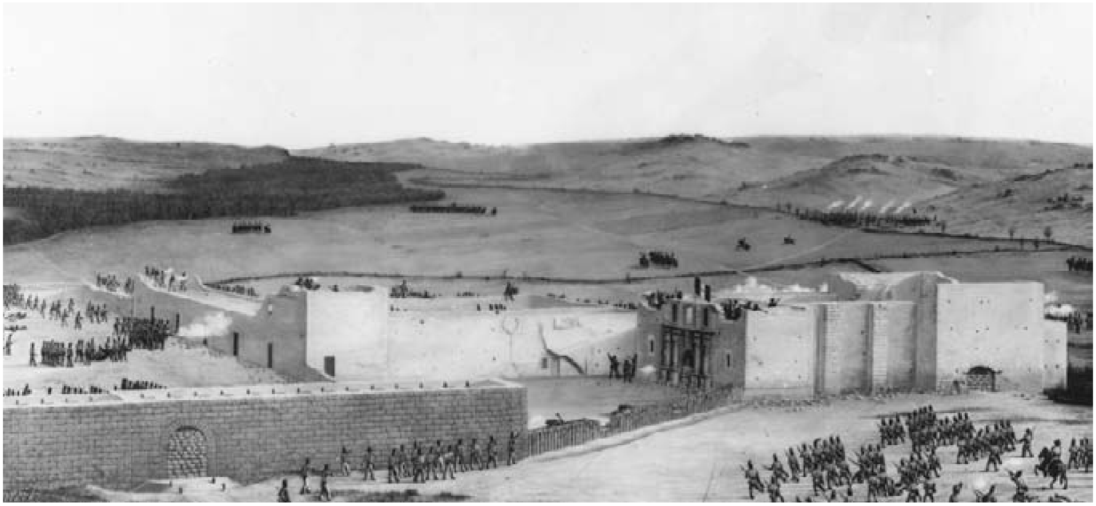


Figure A4.2 *Reconstruction of the 'Fall of the Alamo' 1885 by T. Gentliz. In this depiction the Mexican army is already in the main compound (left). The timber palisade with its artillery (centre) has been abandoned. The Long Barrack, its courtyard beyond and the church building are still defended. The landscape provides an interesting contrast with the modern site context (Reproduced by kind permission of the Daughters of the Republic of Texas).*

Alamo Plaza and Alamo Street, with only part of the eastern side surviving in the form of the Long Barrack. Secondly, the area to the east of the mission has been laid out as a semiformal ornamental park and is surrounded by masonry walls similar enough to style and material to the original elements of the site as to be confusing. As a memorial to the fallen, this green and peaceful setting works well; as an interpretation of the site as it was in the first half of the nineteenth century it is disorienting in the extreme. Further, the Sales Museum, built in 1936 immediately east of the line of the Convento courtyard, closely echoes the architecture and construction of the Shrine (Figure A4.3). The contextual difficulty presented by the iconography and style of the Sales Museum is compounded by the fact that a visitor entrance is located directly in front of it. Lastly, the Shrine itself is recognisable only in plan form; the iconic roofline of its restored west front is the result of post-siege military reconstruction.

Concepts of historic site presentation and interpretation change with time, but past examples, whether they are now considered successful or not, become part of the history of the site. At the present time, when all periods of intervention are seen as valid subjects for preservation, it is unfashionable to consider exceptions and alternatives to this philosophy, unless some modification to what exists truly serves to present the original fabric in a clearer and better light.

Without knowing all the complexities and interests involved, that any visitor to the Alamo suggest what might be done in the future to enhance and improve the site seems a bit presumptuous. Nevertheless, in the context of this book, and perhaps only here at the editor's request, it is possible to set out the observations of one visitor, who has known the site since childhood, which could conceivably be enacted, given the necessary funding (predictably only one of the obstacles to realising such proposals).

From the Alamo archives, one image is particularly striking. Less than ten years after Santa Anna's troops took back the Alamo from Travis' garrison of volunteers, 1st Lieutenant Edmund Blake of the USA Topographical Engineers made a detailed drawing of the west front of the church (Figure A4.4 – Ruins of the Alamo in 1845 from a sketch upon a map of the country in the vicinity of San Antonio de Bexar).

The derelict, post-siege appearance of the church may be thought by some to have an impact far more moving than that of the restored shrine seen by visitors today. In some ways, it provides an interesting parallel with the ruins of the church at Oradour sur Glâne described in the introduction. In both cases, it is the 'untouched' ruined condition, the result of a violent event, which makes the site so emotive and gives it, still, such immediacy. Would partial unroofing and unpicking of the upper restoration level of the west front ever be possible, letting the original

Figure A4.3 *'Ruins of the Alamo in 1845 from a sketch upon a map of the country in the vicinity of San Antonio de Bexar made by J. Edmund Blake, 1st Lieut. Topographical Engineers USA' (DRT) (Reproduced by kind permission of the Daughters of the Republic of Texas).*

Figure A4.4 *The 'Alamo Church and Plaza'. Post 1860 rebuild of the west façade of the Church building and of its roof (DRT) (Reproduced by kind permission of the Daughters of the Republic of Texas).*

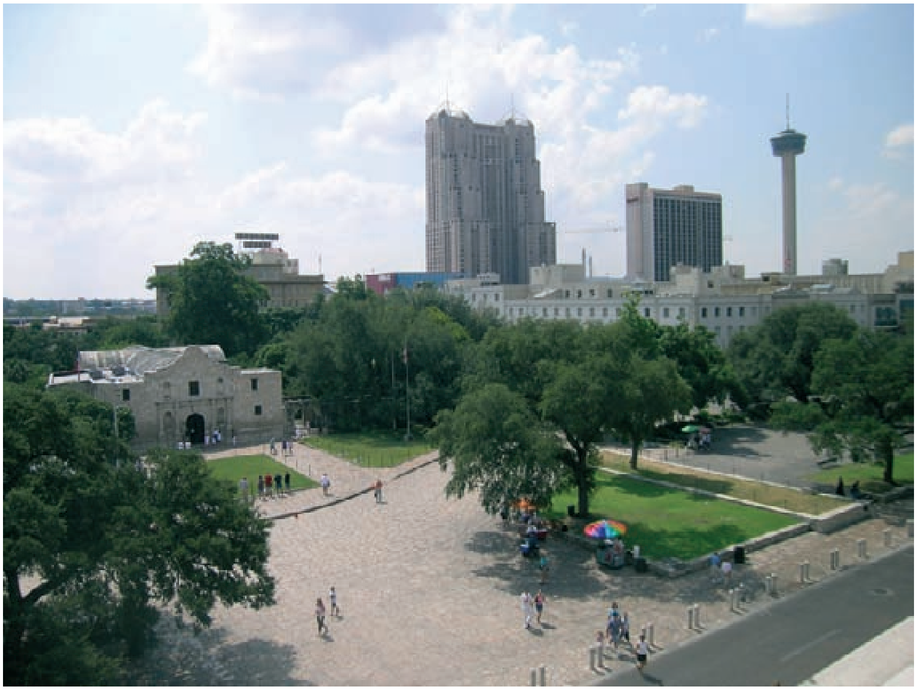


Figure A4.5 *A view across the modern Plaza of the west front of the Church building showing the Alamo in its new context. Photo Rachel Sabino-Gunaratna.*

Figure A4.6 *View across the modern plaza. Compare with similar view in 4.4. Photo Rachel Sabino-Gunaratna.*

Figure A4.7 *The peaceful, green, park setting to the south of the Church building (The Shrine). Compare with the view in 4.4. Photo Rachel Sabino-Gunaratna.*

fabric depicted by Blake to be experienced again? The link with the Alamo's defenders would then be more real than it is at present.

Similarly, although recall of the main compound is now impossible, it is not inconceivable that the *convento* courtyard could be reconstructed on the known lines and to the original height using adobe blocks. This would also entail removing the twentieth century landscaping in this area and replacing it with native plants, thereby providing a much closer idea of how conditions would have been within the compound.

There are markers around Alamo Plaza showing, in part, the extent of the main compound – though these could certainly be made more emphatic. But another interesting and useful aid to the visitor would be the recreation of a section of the palisade from the southeast corner of the church, on its known line.

Fortunately for those who are interested, an enhanced understanding of the original character and setting of the Alamo can be gained by following the Mission Trail: comprised of four missions, contemporary with the Alamo, which today are active parishes within the Archdiocese of San Antonio and whose lands have been designated by the National Park Service.

In particular, the mission of San Jose demonstrates the potential nineteenth century military value of the church enclosed by a defensible perimeter wall; San Juan Capistrano provides the best indication of an uncluttered desert environment. All four, including the missions of Concepción and San Francisco de la Espada, alongside a visit to the Alamo, contribute something to the experience of how San Antonio de Valero would have been.

The Alamo is, of course, more than a memorial. Even in its depleted state, surrounded by modern landscape and buildings, it is still 'the real thing'. Any means of device by which the interested or potentially interested visitor can understand and experience that reality is likely to be justified.

Appendix 5

Monitoring and maintaining abandoned ruins and sites

Asi Shalom

In some countries archaeological and historical sites lie in open country outside the jurisdiction of national and local parks and nature reserves. The unattended sites often do not receive any benign attention in the form of recording, monitoring, emergency treatment or conservation measures.

The exposure of such sites, whether abandoned archaeological excavations or neglected monuments, leads inevitably to ongoing deterioration from year to year. These sites, often of undoubted historic value and sometimes in a surprising state of preservation, suffer only because of their modern geographical location. National or local authorities responsible for maintaining historic sites are overburdened by their own conservation and maintenance responsibilities, and frequently suffer from lack of funding.

Public interest and concern for neglected monuments and their condition can be harnessed and utilised to help to change their fate, but the processes involved in utilising this resource take a great deal of effort and time. The great number of abandoned ruins in some parts of the world make it impossible for them to be included in existing secure borders or to create new security around them; it often seems as though these abandoned and forgotten sites are doomed to complete destruction.

Can anything be done?

Regular monitoring and preventive measures are vital to the survival of these sites, as this book has shown. Once the state of preservation and immediate threats to the sites are recognised and documented, it becomes much easier to find funds for emergency intervention and temporary protection.

What is needed?

A proposed model for intervention involves the following:

- Identification and categorisation of mapped ruins/monuments on existing land surveys and surveys of antiquities.
- Obtaining existing GIS maps of the geographical location of the sites.
- Utilising the human resource potential; contact those whose interest, occupations or researches cause them to frequent abandoned sites (such people could be land and building surveyors, nature rangers, students of archaeology, geology, ecology, etc., and instructors from field schools and other educational establishments).
- Assigning management responsibility for operating the model to an authority such as a nature reserve or heritage body at local or national level.
- Assimilating marked sites from land and antiquity surveys onto the regional GIS maps and assigning them an identification number which corresponds to the survey's number.
- Creating a field record sheet with a very short description of the ruins and sites of the region, detailing their period, function and content.

- Providing a short two-hour training presentation on the nature and characteristics of decay of exposed sites, the physical threats which are presented, methods and times of monitoring, importance of preventive measures, all summarised in a one-page chart.
- A one-page site evaluation form which is user friendly and simple to complete, detailing the immediate threat to the site.

Utilising the model

For the model to work it is first necessary to identify and then inform interested members of the public, students, professionals, etc. of the potential significance of their contribution to the saving of these sites. To do this requires someone with the specialist knowledge and the communication skills to raise curiosity and stimulate enthusiasm, and the desire to be voluntarily involved. This may be implemented as follows:

- Provide a short illustrated training presentation to the interested groups with specific details of how their familiarity with their sites can be used to advantage by training them to see aspects of condition and threats to survival, and to play a role in saving the sites for the future.
- Lead an exercise with the potential groups in filling out the simple site evaluation forms.
- Providing each participant with a folder containing the GIS maps of their regions showing the abandoned sites, the page with the site descriptions, the chart summarising the methods of monitoring and its importance, documenting and recognising the threats, and a few printed copies and a computer disc of the evaluation form.
- A short, joint visit to their region and some of the abandoned sites with a responsible trainer, ideally before critical seasons, to set out and clarify the simplicity of documenting and of the evaluation process.
- Establish a collection point and contact with the responsible authority who will record and process the submitted forms, alerting, organising and finding funds and trained conservation teams to intervene, save and prevent the destruction of the abandoned ruins.

Index