CONFERENCE PROCEEDINGS

HISTORIC SCOTLAND TRADITIONAL BUILDING MATERIALS CONFERENCE

TECHNICAL CONSERVATION, RESEARCH AND EDUCATION DIVISION

CONFERENCE PROCEEDINGS HISTORIC SCOTLAND TRADITIONAL BUILDING MATERIALS CONFERENCE

Historic Scotland Technical Advice Notes

No.1 Preparation and use of Lime Mortars (revised 1995)

No.2 Conservation of Plasterwork (1994)

No.3 Performance Standards for Timber Sash and Case Windows (1994)

No.4 Thatch & Thatching Techniques;
A guide to conserving Scottish thatching traditions (1996)

No.5 The Hebridean Blackhouse:
A guide to materials, construction and maintenance (1996)

No.6 Earth Structures and Construction in Scotland:
A guide to the Recognition and Conservation of Earth Technology in Scottish Buildings (1996)

No.7 Access to the Built Heritage:
Advice on the provision of access for people with disabilities to historic sites open to the public (1996)

No.8 Historic Scotland Guide to International Conservation Charters (1997)

No.9 Stonecleaning of Granite Buildings (1997)

No.10 Biological Growths on Sandstone Buildings:
Control and Treatment (1997)

No.11 Fire Protection Measures in Scottish Historic Buildings (1997)

No.12 Quarries of Scotland:
An illustrated guide to Scottish geology and stone working methods based on the British Geological Survey Photographic Archive of selected building stone quarries (1997)

Available from:
Historic Scotland
Technical Conservation, Research and Education Division
Scottish Conservation Bureau
Longmore House
Salisbury Place
EDINBURGH
EH9 1SH

Telephone 0131 668 8668
Fax 0131 668 8669

ERRATUM

Page 105; right hand column; paragraph 6
reads: 2.5 parts sand
SHOULD READ: 5 parts sand

CONFERENCE PROCEEDINGS

HISTORIC SCOTLAND TRADITIONAL BUILDING MATERIALS CONFERENCE

EDITED BY
INGVAL MAXWELL
AND
NEIL ROSS

ISBN 1 900168 48 0

Edinburgh 1997

TECHNICAL CONSERVATION, RESEARCH AND EDUCATION DIVISION

ACKNOWLEDGEMENTS

The Conference, to be held at Stirling Management Centre and the Logie Lecture Theatre of Stirling University, on 3-4 September 1997 has been ably co-ordinated and managed by Gwen Scott and Karen Connelly of the RICS in Scotland Events Department.

The planning, development and finalisation of the programme was supported throughout by Jocelyn Cunliffe, Gray, Marshall & Associates; Ian Davidson, National Trust for Scotland; Mark Hopton, Law and Dunbar-Nasmith; Bill McConnell, Bell-Ingram Rural, Chartered Surveyors; Thom Pollock, Pollock Hammond Partnership; Stewart Stirling, Heriot-Watt University; Carol Brown and Neil Ross, TCRE, Historic Scotland. Earlier meetings of the Conference Committee were also supported by Robin Kent, TCRE, Historic Scotland and David Leslie, The David Leslie Partnership. Historic Scotland is particularly indebted to all these individuals, who willingly gave of their time, to ensure the success of the event.

Historic Scotland is also indebted to The Royal Institution of Chartered Surveyors in Scotland, The Royal Incorporation of Architects in Scotland, Cameron (UK) PLC, Realstone Limited, and to the Stone Federation, Great Britain (Scottish Section) for their active support and sponsorship.

INGVAL MAXWELL
Conference Director

CONTENTS

FOREWORD

Historic Scotland's Traditional Building Materials Conference has come about as a result of the increased recent interest that has emerged in the use of traditional building materials and techniques. This has already had a considerable impact in the field of historic building conservation and is increasingly emerging in the area of new-build design. The move towards a revival of traditional materials, and an awareness of related craft skills, comes at the end of a century that has seen widespread acceptance of synthetic, prefabricated and mass produced materials, and loss of indigenous character in our traditional buildings.

Historic Scotland, in conjunction with The Royal Institution of Chartered Surveyors in Scotland and The Royal Incorporation of Architects in Scotland is hosting this major conference to bring together all aspects of the current revival. The aim is to raise awareness of the value of traditional building materials and to promote Scottish resources. The intention is to encourage the re-awakening of the associated skills needed for their extraction, manufacture and use. This is occurring at a time when the concept of sustainability is gaining rapid ground; when environmental impact issues are high on the agenda; and when the development and endorsement of appropriate quality and standards is firmly behind many new educational initiatives.

Historic Scotland's Technical Conservation Research and Education Division is at the forefront in many of these associated, and inter-related, enterprises. In supporting Historic Scotland's fundamental objective of safeguarding the nations' built heritage stock, the Division has taken the lead in researching issues related to architectural conservation matters. With others it is also developing and promoting craft skills, whilst being active in raising the standard of conservation practice and understanding amongst owners, and professional groups.

The principal intention of the Division's research and development programme is to ensure that practical conservation work is guided by appropriate academic research where that need exists. Over the last 4 years an increasing number of research report findings and technical advice notes have been published. Events, such as the Traditional Building Materials Conference, have been organised to help promote these studies and other research findings to a wider audience.

Scotland is a compact region with an active internal market and supportive institutions. The building stone industry, for instance, is now in a much fitter state than it was in 1980. It has recently re-equipped and information technology is being applied to remarkable effect. Firms are also showing more involvement in opening quarries, training staff and promoting their abilities.

This commitment and confidence provides ample evidence as to why it is appropriate to consider the development use of traditional building materials in new structures. But, in the history of supply and demand, the industry is complex and a number of issues still have to be overcome along the way.

The lack of understanding and knowledge can make it difficult for some to determine, adopt and use traditional building materials. Given the diversity of what has been used in the past, and the not inconsiderable trend to use non-indigenous materials in modern day designs identifying what has been used can be confusing. To be able to undertake sympathetic repair to historic fabric, this complexity is compounded by the need to accurately re-establish where the material was originally sourced.

In addition, the widespread use of foreign sources can often impose an alien aesthetic character. This often sits in an uneasy relationship with home stock. Here, designers are often guilty of not considering the future maintenance needs of the buildings they produce. "Economies of scale" arguments, backed up by aesthetic considerations, often lead specifiers into determining the use of a "traditional" material which has been transported halfway round the globe. While such arguments may hold good for the initial trouble-free years of a new building's life, it is less certain that the same arguments hold so firm when replacement matching material is required should pieces become damaged in-service. A greater awareness of traditional building materials, and how they were used and performed in the past, is something that needs to be re-established at all levels in the craft, technical and professional education curriculum.

Turning to the future, the study by Hutton + Rostron "A Future for Scottish Stone" that is to be launched at the Conference, provides a timeous strategic overview of the Scottish Stone Industry. Guiding the latter stages of this Report's formation, Historic Scotland established a Scottish Stone Liaison Group in February 1997. This body was given the remit of reviewing the draft report and its preliminary findings. With final report recommendations falling into 2 distinct groups - those which the industry need to consider addressing, and those that are more appropriate to education and training providers - it is hoped that this group, together with the Scottish Conservation Forum in Training and Education, will be able to assist in the development of the proposals with a view to supporting future initiatives in the industry.

In support of this approach, Historic Scotland's TCRE Division will continue to produce and publish technical material. Related to the Conference theme Technical Advice Note publications will be launched to present a historic and geological perspective of Scottish building stone quarries, and offer guidance on cleaning granite buildings. Further publications will soon be released on Scottish slate sources, lime renders, building sands, and the control of biological activity on the face of sandstone structures. Work will also be promulgated on vernacular building, with a continuing emphasis being placed on earth as a building material. An archaeological perspective will be offered on thatch roof constructions and, in the fullness of time, further publications will deal with the traditional use of metals.

A number of these themes will be given an airing during the Conference. In addition, through providing information on how to find sources of materials, suitably qualified craftsmen and women, and conservation professionals, it is hoped that the Conference will provide a state of the art summary of the traditional building materials topic.

It is particularly hoped that the event will be of real practical value to owners, specifiers, architects, surveyors, conservators, contractors and others involved in the repair and maintenance of traditional buildings. Further, it should also help inform manufacturers and material suppliers as to likely demand and should be invaluable to all educators and training organisations involved with conservation.

Supported by the ambitious technical publication programme emanating from TCRE Division, Historic Scotland hopes that this event will be seen as a watershed from which a greater future use of Scotland's traditional building materials will be promulgated at all levels.

INGVAL MAXWELL, NEIL ROSS
Historic Scotland, TCRE, Edinburgh
July 1997

WHY TRADITIONAL BUILDING MATERIALS?

Professor Sir James Dunbar-Nasmith, Architect-Partner, Law & Dunbar-Nasmith

Tradition is the handing down of unwritten opinion or practices and traditional materials are those materials and building methods which we have inherited. The technical steering committee for this conference has defined them as "materials which were used in the contemporary construction (invariably indigenous) of the building". I take issue so far as 'invariably indigenous' is concerned and will come back to that later. The question is 'Why Traditional Building Materials?'. Why, as we approach the third millennium should we be discussing such old-fashioned and intractable things? If we are still using traditional materials why do we make any distinction between traditional and modern at all? What is the distinction? Above all, and this is the nub of the matter - why do we like them? What do they mean to us?

Plato said that 'Man is a being in search of meaning' and there is a particular quality pertaining to traditional building materials, not perhaps to all of them, but certainly to most, which I believe is the most significant aspect of our appreciation of them. Their appearance tells us that they were wrought or created by the hand of man. It bears testimony to the amount of labour and love that went into their fashioning and this commands our respect and sometimes our awe. Hand-made and machine-made bricks may be made from exactly the same clay. Their different appearance however is crucial to our appreciation of them, an appreciation that stems from the realisation that each hand-made brick varies from its fellow, varies because of the way it was moulded and was placed, by hand, individually, in the kiln. The same is true of tiles. I recently used some Keymer roof tiles on an expensive house. Each one was not only hand-made, it had the finger-prints of the maker on the back so that I could have gone to the tile-works and spoken to the individual who had produced it. A hand-dressed piece of stone comes to life in a way that machine dressing never achieves. Every stone on which a mason has worked is actually a carving and one's perception of its value changes as soon as one understands this. It adds a moral dimension. To destroy the stone is to destroy a part of somebody's life. It is an act of vandalism different only in degree to burning an illuminated manuscript.

The psychology of perception extends further. We are comfortable with the concept of craftsmanship. The craftsman is associated in all our psyches with honest toil; we think of him as one of nature's gentlemen; much easier to deal with than those dreadful artists, who are likely to be arrogant and impossible and in any case produce work which none of us can understand. The playwright, Tom Stoppard, said in one of his plays, I think it was 'Jumpers', "Skill without imagination is craftsmanship, imagination without skill is modern art." These good vibrations associated with craftsmanship are inherent in the appearance of most traditional materials. We see the evidence of the craftsman's handiwork and we treasure the result because of it. A material like lead, for example, always reveals the skill of the hand that laid it and is fascinating for that reason. But not all traditional materials demonstrate visually the labour that went into their fashioning and our affection for them is modified accordingly. The traditional material which is used in ever increasing quantity in every new building is often not classed as a traditional material at all - I refer to glass. It is such a practical material and it can be used in so many different ways that we hardly rate it as an object of affection at all. When we do, however, the glass which we value most is that which reveals most clearly its hand-wrought origin. The unique, slightly-bowed shine of crown glass with its trapped air bubbles revealing the arc of its spinning is more endearing than the formal severity of plate glass, however efficient the latter may be. Indeed, how else explain the extraordinary devotion to bottle-glass which manifests itself in themed pubs all over Britain, in spite of the fact that it is usually made of plastic. The reason we forget the antiquity of glass is that it does not show its age.

Most traditional materials not only show their age, they look better because of it and this is a further quality which people rightly associate with them. So far as I know, there is no scientific reason for this unless it is that organic materials seem to be a more receptive host for the growth of natural organisms like lichen than inorganic ones though why this should apply to clay tiles and not to concrete ones I do not know.

The information which traditional materials reveal about their age and about their fashioning is what gives them their cultural significance. Cultural significance is fashionable jargon currently beloved by writers of Conservation Plans - without which, as we all know, you don't get a Lottery Grant - but it is a descriptive phrase, which, like genius loci, conjures an image of something important in one's mind - and it is an image in which the materials of the building play a major part.

At the start of this paper, I mentioned my caveat about the steering committee's definition of traditional materials as being invariably indigenous. Mostly they were but not invariably. Stonehenge was built of traditional materials but they were certainly not local and the Druids would have been furious if you assumed that they were. Purbeck marble was used for the disengaged shafts of virtually every Early English cathedral because it was the only material that could do the job. Iona marble, as it came to be known, was used for the majority of Celtic Crosses throughout the western seaboard of Scotland and its fame spread as far as Avignon. These materials were certainly not indigenous but they were the traditional ones for the job they had to do.

There can be a confusion between the traditional and the vernacular. Vernacular building, which is often assumed to be traditional, used the cheapest materials which would provide the necessary space and facilities with the minimum of on-going maintenance. With the arrival of canals and railways, the requirements did not change but the materials did, since the cheapest material was no longer necessarily the most local. But we have had canals and railways for some two hundred years and we have had foundries and brickworks for much longer so we can hardly claim that traditional materials are only local.

It is also sometimes thought, in the rather muddle-headed way that such matters tend to be thought, that traditional materials are ecologically more acceptable than modern ones. I doubt the truth of this. Although there is still a lot of it around, stone could hardly be described as a renewable resource - clay and lime are much the same. Timber can and certainly should be replanted but the period of growth for the best timber is no longer commercially viable. When Brunel built the timber viaducts on the Devon and South Cornwall Railway in the middle of the nineteenth century, he used Memel pine in unsupported lengths of over seventy feet - some twenty one metres long. Nowhere in the world could one obtain such timber today - it was cut for commercial reasons but not planted or grown for them. The term renewable when applied to such timber may be accurate but it is not realistic.

One of the advantages of being in practice as long as I have, is the opportunity it gives to assess the performance of new materials over a lifetime and to compare them with the survival rate for traditional ones. The traditional usually comes off best in spite of the fact that we may no longer know how to detail them properly. As a young man, I thought that twenty-five years was a perfectly acceptable life span for a bituminous felt roof. Now that I have replaced some of them twice I regard twenty-five years as wholly unacceptable for any part of a building. It comes round too quickly and it is a thoroughly false economy for the client. I no longer subscribe to the belief that we live in an age of throw-away buildings which only need to last a few years. Traditional materials set us a standard by which we may measure new ones and one of the measurements should be longevity.

It is, however, a mistake to think that the way traditional materials were used in the past was fixed for all time. Ruskin himself said "It is not historical simply to retain or repeat the past, history would cease if that were so. To act historically is to bring about the new and thus ensure the continuation of history." The same view, but in a totally different field, was expressed by the composer, Eric Satie, when he said 'Experience is a form of paralysis'. Our predecessors were every bit as anxious as we are to experiment with new methods and, indeed, with new materials. Sometimes these worked but often they did not and, because the non-successes were seldom repeated, we underestimate how much experimentation took place. Improvements to existing techniques which needed no improvement often spelled disaster. Sir William Chambers, working for a Duke at Duddingston House, fixed all the masonry with iron cramps, a quite unnecessary refinement, which ensured the disintegration of the stone two hundred years later. Archibald Elliott, working for a Marquess at Taymouth Castle, recessed all the battens carrying the lathing for the plaster into the masonry thereby ensuring its destruction by dry-rot in rather less time. Had both of them used the more traditional and simple methods they were brought up with, neither building would have given trouble later on. The application of a little scientific thought - and there was plenty around at the time - could have foreseen these disasters and prevented them. The lesson to be learnt is the difficulty of knowing what new materials and techniques will do without actually trying them. It is impossible to simulate all the conditions to which a building will be exposed through a century or more. The only certain test bed we have is buildings which have survived that period. An unusual example of a test bed built solely for that purpose are the stone piers at either end of the road across the meadows in Edinburgh - erected more than 100 years ago by Sir James Gowans, then Lord Dean of Guild, each stone of which is from a different Scottish quarry, with its name carved into it so that one sees how it weathers in the Edinburgh climate.

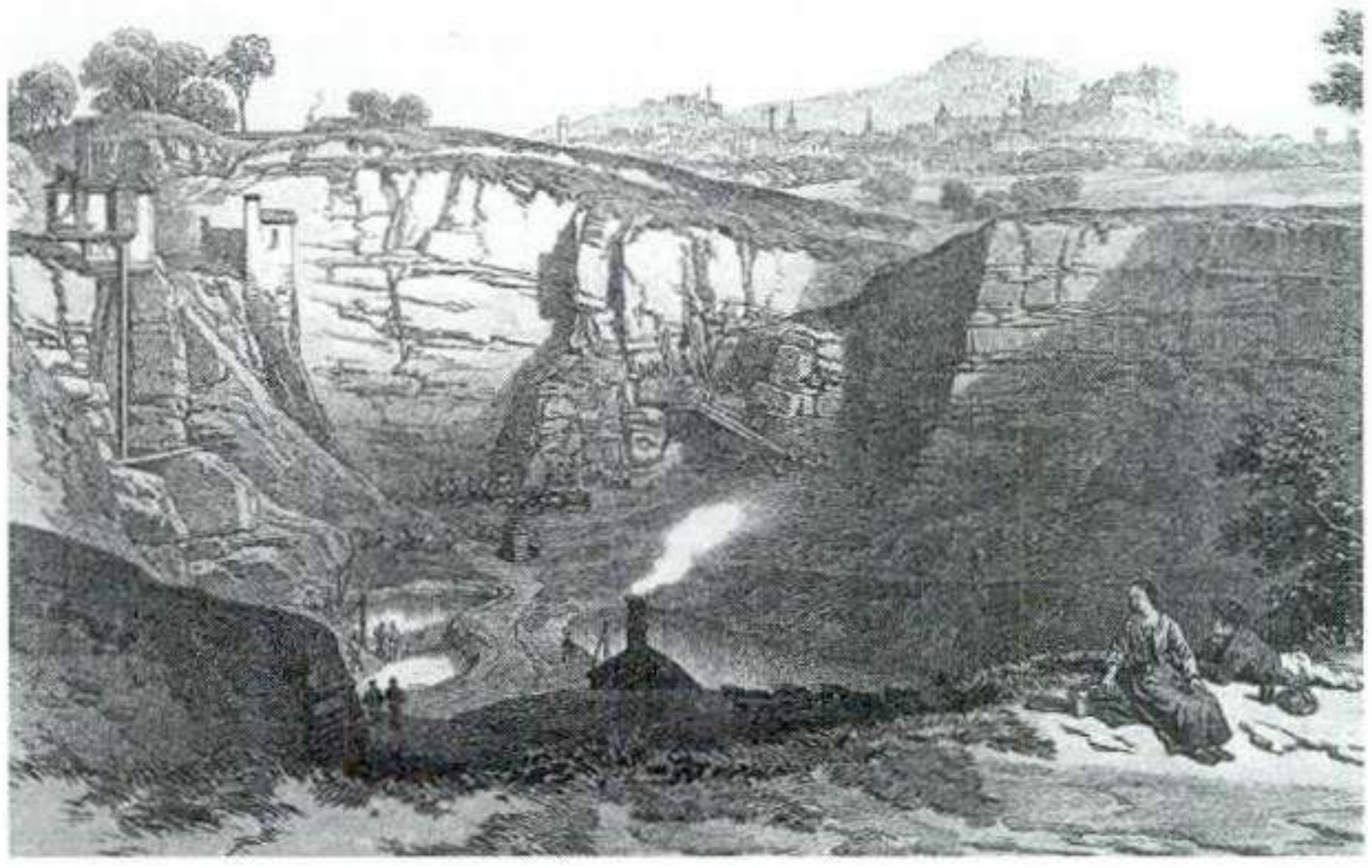
I have suggested to you why I think people want to use traditional building materials. The principal factor militating against their use has been their cost. They are labour intensive and as labour costs increase, the differential between hand-made and machine made products also increases. However, first cost is not the same as life-cycle costing and if you take account of the longevity of traditional materials, the equation is very different. Governments and local authorities are behaving irresponsibly if they take more account of first cost than of the relationship between first cost and the ongoing cost of a building throughout its life.

There is another aspect to this apart from the financial equation. It makes no sense for a government or a local authority to spend time and revenue in promoting employment schemes while commissioning buildings which are designed to employ the minimum of people in their construction. To increase employment, to encourage craftsmanship, to create a true sense of place are all worthwhile endeavours which will benefit any community - using traditional materials does all these things and the case for their use is self-evident. I submit that the question should not be Why? - it should be "Why not?"

THE HISTORY OF SUPPLY AND DEMAND FOR TRADITIONAL BUILDING MATERIALS IN SCOTLAND

John R Hume, Chief Inspector Historic Buildings, Historic Scotland

The range of traditional materials used in building in Scotland has been very wide, and in a summary paper one can only hint at many of the materials used. Clay, unworked timber, river, sea-shore and field boulders and a very wide range of fibrous substances have all been extensively used. Here I will concentrate on quarried stone, slab roof materials, lime and sawn timber, and deal more with generalities than with particularities.

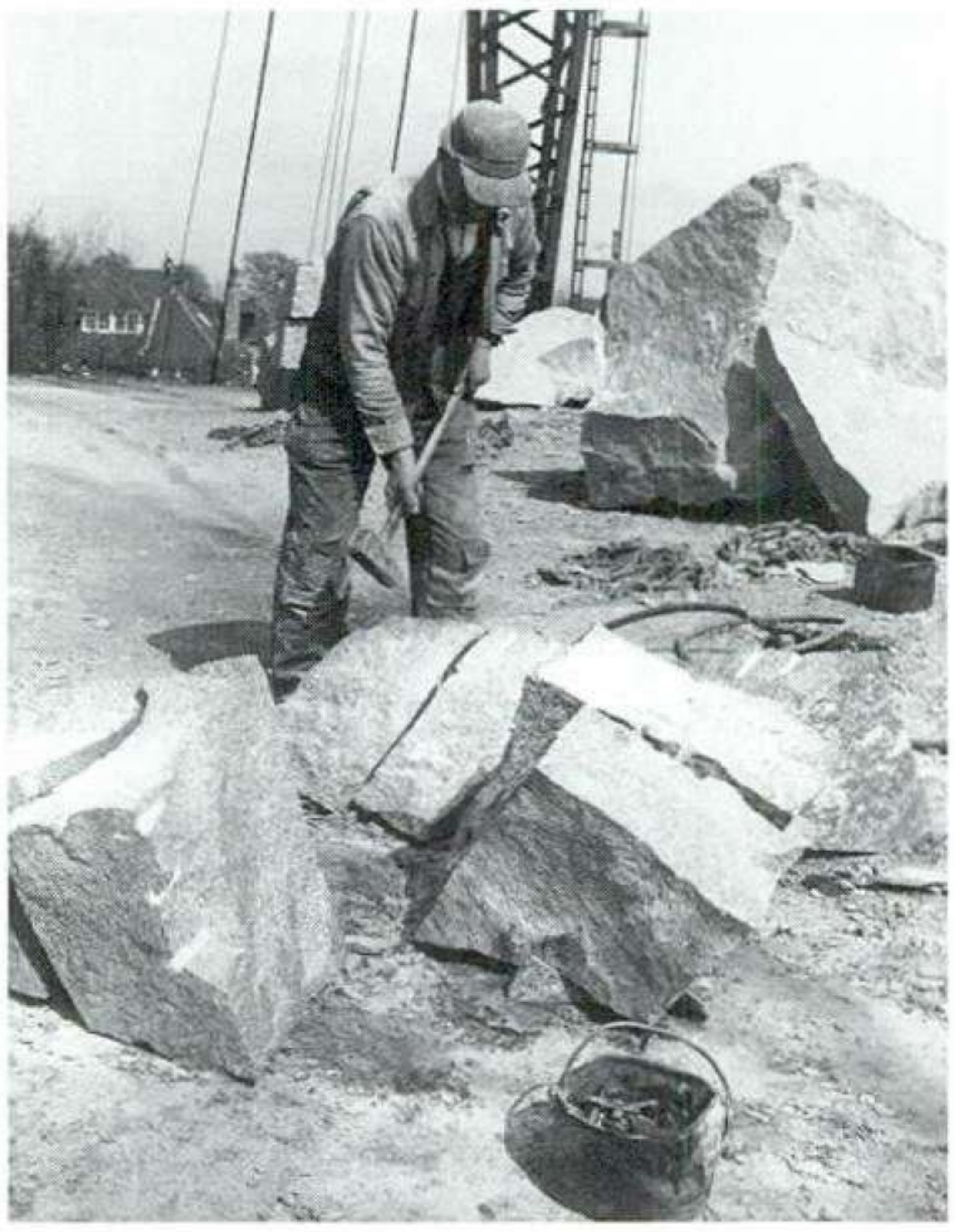


Craigleith sandstone quarry, in about 1854, showing steam pumps and cranes in use

Stone

The range of stones used in building in Scotland has been very wide, reflecting the remarkably varied geology of the country. Quarried stone has been used since prehistoric times, and the availability of easily worked stone has been a major factor in the survival of evidence for prehistoric settlement in Scotland. Stones which are easily split into slabs, such as the sandstones of Angus, Caithness, Orkney and Shetland, and the schists and slates of the western Highlands were particularly valuable for early settlers, as drystone walls of considerable stability could easily be built. The sedimentary freestones of the central belt and of southern Scotland were not very extensively worked until medieval times, when changes in social structure, and the borrowing of ideas from the continent, allowed larger and more elaborate buildings to be constructed. The churches, castles and abbeys of the 12th and 13th centuries were the first large buildings constructed of stone in Scotland, and the techniques they embody, of ashlar and rubble build, including lime mortar, the use of massive worked timber, and of stone slab roofs were immensely influential. These materials were particularly linked to the upper levels of feudal society, and the opportunities to develop a material supply industry correspondingly limited.

Stone building by the Scottish middle classes developed in the 16th and 17th centuries, at the same time as the late flowering of tower-house construction, and a series of disastrous fires in burghs during the second half of the 17th century put a premium on building in stone, and on the use of non-combustible roof coverings. A factor in this must have been the increasing use of coal as a fuel, which required a stronger draught, and therefore taller chimneys, with greater risk of sparks raining on adjacent properties. By the end of the 17th century ashlar buildings were becoming fairly common the larger towns and cities. The availability of freestones and of a skilled group of masons made it possible to adopt fairly quickly the neoclassical styles from the late 17th century, with their strong emphasis on finely-wrought surfaces.



Splitting granite blocks at Rubislaw Quarry, Aberdeen just prior to closure in 1970, using 'plug and feather' technique

The trading opportunities open up by the Union of the Parliaments created great wealth in Scotland's seaports, and encouraged industrial development. The results were dramatic, especially after 1760, and the demand for quality building materials rose rapidly. Quarrying increased sharply, for building stone, limestone and slate. Edinburgh was the largest market, and the Craigleith quarry became the largest in Scotland. The limestone deposits of Fife and the Lothians were also developed to provide lime for mortar, as well as for agricultural purposes, a notable example being the Charlestown quarries of the Earl of Elgin, first significantly worked in the 1750s. Slate came primarily from the slate islands of the Firth of Lorne and from Ballachulish.

Loading slates on to a small steamship at Ballachulish in around 1900. The railway wagons came direct from the quarry, via an inclined plane, to the quay. Note the dressing tables in the left background

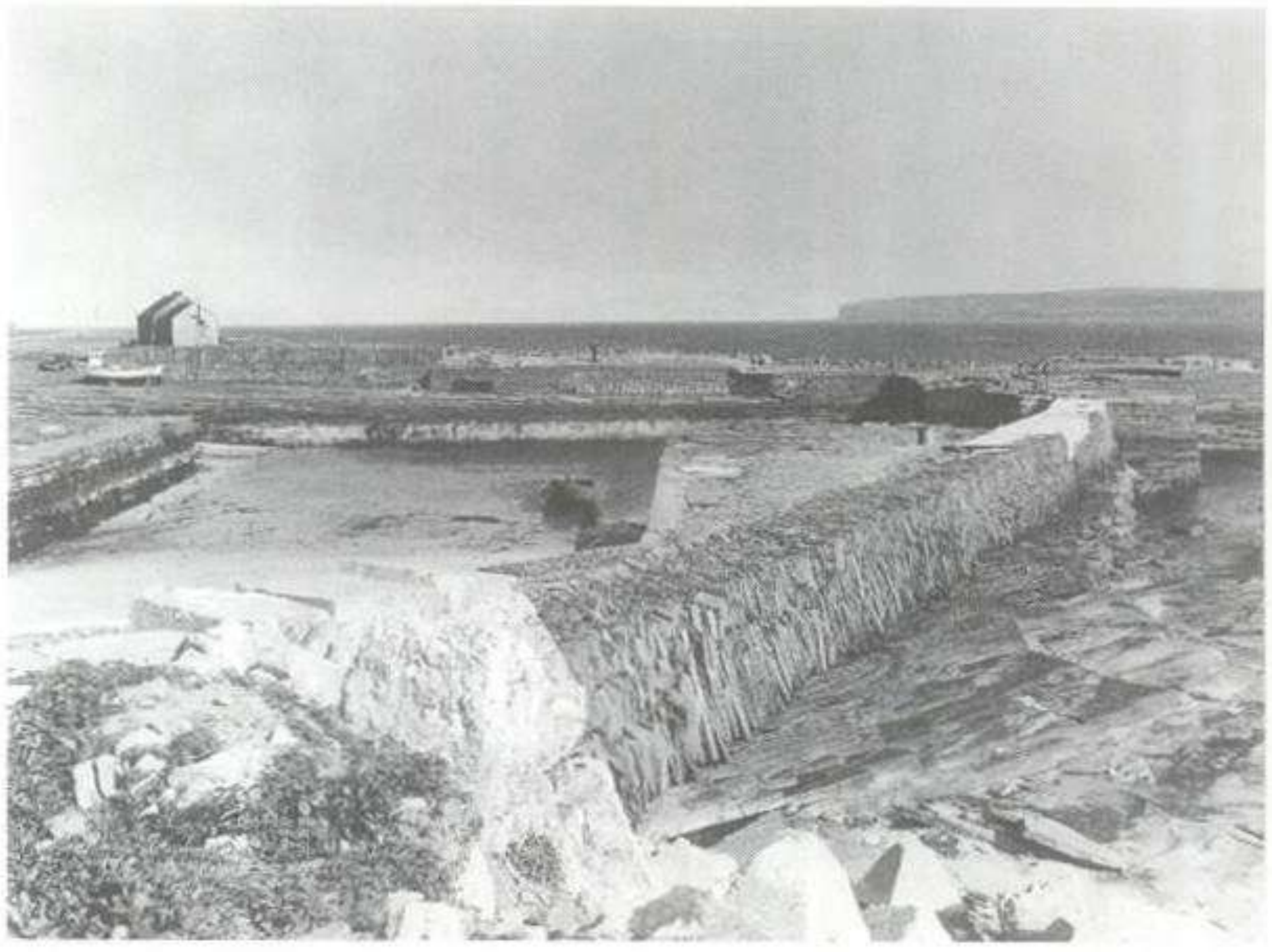
By the end of the 18th century steam engines were available which could pump water out of quarries, and which could power stone saws and stone lathes for turning column drums and balusters. These mechanical aids proved increasingly important during the later 19th century, and resulted in a premium being placed on freestones, with a consequential decline, in the use of less tractable stones. Stone sawing could also be used for slab working, and early found a place in the Caithness, Angus and Dumfries-shire quarries for that purpose. Less tractable stones continued to be used, but generally as infill within a framework of freestone or even brick dressings. One consequence of improved stoneworking techniques was a decline in the use of render. Finely jointed dressed stone generally did not need harling, or even lime washing.

A particularly important development from the middle of the 19th century was the building of railways. These greatly increased the marketing possibilities for individual quarries, and also increased the possibilities for urbanisation. The effect of railway transport was to reduce the cost of building materials generally. This encouraged the trend to develop large quarries, which themselves employed internal railways, and which by the later 19th century were delivering stone sawn or turned to specification, making it easy to build tenements and other buildings quickly and with semi-skilled building workers. Aerial ropeways, particularly in the granite industry (where they were known as 'Blondins') made it possible to quarry more deeply than would otherwise have been the case.

This developed stone supply industry did not long survive the First World War, which resulted in relatively high wages, and reduced the relative purchasing power of the middle call and the upper working-classes. Fashion, too, played a role, with English cottage-type houses, or Scottish vernacular revival buildings becoming attractive. In town centres, steel and concrete-framed buildings demanded at most a thin skin of stone. As demand fell, unit costs rose, further driving down demand. The more easily worked stone was also becoming scarce, and hence the great majority of large building-stone quarries ceased to operate between the wars.

The stone-slab industry's fortunes largely paralleled that of the building-stone producers. Mechanisation in this industry became general earlier than in the freestone trade. By 1869 stone saws and planers were in use both in Caithness and in the Carmyllie quarries in Angus. Slate quarrying, too, was hard-hit in the inter-war years, both by competition from ceramic tile and concrete tile manufacturers, and from the Welsh slate producers, whose raw material was easier to process mechanically. Its decline became terminal after the Second World War.

The lime industry's development largely paralleled that of the building-stone trade. Portland cement began to supplant lime for some purposes in the late 19th century, and with the decline of the use of stone in building became virtually universal in the brick building which took over. The last kilns to operate in Scotland were at Giffen, near Beith in Ayrshire, which closed in the early 1970s.



The harbour at Castlehill, Caithness, built for the shipment of flagstones from the adjoining quarry. Note the flagstone construction of the sea and quay walls

Working faces at East Laroch slate quarry, Ballachulish in 1974. The terraced system of working, though typical of North Wales, was rare in Scotland

The last of the traditional materials I wish to consider is timber. Though in rural areas locally grown timber has been used in many circumstances, it would be fair to say that imported softwoods have been the most important 'traditional' timbers used in Scottish building. From at least as early as the 16th century imported Baltic softwoods were used for structural and decorative work. These were originally often adze dressed for principal structural members or pit-sawn for sarking and panelling.

In the early 18th century water-powered frame saws began to be introduced, but their adoption was very patchy. During the 19th century circular saws and band saws were developed, as well as thicknessing (planing) and moulding machines. These greatly increased the rate at which timber could be processed. To reduce transport costs, timber was imported in semi-finished condition, even to the extent of pre-fabricated and 'knocked-down' roof trusses. The present timber-importing trade can be seen as a lineal descendent of that developed in the 16th century, although the timber species and the conversion techniques used have changed over time.

Finally, a brief mention of brick. Brick was not, until the inter-war years, particularly important as a material for constructing external walls in Scotland. However, brick was been used in a very limited way, since the medieval period and was used to an increasing extent from the mid 18th century. In the south west of Scotland, brick was in use in Dumfries-shire and Kirkcudbrightshire in the mid 18th century, and not much later in Perthshire and Angus. These bricks were hand made from plastic clay, and the costs of production seem to have been high in relation to quarried stone except in exceptional circumstances. The first large-scale use of brick was in the development of the east end of Glasgow in the early 19th century, where bricks made from local clay using local coal proved cheaper than stone. More widespread use of brick began in the mid 19th century, when wire-cut and later pressed bricks were introduced and regenerative kilns were invented. The brick press allowed non-plastic clays to be used (often by-products of coal mining), and though the 'common' bricks made in regenerative kilns were not durable in external applications, they were widely used in internal walls and behind stone skins. Immediately before, during and after the First World War such bricks came into use for external walls, with the application of render to protect them from the weather, and it is only since the 1970s that production of such bricks on a large scale has declined. The facing bricks which have supplanted them owe more in character to the English than to the Scottish tradition.

In conclusion, the demand for building materials has been strongly influenced by population change and by climatic circumstance. Traditional materials have become traditional by long-standing advantages in terms of availability and/or cost. Whether or not they have any significant place in modern new building practice is determined by what inherent advantages they offer, but also to the extent to which modern techniques of production can be applied to them. In conservation their use will be determined largely by absolute availability, and to a lesser extent by cost. In the former, environmental and working practice restraints may well prove determining as to extent to which they can remain, or be brought back into use. This conference will, I hope, begin to draw a map on which routes can be traced which will show how apparently opposing constraints can be reconciled with a good building outcome both for conservation and for new construction. It is in all our interests that the built environment is durable, user friendly and aesthetically appealing. Traditional materials have key roles to play in satisfying these demands.

THE ETHICS OF USING TRADITIONAL BUILDING MATERIALS

Peter Burman MBE FSA, Director, Centre for Conservation Studies,

Department of Archaeology, The University of York

In the Natural History Museum there are some wonderful watercolours of rocks and fossils by F L Swebach-Desfontaines, who died in all probability in the Reign of Terror in the revolutionary France of 1793-4, and in his obituary it was said of him that '….without formal training and supported only by his ardent imagination he embraced all genres in the arts and appeared by turn, sculptor, painter, engraver and mineralogist'; and I feel a certain fellow-feeling with him because without formal training as a philosopher and supported only by my ardent imagination I am attempting to set myself up as a philosopher of the treatment of buildings, especially but not only historic buildings, to explore the historical background to where we are now, and to identify some at least of the issues which concern thinking men and women when they contemplate our building culture - whether in developed or undeveloped countries - in the late twentieth century.

The potential canvas is very large, and the task of drawing boundaries is fraught with difficulties: an ethical approach to the use of building materials, including the use of traditional building materials, is only just now consciously developing, and the literature is small; yet convictions are powerful, because they involve large interests, not just philosophical but also economic and political.

A system of ethics implies a set of moral principles, principles which have been worked out and implicitly accepted by a particular culture or perhaps by a particular profession, such as the medical profession; by contrast with the medical profession the professions and disciplines associated with our building activities seem to have given comparatively little attention to the development of a system of ethics. One reason for this may be that the range of interests and activities associated with building culture is very large, and somewhat diffuse: the interests include those of owners of sites and structures, developers, planners, shareholders; the activities include the professions of architects and landscape architects, surveyors, engineers, geologists, craftsmen, artists, art historians, archaeologists and others including professional associations, national and local amenity societies, and so forth. Small wonder that it is difficult to identify the common links, or to forge an overall vision from which a system of ethics might develop.

In looking into the historical background, and largely but not wholly ignoring the significant philosophical thinking which evolved in classical Greece and Rome and during the European Renaissance, one of the earliest among modern writers to concern himself with a philosophical approach to building matters was John Ruskin who wrote in 'The Lamp of Memory' a persuasive argument for the idea of trusteeship, which is the key to understanding the whole argument of whether or not there is or should be an ethical approach to building materials, and especially traditional building materials: 'The idea of self-denial for the sake of posterity, of practising present economy for the sake of debtors yet unborn, of planting forests that our descendants may live under their shade, or of raising cities for future nations to inhabit, never, I suppose, efficiently takes place among publicly recognised motives of exertion. Yet these are not the less our duties; nor is our part fully sustained upon the earth, unless the range of our intended and deliberate usefulness include, not only the companions but the successors of our pilgrimage. God has lent us the earth for our life; it is a great entail. It belongs as much to those who are to come after us, and whose names are already written in the book of creation, as to us; and we have no right, by anything that we do or neglect, to involve them in unnecessary penalties, or deprive them of benefits which it was in our power to bequeath…. Men cannot benefit those that are with them as they can benefit those who come after them; and of all the pulpits from which human voice is ever sent forth, there is none from which it reaches so far as from the grave.' [The Seven Lamps of Architecture, 1849]

William Morris, as is well known, took this idea of trusteeship in his drafting of a *Manifesto* for the Society for the Protection of Ancient Buildings, which he, Philip Webb the architect and George Wardle, his manager of the firm of Morris and Co., founded in April 1877. But there are many other utterances of his, less well known, which entitle Morris to our respect as one of the prophets of our late twentieth century concern for the whole environment, of which the winning and using of building materials forms such a significant part. One of his earliest Socialist lectures for instance, *Art Under Plutocracy*, which was delivered in University College, Oxford, in November 1883 with Ruskin in the chair asks his audience a compelling question which we are still, in a sense, asking ourselves today: 'He must be indeed a man of narrow incomplete mind, who, amidst the buildings raised by the hopes of our forefathers, amidst the country which they made so lovely, would venture to say that the beauty of the earth was of little moment. And yet, I say, how have we of these latter days treated the beauty of the earth, or that which we call art?' Echoing the sentiments of Ruskin's 'The Nature of Gothic' from *The Stones of Venice* Morris, as elsewhere, makes the point that in earlier times there was an intimate connextion between what he identifies as the 'Intellectual' and the 'Decorative' kinds of art, that '.... The humblest of the ornamental art shared in the meaning and emotion of the intellectual; one melted into the other by scarce perceptible gradations; in short, the best artist was a workman still, the humblest workman was an artist'.

I believe that this issue of craftsmanship is a key one for the late twentieth century, and that we cannot hope to have a philosophically sound basis for our building culture unless we get into order systems for the training of craftsmen who will be, as far as possible, also artists - which is another way of saying that they must have a sense of responsibility for they are doing, understand what they are doing and why, and have choices available to them.

For the purposes of this paper I would like to put forward the idea that many of our concerns about the ethics of traditional building materials can be grouped under three headings, namely: physical, social and cultural.

Physical

Ideally, I would want to try and avoid all emotive language; but that is in the end difficult. It has to be pointed out that the effect of the industrial revolution, in Britain as in other countries soon afterwards, was to produce a great deal of ugliness and exploitation. There are now in place systems of control and to some extent they are working; but I suppose the reason why I am contributing to this conference arises out of an accident which occurred, and impressed itself on my memory, while I was still a teenager. At the age of sixteen I was invited to sing in the week-long Festival of Cathedral Music at Edington Priory, in Wiltshire, and one of the great pleasures of doing so was and is that the afternoons are free from rehearsals and can be spent in exploring the neighbourhood; hence it was that I came to climb the steep chalk down between the neighbouring village of Bratton and market town of Westbury and to scale the heights above the Westbury *White Horse* cut into the chalk at some distant time in the past. From this vantage point, on the very northernmost edge of Salisbury Plain, the most wonderful patchwork of farming culture, of villages with their churches, of orchards and gardens and hedgerows met the eye: to a large extent they still do. But when I returned the following year there had appeared, slap-bang in front of this marvellous stretch of carefully nurtured countryside, a very large cement works. I cannot describe how angry and astonished I felt on seeing this; I have no idea to this day precisely how it came about, but it has made me ever since a campaigner for the environment, for the countryside, for old and unspoiled buildings and countryside, for texture and colour and beauty in buildings, and especially for the vernacular buildings built of traditional and locally available building materials that it is one of the purposes of this conference to celebrate and to investigate ways of perpetuating.

But I would argue that the ethics of the situation do not allow us only to be concerned about beautiful and often vulnerable old buildings - and, casting our net more widely than Britain, I can say that in every country I have ever been to the vernacular building culture has been perilously at risk, and in some cases has practically disappeared already - but we have to take into our purview the whole gamut of environmental concern, for ethically skilful ways of building new as well as caring for the old, and with a sense of responsibility towards the future and, in a word, for *sustainability*.

If I may quote another passage of Ruskin: 'You cared neither for Gods nor grass, but for cash....; you thought you could get it by what the Times calls "Railroad Enterprise". You enterprised a railroad through the valley - you blasted its rocks away, heaped thousands of tons of shale into its lovely stream. The valley is gone, and the Gods with it... There are three Material things, not only useful, but essential to Life. No one "knows how to live" till he has got them. These are, Pure Air, Water and Earth.' [*The White Thorn Blossom*]

A further set of key concerns, then, is the conservation of unpolluted water, air and the earth itself; and today we would want to add to those the sea, and marine life, and timber and indeed much more - for there are indications that some of the resources on which our present civilisation depends, such as the availability of oil, lead, copper and zinc, could be exhausted in thirty or forty years; and there are other resources, such as the immense stone quarry on Morvern by the Sound of Mull, which can only be won it seems by dint of intrusive and unsightly measures. We have to face up to the fact that the construction industry is one of the biggest - if not the biggest - consumers of energy in our society. Materials are brought vast distances, materials are imposed with no sense of local or cultural appropriateness, and materials are used with little sense of their long-term weathering and maintenance values.

What we are looking for, in the physical context, is for ways of recycling elements which are themselves benign: the 'Lime Cycle' seems to me to be the most wonderful example of alchemy; and a less glamorous but no less useful example of alchemy is the use of reed beds to filter sewage.

We must also unashamedly grasp at ways which would enable us to turn our wasteful over-consuming western societies into more ethically-based societies; and one effective way of doing this would be to embrace a culture of maintenance - it sounds so simple, and yet we are far away from having achieved it. In the more exalted echelons of historic buildings preservation and conservation - country houses where good management regimes exist, whether in private ownership or the ownership of one of the two National Trusts, or the Landmark Trust; cathedrals; parish churches to a considerable extent but not evenly across Britain - the culture of maintenance is nurtured through regular inspection by suitably qualified professionals; and as Chairman of two cathedral fabric committees, at St Paul's Cathedral in London and at Lincoln Cathedral, I am naturally enthusiastic about the idea of resident teams of craftsmen and conservators, under the constant inspired leadership of good Clerks of Works and the overall direction of architects with a balanced view of what is needed. Bur the best system for inculcating a culture of maintenance that I know about - and there are probably others that I don't know about - are the *Monumentenwacht* organisations (literally 'Monuments Watch') in The Netherlands, and in that part of Belgium which is called Flanders. These organisations are backed up by the provincial governments of those countries, but the idea is in essence very straightforward; in return for a modest annual subscription paid by the owner of a listed building (which can be great or small) a team comes *regularly* and dependably once or twice a year and - supported by a ladder or two, a van, and a laptop - provides the owner with a succinct report on the state of health of the building, with clear indications as to priorities for repair works, advice on what can be done on a self-help basis, what needs the specialist attention of a good builder, what needs the overall direction or sense of strategy of an architect or an engineer or building surveyor, and so on. Immediately necessary and urgent repairs, like replacing two or three slipped slates or tiles, are done at once as the inspection proceeds; anything more substantial is noted down for attention. Much energy is devoted to counselling and encouraging the owner, whether an individual or a society such as a parochial committee. We need such an organisation here in Britain, and in every country prepared to take an ethical stance in regard to its existing building stock, and we ideally need the system to be available to all buildings and not just to historic or landmark buildings. Good stewardship makes sense, in terms of practical politics and preserving our building stock for continuing use, as well as sound philosophical sense.

This would be much more helpful in my view than the present over-emphasis on energy efficiency, which is encouraged by government and by much but not all green-orientated literature yet without - it seems to me - sufficient or discriminating assessment as to whether it will be in the best long-term interests of the building and the people using it. In this context, it is encouraging to note that a large-scale experiment is under way at the new *Building Research Environmental Building* where no less than six monitoring programmes are in place: one is a detailed breakdown of the energy consumption, assessment of internal environmental conditions, and their acceptability to the users of the building; the second concerns the day-lighting performance, including the performance of the glass louvres; the third involves regular inspection of certain of the innovative aspects including airflow in the stacks, air change rates in the offices, earth contact, and so forth; the fourth involves monitoring the use of space in the office block; the fifth concerns monitoring of the stresses in the superstructure; and the sixth concerns the performance in use of the photovoltaic arrays, both as generators and as elements of the building fabric. I mention this initiative at BRE particularly because it is vital, it seems to me, that conservationists - of which I am unashamedly one - do not get too hooked on one particular approach, philosophically or technically, but participate in a certain cross-fertilisation such as can only come about through open-minded experimentation.

At the same time, we need to find some common ground between conservationists and our colleagues who are engaged in what is increasingly known as eco-renovation; eco-renovation takes a responsible stand towards the sustainability of materials and methods but without always being aware of the experience of building conservators, conservation officers and others who have daily experience not only of what traditional building materials are appropriate in particular cases but also - perhaps even more important - how to use them. The linking up of these two movements, the ecological movement and the building conservation movement, is crucial if we are to retain our older and especially our vernacular buildings in use and in sound health. The two movements should be - and certainly could be - natural allies, but at the moment they are not.

Another whole area of concern, which raises serious ethical issues, concerns the manufacture and choice of paints. I recall once attending a conference at the University of Guildford and feeling physically ill at the seemingly toxic and certainly very disagreeable fumes being given off by the new paint in the residential quarters; and indeed I left early on account of it. It is encouraging to learn of a new house of some architectural quality in Cornwall, Messack House, that mineral paints made from natural materials and earth pigments with no acrylics or oils and a high breathability factor were chosen for the inner and outer wall surfaces; render was chosen externally as bricks are not a traditional facing material in Cornwall, and the rendering plus the mineral paints make the house - which is in an exposed position, overlooking the sea - that much more waterproof. [References in *Country Life* and *Building for a Future* Magazine, Spring 1997, Vol 7, No 1]

Questions of toxicity have arisen also over the use of UPVC for windows and doors; in certain countries, such as Denmark, its use is forbidden on grounds of toxicity alone and the reasons for this need to be better understood and better known. A recent report by *Greenpeace* has highlighted the dangers of using it though, typically of the very complex nature of such matters, there is more to be said on the subject and English Heritage has been working to achieve a balanced view. However, it is not only a question of toxicity: the use of UPVC has been devastating on aesthetic grounds in countless villages and historic towns, and in areas such as the North York Moors National Park close to where I live; the UPVC windows sometimes make an effort to copy the historic forms, but mostly do not, thereby contributing to year another loss in authenticity; and they are by no means as long-lasting and maintenance free as is claimed by the manufacturers and installers. Even more worrying is the pressure householders are put under by salesmen, who often persuade them to replace a whole window or a whole set of windows when a few simple and mostly inexpensive repairs are all that is really needed.

We undoubtedly need more 'ecobuilding', whether in the sense of using environmentally friendly materials (usually of course traditional building materials) in repairing existing structures or in building new ones. Good examples of the latter are two new buildings at Linacre College, Oxford, righly praised by George Monobiot in *Perspectives on Architecture*: 'This is one of the first major projects in Britain whose designers have taken seriously the notion of embodied energy - the amount of fossil fuel required to extract, process and transport the materials from which it is built. They found that plastics, polymer foams and ferrous metals are more energy expensive than local timber and stone. So the floors and windows are made from eco-certified timber, rather that concrete or aluminium. The tiles came from a demolished college building. Recycled newsprint, rather than extruded foam, is used for insulation.... Even the conventional architect's commonest excuse - the expense - turns out scarcely to be an excuse at all. Including the forest the college bought to offset the remainder of its carbon dioxide emissions, the building's green features cost £69,000 of the total price of £2.4 million. Energy and water savings mean that these attributes will pay for themselves within six years. So why can't every building be like this? Why can't energy-costly, people-unfriendly, environmentally destructive architecture be consigned, as it has been in Scandinavia, to the dustbin of history? No one seems to know....' The Abraham Building and the administrative building were designed by ECD Architects. [*Perspectives on Architecture*, April/May 1997, Issue 28]

Other examples currently in the news are the building conservation centre, designed by Edward Cullinan Architect to be built using greenwood timber, at the Weald and Downland Museum at Singleton, near Chichester, in Sussex; and David Lea's addition to a Welsh farmhouse, belonging to the owner of the United Kingdom's largest producer and importer of organic food, using his concept of 'vernacular construction': oak from the farm's own woodlands has been used for the post and beam skeleton of the extension; moreover, new (i.e. not recycled) Welsh slates will be used, thereby helping to encourage the skills of quarrymen. David Lea has also designed, in two stages, that attractive new accommodation buildings at the Royal Agricultural College, Cirencester, which strike a blow for the use not only of traditional building materials but also of heavyweight construction as opposed to lightweight construction with its potential for using short term, renewable resources such as timber, plant and animal derived products; in fact, David Lea has experimented with both heavyweight and lightweight construction in a thoroughly responsible manner and perhaps one thing we ought to be doing in order to develop the clarity of our ethical debate is to have a balanced discussion of the pros and cons. In all probability, this will help to show us what is more appropriate in a particular situation or set of circumstances.

Returning to quarrying, this is another of those complex issues where passions are easily raised; yet it seems to me commonsense to try to do something about the availability of modest local sources of good walling and roofing materials, traditional to their areas, and that can only come about through a revolution in quarrying leading to the re-opening of small local quarries which - while contributing worthwhile skills to local employment possibilities - would be non-intrusive and not cause the problems associated with noise and heavy traffic. In this connexion , it is good to report that during this summer an MSc student from the University of Leicester, Gavin Mennie, has been carrying out a pilot study of the building stone potential within the North York Moors National Park; fieldwork has been combined with analytical work in the laboratory to establish the soundness, durability and strength of the samples collected; and other factors which have been explored include workability, evidence of past use, proximity to areas of demand, colour and texture. The work has been carried out with the support and encouragement of the National Park Authority, the Ryedale Folk Museum, the North Yorkshire Moors Building Preservation Trust (of which I am chairman), and the landowners of the estates where the disused quarries occur; at the moment the report is awaited, but it seems likely to provide material for a better-informed local debate and perhaps will lead to other such surveys elsewhere. The overall aim is to identify the best potential sources for *small-scale* extraction, to satisfy local needs for the future.

Social

It is worthwhile reflecting that the arguments are not all about technical and financial matters, but also social and cultural. Indeed the whole point of having an ethical approach to building culture, including reviving and encouraging the use of traditional building materials, is to re-affirm cultural and social values. Using traditional building materials is essentially about two factors: learning or re-learning, the appropriate skills; and working in association and in harmony with others. Perhaps it is also about wholeness of human personalities; certainly some of the most satisfied people I meet are those who are working in the interface between building conservation and craftsmanship. Yet it is important not to romanticise the craftsman. I well recall a conversation with a stonemason working for Lindsay-Strachan Ltd, at the Building Limes Forum's conference and trade fair at Caroline Park, Edinburgh, in 1995 when I asked him if he were really enjoying using lime instead of cement; "Not really", he said; "it's much harder to work, but I've got a job to do and a wife and children to feed". This attitude contrasted strongly with the singing atmosphere of 'limies' all around us, yet it struck me as very sensible; lime is more tricky to use than cement, and that is one of the reasons why cement was adopted in the nineteenth century with such enthusiasm. But it underlines again how important is good craftsmanship, and also how critical is the attitude of the craftsman; and so it is important that there are now such flourishing organisation as the Building Limes Forum, the Association for Environment Conscious Building, the Ecological and Vernacular Building Forum, and the Scottish Ecological Design Association (SEDA). The Scottish Ecological and Design Association had an important national conference in Elgin in May this year with the theme *Developing an Environmental Agenda in Scotland: Steps to Sustainability* which dealt with aspects of the urban and rural environment, transport, energy, construction and design, natural resources, the implications of Local Agenda 21 (including public participation, implementation, and how to establish networks), tourism and recreation, and forging links with business and industry. It will be noted, however, that there was no explicit mention of building conservation in the declared agenda for the conference - perhaps it was intended to come up under tourism and recreation - and I mention this solely to underline the necessity for us all to work more closely together on the ecological and building conservation agenda. It is just at this very point that the need for a commonly accepted ethical approach to building culture can be seen as critical, and as something needing our urgent attention.

A whole area which demands our attention is the huge problem of the Third World's eager progress towards industrialism and mass tourism.

Returning to Western countries, how are we to provide incentives or rubrics - carrots and sticks, in old-fashioned language - to encourage the use of local and traditional materials? One suggestion that has been put forward is that extensions to existing buildings (or at least listed buildings), and new buildings in Conservation Areas, should be required to use traditional and appropriate building materials, and that these should be specified as conditions. I have noticed on two visits this year to the county of Norfolk, in East Anglia, that sensitive owners and their architects and builders are anyway tending to use flint facing (at least), pantiles or thatch (where appropriate), and weaker mortars more based on lime than on cement; and, generally, to pay more attention to local distinctiveness. The initiatives of the Countryside Commissions in Scotland, England and Wales and the efforts of voluntary bodies such as Common Ground and the Council for the Preservation of Rural England (CPRE) are invaluable in this respect. Collaboration is growing between the official agencies for building conservation and the conservation of nature; but not enough seems to be happening, or it is not happening quickly enough, and - moreover - what is happening is not getting across effectively to the ordinary citizen, whose co-operation and sense of partnership is as important as official efforts. In *Local Agenda 21* we have what appears on the face of it to be an ideal opportunity and mechanism for involving the public, and for linking up all the local networks; yet progress is slow. We need to collect good examples, and to publicise them widely.

Much has been written and said in other contexts about the re-use of large redundant complexes of buildings, and last November I organised in York a conference which was called *The Great Unloved Ones* about the re-use of redundant buildings formerly in the public estate, such as the large nineteenth century hospitals and mental hospitals which have been de-commissioned; these are often striking building complexes, built with craftsmanship of a high order, and in beautiful settings - but much of this is being squandered in the name of development. Yet with more thought about design and materials, and a more long-term approach generally, another layer of history could have been added without spoiling the existing ones. However, imaginative re-use of historic and landmark buildings, including mills and distilleries and railway architecture, has been spearheaded in Scotland by architects such as James Simpson of Simpson & Brown in Edinburgh and by Douglas Forrest of Douglas T Forrest Architects in Huntly; and the work of Kit Martin in the country house field, and now in the field of redundant industrial and other buildings, is well-known. All these good works depend for their success, it seems to me, on a thirst for quality; quality in design (which is where SEDA comes in again), and quality in workmanship and materials. And all these good qualities will not survive without proper training, including apprenticeships in the building trades.

Education, awareness, are still desperately needed.

Cultural

Cultural aspects of an ethical system relating to the use of traditional building materials are usually relegated to the bottom of the heap, yet they are what give the debate meaning; if all our efforts do not lead, in the end, to a strengthening of human culture - which is not at all the same thing as simply preserving effectively the culture of the past - then what is it about? Some of these aspects have already been touched upon, such as the availability of local and traditional materials; and it deserves to be recognised that human skills are themselves part of our cultural heritage. Few things make me feel happier or prouder of my friends and colleagues than entering the carving workshop at York Minster where, currently, the carvers are working on the new Great West Doorway, the designs for which have been prepared by sculptor and building conservator, Rory Young; when this commission is completed, and revealed to the public, I hope that it will make more people aware of the fantastic reservoir of skills which exist and which needs to be given more such opportunities.

One cultural problem which needs to be articulated is the fact that the practice of agriculture is closely related to the survival, or revival, of certain materials and patterns of cultural activity; coppicing, with it huge potential for ecologically sound building materials, and the management of reed beds to produce the materials for reed thatching are two obvious examples. Agriculture in general has been moving away from traditional practices - to put it mildly - in the past half century; but all is not yet lost, as more and more farmers are returning to ecologically sound practices in the interests of harmony with the environment and better food production. Perhaps what is needed once again is a better sense of co-operation between agriculture and building culture. My own father was a farmer, who took great pride in mending his buildings himself with the aid of his foreman and a wonderful collection of tools, and his inspiration has been always before me. Good agricultural practice and good building practice can go hand in hand; and the development of a shared ethical basis would be a great step forward. The revival, or the re-valuing, of traditional building materials and skills is being paralleled by a re-valuing of traditional agricultural practices.

Further parallels could be developed between the practice of building culture and the practice of medicine where, in appropriate circles, the practices of homeopathic medicine are supported in appropriate cases by what my doctor once called the 'shock-troops' of allotropic medicine.

A related cultural issue concerns the late twentieth century preoccupation with specialisation, to the extent that it is virtually a cult, and encouraged by many pressures including the current modes of education and training. It is useless to contemplate turning the clock back, but it is important to try to find a better balance between over-specialisation and a more holistic way of understanding and doing things. It is here that the influence, and indeed the revival, of the Arts and Crafts Movement could be so influential and helpful.

Good building culture has a great deal in common also with gardening and good husbandry.

The literature in English which deals with conservation ethics and philosophy, and by implication with traditional building materials and skills, is as I have already said small; and it deserves to be buttressed by a consideration of what has been written in other countries, as for example in India, a country in which craftsmanship is still highly valued and practised. So it was with special interest that I read a recent review of John Earl's 1996 *Building Conservation Philosophy* by Tony Currivan in *Building for the Future* Magazine. Here he comments shrewdly that 'There is no particular philosophy espoused, but more of an approach based on a quiet continuity and a need to treat each situation on its own merits - to examine all the evidence and options before undertaking any action. It is an approach, I would suggest, that is not dissimilar to that of green buildings and we could learn something from closer study of these methods'.

Conclusion

There is a need to explore further ethical and philosophical questions in relation to building culture in general, and the use - including the revival and re-valuing - of traditional building materials and skills in particular. One way of looking at current concerns has been to consider them under the headings of physical, social and cultural aspects; but of course these relate closely to one another, and overlap, and there are undoubtedly others. It would be no bad thing to develop an international charter on the use of traditional building materials and skills; and the key importance of craftsmanship, and therefore the nurturing and training of craftsmen at a high level, has been stressed. *The Cathedrals Research Unit* at the University of York has been given financial assistance by the Prince of Wales' Trust and by the Radcliffe Trust to develop a survey of existing levels of training, and training needs, in cathedrals and other major religious buildings in the United Kingdom; and that should be a step forward, for the present generation.

But what is needed immediately is a greater sense of common purpose, and a more effective pooling of ideas and experience, between the various official and voluntary bodies engaged in the protection of the environment and of our building culture, and the encouragement of good new design and building culture. It is a task worthy of the present moment in the world's history.

WHAT IS THE RANGE OF TRADITIONAL MATERIALS IN SCOTLAND?

Neil Grieve, Lecturer, Dundee University

I was born in Dysart in Fife in 1948 and lived there only for some months before my father who was a bank manager took us to London. For my mother whose maiden name was Batchelor, this was going home, and we lived with her parents in a large terraced house in Fulham. My grandfather had been a clerk of works with Chelsea Borough Council and my abiding memory of this time was of walking around with "Batch" as everyone called him, looking at jobs he'd been involved in which seemed always to feature brick.

The family moved to Aberdeen, when I was seven, where my initial impression was not of moving from brick to granite, but of a different dialect. But I can also remember vividly going from the school playing fields to see rubislaw, which had been the world's biggest producer of granite, and was still working in the early 60's. My parents moved once more, to Speyside, at which point I set off for Edinburgh to start a planning degree. Other than the occasional visit, I did not really know the city. These days, I envy anybody seeing it for the first time, it can be an extraordinary experience. Then, there was so much going on, this was the period where George square had been redeveloped by the university, St James Square had been redeveloped for the Scottish Office and John Lewis, Princes Street was under threat and people were starting to question whether it was really necessary. I regret to say that as planning students, we were no more than observers. Then I worked for two years with Midlothian County council, where Robert Jack, showed me that conservation was not all about The New Town of Edinburgh, but that the mining villages, milltowns, market towns and rural hamlets had their own character and architectural gems and were important too, conservation was not something that smacked only of privilege.

I started work in Perth and Kinross in 1974 and could at times, feel quite guilty for driving for over an hour from river estuary, over hills to mountains and glens to look at and discuss a building which might be the centre piece of a great estate, usually with an owner looking for grant, a terraced house in a historic burgh which someone wanted to improve, a rural industrial building which nobody knew what to do with, to a crucked roof cottage which nobody knew of and which the owner wanted to demolish. The range of colours and textures was extraordinary, sandstones, whinstone and slate, clays and thatch and harl, and there was a diversity of style, medieval tower to classical mansion, scots baronial to arts and craft, and architects of the calibre of Bruce, Adam and Playfair.

I moved from Perth to Dundee in 1980. Despite living only some 20 miles from the city, along with what appears to be most of the population of Scotland, I'd only occasionally visited the place. I had expected to find industrial buildings and I did. I was not prepared for the large number and just how wonderful these buildings could be. Superb to look at, powerfully atmospheric and technically astonishing. Designed almost always by engineers, they are mainly fireproof jack arch construction and usually they have magnificent gothic cast iron roof trusses. (Fig 1). The stone was more buff than red but is prone to scaling and is mostly patched with portland cement a practice that had thrived in the city throughout this century, with usually disastrous results. The early 1980's began the age of the concrete block or city centre improvement as some people saw it.

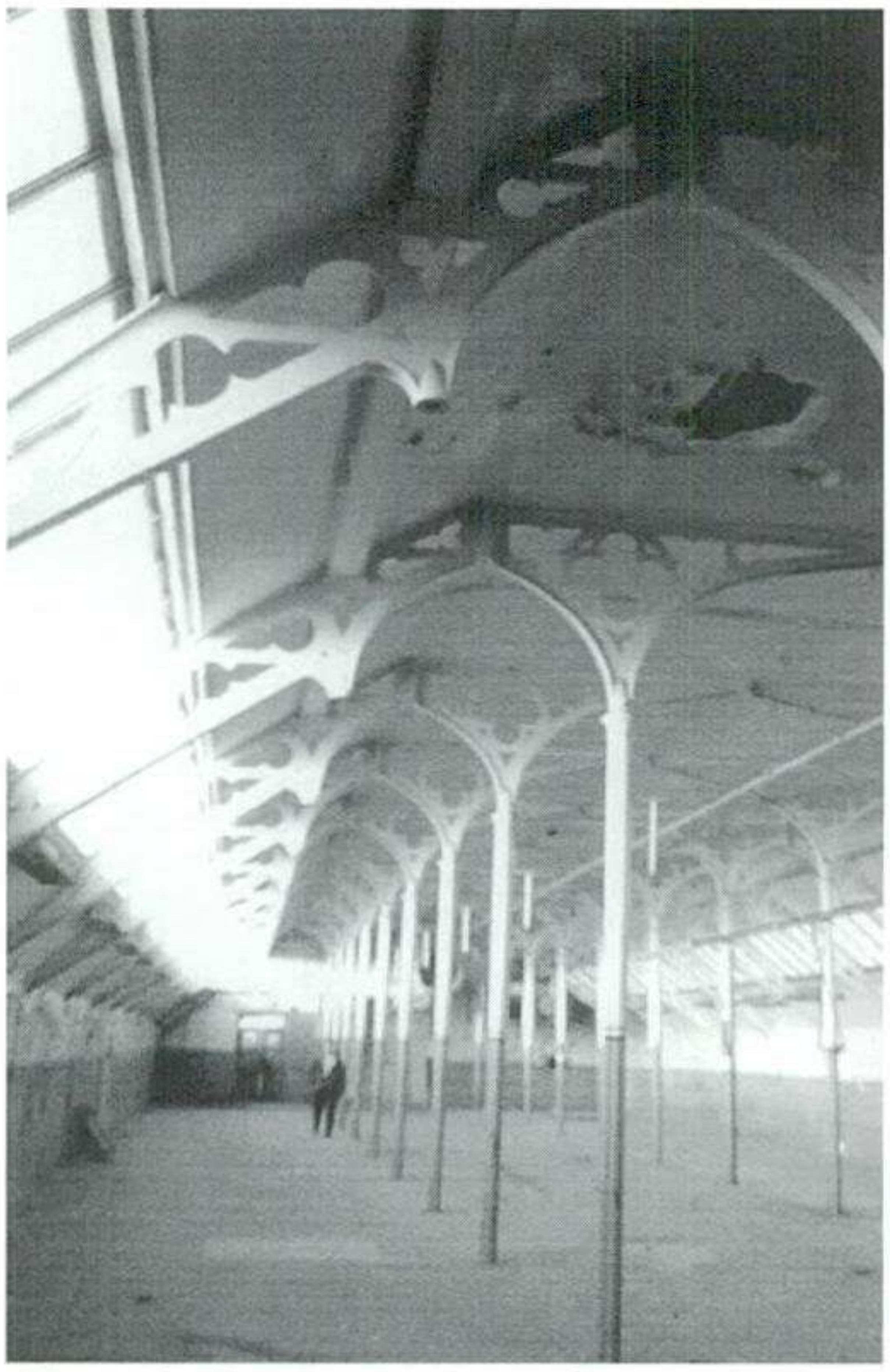


Figure 1: Cast-iron gothic roof trusses in South Mills, Dundee. Circa 1855

In 1991, I moved to Duncan of Jordanstone College of Art, now a faculty of the University of Dundee, to lecture mainly to a postgraduate course on European Urban Conservation. It also gave me the chance to develop Tayside Building Preservation Trust, which I was prevented from doing while with the district council. Some two years ago my colleague Ralph Skea and I began to undertake research into the use of scots slate for Historic Scotland's Technical Conservation, Research and Education Division.

I do not expect you to find this potted history of my personal and professional life that riveting, so why have I chosen to begin my talk in this way. I decided that it was not unreasonable to use the platform of personal experience to fully explore the topic. After all, this experience which I share with a lot of people, has pretty well mirrored the events of the last thirty years, which is a period that has seen the strengthening of conservation law and philosophy, and a growing awareness of the importance of all of our building stock. There have been success stories, but there have been a lot of horrors too. My mother has good memories of Dysart, but as far as I know has never been back, and has therefore never seen the reconstruction of Pan Ha carried out by the National Trust for Scotland in 1968, while there are now reservations about this early work, I am sure she would approve. Neither will she have seen the changes modern architecture, and methods of building - a break with centuries of tradition, made to the town, which is probably just as well.

During this period, there has been a huge decline in skills and the use of local materials which is our tradition. I doubt that you will now find many tradesmen prepared to point to their work as my grandfather did, and I do not think there are any granite yards left in Aberdeen. Consumerism and mass production has ruled, to the extent that by now so much has been let go, that a large measure of academic and practical research has become necessary, to relearn our traditional techniques. I am amazed at how much I have learned during the time of our slate research. This in itself is revealing, why is it proving so complicated, why can't we simply pick up where our forefathers left off. It is because, tradition is a complicated subject, its one of those words we use a lot, without thinking hard enough about what it means. Skill and craft, often used in the same context are two others.

Can it really be that difficult to understand our buildings, to establish what they were made of, how they were assembled, what they were constructed to do, to understand in effect what is traditional? The answer is, that of course it is, and it is perfectly reasonable that it should be so. From the early years of civilisation, through to quite a large part of this century, a great number of our buildings have been constructed in locally available materials, often without input from people with any form of professional training. Methods of building steadily improved, with knowledge being handed down, and for those undertaking the work, that's the way things were, they probably did not recognise just how intricate and ingenious methods of construction had become and now, the logic behind the use of any particular material can be very difficult for us to comprehend. We have the full range of building materials at our disposal - the traditional materials that is - stone, earth and clay, minerals, vegetation and timber. While we could add some animal parts or products, we are basically talking about what grows or can be quarried. These are available to a greater or lesser extent, the world over. But different conditions exist to determine how they are used, and in what combination, whether structural or non-structural. These conditions are not just geographical, although certainly in the early years climate and geology would be most significant, they are also historical, technical, and social and economic too.

If we can consider for a moment the area in which I have lived and worked. It is relatively small, about one half of one side of the country, and think of the range of materials this produces. Sandstone is the predominant building stone, and occurs in a variety of colours from buffs and browns in the Lothians, to Fife and Tayside where it seems to become redder. We have outcrops of the very best silecious sandstones, most notably perhaps the "silverstones" which come from Fife. Lothian stone can be exellent, Tayside is not so good, and then it becomes excellent again as you reach Moray. Some of the stones can be used as freestones, some, most notably in Angus are equally hard but can be split very easily on the bed and can be used for roofing and paving. The north east is noted for its granite, grey around Aberdeen, often becoming redder as you reach Speyside. There are outcrops of other rock including whinstone and limestone. Aberfeldy and much of Breadalbane is built in chlorite schist quarried in the hills above the town, some of which was transported down on blondins. True slate is available in quality and quantity along the highland boundary fault, and up to the 1860's was also quarried in the north east of Scotland. A volcanic schist is available there which splits to provide a beautiful brown, silvery but heavy roofing slate.

Earth is accessible everywhere, and its use for building was common. Good clay is probably far more widespread than people think, and we are only now beginning to realise how extensively it was used. Its availability also accounts for the presence of brick - far more common than people suppose - mainly in the carse and at Montrose, and the pantiles in Fife and East

Lothian. A range of vegetation, reeds, straw and heather were available for thatching and timber, oak, ash, birch, elm etc appears to have been available in quantity at least until the late middle ages. (Fig 2).

Figure 2: The Old Schoolhouse, Cottown, Carse of Gowrie. newly restored clay wall and reed thatch

Initially the only choice was to build with what was available locally, but eventually patterns of distribution of materials built up fuelled by industry, agriculture, fishing and trade. Mining in The Lothians and South Fife bought wealth to a few and a primitive urbanism to many. Agricultural wealth also paid for new settlements, representing a move from buildings with limited life to more permanent structures, and improved estates, which bought a rush of new building types often in an "estate style". A township on Speyside looks quite different from an Angus township which in turn looks quite different from one in Fife. And on top of all of this there is topography and climate. High hills, exposed hillsides, valleys and coastal plains, marsh, fertile soil and rock outcrop, are all built on, and all are subject to varying degrees of exposure, most of which could be described as ferocious.

I could go on, but clearly, however you approach the matter of what is available locally to build with and the factors which evolve to influence the combinations which are available one point quickly emerges, the sheer complexity of it all, due in no short measure to the diversity which exists even in this relatively small area. Expand this outwards to embrace the whole country and it becomes quite incredible. Think of the difference between Highland and Lowland which is not just climatic and geographic, but cultural too. Dr Johnstone undertook his tour of the Highlands to "contemplate a system of life almost totally different from that we had been accustomed to". Think also of the east west divide, which is not just confined to Edinburgh and Glasgow. Sandy Fenton has suggested seven or eight different ethnological regions of Scotland which he identifies through a number of criteria including building, dialect and language. Robert Naismith identifies twelve character zones on mainland Scotland, based on differences that occur in rural buildings. How many more zones would he have included if his study had also covered urban areas. It seems that we have a divergence of opinion on just how diverse we are! This is an important issue which deserves to be taken more seriously. Many local authorities issue guidelines recognising local traditions but nowadays, their boundaries probably bear little resemblance to the extent of those traditions.

R. W. Brunskill in "Traditional Buildings in Britain" recognises only three different areas, the southern uplands, the central lowlands and the highlands. He is in effect seeing us as a country of stone, which is a common but not entirely correct assumption.

Stone is however for the most part what you see, and it has shaped our building and influenced our architecture for centuries. It can be manipulated and used in a variety of ways, all of which require skill and awareness of the properties of the material. Nationally, all of the different geological types are represented, and there many variations in their characteristics. Sandstone predominates and the range is immense. The building quality, which depends mainly on the material cementing the sand particles together, and the depth of bed, can be very bad or very good, and all have been used. We can think instantly of the red stone of the south west which produces fine blocks, and the dark grey stone of Caithness which splits easily into large flat sheets. There is a great deal in between.

We have a tendency to broadly categorise our stonework as being either rubble or dressed which includes ashlar. Rubble, I find a rather derogatory term, it suggests a sort of collapsing into place. Random conveys the impression of something being done without aim or purpose! Many differences in construction and detail have been produced through the ages. We have evidence of complex structures dating back over 5000 years. The freely available flat stones of the north allowed sophisticated corbelling techniques to be developed. Because of the slight batter of most early walls, we have assumed that a dry stone build was used. In most areas flat stone was not available, and the skill of using irregular shapes, ranging from round to almost square to produce stable structures became commonplace. While at times they can be difficult to detect, the masons worked to levelled courses, producing the horizontal appearance for which much of our building is noted. The horizontal is of course, countered by the vertical emphasis of the openings, which were limited in width by the stones used as lintels and the need to keep out weather.

As mortar technology evolved, masons once more built upwards in the interests of defence, with towers and tight easily defended stairs, using, in the absence of long timbers, vaults and relieving arches to give these early structures a massive stability. Often buildings could be enriched by decoration, a tradition dating at least from the wonderful stonecarving legacy of the picts. The interaction of the stones and the mortars, and the stresses within the structures were clearly understood. As Alistair Urquhart has demonstrated, many of our most important earlier structures did not use quarried material. Before quarrying techniques improved, material was made available from convenient outcrops or spots usually close to water where transport was available. The centre block of the school I mentioned, Gordon's College designed by William Adam in 1731, was built in granite from a local source, probably a small outcrop rather than a quarry, in nearby Rosemount. (Fig 3). Once good reliable stone in quantity appeared, building came to embody what is usually referred to as the little and the great tradition, the local or vernacular cultures and the "polite" architecture of greater civilisation of which they are a part. In point of fact, many of our very early buildings had proper design from architect masons, but there can also be little doubt that these men and the great architects who followed were a product of local techniques, William Adam, Gibbs, Colen Campbell, Chambers and Bruce, whose buildings were international. The front elevations of the New Town of Edinburgh are in expensive dressed stone, all of which is correctly used. The buildings exhibit the influence of international knowledge, but look to the rear and we find rubble, tight stairtowers and where necessary the relieving arch of a more local tradition. We would also be looking at buildings that work structurally, are hundreds of years old, and exhibit little signs of distress. The details on these buildings shed water, the wall construction, steadily getting thinner but of inner and outer leaf - traceable back to the brochs - core material, mortar and bonding stones, all work together. This is tradition.

Figure 3: Robert Gordon's Hospital, now College, begun by William Adam, 1731

While stone is our main building material, it is not the only one. I have mentioned the use of mortar in which I should also include plasters. The majority of building mortars require lime, and limestone is widespread. While production of mortar was essentially local, which meant that numerous different types were used, it was also available in quantity from Charleston from the mid 1700's through until the 1930's. Whatever the source, the mortar used was always softer than the stone it bonded or protected. I have also referred to clay and the fact that its use was far more common than most people imagined, as a mortar on its own or guaged with lime, as a plaster, and in different types of claywall. It was once common in the Carse of Gowrie where the shuttering skills that were necessary were used in early concrete construction, first in strip foundations, and then whole buildings. It was also used extensively in the north east, and probably in many other areas too. There is a need to examine its occurrence in more detail. In addition, the use of puddled clay as a waterproofing membrane has not, as far as I am aware, been properly studied.

Brick has been with us far longer than most would imagine. There are good examples of early buildings in The Carse and Montrose, whose thick solid walls and the use of relieving arches, mimic stone construction. There were any number of local brickworks, John Dunbar has estimated that in 1840, there were about 48 million bricks produced. While I confess to being surprised, in Dundee alone, there was a great deal of industrial building taking place around this time. Pantiles seemed to arrive in Fife and the Lothians in the early 1700's. William Adam was one of the manufacturers, but I have seen them throughout Scotland including on tenement roofs in Dundee, and there is a need to examine their occurrence and historic use. Dunbar mentions that in 1611 a licence was sought for manufacture of "good and sufficient tyill for building and sclaitting of housis".

What of earth? There are numerous descriptions of earth or turf "huts", from Dr Johnstone through to the early statistical accounts. The techniques of turf construction have been lost but are being relearned at Turis Tim the ambitious museum of Highland Life Project at Newtonmore. Here we can see cruck frames being erected and clad in turf reinforced with wattle. This, erecting a frame and then cladding it is one of the two methods of building used worldwide, and until the establishment of the early iron framed industrial buildings, seemed to have no particular place in the Scottish tradition. How we have used timber is I think something of a mystery, which is ironic, because archaeology can demonstrate that some 3500 BC, timber was being used to construct large rectangular halls far in advance of techniques being used elsewhere in Europe. We can see evidence of timber construction in many of our burghs, but I do not think we really know how much was primary structure or how much was superstructure. From the mid 1600's there was a move away from the tradition of timber and thatch to the use of stone and slate. Few roofs survive from this period and oak in our buildings is practically non existent.

Tayside Building Preservation Trust is working towards restoring Gardyne's Land in Dundee, a complex of three buildings, grouped around a small courtyard, the earliest dating from 1560. There are doors, now half blocked to form windows leading into the courtyard at second floor level. Perhaps the courtyard is in fact, the outer walls of a building, or perhaps these doors lead onto timber walkways. Despite a very comprehensive feasibility study, we still do not know. One of the other buildings on the site has a remarkable internal timber frame. Only one solid upright remains, but looking at it, I cannot personally accept that it is an isolated example, I believe it belongs to a tradition of timber construction, but would concede the town had a shipbuilding and trading tradition and it may therefore, be an exception. (Fig 4). This building also has a steeply pitched roof of massive timbers, with a wonderful sequence of assembly marks, which clearly was originally an ashlar post construction. I have recently been surveying a building in Brechin for the Trust which has an ashlar post roof still remarkably complete, my guess is that it dates from the late 1600's and I wonder just how many we might find if a comprehensive study was mounted.

Figure 4: Vertical timber support, Gardyne's Land, High Street, Dundee

The roof in Brechin is a far more subtle construction than it may first appear. Single collars are at high level. This saves long span timber and allows head room. The ashlar posts arrest the thrust from the foot of the rafters, preventing them spreading outwards under the weight of what were probably stone slates. (Fig 5) Walls of the time were thick enough to allow this. The rafters are slightly concave a sign that they have settled. I am certain they were used while still green so that the slight bowing that would occur, would encourage the stone slates to bed together to form a more watertight roof. The trusses are bound together by simple scarf joints, with heavy pegs, which suggests they may have been bored and drawn. This is a system which was not worked out overnight, once again, this is tradition.

Figure 5: Ashlar post roof at High Street, Brechin

Nationally, roof coverings varied, mainly they were thatch, which was available in various forms such as straw, reed, heather, even seaweed, and there is plenty of evidence of clay thatch. But better quality materials were available for the rich, lead, stone slate, and from the late 1500's, true slate. It was not until the early 1800's that the slate industry mechanised and the material became more widely used.

Slate is the material I know best. Scots slate was cut by hand, and every piece possible was utilised. This meant that an extreme range of sizes was produced. These were laid on the roof in diminishing courses on continuous roofing boards called sarking. (Fig 6). Single nailed, and shouldered they could be swung aside to expose the nailhead which makes replacement easy. Most people know this, but might fail to focus on the obvious. This is a system that worked. In a very harsh climate, with strong gusting winds, roofs remained watertight, the boarding provided insulation, and it could be easily maintained. Once again, we don't often spot all the subtleties. The use of thicker slate on wallheads so that water ran into the centre of the roof rather than down the walls for example. The way that nailholes if struck properly cause a spall in the slate which allows the nail head to be naturally countersunk. This is knowledge that is not taught as such, this sort of detailing is the bastion of the skilled craftsman, who earns his skill by virtue of a long tradition. The slater could be proud of his trade and sometimes it showed. General Wharburton, a welsh quarry owner gave ladies titles to the different sized slates, and a slater could boast more with pride than humour, that he had laid 250 countesses that afternoon.

Figure 6: Scots slate laid to diminishing courses

So far I have not mentioned metalwork, by which I suppose I mean iron, wrought and cast. Yetts, these wonderful through and through constructions can be dated back to the 1400's. Blast furnaces were introduced in the early 1600's after which a tradition of making full use of the material evolved, and Scotland became home to some of the great foundries. Iron was used decoratively in polite architecture, and structurally, in bridges and buildings. We have one of the worlds earliest iron bridges spanning the Dighty at Linlathen near Dundee, and in Thomas Telfords bridge on the Spey at Craigellachie of 1814, one of the most picturesque. (Fig 7). Telford's early training was as a mason. Our iron framed buildings, of which many of the Dundee mills provide good examples, are wonderful essays in something essential to our understanding of tradition, the matter of materials working together. The iron frame contains brick arches, the bricks probably come from the Carse, which supports stone flags, probably from Angus, possibly from Caithness. The iron frame prevents the brick arch from spreading, the weight of the slabs holds everything down. They also support any weight of machinery, and do not burn which was of some comfort to the occupants. The stone cladding is both robust and decorative. Cast iron was replaced by mild steel which is easier to produce, but is not so durable. But cast iron is coming back into fashion as a structural material, due in part to the development of SG (spheroidal graphite) malleable cast iron, which has flexibility and tensile strength, and functions more or less like wrought iron. This development, I see as tradition.

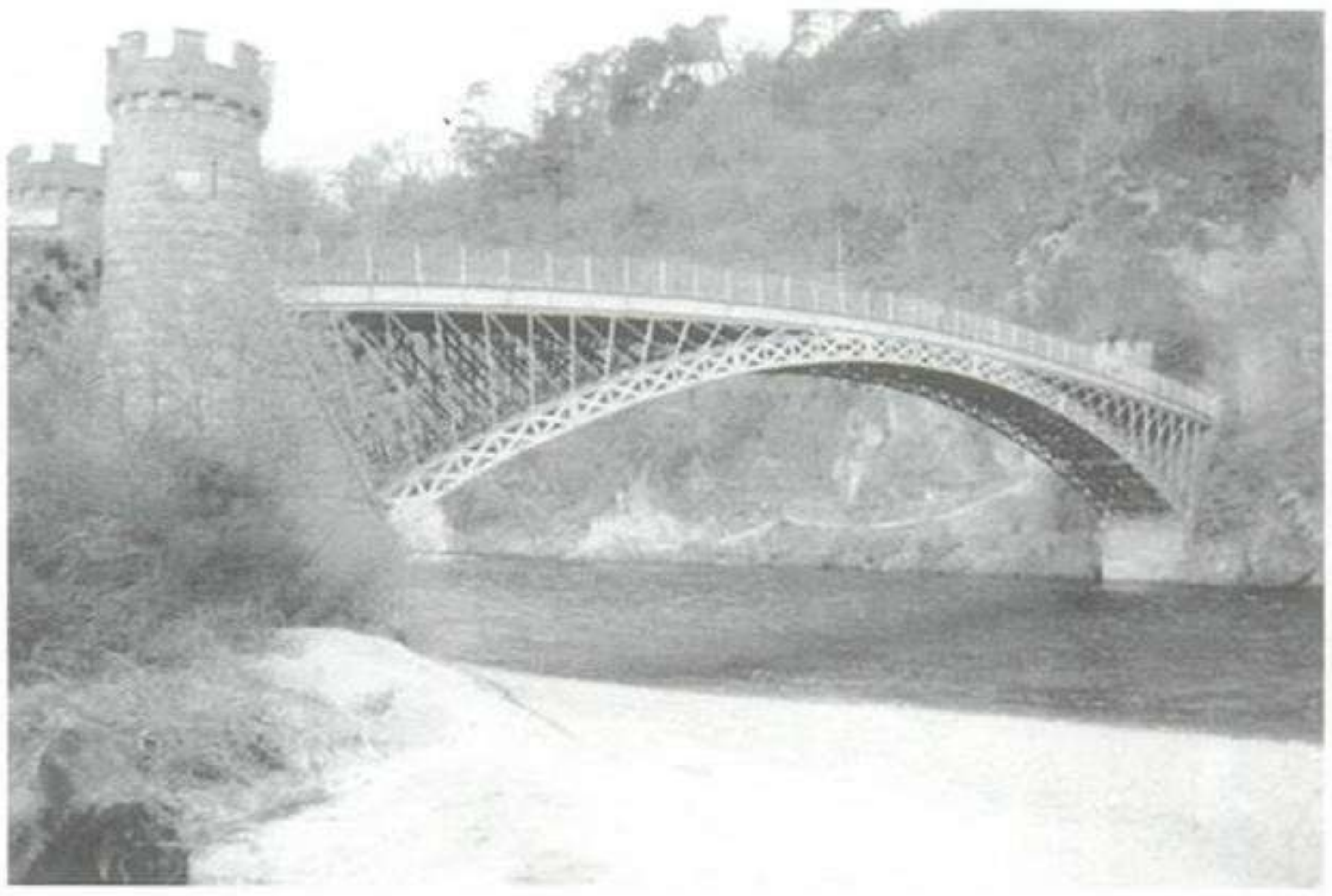


Figure 7: Thomas Telford's bridge on the Spey at Craigellachie, 1814

This jack arch construction is not new, we can see all of these principles embodied in our early masonry structures. Neither is the interaction of the use and the construction of a building something new. There is the example of the open hearth fire and the smoky atmosphere acting as a preservative for timber, and the heat travelling through what might be a very tousled thatch, keeping water out. Dr Johnstone while complaining of, for example, having to step from his comfortable bed with sheets of Egyptian cotton onto an earth floor, acknowledged that it was part of a system of building that in total, worked. The floors were warm and allowed moisture to dry off. Many trades had two or more skills, slating and plastering go together, which is practical and demonstrates this understanding of the interaction between different materials.

On top of the practical aspects of these combinations, think of their aesthetic qualities. Slate roof, stone facade, flagged or cobbled pavement or forecourt, setted road surface. (Fig 8). They combine wonderfully well, as does clay wall and thatch. Application of coats of limewash has a practical purpose but it can also look stunning. Quite apart from the lengths people would go to, to introduce different pigments, the double light refraction quality of calcite crystals means that it can be ever changing. Was aesthetics a consideration in deciding what size for example a granite sett should be or the size a paving slab should be cut to? I like to think it was. Robert Naismith has gone some way to demonstrating that even the crudest building was usually erected with some thought given to how it would look, and I believe this is an important aspect of tradition.

Figure 8: The City Mills, Perth. A wonderful combination of slate, sandstone and granite setts

I have been recently introduced to a wonderful book "The Old Cottages of Snowdonia" by Harold Hughes and Herbert North. They were particularly interested in the random slating still evident on cottage roofs, which they described as "having natures fingerprints still on them". Its a beautifully evocative description which I am sure we would like to apply to all of our traditional building materials. It is of course impossible. Not all of the materials I have discussed wear nature's fingerprints, and they don't need to. Tradition is about handing things down, and you don't hand things down that are not any good, neither would you wish to deny that there might be room for improvement. It's human nature to want to hand on things in a better working order than we found them - or it should be. We have been guilty of looking for universal or foreign solutions to what were essentially local or regional problems. Very few of these foreign solutions have become naturalised. Cement works well in numerous situations but the cement plaster applied to buildings in Dundee is starting to fall off all over the city because it is harder than the stone. The Trust have restored The Sea Captain's House in the centre of Dundee, and I am very pleased with what has been achieved, but the repairs to margins, cornice etc in lime seem to owe more to cement plastering techniques than anything else and I hope it lasts. We are in effect suffering here from a break in the tradition of using lime to protect our stone, and these breaks in tradition concern me.

How many of the city centre improvements of the 80's have stood the test of time, how many concrete blocks or slabs are now failing, and are no longer manufactured. We are starting to see native materials coming back onto the market, Caithness slab for example, but engineers specify not sand, but 450mm concrete as a base. Building regulations insist on expansion joints every seven metres in new walls, never mind that we can count over 650 metres of continuous building in Edinburgh's New Town, without an expansion joint in sight, and no sign of distress in the build. I am sure most of you are familiar with this last example, and can quote many of your own. We all have our opinions of UPVC windows, and I surely cannot be alone in being concerned that we are hanging large thin sheets of stone on the elevations of new buildings. The fundamental point to all of this is that I am convinced we ignore tradition at our peril, but first we must understand it.

REFERENCES

R W Brunskill (1992). Traditional Buildings of Britain, Victor Gollancz Ltd.

R W Chapman ed (1970). Johnston's Journeys to The Western Isles of Scotland and Boswell's Journal of A Tour to The Hebrides With Samuel Johnstone LLD. Oxford University Press.

John Dunbar (1966). The Historic Architecture of Scotland, Batsford.

A Fenton (1976). Scottish Country Life. Edinburgh University press.

Harold Hughs, Herbert North (1908). The Old Cottages of Snowdonia.

Charles Mckean (1994). Scottishness in Architecture - Towards A Theory of Regional Interpretation, in Cultural Tourism ed J M F ladmark, Donhead.

Robert Naismith (1985). Buildings of The Scottish Countryside, Victor Gollancz Ltd.

Anne Riches, Geoffrey Stell (1992). Materials and Traditions in Scottish Building, Essays in memory of Sonia Hackett, Alden Press, Oxford.

Alistair Urquart (1977) Apprenticeship and Practice in Stonemasonry, Dundee Conservation Lecture, 4th February.

THE SUSTAINABILITY OF TRADITIONAL MATERIALS

Howard Liddell, Principal Architect, GAIA Architects

"Everything should be made as simple as possible but not simpler"

Albert Einstein

Introduction

The territory for this paper is specific to the issue of sustainability. Preceding and later papers deal with issues of defining and describing traditional; and with information, sourcing and standards issues.

The paper sets a framework using material types and processing methods to assist in categorising and clarifying the sustainability, or otherwise, of a material. A number of tools are introduced and discussed with respect to their value in guiding specifiers.

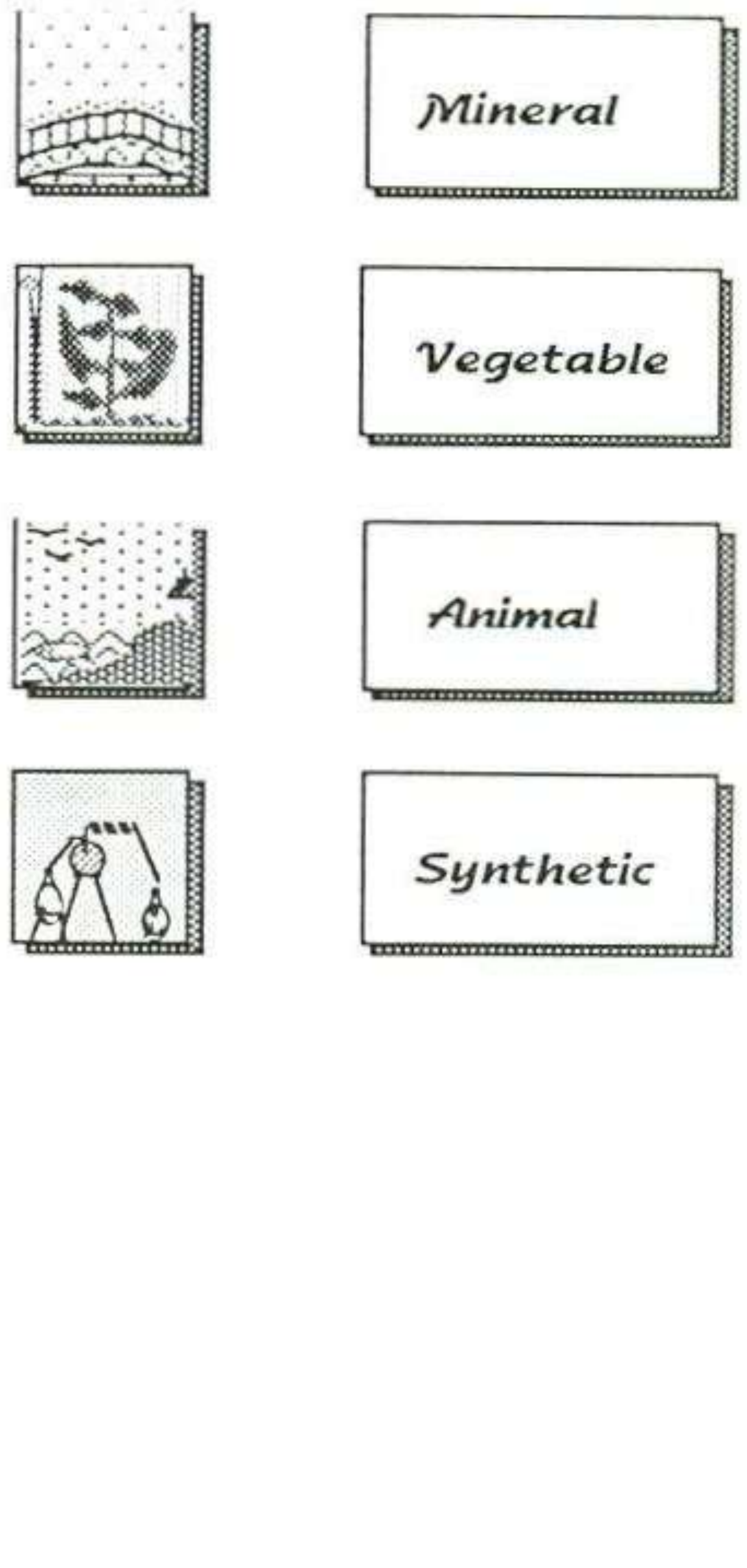
The paper concludes with some best practice examples of materials, products and buildings.

In terms of a general definition of sustainability the Brundtland definition will suffice.

That states that we should seek:- *"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs "*[1]

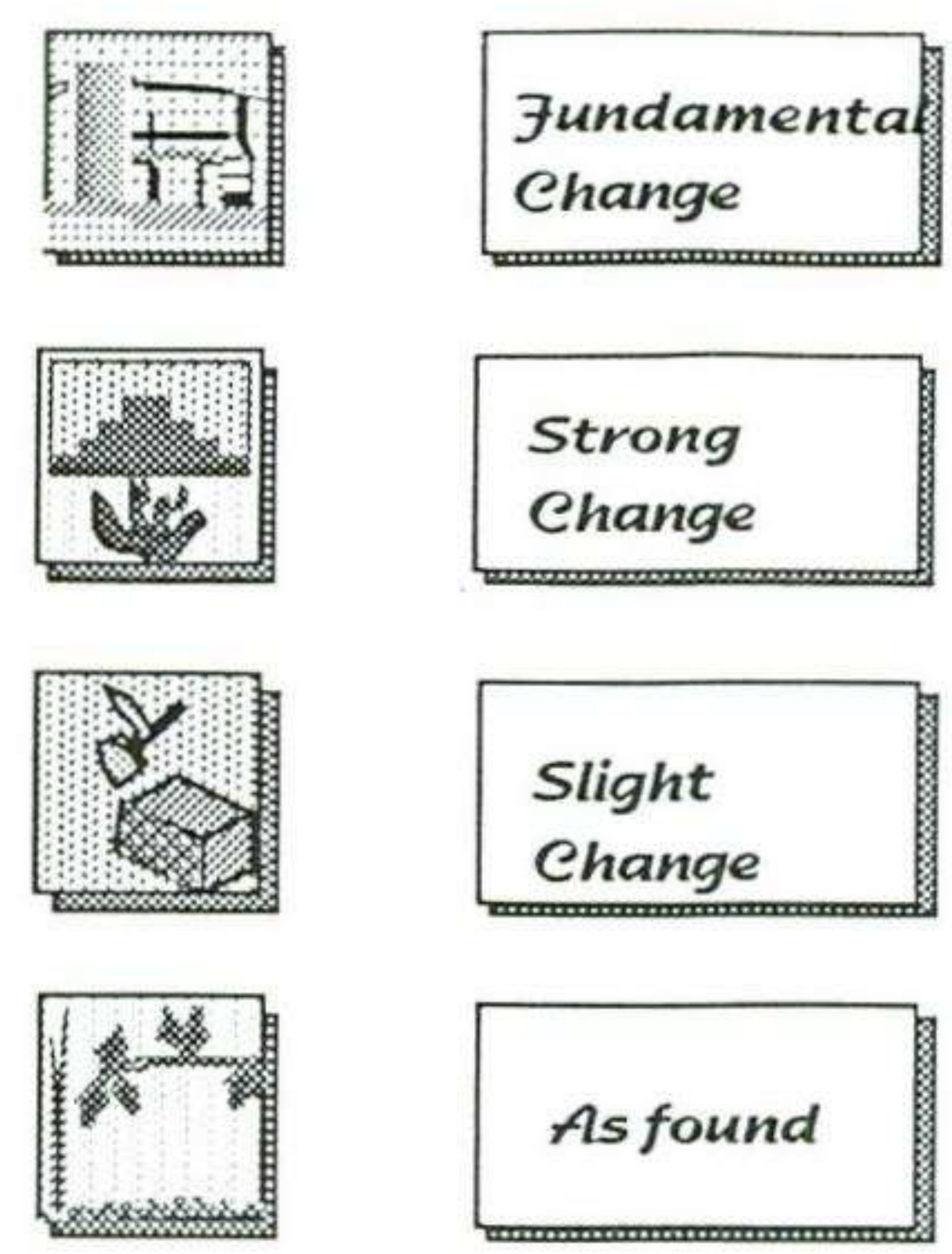
A Framework

In order to establish a framework for determining the sustainability of traditional materials it is necessary to start with some basic definitions.



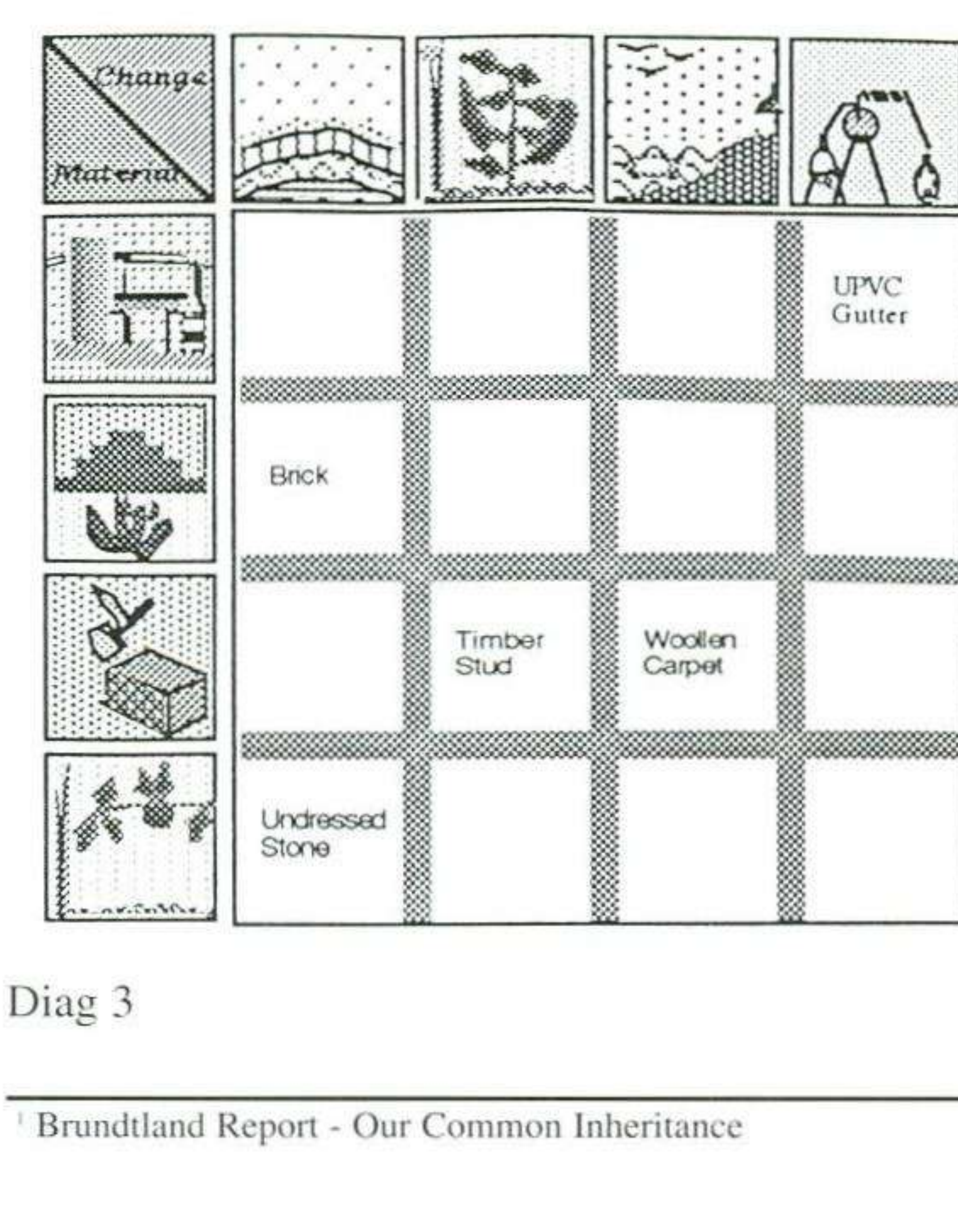
Diag 1

Materials come from a source which is either mineral, vegetable, animal or man-made. They are then used "as found", or they are transformed by mechanical means, which involves the application of energy in some form, or by chemical action, forming a new composite entity.



Diag 2

Combining these two sets of criteria creates a matrix which spans from very natural (traditional) to very unnatural (modern).



Diag 3

[1] Brundtland Report - Our Common Inheritance

As an architectural practice seeking to design in a manner which is sustainable as a general rule of thumb we operate a pre-assumption for those materials which appear at the bottom left of the matrix and against those at the top right.

Given the complexity of some of the tools under development simple rules of thumb such as the above are very valuable design tools. For pragmatic necessity and expediency we take the view - albeit not foolproof - that traditional materials are those which were ubiquitous before the invention of the steel frame building, one hundred years ago.

Life Cycle Analysis

There is a rapidly expanding new profession of people involved in Life Cycle Analysis (LCA).

This approach to the assessment of buildings and building products seeks to evaluate the environmental impact of design and construction from the cradle to the grave through the perspective of a whole range of criteria which reflect aspects of environmental concern. Within this new profession there is a fairly heated and lengthy ongoing debate into the validity, method, purpose, and applicability of the various different approaches. Very few of these approaches are as yet sufficiently mature or user-friendly to be of significant value to the practising architect. Fewer still have broached the level of complexity necessary for the life cycle analysis of a building. Most would be incapable of operating at the level of sophistication of most modern buildings. An architect may already make around twelve thousand decisions in the average project, and lengthy research is an expensive luxury, rarely reflected in the fee structure, and equally rarely undertaken.

Most architectural decisions involve products rather than materials. Products usually incorporate a whole range of contents each of which has its own profile of environmental impacts. This is the reason that life cycle analysis gets so complicated. If every product is to be vetted then it rapidly becomes a specifier's nightmare. However it is precisely this which we have to address. The complexity of the way in which modern building products are manufactured and assembled means that we have to be able to unstitch the sequence of operations from cradle to grave in order to be able to establish an environmental impact profile.

However there are systems that show promise and the more simple the output (albeit from a very sophisticated input) the more it will be used.

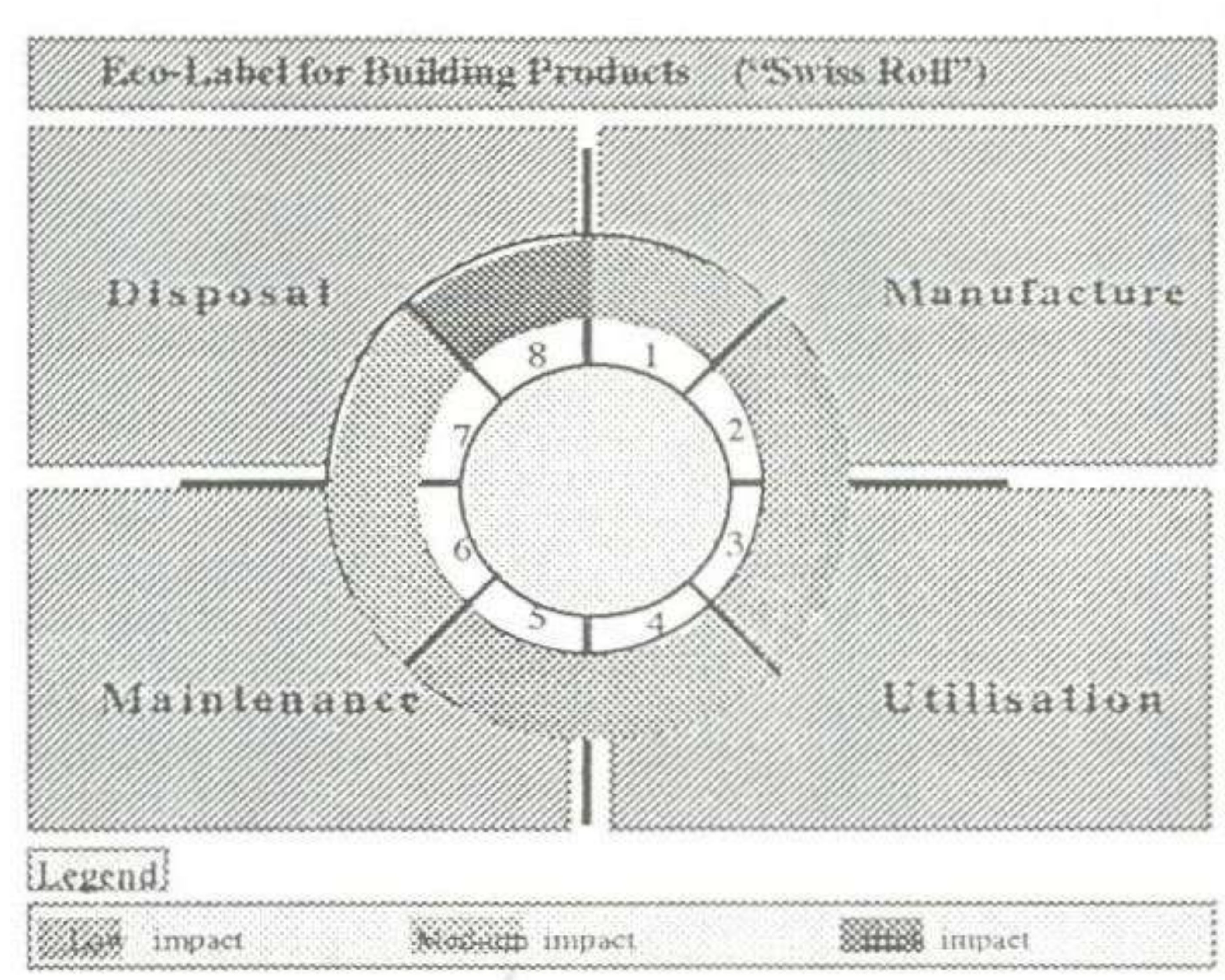
The Swiss Roll

One LCA system, that is being developed by SEDA (the Scottish Ecological Design Association) has been imported from Switzerland, where the tradition of Baubiologie - and materials vetting - has been in existence for nearly 40 years. The system is currently being evolved on a Scottish Bio-regional basis, which is significant for an ecological approach, where geographical and cultural context matter.

The following list identifies the main criteria applied to materials when they are being vetted for their environmental impact by the SIB (Swiss Institute of Baubiologie):-

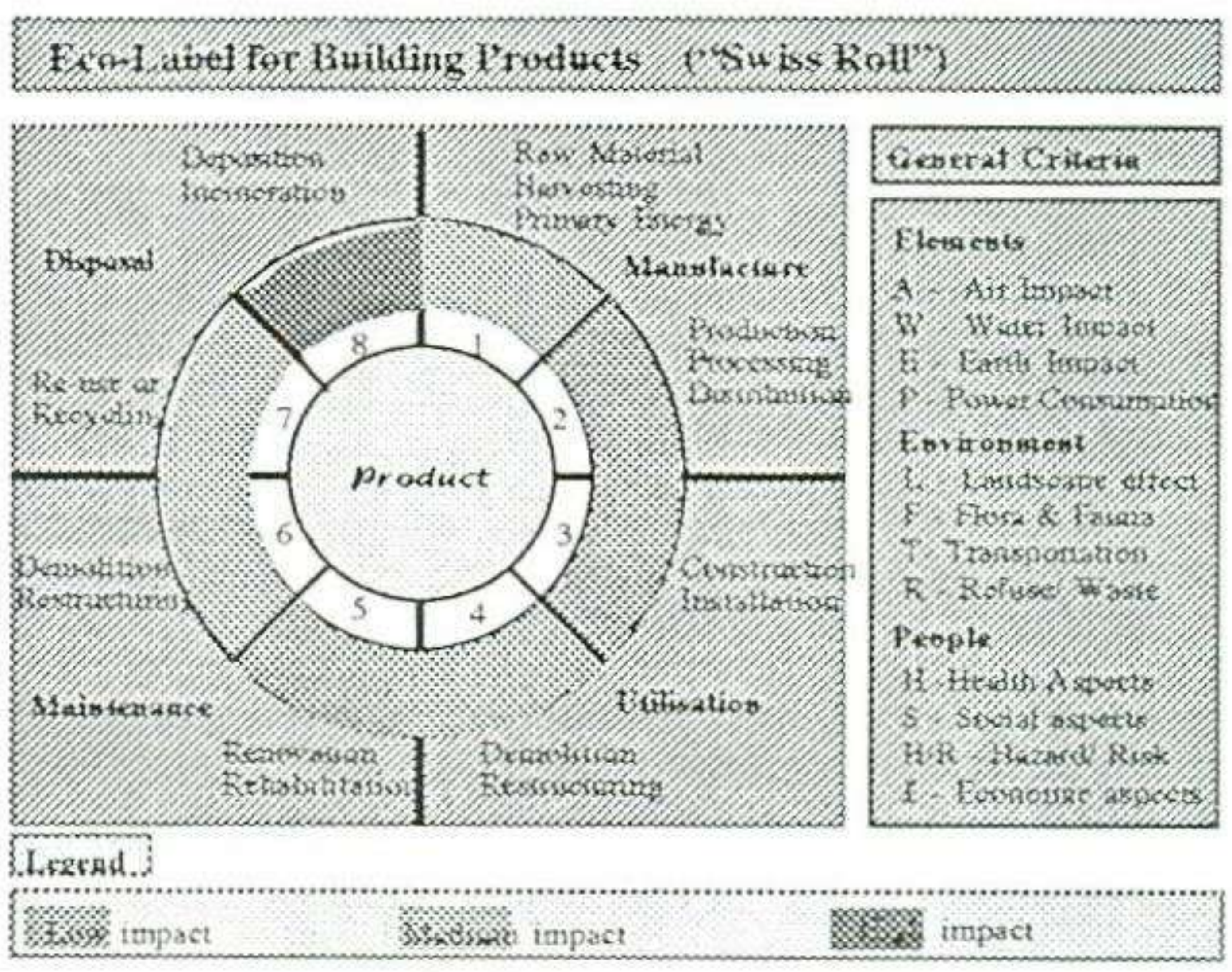
Earth, air and water impacts and the effect on landscape, flora & fauna; power consumption and transportation, human health, hazard and risk aspects; refuse and waste stream issues and social and economic aspects.

It will be appreciated that some of these criteria such as power consumption (embodied energy), radiation risk, etc can be accurately measured within certain defined constraints, whereas others such as economics, social equity etc are more subjective. What is absolutely crucial in such circumstances is not to limit the assessment to the objectively measurable at the expense of the subjective. It is important also to respect the precautionary principle - ie something is assumed to be a risk rather then a boon until evidence indicates otherwise.



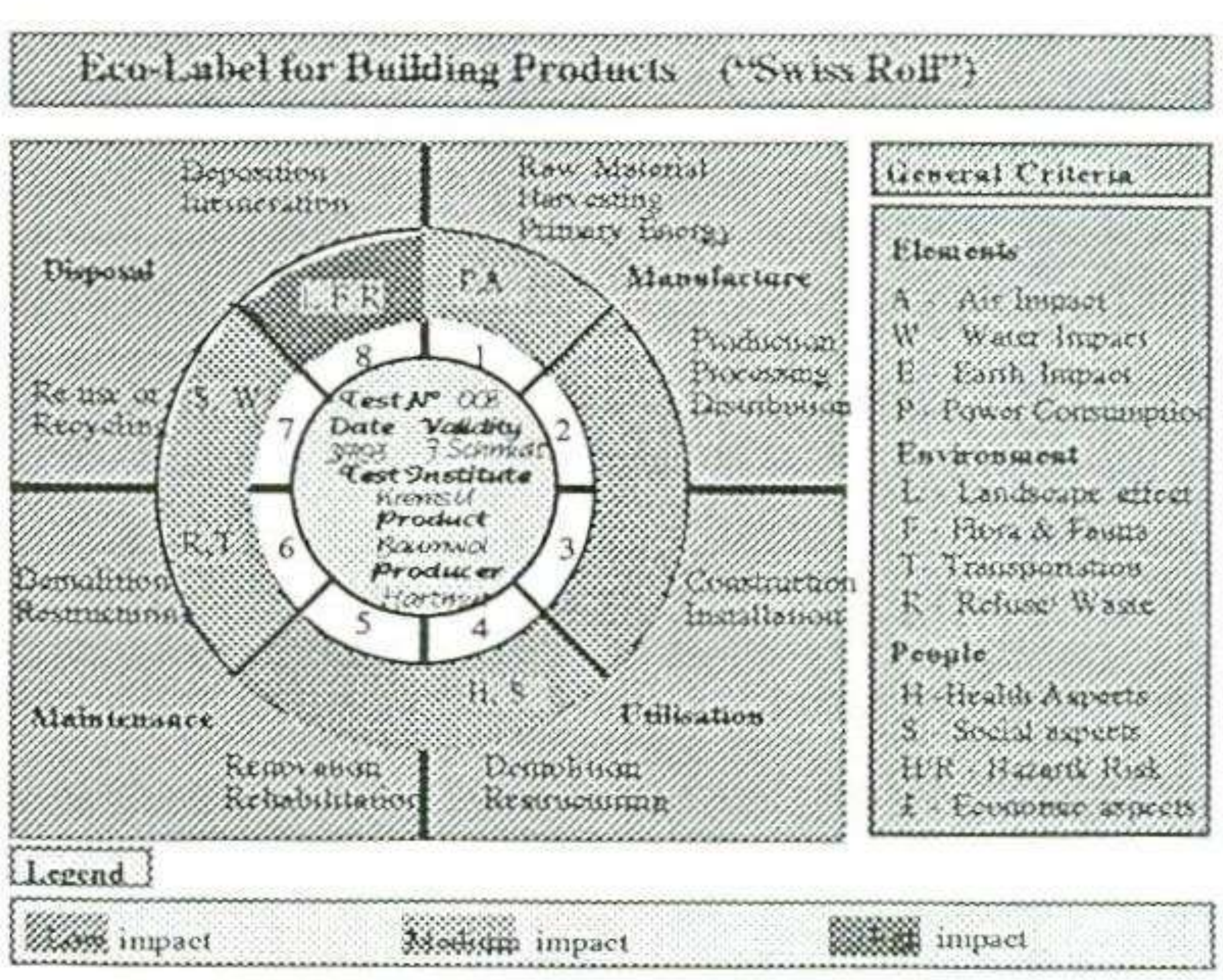
Diag 4

Diagram 4 shows the basis of the so-called "Swiss Roll" the Life cycle of a material is traced from the cradle to the grave. There are 4 major quadrants - each divided into two subsections.



Diag 5

The eight stages of the life cycle are each in turn looked at from all the twelve different criteria which are being considered as relevant in creating an eco-profile of any material.



Diag 6

Red, amber and green - are used as an effective method of giving an instantly legible view of where a material excels, passes or fails - but overlaid on this are the initials of the critical aspects in determining the weaknesses shown up by the assessment procedure.

It is of course important in such systems that they are supported by expertise that can command the respect of the green building product specifier. For instance in the well-informed, middle European context served by the SIB label described above, it tends to be university departments with the appropriate expertise relative to the material in question. The Chemistry department of Krems University is often employed by the SIB to undertake the key parts of the environmental impact investigation. This will cost the manufacturer approximately £5000 for the first assessment, which indicates where improvements can occur, and the same amount for the second, which is to establish whether the revised product has resolved successfully the problems identified.

Such labels are a significant marketing advantage to companies who can then put an SIB label on their product and valued more than the EU Eco-label, which deals with only 6 criteria and does so with a lot less rigour.

The Egon Ronay Principle

It would perhaps be useful to introduce, at this stage, what I term the Egon Ronay principle of assessment.

Travellers do not expect Egon Ronay to judge his epicurean experiences by using a scientifically verifiable checklist. Rather they trust his years of experience, an educated palate and good judgment. Since materials selection by specifiers is usually a matter of individual choice and taste then assessment methods for these should also reflect the very nature of the context within which those choices are made.

In our practice we find there to be a lack of hard information, or indeed where information is available we find it to be of limited value. We therefore have to make specification judgments based on experience. If I am really pushed, I tend to fax Bjørn Berge my Norwegian colleague and one of Europe's most respected experts on the environmental soundness of materials. I always get a fax by return, with at least one side of A4 giving me his expert opinion of the material. He is my Egon Ronay equivalent, the ultimate arbiter within our internal vetting system, - and he saves me hours of library work.

The choice therefore lies between a system which is constantly challenged for its status, accuracy and relevance and on occasions whether its findings will stand up in court, - or the confidential view of an expert, who does not have to couch every word in legalistic jargon, but is allowed to give subjective judgment and a rounded view, as someone who understands the whole range of environmental issues? As environmental assessment starts to come to the fore, and begins to edge into the CDM Regulations, which deal with Health and Safety issues in buildings, we shall need to beware of the supremacy of the measurable to the detriment of the valuable.

It would surely be more effective - and more quickly - to have a simple mandatory manufacturers' labelling system, than to pursue a voluntary (and little-used) eco-labelling mechanism. The former requires merely the legal framework to require manufacturers to display the contents of their products - as with food. The latter requires an assessment system, vetting methods and policing, and this is where such systems not only cost more money but tend to fail. At the end of the day who assesses the assessors?

To give an example:-

My acquaintance David Norman, the co-founder with David Bellamy of the Scottish Hardwoods Charter, has recently returned from the Far East and confirms the reports I heard a couple of years ago, that the sustainable forestry being claimed by most of these countries does not bear scrutiny. With biodiverse-rich forest being bulldozed and replaced with fist fulls of monocultural species - most of which wither and die in the first few days after planting - sustainable forestry this is not. Effective policing of a charter such as this is the key, and resourcing this to the requisite levels would be virtually impossible.

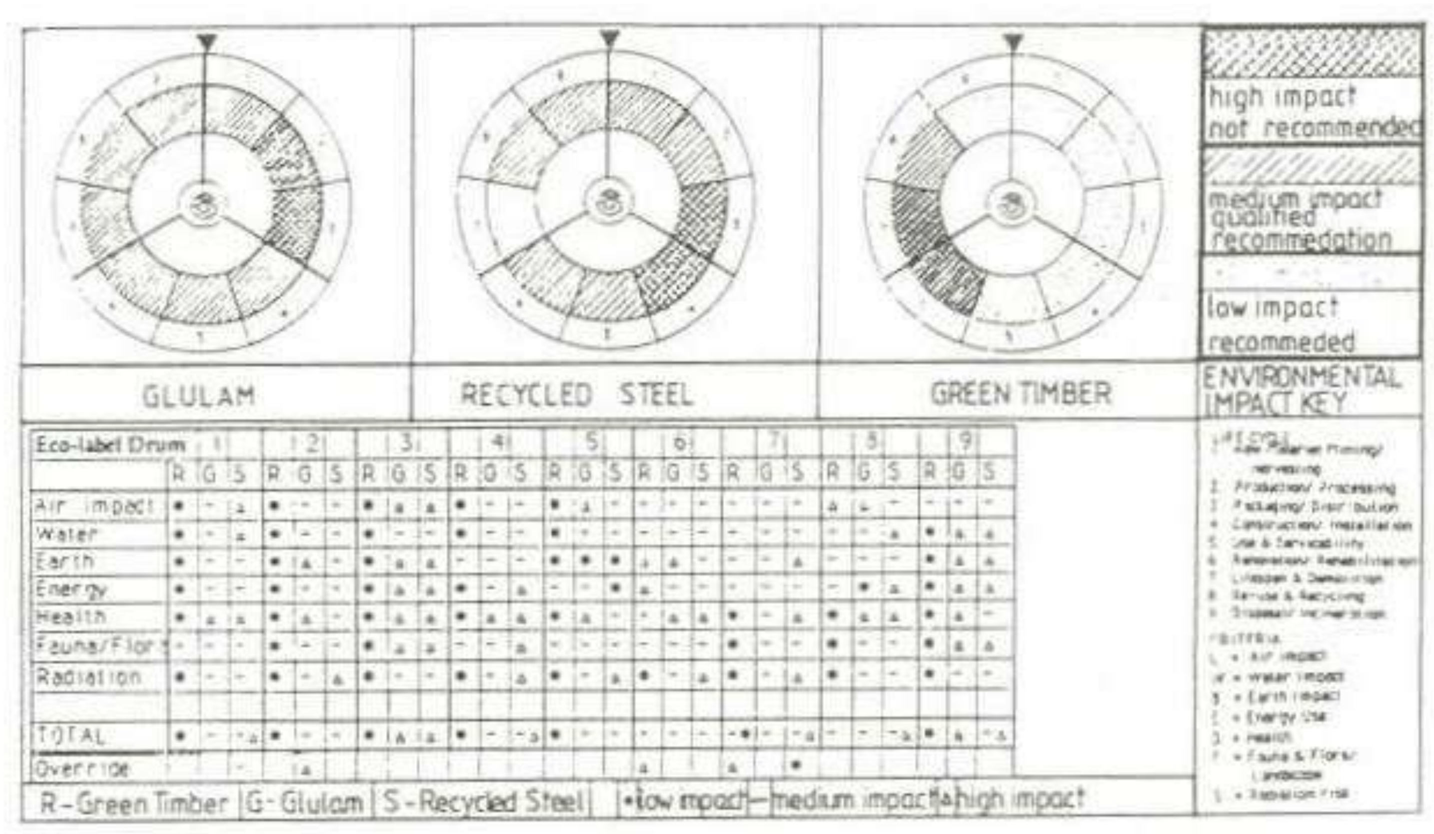
Products

Thus far I have talked about materials rather than products - however it has to be said that the Swiss roll system does assess products - made up from a number of different materials, and therefore the complexity is increased for every additional material used to make up a composite product

Let us take a perfectly simple element such as a window, for example:-

A traditional window will have wood as a frame (maybe from two sources:- softwood for mullions and hardwood for cills) these will then be glued and screwed - then there are the other metal elements - possibly even an alloy such as brass which makes up the hinges and the fixing screws which may be from the same alloy but arrived at via a different route. Then there would be putty with all its constituent parts, Linseed, chalk etc. Then the Glass - with all the potential choices thereby, and finally the various treatment options from paints and stains to chemical pre-impregnation. And this is the environmentally friendly option - I leave it to the audience's imagination how an eco-profile for a double-glazed, argon- sealed, neoprene gasketed, UPVC Window will take you round the globe - and it does not all make for a very pleasant picture at a number of junctures in its journey to a building and beyond.

When we were investigating the options for the Drumchapel Ecological Sports and Environment Centre we looked at roundpole timber, Glulam and recycled steel, and it was by no means a clear cut case for round pole. The most interesting outcome of our small amounts of research was that the British Standard on Glulams has only three options for structurally acceptable glues - and all are phenol-formaldehyde based. It was also very difficult to be able to obtain timber which had not been CCA treated - therefore on two accounts this was not the natural environmentally sound choice.



Diag 7

Diagram 7 shows roughly what we came up with when we did a simple eco-profile based on limited and subjective judgment - indeed what else can specifiers do faced with a lack of absolute information, or the resources to look behind every choice. Will there ever be enough accurate and ratifiable information? I doubt it.

Materials and Pollution

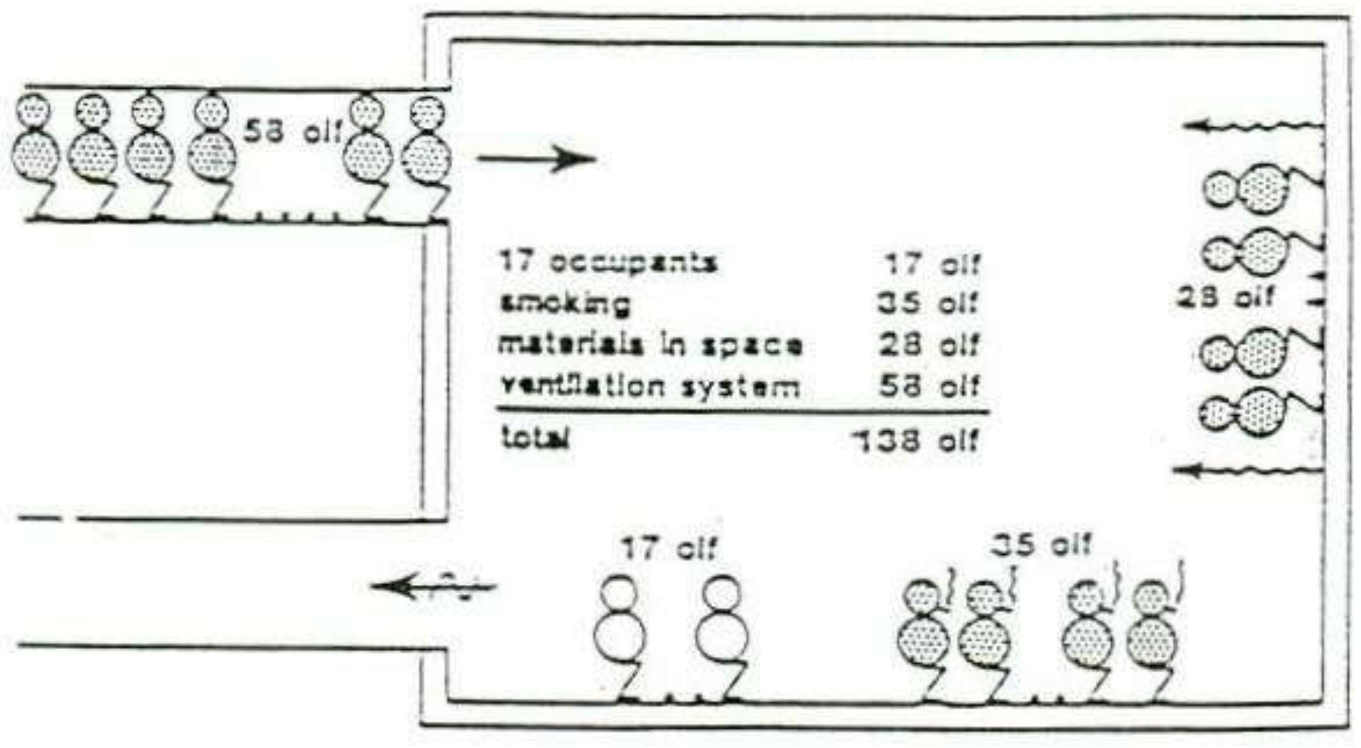
One of the most radical approaches to combating the problem of polluting products is that being proposed by the Natural Step Programme in Sweden. This is proposing - and indeed has costed to a high level of credibility - that all forms of taxation can be abolished if a single tax on the wastestream was effectively implemented, such that every product should be returned at the end of its useful life to its original constituent parts. The tax would be in direct proportion to the difficulty of this being achieved. Of course in the case of alloys, plastics, etc this is a non-reversible circumstance. What a challenge for these industries.

The situation is perhaps best encapsulated in Paul Hawken's radical question "What will eat your building?' He maintains that if you don't know what will eventually absorb your creations benignly then you should redesign them until you do.

It is also in Scandinavia that a one to one relationship between plastics and indoor toxicity levels has been established[2] . This is the tip of an iceberg, which was identified as long ago as the 1960's by Baubiologists monitoring offices and the amount of particulate matter in the air in offices over a twenty year period - where a one hundred fold increase from single figures to literally hundreds of trace elements of materials were measured in the indoor climate at levels in excess of the WHO permissible levels (in terms of Parts per million in the atmosphere). This is not just an issue of individual particles being just over the limit - each one of which may individually not represent a serious hazard on its own - it is the unknown cocktail effect of a combination of elements whose chemical permutations run into billions. The specification of one material over another by an architect can actually condemn a building user to health responses ranging from a runny nose or dry throat through to asthma of various degrees of seriousness and even carcinogenic triggers.

" In 1971 the state laboratory for the control and inspection of foodstuffs in Geneva was given a new, state of the art building with all the latest in sophisticated technical installations. After occupation all the food tests started to register excessive toxicity levels. When control measures were made back in the previous building the toxicity levels were found to be 'back to normal'. Ultimately it was discovered that the 'high-tech' materials in the new building were the cause of the high toxicity levels in the foodstuffs, and that it was occurring after only a short storage time in the building. Toxic emissions were found to be leaking from paints, plastic materials, varnishes, flooring and furniture and were poisoning both the room air and the foodstuffs waiting to be tested. The scandal was soon forgotten. There was no change in the building regulations or the standards for approving building materials."Hubert Palm, Geneva, 1974.[3]

The contribution of building materials to indoor climatic pollution has now been well documented by Fanger in Denmark[4] whose seminal study of 14 offices in Copenhagen has led to the quantification of the extent to which modern building methods contribute to new forms of indoor-induced, ill health. All of this was caused through good intentions - in seeking to stem the previous generation of health problems, emanating from damp and poorly heated structures. What Fanger has identified are the various sources of indoor pollution. Given that mechanical ventilation was introduced to get rid of body odour (CO2, sweat, etc) and the pollution from people in a sealed environment, it maybe comes as a surprise to discover that the very means of getting rid of the pollution is in fact one of the prime contributors to it.



Average pollution sources in 15 offices in Copenhagen.

Diag 8

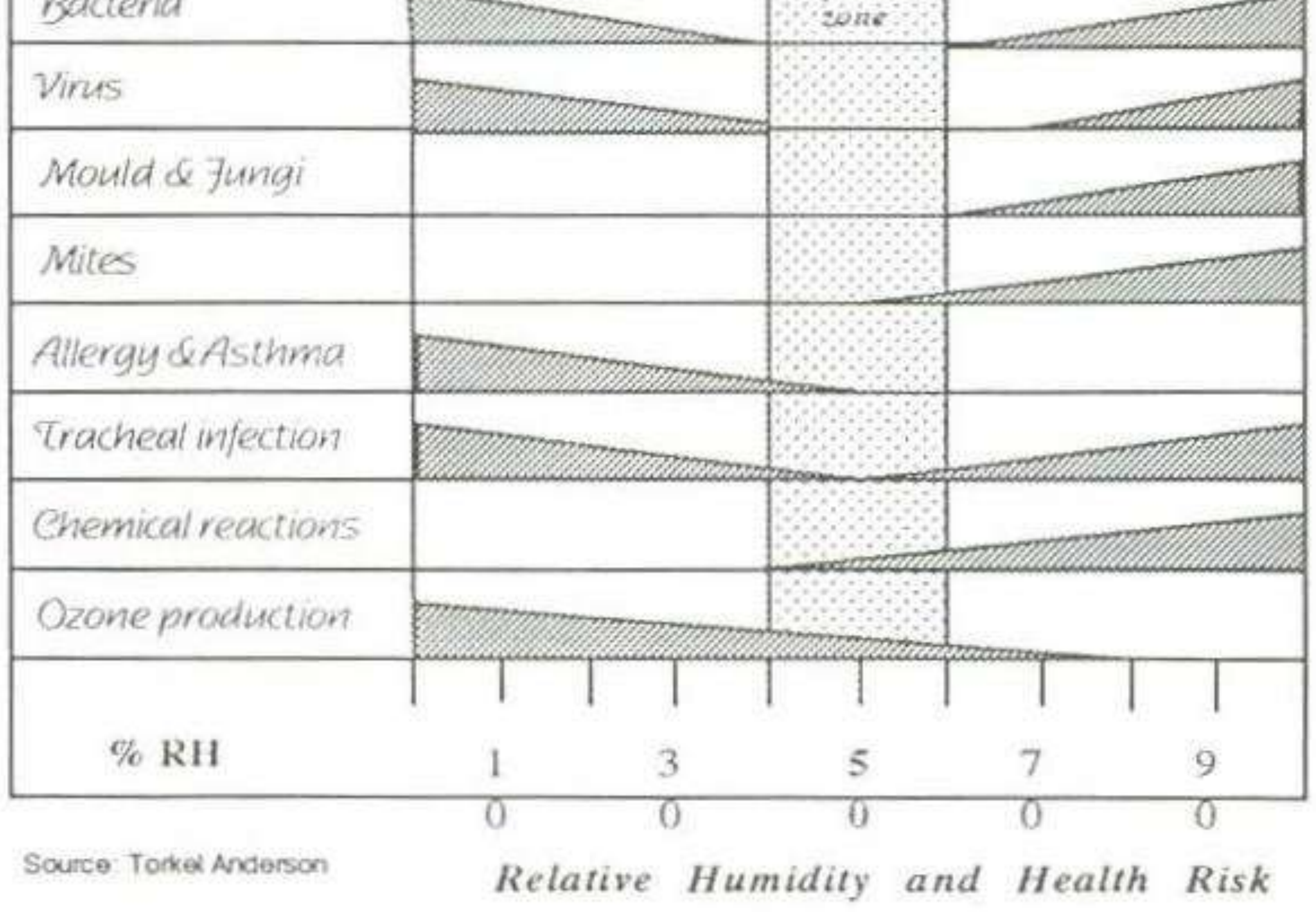
Diagram 8 shows that the amount of pollution coming from people is the lowest factor of all with the building materials contributing an amount not far short of that made by smokers. But it is most alarming to note that the biggest single problem comes from the ducts (which rarely, if ever, get cleaned) that are supposed to introduce the so-called fresh air into buildings. It is all part of a "fit and forget" approach to building procurement - every one in pursuit of the goal of maintenance free. Unfortunately maintenance-free too often means unmaintainable.

"Natural" Construction Methods

It is because of findings such as this that there has arisen a large interest in the fabric of buildings reverting to the breathing form they used to have in previous generations. Yet within the context of modern temperature and humidity control regimes. This has also led to renewed interest in the tempering effects and inertia potential of structures built from natural materials.

So for example an earth wall is not just something which has low embodied energy - through not being fired into bricks, it also has a moisture storage potential where its hygroscopic properties are such that it takes up and gives off at the same kind of rate and the fact that it can store moisture means that the indoor climate is kept within the scale at which humans feel most comfortable - namely 40 - 60 %.

[2] Lief Øye, Trondheim
[3] Hartmann/Schneider - Gesundes Bauen Gesundes Wohnen (1974)
[4] Ole Fanger Hidden Olfs in sick buildings ASHRAE Journal Nov 1988



Diag 9

There is of course a symbiosis between the conditions in which a human feels comfortable and those which are efficacious for the natural predators and health threats, which tend to thrive at the extremes of the comfort zone for humans.

Every building has within it the potential for dry rot, wood worm and so on, but the conditions for their thriving are essential predeterminants to their being a real threat.

All buildings are ecosystems and to varying degrees play host to a whole range of wildlife - mostly microscopic but much of it visible from dusty mite to the house fly to its natural predator the spider and even mice. Anyone who has a dog or a cat in their house immediately invites the host of predators which like to live in their ample fur. All life is there.

The Problem of Misinformation

It is perhaps a cynical but nevertheless an identifiable trend that those industries who have most to lose in a world watching for environmental soundness will be the first to utilise marketing rhetoric, whilst seeking also to define the terms of reference for control mechanisms and regulations, in a manner which will least harm the economic viability of their products. Often this entails selecting a single criterion - such as longevity in materials which are non-biodegradable for example - and trying to turn this into a positive environmental attribute without looking at related disbenefits. It is therefore not to do with changing the product itself, but merely changing the way it is described - as if this marketing rhetoric will make the environment understand that it is really not so hazardous after all. It's a bit like lying to God and hoping you wont get found out.

I remember very clearly the rearguard action being fought by the asbestos industry, who took 30 years to be prosecuted effectively for production of a material which was really indefensible. This was only the first of a number of materials which will become vetoed over the next twenty years. One hopes that companies will take the positive option of developing benign alternatives rather than defending the indefensible, in an orgy of litigation.

Sooner or later initiatives such as the Natural Step programme or the polluter pays principle will take hold and I would anticipate that this will drive the market to looking at a greater reinvestigation of natural materials and traditional products with a depth of understanding that has thus far tended to be reserved only for hi-tech products.

The Categories and Examples

Illustrated are descriptions of the 12 key categories in the "Swiss Roll" (SIB) LCA with some examples of materials/ products and their possible scores. The examples are generalised indications over the whole lifecycle - where in the SIB system they will score differently at each stage. It is uncorroborated personal opinion on my part, but there to show some possible results for illustrative purposes only.

A:- The four elements

Designing to cope with the cycles of the four elements in a cyclic (on site) rather than a linear (out of sight) manner is a major consideration in an ecological design approach to buildings and products.

Earth impact

A material can be from a non-renewable source, and consume other scarce commodities in its manufacture. It can also be difficult to dispose of back to earth or to recycle once processed.

Example

Low	rammed earth wall
Medium	copper pipe
High	CCA treated timber

Air impact

Pollution of the earth's climate is most known from products which give off CO2 and other greenhouse gases, or ozone layer depleting chemicals. But off-gassing to the indoor climate - can be a hazard.

Example

Low	Untreated timber floor
Medium	Particulate boards
High	CCA treated timber

Water impact

Apart from the problems related to the wastestream cycle of materials which can eventually pollute the water table, water itself is becoming a valuable commodity, and materials with high embodied water content in their manufacture are increasingly an issue.

Example

Low	Natural stone
Medium	Brick
High	Plastics

Power consumption

The fire element in terms of energy usage is most significant if it comes from either a non-renewable or a polluting source. Embodied energy in manufacture and distribution becomes of an issue as attention focusses on greater insulation .

Example

Low	Earth block
Medium	Glulam beam
High	Aluminium window

B: Environmental

There are those aspects of materials which have a direct health impact on humans and those which are indirect - in that they poison our habitat rather than ourselves. The difference is rather academic, since we cannot be healthy in a poisoned habitat.

Landscape effect

This category looks at the strategic landscape impact of a material rather than the detailed ecological impact on the geology, flora and fauna etc

Example

Low	Wool carpet
Medium	Dressed stone
High	Clear-felled hardwoods

Flora and Fauna

This category concerns itself with issues such as the loss of habitat, the creation of toxicity, the loss of endangered species, etc. A strategy which seeks a more biodiverse environment is necessary.

Example

Low	Cellulose insulation
Medium	Steel elements
High	Tropical timber

Transportation

Both direct and indirect pollution are well understood by-products of increased use of vehicles dependent on petrochemicals. The travel distance required by a product is a significant factor in its embodied energy.

Example

Low	Local timber
Medium	Concrete
High	UPVC

Refuse/ Waste

This is a growing area of concern. Design using recycled products and design for future recycling, are now significant. Issues include reusing a product before recycling its materials, embodied toxicity in recycled materials, and the need for transfer stations regulated recycling

Example

Low	Nail-free timber Joist
Medium	Stud Wall
High	Non-biodegradable plastic

C: People-related

Given the symbiotic relationship between people and habitat, this category is identified separately from the above merely because the impact is perhaps more immediate and more direct on humans

Health aspects

Human health problems differ with each generation. Without a holistic framework, we run the risk of perpetuating the sequence of causing new diseases in the process of curing present ones.

Example

Low	Opening window
Medium	Electrical Equipment
High	Solvent based glues

Social aspects

Social aspects were added recently to the SIB list when they realised sound materials can be procured in unacceptable ways. Protecting the interests of future children starts with protection of the present ones.

Example

Low	Local craft products
Medium	Imports, vetted companies
High	Carpets, child sweatshops

Hazard risk

Chemical, electrical and radiation risks are the three main areas of concern under the heading of hazard risk - each has its own associated risks, but all thee are combined here.

Example

Low (chem)	Borax treated timber
Medium Rad'n)	Granite blocks
High (elec'l)	High voltage power line

Economic aspects

The extent to which a material contributes to a local economy can be of significance and looks at building as a local process rather than a set of imported products. Some buildings might be hazardous to a local economy if they challenge local building procurement traditions.

Example

Low	Local material/ local labour
Medium	Recycled slate
High	Ind'd system/ ext'l labour

Diag 10

Best Practice Examples

Examples of best practice in terms of traditional materials being used in modern buildings can be categorised at three levels - each more complex than its predecessor:-

Materials - which make up:-

Products - which make up:-

Buildings- which make up cities.

Materials

Whereas undressed stone and recycled slate are still high scorers in the natural materials and low environmental impact stakes, interest in more unconventional materials is growing - such as the use of unburned clay in pisé construction, the use of thin roundpole sections in structural design and the use of wood shavings in insulation are all being re-visited as possibilities in a new generation of innovative buildings.

Products

Manufactured earth blocks and bricks and ceiling elements are all being investigated currently as marketable commodities. Straw bales and low quality sheep's wool are a potential waste to useful product opening - hard on the heels of the success of cellulose fibre (recycled newsprint) and flax insulation.

A full-scale borax timber treatment plant has opened in Scotland in the last year to provide alternatives to CCA treated timber products

Buildings

In Kolding, Denmark a demonstration house has been constructed from recycled materials. Nearer to home there are examples of very low impact designs at Weem and Killin in Perthshire, and at Ullapool and Findhorn. In Perth city a whole housing scheme has been produced using ecological design principles and addressing the criteria of the SIB assessment method.

Conclusion

It has been argued that traditional materials are more likely to deliver sustainable development for future generations than the modern materials which are so often put into situations where they are over engineered for their purpose. - too strong, too permanent, over manufactured and over-sophisticated.

Fritz Schumacher identified the tendency for post-war industrial development to become "too clever to be wise", and it would seem that we have now reached a crossroads where we should review critically what is the best of both worlds, and worthy to pass on to future generations.

We cannot regain an innocence lost, but we should perhaps look at the difference between our current environmentally-unsound, guilty technology and a future possibility of scientifically and environmentally sound design. The application of the latter would preclude the development of the former. I would therefore claim that it is a designer and specifier's issue, just as much as it is a client issue. The responsibility lies with all of us - and the materials are all there - we merely require the will and the skill to use them.

SOURCE TO RESOURCE - FINDING INFORMATION ON SKILLS, MATERIALS AND SUPPLIERS

Carol E Brown, Conservation Information Officer, Historic Scotland

Summary

This paper aims to summarise the existing methods of finding information on the materials talked about at this conference. It also addresses how to find the people with the skills to use these products, and where to obtain advice on choosing materials, professionals and contractors. It is hoped that, by giving professionals and public alike a better idea of the range of who and what is available, this will promote the use of conservation skills and traditional crafts as well as acting to encourage the revival of the use of traditional materials in building.

Bureau experience

I am speaking from the point of view of our day-to-day work in the Scottish Conservation Bureau, where we spend a lot of time answering queries about the availability of skills to match jobs. We do receive enquiries about materials and products, but, notably these are few towards the demand for lists of names for contractors and those providing various services.

Is this a significant statistic in itself? The Bureau is recognised as a source of information about people, but why are there not more enquiries about materials? The answer is most likely that, while finding sources of "standard" materials is not a problem for specifiers, not much can be achieved without the appropriate person to do a job. The problem is, rather, how to encourage specifiers to broaden their range of knowledge and appreciation of the qualities of materials and their properties. This is, perhaps, beyond our powers - no-one will come to the Bureau for information on how to find a material until they have discovered that a more traditional or indigenous alternative exists and come to the conclusion that it might be a good idea to use it.

Consequently, much of what follows has to do with the Bureau's experience concerning availability of information about skills, rather than materials.

Why is this information so difficult to find?

There's not much around?

It is clear that much has been lost over the last 50 years - both in terms of skills techniques, availability of sources and the awareness of how to make best use of what is local. Modern regulations and mass manufacture have helped obviate need for materials then skills - and this has been addressed elsewhere in this conference.

Decentralisation

Information does exist, but it is not always simple to get hold of, to organise into an understandable form and present to others. As is often the case with the smaller, specialised workshops we are dealing with, information sources are somewhat de-centralised, often deliberately so. Attempts to gather together existing data into a usable central database can be made difficult by the holder's desire to "protect" their own list. Many of those engaged in this kind of work quite rightly refuse to have their names made available widely as they reserve the right to restrict where they will work and for whom. Many in this field are wary of being subcontractors on a job, for various reasons and prefer to act as sole contractors, working for clients they are familiar with.

Lack of co-ordination

Scotland is the only part of the UK where a serious attempt has been made to provide a centralised information service - within the Scottish Conservation Bureau, initially developed within the SDA and then within Historic Scotland. Attempts to set up a "one-stop-shop" building conservation centre have been in progress with DOE/EH for many years now, and there is a feasibility study going on at the moment for the same. These types of plan tend to suffer because of the way that government responsibility for the Heritage is divided up between many departments, commissions and agencies. Fortunately, the particular history of the Bureau has ensured that our information is not solely restricted to the "museums and portable heritage" category or to the "buildings and architectural" field - we have preserved a remit for both . It is also fortunate that, because of this, we are able to transfer the format of the tried and tested system currently used for the Museums and Galleries Commission/Historic Scotland Conservators' Register to the Buildings side as well. We believe that this "across-the-board" approach will be of benefit to the whole industry.

Problems of recommendation

Another reason for difficulties in finding data involves the problems in being seen to be recommending or validating individuals or firms. This is a difficulty for all, let alone government bodies which have to exercise particular care in disseminating any lists. Even the strongest disclaimers can fail to provide protection from liability; inclusion on any list can be taken to be an "official" recommendation by the distributor and accepted in law as such. As a result, many amenity bodies and government departments hold "unofficial" lists: the contents may be revealed to fellow professionals or local contacts but are generally withheld from others, including the enquiring public.

What are you looking for?

Enquiries usually fall into four categories, which make a useful division for the purposes of this paper: People with skills to do things (Conservation, Conservation-related craft or construction skills), sources of products, sources of raw materials and advice and information on all aspects of the above.

Some suggestion on sourcing skills in Scotland

Skills: 1. Conservation - Selective

Building Conservation Register
Currently under construction at the Scottish Conservation Bureau and hopefully, on-line by Autumn this year. The register lists over 1200 consultants and contractors who have had experience of conservation work related to a Historic Scotland HBGrant scheme project or work on Properties in Care. This is combined with data gleaned from existing professional and trade accreditation schemes and a degree of financial vetting to provide up-to-date information on conservation consultants and contractors in the buildings field. The enquiry service will offer print-outs of names on a regional basis and will possibly be marketed, in future, as an on-line system to others.
Contact: Scottish Conservation Bureau: 0131 668 8668

Conservation Register
Operated by the Museums and Galleries Commission in association with the Scottish Conservation Bureau. A comprehensive, UK-wide list of conservators of portable heritage (books to stained glass, stone, textiles and Natural History collections). Conservators have to meet specified criteria concerning levels of training and experience, documentation, security and insurance for workshops and have to provide five client references. Again, enquirers are given a print-out of names and workshop details on a regional basis.
Contact: Scottish Conservation Bureau: 0131 668 8668

Con Reg./CMIS
(Consultants Register/Construction Management Information System)- the DOE's (or rather DETR's) on-line system for those seeking approved contractors and consultants for public-sector work. This is industry-wide but does have a Conservation element in the Architecture category. These two databases will shortly be expanded and made available for use by all public sector procurement bodies, such as local councils. This will also be made accessible through on-line computer links, with a set-up fee to users.
Contact: Edinburgh Office: 0131 558 1508

Professional registers
Those professions with conservation accreditation schemes within Scotland:
Contact:
Royal Incorporation of Architects in Scotland: 0131 229 7545
Royal Institute of Chartered Surveyors, Scotland: 0131 225 7078
Scottish Society for Conservation and Restoration: 0131 556 8417

Skills: 2 Conservation - Non-selective

Heritage Building Contractors Group (HBCG)
A grouping of leading independent firms specialising in repair, conservation and restoration of historic buildings and ancient monuments. As yet, no members north of the border - this is to be redressed soon!
Contact: 01904 412624

Local Authorities unofficial lists
Various authorities have lists, but these are usually for internal use only and are not generally promoted.
Contact: Local Conservation Officers/Planning Dept for further information.

Amenity bodies unofficial lists
Usually more pro-active in promoting lists, especially for work within their regional, area or project remit. For example: Edinburgh New Town Conservation Committee (0131 557 5222), Glasgow West Conservation Trust (0141 339 0092), any Building Preservation Trusts, SPAB in Scotland (0131 226 1345)

Bonhams Directory
Directory of "repairers and restorers" published annually.
Contact: Bonhams, Montpelier St, London SW7 1HH

Guild of Master Craftsman -"Care and Repair"
Directory of members, building and antique restorers - published every 3/4 years
Contact: 01273 477374

Skills: 3. Crafts/Conservation related

Scottish Arts Council
The crafts division of the SAC keeps a register of craftspeople (some working in traditional crafts fields) in Scotland.
Contact: 0131 226 6051

Trade bodies/associations
Dry Stone Walling Association-4 Scottish branches
List of members/craftsman certification scheme
Contact: Central 01738 828882
Caithness and Sutherland 01847 664465
Stewartry 01557 814361
Isle Of Skye 01471 822795

Stone Federation - Scottish Sector
Members list
Contact: 0131 221 1527
Other materials eg. Brick, Tile, Thatch, Copper, Zinc, Cast & Wrought Iron, Lead, Timber have representative bodies that are based south of the border. Details of these can be seen in: The Conservation Sourcebook (MGC/Christie's - HMSO 1991-ISBN 0 11 290493 9)

Directories and other lists of contractors/consultants
Natural Stone Directory, every 3-4 years, compiled by Natural Stone Specialist
(Herald House 01903 821082)

Building Conservation Directory and supplements, annually compiled by Cathedral Communications Ltd (01747 871718)

RIAS Special Skills List
Contact: Jane Bendy at RIAS 0131 229 7545

SEDA Specialists database (Scottish Ecological Design Association)
List of those working in Ecological Design
Contact: SEDA at RIAS 0131 229 7545

Association of Scottish Visitor Attractions
ASVA has a list of members: retailers but also craftspeople and consultants working in the heritage sector in Scotland.
Contact: 0131 220 0888

Sourcing Supplies and Materials

The term "traditional material" is used to describe two different phenomena. Firstly, it can stand for the "undeveloped" form of a material which is still in current use, for example, mortar, brick, tiles, paint - where the term is used to imply a type, form or recipe that was used over 50 years ago. It can also be used to describe a natural material from a source no longer worked, exploited or grown, slate, earth, thatch, stone.

The problems with procuring traditional materials can therefore be summarised as:

- Finding it (or its' constituents) at all
- Finding/persuading someone to manufacture it again
- Finding/persuading someone to extract/exploit source again
- Taking consideration of Health & Safety issues
- Taking consideration of environmental and sustainability issues
- Taking consideration of building regulations

Clearly many of these factors involve finding a source of appropriate contractors as well as the materials themselves.

Materials/supplies

General Directories
Building Conservation Directory
Contact: as above

Natural Stone Directory
Contact: as above

On-line systems
Scottish Conservation Bureau
Contact: as above

RIBA Products Directory
Contact: 0171 250 4050 RIBA Information Services - Product Selector - CDROM or printed version

Timber Research and Development Association
Timber sourcing
Contact: 01494 563091

British Geological Association- Scottish Office
Geographical Information Systems for mapping stone sources
Contact: 0131 667 1000

Scottish Lime Centre
Information on sources of limes and aggregates, products, tools
Contact: 0131 553 4999

Alpha Dido On-line Products Directory
Technical guidance and products information
Produced by Hutton and Rostron
Contact: 01483 203221

Internet sites

Building Centre
Product and technical information
Contact: http://www.buildingcentre.co.uk

Conservation On-Line
Bibliographic database and bulletin board - mainly portable heritage
Contact: http://www.palimpsest@stanford.edu

SOURCE TO RESOURCE - A PERSONAL VIEW

Benjamin Tindall, Partner, Benjamin Tindall Architects

INTRODUCTION

I speak as an Architect with a background in carpentry, trained by Ingval Maxwell with Historic Scotland and, in Worcester, by F W B Charles, Britain's foremost expert on medieval timber-frame buildings. As a small practice we do not have the benefit of someone like Carol Brown being in the office.

I am also the Convenor of the Society for the Protection of Ancient Buildings in Scotland; whose philosophy is to repair rather than restore with traditional materials and skills, whilst encouraging new work to be distinctly new, but knowledgably sympathetic.

I think that I can offer a four-point way of finding out about materials, suppliers and contractors which leads to getting the best possible results, within the framework of what is available. Budgets, timescales, life and personalities conspire to make sure that the job is never easy, or dull.

HISTORY

Research and find the original material - get it right!

Before specifying a material it is essential to work out what is required. An important way of doing this it obtain as full an understanding as possible of the original design and building process. Many of our finest buildings were built when to "cart away" meant just that, with a cart, with a horse, with a horse fed on oats. The logistics of building restricted the choice, and maximised the ingenuity. The lessons learnt by trial and error were not forgotten.

Before the era of cheap printing information is hard to come by and then only with considerable uncertainty. In our office we have a collection of sources books which we find invaluable, the best for early construction being Building in England by L F Salzman (1952).

For later periods information is easier and can come from many sources. Books on particular trades, like Robert Riddells's Elements of Handrailing (1870) are easy enough to find and will provide information ignored by current publications wishing to sell branded goods and services.

Scientific examination will, of course, also help, but in our experience it tends to confirm rather than lead an investigation. Examination of the micro-structure of stone might confirm that one has found the right quarry, or dendro-chronology might confirm that all timbers were of one build, etc..

With Freddie Charles, an early lesson was at Baston Barn where it became evident that the slats were the off-cuts of the beams and rafters. Like the proverbial pig nothing was wasted, not surprising considering the efforts involved in getting the material to site.

GEOGRAPHY

400 yards is far enough to go! Traditionally materials, obviously, came from as close as possible, and indeed this is one of the most striking and beautiful things about old buildings. The variety and appropriateness of local materials can never be perfectly matched by substitutes. The time sometimes spent in attempting to do this should simply be spent in getting the right local material. The right sand is very likely to be from the nearest river or sand bank, and the effort in actually getting, sieving and cleaning this will very probably be a fraction of the time spent trying to match it.

SPAB philosophy is sometimes held to say that one should not attempt to make a perfect match, as try to do so is doomed to failure, and it will confuse and devalue the original conception. The same however, does not apply to craftsmanship where the SPAB has always been in the forefront of preserving traditional skills. The two aspects come together by new work being carried out with traditional skill sympathetically and sensitively, letting the old dominate. The use of local materials is often crucial.

In repairing Hermits & Termits I discovered that 12 different kinds of stone were used, the 12 different kinds available from the scree of Salisbury Crags.

It was here, in two cottages we repaired outside Marlborough in Wiltshire, that we invented the 400 yard rule. The sarsen stone and mud came from the fields, the oak rafters and boarding from the Savenak Forest, and the thatch came from the river. The client carried out most of the work himself, as the original owner would have done, and the thatcher was from the village.

PEOPLE

Find the right person; work is done by human beings. Organisations do not carry-out work, they only facilitate it. The 'right' person is someone obviously experienced, but also enthusiastic and committed, and again preferably local. Such a person will have a stake in the work's success.

Skills are seldom 'lost'. Anyone who likes working with a particular material is naturally delighted to do a good job, but far too seldom asked to do so. This is a matter of supply and demand, and with the ingenuity of the human race the demand will always be met. It is my belief that if skills appear to be 'lost' this is therefore because they are no longer asked for. If there is any blame in this situation I believe it lies with the specifier.

The same, by and large, goes for materials. The exception of course being where man exhausts the material concerned. There are still millions of tons of Craigleith or Rubislaw stone or Ballachulish slate, some of the finest materials known to man. (Unfortunately demand declined and unbelievably short-sighted lack of planning allowed the quarries to be destroyed; at the very least they should have been preserved for future working.)

Adverts, on television or the like, are not the best way to find out about woodworm treatment, window repairs, damp-proofing, 'water-seals' and the like. In fact, adverts, by their very nature, are such a partial source of information that they are best avoided all together. Unfortunately this goes for endorsements by certain well known organisations for ranges of so-called historic paints. Historic Scotland's Technical Advice Notes, the SPAB and professional advisors; all without a commercial interest in the products concerned, are where people should go for advice.

ENERGY

The lowest 'embodied-energy' solution is the long-term solution.

Human energy, traditional skills and materials, and the like are all, ultimately, fuelled by renewable energy. Plastic windows, window seals, magic resins, silicones, stihl saws and the like are from non-renewable fossil-fuels. In our high energy wastage world these are cheap, but they produce results which are far removed from the original, and certainly unsustainable. Such materials and techniques cannot be used endlessly.

SUMMARY

- The right answers are not necessarily easy, they need careful research.
- If the solution lies more than 400 yards away it is probably wrong!
- Building is about personal relationships. The power of the people's brains is infinitely greater than anything else available. Ask around.
- The 'green' solution is probably the right solution.
- Lastly, quite apart from all these questions are matters of Design, the original design qualities as well as contemporary, but this needs to be subject of another conference altogether!

CODES AND STANDARDS - PANACEA OR FALLACY?

James Simpson, Partner, Simpson & Brown Architects

Abstract

Theory is necessary as basis for practice, not for its own sake. Decisions on building and conservation matters cannot be made 'by numbers' or on the basis of rules alone. Judgement is an essential factor in all professional activities an inherent in the exercise of judgement is the risk of being wrong. It is not necessarily negligent be wrong, but professionalism implies a duty of care.

Structural codes and building regulations have a long history. They deal primarily with matters which can be clearly defined and quantified and exist to protect human health and safety. Even in such matters, however, there may be conflicts, there is a need for flexibility and judgement may be required.

The aim of manifestos, charters and guides is to define objectives and to establish a theoretical framework against the background of which good decisions may be made. The SPAB Manifesto of 1877, the ICOMOS Venice Charter of 1964, the ICOMOS (Australia) Burra Charter of 1977 and the forthcoming BS Guide to the Principles of Building Conservation should be viewed in this way,

Thinking moves on, however and theory must develop. The ICOMOS (UK) Committee has begun to plan the preparation of a new ICOMOS (UK) Charter...

CURRENT TRAINING AND EDUCATION INITIATIVES IN BUILDING CONSERVATION

Ingval Maxwell, Director, TCRE Division, Historic Scotland

The Conservation Renaissance

Over the last two or three decades an increasing awareness of historic building conservation matters has been steadily gaining ground. With this has arisen a growing understanding of the need to re-learn much of what has been lost. As a result, the demand to accomplish sympathetic work in accordance International Conservation Charters, and other recognised guidelines, is increasing. Associated with this is the need to instigate a programme through which the philosophies and ethics of conservation are adequately promoted. Whilst traditional avenues of education are still available, the recent Vocational Qualifications initiative in Architectural Conservation provides an ideal framework within which such a development can take place. The key to effectively pulling together the emerging range of conflicts must be through the creation of an awareness of all the factors involved.. The need is for industry to work together to achieve a satisfactory result. This must be enhanced by a requirement to determine the appropriate level of work and the direction of any subsequent management strategy to be adopted. The two aspects must run hand-in-hand.

However, a number of these opportunities are also revealing themselves as significant challenges. It is recognised that a large number of new conservation courses have suddenly become available in the market place. This inevitably raises questions of who validates them, what consistency of approach exists, how does the student choose what is the most appropriate course, and who trains the trainers? A plea is also being heard for practically based qualifications, but there is a need to resolve the major lack of student or apprentice work placements with contractors. It is also acknowledged that clients have an important part to play, but there is a need for their interests to be properly informed so that realistic project briefs can be devised. Trends also identify the role that Lottery funded projects are playing in trying to ensure that there is a future need for traditional materials and appropriate craft skills.

Through building upon these, and other, initiatives that are being developed by a number of institutes, a programme that educates and trains to commonly understood principles is being recognised as a prerequisite of success. By working with established strengths, and crossing disciplines, an increasing awareness at all levels is making it possible to devise more relevant common standards that are applicable to future needs. But, a fuller and broader range of co-operation and integration will be necessary before this can be fully achieved.

Conservation Education and Training

As an effective operational tool within which technical education and training needs of building conservation can be addressed, the International Council of Monuments and Sites (ICOMOS) have prepared and promoted a pragmatic framework of guidance. Promulgated by their International Training Committee at Sri Lanka in August 1993, their *Guidelines for Education and Training for the Conservation of Monuments, Ensembles and Sites* projects a holistic methodology. Their document states:

Conservation work should only be entrusted to persons competent in these specialist activities. Education and training should produce from a range of professionals, conservationists who are able to:

(a) Read the monument, ensemble or site and identify its emotional, cultural and use significance;

(b) Understand the history and technology of monuments, ensembles and sites in order to define their identity, plan for their conservation, and interpret the results of this research;

(c) Find and absorb all available sources of information relevant to the monument, ensemble or site, their content and surroundings, in relation to other buildings, gardens or landscapes;

(d) Find and absorb all available sources of information relevant to the monument, ensemble or site being studied;

(e) Understand and analyse the behaviour of monuments, ensembles or sites as complex systems;

(f) Diagnose intrinsic and extrinsic causes of decay as a basis for appropriate action;

(g) Inspect and make reports intelligible to non-specialist readers of monuments, ensembles or sites illustrated by graphic means such as sketches and photographs;

(h) Know, understand and apply UNESCO conventions and recommendations, and ICOMOS and other recognised Charters, regulations and guidelines;

(i) Make balanced judgements based on shared ethical principles, and accept responsibly for the long-term welfare of cultural heritage;

(j) Recognise when advice must be sought and define the areas of need of study by different specialists e.g. wall paintings, sculptures and objects of artistic and cultural value, and/or studies of materials and systems;

(k) Give expert advice on maintenance strategies, management policies and the policy framework for environmental protection and the preservation of monuments and their contents and sites;

(l) Document work executed and make same accessible;

(m) Work in multi-disciplinary groups using sound methods;

(n) Be able to work with inhabitants, administrators and planners to resolve conflicts and to develop conservation strategies appropriate to local needs, abilities and resources.

Due to their pragmatic approach, these Guidelines have been used as the foundation for recent work on the formation of *Occupational Standards* for professionals and others working in the field of conservation of the built environment. The emerging standards will soon be promulgated as *Scottish and National Vocational Qualifications* (SVQ's/NVQ's).

The Scottish Vocational Education Council (SCOTVEC).

Established by Government in 1985, *SCOTVEC* worked in close partnership with all the Scottish sectors of commerce, industry, government and training providers. It aimed to develop qualifications that were relevant to the needs of employment, were flexible, and were recognised at both national and international levels. The range of awards included National Certificate modules, Higher National Certificates and Diplomas (HNCs and HNDs), professional development awards and Scottish Vocational Qualifications (SVQs).

The Scottish Qualifications Authority (SQA)

When SCOTVEC ceased to exist on 1st April 1997, it was replaced by the Scottish Qualifications Authority. Established in September 1996. The SQA has become the national certifying body for qualifications, and the accrediting body for SVQs, in Scotland. Its role will build upon the success of SCOTVEC, and the Scottish Examination Board (which was also incorporated) to develop, accredit, award and keep under review the qualifications which were previously available from both bodies. It will certificate the majority of Scottish courses and awards, and co-ordinate education and training routes to ensure greater coherence and effectiveness between schools, colleges and training for employment. Ultimately, with its interest covering school qualifications, national certificate levels, vocational qualifications and professional development awards, it will impact on all aspects of the community.

Scottish Vocational Qualifications

Scottish Vocational Qualifications were introduced in 1989 as part of a national drive to improve the skills of the British workforce. SVQs, like NVQs, are qualifications that are directly related to jobs. They are designed by industry, for industry, and intend to prove that someone can do a job to a specified standard. This is defined, and set, by a consensus of related industry interests. SVQs are not training courses. They are qualifications based on an assessment of what people can do under workplace conditions.

SVQs and NVQs are based on the same national standard, so are compatible and enjoy mutual recognition throughout the United Kingdom, and elsewhere. Overall, through a series of *Levels*, they plot a route for a wide-range of participants who can show they can undertake elementary routine tasks under supervision (Level 1), up to a clear demonstration of complex problem-solving and managerial skills (Level 5).

The higher the Level the more of the following characteristics it is likely to have -

- a breadth and range of competencies
- degrees of complexity and difficulty
- requirements for special skills
- the ability to:
  - undertake specialised activities
  - transfer competencies from one work environment to another
  - innovate and cope with non-routine activities
  - organise and plan work
  - supervise others

However, the particular combination of factors that determines the Level of an Award will vary from award to award, and the topic covered. Broadly speaking, they can be described as follows -

Level 1 competence is required in a range of varied work activities, most of which are liable to be routine and predictable.

Level 2 competence exists in a significant range of varied work activities, performed in a variety of contexts. Some of the activities are complex, non routine, with some individual responsibility and autonomy involved. Collaboration with others, perhaps through membership of a work group or team, may often be a requirement.

Level 3 competence exists in a broad range of complex, non-routine and varied work activities performed in a variety of contexts. There also has to be considerable responsibility, autonomy, and control in the range of duties, and guidance of others is often required.

Level 4 competence requires a broad range of complex work activities to be performed in a wide variety of contexts, with a substantial degree of personal responsibility and autonomy. Responsibility for the work of others, and the allocation of resources, also needs to be present

Level 5 competence involves the application of a significant range of fundamental principles and complex techniques across a wide and often unpredictable variety of contexts. Very substantial personal autonomy, and often significant responsibility for the work of others and for the allocation of substantial resources, feature strongly; as do accountabilities for analysis, diagnosis, strategic design, planning, execution and evaluation.

The National Standards format explained

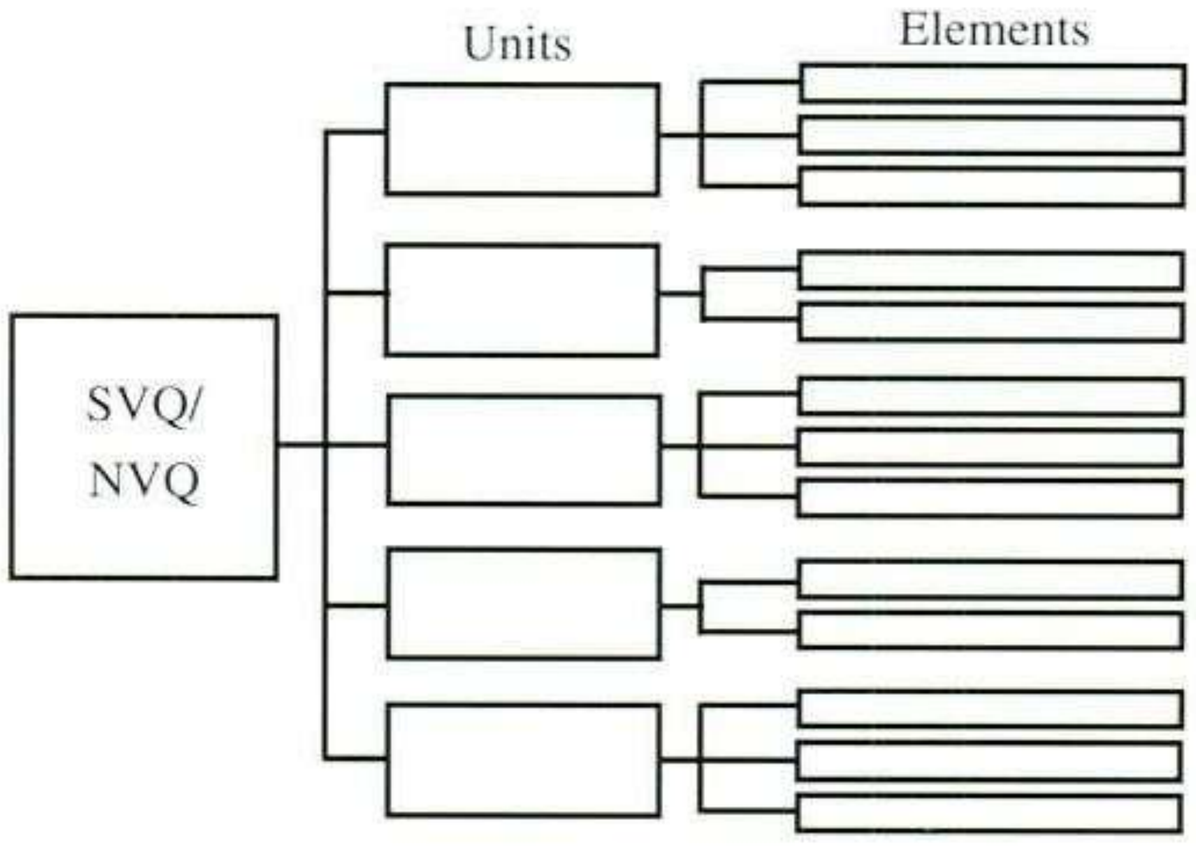
The *National Standard* is broken down into various parts. To be successful, any organisation committed to the Investors in People initiative will have to demonstrate that it effectively meet all the indicators of these in what is, essentially, a plan of good practice. Topics covered include links between management plans and individual job descriptions; the type of information available to assist staff to find out about training opportunities; and whether management and staff talk about training and development needs.

Standards conform to the same format, irrespective of the industry within which it applies. A standard consists of a variety of identifiable parts. The *Element Title* describes the area of activity to which the standard applies. The *Performance Criteria* describes critical aspects of performance, by which one can judge that the standard has been met, and the *Range* describes the scope of situations and contexts over which this performance is expected to apply.

In the structure of SVQ and NVQ qualifications, *Elements* describe the *Standards* and are separately assessed. *Units* are groups of elements that represent competence in a free-standing area of work. They are the main building blocks of a S/NVQ and the first level of recognition. *S/NVQ's* are groups of Units and are the actual qualifications. *S/NVQ Certificates* are the full award. They list the Units that have been passed and indicate the individual's competence.

Figure 1

The Structure of SVQ/NVQ Qualifications



- **Elements**

  describe the Standards

  are separately assessed

- **Units**

  are groups of elements

  represent competence in a freestanding area of work

  are the main building blocks of a S/NVQ

  are the first level of recognition

- **S/NVQs**

  are groups of Units

  are the qualifications

- **S/NVQ Certificates**

  are the full award

  list the Units which have been passed

  indicate the individual's competence

The *Awarding Body* is responsible for the assessment and certification process. It registers candidates and appoints assessors to ensure that assessments are conducted properly. In partnership with lead bodies it also keeps the standards relevant and up to date. The Awarding Body develops systems for the assessment of candidates throughout the UK, the registration and tracking of candidates' progress when, and wherever, they move over long periods of time. It also controls the issue and of award certificates, maintains quality assurance, and field- tests the qualifications.

Figure 2

The National Standards Format

National Standards conform to the same format, irrespective of the industry within which it applies. A standard comprises:

Element Title

This is the area of activity to which the standard applies

Performance Criteria

These describe critical aspects of performance, by which one can judge that the standard has been met

Range

This describes the range of situations and contexts over which this performance is expected to apply

Lead-body developments in the field of Architectural Conservation Training and Education

Following the international work by ICOMOS, the key players in the development of Architectural Conservation SVQ and NVQ's have been the *Conference on Training in Architectural Conservation* (COTAC); the *Construction Industry Standing Conference* (CISC); and the *Construction Industry Training Board* (CITB). Through this work, COTAC is acting as the catalyst. In its previous incarnation its work during the late 1950's led directly to the setting up of a variety of post-graduate courses, such as those at Heriot Watt University, Edinburgh and the IAAS York. Yet again it is influencing the national trend that will affect a wide variety of professional, technological and craft groups on how architectural conservation training and education should be dealt with in future.

Through working in tandem with education and training providers, the foundations are being firmly set, upon which industry lead-body targets can be realised. Furthermore, in taking this lead COTAC has done much to determine what the actual operating levels of these standards should be, and how these should be more widely recognised.

Education initiatives in architectural conservation has recently risen in their ascendancy at a remarkable speed, and the COTAC communication Networks go a long way to help address the critical issue of who "trains the trainers". *The Scottish Conservation Forum in Training and Education*, which was formed by Historic Scotland in 1994, greatly benefit from its COTAC links in this regard.

Inevitably there are regional differences that have to be accommodated. Issues, such as local variations, caused by special abilities and divergent needs dictate their character. And a variety of related topics, such as the impact of available finance, core expertise, and the dissimilarity of materials used to construct our built stock, also have to be looked at. That, however was, and is, part of the national challenge which COTAC recognised and encourages the local partnerships to address.

In the spring of 1994 COTAC was invited by CISC to investigate the possible development of S/NVQs for Building Conservation. Covering the national perspective, COTAC subsequently invited a multi-professional group of practitioners directly involved in built heritage conservation, to consider the potential demand and to explore the range of work that would be necessary to produce these. As a result, in the following October COTAC and CISC established a conservation Working Group. This was given the remit to open discussions with Awarding Bodies to establish a new set of architectural conservation units. In this process it supported four Sub-Groups. They were invited to develop the awards and set up and run associated field trials. Finally it plans to submit the refined standards to CISC for endorsement, before being formally accredited as SVQ's and NVQ's.

The four Sub-Groups concentrated their work on -

- Professional advice and related services in conservation
- Maintenance management of conservation sites
- Statutory control relating to conservation of buildings and areas
- execution of conservation projects

The Sub-Groups' work was to clarify the functions that were specific to the conservation specialist. To do this they had to identify those aspects that go significantly beyond the expected capability of a person generally qualified in the construction and management fields. From the CISC standards framework, they then selected, adapted and refined the existing standards for each group. This helped determine the performance and knowledge evidence that would be required for assessment of the standards. There was also a need to advise and assist in the associated field trials. These were designed to test the standards directly with the various practitioners in their conservation roles. Finally they were invited to advise on the assembly of the specialist standards into appropriate groups so that they could be used in the provision of CPD, or as full S/NVQ's.

Over the last three years, the four groups have been working to this end. A series of Scottish and English field trails were also successfully carried out from December 1996 to March 1997.

When complete, the standards, which have just completed their trials, will be relevant for -

- advisers on conservation strategy and practice
- managers of conserved buildings and sites
- conservation officers
- site managers and supervisors of conservation projects.

The Construction Industry Training Board also provides support for conservation in a variety of ways. Covering craft levels, development works on the conservation unit inputs were complete for SVQ/NVQs Levels 3 in October 1995. Conservation option units (and/or assessment guidance) covering painting and decorating, plastering, bricklaying, masonry and wood trades have been accredited by CITB are now available for college use. Other occupations are being addressed, with development work on conservation units for a Level 4 award in Building Site Management currently being considered. In addition CITB supports and advises construction companies "in scope" to them with Training Advisers and the provision of finance for training through their Grants Scheme. Finally, it is also supporting an exchange programme for Conservation Site Managers under a European Leonardo programme.

Using the ICOMOS Guidelines as the base reference, the Level 5 conservation standard has been designed for professionals who have already qualified, and whose principal role is in providing advice at strategic level. The emerging suite of units target architects; structural and environmental engineers; landscape architects; building economists; surveyors; urban designers and town planners. In addition, the framework of these standards can also be used to assist individuals, who have had backgrounds in a more diverse range of disciplines, to achieve and satisfy their individual Continuing Professional Development (CPD) requirements. With time the same standards could assist the various professional bodies who are either running, or are contemplating setting up, accreditation schemes for practitioners operating in the conservation work area.

Associated initiatives

On the national education and training scene, a number of inter-related initiatives have now reached the point where their combined influences are beginning to produce additional benefits and visible results.

Individual conservation training schemes

A number of private sector 'hands-on' training courses have recently been established and promoted. These include thatching, hard landscaping, masonry conservation, and the understanding of lime, working with traditional additives, and its application. Arranged and managed by organisations such as the Local Enterprise Companies, National Trust for Scotland, SPAB, the Iona Cathedral Trust, the Building Lime Forum and Scottish Lime Centre, it is encouraging that such initiatives have been so progressive, and reasonably well supported. Some have also been successful in developing and promoting associated SVQ's.

The Prince's Trust

By offering young people, in the age range 16-25 years, a personal development programme to work on projects that have community benefit, the Prince's Trust Volunteers provides the framework for rewarding experiences. Participants join a group of up to 15 to work together to plan and deliver a variety of practically orientated projects, some of which are conservation orientated. Programme options range from 20 days to 12 weeks, although longer periods are also possible. In this time a minimum of 5 days residential experience is also required. All Trust programmes incorporate a Level 2 Core Skill Unit - "Working with others" that can aggregate to an organisation's Investors in People award.

Investors in People

Investors in People is a national initiative concerned with good practice for auditing staff development and training. The aim is to assist organisations achieve maximum staff potential, from the time they enter service until the time they leave. The initiative is about ensuring that training and development commitments have a clear focus that helps the organisation meet its overall business objectives. The initiative is also about ensuring that the investment that is made in training and development is evaluated, and that the expected outcomes will be achieved. As a result, it helps organisations consider how they can become more effective in the future.

Advisory Scottish Council for Education and Training Targets (ASCETT)

The establishment of ASCETT was announced by the Secretary of State for Scotland in March 1993. Its stated remit is to oversee, and report annually, on progress towards achieving the *National Education and Training Targets* (NETT). It also has a role to advise government on performance and on policies needed to achieve the targets whilst, at the same time, providing employer leadership to raise the skills levels implied by the targets.

The National Education and Training Targets were first promoted by the Confederation of British Industries in 1989 in its publication "Towards a Skills Revolution". These targets have been endorsed by the government and are widely supported by the principal education and employment interests. They also underpin the government's "Strategy for Skills".

Under the banner of "developing skills for a successful future" the aim of NETT is to improve the UK's international competitiveness by raising standards and attaining levels in education and training to world class levels. This is to be achieved through ensuring that all employers invest in employee development to achieve business success. In addition, all individuals should have access to education and training opportunities, leading to recognised qualifications, which meet their needs and aspirations. Over and above, it is recognised that all education and training provision develop self-reliance and flexibility in breadth through, in particular, fostering competence in core skills.

ASCETT operates in parallel with the *National Advisory Council on Education and Training Targets* (NACETT), a body that carries out similar tasks in England and Wales, and co-ordinates, monitors and reports at national level.

At its 1994 launch, ASCETT delivered a compelling case for the need to achieve the required training targets. It also promoted the view that this could be realised through an involvement by companies in the Investors in People initiative.

In Scotland, ASCETT's intention is that all young people who can benefit should be given an entitlement to structured training, work experience or education, leading to a SVQ level 3 or 3 Highers, or equivalent (GCE A levels). In 1994 it was hoped that at least half of the employed workforce should be aiming at qualifications (or units towards them) within the S/NVQ framework by 1996, preferably in the context of individuals following personal plans, with support from employers.

With a requirement that all education and training provision be structured and designed to develop self-reliance, flexibility and a broad competence, ambitious targets for the year 2000 were set -

85% of young people to attain SVQ level 2 (or 5 Standard Grades, or equivalent), in their foundation, education and training;

70% of young people to attain SVQ level 3 (or 3 Highers, or equivalent), as a basis for further progression;

60% of the employed workforce to be qualified to SVQ level 3 (or 3 Highers, or equivalent), as a minimum;

50% of organisations to be recognised as, or committed to, "Investors in People".

Technical Conservation Research and Education Division (TCRE) Historic Scotland

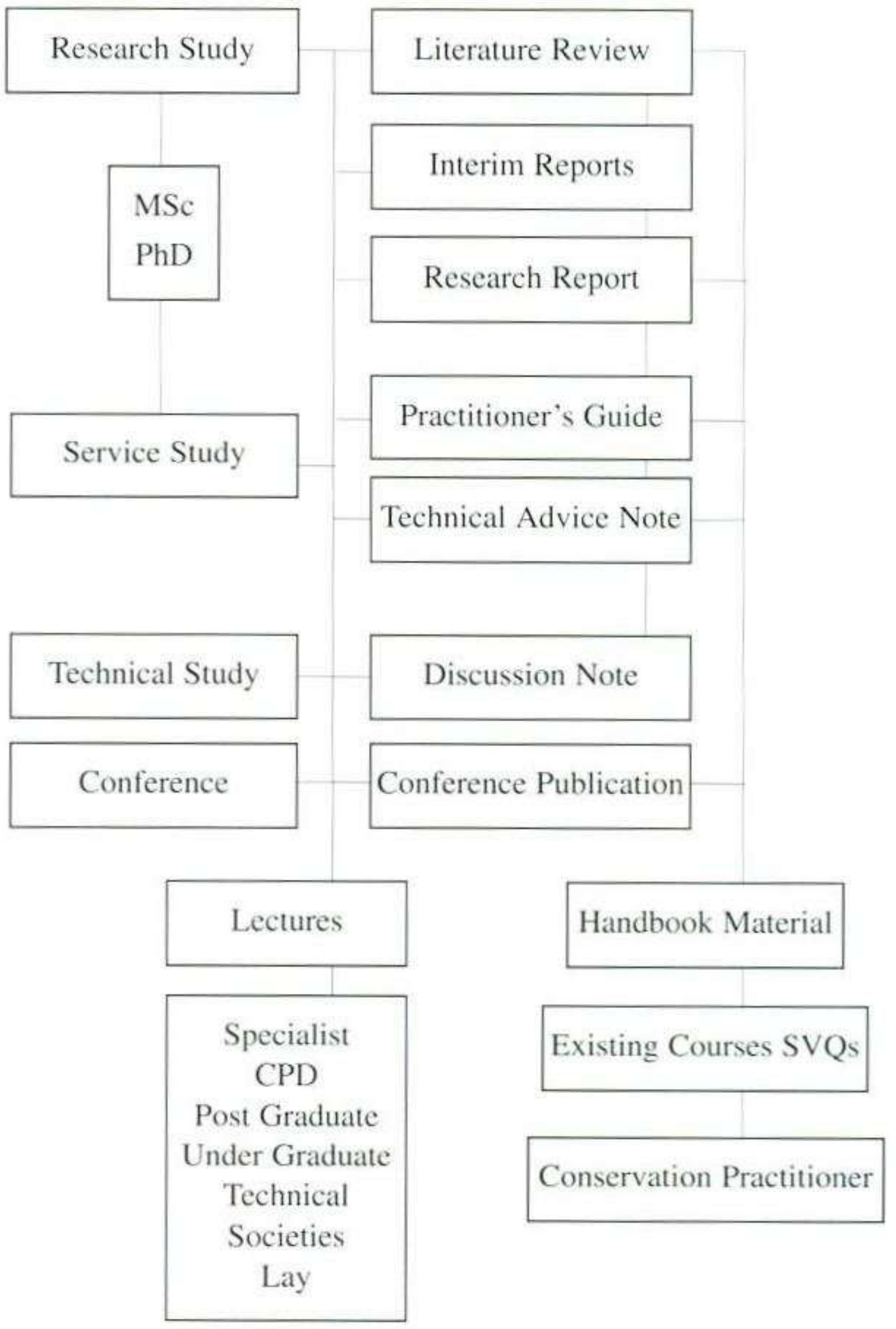
With overall responsibility for the built heritage in Scotland, Historic Scotland established a Technical Conservation, Research and Education Division in 1993 to assist with this process. The Division is charged with the responsibility of researching appropriate issues, developing skills relating to the built heritage, and raising the standard of conservation practice among owners, contractors and professional groups. In support of the national initiatives the work of TCRE also aims to integrate research requirements with training and education needs, and materials supply availability, in Scotland.

Undertaking relevant conservation research is a fundamental requirement of the work of the Division. Through looking at specific Scottish conservation issues, the majority of the projects are commissioned from Scottish Universities or practitioners. Where possible, they are also undertaken in partnership with industry interests. The aim is to translate the scientific understanding of conservation matters into helpful material for the practitioner. As the material is also commissioned and written with the education and training provider in mind, TCRE is finding that its published works are steadily being incorporated as relevant conservation course curriculum material throughout the country. As a bi-product of this approach the researchers themselves become better informed on Scottish conservation matters, and are therefore better placed to educate future generations of students. A further beneficial spin off exists where students have also been involved in the research process.

The publication programme that emanates from TCRE's research has also been devised to be supportive of the development work that is occurring in conservation S/NVQ units. Here, the research reports, practitioner's guides and technical advice notes are already being integrated as core material.

Figure 3

TCRE Information Dissemination Framework



A future aim of the Division is to work more closely with the education and training providers. This approach will, hopefully, help to plug any curriculum gaps by focusing the future research programme where that is needed the most. As a result, Historic Scotland is attempting to address the question who "trains the Scottish trainers" whilst, at the same time, providing relevant material in support of the wide range of current initiatives.

In this approach, the dissemination of relevant information is essential. Access to developed database material, identifying who is operating in what field of conservation, and at what level, is a critical requirement from the practitioner's point of view. Through the provision of data on trained conservationists, consultants and contractors, enquirers of the Divisions' *Scottish Conservation Bureau* will be much better equipped to effectively match their intentions, resources and aspirations.

To achieve this broad-brush approach it has been identified that there is a need to -

- Undertake a programme of research initiatives relating to historic structures in conjunction with others.
- Disseminate the products of scientific conservation research and analysis through a structured and integrated approach to publications, lecturing and training.
- Develop and improve training in conservation skills with Scottish educational institutions and colleges.
- Devise standards for accreditation of professional competence and quality control.
- Investigate the supply of traditional building materials to encourage the revival of key industries.

In planning to undertake research project on cultural heritage topics, due regard is given to the relevance of the study to the wider aims and objectives of Historic Scotland. In particular, study themes are pursued where the -

- industry is creating unnecessary risks or damage to the building stock
- scale of influence will bring the greatest degree of benefit to the :
  - buildings and sites
  - original materials used
  - retention of features and details.
- topics are particularly relevant to Scotland, Scottish materials and traditional skills.
- topics which also have an international relevance
- technical support that will bring added value to the work of other Historic Scotland Divisions.
- previous knowledge or available information is sparse.

With a commitment to promoting the results of the commissioned research programmes the following *Reports and Technical Advice Notes* (TANs) were published during 1996 -

- Thatch and Thatching Techniques TAN
- Earth Structures and Construction in Scotland TAN
- Access to the Built Heritage TAN
- Lime Conference Proceedings
- Case Studies of Traditional Lime Harling Discussion Document
- Cleaning of Granite Buildings Report + Literature Review
- Biological Growths, Biocide Treatment, Soiling and Decay of Sandstone Buildings and Monuments in Scotland Report + Literature Review.

In addition, the ongoing research programme will be working towards producing further publications during 1997. The topics are likely to include -

- Application of Biocide to Masonry TAN
- Graffiti Removal Treatments TAN
- Stonecleaning of Granite Buildings TAN

- Guide to International Conservation Charters TAN
- Composite Masonry/Steel Framed Buildings Defects TAN
- Fire Prevention in Scottish Historic Buildings TAN

The overall intention of such a publication programme is to address relevant topics that assist the specifying professionals and the education and training providers, and for the general benefit and care of the built heritage. However, the number of issues yet to be addressed and resolved is well recognised. For the future therefore an integrated approach, incorporating information and data from a range of associated interests, lead bodies and education and training establishments, amongst others, is going to be essential if this is to fully succeed. Through adopting this approach it is believed Historic Scotland is directly supporting the Investors in People initiative, whilst providing fundamental material to help determine, and support, the emergence of relevant standards in the Scottish vocational qualification field, and elsewhere.

Historic Scotland's conservation aim is to achieve on-site solutions that effectively conserve and stabilise historic fabric. To achieve this there must be adequate-

- professional and technical specification, planning and management of the works
- craft skills to carry out the work
- a critical understanding of the behaviour of the materials used by all involved

In the general building industry, there is currently a distinct lack of understanding of traditional materials and how to use them. In a pioneering approach during 1994-95, Historic Scotland, through the Scottish Conservation Bureau, offered a one year Internship in the repair and conservation of historic buildings. The post was based at various sites in Scotland where the intention was to provide a breadth of understanding and experience. The post holder worked under the supervision of Historic Scotland and in conjunction with a graduate general builder and a Society for the Protection of Ancient Buildings (SPAB) fellow. The successful candidate received practical project-based experience and training in building repairs; the renewal and preservation of renders; and in the preparation of traditional mortars and other lime treatments. The programme also covered an assessment of the deterioration process of buildings, and the ethics of repair. On successfully completing the programme, the intern has since set up a commercial business thereby fulfilling the objective of increasing the available knowledge base in the private sector.

Conservation as repair and maintenance

For statistical purposes, practical conservation work at its more basic level is commonly categorised, and incorporated, in the *repair and maintenance* sector of the construction industry. The significance of this grouping becomes considerable when, in the UK, the acknowledged split between "repair and maintenance" and "new build", in terms of total construction expenditure, is commonly found to be on an equal 50/50 split. This trend has now been held at these levels for some time and it is anticipated that the balance will rise further in favour of repairs and maintenance needs. Certainly, if Eastern European countries are considered the present split is 70/30, if not higher.

Conclusion

Currently few, if any, Institutes incorporate ICOMOS (or any other) Guidelines in undergraduate or technical college curriculum subjects because, in the main, they concentrate on new build training and education. Given the industry statistics, it could be argued therefore that the need for conservation training and education is much greater than the existing establishment provides. In this sense the COTAC initiative, which spans the full range of industry interests, is all the more critical. Presently, it offers the only integrated practical way to address this inadequacy.

However, this overall strategy will fail if difficulties are still to be found as to where to obtain appropriate traditional building materials to effect good quality maintenance, repair and conservation works. The physical success, or otherwise, of a completed conservation scheme centres on the ability to ensure an adequate supply of all relevant traditional materials and the availability of properly trained craft skills to work them. Fail on any one aspect and the inferior quality of the finished project is liable to compromise the value of the whole.

Partnership involvement is critical if this approach is to succeed. The need is to work in conjunction with others who have mutual aims and objectives. Those presently working in this field have a unique, but awesome, responsibility. However, their direct involvement is only of a transitionary nature when compared to the age of much of the built heritage. If we manage to achieve a balanced approach, and make the correct decisions, those in the future will applaud us for it. If we fail in this regard we run the risk of altering the evidence of history and of creating an unjustifiable hybrid for future generations.

To help prevent this, a better appreciation and understanding is required across the range of all associated disciplines. By its longevity, our existing built heritage well illustrates how traditional building materials can readily satisfy a wide range of requirements. What is now needed is a strategic integration of industry, educational providers, and client awareness to recognise this gain. Currently, with all the range of initiatives and activities that we have in place, we are faced with a window of opportunity. It should not be lost, for it could readily encourage an essential, and comprehensive, revival of the building industries conservation sector.

TRAINING AND EDUCATION IN THE USE OF TRADITIONAL MATERIALS- THE COLLEGE PERSPECTIVE

John Macdonald, Head of Building, Edinburgh's Telford College

INTRODUCTION

The Scottish Construction Industry has a proud history of training, it represents 9 % of the mainland Britain construction workforce and 9% of GDP but is responsible for 18% of the training carried out across mainland Britain. The industry in Scotland has recently taken far reaching decisions regarding the training of its workforce. The first of these was to retain a time serving apprenticeship system when Government was encouraging employers to move to a competence based system with no time serving element. The Scottish construction industry did not ignore the competence based approach but incorporated it within the traditional apprenticeship by working with SCOTVEC, now SQA, to introduce a competence based modular system of training, the final element of which was a trade skills test.

The industry was supported throughout this and represented by the Construction Industry Training Board, (CITB). Programmes of training were based on a National survey, (NTI) conducted by CITB to ascertain the specific areas of training required by the different sectors of industry. The nature of this survey and the range of employers involved meant that it addressed the training requirements of a modern industry covering all aspects of ongoing work only a part of which related to traditional building materials but the inter-relationship of techniques was and still is vital.

Reacting to this survey development teams were established for each trade working for and under the direction of SCOTVEC to produce a range of module descriptors, specific to the training requirements of each trade as indicated by the NTI document. Each trade development team, which comprised representatives from employers, CITB, unions and colleges, produced a programme of module descriptors covering a comprehensive range of practical skills and core subjects.

These descriptors form the basis of all construction Scottish Vocational Qualifications, (SVQ) to level three. It is a condition of achieving tradesperson status for trade apprentices to successfully complete all modules within a trade specific programme and to pass the trade skills test thereby gaining a Scottish Vocational Qualification level three. Consequently every trade apprentice who achieves tradesperson status will have experience and knowledge relating to a comprehensive range of trade skills and techniques. The very nature of this programme of training means that trade apprentices are introduced to some very sophisticated techniques early in their apprenticeship and, in certain circumstances, this may be the only opportunity for them to experience some of these skills and techniques. It is often discovered that apprentices attending for trades skills tests towards the end of fourth year of apprenticeship have already lost some of the skills at which they were assessed as being competent some two years earlier. This is down largely to the restricted nature of their work experience since leaving college. There is a constant need for programmes of skills updating within the working lifespan of many construction workers.

Inspection of current trade programmes at National Certificate level, which have been recently re-drafted for introduction in Session 1997/98 shows a good balance of skill and core aspects. The range cover by a student in stonemasonry, for example is:

Skill Units

Unit Title	*Hours*
Cutting Straight and Circular Mouldings with Obtuse Angled Returns	60
Snecked and Random Rubble Walling	40
Stair and Step Construction	20
Surface Finishes for Stone	40
Cutting and Building Wrought Stone	40
Concrete Practice and Paving	20
Cutting a Straight Through Moulding	40
Cutting a Plane Surface on a Block of Stone	40
Cutting a Return Head	40
Forming Openings in Stone Composite Walling	40
Returning Mouldings to Masons Mitres and an Ashlar Stop	40
Building Solid Ashlar Walling with Return Corner	40
Setting out and Building Masonry Arches	40

Fixing Natural Stone Cladding	40
Building Circular and Battered Rubble Walling	40
Cleaning and Restoring Stonework	40
Total	620

Core Units

Scaffolding Appreciation and Use	20
Construction Drawing 1	20
Construction Drawing 2	20
Introduction to Building Craft Science	20
Building Craft Science: Atmospheric Pollution and Thermal Properties	20
Craft Projects	60
Construction Studies	20
Total	180

The total of 620 hours for skill unit training represents the practical activities and supporting theory with an approximate 80% - 20% split which indicates that a stonemasonry craft apprentice would spend approximately 500 hours on practical skills training most of which would be in traditional materials and techniques. The total time spent in college be a craft apprentice to National Certificate level is twenty weeks in year one with a further twelve weeks in year two which represents a total of 1042 hours. A high percentage of the 242 hours difference between the SQA recommended time and the programme allocation is also spent in practising practical craft skills. These National Certificate programmes are completed over the first two years of the trade apprentices' training programme and should be supported and complemented by the work undertaken during employer work placement. The depth of knowledge and practical experience will, therefore, vary greatly between apprentices dependent upon the nature of work undertaken by their employer and, in particular, the attitude of his/her site colleagues and the employers training programme.

The opportunity exists for apprentices in most trades to augment the National Certificate training through the SQA Advanced Units programme. These programmes are largely practical in content and are designed to extend the students' skill and knowledge within their own craft area. The programme for stonemasons, for example, includes; Tracery Cutting, Interpenetration and Raking Mouldings, Cladding, Restoring, Preserving and Conserving Stonework, Machine Production of Stone, Drafting Stonemasonry Details, Bay Windows and Circles in Stone.

It is up to employers and educationalists to retain this level of training but it concerns me greatly when decisions such as removing sash and case windows from the windows unit in carpentry and joinery goes through virtually unchallenged. Where else will many apprentices have the opportunity to understand the manufacture, workings and repair of these windows?

Another important decision taken by the Scottish Industry was to retain a college based programme rather than a work based model for their apprenticeship training The broad range of skills encompassed within any of the trades programme and the level of supporting assessment required could be difficult for many employers to guarantee. Many apprentices would be deprived of the opportunity to experience many aspect of the relevant SVQ because of the nature of their employer's work programme. The movement of apprentices between contracts imposes difficulties relating to responsibility for assessment and verification and for virtual ownership of the apprentice and his/her training programme. It was for these reasons that industry recognised the advantages of a college based system and also recognised the benefits of extending the time allocated to college training, beyond the basic time requirements of the modular programme, to reinforce particular elements of skills training. Latest indications are that the industry will move either partly of wholly to a work based SVQ sometime in the future.

There are advantages in work based assessment. Trainees/apprentices can be assessed in realistic working conditions on full scale operations. Good colleges strive to attain realism but restrictions of costs, space and time are imposed and therefore affect the reality. A good apprentice working with a good craftsperson, who has the time and dedication, working on a relevant project will gain experience that colleges can only hope to attain, but the college environment can replicate such experiences again and again and dedicate the time to the learning experience

TRAINING IN THE USE OF TRADITIONAL MATERIALS

The content of the individual trade National Certificate programme retains an element of the knowledge, skills and techniques required for working with traditional building materials but it was recognised that a gap existed for training craftspersons in conservation, building maintenance and repair activities.

Further Education establishments were first alerted to this by the activities of the Blackburn House Trust and the drive of that organisation to establish an HNC in Conservation. Their motivation was anticipated impending EC legislation relating to the employment of labour on work in listed buildings. Indication at that time were that only contractors employing personnel at management and operative level holding relevant qualifications in conservation/maintenance and repair would be invited to tender for such work. The question asked was do we await the legislation before training or start training in anticipation of the legislation. The Blackburn House Trust opted for the latter, their concept was excellent, take a run down property of some historic significance and use that as the medium to teach the conservation/building repair ethic. The property was ideal, encompassing as it did work for a wide range of trades but it required people with existing skills, knowledge and techniques to begin to understand and be able to undertake the execution of the work. Commencing as they did with a group of unemployed non-building personnel and hoping to raise their skills level, over a wide range of trades showed little respect or understanding of the complexities of each trade. The project may have failed but the seed was sown.

Training, almost inexplicably, commenced at HNC level and attracted recruits with management rather than practitioner aspirations. Very few of the early recruits came from a trade background and therefore lacked the necessary skills to become involved in the practical aspects of any future site operations. The HNC in Conservation is now well established and efforts should be made to encourage and attract skilled young craftspersons to this career path. Each year, through the education and training programme, we produce a raft of excellent craftspersons in most relevant trades. A few return to college to further their career on a part time basis by attending courses such as HNC Construction Practice and then progress to supervisory/junior management positions in industry. It is vitally important that such potential students are given awareness of the need for conservation and building repair and given the opportunity to direct their future career path accordingly.

There are many excellent young operatives whose strengths lie in their practical skills and efforts must be made to attract such people and their employers to see the advantages of improving their expertise in the fields of conservation and building maintenance and repair. Imagine a project similar to the Blackburn House programmed and financed with a team of young proven craftsmen in stonemasonry, plastering, carpentry and joinery, roofing and painting and decorating. The long term benefit to the individuals and the industry is incalculable.

The need to raise understanding of conservation and building maintenance and repair at an earlier stage in the educational programme was also recognised. The gap at National Certificate level has been addressed by the recent introduction of a course in Building Maintenance and Repair. It is envisaged that this course will attract school leavers with an interest in building conservation and who wish to achieve a relevant qualification to allow them to seek employment within the relevant sector of industry from a knowledge based on basic practical experience rather than a specific practical trade background. The full time one year course has been devised to give students practical experience in certain trade skills supported by a good knowledge of maintenance and repair and conservation. It is envisaged that such students would progress to the HNC Conservation to complement students from the craft apprentice route.

The relevant question relating to this whole programme of courses still relates to the legislation concerning the use of qualified labour on listed buildings. Colleges are now in the position to provide the training for recruits to the industry to establish a good understanding of the use of traditional building materials will industry continue to demand and support such courses without the legislation?

The Building Department of most colleges realise that the need for training continues far beyond the traditional apprenticeship period and strives to address this by retaining close contact industry. The important link with CITB is supported by direct contact with employer organisations representing the individual crafts and with organisations like Historic Scotland. One very important element of any ongoing training programme is the short course programme. This programme of courses enables the college and industry to work together to initiate training specific to short term labour supply shortfall. The use of certain traditional building materials can demand very specialist high level skill and knowledge, in certain circumstances a skill that is retained by relatively few practitioners. Colleges can provide the resources and contract the specialists to provide the training opportunity for employers and operatives to ensure the retention of and future development of such skills.

In summary I would suggest that, through the activities of CITB, current training programmes are addressing the general training needs of the construction industry in Scotland and that this addressees the immediate training needs of new entrants relating to traditional building materials. I would also suggest that through the interface with Historic Scotland that the industry at large and colleges and other training organisations in particular are aware of the need for a constant review of the ongoing training needs relating to traditional building materials.

EDUCATION AND TRAINING IN CONSERVATION FOR SURVEYORS

Stephen Boniface, Sole Principal, Boniface Associates

Background

No professional body in the world includes Conservation as a core subject in its basic/undergraduate training. Few include it as an optional module. Most training focuses on modern technology, materials and methods of construction.

In the early 1980's Surveyors were being criticised for their role and detrimental impact on historic buildings. Why Surveyors and not other professions is something I have never understood as we were all guilty of failing to provide adequate training to our members. However, the criticism created an impetus within the RICS to do something about it.

The RICS Building Conservation Group

In 1987 the Building Conservation Group was formed by a number of Surveyors concerned about the criticism and wanting to ensure that Surveyors were gaining appropriate input. This year we shall be celebrating our 10th anniversary in November at the Historic Houses Association annual conference.

Over the years the Group has provided many training days on a variety of subjects including; lime, thatch, timber frame repair, lead etc. There have been a number of interesting visits to see work in progress on prestigious projects. In addition, the Group produces a journal that is published three times a year. This includes a mixture of news, learned articles and information.

Until now the Group has only been open to Surveyors but this year it has been decided to open membership of the Group to other professionals.

The RICS/CEM Diploma Course

The RICS Building Conservation Group recognised the need to provide more in-depth training than could be achieved on day courses, etc. In conjunction with the College of Estate Management at Reading, the Diploma in Building Conservation two-year course was inaugurated in 1990. The course directors were Stephen Bond and John Gleeson - who had met whilst undertaking the Architectural Association Course.

Until then the AA course was the only in-depth training open to the professions and this was a limited course designed primarily for Architects. The RICS/CEM course was therefore the first of its kind - leading the way for the many courses we now see.

It has always been a post-qualification course and was initially intended for Surveyors only but is now open to all professions - as witnessed by the high numbers of students from other professions now undertaking it. It is a distance-learning course spread over two years. It includes the need to complete a number of assignments, an exam at the end of each year and a dissertation at the end of the second year. I believe that it is still the only distance-learning course (others tend to be day-release courses).

The course has been acclaimed due to its high standards and it is continually being re-assessed. Over the next few years it is hoped to expand to incorporate the option of a Masters course.

RICS Accreditation

Some years ago there was a need for Surveyors to show that they were capable of undertaking conservation work on major projects. This was linked with the RICS successful attempt to gain recognition for Building Surveyors to officially undertake work under the Care of Churches and Ecclesiastical Jurisdiction Church Measures.

A scheme was devised in order to try and establish whether Surveyors had the appropriate background and experience to undertake work on prestigious conservation projects. The scheme requires the applicant to submit details of five projects. These are then assessed internally. Provided the internal assessors consider the applicant demonstrates sufficient experience in the projects submitted, the application is then passed to one of a number of external assessors (today's Conference Director being one of them).

Passing the assessment results in being listed as accredited. Failing to pass this will usually result in being listed on Appendix A of the scheme. Appendix A is intended to list those who are recognised as having reached a high level but not quite the level required for full accreditation.

The scheme is constantly under review in the hope of improving it. To date the RICS is the only profession to put its members through such a vigorous system but I understand the others are considering a similar scheme.

The RICS Building Conservation Practice Panel

Some years ago the RICS underwent changes to its internal organisation and set up a number of Panels to specifically concentrate on various topics. Membership of a Panel is open to any Surveyor having an interest in the topic or specialist knowledge that might assist the panel in its work.

It was a straightforward transition to develop a Building Conservation Panel from the RICS Building Conservation Group. The two remain inter-linked but the Group is a separate entity from the Panel. The Panel was set up in 1992 and serves a number of purposes.

The over-riding aim of the Panel is to continue to develop professional standards in building conservation and the use of competent Chartered Surveyors in such work. This is achieved by:

- the creation, continuance and improvement of the accreditation scheme,
- identifying training requirements and how best to meet these,
- dissemination of information and knowledge,
- making representations on consultative documents, legislation and standards,
- responding to requests for advice,
- networking within the RICS and externally wit English Heritage, the amenity societies and other professions.

Output over the years has been quite extensive. We have had representatives involved with the writing of PPG 15. Others have been involved with the thorny issue of a British Standard. With English Heritage we have written guidelines regarding the insurance of historic buildings. With English Heritage and the Department of National Heritage (as was) we commissioned research into various valuation related matters - the 'Investment Performance of Historic Buildings', the 'Value of Conservation' and the 'Social and Economic effect of Listing'. A working party was set up a couple of years ago to consider the issue of mortgages on historic buildings, to identify problem areas and how to resolve conflicts. We have had input into a number of RICS publications, official guidance, etc. More recently we have produced a training cassette and have embarked on a number of technical guides (published within the Group's journal). Several of our members have had articles published within the RICS and within the professional press generally. Members have been involved in several TV programmes and magazine articles. The one thing we have never ceased to pursue is the matter of VAT on works to historic buildings and the issue of other tax incentives for owners of historic buildings.

From the above you will appreciate that the RICS Building Conservation Practice Panel is very active and I am told that its workload is believed to be on the highest of all the RICS Panels.

The Future

I have already mentioned that several areas of work are constantly under review. The accreditation scheme is being improved. The Diploma course is to develop to include a Masters option.

There are a number of ongoing works. The Group continues with its publication of the journal three times a year. There are the day courses, visits and conferences that the Group organises. We also provide speakers for conferences run by others both within the RICS and other professions.

We are presently organising a marketing campaign to improve the profile of Surveyors within conservation.

Within the next few weeks we are meeting with Directors of several under-graduate Surveying courses to discuss how conservation can be incorporated at the earliest opportunity in a Surveyor's training.

We are working with the BCIS to develop guidance on insurance re building costs for historic buildings to assist Surveyors having to assess the reinstatement value for insurance purposes.

A series of articles are planned to be published within the RICS regarding conservation topics, particularly aimed at Valuers.

We are working with the Television Education Network to produce a number of training videos.

A series of technical guides are presently being written and will be published with the Group's journal but will also be available separately.

A conference is being organised to consider the future of thatching in this country and how its future may best be protected. The aim is to bring together scientists, academics, conservationists, property professionals and thatchers in an attempt to discuss differences and resolve conflicts that are slowly destroying the industry.

Work is underway to set up an inter-professional forum to jointly promote greater awareness of building conservation issues.

We have been supportive of the Association of Conservation Officers in the transition to the Institute of Historic Buildings Conservation and we look forward to working closely with them in future - a number of our members sit on their working parties and most of use are members of the IHBC.

Next month a number of us will be attending an architectural field trip to Tuscany, Italy. If this is successful others may be organised in future.

In the past their has been an air of competitiveness between the professions - most notably between the RICS and RIBA. Perhaps it is time to recognise that we each have different skills to bring to conservation. It is not true to state that any architect or surveyor could undertake conservation work. Neither is it true to state that an architect or surveyor experienced in conservation is capable of undertaking all the varied fields of work that conservation of buildings can involve. It is time that we work together. This is happening on a small scale in the real world - I and other of my Surveying colleagues regularly work with Architects and other professions because we recognise that our skills are complimentary.

There is a growing awareness of conservation issues amongst the general public. There is a need to ensure that all of our professions have an improved knowledge of conservation and that we work together to compliment each other.

EDUCATION AND TRAINING IN CONSERVATION FOR ARCHITECTS

Sebastian Tombs, Secretary & Treasurer, Royal Incorporation of Architects in Scotland

1 INTRODUCTION

Since 1958 the education of architects has been predominantly within an academic structure, combining the development of knowledge through lectures and written work, with the development of design skills principally through studio-based project work. This latter aspect is seen as the key ingredient to successful design education. Five years of academic work, with two years of practical training are required prior to eligibility to sit the professional entry examination (RIBA Part III), and Registration with the Architects Registration Board (previously ARCUK).

Opportunities therefore exist throughout that education process for the introduction of conservation issues, and the honing of design skills in existing buildings and structures.

Thereafter, continuing experience of conservation issues, supplemented where appropriate by more focused CPD activity had, up to the late 1980s, been viewed as sufficient. Since then, the debate regarding the need for specialist skills, particularly when dealing with the country's most significant heritage structures, became more serious and the Incorporation embarked on an accreditation process.

2. ETHICS & PHILOSOPHY

2.1 ICOMOS

The fundamental guidelines on education and training in the conservation of monuments, ensembles and sites, agreed in August 1993 at Colombo, Sri Lankra, provides the underpinning philosophical approach that informs the development of education and training courses. These emphasise the need for appropriate information gathering, development of understanding of the issues, technical abilities, and the ability to make balanced judgements based on shared ethical principles. No mention is made with regard to issues of design specifically.

2.2 Council of Europe

In a statement by the Committee of Ministers in 1980, the Council of Europe was recommended to refer Member States and their authorities, to a set of "principles regarding the specialised training of architects, town planners, civil engineers and landscape designers", with particular regard to the conservation of the architectural heritage within Europe.

This 27-point statement reinforces the proposition that conservation cuts across disciplines, and should not be seen as a narrow specialisation.

Indeed, the document recommends training begin in primary and secondary schools "which should encourage a sense of observation, the perception of space, a critical spirit, creativity, awareness of social interdependence, a pride in past values and respect for the environment". These principles are reiterated at university level, and it is suggested that a common core be established for the four disciplines directly concerned, demonstrating that each is "but partial", and to foster the adoption of a common language.

Critical to what is termed "this education reform" is the setting out of three subject areas:

(a) Modes of perception of space;
(b) The history of the heritage and of civilisations;
(c) The relationship between man and his environment.

The document argues not for encyclopaedic knowledge, but for the intelligent application of methods taught. Indeed the approach "should go well beyond the framework of curricula, as it is mainly of an ethical kind".

Prior to looking at specific principles regarding each of the four disciplines, and the need for refresher training, the statement emphasises the special attention required in the selection of teachers, "capable in the face of the vast quantity of information, of choosing the most instructive type of material and keeping a sense of what is essential".

2.3 Three components

In addressing an ICOMOS Training Committee meeting on Conservation Training - Needs & Ethics in 1995, Dorothy Bell of the Scottish Centre for Conservation Studies, Edinburgh College of Art pinpointed three critical components:

(a) The identification of the task (the concept)
(b) The particular mental process which must be gone through to achieve the resolution of that task; and
(c) The information employed in carrying out the task.

She states that the mental process itself is universal, invariable and constant, and constitutes the ability to play with abstract concepts and three-dimensional forms simultaneously, and to make immediate connections from one to the other. In addition, it includes the capacity to adapt and adjust to adverse circumstances without losing sight of or abandoning the main objective; and the ability to plan each move towards achieving its end by whatever route is appropriate in the particular circumstances.

Essentially, she states, "conservation is not a mechanistic pursuit, but primarily a creative task within a rigorous ethical framework".

Thus she sees the conservationist's skill as translating cultural significance into its physical form, in pinpointing the factors which are eroding the cultural significance - be they physical, social or aesthetic; in understanding their nature (or finding specialists who do); and in designing a minimal solution to the problems of slowing that decay - a solution which may be social, financial, physical or a combination of all three.

Interestingly, she states that the mental skills needed to practice conservation are almost identical to those of architecture - and this discipline has a tried and tested educational method already in existence.

3. UNDERGRADUATE/GRADUATE EDUCATION & PRACTICAL TRAINING

3.1 Traditionally architects are educated for three years, followed by a practical training year, two further academic years and a final training year.

3.2 Three of the six Scottish Schools of Architecture responded to an enquiry regarding the integration of conservation studies into their educational programmes, and the following paragraphs are drawn from their remarks:

Generally, conservation is not seen as a distinct topic. The theory of materials and construction is introduced in the early years, and increasingly that is being done in some schools in an historical fashion, comparing practice over recent centuries with current practice, and a discussion of principles involved.

Opportunities are taken, of course, for studio work to address issues of existing buildings, but it appears that conservation as a distinct topic only occasionally in the curriculum prior to third year.

3.3 Robert Ferguson in his response from Strathclyde, laid out clearly the structure of the Conservation Special Study run as a third and fourth-year elective class. Approximately 75% of students have passed through it over the past 8 years - consisting of 25 hours of lectures and 25 hours of project work or research. The topics covered are included in appendix 1. That initiative was followed in the early '90s with a Conservation & Rehabilitation Design Unit in 3rd and 4th years. The format is enclosed as appendix 2.

3.4 Equivalent approaches are adopted at other Schools, and in Honours year, students may have an option to select a given project which will contain conservation issues; students may also choose a conservation elective.

At the Robert Gordon University, Aberdeen, the Post Graduate Diploma/MSc in Advanced Architectural Studies runs a Conservation Unit which concentrates on a conservation project and exercises students in the preparation of surveys, measured drawings, a full evaluation report and drawn proposals with specifications. This is done with the help of staff who are experienced in conservation, and draws upon the experience of other experts in the field, including research which has been carried out in the School and Faculty.

3.5 At Duncan of Jordanstone College, Dundee there is a linked MSc course in Conservation & European Urban Design in the School of Town & Regional Planning. Here it is the 2nd and 3rd years in which a major building programme addresses an existing building, with input both from the MSc course, supplemented by lectures on conservation, the Burra Charter, and attitudes to change in conservation. A conservation option is being contemplated for 4th year, to focus on the reinhabitation of ancient ruins. Often in 5th year, a project involves the re-working of an existing building (e.g. Linlithgow Palace).

Similarly to other Schools, the subject of dissertations is often encouraged towards conservation issues (one of which is addressing how to conserve inter-war buildings given their particular materials and functions).

3.6 The years of practical training may well involve experience of dealing with existing buildings, and some students choose to seek employment with practices known for their conservation skills and workload.

3.7 Thus, at the end of an academic process, and at the point of registering as an architect, the general abilities should be in place relating both to design disciplines, and a basic grounding in conservation ethics and understanding.

3.8 The Scottish Centre for Conservation Studies at Edinburgh College of Art, remains as one of the four centres running courses exclusively on conservation. Sadly, it is mostly populated by graduates from outwith the UK. However, it aims to be integrated physically with the mainstream architectural school, encouraging discussion and studio debate.

4. CONTINUING PROFESSIONAL DEVELOPMENT

4.1 The Incorporation formed its Conservation Working Group in 1987. It has highlighted issues for development and presentation to the membership generally on specific conservation issues, through CPD.

4.2 Numerous events have been held since the mid-'80s on conservation-related topics, and as the issue became more widely discussed, it was agreed that the quarterly Practice Information, a subscriber service for practices in Scotland, should include a section on conservation which, like accreditation, commenced in spring 1995. Initiatives have also been taken with other professional institutions, such as the RICS.

4.3 The Robert Gordon University is offering its MA in Scottish Architectural History, and its MSc in Heritage Management in a part-time mode, with the intention that practitioners can gain these qualifications in stages by attending short courses. In June 1997 the University hosted a course of American students from Mary Washington College and this was also attended by some Scottish architects.

4.4 The Conservation Lecture Series (Masterclasses) at the Edinburgh College of Art have also proved a popular way for practitioners of many disciplines to keep up to date with conservation developments.

5. RIAS ACCREDITATION

5.1 Following the initiative of the RICS, and recognising the desire by government agencies and major clients for reassurance regarding the expertise of those undertaking work in important historic structures, the Incorporation decided to embark on a process of accreditation in building conservation - initially as a pilot. This was inaugurated in 1995, and provides for 4 levels of externally-assessed skill in conservation. Appendix 3 provides a set of application documents, itself setting out the full classes of accreditation.

5.2 Essentially, the process involves the submission by the applicant of evidence regarding 5 conservation-related projects, demonstrating the applicant's expertise, judgement employed and role in the project, alongside evidence of continuing professional development. Projects should ideally have been undertaken in the 5 years immediately prior to the application date.

5.3 The applications are assessed initially by an internal panel comprising the Chairmen of the Conservation Working Group, Practice Committee and CPD Committee; followed by an external panel, currently comprising representatives of the National Trust for Scotland, the Scottish Civic Trust, and Historic Scotland. At present, all assessors are architects. The assessment panel reserves the right to consult clients, or visit buildings, although this has not yet been found to be necessary.

5.4 In reviewing the accreditation process, the 5-year limit is likely to be a subject for discussion - some members, particularly those from smaller practices, have felt some injustice where their workload for a variety of reasons has not yet included sufficient conservation projects to enable an individual to seek accreditation. There is also a "catch 22" difficulty for some individuals - how can you ever become accredited if you can never get the work?

6 CONCLUSIONS

6.1 The Incorporation, encouraged by a growing awareness of the issues involved in conservation work, has developed its assessment criteria, and accreditation is now becoming more widely accepted as a form of recognition of expertise. Certainly clients appear to be becoming more conservative in seeking reassurances about the abilities of the architects employed in practices. The Incorporation is happy to promote the achievement of individuals who have been accredited through its Directory.

6.2 It seems likely that such recognition, and methods for assessing it, will become more widespread in future. The equivalent or consequent accreditation of practices, rather than individuals, is a difficult topic, and although raised regularly by members in correspondence, has not yet been seriously addressed by the Incorporation. I understand that the idea has been mooted by the RIBA, however.

6.3 The Incorporation will continue

- to encourage an integrated approach to conservation in the Schools of Architecture;
- to implement elements of CPD through events and Practice Information, and
- to seek to widen the number of members with accredited conservation skills.

APPENDIX 1

UNIVERSITY OF STRATHCLYDE'S TRAINING OF ARCHITECTS IN ARCHITECTURE: CONSERVATION SPECIAL STUDY: 3RD & 4TH YEAR ELECTIVE CLASS

1. Legislation

Listed Building legislation

Building Regulations

Financial difficulties and sources - mortgages, surveyors etc

Historic Scotland, etc

2. Design Theory & Approach

Discusses the view of architects in Scotland and England and compares them with recent work in Scandinavia, Italy, Spain and Eastern Europe. Based on Case Studies.

3. Technicalities

An introduction to masonry, random rubble, lime mortar, their drawbacks and advantages. Timber, dry rot, wet rot, woodworm etc.

4. A Design Approach

Case Studies and visits to the tutor's projects. The spirit of the place, briefing clients, searching for the "transformation key".

The nature of materials, imagery, furnishings, lighting, natural light, etc.

The final project is always based on a building at risk with prospective clients and their brief. In many cases student work has led to the potential of the building being realised and a project will then go ahead.

APPENDIX 2

UNIVERSITY OF STRATHCLYDE'S TRAINING OF ARCHITECTS IN ARCHITECTURE: CONSERVATION & REHABILITATION DESIGN UNIT: 3RD & 4TH YEARS

Note: lecture course and project work can run in parallel.

The course consists of a 12 week semester in which students are required to survey and draw up a building usually taken from the Civic Trust "At Risk" Register, or supplied by local authorities. A brief is then drawn up in consultation, and a design prepared. Finally students investigate a technical aspect of the design, usually the meeting between existing and new fabric.

(The success of the project may be gauged from the fact that within the 5 years since SPAB set up the Philip Webb Prize, Strathclyde students have won it three times and been 1st-equal once)

APPENDIX 3

ACCREDITATION FOR CHARTERED ARCHITECTS IN BUILDING CONSERVATION

APPLICATION FORM & GUIDANCE NOTES

THE ROYAL INCORPORATION OF ARCHITECTS IN SCOTLAND

CLASSIFICATION

GUIDANCE NOTES FOR APPLICANTS FOR ACCREDITATION IN BUILDING CONSERVATION

These notes are to be read in conjunction with the application form for the RIAS Accreditation for Chartered Architects in Building Conservation procedure approved by RIAS Council in November 1994.

1 INTRODUCTION:

Those responsible for historic buildings are increasingly seeking access to specialist services in connection with the maintenance of fabric and contents, and for works proposed thereon. In particular, funding agencies, especially those disbursing taxpayers' money, are seeking reassurance that those employed to prepare projects, have the appropriate qualifications and experience.

The RIAS, after consultation with colleagues in the industry and responsible client groups have developed an accreditation scheme for its members as individuals. The accreditation relates to the demonstration of a high level of conservation skills, rather than to a sympathetic design approach to monuments, buildings or structures which are Listed.

It is anticipated that over the years, accredited members will be listed in a separate directory or register, and it seems likely that funders may make it a prerequisite of grant aid under certain circumstances, that the work be overseen by accredited professionals.

2 GENERAL PROCEDURES:

Applications submitted by members will be subject initially to scrutiny by an internal panel composed of the three Chairmen of the Practice Committee, CPD Committee and Conservation Working Group. Those successfully clearing this stage will then be submitted to an external panel composed of nominees from bodies such as the Scottish Civic Trust, Historic Scotland and the National Trust for Scotland.

While it is not possible to give firm indications about the frequency of meetings, until the take up of the scheme is known, it is anticipated that, once established, applications would be assessed on a quarterly basis, and once approved will remain valid for a period of 5 years.

Where an application is, for some reason, not considered acceptable, the applicant will be advised of the reasons, and offered guidance on what steps should be taken prior to re-submitting. In the case of an application failing on the second attempt, should the member feel sufficiently aggrieved to appeal, such an appeal would be referred to the President to request an independent report on the adequacy of the procedures adopted in that particular case.

Of course members' comments on the procedures and their implementation would be welcome, particularly in the early stages of the scheme.

3 SECTION A:

Personal details:

Contact addresses: please include both home and workplace address, and mark which you wish mail on this subject to be forwarded to. A short CV could also be useful.

Other details:

Please specify information which is relevant to this Accreditation, rather than general information.

Length of relevant experience:

Normally a period of 10 years' from Registration would be considered appropriate, but exceptions may be made where, for example, an architect completed a postgraduate course in conservation and has been working consistently in that area of activity since registering.

Geographical areas of experience:

This should include different areas within Scotland, where conservation practice and traditional forms of construction may vary. Experience outwith Scotland will, of course, be of relevance, where achieved in the conservation sector (but note that no more than one project submitted should be outwith Scotland).

Class of Accreditation sought:

The classes of conservation work (extracted usefully from the RIBA 1990 Appointment related to such work) are set out on page 6.

Applicants should state clearly the class of work to which they wish to be accredited.

Experience/client List:

A full page has been allowed for this but, as with other elements, supplementary sheets can be submitted.

Please note that the Assessment Panel may wish to contact a limited number of more recent clients listed.

4. SECTION B:

Brief description of 5 projects:

Each project should have reached completion. In large phased projects, however, where individual buildings or groups of buildings are themselves complete these could form part of a submission related to that project.

Please photocopy pages 10, 11 and 12 and submit one set for each of 5 projects undertaken in the last 5 years. Where possible these should show a spread of experience and building types.

Age of Building/Site:

Attach extract from Statutory List, where available. In other cases, please insert date of original building. Reference should also be made to any advance study of the building or research on its history or related archaeology.

Class types 1-5: are outlined on page 6 of the form. Where a particular class does not encompass the scope of the work adequately, please clarify.

Applicants should state in Part A, the appropriate class of work to which they wish to be accredited.

Role of individual/practice/organisation:

Parts III and IV are designed to identify clearly the role of the individual, and the practice within each conservation project. In most cases it is expected to read Architect and lead consultant; and details of other firms involved are requested.

The role of the individual recognises that valuable experience can be gained at all levels in practice from assistant through to partner/director.

Both parts require a statement regarding the conservation strategy adopted and decisions taken, although there may well be overlap between these. These should be specific to each project, and should illustrate the exercise of professional judgement. Documents or publications referred to could usefully be listed.

Appraisal of project:

This is important, and should be completed by the applicant regarding his or her own assessment of the success of the strategy as implemented, and any awards achieved.

Photographs:

Photographs of the project showing 'before' and 'after' images from the same vantage point, and showing specific details, can assist the panels assessing applications. This is not a mandatory requirement however. No more than 6 photographs per project would be helpful.

5 SECTION C: PRACTICE/COMPANY DETAILS

This is included as a separate section because experience may be gathered by applicants within different practices. If experience is gained within a single practice, please photocopy the sheet but attach a copy to each project number.

Please return the application forms with a cheque for £100.00 to the Secretary, RIAS, 15 Rutland Square, Edinburgh, EH1 2BE.

CLASSES OF BUILDING CONSERVATION WORK

CLASS 1
Work where one particular repair element predominates and is of a straightforward nature (e.g. large area of re-roofing).

CLASS 2
Work of general repair which does not include a great deal of internal alteration.

CLASS 3
Work of general repair and alteration where the alteration work is a substantial part of the contract and which requires good historical understanding and design ability.

Repair work where the services installations in the building are to be renewed or replaced.

CLASS 4
Work with a high content of specialist conservation work which requires a great amount of detailed specification and inspection work by the professional conservator in charge.

CLASS 5
Work on engineering structures.

IMPORTANT NOTE:
The RIAS Accreditation relates to the above classifications of work. It is therefore important that the applicant can demonstrate consistent achievement in the highest class that is sought for accreditation.

Applicants are asked to complete all sections of the form in block capitals in the space provided. Details of five building conservation projects should be completed on the forms enclosed and all supporting documents should be clearly marked with the appropriate number. If space is insufficient, please append further information separately. Applications which follow this format, on applicants' own word-processed forms are also acceptable.

SECTION A PERSONAL DETAILS

(Please circle preferred mailing address: [H] [W])

SURNAME FORENAMES

HOME ADDRESS WORK ADDRESS

POSTCODE POSTCODE

TELEPHONE NUMBER TELEPHONE NUMBER

DESIGNATIONS/QUALIFICATIONS

(tick) RIAS FELLOW [ ] ASSOCIATE [ ] MEMBERSHIP NO [ ]

POSTGRADUATE OR OTHER RELEVANT COURSES (Include CPD & Short Courses)

LENGTH OF RELEVANT EXPERIENCE IN PROFESSIONAL CAPACITY

GEOGRAPHICAL AREA(S) OF EXPERIENCE

CLASS OF ACCREDITATION SOUGHT [1] [2] [3] [4] [5] (Please circle)

MEMBERSHIP OF OTHER RELEVANT BODIES/SOCIETIES

SHORT CV SUBMITTED: YES/NO

SECTION A:

BRIEF SUMMARY OF BUILDING CONSERVATION EXPERIENCE/LIST OF CLIENTS

SECTION B:

PROJECT NO [1 2 3 4 5] Page 1 Note: Five completed projects to be submitted which have been undertaken in last 5 years.

PART I - DETAILS OF PROJECT

NAME OF PROJECT

LOCATION/ADDRESS

STATUTORY PROTECTION
(Please tick as appropriate)

SCHEDULED ANCIENT MONUMENT [ ] ARCHAEOLOGICAL AREA [ ]

LISTED BUILDING - CATEGORY [ ] CONSERVATION AREA [ ]

AGE OF BUILDING/SITE

CONTRACT PERIOD (dates)

CONTRACT VALUE (if appropriate)

BRIEF DESCRIPTION OF PROJECT
(circle Class Type 1 2 3 4 5) see classification on p6))

DETAILS OF GRANT AID APPLICATIONS

PART II - FULL DETAILS OF THE CLIENT
(Please note that references may be taken up as required)

NAME

ADDRESS

POSTCODE

SECTION B:

PROJECT NO [1 2 3 4 5]

PART III - ROLE OF INDIVIDUAL

POSITION HELD

PART PLAYED BY APPLICANT

APPROACH AND CONSERVATION STRATEGY

DECISIONS TAKEN

SPECIAL SKILLS REQUIRED

OTHER RELEVANT INFORMATION

APPRAISAL OF PROJECT (include assessment on success of the strategy and any AWARDS achieved)

PHOTOGRAPHS: (please list if submitted).

PART IV - ROLE OF PRACTICE/ORGANISATION
(Please complete where appropriate)

POSITION HELD

DESCRIPTION OF SERVICE

DETAILS OF OTHER FIRMS INVOLVED

APPROACH AND CONSERVATION STRATEGY (if not covered above

DECISIONS TAKEN (if not covered above)

PROJECT NO [1 2 3 4 5] Page 3

SECTION C PRACTICE/COMPANY DETAILS
(If appropriate)

NAME

ADDRESS

POSTCODE

TELEPHONE NUMBER

TYPE/SCOPE OF FIRM

NUMBER AND LOCATION OF OFFICES

GEOGRAPHICAL AREA OF OPERATION

SIGNATURE DATE

A FUTURE FOR STONE IN SCOTLAND

Geoffrey Hutton, Senior Partner, Hutton + Rostron

The study was commissioned by Historic Scotland to examine the existing market for dimension stone products, to explore ways in which the stone industry in Scotland might arrest the decline in the use of natural stone in buildings, and in particular the scope for developing new products suitable for modern forms of construction.

The study draws on the experience and data collected as part of a broader investigation of the dimensioned stone industry carried out on behalf of the Department of the Environment and the industry published by HMSO in 1980 as *A future for stone, A study into the potential use of stone in new building.*

The major finding of that study was that the many firms and diverse interests of the stone industry must co-operate to survive. Small units can be highly productive and innovative but, individually, cannot afford the scale of research costs and promotion necessary in today's technical and marketing conditions. This demands collective action. This action in itself will be wasted if it is not matched by prompt delivery of the right product at the right price. The industry has the active interest of many professional and lay people to an extent that might be envied by others. It was proposed that stone should be launched as if it were a completely new product and the government and public encouraged to think of stone when making economic and design decisions.

The building stone industry is in a much fitter state than it was in 1980, the standard of machinery in use is impressive, and there is an air of optimism and activity in quarrying and manufacturing in Scotland. Resurgance in the industry is putting pressure on lead times and will improve margins, but these are factors which quickly limit the market. To expand, the industry must provide specifiers with the information and confidence to use stone. It must ensure that every stage of production up to installation and maintenance delivers the quality inherent in the materials. The development and marketing of standard stone products can provide continuity of production for stock; this will reduce lead times, waste and prices. The aim should be a sufficiently well-based stone industry in Scotland to progressively replace imports in an expanding market and then to develop its exports.

Given a sympathetic regulatory regime and some support in establishing the quality, training and information infrastructures, there is a promising future for stone in Scotland.

1.1 THE DECLINE

1.1 Without equal

Stone is a widely used material throughout the British Isles, and surviving buildings in Scotland show the economic importance of the material from Skara Brae to the Royal Mile. In addition to stone's natural virtues, it has great symbolic significance, and it is the material of choice when national spirit, stability, quality and wealth require display, and it memorialises both deeds and the sculptor's skill.

Knowledge of stone was once fundamental to civil engineering and architecture, and its use was familiar from crofter to the masons working for the most eminent architects and their clients. By habit, apprenticeship, and pupillage, the natural characteristics of the material were understood and exploited in the most appropriate way whether in field stone, boulder or ashlar walls. The evidence is everywhere in Scotland both in the landscape and in its buildings.

Stone is now widely regarded as a luxury to be applied as a pretence, or as a `heritage' material for expensive repairs in contexts justified by sentiment and tourism. What has happened and can anything be done?.

1.2 Perception of quality

Stone in the UK is associated with the concepts of `expense' and, unfairly, with `high maintenance' due to the public appeals for work on the care of historic buildings although these, in fact, demonstrate `durability'. It is the concept of `quality' as a combination of performance durability and intrinsic value which is critical to the choice of natural stone. In British practice, the idea of `value' is more likely to be associated with `price' than with `performance'. The introduction of formalised quality assurance mainly concerned with procedures does not address this misconception. Price as a determinant rather than a consequence is strongly established in contemporary culture. The evidence of earlier habits can be seen in towns throughout Scotland where quality was expected as part of a proper concern for self-respect and durable utility in a stable society. Nineteenth century construction of this sort is rarely replaced because it is physically worn out, but usually for better economic exploitation of the site.

1.3 Mechanism of decline

The Government supports the principle of sustainable development and is making it an integral part of its domestic and international policies. Building stone is a low energy, environmentally friendly, durable and reusable material of proven performance to match these policies.

All resources are depleted, and sustainability is an ideal. Nevertheless, by economy and recycling a balance can be struck with the available resources in a way which minimises loss to the system and excessively damaging by-products. However, the rate of change is accelerating, driven by cheap energy, and the by-products are unacceptable.

Traditional technologies evolved when raw materials were used close to their natural state. Recycling and secondary uses were part of the economy because the cost of the work involved was less than the other resources. Such methods are sustainable over a longer period than energy intensive industrial processes, but can still lead to a desert if too much is demanded of the system by over-population or consumption.

Until the fifteenth century, thermal energy was generated only by solar rays, friction, animal metabolism, the combustion of bio-mass and, in rare cases, geo-thermal sources. Very high temperatures were difficult to achieve except by combustion and in limited circumstances. Fuel was expensive to produce from woodland and was confined to the more fertile regions. Thermal process energy was too expensive for anything other than limited domestic purposes, pottery, glass making, and the smelting and working of metal. The first of these was essential to life, and the others gave significant portable added value. Woodland was steadily denuded, not only in the interests of agriculture and construction, but progressively as a source of fuel. With the advent of coal, initially transported by sea, fossil energy became a new source of energy for brick and tile making in those areas that lacked readily available stone. The best stone was, of course (and still is), transported great distances for the most important buildings. Utilitarian buildings continued to be built in the most appropriate local stone.

In Scotland, stone, as the construction material of choice, continued to be used wherever it was available either picked off the fields, or cut in the range of sizes permitted by the local geology. Until the eighteenth century, coal was not suitable for metal working for which wood was still the only practical fuel. Later in the century, the use of steam to generate motive power led both to a revolution in transport and to a rapid expansion of coal mining which continued and accelerated through the nineteenth century. The relative scarcity of timber and the availability of coal enabled thermal energy or its surrogates in the form of bricks, tiles, lime and cement, to be available throughout the lowland regions. This generated traffic for the railways and docks as the economy became coal driven. It also made a market for stone in construction works and for slate in industrial roofing in areas which would once not have known the material, and, indeed, stone from this period is still being reused.

The low cost but gradual depletion of coal, followed by the discovery of oil and gas as supplementary fuels, has reinforced the success of those building products using high temperatures in production and relying on transport to justify volume production for an extensive market. Yet up to the end of the nineteenth century, it was common to find stone used for `common' work, such as back walls and gables, even where brick was used for quoins and main elevations, showing the relative worth of the materials and the labour involved. In the second half of the nineteenth century, red sandstone was still exported to North America as part of a regular trade. Through the first half of the twentieth century, the balance changed decisively in favour of the manufactured materials, driving natural stone into more specialised, high value, fashion applications or `heritage' work. This resulted in the abandonment of quarries, run-down workshops and loss of skills reaching what can now be seen as a nadir in the 1970's. Stone is now no longer considered to be a common material for use in utilitarian construction. This market has to be recovered.

From this broad account, it will be clear that the common use of stone, as a construction material of choice, has declined with the increasing availability of cheap thermal production energy, and to a lesser extent, the application of fossil fuel to power for alternative materials transport from centres of production close to the energy sources. The decline has not been due to lack of, or working out of resources, nor to a shortage of skills, but the consequence of the surge of cheap fossil energy in the nineteenth and twentieth centuries.

Nor has the decline been due to imports. It is interesting to note that the countries from which we import stone did not enjoy the fossil energy resources which built the industrial revolution in the UK and, consequently, maintained active stone industries which are in a position to export. Germany which had the same industrial experience slightly later than the UK, is also a market for stone exports.

The pattern of production which has evolved around fossil energy in the last 500 years and intensified in the most recent 150 years cannot be maintained. Long before fossil fuels are exhausted, the cost of extracting the marginal supply will progressively reduce the range of products which can bear the expense and environmental consequences of high thermal energy production processes, especially for low value, low performance materials such as brick Energy intensive industrial processes also tend to be heavy users of fresh water. Although in the macro environment no water is absolutely lost, the demand at any one point, for example in the ground, can be unsustainable. The necessary human and agricultural demands on water supplies will continue to increase, placing restrictions on industrial use It is disappointing that, of the 30 million tonnes of construction waste generated in the UK each year (8 million tonnes in Scotland), 45 per cent goes to landfill. There is no reason why any of this should include building stone. Building stone has been extensively reused from pre-historic times, as whole architectural features, as components, re-cut or as rubble. The most familiar example is the kerb stone which outlasts the road.

1.4 The future for stone

Natural building stone incorporates the process value which is the result of geological thermal energy, pressure and reprocessing. Its capital value has, for a period, been undersold by the speedy conversion of fossil fuel reserves, into relatively short life, low value products; and, worse, dispersed in the form of thermal energy for space heating to the atmosphere. The burden on the environment during this period has been acute and will continue after the resource is exhausted.

In this context, it is concluded that natural stone could inherit much of its previous market, based on the low production energy required in manufacture, its ready availability, low impact on the environment, which is easily restored after extraction, and modest water consumption in production.

2 THE ECONOMIC BACKGROUND

2.1 The construction industry

During the period 1970 to 1993 there have been major peaks in 1973/74 and 1988/90 with intervening recessions of increasing magnitude so that current output is smaller in real terms than in 1970. The peaks cause the whole industry to overreach its capacity, consequently prices rise and quality falls; the troughs destroy firms and disperse skills This is a poor business to be in, and yet the stone industry has not merely survived, but has substantially re-equipped since 1978; it is using numerically controlled machines, it is considering opening new quarries, extending workshops, and it continues to take apprentices. There is spare capacity, and it is clear that given the right demand and some rationalisation, turnover could increase The reasons for this resilience seem to be the large proportion of restoration and maintenance work undertaken which is not subject to the fluctuations found in new building, the conversion of material for direct sale to the public, and the core market in high quality building supported in some areas by planning requirements. Finally, many of the firms are small, with highly motivated management and a commitment to the product.

2.2 Opportunities

It is probable that, even as recovery from the current recession takes place, there will not be a major programme of new building. Business, medicine and education requires less building rather than more as telecommunications and work dispersal, less intrusive surgery, care in the home and distance teaching develop. Many buildings will remain empty or partly used. Repair, maintenance, public works andlandscape projects will continue. High profile projects supported by lottery funds will provide orders but not continuity. Leisure and retail buildings are unlikely to be the beneficiaries of a recovery as most areas are reasonably well served. Residential building, public or private, will recover with the economy, but there is no absolute shortage, and the potential demand is for higher standards of space and surroundings.

The vernacular revival and `Post-modernism' have favoured the use of natural stone as was anticipated in *A future for stone* in 1980. This fashion can be expected to run for a further decade or so, giving opportunity for the stone industry which helps to account for its current activity. However, fashion is fickle and longer term prosperity must be based on common products in continuous demand.

It is concluded that the Scottish stone industry is well placed in the current construction industry to expand sales in repair and maintenance, to expand public works associated with urban renewal projects, new building, road works and the landscape, and to exploit opportunities for stone finishes in major new building. The housing market requires a stock of reasonably priced components to use in standard construction if it is to be developed.

2.3 Communications

The construction industry is a complex organism of natural resources, processors, manufacturers, agents, suppliers, stockists, sub-contractors, self-employed, main contractors, maintenance contractors and administrators. Large material and component manufacturers, characterised by the high energy products providing the substitutes for stone have developed communication systems capable of linking with industry and project networks. These take the form of research, publicity, technical literature, specifications, standard details, consultancy, training and site representatives. The effect may be shared within a group or between companies, for example roof trusses and tiling. These communications systems and relationships are the `product' effectively purchased by large parts of the construction industry; the brick, block or paving slab is only one aspect of the purchasing decision. The questions lying behind that decision are: will it save me time? Are there problems in coordinating the work? Will the schedule be maintained? How many linked decisions must be made? What are the uncertainties? Can we communicate easily? Product performance, appearance and price are taken for granted; can it be delivered by Friday?.

It is encouraging that a number of firms visited in Scotland have invested in CAD systems or have made arrangements to use those of others, and that efforts are being made to provide design services using the exchange of digitised data. However, the stone industry must do more to establish itself in the communications network of building construction. The building stone industry is made up of dispersed small- and medium-sized enterprises (SME's) in strong competition. There is scope for the use of inter-firm cooperation networks for strategic development on the lines of schemes for SME's being developed in Denmark as part of a European industrial policy. In the case of Scotland, a virtual industry supported by telecommunications would enable companies to share resources, bid for larger projects and provide services not achievable by the individuals.

2.4 Competition

Competition between stone firms is strong. This is often self-destructive and it does little to expand the market. The collective interest of all the firms in the industry is to find technical substitutes for the alternative products, mainly brick and concrete.

Competition is more difficult in the care of historic buildings where the stone to be used is given and other considerations apply such as the quality of the craftsmanship. Indiscriminate tendering for such work can be damaging to the industry and buildings concerned, and longer term maintenance and budgetary methods are appropriate. The continuity of work and the training offered is valuable to the stone firms concerned and has benefits to the building industry generally Imports are not a threat, indeed, they are essential if the variety of stone is to be promoted and irregular demands met. Expanding the market for stone will draw in imports which may have value added to them by local manufacturers and construction workers. As the market for stone expands, there will be opportunities for import substitution and for the export of stone as production increases and unit costs fall.

The variety of stone available is one of its attractions in new building, and presenting these to the specifying public is most easily achieved by merchants and importers. The sales efforts for individual stones is disproportionate and a marketing consortium could address this problem.

It is necessary for the whole industry to coordinate its efforts to ensure that its merits are recognised for all suitable purposes for which high energy processed materials are currently used, and to do this, a major promotional and technical effort is required.

3 CHARACTERISTICS OF STONE

3.1 Structural

The fundamental characteristic of stone is its performance as a structural material in compression. It is in its load- bearing function that it is found in historic buildings, fortification and civil engineering works. The value of its performance in this respect is now rarely exploited and few structural engineers would feel comfortable in designing load- bearing masonry.

Development is required to exploit the load-bearing capacity of stone as part of the overall structural economy of building construction including composite structures and post stressing.

3.2 Durability

Associated with the strength of stone is its durability. Although this characteristic varies widely, types can be selected to meet a range of variables in porosity, chemical resistance, frost resistance, abrasion and solubility. A selection can be made to suit any circumstance, and it is normal to find such slow rates of deterioration that the stone product can be recovered and re-used beyond the life of the structure of which it formed part. Research is required into life cycle costs and the value represented by reuse.

3.3 Appearance

Appearance is now, perhaps, the principal reason for the use of building stone, either to match existing work or as an aesthetic judgement. Sometimes this will be constrained by Historic Scotland or by planning requirements. Except in these two circumstances, however, marketing on the strength of appearance alone can be uncertain. Fashion is also a fickle basis for promotion in the long term although it can be manipulated in such fields as domestic surfaces and garden ornaments.

Natural products such as stone and timber show the marks of their formation and the forces of evolution.

Stone commonly displays staining, colour banding, random figuring and fossil marks which challenge the imagination of designers and enrich the surfaces exposed to view to stimulate the interest of the closest observer. Even the wear and weathering of stone adds to the character of buildings. Substitute materials provide only bland uniformity however good the simulation. The random features which are characteristic of natural materials are condemned by increasingly theoretical specifications as 'faults'. The result is that perfectly sound material may be rejected. Uniformity is an easily applied yardstick which, when applied to stone, can reduce its appearance to that of precast concrete. The variety and subtlety of surface appearance which characterises natural stone makes both it, and the building in which it is used, unique.

The industry must promote the variety and variability of stone and ensure that standards and technical specifications do not, by definition or default, unnecessarily define natural characteristics as defects.

3.4 Thermal properties

Natural stone is a dense material with a low thermal insulating value unless used in great thickness. Cavity construction is firmly established as a method of providing insulation for brick walls, and stone can be used in the same way. However, traditionally, solid stone walls were used, often with a rubble core, and these have a high thermal capacity. The mass of the structure acts as a diurnal and seasonal balance between the external and desired internal temperatures. Because of the black radiation from a heated structure, lower internal air temperatures may be acceptable, condensation is reduced and higher ventilation rates can be used than can be afforded when using space heating.

The high thermal capacity of stone favours building designs exploiting solar energy, passive heat gains, low rates of fossil energy input and continuous heating, and the industry should encourage the development of such techniques of energy management.

3.5 Acoustic properties

Sound insulation is the ability of a material to reduce the transmission of sound, as in a party wall, is directly related to mass and to the elimination of gaps of flanking paths in the construction. Solid masonry is an excellent sound insulator and there is a choice of very dense stones for the most critical applications.

3.6 Versatility

In addition to the characteristics established above, stone has a range of properties which may be significant in particular circumstances. For example, stone is self-finished and requires no treatment and they can be selected to resist chemical attack. Very hard materials are capable of resisting impact and abrasion as well as being dimensionally stable; stone can be obtained in large units from which complex shapes can be cut, and it can be cut by hand and machined to very precise limits.

3.7 Building regulations

The Regulations generally, and in principle, place no restrictions on the appropriate use of natural stone. A concerted effort is required of the building stone industry to research, and provide, application specifications and details to ensure that deemed-to-satisfy solutions can be offerred within the Regulations and as construction for historic properties. Such details should be fully costed for comparison with other materials on a performance, process energy and life-cycle basis.

4 DESIGN AND SPECIFICATION

The various professionals in the construction industry have lost the habit of using stone as a common building material and the knowledge that went with it. The use of stonework in modern buildings is generally superficial and hardly exploits the available properties, and it is only in the care of historic buildings that traditional techniques survive. Efforts are made by firms in the stone industry to provide pre-contract design services, but these are inhibited by the nature of competitive tendering and the difficulties of commissioning firms as design consultants, who may not subsequently win the production and fixing work.

The use of diamond and tungsten tipped saws, now commonplace, has revolutionised production rates in masons' workshops. With numerical control and, ultimately, computer aided manufacture (CAM), further increases in efficiency and a closer working relationship with designers can be expected. However, the straight-edged off-cuts produced have few traditional applications and work is required to develop secondary and tertiary applications for this material The precision achieved has favoured ashlar walling and tight paving which has encouraged designers (who need little encouragement) to assume that the finest joints are the best. This tendency to take stone 'up market' by precision and over- design results in the use of premium material, expensive processing and fixing which increase costs. Design should be appropriate and not wilfully elaborate to show off the stone.

Overspecification of the context in which stone is to be used increases the elemental cost and again reflects on the economy of using stone due to the failure of designers to understand the natural properties of the material.

Stone was a common material up to the early 20th century and remains so in building conservation. Inspection of these applications shows: variations in size and colour in paving units, mixed stones in walls and paving, easy jointing, paving set to a lower specification than the adjoining buildings, use of random lengths in ashlar and paving, fine joints confined to the very best work, the use of load-bearing walls, flexible paving in styles appropriate to local material and traffic, self-finishes or tooled surfaces with only internal floors and monuments taken to a high level of finish, the use of secondary and tertiary quarry products to back fine masonry or for surrounding elements, tolerant interfaces between different materials, between paving and elevations, and between adjoining structures. The economy of using natural stone is established by the choice of stone, its detailing and standard of workmanship required. The `highest' standard is not always appropriate.

Dimensional uniformity prompted by the necessities of mass production in alternative materials can dictate the specification of stone. Random course heights and lengths, and natural colour variations are desirable in converting stone. This reduces waste but also contributes to the interest of a wall or paving.

The stone industry must be prepared to produce standard designs and specifications exploiting the properties of a range of stones to demonstrate the versatility and economy of natural stone in applications for primary, secondary and tertiary products. Designers now need detailed product information to meet the requirements of regulations and insurance. They expect advice not only on the stone itself, but on its application, such as access to services, maintenance, cleaning and public liability. The industry must ensure that recommended standard details are backed by the fixing skills needed to achieve them.

5 PRODUCTION

5.1 Geology

As in the UK as a whole, Scotland offers a great variety of stones in a relatively small area with intricate geology, disturbance, and faulting which makes for difficult working in many locations.

It is probable that Scotland would have difficulty in supplying large orders of consistently big slabs of the kind regularly specified for cladding major buildings without unacceptable ratios of waste. Such projects may well continue to be supplied from abroad. However, there is a potential demand for a range of medium sized and variable block and slab stone products and some indication that these could be exported. There was evidence to indicate that old quarries are being reconsidered, even when filled with rubbish, that new locations are being sought and that existing quarries have plans for extension. This is a marked contrast in activity and optimism with the findings of *A future for Stone* prepared in 1978/79.

5.2 Quarry management

The environmental impact of building stone quarries is not great but in the public mind they are associated with dust, noise and traffic generated by other mineral workings. Most building stone quarries are unobtrusive in rural surroundings; they create no dust and little noise even if saws are installed, and they merge into the landscape for most passers- by. Transport is less obtrusive than that from aggregate quarries. Reinstatement is not difficult if the value of the quarry product can pay for it; a range of secondary uses are possible which are not incompatible with SSSI status. Indeed, Scottish Natural Heritage regard active building stone quarries as a valuable source of geological and palaeonological evidence, and both working and abandoned quarries as habitats for flora and fauna.

A national planning policy is required which recognises the importance of building stone, encourages its production and use, and provides for the identification and protection of resources in local development plans The stone industry must concentrate on being an environmentally good neighbour and work to disassociate itself from other mineral extraction industries.

5.3 Manufacturing masons

The re-equipment of workshops since 1978/79 is an impressive vindication of the forecast in *A future for Stone*. Every installation visited was equipped with modern machines, many with various degrees of numerical control for unattended operation, with an average age of about 5 years. Machine utilisation could be improved although all the firms visited were active. There is, obviously, capacity in hand to serve a larger demand if this could be stimulated. Some firms were installing, or had ordered, new machines, typically saws and guillotines, in anticipation of further business. Production is mainly directed towards precision cutting of material to meet specific orders. Very little is done speculatively or for stock. As found in the previous study, large projects are attractive in these circumstances, but they monopolise the firm and delay or lose subsequent work. This problem is addressed by some firms in providing design services, attempting to secure pre-contract orders and sub-contracting. The design services are quite sophisticated using computer- aided design (CAD), but not computer-aided manufacture (CAM), with some digital data exchange with specifiers.

An effective and prosperous manufacturing sector can win export business for UK quarries, encourage UK stone processing machinery firms and exploit British expertise in computing and project management.

5.4 Lead time

Length of lead time is a deterrent in modern construction, and it is directly related to stocks of rough and finished materials and processing capacity. The average lead time is now about four months which effectively confines natural stone products to later stages in even medium-sized projects. This can be improved by pre-ordering (which is difficult in current tendering practice), by the use of stock products, by the use of large producers with access to semi-finished stocks or by work sharing. Short lead times favour imported stone which may be worked abroad instead of value being added in the UK.

6 MERCHANTS

No independent stockists of stone products on a significant scale were identified in Scotland, but one serving the Scottish market from England was visited. In the case of alternative building products, this function is served both by the stock held in manufacturers' works and regional depots, and by the network of builders' merchants and distributors covering the country. It would be difficult to find natural stone of any kind held by any of these distributors, although precast stone will be readily available. Products such as setts, paving, walling, worked sills, thresholds, porches and garden features of quality (because of natural stone) need not underprice alternative materials, nor need they be unblemished or made to exacting tolerances, but they must be readily available with back-up supplies.

Gardening is one of the most popular leisure activities in the UK served by a network of garden centres which could provide an outlet for stone products from natural rock to turned balusters Stock held by the industry is in the quarry and in masons' yards in the form of unworked block and semi-finished scants. Turnover of stock of this kind is slow and space consuming as specimen block or leftovers from previous orders are held against the possibility of a specification rather than as part of a work flow. It would seem desirable that masons should convert as much uncommitted block as possible to finished standard products to be passed down the distribution chain.

7 TRAINING

Lack of knowledge and skills in the broadest sense is a major impediment to the more extensive use of natural stone in building. The emotional acceptance of the qualities of stone by the general public and sympathy by designers should be developed at every level into a deeper understanding of the material, its past and its present potential. This must start in the schools as educational projects and be carried through to the professional and technical levels of the construction industry.

The general public, while admiring the scenic effect of historic buildings and landscapes largely made of stone, cannot easily detect the difference between the actual material and the simulations. This is true in other fields (including food) and it is important that every opportunity is taken to develop discrimination in those who may occupy positions as clients and public servants as well as those more directly involved in construction.

Very little of the formal education of professionals in the industry is concerned with the properties of stone or its applications; only those concerned with building conservation will be familiar with stone as part of their speciality. The best informed professionals have acquired their knowledge in practice by working with the stone industry and studying traditional practices.

8 RESEARCH

The importance of a continuing research and development programme and the dissemination of the results is necessary to any industry, and a good example of this is the well respected work of the Timber Research and Development Association (TRADA) on behalf of another traditional material. TRADA now also undertakes certification to ISO 9000 (BS 5750) and BS 7750 for environmental management. The stone industry has no such body and seems disinclined to support activities which seem to be merely confirming common knowledge.

The only coherent programme of investigations is not the responsibility of the stone industry but that instituted by Historic Scotland's Technical, Conservation, Research and Education Division (TCRE) which has work in hand on a series of related projects by BRE, Robert Gordon University, Glasgow University, Scottish Enterprise (SE), the Scottish Lime Centre and a number of consultants; further projects are planned on a building stone library, lime rendering, interaction of stone and lime, stone consolidants and training. Although focused on the conservation of historic buildings, much of the work is of general interest.

Perhaps the most disappointing finding is the failure of the UK stone industry to make use of EU research funding. Of the twenty-one projects identified involving stone only two had UK leaders with six others as partners.

9 RE-USE AND RECYCLING

The quality and easy recovery of stone products puts a premium on their re-use in original or re-cut form, the environmental impact of their first production is proportionally reduced by each re-use and in an atavistic sense, links with the past are retained. This sense of ancestral ties is indicated by an objection to recovered materials being 'exported' to England implied in *New from Old*. It is always better that materials should be used in context, but any re-use is better than tipping or destruction.

10 IMPORTS AND EXPORTS

It is clear that Scotland has been a significant exporter of building stone; for example, the triangular trade between Annan and North America exchanging Corsehill sandstone for Canadian timber. The home market, even when developed, cannot be large, and an expanding stone industry will seek to export to build capacity and establish continuity on higher levels of production. There is a very large international trade in stone and not solely on price. Variety is sought and therefore there will always be imports, even in stone-rich countries. For example, it is conceivable that Ledmore marble could be sold in Portugal via processing in Italy.

Imports on the other hand require no support but are drawn in by the available trade. Agencies are soon obtained and the capital required is not great. Importers are regarded as the demon king by home producers, but imports would be necessary, however successful UK quarries were to be, because of the variety of natural stones required and the choice offered, particularly in marble and granite. All other things being equal, it is desirable that indigenous materials should be used to maintain the character of a region, the granite of Aberdeen and sandstone of Glasgow for example, and this is of even more importance in rural landscapes and historic buildings. This consistency of local appearance deserves a premium, but apart from these considerations, imported stone contributes to the strength of the stone industry by ensuring that specifiers have the choice of affordable stone when alternatives might be considered; it provides work for manufacturing masons and fixing trades, and makes for an active and affordable image for stone in the construction industry

It is concluded that the stone industry could claim favourable treatment on global ecological grounds, and in the national economy as an import substitute and for its contribution to the environment.

Four aspects of planning control require review and coordination of policy:

a the balance between the desirability of using stone and the proper encouragement of quarrying as a rural industry for economic, environmental and aesthetic reasons.

b the identification of existing quarries and potentially workable deposits in development plans to avoid loss of access as a result of future planning approvals.

c the protection of existing and previously worked quarries essential for work in conservation areas and for the repair of listed buildings and scheduled monuments.

d the coordination of policies related to the extraction and use of building stone between the planning system, Scottish Natural Heritage, Historic Scotland and the Scottish Environmental Protection Agency.

Planning authorities should be encouraged to be adamant in their decisions to require natural stone in appropriate localities.

11 FISCAL POLICY

The funding directed towards natural stone in the form of support for projects by the LEC's and EU to encourage the use of natural stone which is undoubtedly welcome. It is unlikely to be sustainable in the long term and could produce an artificial market for the industry. A regular flow of smaller projects using fairly standard products could give the industry a more sustainable demand. This would encourage investment, and develop a more regular and competitive supply of building stone from smaller firms in the localities concerned.

12 PROPOSALS FOR REVIVAL

There appears to be an air of optimism about the UK stone industry in general, and a notable sense of determination and coherence in the Scottish industry. The level of governmental support in Scotland is impressive. It is possible that a model for the whole industry could be developed in these circumstances.

12.1 Organisation

It is recommended that:

a the Scottish branch of the SF should be developed to support publicity, awards, technical information, communications, industry funded research, training and quality assurance.

b a Natural Stone Institute (NSI) should be formed with constitutional links to the SF, Geological Museum and the British Geological Survey to act as a learned society with a museum and library.

c the Scottish branch of the SF and the NSI should devise comprehensive linked training courses covering S/NVQ's 1 to 5 with an emphasis on practice using a stone industry syllabus.

d the functions developed by Historic Scotland TCRE should be broadened and linked to the proposed NSI to provide the initial coordination.

e a distinguished and active patron should be sought for the NSI, founder private and corporate members should be appointed by invitation f promotion of the industry should emphasise both the high technology and the craft tradition 12.2 Communications (STONET).

It is recommended that a virtual stone industry should be formed using telecommunications to give a sense of community (Stonet) and provide business support such as news, design advice, directories, product and statistical data. The information could be provided by SF, NSI, the Scottish Office and primary sources such as BSI; secondary sources such as Glenigan, and special interests such as the Scottish Conservation Bureau.

12.3 Research

It is recommended that work in hand should be reviewed and that a coordinated programme of research should be established exploiting EU programme when possible.

12.4 Database

It is recommended that a range of directory, bibliographical, material, statistically and other databases should be established under the direction of a coordinating committee with working parties, and maintained via Stonet.

12.5 Standard products

It is recommended that a range of standard products should be developed in stones and finishes appropriate in scale and character to the market in Scotland.

12.6 Marketing and production cooperative (Stonemart)

It is recommended that a marketing company should be established to stock and sell standard products identified in 12.5. These should be specified for manufacture by individual firms or consortia who would bid for annual quotas. Firms would also be able to produce to the same specifications to sell surplus production capacity at cost to Stonemart or by direct sales at their own margins. Stonemart could purchase idle production capacity to support firms between bespoke orders. Block stone to export quality specification should be purchased for sale to manufacturing masons, for export, and for re-sale to meet peak orders.

12.7 Training

It is recommended that:

a the SF(S) should develop training courses for all quarry, masonry and fixing trades in consultation with the CITB, SE and the NSI.

b a school of stone technology (Stonetech) should be established at a Scottish university.

12.8 Publicity and public relations

It is recommended that:

a a publicity plan and budget should be prepared for a 5 year programme of publications. These should complement, but not replace, promotional material produced by individual firms. The publicity plan should be designed to derive income from payments for editorial and display space. The publicity, technical information and other publications should have clearly recognisable corporate design standards.

b An open-air museum of quarrying, slate and stoneworking should be established as an educational and tourist facility.

c A 'Scottish stone' labelling scheme should be introduced to identify products produced by members of SF(S). A site sign to match should be available for use by members of SF(S).

12.9 Quality assurance

It is recommended that the Scottish region of the SF working with the proposed NSI should produce schedules for ISO 9000 and BS 7750 assessment.

12.10 Implementation

It is suggested that a provisional development committee should be formed to initiate the proposals and recommendations.

THE POTENTIAL FOR SCOTTISH SLATE IN BUILDING REPAIR AND CONSERVATION AREA ENHANCEMENT

Dr Ralph Skea, Centre for Conservation and Urban Studies, University of Dundee

1.0 Introduction

The purpose of this research study, commissioned by Historic Scotland, has been to investigate the key problems related to the use of Scottish slate in the repair and restoration of buildings in both rural and urban contexts, including the preservation and enhancement of conservation areas. The spatial focus of the research project has been two regions of Scotland, namely Tayside and Central, plus one major city, Glasgow. From initial discussions with conservation agencies and local authorities, it was apparent that certain key issues were seen as important and should be addressed by the research project:

(i) the relative unavailability of this traditional building material in comparison with its foreign and modern alternatives;

(ii) the low market demand for Scottish slate in may parts of Scotland;

(iii) the perceived high cost of the material in building repair and restoration projects;

(iv) the minor use of this traditional material in new infill development;

(v) local authority planners' difficulties in controlling the reuse and the replacement of Scottish slate in repair programmes, especially within conservation areas.

These perceived issues formed the basis of the research design which took as its empirical framework six interrelated aims:

1. To assess the historical and aesthetic importance of Scottish slate in the listed buildings, non-listed buildings and conservation areas located within the study areas;
2. To determine the reasons for the current low demand for and general lack of use of this building material;
3. To identify the alternatives to Scottish slate, for example foreign slates and synthetic materials, and to investigate the reasons for their current use;
4. To assess the potential market demand for Scottish slate, including those factors likely to affect such a demand, in the study areas;
5. To investigate the attitudes of conservation bodies, local authorities, architects and developers to the use of Scottish slate in building repair work and new infill development;
6. To assess the technical, financial and aesthetic issues involved in using traditional Scottish slate in new infill development within the study areas.

As well as setting general aims, any research exercise must begin from a foundation of premises or assumptions based upon currently known facts or opinions. From provisional discussions with conservationists, the following premises or hypotheses were established. It was decided to use this set of assumptions as a benchmark by which research findings could be appraised:

1. While Scottish slate makes a major contribution to the character of Scotland's listed buildings and conservation areas, it is now very rarely used in repair programmes and major new infill developments;

This speculation was based on the fact that Scottish slate was no longer quarried and that stocks of salvaged slate seemed to be diminishing. It was assumed, therefore, that the ensuing scarcity and high cost of Scottish slate would make it less used in repair work and new development projects. Thus, this hypothesis was seen as the logical consequence of a diminishing supply of a once plentiful natural roofing material which required a specific and labour-intensive laying technique.

2. This situation is eroding the intrinsic character of Scotland's built heritage;

This premise was deduced from the assumed validity of Hypothesis 1. Also, whilst it was known that Scottish slate roofs had distinctive aesthetic characteristics, it was assumed that, if Scottish slate was no longer widely used for repair or new build, the aesthetic integrity of the finest townscapes would be subject to dilution by the intrusion of materials with different visual qualities.

3. Local authorities could do more to promote the use of Scottish slate in repair and new build programmes;

Both the research co-ordinators had experience of working in local authority planning offices, and they speculated that perhaps local plans and conservation policies could stress more the desirability of aiding the survival of Scotland's distinctive slating material and related roofing technique in rehabilitation projects and new development.

4. The use of Scottish slate could be made to be more economically viable;

The assumption here was that the material was relatively costly and that perhaps a range of factors, for example subsidies, could make the desired use of the material an economic proposition for property owners and developers.

5. Architects and developers are ambivalent about the use of this building material;

It was assumed that, while many architects and developers would be aware of the historic and aesthetic importance of Scottish slate, they would be wary of specifying its use for supply, cost and technical reasons, for example its second-hand nature.

6. There is a general assumption in the building industry that alternative roofing materials are better value for money that Scottish slate;

The premise was that, given the wide range of roofing materials currently available at a comparatively low cost, the building industry, as a whole, would be dominated by the cheaper, artificial roofing materials. Natural slate would represent a relatively small part of the roofing market, with imported slate being much cheaper than salvaged Scottish slate. Thus, most developers and building professionals, faced with tight cost limits and eager for quick financial returns, would avoid where possible the use of expensive natural materials.

In order to explore the validity or otherwise of these six hypotheses, a research programme was devised which employed well-tried empirical techniques. Firstly, a review of relevant literature including books, articles, pamphlets, standards, codes of practice, government advice notes, trade literature and unpublished theses was undertaken. A questionnaire regarding a wide range of planning control and conservation issues was sent to every local authority prior to local government reorganisation in 1995. The purpose of this was to obtain a national picture of the attitudes of local planning authorities to Scottish slate and other roofing materials. Structured interviews were held with a wide range of agencies, professional groups, conservation bodies and trade representatives from throughout Scotland. Thus the views of these experts were sought with regard to the key issues regarding the current and potential use of Scottish slate. In the three study areas an appraisal was made of (i) the importance of Scottish slate in selected areas of the built environment, (ii) the attitudes of planning and building professional groups and (iii) the use of Scottish slate in repair work and new infill development. In addition to the preparation of a research report, a video highlighting the key problems, issues and potential of this traditional building material is being prepared. Also the key findings will be illustrated in associated exhibition display panels

1.1 State and Other Materials

While the roofing industry in the 19th century was homogeneous, and dominated by slate, the roofing industry today is heterogeneous, with many diverse products competing in a variety of specialised markets. Imported slate is the fastest growing sector of the roofing market, and Spanish companies now almost equal their Welsh competitors' share of the UK's natural slate market. At the same time, the long held assumption that man-made alternatives to natural slate offer better value for money is being strengthened by the development of these artificial 'slate' products which are claimed by their manufacturers to be equal in quality to natural products and indistinguishable in appearance from natural slate. This latter point is particularly pertinent to the roofing industry in Scotland, where historic townscapes still are dominated by slate roofs. But artificial, synthetic products and imported (natural) slates which claim to mimic the appearance and qualities of the indigenous Scots slate are achieving unprecedented popularity as they seek to infiltrate the conservation and restoration market. While new imported slate appears to be able to meet the demand for natural roofing materials at a reasonable price, Scottish slate, as a second hand material, faces the inherent problems of inconsistency of supply and increasing costs. As part of the beleaguered natural slate industry of the UK, salvaged Scottish slate fights to compete in cost against the surfeit of artificial slate products and imported natural slate which increasingly are dominating the heritage roofing industry.

As Figure 1 reveals, natural Slate forms a very small percentage of the total roofing products used in the UK today - in fact just 7% of the total. Within the category of 'slates', it competes against fibre cement slates which have 11% of the market, resin based slates with 3%, and against concrete tiles with the lions share of the market at 72% (Roofing, April 1995a). The figure of 7% for natural slate is made up of the second-hand slate market of Welsh, English and Scottish slates, the new slate produced by the remaining quarries of England and Wales, plus natural slates imported from abroad.

SLATES	**21%**
Fibre Cement	11%
Natural	7%
Resin Based	3%
CONCRETE	**72%**
Interlocking tiles	61%
Plain Tile	9%
Stone Faced	2%
CLAY	**6%**
Plain Tiles	5%
Interlocking	1%
OTHER metal/shingles	1%

Figure 1 Table of the market share of roofing products 1995: (Source: Roofing April 1995).

Prior to the Second World War, slate still formed the UK's dominant roofing material, with the majority of it being home produced. Today, after the massive post war housing programmes, which looked to mass production and, in particular, to concrete for a modern and more economic means of construction, natural slate may be considered a casualty of the 20th century construction industry, where natural and traditional materials have been rejected in favour of cheap new products. The national companies, Marley and Redland, now between them hold control of the concrete tile industry, and, at 72% of total roofing products in use, this equates to the bulk of new building each year: the housing estates, retail and commercial parks.

Compared to these figures, the use of natural slate appears to be marginal with the use of salvage-based materials like Scottish slate in particular being relatively insignificant. However, as building in historic areas returns to a greater use of traditional forms, and the conservation of historic towns places greater emphasis on traditional materials, the country has seen a small but significant resurgence in the use of natural slate. In the UK, however, this demand has not been met by the UK natural slate quarries, but rather by synthetic products and imported natural slates. In particular, some artificial roofing materials retail at a fraction of the cost of UK slates, and are making significant inroads even in heritage roofing markets. Consequently the UK's quarries have faced a huge fight to remain viable. In terms of the natural slate roofing market in the UK by market sector, of note is the very small use of natural slate in house building (11%) despite this land use's dominance in the development process. Furthermore, new slate predominantly is being used in prestige commercial and civic projects often located in conservation areas.

1.2 Listed Buildings and Conservation Areas

It was believed by interviewees that most of Scotland's listed building stock had slated roofs. When seen in conjunction with the large number of unlisted buildings with traditional slate roofs, this constituted a large percentage of Scotland's built environment. Many interviewees believed that these buildings provided both a real and potential maintenance market for natural slate in general and Scottish slate in particular. However, due to the lack of new Scottish slate, many were being forced, reluctantly, to use salvaged slate of unknown origin. Some felt very strongly that this was unacceptable when restoring major listed buildings:

> *"It is really a nonsense to be using a second-hand material when restoring important historical buildings. Despite Scottish slate's longevity, inevitably you are creating a maintenance obligation. Even with good slates and a competent slater, a few slates will have to be replaced in the first year after a reroofing project."*

However, one interviewee believed that, "given the supplies of Scottish slate are running out", suitable alternative slates had to be used in large new developments. But the priority for the use of the increasingly scarce Scottish slates should be Scotland's stock of listed buildings:

> *"Scottish slate really must be limited to listed buildings in future".*

Surprisingly, the questionnaire results showed that a number of authorities sometimes considered artificial slate to be an acceptable alternative to natural slate for works to listed buildings (categories B and C(5)) (10%-30%) of LAs and extensions) to listed buildings (all categories) 2%-39% of LAS).

Many interviewees stressed the importance of conservation areas in terms of the preservation and repair of the finest Scottish slate roofs. Most believed that Scotland's conservation areas represented spatial focus points of traditional roofscapes in most towns and rural areas. Interviewees accepted that there "must always be great control of materials in conservation areas". One architect felt that conservation areas represented a great latent demand for natural slate in general and Scottish slate in particular:

> *"These areas have a guaranteed demand for slate in their maintenance requirements and for new building both within and adjacent to their boundaries."*

One conservation officer agreed with this viewpoint but stressed that, even in conservation areas, it was a struggle to achieve a high quality of preservation or enhancement with regard to roofscape. She did not believe that the fight for traditional roofing in repair or new build could be extended beyond conservation area boundaries or outwith the stock of listed buildings:

> *"It is an all-out battle to look after conservation areas. To extend the conservation remit beyond them is not feasible. Outside conservation areas, insistence on 'correct materials' is difficult to justify except with regard to listed buildings".*

Indeed the questionnaire showed that 61% of local authorities felt that artificial slate was acceptable in works to non listed buildings, while 78% found the material acceptable in new buildings.

Listed buildings and conservation areas, however seen as being the most important existing and future repositories of Scottish slate. Many interviewees cited the conservation practice in Edinburgh as evidence of this. In Edinburgh's New Town, from 1975 onwards, a very high standard of repair work, including work to roofs, has been achieved using "the highest standard specification" even though most of the work was publicly funded. In fact, it was the housing repair grants of up to 90% for approved works plus the conservation grant aid administered by the Edinburgh New Town Conservation Committee (ENTCC) which made the repair and restoration programme financially feasible. The fact that most of the buildings were listed was of crucial importance in controlling the high standard of repair work:

> *"Achieving this was largely due to the fact that the buildings were listed. Change needed listed building consent and the planning department insisted on all possible traditional materials being reused, and replacement materials of good match."*

Over £40m has been spent on rehabilitation, repair and restoration work in the area since 1975. One interviewee stressed the importance of the financial and administrative collaboration between housing officers, conservation officers and the ENTCC. This was made possible by the New Town's status as an outstanding conservation area:

> *"The enormous amount of grant aid pumped into the New Town was a reflection of the national importance of the area plus the public concern for its evident deterioration."*

In the Old Town also, the strong commitment to conservation since the mid 1980s has meant that slate roofs have been protected and well repaired. This has been crucial in an area where the characteristic skyline and dramatic changes in level make the roofscape a very important architectural feature. The planning department has insisted on like-for-like slate in repair work and there has been a presumption in terms of the use of slate in the new infill development. Both conservation areas have benefited from strong citywide policies in favour of conservation and good development control practice backed up by the availability of grant aid.

1.3 City Policies and Planning Control

A surprising number of interviewees dwelt at length on the importance of city policies with regard to Scottish slate, and the crucial role played by planning departments in protecting and enhancing traditional roofscapes. Indeed, the contrast between policies in Edinburgh and Glasgow was seen by many interviewees as lying behind most of the recent issues regarding the salvage slate industry in Scotland: supply, demand and cost. Between 1975 and 1995, Glasgow and, to a lesser extent, Dundee, represented the main supply source of second-hand Scottish slate, while, during the same period, Edinburgh was the major focus of demand.

As the market was flooded with salvaged Scottish slate, the price of the product could be kept low. However, since 1995 when Glasgow introduced a roofing policy which favours the retention of slated roofs in conservation areas and the use of natural slate in all reroofing work within conservation areas and related to listed buildings, the supply of second-hand slate has fallen dramatically and the cost of the scarce material, which is still in demand for conservation work, has risen dramatically. Thus, the recent history of Scottish slate can be said to be related crucially to city policies. It is relevant to outline certain key features of the city's policy with regard to slate roofs especially in the light of Edinburgh's espousal of the material's protection and reuse. One interviewee summed up well the interaction between Scotland's two major cities:

> *"At the national level was the very different refurbishment policies of Edinburgh and Glasgow in the 1970s. Edinburgh was very much more conservation based - insisting always on slate with slate replacement. In Glasgow they found it easier to strip and replace with concrete tile. And, of course, one city's policy aided the other".*

Many interviewees confirmed that, in their opinion, Edinburgh over the last decades had been relying on Glasgow as a source of salvaged Scottish slate. One Edinburgh architect believed that Edinburgh's architectural quality had survived in part due to its use of salvaged slate from Glasgow and Dundee where city policies had not been insistent on the retention of slate during 1960s redevelopment projects and throughout the housing improvement programmes from the mid 1970s onwards. In his opinion, past city policies in Dundee and Glasgow had led to a large supply of Scottish slate and a reduction in its market price. One interviewee told of a well-known yard, operational in the 1980s, where Scottish slate from Glasgow was stockpiled for redistribution to Edinburgh. Since 1975, Edinburgh's city policy has been to use salvaged slate for repair and re-roofing projects in conservation areas and related to listed buildings. Also, the city has promoted the use of natural slate in new infill development in conservation areas. In those conservation areas where grant aid is available, the city has been able to exercise tight control over the repair and reroofing of historic properties, ensuring good matching of slates in terms of size and grading. One conservation officer commented that "people accept the local authority's policy on the need for high standards of conservation".

In contrast, the planning committee in Glasgow has, until February 1995, taken the view that slate roofs in conservation areas could be replaced by concrete tiles, due to the fact that Scottish slate was no longer being quarried:

> *"In a city where the traditional roofing material was West Highland slate, there has been a tendency over recent decades to replace this with concrete tiles which were previously thought to be an acceptable alternative to a material which was, and still is, no longer in production" (Glasgow DC, 1995).*

Edinburgh, however, has always viewed the concrete tile as an unacceptable alternative to slate in conservation areas, and thus a market for salvaged Scottish slates has been promoted and maintained within the capital. In Glasgow, concrete tile roofs have started to fail, and the visual damage in the city's residential conservation areas is apparent. All salvaged state "is now reused within the city", and the supply to Edinburgh "has now stopped". Furthermore, the availability of competitively priced imported slate has led Glasgow to discourage the use of concrete tiles in conservation areas. Its new policy stresses the importance of using "more affordable natural slate from other sources" rather than concrete tiles (Glasgow DC, 1995). While the new policy has been welcomed, many interviewees felt that it was "twenty years too late".

While Glasgow's past policy of allowing the removal of slate roofs and their replacement by concrete tiles "has been very convenient for Edinburgh", the city's new conservationist policy also could have important ramifications. One interviewee perceptively predicted that, given Glasgow's new policy, the availability of salvaged Scottish slate "is going to decrease" given that Glasgow has been the main source over the last twenty years. While the supply will decrease, the demand will increase due to Glasgow's new desire to repair roofs in conservation areas and on listed buildings with matching slate. The same interviewee noted that the price of Scottish slate had increased over the last few years and predicted that the price would "go shooting up" when Glasgow's citywide policy began to take effect. He concluded that this scarcity of an ever costly building material, which was greatly in demand for the repair and restoration of Scotland's built heritage, could lead to "the real prospect of new Scottish slate being required". Thus it can be seen that Glasgow's new policy and practice could be crucial in terms of the economic viability related to both salvaged Scottish slate and any future quarried slate. Glasgow's new policy will reduce the supply of second-hand slate in the market and, given the healthy demand for the material in conservation areas and in projects related to listed buildings throughout Scotland, the cost of the diminishing resource will rise dramatically. As a consequence, the stripping of slate roofs for lucrative sales already is commonplace throughout Scotland. Likewise, local authorities are very aware of the danger of theft due to the increasing scarcity of good quality Scottish slate. Hence the dilemma for development control planners and their conservation officer colleagues when encouraging owners and developers to use matching slate in repair and new build projects: while wishing to promote authentic repair, they do not wish to encourage, inadvertently, an illicit trade in salvaged Scottish slate.

Many interviewees emphasised the crucial role played by planning officers and planning committees in protecting Scottish slate roofs, in promoting high quality repair work and in encouraging the use of natural materials. While some interviewees were supportive of planning authorities, others felt that, while they are "in a key position, they are not doing enough to preserve Scottish slate". However, one architect felt that, despite the "serious shortage" of second-hand slate, planning authorities still were making its use a condition of planning consent "in a significant number of instances - they are very specific on what they want to see". One Dundee Clerk of Works, however, felt that local authorities should be "much tougher" regarding the use of natural materials in design sensitive areas. While supportive of this viewpoint, one architect was aware of the legal and financial implications:

> *"The worry that planning departments have, however, is that if they go to appeal and lose, they will have to pay costs, which can amount to a large sum of money. It is easier to be relaxed and give in to things".*

With regard to this issue, one Edinburgh planner stressed the importance of statutory local plans for laying down appropriate standards of materials in sensitive urban areas. While it was noted that many local plans in Scotland avoided stating the necessary policies regarding materials and design, it was felt that Edinburgh's central area local plan and the city's Development Control handbook together provided a good framework for development control decisions. As a general rule, it was felt that traditional materials should be respected and repeated where appropriate. Furthermore, the local plan promotes the greater use of traditional materials, including roofing slate, in new developments, particularly in sensitive locations like conservation areas. These local plan policies are useful in pre application discussions with the general public and are used as guidance as to what is likely to gain consent. Also, they are used to justify refusals and, in appeals, to justify decisions.

And so, planning authorities play a major role in promoting the use of natural slate in general and Scottish slate in particular. As one surveyor confirmed, while these materials may be more costly, developers are "not guided by price alone - the use of slate really depends on the wishes of the planning department". However, given the shortage of Scottish slate, one architect noted that in general, planning authorities normally would not apply conditions with regard to a specific type of slate, except for major listed buildings. Another architect noted the problem that owners had in such cases in obtaining a local supply of high quality slates. He suggested that more information on sources should be provided by local authorities:

> *"Owners can't be expected to search and search for second-hand Scottish slate when it is not readily available".*

One conservation architect felt that planning control was the major way to promote the greater use of natural slate in Scotland, and, as a consequence, the greater use of Scottish slate. He did not believe, however, that the reopening of a Scottish quarry would ever be economically viable, and felt, instead, that planning authorities should insist on imported slate which matched the aesthetic characteristics of the indigenous material:

> *"A more realistic option would be to use the planning legislation to insist on Welsh, Cumbrian or Spanish slate of the proper thickness and laid to diminishing courses - correctly, not using the four or five slate sizes currently available. While this requirement undoubtedly would increase the cost if imported slates to Scotland, they would still be cheaper than slate extracted from a new Scottish quarry".*

Thus the future use of appropriate new slate in repair work and in new infill developments will hinge on the attitudes of local authorities to their planning and conservation responsibilities. As planners control the early stages of the development process, it is crucial that effective local plan policies are in place to enable good levels of control to be implemented. As regards protecting and enhancing the quality of Scottish slate roofs, much depends on the availability of high quality salvaged material. Otherwise, local authorities will continue to resist specifying this material for fear of encouraging erosion or theft elsewhere in Scotland.

1.4 Supply and Sustainability

A constant refrain from those interviewed was that there is now a serious shortage of second-hand Scottish slates. One conservation officer put it more bluntly:

> *"Everyone is aware that supplies of second-hand Scottish slate are running out".*

While legitimate demolition was, and still is, the main source of second-hand Scottish slate, many conservationists felt guilty that some of the much needed supplies have been achieved by the "quarrying of other buildings". Despite this, many architects reported that it was now impossible to find enough Scottish slate for large new build contracts, and Burlington slate is a "favourite substitute" for roofing important public buildings. One architect confirmed that the lack of suitable Scottish slate in large enough quantities made its use impractical for large new infill development in conservation areas where, increasingly, Spanish slate was being used. Even more worryingly, one architect reported that there was "no steady supply throughout Scotland to meet the demand for even small quantities of slates for repair work". In his view the second-hand market in Scotland "is virtually drying up". One conservation expert acknowledged that "it was inevitable, given the current interest in conserving rather than demolishing historic townscape, that there should be less second-hand slate available for repair work". While in the recent past there had been "a ready and efficient supply through recycling" now there was a great shortage due to cities like Glasgow "tightening up their policies".

Architects and slaters pointed out also that there was a shortage of slates "large enough for eaves courses". This was due to the reduction in size caused by necessary redressing at the time of salvage. One slater felt that this reduction of average size in the general stock of Scottish slate was "a major problem" especially when slate had been reused "three or four times". One architect felt that the diminishing size in the average salvaged slate had "implications for the visual appearance of the roof and in terms of the life of the slate". He ended his interview with a rhetorical question:

"How many times can a slate be redressed before it becomes too small to be used again?"

Another architect confirmed that the small size of salvaged slate was a problem for large listed buildings. He had been commissioned to restore a major public building in Edinburgh but he suspected that it would prove "difficult to find slates large enough".

Because the existing stock is diminishing and is not being replenished by new slate, the Scottish slate industry in its present form can not be classed as "sustainable". Slaters and architects stated that between 30% and 50% of slates are lost at the time of redressing, even when the roof is of "good quality slate". One conservation expert acknowledged the finite nature of the sock of Scottish slate but stressed the importance "of making the best use of a diminishing resource". Often this resulted in the best Scottish slate being used on the most visible roof pitches, with other new imported slate being used elsewhere. So, while an interviewee, somewhat romantically, (and inaccurately) stated that Scottish slate is "infinitely reusable", the reality is that, however good the original slate, we are faced with a diminishing resource. The spirit of sustainability survives in the heritage repair industry where conservationists are committed to "making the best use of materials". The non-sustainable reality is that no new Scottish slate is entering the market which is reliant, as it has been since the closure of the quarries, on the legal and illegal stripping of existing roofs.

1.5 Erosion, Theft and Legitimate Salvage

One national conservation agency confirmed that the intrinsic character of Scotland's built heritage is being eroded by the loss of fine Scottish slate roofs. The agency reiterated the fact that "roofs being stripped of their slates for sale is a big problem in Scotland". Many buildings subject to demolition proposals studied by the agency already had lost slate through theft or stripping for sale. Some buildings, about to be demolished, had very fine ornamentally slated roofs which were unrecorded, uncared for but potentially valuable in the salvage industry. The lack of legal controls, especially related to agricultural buildings had resulted "in a marked deterioration in the quality and character of rural buildings". Rural buildings in Lothian region were singled out for special comment by two interviewees. Here it was felt that permitted development rights regarding reroofing had led to "farm steadings being quarried for slate". And, of course, the proximity of Edinburgh, where the demand for high quality Scottish slate is vibrant, has exacerbated the problem in Lothian region. This situation has led to a joint venture being established by the 'Rural Building Initiative' and the 'Lothian Pilot Project'. The aims are (i) to raise awareness of the problem, (ii) to increase the protection offered to rural buildings and (iii) to produce a good practice guide for the repair, restoration and extension of existing rural buildings and for the sympathetic design of new buildings in the countryside. This illustrates that, despite the existing national guidance it is important that local authorities and conservation agencies interpret this advice at regional and district levels. While theft in the countryside "is a particular problem", conservation officers felt that they could do little to stop such illegal activities. Furthermore, it was not possible to ascertain the provenance of slates "which, to most people, all look the same whatever their source". One architect felt that an old, empty building, which was unprotected by listing or conservation area designation, potentially was a risk to the erosion of its Scottish slate roof:

"We are very definitely seeing old and empty buildings being stripped of their slates for the second-hand market - either through theft or the slates being sold off en masse".

One conservation architect felt that this legal, and often illegal, trade in salvaged slate raised ethical issues for those committed to preserving or enhancing Scotland's built heritage:

"The conservation ethics of using Scottish slate are difficult to sustain. Taking slates off one roof to put on another must be a highly doubtful idea".

A cynic might respond that, doubtful or not, in a market economy such an activity has always been commonplace. Entrepreneurs merely are satisfying the demand which exists in our finest townscape areas for Scottish slate. The danger, however, is that the general environment of Scotland will suffer in order that slated listed buildings and conservation areas can be restored. However, some interviewees saw this as an inevitable consequence of the diminishing resource. Better to use what Scottish slate was available on our finest historic buildings than to allow it to be reused in an ad hoc manner. However, many interviewees sympathised with local authority planning officers regarding this issue. It was appreciated that, by applying very detailed conditions, planning authorities unwittingly could be accelerating the erosion of Scottish slate roofs in vulnerable urban and rural areas. But some conservationists felt that all available salvaged slate should be used on listed buildings using the traditional graded roof practice. Their motto appeared to be: 'make the best use of diminishing resources by means of diminishing courses!'

"Slates wanted on or off roof, cash paid" read the advertisement in a national newspaper. As part of our research we interviewed the building merchant who was responsible for placing it in the newspaper. He had outlets in Carlisle, Glasgow and Aberdeen, and found that slates were available mostly from barns, houses and, occasionally mills. Usually, the main reason that the slates were being sold was due to demolition or replacement of the roofing material but "a fair number related to roofing improvement grants". Often, the slates were purchased while they were still on the roof, with the building merchant preferring to remove them from the roof himself. In Scotland, the most common salvaged slates were Ballachulish and Easdale, followed by Welsh slates, echoing the main slate types found in Scotland's historic areas. Care was required at the roof stripping stage in order to reduce the level of wastage which ranged from 30% to 50% depending on the size of the slates (with larger slates having the former wastage rate). If slates are smaller than average, an inexperienced salvage firm may discard as much as 50%, as very small slates will be difficult and expensive to relay.

One conservation agency spoke of a very lucrative salvage industry in Scotland where "slates are known to be valuable and are recycled anyway". One slater pointed out that the method of salvage affected the retail price of the second-hand slate. The cheapest (c £300 per 1000) usually were those which had been 'acquired', while the dearest (£760 per 1000) had been very carefully salvaged from secure scaffolding, and with each nail meticulously extracted to avoid unnecessary damage to the slates. The average price of salvaged Scottish slate was found to be in the region of £440 per thousand which, according to one supplier, "can increase a roof cost by 50% thus making the use of salvaged Scottish slate commercially non-viable". The same supplier felt that Edinburgh's conservation areas provided the main market for this expensive slate in Scotland.

1.6 Demand

Many interviewees were optimistic about the demand for natural slate in Scotland. Although it was acknowledged that slate forms a very small percentage of the roofing market today, slaters noted an increased interest amongst clients and their architects in using slate. One conservation architect highlighted the change in attitude which he perceived as having occurred in the last ten years:

"The situation is changing. Interest in conserving historic architecture has grown, planning authorities are tightening their policies and, in new architecture, quality natural materials have returned somewhat to favour".

One representative of a national agency pointed to the growing use of Spanish slate in new infill development as illustrative of the "latent demand for natural slate, especially for new build in design sensitive areas - the demand is there for natural slate". But, of course, without a supply of new Scottish slate, developers are reliant on imported slate. As previously noted, conservation areas were singled out by many as representing a guaranteed demand for slate, provided that suitable development control policies were in place. Also, in Scotland, the stock of listed buildings, most of it having slated roofs, provides a huge maintenance market for natural slate. Although it has been noted in 1.2 that many planning authorities have allowed artificial slate and concrete tile to be used in design sensitive areas, it should be stressed that this development is 'reversible'. In twenty years time, owners, given the right circumstances, could reroof their properties using natural slate. Grant aid, as in town schemes, may be required in future to stimulate high quality reroofing, but at present, interviewees did detect a market for high quality materials. One national property agency confirmed that, throughout Scotland, in selected areas, there was a demand for properties where the integrity of the historic architecture had not been destroyed by the use of artificial materials. Properties which retained such materials intact or which had been sympathetically restored, undoubtedly formed the top end of the property market throughout Scotland. One conservation architect felt that more should be done to "strengthen this demand for natural slate, especially in conservation areas". Another architect speculated that if housing associations "all agreed to use slate - 10,000 slates at a time - slate would be much cheaper". A number of representatives from housing associations were interviewed in order to pursue this issue. For cost reasons, associations specify roofing materials with a life of 60 years and usually this means the specification of clay tile for new developments. Many admitted that, after cost cutting, concrete tiles with a life of 25-30 years were being used. For cost reasons, therefore, natural slate was not likely to be specified unless substantial grant aid was available, as in a small number of conservation areas.

In terms of demand for Scottish slate, one slater felt that there was a crucial link between supply and demand. Demand, he believed, was "not that great" chiefly due to the real problems of obtaining a supply of large quantities of good quality Scottish slate. If new Scottish slate could be made available, he was of the opinion, somewhat paradoxically expressed, that "demand could go through the roof". One conservation officer confirmed that, in her opinion, "unquestionably, there is a latent demand". However, this demand is "not expressed fully at present" due to fears regarding the potential damage to Scottish townscape that increased salvage would cause. Conservation Officers, therefore, are unwilling to demand the use of Scottish slate for this reason. One national conservation agency agreed that, while there was a steady demand for small quantities of Scottish slate for repairs, there was no steady supply. Slaters, with regular maintenance contracts, were no longer able to obtain a regular supply. Therefore, while theft was increasing, it did point to a latent demand for Scottish slate:

> *"Theft is a big concern, and happens more often than you think. It does, however, demonstrate demand."*

One conservation architect felt that, while in the 1960s "supply was greater than demand, keeping the price of Scottish slate artificially low", now demand was much greater than supply "thus potentially favouring new Scottish slate quarrying". He stressed, however, that it was not realistic to try to compete in the general roofing materials market. All interviewees felt that the main market for new Scottish slate would relate to the repair of traditional buildings and "quality new build in conservation areas". As regards current repair work, one national agency noted the present mismatch between demand and supply:

> *"It is amazing how many specifications on drawings ask for Scottish slate without knowing where it could come from".*

Likewise, some local authorities, as in Edinburgh, make the use of Scottish slate a condition of planning consent related to listed building and conservation area development. Undoubtedly, therefore, planning conditions increase the demand for Scottish slate in certain towns and cities.

A few interviewees felt very strongly that demand had to be "strengthened" and "organised" in Scotland. However, the problem remains that a "strengthened demand" in present circumstances will lead to greater erosion of Scottish slate roofs in unprotected areas and from unlisted buildings. To insist, as one conservationist argued, on the use of Scottish slate "with no other alternative being acceptable" would, without a new source of slate, lead to an accelerated rate of theft and the stripping of Scottish slated roofs. As regards "organising" demand, three interviewees felt that this could only be done by a national campaign which should aim to promote and subsidise the use of Scottish slate in heritage planning projects where they felt the main demand could be anticipated. It was felt that "there would have to be a policy decision to promote slate". One conservationist proposed that Historic Scotland should introduce a national marketing campaign advocating the use of Scottish slate in "major flagship projects", perhaps offering 90% grants for authentic roofing works. The other two interviewees supported the case for targeting grant aid on major restoration works using Scottish slate. However, all three acknowledged that, without the supply of new slate, such a campaign could only focus on making the best use of salvaged Scottish slate. The dilemma remains that while demand could be increased, the short term consequences for unprotected buildings could be dire. Yet, without increasing the demand for Scottish slate nationally, it was felt by most interviewees that the possibility of re-opening a Scottish slate quarry seemed remote. One architect felt that the revival of Scottish slate quarrying was dependent on the question of organising demand:

> *"When demand is there, all the other factors will fall into place: supply and workmanship being most important."*

So, while it was felt by interviewees that, currently, there was a demand for Scottish slate for quality repair work, increasingly the supply of salvaged slate could not meet the demand. While many saw the possibility of increasing demand by tapping a latent desire for high quality authentic materials, the short term consequences could be damaging for Scotland's current stock of Scottish slated roofs. As stocks of salvaged slate were being used up, the cost of Scottish slate continued to increase, making its use increasingly dependent on a high degree of awareness, commitment and affluence on the part of property owners.

1.7 Cost and Grant Aid

Scottish slate is now perceived as being a relatively expensive roofing material with the price of slates "fluctuating dramatically depending on how they have been salvaged". Slaters commented that Health and Safety regulations are making it more expensive to salvage slate, the average price of which, as previously noted, is approximately £440 per 1,000. One slater noted that for an average sized house the cost of reslating in salvaged Scottish slate could range between £4,500 and £6,000, making it an "expensive option for most people". One architect highlighted this problem with regard to his clients:

> *"If using Scottish slate is going to cost £1,000 extra, you would have to be a real aesthete, or fairly wealthy, to contemplate it".*

Of course, if the applicant was permitted by the planning authority to use concrete tile, the short term saving could be as much as £4,000. So, unless the planning authorities insist on the use of natural slate, "most people will be driven by cost". One conservationist noted the prevalence of properties which had original slate on the street-facing pitch but new concrete tiles on the rear pitches. The reason for this rash of strange roofing material juxtapositions "is purely financial". While one interviewee noted that, in life cycle terms, slate was a better investment than cheaper artificial materials, he concluded that "no mechanism is in place that recognises value in the longer life span; the short term view is always taken - in fact the developer wants his money back in six months".

In rural areas, farmers often were resorting to cheap corrugated metal sheeting as a replacement for their slated roofs which were much in need of repair. It was felt by many interviewees that such replacements were cost driven. Only when steadings were listed or were subject to strong estate policies, were Scottish slated roofs being repaired or restored. Without grant aid one national agency felt that such authentic repair work "will always be an elite activity". One architect believed that it was not only the high cost of the material which was at issue but also the extra labour costs involved in laying a properly graded roof:

> *"The problem with trying to encourage a greater use of Scottish slate is that it is craft based. That is, it requires skill, knowledge and extra time. And, therefore, labour will be more expensive."*

For this reason, many interviewees felt that, unless there is a regulatory control and grant aid in place, "most people will go for the cheaper option". Without grant aid in conservation areas or related to listed buildings, as one interviewee asked, "who is going to match the difference in price that natural materials incur?" Many local authorities feel that town schemes, jointly funded by Historic Scotland and themselves, and offering grant aid of 50%, can foster the use of natural materials and high quality workmanship in outstanding conservation areas. Furthermore, it must be remembered that the extensive use of salvaged Scottish slate in Edinburgh since 1975 has been grant aided through the housing improvement programmes and also through conservation subsidies in the New Town and Old Town conservation areas. One national agency felt that, without grant aid to subsidise its use, salvaged or, for that matter, new Scottish slate "will always be more expensive than other natural slate".

1.8 Other Natural Slate

The most common natural slate found in Scottish townscapes, apart from Scottish slate, is of course Welsh slate. One conservation architect confirmed the historical importance of Welsh slate in the traditional building environments of Scotland:

> *"We must accept that Welsh slate is traditional to Scotland as well".*

Imports of Welsh slate increased in the 1880s, and the material still is predominant in many of our coastal towns. In the late 19th century and early 20th century, Welsh quarries exported their thicker, rougher slates to Scotland where the climatic conditions favoured the use of such slate. One building merchant felt that the use of thick, rough Welsh slate had been "far more widespread than most people realise". As it was laid sometimes to Scots practice, it is difficult often to distinguish between this "coarse Welsh import" and true Scottish slate. The same dealer felt that, of all his stock of second-hand slate, Welsh slate provided the best quality. However, many slaters and architects concurred with another interviewee who concluded that recent slate from Wales "is cheaper and lighter, but it tends to break". Conservation agencies in Edinburgh also were somewhat ambivalent about Welsh slate. In the Old Town, Scottish Easdale slate was considered as being the 'original' material for most roofs and, consequently, Welsh slate roofs, which were considered as being "relatively recent", were being reslated using Scottish slate. However, in the New Town, where roofs predominantly are "West Coast Scottish", owners might be given grant aid for the repair of a Welsh slated roof. Nevertheless, Scottish slate is the dominant roofing material in the New Town and was still being used in the 1880s when the last tenement properties were being built.

As previously discussed, Cumbrian slate was felt by some interviewees to be the most closely comparable with Scottish slate, and was being used by conservation agencies for the reroofing of major listed buildings where either second-hand Scottish slate was not available in suitable sizes or quantities or when architects preferred to use new slate. Burlington Peggies were thought highly of by many slaters, and it was felt that this slate coped well with the extremes of the Scottish climate. However, while admired for its intrinsic qualities, Cumbrian slate generally was seen as being finer and smoother than most Scottish slate. Some interviewees were aware that Burlington, suppliers of Cumbrian slate, had investigated the feasibility of quarrying slate blocks in Scotland and then transporting the blocks to Cumbria for dressing. Burlington's related industry which promotes the decorative use of slate, for example to make worktops and fireplaces, was seen as a good example of the diversification which any future Scottish slate quarry would have to emulate. As previously discussed, one interviewee felt that, by using stricter planning control in Scotland, Welsh and Cumbrian slate to match the aesthetic of Scottish slate could be specified for new building work, especially in conservation areas. If such material could be imported and laid in diminishing courses then the aesthetic and practice of Scots slating could be preserved. Such slate, in his opinion, would always be much cheaper than new Scottish slate produced from a re-opened Scots quarry. However, doubts were expressed as to the ability of Welsh and Cumbrian quarries to produce thick, rough slate which truly matches the distinctive qualities of traditional Scottish slate. One slater noted that one Welsh distributor, Penrhyn, recently had introduced slates particularly for the Scottish market - the riven 'Celtic' slate. He pointed out that only approved roofing contractors would be able to procure this product.

Spanish slate proved to be the most controversial of all the imported slate to Scotland. While most interviewees acknowledged the importance of Spanish slate in promoting the wider use of slate roofing in new build developments, many were very dubious as to its quality, especially in relation to its durability in the Scottish climate. However, it was noted that, in recent years, imported Spanish slate was of a much better quality and distributors were "doing everything they can to match market demand". The main advantage of the relatively cheap Spanish slate was that it provided an economic alternative to artificial slate and concrete tile. One architect, who was sceptical of the quality of much Spanish slate, felt that "at least Spanish slate is a natural material". Others noted that Spanish slate was made to five grade sizes and that they could be provided to ten different sizes if required. While this would increase costs, it would enable a graded roof to be achieved. However, one building preservation trust representative did not feel that Spanish slate sales representatives really understood what constitutes 'randomness' of slate sizes in Scottish slate practice terms. He felt that to reproduce a traditional graded roof in Spanish slate would be very expensive. One conservation architect was very dismissive of the whole idea of using Spanish slate to simulate the aesthetic of a Scottish slate roof. As the Spanish manufacturers are geared to producing uniform sized slates, he felt that such a simulation of Scottish practice would be "a complete fake" and a "waste of material". The same architect did not believe that, at present, Spanish slate could be provided which could be used to mimic convincingly the qualities of a traditional Scottish roof:

> *"The slate on offer does not match in appearance and, for historic buildings, does not provide convincing diminishing courses."*

The smooth aesthetic of Spanish slate was seen as a better match for Welsh slate than for Scottish. Indeed, Spanish slate imports were seen as posing a threat to the Welsh home market "as it can be easily argued that Spanish slate can mimic the qualities of Welsh slate". In fact a recent European Union ruling has allowed Spanish slate distributors to compete freely with the home based slate manufacturers in Wales. Furthermore, independent tests have shown that there is no significant difference in colour, texture and durability between Welsh (Cwt-y-Bugail) and Spanish slate (Del Carmen). However, despite Spanish slate having "passed durability tests" many Welsh slate manufacturers felt that such imports were "prone to colour change, lacking in lateral strength and had a tendency to break during laying and when subject to severe wind loads". This criticism was reiterated by some Scottish interviewees who had experienced "softening of slates at nail holes, possibly due to vibration caused by the wind". While some conservation agencies, therefore, were "cautious about the use of Spanish slate", some interviewees acknowledged that the general standard of Spanish slate had improved and that some products were of a high standard and competitively prices:

> *"The confidence in Spanish slate has waned but certain companies are producing a good product, for example CUPA."*

The National House Building Council (NHBC) felt that most of the problems concerning Spanish slates had related to their thinness. The NHBC currently rules that "slate must be no thinner than 5mm". Many interviewees felt that, while standards of Spanish slate had improved, the supplies often were variable in quality due to the distributor obtaining slates from a variety of quarries. Undoubtedly, however, the availability of Spanish slate has led, in recent years, to a greater use of natural slate in major infill developments, especially in conservation areas. And its availability has been a major factor in the change of policy in Glasgow with regard to the reroofing of traditional tenements in conservation areas. The major consequence of this policy is that concrete tiles are no longer seen as an acceptable replacement for natural slate in conservation areas.

1.9 Conclusions

It is important that urgent action is taken to safeguard existing Scottish Slate roofs. The finest examples should be identified and recorded in order that special protection and restoration measures can be introduced at national and local levels. In England, English Heritage has initiated a campaign to save traditional stone slate roofs - perhaps there is a need in Scotland for a similar campaign to save the finest surviving examples of Scottish Slate roofs.

However stocks of salvaged Scottish slate are diminishing and the material is no longer used for large infill developments, even in conservation areas. Without a supply of new Scottish slate the demand for the material is unlikely to increase significantly. While there is a healthy demand for Scottish slate for high quality repair and restoration projects, increasingly local authorities, due to supply shortages and rising costs, are being forced to accept alternative natural slate, and even artificial roofing materials. In the long term, therefore, unless a supply of new Scottish slate is created the quality of Scottish townscapes undoubtedly will be eroded by the use of unsuitable roofing materials in repair work and new development projects. There is an important need therefore to assess the feasibility of re-opening a Scottish Slate Quarry in the near future. But even if a Scottish slate quarry is not reopened in the near future, much can be done to preserve the finest graded Scottish slate roofs well into the twenty-first century.

REFERENCES

Glasgow District Council Director of Planning (1995) Roofing Material for Listed Buildings and Buildings in Conservation Areas in Glasgow, Glasgow District Council.

Roofing (ed) (1995a) 'Man Made Slate', Roofing, April 1995.

SCOTTISH SLATE RESEARCH

Shelley Brown, Scottish Lime Centre Trust

Introduction

This paper derives from a research project commissioned by Historic Scotland TCRE, and carried out by the School of Town Planning, Dundee University. The study began in June 1995, the objectives being to examine and quantify the conservation issues arising from the loss of the Scottish slate industry; to determine its contribution to Scottish architecture, attempt to gauge the reasons for and extent of its loss, and offer some understanding of the potential market for a new Scottish slate. I am not reporting on the findings of the study here, but instead would like to raise some of the pertinent issues with you and offer my own views on the subject.

Historic Scotland has also commissioned the Department of Geology, Glasgow University, to carry out research to identify the qualities and performance that are distinctive to Scottish slate and to assess the potential of Scottish slate quarries with a view to encouraging the revival of the slate industry in this country.

When asked to write this paper, I was given a resume of the aims of the conference and its primary themes. The themes included examinations of the skills linked to traditional materials, correct specification of those materials and skills and their current availability. I intend to focus on the first theme offered by the conference organisers, to "describe the qualities of the particular material for conservation use". I want to examine the quality of Scottish slate.

Quality is an illusive concept. It can mean both an attribute of something (an objective view) or a degree of excellence of that thing (a subjective view). The relative value of one object to another can be discerned by the appreciation of quality.

Quality is very pertinent to the issue of Scottish slate because, as I will attempt to describe, it is a unique material. It differs both markedly and subtly with the other slating traditions of Britain, both in its physical characteristics and in the way practice has developed to lay it. It is regionally specific, both as a 'Scottish' material and between distinct areas of Scotland.

An appreciation of the specific qualities of Scottish slate is essential, because it is those qualities which are being lost. No slate quarrying has been undertaken in Scotland since the 1950's, and since then all Scottish slate used has been recycled from the demolition of whole buildings, material salvaged when a slate roof is replaced in another material or, as frequently occurs, simply stripped of its slate leaving the building to decay. Obviously this source is finite and diminishing. The perceived alternatives to Scottish Slate are other natural slate from elsewhere in Britain and abroad and synthetic materials. I will contend that the characteristics - the 'qualities' - of these materials do not realistically reproduce the character and appearance of a Scottish slated roof. I want to make the case for authenticity.

CHARACTER: A Ballachulish slate bearing the company stencil.

The Qualities of Scottish Slate:

So what are the qualities of Scottish Slate?

There are a variety of slates indigenous to Scotland. There in no one 'Scottish Slate'. The term 'slate' generically (though not geologically) would include all riven natural slab materials, such as the sandstone slates as found in Orkney, Caithness and Angus (the famous Carmylie stone slates), as well as slates of variable metamorphosis - slaty flagstones, shales, mica-shists etc, - found variously in areas of Dumfriesshire, the west coast, the Borders, and the Grampian Highlands. These materials have their own peculiar characteristics and traditions, such as the use of huge slabs of sandstone in Orkney and the torching up of Carmylie stone slates with lime mortar.

Sandstone and shale slates can be split due to the close set nature of their bedding planes. Scottish Slate, however, is generally the term given to the true slates of Scotland. True slate is a material which has undergone full metamorphosis, where intense pressure and heat has profoundly changed the original sedimentary material, setting up a new set of planes along which the rock splits readily.

Ballachulish because Scotland's largest and most famous slate quarry which dominated the industry in the 19th century. Scottish Slate is not confined to Ballachulish, however, but is found in four main groups in Scotland:

1. Ballachulish slate belt. Several small quarries exist, neighbouring the main Ballachulish quarry, all close to the coast on Loch Leven.
2. Easdale slate belt. This group consists of numerous quarries opened on the islands of Oban. The largest included Easdale Island, Ellenabeich and Balvicar of Seil, the small island of Belnahua, and Cullipool and Toberonochy on Luing. This group is known as The Slate Islands.
3. Highland Border slate belt. This belt is a strip (4 miles wide at the maximum) which runs diagonally across the country from Arran to Stonehaven. Quarries are numerous (many appear associated with estate building) but the largest have been opened at Luss, Aberfoyle, Craiglea near Comrie, Dunkeld and Birnham.
4. Banff-Aberdeen slates. Slate occurs on the coast at MacDuff and at the Glens of Foundland, south of Huntly. True slate, however, forms a very small part of the many quarries to be found here, which also include flagstones and schists.

Each of these groups have distinct characteristics which are clearly recognisable. I have little doubt that the quarrymen and slate suppliers of old could pinpoint a slate to the particular quarry.

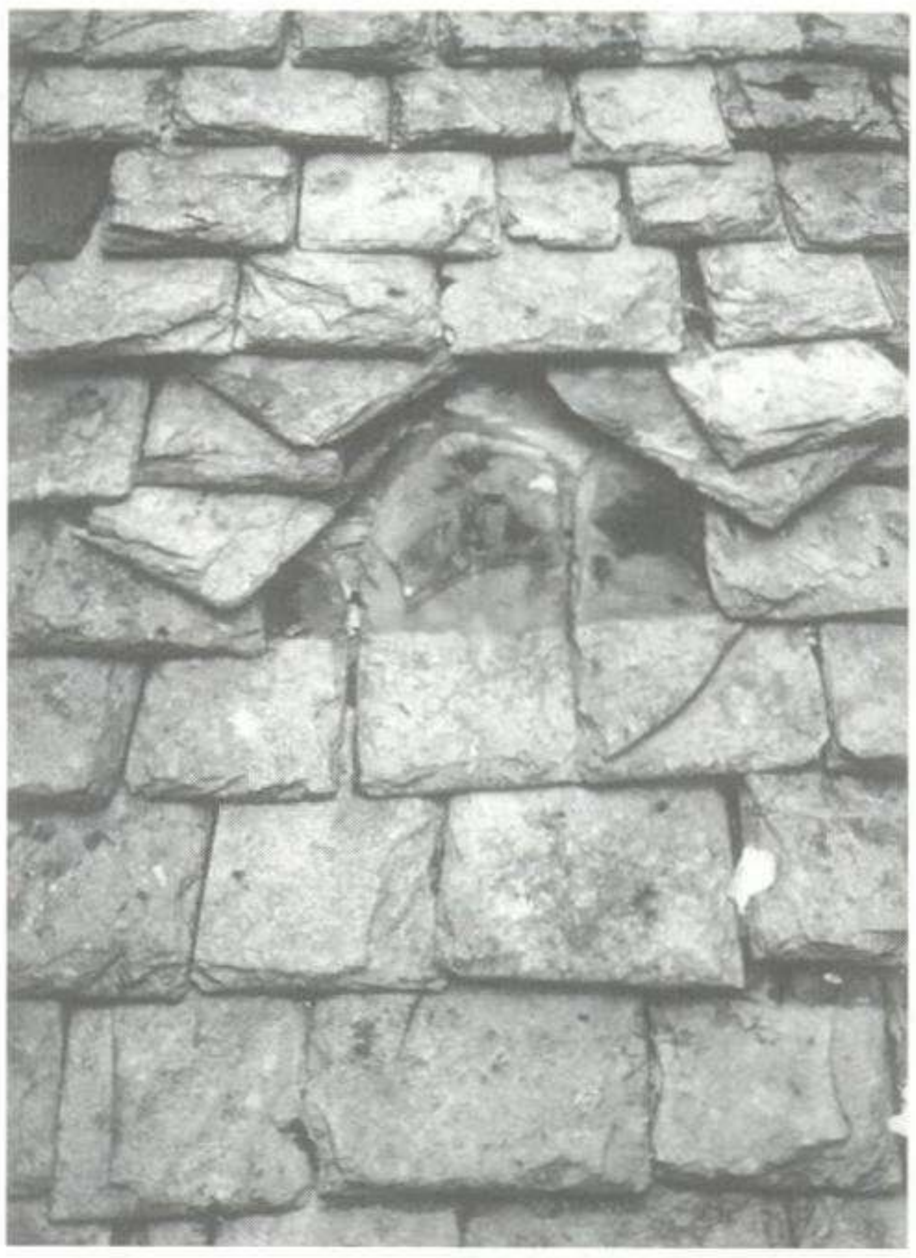
Ballachulish slate has generally been regarded as the finest of the Scottish slates. The slates can be large and are blue to grey, often quite even although they can show a well marked grain, and are characterised by the inclusion of iron pyrites crystals, which the quarrymen called 'diamonds'. You can tell a good slate by striking it with a coin. It should ring when struck showing the 'metal' of the slate.

Easdale slates, the other west coast slates, are similar to Ballachulish, also often containing pyrites, but tend to be characterised by a more marked grain.

The Highland Border slates are quite different. These are smoothly textured, and grain and pyrites are rare. There are a variety of colours including blue, grey, green and purple. Also mottled mixed colours, for example the 'Aberfoyle Tartan' - although I have never actually seen one of these elusive products! Highland boundary belt slates can be slightly thicker and less regular splitting, although are not invariably heavier,

Banff-Aberdeen slates are quite a sombre dark blue grey. They are the roughest and thickest of Scottish Slates, again without grain or pyrites, but often appearing quite shiny from the flakes of mica exposed on the surface.

Colour, texture, weight etc. contribute to the physical nature of a material and help to make it identifiable. We can discern these particular attributes from materials with similar ones. We appreciate one characteristic from another, and judge good from bad; judge quality.



PRACTICE: The traditional practice of random slating to diminishing courses. the slates are shouldered, single nailed at the head and laid on sarking.

The way the material is used or arranged also contributes to its particular characteristic.

I have visited many of the quarries mentioned above, and working your way around the contorted rock faces and huge waste tips of off cuts and unusable material you can begin to understand the intensive labour that was involved in quarrying. The difficulties involved created the need to make the best use of the material extracted, and this is what has given the tradition of random slating to Scotland. Slates were produced in variable widths and lengths (the largest slate possible from each quarried block). The randomly sized slates were then sold as either 'sizeable' which was above a particular size or as 'undersized'.

On the roof, these randomly sized slates are arranged to diminishing courses, the largest at the bottom, diminishing to the smallest at the top. Considerable skill is involved in working out the correct rate of diminishing. Unlike regular Welsh slating, the head-lap and side-lap of slates will not be all the same. Very rough slates may have to be graded for thickness too - a third dimension.

Random slating was the earliest technique of arranging slates. It is used in the Lake District, in Cornwall, in the many areas of Britain where stone slating occurs, and indeed it was once used in Wales. Regular slating has developed in Wales by the mid 18th century, where the fine and uniform texture of the material which split easily into large and thin slates, suited standardisation. The difference in character between that of a roof of random, diminishing and generally smaller slates, with that of a roof of large regularly sized slates is huge. The former has a natural order. The latter has the regular bond of brickwork.

Within Britain's various random slating traditions, it should also be appreciated that each have their own idiom. The tradition of one part of the country cannot be transplanted into another.

The properties of the slates - their random size and heaviness - has contributed to other characteristics of Scots slating in the practices adopted for laying. These included the shouldering of slates (slanting the top corners), head-nailing slates with a single hole, and adopting the use of sarking board instead of battens (increasingly battens are used for both regular slating and random stone slating).

Scots make various claims for the rationality and advantages for their system of laying:

1. Sarking is more expensive but makes the laying of small and random slates easier to set out. Sarking gives a close-coupled roof rigidity and a second layer of protection against water ingress.
2. Nailing at the head ensures that two thickness of slate cover the nail hole. Single nailing at the head also allows the slates to be swung, so aiding replacement of damaged slates.
3. Shouldering eases the jointing of slates against each other, preventing them from rocking, thus allowing rough slates to be laid more easily.

CONTRAST: Do the imported slates of the rear roof really bear the same characteristics as the Scottish slates in the foreground?

Did you know all this? Quite possibly. However, what I am trying to demonstrate is the specific and variable nature of the material - its peculiar characteristics of both form and practice - which create its quality.

All these factors create the particular appearance of traditional Scottish slated roofs which in turn contributes to the character of Scotland's town scape. It will be seen that character will subtly vary between the towns and cities near the coast (for example Glasgow, Edinburgh and Dundee) which received slates largely by ship from Ballachulish and Easdale, with the towns of the central belt which had their own local slate quarries, and with the Highlands and Borders which again had a variety of slating materials and traditions.

It should be said, that from end of 18th Century, slates were also brought up to Scotland from Wales and the North of England, often by ship, and again concentrating on the coastal towns and cities. In Victorian buildings, regular slating may often be found, or patterned slating using a mixture of slate colours, both in random and regular slating. Interestingly, the slates often supplied from Wales were those they classed as inferior - smaller and rougher slates - which were less saleable to the English markets. These slates, termed 'Welsh Moss' and 'Welsh Rogue' suited the Scots aesthetic, however, and are usually laid to Scots practice.

All this further adds to the diversity of character of traditional slate roofing in Scotland.

The Conservation Issue

The last quarries closed in the 1950's, and for the past 40 years demand for Scottish slate and has to be met by re-cycling. Look around you and you will find many forlorn slate-less buildings, mostly gate lodges, farms and industrial buildings, whose slates have been considered of more value than the keeping of the building. Demolishing buildings to preserve others is not good conservation.

Obviously this is an unsustainable situation. It can only be a diminishing one. While the slate to be reused will often still be sound (150 years maybe from first use), each time they are stripped from a roof as much as 40% is lost through discarding and dressing down. The very smallest slates especially, are often discarded as too much effort and expense to re-lay. All this can change the character of a roof.

LOSS: Scottish slates lost and probably recycled for another building. An unsuitable source.

The alternatives are new quarried slates from Wales, Cumbria and abroad and artificial slates of various recipes. Increasingly many of these producers are suggesting that they can provide a 'Scottish slate' - a heavy, textured slate with the correct qualities - a Ballachulish look-alike. How many of these slates however, are supplied in fully random sizes to be laid in diminishing courses? How many are as small as Scottish slate can be? What of the other traditions, the shouldering, the head nailing, and the skill needed to lay diminishing courses? And what of the amazing range of colour and texture found in the different Scottish slates which can identify a Dunkeld roof from a Fort William roof? These materials do not reproduce the specific qualities of Scottish slate. You could tell the difference, I'm sure. But more fundamentally the new materials significantly alter the grain of our streets, towns, villages and rural buildings.

These materials, of course, will have their place. New buildings of quality today are often clad in natural materials. Development in conservation areas require visually appropriate materials. Works to listed buildings, however, should really use the authentic article. But recycled Scottish slate is a scarce resource and, in a sense, must now be rationed to the most deserving of buildings.

The problem of conserving Scottish slate is thus two-fold: both the use of second hand Scottish slate and also its replacement by other materials is eroding Scotland's built heritage. How much better is would be to have the real thing - new Scottish slate.

Re-opening quarries is a huge undertaking, and I won't try to consider the implications here. The most recently worked quarries have been abandoned for some forty years. Now coming up to the 21st century, there is so much more we have to take into account before embarking on such an enterprise.

The debate on Scottish slate has been going on for many years, and involves much more than I can attempt to cover here, however, the viability of any enterprise rests on supply and demand, and at the end of the day, only a demand for Scottish slate will support its revival. I would suggest that there is a demand for Scottish slate - why else would we see such a flourishing second hand market, and why else would quarries of Britain and abroad now be designing slate to suit the Scottish market. Whether demand for slate may be translated into a supply of real new Scottish slate however, will wholly depend on how discerning that demand is.

It is up to specifiers - architects, surveyors and planners - to accept only the real traditional material in conservation work in order for industry to accommodate this demand.

Scottish slate is an individual material. It is UNIQUE and it is BEING LOST. With the loss comes erosion of the character of Scotland's distinctive architecture. You can tell the difference.

GROWTH RATES AND DURABILITY OF TIMBER

Dr Brian Ridout, Managing Director, Ridout Associates

The history of timber usage throughout the British Isles is complex and it is unwise to generalise too far but it is probably true to say that, whilst oak (hardwood) construction timbers were historically home grown or imported, most of the pine (softwood) used was brought to these islands from abroad and had been removed from natural forest where they had been grown for perhaps 200 - 250 years. Scots pine trees though native to Britain, grew only in localised areas of Scotland, and had disappeared over most of England by the time of the Romans. Attempts at planting larch north of the border in the eighteenth century were plagued by decay fungi, whilst the first pine plantation in England (Hampshire) is thought to have been planted in 1766. The situation changed a little during the nineteenth century, even when the Forestry Commission was founded after the 1914 -1918 war, but home grown softwoods have still formed only a small part of the timber consumed by the construction industry. Even in Europe, our major supplier, forestry had changed as accessible wild forest were felled and plantation growing became the standard twentieth century practice. Pine trees might now be only 40-50 years old when felled.

All this may seem irrelevant to the theme of this conference, but in fact the speed of growth may affect a timber's durability as much as the species of the tree, and speed of growth is directly influenced by forestry methods. Plantation grown timber may not have the same properties as wild grown. This needs to be understood because slightly decayed but durably slow-grown timbers are frequently removed and replaced with inferior materials for economic reasons when repair is practical. Thus the retention of an eighteenth century rafter may have a practical value which augments its historical significance. In order to understand why this change in durability occurs we need to know a little wood anatomy.

The term softwood refers to the conifers, the needle leafed or cone bearing trees. These are botanically known as gymnosperms (Greek for 'naked-seeded') because the seeds develop exposed on the surface of a cone scale. The gymnosperms living today are the representatives of a group which extends back in time for more than 350 million years.

Softwoods have a uniform structure. Between 90 - 95% of the wood consists of slender cells orientated along the stem axis with closed flattened or tapered ends. These cells are known as tracheids and they must supply strength to the tree whilst allowing sap conduction. Sap conduction is rather indirect because fluid has mostly to pass from cell to cell via valves (figure 1) which may be shut if water loss is too great. Needle shaped waxy leaves, an open growth form and a controlled sap conduction system, all allow the trees to grow in harsh environments. Sap conduction, and hence growth, maximised in the early part of the year by the production of thin walled tracheids with a wide interior, whilst in the latter part of the year thick walled tracheids are produced to provide strength. This seasonal variation in cell wall thickness produces characteristic early wood/late wood bands.

Hardwood, or broadleafed, trees are botanically known as angiosperms or 'hidden seeded' plants because the seeds develop enclosed in an ovary which eventually becomes a seed capsule. They are a more recent addition to the flora, and do not appear in the fossil record until about 100 million years ago. Hardwood trees have a more complex anatomy than softwoods. Most of the sap transportation takes place in elongated cells which join end to end over considerable distances. The dividing walls disappear to a greater or lesser extent, and the result is a direct transport system rather like drinking straws (figure 2). Strength is mainly supplied by long narrow cells called fibres so that the two functions of strength and conduction are carried out by two different cell types. Hardwood trees, as a group, are quite versatile, but most grow naturally in more fertile environments than softwoods.

Having explained the relevant differences in anatomy we can now see the consequences of changing growth rates by planting on fertile soils and/or crop thinning.

	Anatomical changes	*Consequences*
Softwoods (eg Pine)		
	A preponderance caused by an increased growth rate of thin walled early wood cells	Loss in strength/durability
Hardwoods (eg Oak)		
	Wide and thin walled vessels but plenty of fibres	Increase in strength

Thus plantation growing is likely to weaken softwoods and strengthen hardwoods.

Conduction is all timbers takes place in the outer band of sapwood which contains living cells within its rays. This sapwood is particularly vulnerable to attack by fungi or insects when it dries because it contains nutrients. When the living tissue dies then the cells may become blocked with a variety of deposited materials and the dead sapwood cells increase the diameter of the heartwood. It is the heartwood which may confer durability on the timber. Wide old trees have thin sapwood bands in proportion to their girth. If a vigorously growing tree is cut whilst young and narrow then the proportion of sapwood present may become 80 or 90% of the timber. Any durability the species of timber may potentially have is lost, and can only be partially replaced by the application of preservatives.

Morals: Conserve old timber. Eighteenth or nineteenth century wild grown softwoods are practically irreplaceable, and have a natural durability which cannot be reproduced with modern softwoods of the same species.

LIME

Pat Gibbons, Director, Scottish Lime Centre Trust

Introduction

Lime is one of the basic traditional building materials, found throughout the world and with evidence of use stretching back over seven thousand years. Limestone, locally the main raw material for lime production, is found in many locations throughout Scotland. In addition to its use in building, lime was, and still is, widely used in agriculture and industry. Lime is known to have been used in building in this country since at least Roman times, but it was during the 18th and 19th centuries that its production and use became widespread. During this period the major source of lime production in Scotland was at Charlestown, on the north shore of the river Forth, from where approximately one third of all the lime used in Scotland was produced.

The Scottish Lime Centre Trust is a specialist building preservation trust, based at Charlestown. The Trust seeks to promote the appropriate repair of Scotland's traditional buildings, through training, advice and research. A major part of the work of the Scottish Lime Centre Trust involves practical, and theoretical, training for repair of lime-built structures. Practical workshops are held weekly (except during the winter), supplemented by commissioned workshops for specific clients throughout Scotland. The other activities of the Scottish Lime Centre include specialist consultancy for building repairs; materials investigations, analysis and advice; and commissioned research and publications. Relevant work in progress at present includes a Technical Advice Note on external lime finishes and a comprehensive database, with supporting Advice Note, on Scottish aggregates for building conservation, both commissioned by Historic Scotland. Work is also in hand for a publication on hydraulic limes, and the Trust is actively promoting the re-introduction of Scottish limes.

For anyone who aims to be professionally involved in the repair or conservation of traditional buildings, whether as a specifier or as a tradesman/contractor, a working knowledge of lime-based mortars is essential. Contrary to popular belief, lime mortars are not mysterious to specify or particularly difficult to use, they are just different from cement-based mortars.

Within the time available in this short session I am not going to attempt to provide detailed instructions on how to use lime-based materials, but rather to explain why they should be used and to give you a general overview. More detailed information and advice is available on a consultancy basis from the Scottish Lime Centre Trust, and from various Historic Scotland publications, such as Technical Advice Notes 1 'Preparation and use of lime mortars' or 2 'Conservation of plasterwork'. A discussion document, published by Historic Scotland, is also available, containing case studies of various harling projects undertaken by Tim Meek Associates.

This presentation today describes the benefits of using lime, outlines the background to its historic use in Scotland and explains, briefly, the technology of lime-based materials and criteria for their specification and use.

Benefits of lime

The two basic reasons for using lime mortars are first, to use it where it is the best material for the job and, second, to use it where it is historically and aesthetically correct.

To successfully repair old buildings some understanding of traditional building technology is essential. Traditional building construction, in all its forms, is the original permeable, 'breathing wall' construction; the modern re-invention of the 'breathing wall' is a move to recover the benefits of this type of construction, lost in the change from traditional mortars to cementitious mortars. Permeability is absolutely vital to the successful performance of traditional masonry and if this permeability is compromised, for example by the use of impermeable mortars or coatings, behaviour patterns will be altered and problems of some sort will be almost inevitable.

Weatherproofing

Solid-wall masonry structures exclude water from the interior of the building by absorption and evaporation. The typical cross section of a rubble masonry wall shows two outer skins of masonry with a rubble and rough lime mortar core. The individual stones are closely laid, often in direct contact, and are stabilised by small pinning stones and by the mortar filling. This type of construction handles moisture, or even direct water penetration, by 'mopping up', or absorbing, the water before it can penetrate to the interior and by allowing the moisture to evaporate back to the outside air. Where dense impermeable building stones are used in single skin masonry, the presence of a mass of permeable lime mortar, in the wall core as well as the joints, is essential if the structure is to exclude water. Without this ability to mop up penetrating water, wind driven rain may penetrate through open joints, through hairline cracks in cementitious mortars or through fissures in the masonry itself, and appear on the interior faces of external walls. Most traditional rubble masonry buildings were originally given a coating of lime mortar, which contributed to the effectiveness of the moisture holding and evaporation cycle. The loss of these coatings or, in the case of late 19th century 'romantic' buildings, their total absence, can in itself be a cause of water penetration which is not easily remedied by repointing.

Stone decay

The degree of permeability of a mortar will also influence the pattern of movement of moisture within the masonry walling. A dense, impermeable (normally cementitious) mortar will cause all absorption and evaporation of moisture to take place in the stones and the resultant crystallisation of salts or frost will damage vulnerable stones. Where cement-based mortars are used this decay process can be exacerbated by the presence of soluble salts formed during curing of the cement.

Movement

Masonry set in lime mortar has an ability to accommodate movement, both structural movement and seasonal/thermal movement, without significant damage. The modulus of rupture and the bond strength of an appropriate, well cured mature lime mortar are such that movement joints are not required in new construction.

Environmental issues

Throughout the full cycle of its manufacture and use, non-hydraulic lime achieves a carbon dioxide balance, unlike cement which makes a finite contribution to the release of carbon dioxide into the atmosphere. The production and use of any building material has some degree of environmental impact. Whilst the large scale quarrying and burning of limestone, whether for production of cement or lime, is environmentally undesirable, the production of lime requires less embodied energy than cement and, over the life cycle of the material.

Other environmental benefits result from the 'reversibility' of works and the consequent possibility of recycling building stone and bricks. Old lime mortar itself can also be recycled.

In well maintained traditional masonry construction the use of lime mortars and coatings can contribute significantly to the thermal performance of the building. In themselves, these materials contain a high proportion of pores, providing good insulation, and their ability to transmit moisture vapour reduces the risk of condensation. If the lime mortar or the masonry become saturated with moisture which cannot evaporate, for example because of the application of a cementitious render, then these pores will fill with water and the insulation value will be reduced.

Appearance

The appearance of Scotland's traditional buildings derives directly from the materials used as well as the 'architectural design'. In vernacular building, of course, the two are inseparable. Attempts to repair or recreate traditional details or finishes in non-traditional materials are inevitably unsatisfactory from a visual, as well as a practical, point of view. This applies as much to masonry, mortars and surface coatings as it does to windows, roof coverings and external fittings. Without some sensitivity to the need to use local materials on a like for like basis, the variety and 'local distinctiveness' of our built heritage will soon be lost.

Historical background

Because it is important to understand the nature and behaviour of a building before attempting to carry out repairs, it is important to identify the type of materials, in this case lime-based materials, originally used.

Lime, of various types, has been an important building material for many thousands of years and has probably been in use in Scotland for at least two thousand years. Before the use of Portland cement became commonplace around the mid twentieth century, lime was the most widely used binder in structural mortars. In addition to its function as a construction mortar, lime was widely used as a finishing material in the form of external rendering or harling, internal plastering and as a protective and decorative coating in the form of limewash.

Clay mortars were also important - these will be covered in the next paper. In fact we should not make a specific distinction between lime- and clay mortars, since many combinations and variations of these two types of binder exist in practice.

As might be expected, for all but the most important buildings, lime, like other materials, was sourced locally if possible, and was combined with local sands to make mortars. The nature and properties of lime mortars can therefore be seen to vary geographically and, because of the complex nature of Scottish geology, a number of different types of lime, and different sands, were in use.

The properties of lime mortars used in the past were also dependent on methods of processing and production. It is becoming increasingly clear that traditional lime mortars were sophisticated and complex materials and that attempts to use over-pure, highly processed modern limes (which, after all, are produced primarily for the chemical industry) have not been entirely successful, particularly where an understanding of good site practice has not been present. Current practice, therefore, aims to replicate the more complex structure of traditional materials and to ensure that the basic principles of good site practice are applied.

When repairing old buildings it is important to be able to recognise the type of lime used, the type of sand or other filler used, the relationship of the lime binder to filler materials, and the function of the lime-based materials in the overall behaviour of the building.

What is lime?

Lime, as used in building, is the binder paste in lime-based mortars and other similar materials. It is closely related to modern Portland cements, which derive from more intense processing of similar materials, and which, consequently, produce harder, more brittle and less permeable mortars. Lime is a calcium-based material, normally produced by heating a calcium carbonate such as limestone or chalk, to convert it, initially, to quicklime (calcium oxide) and thereafter, by the addition of water, to lime putty or hydrated lime (calcium hydroxide). To produce a stable, durable material a further conversion needs to take place once the mortar has been used, to return the lime to its original chemical form of calcium carbonate. This is known as carbonation and is a fundamental part of the curing process of lime mortars.

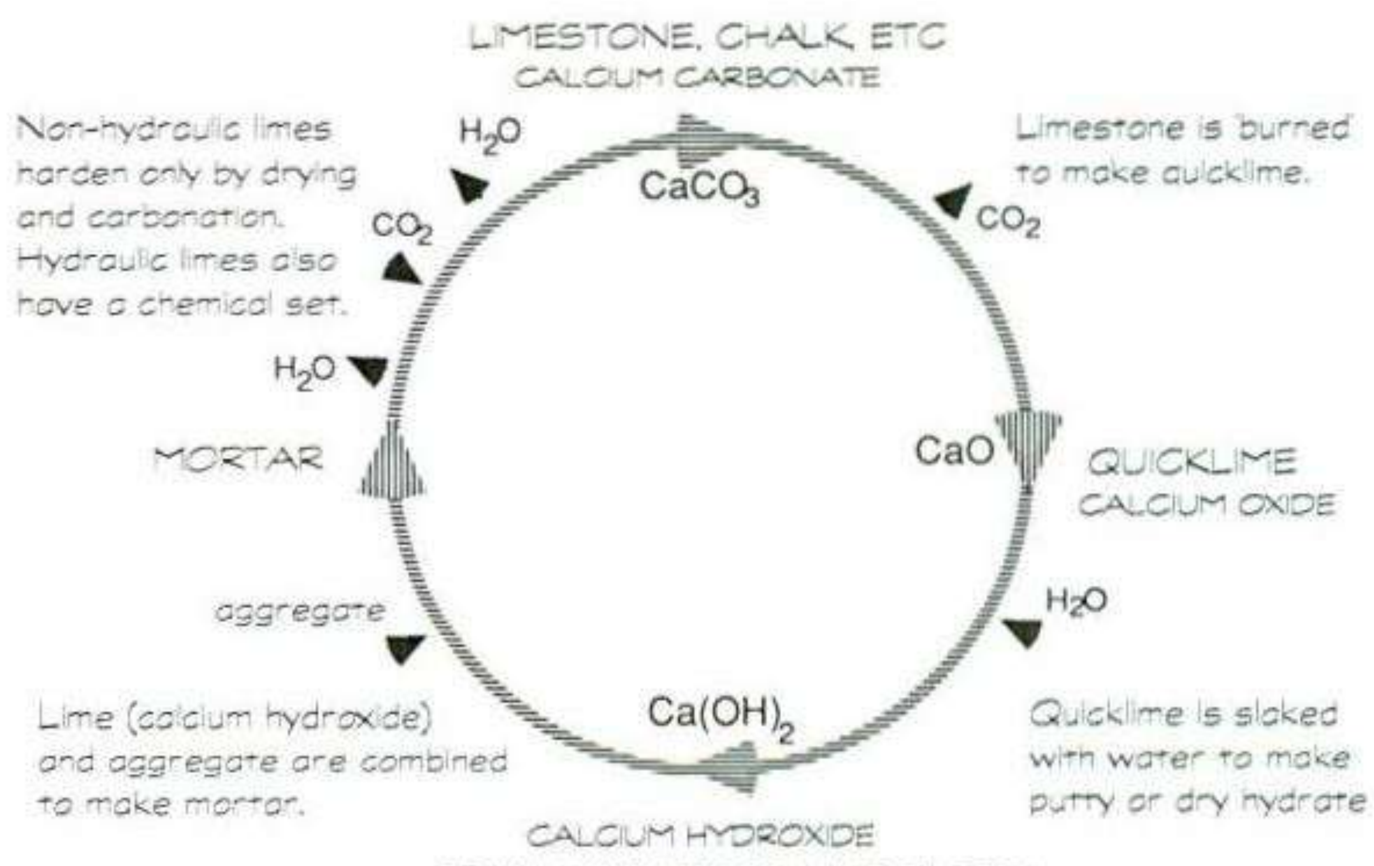


Fig 1 Simplified diagram of the lime cycle

Hydraulic limes

Not all lime is produced from completely pure limestone and therefore building limes have varied historically with geological variations in the available limestone. If clay minerals are present in the limestone reactive silicates and aluminates will be formed during the limeburning process. These minerals combine readily with calcium hydroxide (lime) and water and will impart a degree of chemical set, the strength of set depending both on the proportion of reactive minerals present and on the temperature at which the material was fired.

Limes which contain reactive clay minerals are known as hydraulic limes. The descriptions 'feebly hydraulic', 'moderately hydraulic' and 'eminently hydraulic' are used to describe the degree of set present. In normal hydraulic limes the chemical set is present in addition to the carbonation process, it does not replace carbonation. Materials known as 'natural cements' contain very high proportions of reactive clay minerals and rely totally on the chemical set, rather than carbonation, as do modern cements. Modern Portland cements are, in fact, artificially produced very strongly hydraulic limes.

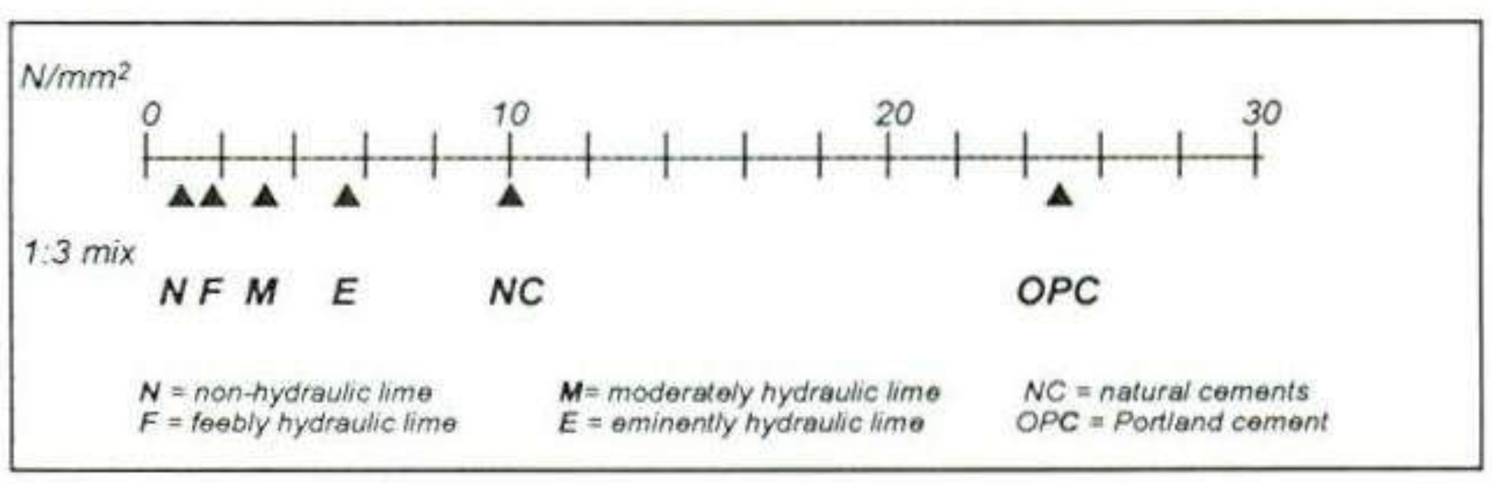


Fig 2 Comparative compressive strengths of various mortars

Pozzolanic additives

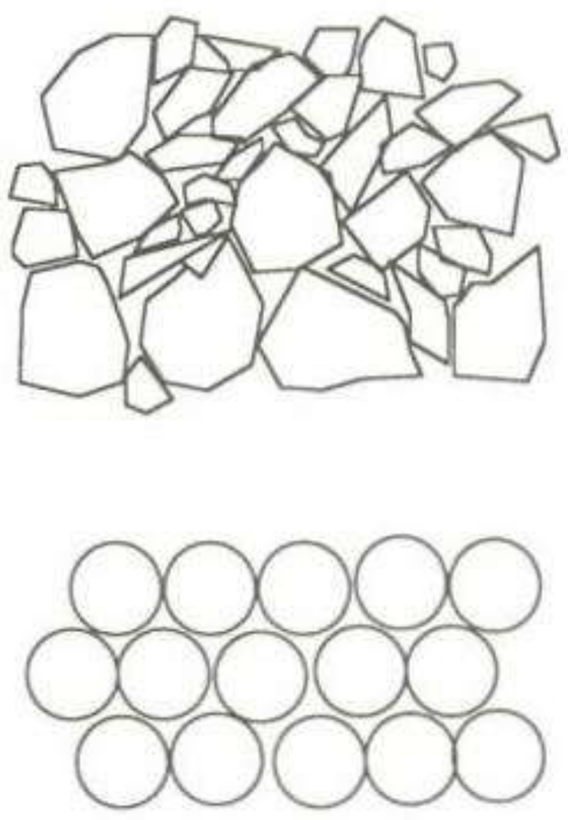
Historically, where there has been a need to modify the properties of lime, or where naturally hydraulic limes have not been available, materials known as pozzolans have been added to lime mortars. Pozzolanic materials contain reactive silicates, similar to those found in natural hydraulic limes, which will react with lime and water to create a degree of set. Materials likely to have been used in the past are ashes/earth deposits of volcanic origin, fuel ash and fired clay products.

Currently available pozzolans include soft-fired brickdusts, which tend to improve durability without significant increase in hardness; limeash from coal-fired lime kilns (a traditional pozzolan); pulverised fuel ash (PFA), which tends to produce a hard brittle set; ground furnace slag, again giving a hard set; waste powder from the production of ceramic insulation (HTI), which is a little unreliable and does not appear to have any advantage over brickdust; and a specifically manufactured clay-based pozzolan, intended primrily for use with cements.

Sands and aggregates

In a lime mortar the sand, or other aggregate, normally comprises up to 75% of the total volume, and has a significant influence on the properties of the mortar.

Scottish sands and aggregates show a range of compositions and colours which reflect the diversity of rock types to be found throughout the country. To achieve a sound mortar a sharp, coarse sand is normally selected so that the individual grains can lock securely together.



Sharp grains of different sizes will interlock to give a well bound mortar

Rounded grains behave like ball-bearings, with no physical interlocking

Fig 3 Comparison of shape in aggregate grains - 'sharp' and 'soft' sands

The sand acts as a filler, reducing the amount of lime paste required and reducing drying shrinkage. The sand should contain a range of grain sizes, with smaller grains filling spaces between the larger ones and, generally speaking, should not contain more than 5% to 10% silt or other fines.

The colour of the mortar is influenced by the colour of the finest particles and mortars with grey, buff or pinkish tones are therefore possible.

In addition to naturally occurring sands, crushed rock products can also be used. A fine silica 'sand', produced from crushed sandstone, is often used for fine ashlar pointing mortars.

Scotland contains significant quantites of volcanic rocks and some of these, such as basalt, can produce a pozzolanic effect when added, in a finely powdered form, to lime mortar.

Lime mortars

Except in the case of limewash, lime is always combined with a filler, such as sand, to provide bulk. The properties of this filler, or aggregate, and the relative proportions of lime and aggregate have a significant influence on the properties of the mortar. To achieve a matching repair is usually necessary to select a local sand or, if suitable local material is no longer available, a matching sand from another source.

The proportions of lime and aggregate are normally derived from the amount of lime paste which is required to fill all voids between the sand grains and provide good workability. With the use of a well graded sharp sand this usually means a ratio of one part lime to up to three parts sand, although the proportion of lime may need to be reduced as the hydraulicity of the lime increases. The use of insufficient binder paste will result in a harsh mix with poor workability (and thus in the undesirable addition of water on site) and in a poorly 'cemented' mortar. It is important to note that the strength of a lime mortar is controlled by the appropriate curing of the material and by the degree of hydraulic set, not just by the ratio of binder to sand.

Specification guidelines

Specifications for lime-based materials should cover:

- choice of repair strategy,
- selection of mortar ingredients and proportions,
- method of mortar production,
- information on methods of application, and
- information on methods of curing and aftercare.

Lime mortars are sophisticated materials with a wide range of potential properties, and old buildings have an equally wide range of potential requirements. The secret of successful specification is to understand and match these two parameters. There is no magic standard solution (least of all the use of quick-setting cementitious mortars) capable of dealing with all possible situations. In practice a basic range of mortars can be utilised, with adjustment to suit specific requirements.

Selection of materials

The type of mortar and details of mortar ingredients should therefore be selected on the basis of performance requirements. Selection of a repair mortar which is compatible with the stone and with surviving original mortar is essential and a good visual match will also be required. The mortar will also need to be sufficiently durable for its location and exposure. Analysis of a sample of original lime mortar can provide useful information on the types of lime and aggregate used and on their relative proportions, and thus provide a basis for the specification of a compatible matching mortar. Actual job specifications should always take into account current site conditions as well as information on historic materials.

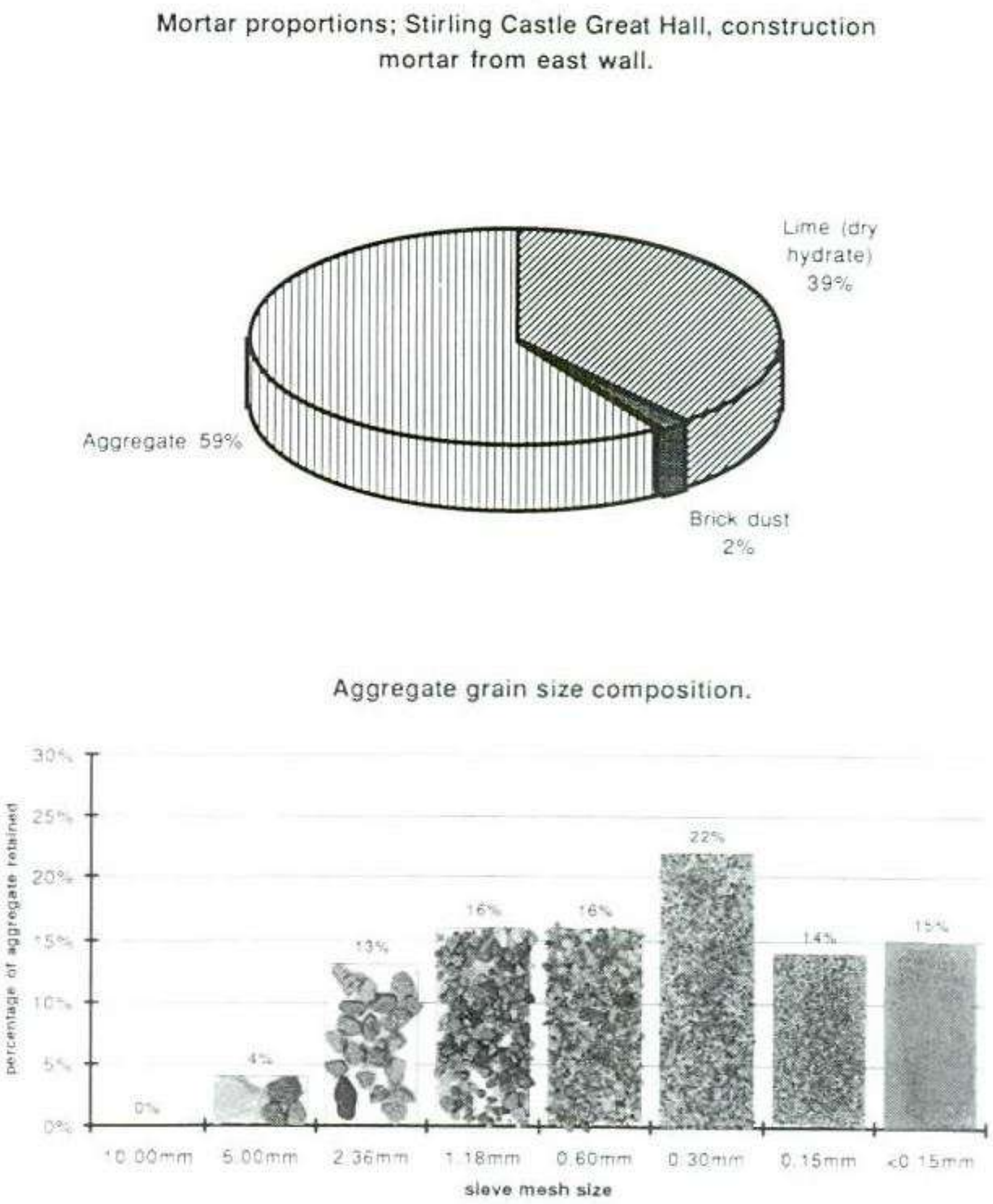


Fig 4 Mortar analysis information

At its simplest level, specification of a repair mortar might involve the selection of an appropriate ready-made traditional mortar. Alternatively the mortar can be specified in detail and either made up to order or made on site.

One of the most common applications of lime mortar is for repointing and masonry consolidation. For soft sandstones a non- or feebly-hydraulic lime will normally be required, in combination with a local coarse sharp sand. Where additional durability or frost resistance is required without sacrificing permeability, a pozzolanic gauging of crushed tile/brickdust can be used; up to equal proportions of brickdust and lime are possible, with the sand proportion reduced where necessary to retain workability. Typical mixes might be one part lime paste, one part brickdust and one to two parts sand. A surprising number of historic mortars in Scotland contain brickdust, including medieval mortars from Stirling Castle.

- A typical specification for repointing a decaying or very porous stone in sheltered conditions might be a plain, un-gauged lime mortar comprising:

  1 part non- or feebly hydraulic lime :
  2.5 to 3 parts sand.

Aggregate should be sharp and well graded, geologically matched to the original material and water content should be kept to a minimum to minimise shrinkage.

- For exposed locations this mix might be modified by the addition of a gauging of brickdust, for example:

  1 part lime : 0.5 to1 part brickdust :
  1 to 2 parts sand.

For harder stones in more exposed locations a mortar with the appropriate degree of hydraulic set might be specified, but it should be remembered that permeability tends to be reduced with increasing hydraulicity of the mortar. Hydraulic lime mortars of various strengths, generally feebly or moderately hydraulic, have been widely used in Scotland over recent years. In the current absence of a range of 'homegrown' hydraulic limes these mortars are generally composed of a blend of English non-hydraulic lime and imported hydraulic lime to achieve the desired strength. To achieve the best possible distribution and blending of the different materials the two types of lime are used in (near) equal proportions and the mortar strength is controlled by the inherent strength of the chosen hydraulic lime.

- A mortar for repointing sandstone in all but extreme exposure might therefore be made up from a mixture of non-hydraulic and moderately hydraulic limes, eg:

  1 part non-hydraulic lime: 1 part moderately hydraulic lime : 4 to 5 parts sand.

This type of gauged mix is normally based on a 1: 4.5 coarse stuff with the addition of 1 part hydraulic lime (run to a slurry) shortly before use. As a basic rule of thumb 1kg of hydraulic lime is required for every 10 to 12kg of the coarse stuff. Gauging quantities should always be accurately measured to ensure consistency.

In more severe conditions this mix can be modified by the addition of a gauging of half to one part brickdust and a compensating reduction in the proportion of sand.

- For some specialised situations (eg. with a harder stone, such as granite or whin, in very exposed locations) a more hydraulic mix might be used for repointing:

  1 part non-hydraulic lime : 1 part eminently hydraulic lime : 2.5 parts sand.

This mix may, if required, be made up in the same way as a modern cement/lime/sand/ mortar from a blend of powdered (hydrated) non-hydraulic lime and hydraulic lime mixed with sand and water. Aggregate should be sharp and well graded; normally concrete sand is used.

Water content should be similar to that required for a cement-based mortar to ensure complete hydration of the dry powdered materials.

Mixes for harling, rendering or plastering are similar to construction or pointing mortars but will often contain a higher proportion of lime, and will be used wetter to aid spreading or casting. Shell sand is sometimes found in old harling but it is rare to find large aggregate, or pebbles, in a traditional Scottish harl. Mixes intended for trowel applied coatings, such as internal or external plasters, usually contain a slightly finer grade of sand in the top coat.

Site practice

The successful use of lime mortars relies heavily on good site practice. Almost without exception, failures of lime-based materials are due either to choice of inappropriate materials, to poor building detailing (and poor maintenance of building details) or to poor site practice in terms of preparation, application or curing. It is very rare to find failures due to inherently poor quality lime.

Production of mortars

Unless the mortar is to be purchased ready-made from a reputable specialist supplier close attention should be given to specification and supervision of mortar production. The majority of contractors are not in a position to produce good mortars without very close guidance. Unless an experienced specialist contractor is involved it is likely that the basic mortar will be made up by blending matured lime putty and sand, to which the addition of hydraulic or pozzolanic gaugings might be specified. Accurate batching and thorough mixing and beating are essential. Water content should be kept to a minimum consistent with the proposed use, eg spreading mixes need to be wetter than mixes for repointing, and workability should be achieved through knocking up, not by the addition of water.

A traditional roller pan mill is ideal for making and knocking up mortars, and any contractors working regularly with lime-based materials and making their own mortars would benefit from the reduced labour and improved material quality afforded by these machines. In the absence of a roller pan mill mortars can be made by other methods, including by hand, but the actual production of good mortars without suitable equipment demands great commitment on the part of the contractor.

Alternatively, ready made and matured traditional mortars can be purchased and these can often be supplied knocked up for short term use. Where gauging with hydraulic lime is specified the hydraulic lime powder is normally run to a slurry and beaten into the basic mortar up to 24 hours before use. Gauged mortars can gain improved workability by being allowed to stand overnight before being knocked up for immediate use, but the standing time is dependent on the type of hydraulic lime used.

Where an experienced specialist contractor is employed the mortars might be made up by slaking quicklime together with the sand, and maturing to ensure completion of the slaking process. This method produces a good, workable mortar with characteristics closer to the complex structure of traditional lime mortars.

Preparation of the work

Preparation of the work before application of mortar is equally important. Previous decayed or over-hard mortars must be thoroughly removed back to a sound clean surface. Suction of the background should be controlled by damping down dry masonry to achieve a moisture balance between background and new mortar. Conversely, impervious, wet backgrounds must be allowed to dry sufficiently before application of new mortar.

Application of lime-based materials

Lime mortars should be well compacted into place without over-working and the surface of the mortar should be left with an open texture, without laitence. Although joint faces in repointing can sometimes be finished as work proceeds, it is normal for the mortar to be allowed to stiffen up, before tamping and compressing back the mortar and lightly scraping the surface to achieve this open texture. Joints should generally be slightly over-filled in the first instance to allow this finishing work to take place.

In order for the process of carbonation (curing) to proceed effectively the mortar must always be used in thin layers and small volumes. This can be assisted by the use of small 'pinnings' or packings of suitable permeable material within the depth of mortar joints and, similarly, for filling out surface hollows prior to harling or rendering.

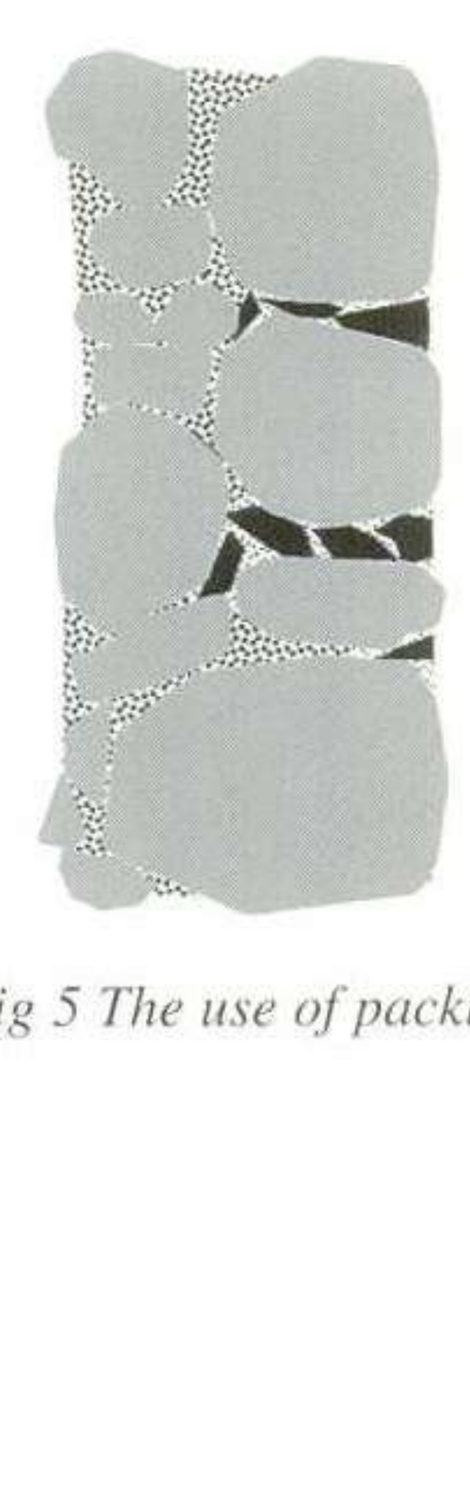


Fig 5 The use of packings and pinning stones

Surface coatings should be applied in consistent, thin layers, whether cast or trowel applied. There is some evidence that many flat-surfaced external coatings were in fact applied using harling (casting on) techniques and subsequently pressed back. The casting on process ensures a good bond between coating and background and allows for the application of very thin coats. The benefits of a textured surface, as achieved by casting on, are increased surface area for evaporation, reduction in the rate of surface run off, and a degree of masking of minor surface imperfections.

Harling was frequently finished by the application of limewash - a process which follows the same basic principles as other lime-based materials - good preparation of backgrounds, including effective elimination of mosses, lichens, etc, application of several (usually 4 or 5) very thin coats of the limewash and correct curing.

Protection and curing

All lime-based materials require slow curing. This normally means provision of effective protection from sun, wind, rain and freezing until the mortar has carbonated to a sufficient depth or, in the case of hydraulic limes, achieved sufficient set, to remain stable in wet and freezing conditions. Curing times will vary according to weather conditions and to the thickness or volume of mortar used. It is always quicker, and more satisfactory in the long run, to apply and cure several thin layers of mortar, rather than one thick layer. As a rule of thumb a single, 8mm thick, coat of harling will cure in approx one to two weeks in warm, slightly humid conditions. Thicker layers or successive build-up of layers, will take increasingly longer than the equivalent thickness cured in a series of single coats. If correctly cured, mortar in repointing work is likely to be stable to normal exposure within two weeks or so, but should not be exposed to frost for at least 12 weeks. (Modern site practice, as set out in BS8000 also calls for 12 weeks curing before cement-based mortars are exposed to freezing.)

The actual length of curing time and extent of protection required depends on local circumstances but, in practice, a fully sheeted scaffold, using debris netting and with enclosure at wallhead level to exclude rain, is the minimum requirement. Provision should be made for temporary rainwater disposal where rainwater goods are removed. During hot and/or windy weather damp hessian may be placed over the new work to maintain humid conditions and mist spraying of the surface may be necessary at intervals. The aim should always be to allow the mortar to dry from the depth outwards. In exposed locations and cold, wet or windy conditions monoflex-type protective sheeting will be required, and additional protection, in the form of insulating batts placed against the face of the work, may also be necessary.

In principle, there is often no technical reason why lime work should not proceed during winter months, provided an adequate enclosed environment is created. In practice this rarely happens, but there are situations where protected winter working would be less costly than stopping work, and less costly, too, than the remedial work involved after inadequately protected winter working.

Sources and suppliers

Ready-made traditional lime mortars are available in Scotland from specialist suppliers. It is normally possible to choose from a range of off-the-shelf matured mixes based on non-hydraulic lime putty and a variety of sands, both coarse and fine.

The 'coarse stuff' mixes are intended for most construction, repointing and harling, rendering and (undercoat) plastering jobs. 'Fine stuff' is used for plastering finishing coats and for repointing fine-jointed masonry. The mixes are available with various ratios of lime to sand, to allow for later gauging (if necessary) with hydraulic lime or brickdust. All these mixes may be modified for, or by, the user to add, for example, shell aggregate or to increase the proportion of lime for harling work. Currently for one-off contracts this is probably the most cost-effective source of materials.

In addition to Scottish suppliers there is a growing number of producers south of the border, but ready-made mortars from these sources do not incorporate local Scottish sands.

For contractors continuously involved in conservation and repair of traditional buildings, production of their own mortars, either from quicklime or slaked lime putty, purchased from a specialist supplier and blended with local sands, is likely to be more realistic.

Future developments in Scotland are likely to include the availability of a range of different quicklimes from traditionally burned Scottish limestones, suitable both for off the shelf mortars and for site slaking and mortar production on an individual job basis, and these should significantly increase the range of types of lime available.

Current costs of materials range from around £7.50 to £12.50 per 40kg bag of ready-made mortar (£300 to £450 per cubic metre) ex works. Equivalent volume costs for a similar mortar made up on site might be around £160 per cubic metre, whilst amodern white cement/lime/sand made on site would cost around £145 per cubic metre. Assuming that ready-made traditional mortars are knocked up on site, the site labour costs are likely to be roughly equivalent and, given the normal wastage rate of up to 15% for cement-based mortars, there is no significant cost differential between the production of site-made non-hydraulic lime mortars and cement-based mortars.

Summary recommendations

The basic rules for *specifying* lime mortars can be summarised as follows:

- Understand how traditional masonry buildings work and, in particular, how the building in question is working. Understand what lime mortars are and how they work. (Ensure that your client understands too, since many reported 'problems' are due to expectations rather than performance.) Develop a logical strategy for the work which repairs or resolves any unsatisfactory detailing.
- Select type of lime, or blend of types, to produce the degree of hydraulic set, if any, suited to the function of the mortar and the current conditions of use. (This will often, but not necessarily, be the original type of lime). It is important to use good quality limes.
- Select the aggregate to be technically suitable and, as far as possible, to match the original.
- Specify the addition of pozzolanic gauging materials (normally brick dust from low temperature firings) where extra durability is required without increased hardness.
- Specify the methods of production and maturing.
- Specify the methods of working and application (site skills).
- Specify the requirements for working access and the nature and extent of protection and aftercare required during work and throughout the curing period.

Basic rules for *site practice* are

- Ensure all building detailing is satisfactory.
- Ensure good access and protective coverings/enclosures are in place.
- Measure and prepare materials accurately and thoroughly, mature and knock up vigorously before use. Do not add water as a substitute for knocking up.
- Prepare backgrounds to provide sound, clean surfaces and control suction by damping down as necessary.
- Apply mortar in thin layers and small volumes, well compacted and packed out with permeable pinnings.
- Do not overwork the surface. Leave with an open-textured finish.
- Provide adequate protection to ensure slow even drying from the depth of the material outwards. If necessary dampen down to maintain moist conditions during curing.
- Do not expose new lime mortars to freezing within three months of initial curing.

This presentation has explained the central role of lime-based materials in traditional building technology and the importance of endeavouring to achieve a like for like repair, and has outlined the basic principles involved. For further more detailed advice you can contact the Scottish Lime Centre, or even come along to some of the practical workshop days.

EARTH

Christopher McGregor, Regional Architect, Historic Scotland

During the greater part of Scottish history earth has been the predominant building material. Granted many of the major monuments from the past are of masonry construction but these were non typical buildings even at the time they were constructed and many relied on earth technology in their construction. Major masonry structures such as the fourth century BC chambered tomb at Maes Howe, Orkney were constructed using a fine clay lubricant mortar to position and bed the stones, puddled clay as a waterproofing agent round the stone structure, mounded earth to form an earth shelter and fale or turf to construct the enclosing bund.

The largest earthen structure in Scotland is the Antonine Wall built by the Romans to form a defensive structure between the Rivers Forth and Clyde and had the Romans been more successful in Scotland, this structure might eventually have been stone faced in the same way as Hadrians Wall.

The use of earth in the construction of important defensive structures and upper class residences can also be seen in the timber framing and mudwall infill found in early castles and towerhouses. Indeed, much of the distinctive aesthetic associated with the later masonry towerhouses derives from constructional details associated with timber-framed structures with mudwall infill. Occasionally, the framework of these structures appears to survive within the walls of eighteenth century classical mansions such as Foulis Castle, Evanton, Ross and Cromarty. A similar situation existed in the burghs and timber-framed mudwall-infilled structures were being demolished in all the Scottish burghs throughout the nineteenth century. By the third quarter of the century there were few wooden lands left. Many of these structures were erected in the first half of the sixteenth century but by the end of that century all the new buildings of quality were being constructed in masonry. At the lower end of the social scale various forms of earth construction continued to be the norm until the second quarter of the nineteenth century, in the rich coastal areas and the central belt, and until the beginning of the twentieth century in the Highlands and Islands.

Even after the demise of the obviously earthen structure earth continued to be used as a mortar, plaster, render, anchorage or top dressing for thatch, waterproofing agent and so on. By the end of the nineteenth century architects were moving away from earthen materials such as mortars, plasters and renders in favour of lime but engineers continued to use the material. Puddled clay was used as the waterproof barrier to contain water in aqueducts, dams, canals, lochs, docks, harbours, seawalls, and for flood control barriers. Rail and road bridges and viaducts were waterproofed using puddled clay and had structural rammed-earth coves and more recently selected clays were used as lubricants for the drilling of exploration shafts and oil wells in the North Sea.

The perception that earth must be a low-tech material is completely erroneous and earthen structures, plasters and renders are again in the forefront of European constructional innovation where modern apartment blocks, offices, hospitals, schools and other structures are using the material with imagination and flair whilst counteracting the problems of sick building syndrome. The Germans and French are making the running with the innovative use of earth products but Historic Scotland are in the vanguard regarding its use for conservation purposes. The Historic Scotland Technical Advice Note 6 - Earth Structures and Construction in Scotland(1) summarises the historical data and provides a guide to the recognition and conservation of earth technology in Scottish buildings. This has attracted considerable international acclaim and provides a framework for further study and experimentation. The need for experimentation stems from the ambiguity of many of the historic statements and reports and the fact that the techniques were so common that it was considered unnecessary to describe them. The documentation that does exist is often in the form of recommendations put forward by non practitioners. Usually the results achieved are not recorded although the case of Lord Gardenstone's observations on German methods of shuttering mudwall, the structures surviving show that he fully understood the German techniques and was able to pass these on to his own tenants.(2)

Four conservation projects were undertaken before it was decided to build a series of experimental walls.

The first was the Historic Scotland Blackhouse at 42 Arnol, Lewis. This involved repairs to the mudwall hearting between the drystone skins of the outer walls, waterproofing the wallheads with blue clay from the peatbog, protecting the blue clay with a living turf topping, repair and partial renewal of the clay floor in the byre and the clay and cobble floor in the dwelling and the replacement of the turf substrata to the thatched roof. The whole process was fully recorded at the time, that is, in 1990 and a report has been published in the form of Historic Scotland Technical Advice Note 5 - The Hebridean Blackhouse: A Guide to materials, construction and maintenance(3).

The National Trust for Scotland longhouse at Morlannich, Killin, Perthshire produced a hitherto unknown form of earth construction. The external walls were bulging owing to pressure exerted by failing cruck frames and parts of the wall had to be dismantled and re-constructed. The walls comprised two drystone skins forming the inner and outer leaf and a dry rubble cove. The drystone skins had the tails of the stones set in an earth mortar in place of the more usual pinnings. This mortar was analysed by Masons Mortar, Edinburgh and an earth mortar was made to match using Gallowflat clay from Errol, Perthshire. The mix was supplied in plastic tubs and set hard as the wall was being reconstructed. The outer face of this wall was pointed with lime mortar, the inner face finished with clay plaster to match the existing finishes.

A former longhouse on Corse Croft, Kinnoir, Huntly, Aberdeenshire received grant aid from Historic Scotland for the repair and conservation of a turf gable. The gable had been covered with ivy and this had been removed prior to purchase by the present owner. A member of the Scottish Vernacular Buildings Working Group had been interested in purchasing the property and had seen the gable and returned to inform the new owner of its importance. The conservation of the structure was carried out by Rebecca Little, Mud Mason, from Edinburgh and local knowledge was sought regarding the possible source of the turf. The turf was obtained from the site of a former brickworks and matched the clayey turf of the gable. Although all the turf on the gable was grey in colour when freshly cut, some turned an orange-red on the exposed face possibly resulting from the oxidisation of iron particles in the clay. The material was cut into blocks of the same dimensions as those used in the gable and dried quickly into hard blocks similar to the mudwall blocks manufactured for the repairs at Cottown. Damaged turves were cut out and ties were created where vertical cracks had developed. The damaged turf was cut in the same way as the mudwall and the new turf was trimmed to form indents of the exact size of the original. The trimming was carried out using a cross-cut woodsaw and a small adze-shaped tool used for the removal of plaster. The old and new materials were linked using a thin mudwall mortar. After consolidation the gable was rendered with an earth render to fill any crevasses and finished with several coats of limewash. The repair techniques appear to have been successful and have survived their first winter. The structure also had the remains of a clay thatch preserved under a later corrugated-iron roof surface. Samples of the turf gable and the clay used to anchor the thatch were removed for micromorphology. This will be discussed later in the paper. It is hoped to include a full report on this building in a future miscellany of earth building conservation case-studies.

The most significant of the earth structures conserved to date is the building known as the Old School and Schoolhouse, Cottown, St Madoes, Perthshire. This is a predominantly mudwalled structure which was purchased by the National Trust for Scotland and has been restored with grants from the National Heritage Fund, Historic Scotland and the Perth and Kinross Heritage Fund. The conservation works have been carried out under the control of a National Trust for Scotland committee in partnership with Historic Scotland.

The building is thought to date from 1745 with rebuilding after a fire in 1766, extended in the 1770s and remodelled in 1818 with further additions in the 1940s and 1950s. It was the first mudwall structure to be conserved in Scotland and, to allow freedom in the initial investigation and for the subsequent conservation works, an agricultural shed was erected over the entire structure. This proved to be a cheap and effective protection and the shed was removed to another Trust property at the end of the contract.

A method of working was devised that allowed for the careful removal of damaging impermeable plasters and renders whilst retaining the structural integrity of the building. This was essential since the building had been subjected to flooding prior to its purchase by NTS and the base of the earthen walls, sandwiched between impermeable renders, was still drying out. The removal of the external cement renders was carried out by Bruce Walker and Gregor Stark of Historic Scotland. Several areas of cement render were left insitu at the time to ensure structural integrity but as much as possible was removed to allow drying and further investigation of the structure. At this stage the internal renders were left insitu.

The mudwall repairs were carried out by Rebecca Little assisted by various groups of volunteers. The mudwall required indenting at the base of the wall where there was a combination of erosion and rat runs, replacement of some poor quality sandstone blocking that was slack and obviously allowing water penetration into the wall, plastic mudwall filling to internal rat runs, plastic repairs to shallow hollows in the wall surfaces and to the wall-top of the gable; mechanical ties (mudwall) between the mudwall and a poor quality sandstone-clay mortar panel in the south elevation and analysis of mudwall, earth and lime renders from various parts of the building.

All indenting was carried out using pre-shrunk mudwall blocks and tiles, prepared over the winter months and air dried within the building. The original mudwall mix incorporated straw but the straw available locally had been grown using intensive nitrate fertilisers resulting in a poor quality straw (refer to paper on thatch). Locally grown flax was also available and although the vegetable material of the flax straw also broke down readily due to a high free-nitrogen content, the fibres improved the tensile strength of the block. The blocks were trimmed to size using the same tool as described for Corse Croft. The blocks were bonded with an earth mortar of similar mix to the block but omitting the larger aggregate.

After the consolidation of the external surface of the external walls, the same process was repeated on the internal faces. There the impermeable cement render tended to be at the base of the wall, almost as a continuation of the cement screeded concrete floor. Archaeological investigation of parts of the floor failed to reveal the original construction and it was decided to leave the concrete floor as found. This necessitated the formation of land drainage round the property directly under the drip from the thatched roof. This will minimise the likelihood of rising damp in the walls.

One of the internal walls is of kebber and motte construction (closely spaced vertical poles with the clay and mortar pressed in and completely covering the poles). This had also been subjected to flood damage and rot in the base of the timbers, possibly due to rising damp. This wall was repaired using a mixture of mudwall block and plastic mudwall repairs - mudwall block where the evidence had disappeared and plaster repairs where the original construction was obvious. The chimney flues are of similar construction to this wall but utilise lighter timbers. These support brick chimneyheads.

Lime plasters were retained and repaired internally and lime was used to replace the cement renders at the base of the walls.

A mudwall and turf ridge was used to complete the thatch. This is a traditional finish in this area and can be seen in some of the early photographs.

Work is now complete and the house should be open to the public from September 1997. Interim reports have been published [4] and a Historic Scotland Technical Advice Note is in preparation [5].

The series of conservation projects listed above show that Historic Scotland has the capability to maintain and retain this type of structure. The material also has the potential to assist in the stabilisation and maintenance of masonry structures. The Properties in Care Division of Historic Scotland was quick to see this potential and decided to set up a series of wallhead consolidation experiments on a roofless structure at the Doune Castle Mill complex, Doune, Perthshire. Various mudwall mixes were prepared and applied to a wallhead in the form of a 100 mm deep cope. One section of each mix was covered with a 100 mm deep turf, the other left exposed to the weather. The experiment ran for one year and all the mixes stood up to the winter frosts without damage. At this point it was decided to re-roof this particular building but the experiment then moved to the mill building adjoining the river. There the walls have been capped with a half-round mudwall cope topped with a 25 mm cultivated turf. This has been particularly successful and the same mix was then applied to walls where the inner face had collapsed leaving the outer face vulnerable. Scaffold boards were used as shuttering and by taking the wall up slowly, one scaffold board at a time, the wall has been consolidated and capped in the same way as the other walls. Not only does the material waterproof the wallheads but it also anchors loose masonry and therefore prevents further damage.

The longevity of this type of cope was questioned initially but a recent inspection of a "turf topped" estate wall round Gordon Castle, Fochabers, Morayshire revealed that the "turf" coping was in fact mudwall.

Other bodies have been carrying out their own experiments. This includes the reinstatement of several large fale dikes on the Culloden Battlefield by the National Trust for Scotland, and the archaeological reconstruction of Raits township in the Highland Folk Park, Newtonmore, Inverness-shire.

Realising that this is only the start of what could become a massive conservation exercise, Historic Scotland decided to set up a series of experiments using different techniques on a range of sites. To do this they used information published in Historic Scotland Technical Advice Note 6 *Earth Structures and Construction in Scotland* to prepare a series of specifications then repeated these on three external sites each with different topology. The sites are at Fort George, Ardersier, Inverness-shire - an open wind-swept site at the edge of the firing range at Fort George: Battleby, Redgorton, Perthshire - a semi-enclosed site in the grounds of the Scottish Natural Heritage HQ: and Culzean Country Park, Maybole, Ayrshire - an enclosed site adjoining the National Trust for Scotland joiners shop which is surrounded and overhung by large forest trees. Local clays were sourced and used at each site but one wall on each site was constructed using a Gallowflat clay mudwall mix. This was used as a standard against which the other clays could be judged and possible variations in weathering resulting from the different exposures could be monitored.

The walls were constructed to dimensions already set down by CRATerre-EAG, Grenoble, France thereby allowing Historic Scotland to make direct comparisons with results achieved by this European Centre for Earth Construction.

All the test walls stood up well to the first year although there was some damage to the kebber and motte on each of the sites. The overhung site at Culzean produced the best results with even the feathering of the material at the junction of the shutters surviving the whole year.

The walls have now been rendered or lime washed over two-thirds of their surface but the other third has been left exposed to assess the potential of unrendered earth construction. This is a severe test for the renders but should highlight any potential weakness at an early stage.

Similar experiments with various forms of internal wall have also been undertaken in the ground floor flat of the Mid Mill at the Stanley Mills, Stanley, Perthshire. The initial results of all these experiments will be published early next year in a first interim report.

In parallel with the above tests the Building Research Establishment, East Kilbride, has carried out a series of water penetration and freeze-thaw test on mudwall block panels. These tests were derived for fired brick and are somewhat severe but they are producing interesting results. The programme for setting up the test rig demands some form of previously prepared block and the weak points appear to be at the joints taking the full impact of the spray or the renders which do not have the same opportunity to dry out prior to the test but even with these drawbacks the blocks are performing well. Full details will be published in the forthcoming Earth Walls Experiment Report.

At the present time simple tests are being carried out to establish the size and proportions of aggregate in the mix but it is known that many other additives were tried and adopted in various parts of the country. To try to establish a methodology for identifying the additives it was decided to use micromorphology, that is the preparation of thin sections through the material to allow them to be studied under a microscope. The technique shows great potential but it will be necessary to set up a series of test slides using various proportions of an additive and to gradually build up a reference library that can be used for comparative purposes when studying walls where the original ingredients are not known.

The conservation processes listed above will continue to develop through careful monitoring of the work carried out to date and further experimentation but significant progress is going to depend on an increase in the use of the material and the development of the craft of the mud mason. Organisations such as the Scottish Environmental Design Association are interested in the material and a number of new build initiatives are being considered. Should this happen and the material be re-adopted by the building industry the survival of the historic examples will be assured.

References

1. WALKER, Bruce, McGREGOR, Christopher in collaboration with LITTLE Rebecca: 1996: *Earth Structures and Construction in Scotland: A guide to the recognition and conservation of Earth Technology in Scottish buildings* Historic Scotland, EDINBURGH.

2. GARDENSTONE, Lord: 1795: *Travelling Memorandums* EDINBURGH 129-130.

3. WALKER, Bruce: 1977: *Clay buildings in North-east Scotland* SVBWG, DUNDEE and EDINBURGH.

4. WALKER, Bruce and McGREGOR, Christopher: 1996: *The Hebridean Blackhouse: A guide to materials, construction and maintenance* Historic Scotland, EDINBURGH.

5. WALKER, Bruce and McGREGOR, Christopher: 1995: "The mudwall school and schoolhouse at Cottown, St Madoes, Perthshire" in *Out of Earth II* PLYMOUTH. 204-207.

6. MYLES, Ray and WALKER, Bruce in collaboration with LITTLE, Rebecca and McGREGOR, Christopher: 1997: *The Conservation of a Scottish Mudwall Structure: The "Old School and Schoolhouse" Cottown, St Madoes, Perthshire* Historic Scotland, EDINBURGH.

CLAY STRUCTURES

John Hurd, Senior Conservator, John Hurd Conservation

One third of the population of the planet live in structures made of unfired clay subsoil. Many more buildings depend on unfired clay in the form of mortars or renders. Before 1910, when sand washing was introduced to help the concrete industry, dirty sand often contained as much as 30% clay.

There are six principal methods of earth construction:

1. Monolithic wailing (clob, clom).
2. Clay blocks (Adobe, clay lump).
3. Cob on frame (stake and rice, mud and stud).
4. Shuttered rammed earth (pisé).
5. Poured earth.
6. Earth sheltering.

All of these types occur in the British Isles, although pisé and poured earth are rare.

Slides to illustrate the range of types in the British and International arena. An examination of the spread of construction types, an investigation of regional accents in this vernacular language.

Earth walling is usually made from unadjusted subsoil often tempered with straw or another organic material. It is often quite soft and tends to perform best at a slightly higher moisture content than other types of masonry. An important aspect of clay construction is therefore the way in which it manages both land moisture and rainwater. This usually means a plinth of some sort, a good overhang on roofs and often a subtle range of internal and external plasters aimed at allowing moisture to find egress into external air at the lowest possible point.

Clay walls are particularly vulnerable to damage from repair by inappropriately hard materials, even lime can be too hard and impervious. This demands then, careful analysis and understanding of hardness and porosity in order to achieve an appropriate repair medium, often identical subsoil.

Simple rules of conservation:
Earth structures require the same range of considerations an ethics as any other type of conservation:

1. Minimum intervention.
2. Reversibility.
3. Repair in like for like material.
4. Research and analysis.
5. Recording.

In the British Isles, there is an efficient network of people concerned with the conservation of clay structures. This is largely carried out at grass roots by regional interest groups. Each of the regional groups is in turn represented on the ICOMOS UK Earth Structures Committee, as are the principal heritage organisations, together with education and research bodies.

The conservation of earth is a relatively new field and although much has been achieved there is still a long way to go. It is probable that there are hundreds of thousands of inhabited earth structures in the British Isles, and an attempt is now being made at assembling a record of types and distribution.

BRICK

Andrew Clegg, Director, Errol Brick Company Ltd

THE HISTORY

Brick and tile making can be described in the smallest compass imaginable. We take a piece of mud, we give it form and shape and pass it through fire. If this simple process has a biblical ring to it, it is only appropriate because clayworking is the most ancient of skills and brickmaking the earliest form of industrial activity known to humanity. There were 85 million bricks involved in the building of the Tower of Babel, some two thirds of the total annual production of clay bricks in Scotland today, and Babel's ill starred tower was by no means the earliest example of such brick usage in antiquity. That honour belongs to building remains in the Nile Valley, whose bricks of loam and straw were first laid down 15,000 years ago. In short, arising in the river basins of the Nile, the Tigris and Euphrates, the practice of using natural clays for both civil engineering and common building purposes was well established long before the time of King Nebuchadanezer and was communicated to the modern world by the Romans, who learned the art in their own turn from the Etruscans and the Greeks.

THE MATERIAL

Most clay bricks currently produced in Scotland are made of shales, a by product of the coal industry released by deep mining or, as is more common now, open cast operations. Uniquely, however, the bricks and tiles manufactured in the brick fields of Bevershire on the north shore of the River Tay, home of the Errol Brick Company, are formed of 'glacial alluvium' laid down near the end of the Ice Age.

All of the planet's bounty is in limited supply, of course, including 'brick earth' (glacial alluvium by its common name) but being of all clays the most abundant and accessible, easily extracted from shallow quarries, a comparison of its eco-qualities with the exploitation of any other brickmaking materials, carbonaceous shale or fireclay, can only show in its favour.

Nobody as yet has divined just how much of this 'prima materia' exists in Scotland. In the Carse of Gowrie, however, on Tayside, it is estimated that some billions of tonnes were deposited as a result of glacial movement twelve thousand years ago. The crofters in the lands of Bevershire found such clay useful to hand in the 18th Century and in making horseshoe drain tiles and domestic field bricks from unmilled clay, their practice (which began as a sideline to their agricultural interest) has been continued with only seasonal variations in the locality to the present day. Among the earliest examples of the use to which their bricks were put is Stanley Mill near Perth, built in the later part of the 18th Century and the farmhouse at Flatfield near Dundee, which was completed in 1785.

Of the 169 Scottish brickworks on record in the final quarter of the 19th Century, one third of them adapted brick earth for their purposes. Of the six brickworks in the land today, only Errol Brickworks makes use of this natural material to produce 'terra cotta' bricks, which is to say, bricks formed of 'burned earth.' The raw material is simple and elemental. The process involves earth, air, water and fire. The product is a wholesome, natural building material that will endure in all probability for centuries, requiring minimal maintenance, and upon whose appearance the passing of time and the seasons will have an altogether pleasing effect.

The area where the clay is quarried can be returned to farmland and woodland without undue difficulty, and should the shallow pit be simply abandoned, it fills with rain water and becomes a natural pond. The clay is water resistant and is employed, amongst other uses, for the lining of garden pools, both large and small, and as a barrier against inroads by flooding.

THE PROCESS

The preparation of clay for brickmaking bears a striking resemblance to the baker's preparation of his dough. Once dug, and stockpiled, (a stage of preparation akin the the dough's proving), sand is added to the raw material to improve its workability, which it does by 'grogging', and opening up the clay's close texture. This mixture of clay and sand is milled to reduce it to a particle size of approx 2mm and is extruded in this refined form on to a shaping table where a brick cutter sets it in the appropriate modules, according to which shapes and dimensions are called for, whereupon the prepared loaves of dark wet chocolate coloured clay are removed to the drying chambers. Once dried (and looking like bricks of pale 'adobe') they are transferred to railcars which will carry them into the kiln, where they are brought up to the required heat over a period of seventy two hours, being fired at temperatures in excess of 1050 degrees.

Cooled on their withdrawal from the firing zone, the cold air that flows through the bricks absorbing their heat is ducted to the drying chambers so that no energy is wasted, and the bricks are, so to speak, free dried, with no additional expense being involved in fuelling this part of the process. At Errol, as a result of oxidisation in the kiln, orange red bricks are produced, worthy of the description 'terra cotta'.

The burning material at Errol Brickworks is natural gas, and the burning process, as in most modern brickworks, is continuous, twenty four hours per day. Most kilns in present day use have the capability of burning clay for several years without interuption. So called 'tunnel kilns' (patented by Otto Boch in Brunswick in 1877) their burning zone is fixed and permanent. It is by means of a simple system of rails and rolling cars that clay products can be so efficiently passed through the fire.

In spite of modern technologies, PC controlled processes, chamber driers and tunnel kilns, quality control operations and all the bustle of a late 20th Century industrial workplace, brickmakers from the river basins of the ancient world would recognise their former craft at a glance, so little has changed in the basics of the operation. Indeed, it is humbling to know that in the ceramic artistry of Babylonian kiln masters, a peak of achievement was arrived at, compared to which the scope of modern brickmakers, even the most innovative and imaginative, is the stuff of skilled apprentices, no more.

THE BUILDERS

Bricks need lime and mortar to become brickwork, and, naturally, bricklayers whose scarcity, while often exaggerated, is a matter of some concern to the current Chief Executive of the Brick Development Association. Without the bricklayer's skills and expertise, brickmakers, specifiers, engineers and contractors are denied the opportunity of expressing themselves in the use of the oldest manufactured unit of construction known on earth. The system of employing freelance squads on piecework, which has become the norm, has been detrimental to the development of much modern brickwork for obvious reasons, slapdash and haste. A genuine lack of quality structures has further dented the image of the trade when a preponderance of brick clad houses, often timber frames, ignores the inherent structural and engineering properties of the fired clay. Private housing with its perceived requirement to conform to some vague norm, and to keep costs as low as possible, is scarcely the medium to encourage innovation and an imaginative exploration of ceramic possibilities. Among bricklayers, old and young, however, the challenge of an interesting elevation, a sequence of loadbearing arches, a superbly crafted ceramic panel, or a simple expression of special shaped bricks, is what they aspire to, if only to lighten the monotony of having to provide a bemused public with acres of bland yellow brick cladding.

The bricklayer's trade, of course, like others in our industry has been robbed of its full complement of practitioners by the virtual demise of the apprenticeship, a cause for concern, which the current trend in favour of 'de-skilling' scarcely begins to address. Do you wish to see your future projects and developments built by 'de-skilled' bricklayers?

THE SPECIFICATION

For outdoor brickwork in Scotland no-one should specify any other than a frost resistant brick type. Designation "F" BS 3921 (1985) is the mark of a brick that can be used even in conditions of extreme exposure. Designation "M" is the mark of a brick that can be used in conditions of moderate exposure. The designation "O" marks a non frost resistant brick and one whose use should be restricted to internal brickwork only. In view of a possible confusion between severe and moderate exposure to freezing, it is advisable in Scotland to specify "F" Bricks.

The specifier's choice, thereafter, is a matter of consideration. Whether a non porous brick is required to act as an oilskin, which is to say, a brick with the low water absorption of an engineering brick, no greater than 7% {class B} or 4% {class A}, or whether a more absorbent unit is wanted to fulfil the role of a woven overcoat and suck in moistures that might otherwise find their way through imperfect mortar joints.

As a rule of thumb, the lower the porosity of the brick type, the better the performance of the brickwork in a cold and wet environment. The oilskin / gabardine argument, however, does give us something to ponder, and both schools have their afficionados who point to their successful experience with different types of brick. It would be inadvisable to draw a line at any particular point of porosity and say "thus high and no higher". It is worthwhile to repeat, nonetheless, the brief statement above relating to low porosities.

Terra cotta bricks are units of very low water absorption and high crushing strengths. Those produced at Errol, for example, are engineering bricks, both Class A and Class B, and they are, being brick earth and hard fired, naturally frost resistant, even when built in conditions of extreme exposure - designation "F".

Any brick manufacturer will be able to supply on demand test certificates relating to their products, to their water absorption, to their crushing strengths and to their performance when tested under conditions designed to simulate the effects of the freeze / thaw cycle on ceramic masonry.

The presence of ionised salts and sulphates in clay is determined by tests laid down in the British Standard, BS 3921 (1985). Category "L" shows a low salt content, and Category "N" a moderate presence of such substances. The designation for frost resistant bricks is most commonly, but not uniquely, found in conjunction with the lowest category of salt content, which is to say "FL". Again, wherever possible, it is advisable in Scotland, in most circumstances to specify clay bricks which are durable and frost resistant, and which conform to the lowest category of salt content. There are negligible traces of such salts in brick earth and all 'terra cotta' bricks are in the category "FL". As in the oilskin/overcoat comparison above, there are plenty instances of frost resistant brickwork in Scotland where "FN" bricks have been built.

EFFLORESCENCE

Before addressing the topic of maintenance of clay brickwork it may be helpful to mention one of the most common criticisms of clay building units, which is to say the unpredictability of the appearance of crystallised salts on the surface of the masonry. Sodium and Calcium Chloride, and in certain rare cases in fireclays Vanadium, can leave harmless if unsightly deposits on bricks, particularly when masonry is in the process of drying out, and while such traces will vanish in time by a process of normal weathering, their reappearance in the sunlight after rain can be most vexatious for builder and client alike.

All that can be recommended after their occurrence is patience or, in some cases, a series of light wash downs with clean water, which is, in effect, only an attempt to speed up the process of natural weathering. Much more can be done before the event, and although presently speaking none but a fool would specify any particular course of action to guarantee the non appearance of efflorescence, (the name given by the British Standard to identify these harmless salts), there are guidelines available which can be summarised as follows:

1. Specify a brick with a low salt content, with a liability to efflorescence of either "Nil" or "Nil to Slight". A further category "Moderate" can be misleading since it is the highest category allowed by the British Standard, and should be avoided by those for whom the appearance of salt deposits is a concern.

2. Select bricks that are less likely than others to retain moisture, (the catalyst responsible for the reaction which leads to the crystallisations).

3. Ensure through good site supervision that 'green brickwork' is protected at all times and kept dry.

MAINTENANCE

After brickwork has been washed down, clean water only, its life expectancy can be long and trouble free if proper attention has been paid to the specification of the brick or brick types at the outset. Remedial pointing is the only necessity and should be carried out on a relatively regular basis, on a five yearly cycle for perfect results. Some may consider this too short an interval and might recommend an eight or ten year cycle. As ever, prevailing weather conditions will be the final arbiter. Lime. Of course, enjoys a longer life than cement mortars, as many Victorian and Edwardian buildings in our towns and cities can testify, their joints and perps, if a little dog eared and grubby, proving their robustness through the decades.

THE MARKET

Availability of bricks can vary with the seasons, both temporal and economic. In round terms, however, their production can be organised in a relatively short period, especially where a works has a proven record of flexibility of technique, and a positive approach to clients' requirements. It is advisable to bear in mind, of course, that unusual commissions may require a longer time scale to bring to fruition.

Varying a product range to accommodate 'odd requests' is an essential part of the customer driven philosophy of many European brickmakers, in Germany and Italy in particular. Presently speaking, in Britain, only a handful of small and imaginative brickworks appear sufficiently motivated to fulfil this need, often in their case a market necessity. As an increasing number of the fine structures making up our urban and rural fabric avoid the demolisher's hammer and require enlargement or repair, such companies (whom you may like to think of as the 'Aladdins' of the clay industry) are already geared up to produce 'old style' bricks in various dimensions and forms.

For the repair of historic buildings the number of shapes and sizes of bricks is legion. Before the onset of the standard metric module in the clay industry, bricks were produced in many imperial dimensions and indeed there would appear to have been as many different forms in Scotland as there were brickworks, including a huge variety in the heights of bricks, from the 2 inch (50 mm) hand thrown unit, to the more common pressed varieties measuring variously from 73 mm to 100 mm and more.

Although less crucial from the point of view of blending new and old brickwork, the lengths of the units also show a bewildering mix of long and short. As if to add spice to the specifier's palette, all of these dimensions vary greatly among themselves, individual buildings often showing a wide diversification of sizes in the same elevation, a feature, we might agree, which redeems them from the universal sameness and blandness of many modern masonry structures. A site visit by a brickmaker, however, will prove helpful in such a situation. To the flexible manufacturer, non standard dimensions are relatively simple to copy, often involving no more than a change of dye and instruction to the carpenter to prepare a new mould. Hand thrown bricks, it is useful to remember, may require a greater lead in time for orders to be fulfilled since the process of shaping the bricks is labour intensive and slow, and is indeed an aspect of the brickmaker's craft only now being re-learned in Scotland after a lapse of some centuries.

Colours and composition of bricks in traditional buildings can be less straight-forward to reproduce in modern forms. Where the new brickmaker is using the same base material as the old, there will, of course, be a distinct advantage. Where the bricks can be described as terracotta, for example, the uniformity of the character of the clay, whether quarried in the Tay estuary, or Seaton, or Doon Valley, or Afton, or Glamis, will be of little moment and reproduction of their distinctive orange red characteristics, as they were when they were first built, should be easily achieved.

The weathered appearance of the old, however, can present a potential difficulty. Centuries of grime are hard to imitate and since it cannot be guaranteed, in a relatively clean age, that the passing of time will allow the new to catch up with the old, an appearance gap is guaranteed to persist, albeit softening to some degree over the seasons. The 'distressing' of bricks is a recent innovation in the industry and can be described, briefly, as a permanently applied ceramic finish, which is to say, a form of sprayed antiquity which is wind and rain resistant, and frost-proof. In this manner the new can be produced to simulate the old, giving an historical appearance to modern brickwork.

There are several statagems available to overcome difficulties in discovering a brick match when the originals are made from a clay no longer to hand. Once again a site visit by a brickmaker will be helpful.

Some solutions are simple, a brick laid 'back to front' for example, where small clots of burned clay adhere to the smooth back of the unit can provide a reasonably close match for many types of pressed or slop-mould bricks made from soft muds and shales. More complex, and time consuming, is a special mix of clays for a particular purpose. There exist also specialised contractors whose skills in ceramic cosmetics can produce results more in keeping with the originals than the nature of their business might imply.

Clearly, however, for the traditionalist the first port of call should be a brickworks where challenges are welcome and where, for the majority of restorations, lead in times are sustainable and short. One such is the Errol Brick Company.

THATCH

Dr Bruce Walker, Conservation Architect, Historic Scotland

All natural building materials vary even when taken from the same source and the traditional skills required to use these materials successfully rely on an intimate knowledge of the material, the topography of the site, the form of the building and the prevailing climatic conditions, rather than on standard specifications.

Most professionals and operatives in the building industry are aware of, and accept, these variations yet still expect a standard specification to be provided in advance of the contract. This is comparatively easy with manufactured materials such as brick, tile, glass, steel or concrete and can also be achieved with consistently high quality natural materials such as slate, granite or freestone but, in general terms the more local and individual the source of a natural material, the more variation that can be expected and the more reliance is put on the intimate knowledge of the operative. Thatch falls into this category of local material and there are an infinite variety of thatching materials each associated with "locally correct" methods of application.

Conservation policy is often based on like-for-like replacement or the continuing use of traditional materials. This is the weakest part of the argument in that the cereal strains have changed, the types of fertilisers have changed and the atmosphere has changed and these factors combine to change the performance of the material.

The traditional thatching material may have been a particular strain of cereal straw, now no longer grown. Even if the original strain is still available, growing conditions have often changed and the presence of acid rain or the continuing use of concentrated nitrate fertilisers results in a high concentration of free nitrogen in the straw which reduces its strength and hastens its decomposition. Changes in farming methods also affect the quality of the straw. Thatching straws were cut whilst the crop was still slightly green or "in milk". These were ripened in the sheaf for several weeks before being transported from field to stackyard. This produced a tougher straw that lasted longer on the roof. Threshing was also important as a poorly threshed sheaf could germinate on the roof providing access routes for surface water, yet, the introduction and use of efficient threshing mills and later combine harvesters, tended to destroy the straw by breaking it during the threshing process. Various devices were developed to allow the threshing to take place without damage to the straw but these are all time consuming and therefore add to the cost. The traditional threshing method was to use a flail, but knocking the heads of the grain against a series of fixed bars, prongs or projecting stones was used in some areas. Small quantities of grain could be stripped by hand or by burning oat seeds from the fine stalks. The commonest threshing method was to try to prevent the entire sheaf from entering the threshing drum. This was a difficult operation and a proportion of the straw as pulled through the drum and damaged. Some specialist thatchers, or thatch suppliers, developed threshing mills with hinged beaters and wide mouths to make it easier for the labourer to hold the sheaf and prevent its being pulled into the drum.

Other "natural" materials are also in the process of change and require positive action to produce a satisfactory thatching material. Acid rain is detrimental to all natural thatching materials and is changing the quality of the materials from year to year. Materials such as heather, broom or marram grass must be husbanded to produce good thatching materials. Heather must be protected from the burning practised on grouse moors and sheep walks. Marram must be protected from cattle and both broom and marram should be cut regularly to ensure a strong healthy plant and more suītable growth for thatching. The only material to thrive when not husbanded and harvested is bracken and bracken pulling for thatch might help control this invasive plant.

Unfortunately, when it comes to the building industry, thatch is often perceived as a standardised vegetative roofing material which does not require detailed examination, analysis, or description. This situation is highlighted in many building condition surveys where a surveyor would report on the condition of a slated roof by making observations on: the size range of the slates: possible source: colour: texture: thickness: method of laying, for example in diminishing courses or half slating: ridge type: flashing and gutter types: decorative features: and where possible whether single or double nailed: nail or peg types: on battens or sarking: set in mortar or dry: or with or without underfelt - yet, when the same reporter describes a roof with a vegetable roof covering, often stops with the single word "thatched".

This limited approach stems from ignorance possibly stemming from the period when local thatches were commonplace and the local thatcher did not divulge the secrets of his trade or where everyone in a community knew the local method of thatching and there was no need to describe it. Unfortunately, the approach has extended to British books on thatching methods and techniques with the most recent publications simply describing the three generally recognised English methods, that is: reed thatch, using common water reed (phragmites communis): wheat-reed, using sheaves of wheat straw with the butts to one end of the sheaf and applied in a similar manner to water reed: and long-straw, where the wheat straw is "drawn" to remove the weeds and flag and the straws are formed into even-thicknessed "bottles" with heads and butts to either end of the bottle. Many of these publications fail to mention other thatching materials and one has to refer back to C F Innocent's publication of 1916 [2] to obtain some impression of what existed, and has been lost, over the last century. Innocent was only concerned with England but explains in detail that the main cause of the loss of traditional thatches was the wish to use standard specifications.

None of the three thatch types appearing in British publications are traditional to Scotland although there was a gradual acceptance of them in southern and central Scotland from the end of the nineteenth century. This acceptance was far less wholehearted in Scotland than it was in England even although there was an equally wide variety of thatches in use in England prior to the first World War.

The existing wide divergence in thatching materials, techniques and principles between England and Wales on one hand and Scotland and Ireland on the other is not accidental but stems from differences in topology, economy and climate, particularly wind speeds.

In England and Wales, the availability of large scantlings to create large steeply pitched roofs that shed rainwater quickly, combined with a low to moderate rainfall, lower average-wind-speeds; rich agricultural holdings, substantial reed beds and an efficient transport system combined to produce an economic climate favourable to the specialist contractor producing an expensive but long lasting thatch that requires only minimal maintenance at widely spaced intervals. Whilst in Scotland and Ireland, particularly in the north and west, the scarcity of large scantlings and slacker roof pitches combined with moderate to high rainfall, higher average-wind-speeds, small agricultural holdings, lack of substantial reed beds and less efficient transport systems combined to favour the family or community group acting as their own contractors, producing a cheaper, simpler form of thatch with easily repairable and renewable external restraint, and requiring annual or bi-annual top dressing to maintain a strong, tough layer of thatch to counteract the effects of wind vibration.

English style thatches can be used anywhere in Scotland and are being promoted by an ever increasing band of English trained thatchers looking to extend their operational base. The problem is that in the north and west the wetter conditions, higher average-wind-speeds and lower pitches to the roofs combine to cause rot and wind damage thereby reducing the potential life span of the roof from the eighty to one hundred years expected in Norfolk to less than five years on Skye. This is totally uneconomic and it is therefore essential to preserve as many examples as possible of the wide range of thatching techniques developed and practised in the various regions of Scotland.

Scotland has one of the widest ranges of surviving traditional thatching techniques in Europe. Unfortunately the stock of houses and the range of types has been reducing steadily since late last century to a situation where once common techniques have disappeared or are down to a single known example. Nowhere has the deterioration and subsequent replacement been so dramatic than in Auchtermuchty, Fife where Jock Brough, the last commercial thatcher in Scotland, was based. Brough died in 1969 and a survey of Auchtermuchty carried out by students from the University of Dundee in 1974 recorded forty-four complete thatched roofs. By 1994 this was down to three thatches in the entire burgh and all of these have been rethatched in reed. Two of the last roofs to be stripped showed that the original thatch was straw stobbed into a base coat of turf then top dressed with cut lengths of reed to give the impression of full reed thatch.

The whole Scottish thatching stock could have been lost but for the introduction of the Thatched Houses Grants Scheme by Historic Scotland. This only applied to the Highlands and Western Isles but encouraged local thatching traditions at a time when many were moving to other less demanding materials. Unfortunately even the traditional thatchers encouraged by this scheme are now dying off and if the techniques are to be kept alive new thatching training schemes must be put into operation but teaching the thatching techniques and principles used locally rather than working to a national curriculum with standard solutions.

The introduction of corrugated iron as a building material in the 1820s caused many thatched roofs to be swept away whilst others were covered by a skin of the new material thereby protecting the historic thatch in a way that is not possible with continuous maintenance and renewal. The potential of this resource is not always recognised but the Technical Conservation

Research and Education Division of Historic Scotland commissioned a series of archaeological investigations of thatched roofs to assess their potential as a source of information on the materials, techniques and development over a number of years. It was decided not to investigate complete and watertight roofs but to target roofs that were in a state of collapse or were about to be demolished. Examples were selected in Orkney, North Uist, Wester Ross, Highland Perthshire, Aberdeenshire and Inverness-shire. The work was carried out by Dr T Holden, of Headland Archaeology, Edinburgh and has produced some particularly interesting and significant results. These include: obvious changes in the agricultural practices during the life of the roof: the establishment of "archaeological signatures" for various types of thatched roof: giving data to archaeologists excavating below ground: changes in thatching materials at various periods of the life of the thatch: dating evidence and so on. Dr Holden's report is planned for publication as a Historic Scotland Technical Advice Note [3] and will give valuable guidance on the scientific study of thatch remains and its significance to local, building and agricultural history.

One type of thatch is of particular interest in that it is linked with earth structures. It appears to have been developed in the late eighteenth century and involves top dressing various types of thatch with a clay render. This thatch is found in areas where estate walls are coped with a mudwall mix rather than with stone, ceramic or fale. The longevity of this type of thatch and the fact that the clay top-dressing appears to remain impervious to erosion is a mystery and hints at some hitherto unrecognised ingredient that increases the waterproofing qualities of the clay and thus prevents its being washed off the roof. Some elderly informants, interviewed in the 1970s reported the use of a thin coat of cow sharn as a waterproof coating. This is possible and has been observed on seventeenth century earth renders in France but many of the old photographs of this technique and the few examples recorded by the author appear to present a clay topping to the elements. The answer may lie in an additive that has been used in the Mediterranean region for at least six thousand years - seaweed. According to archaeologists seaweeds have been added to earth building materials either whole or in the form of alginates dissolved in alkali since the fourth century BC. The first known documentation as to why appears in the works of Vitruvius [4] who talks of using dried alginate dissolved in an alkali solution as an additive to mortar - either lime or clay - to provide a material for making aqueducts or cisterns. Our interest in the material is two fold. It should allow us to recreate or re-expose clay thatches used in terraces and still comply with the current regulations regarding fire spread and it should allow the reinstatement of damaged areas of mudwall copes particularly on walls round estate policies.

Ejé Aren, a Swedish archaeologist who has spent most of his career thatching for Skansen Open-Air Museum, Stockholm and many other open-air museums in northern Europe, in addition to preparing full size archaeological reconstructions from archaeological and ethnographic evidence, prepared a diagram to show an ideal relationship between: building owners, craftsmen and suppliers, supported by appropriate conservation bodies to protect the remaining stock of thatched buildings. This diagram also highlights: the need for good communication between the various interested parties: the identification and protection of the best examples of each type of thatch: the limits set by the various authorities in taking special care of these properties: and the inevitable scatter of properties outwith the conservation system. It illustrates the way forward and the decisions that must be reached to achieve an adequate level of protection for the remaining stock of thatched structures.

The Scots and the Swedes appear to be taking the lead in the recognition and conservation of a full range of thatch types and hope to set up joint investigations into ways of improving the availability of suitable thatching materials by trying to identify genes in traditional straws that produced a tougher straw and by the study of traditional handling practice that were thought to achieve a similar result. Thatch may be one of the oldest building materials but it is going to need a radical change in direction to counteract the effects of modern fertilisers and other pollutants.

References

(1) WALKER, Bruce, McGREGOR, Christopher and STARK, Gregor: 1966: *Thatch and Thatching Techniques: A guide to conserving Scottish thatching traditions* Historic Scotland, EDINBURGH.

(2) INNOCENT, C F: 1916: "Chapter XIII: Thatching" *The Development of English Building Construction.* 188-222.

(3) HOLDEN, T: 1997: ... *The Archaeological Investigation of Thatch.* TCRE, Historic Scotland, EDINBURGH.

(4) VITRUVIUS (translation by Morris Hickey MORGAN: (1914) 1960: *Vitruvius: The Ten Books on Architecture* Dover, NEW YORK.

WROUGHT IRON

Chris Topp, Director, Real Wrought Iron Company Ltd

Wrought iron has been used in building from the earliest days of civilisation, wrought iron door furniture being commonplace in Roman times. The structural use of iron dates from the middle ages, when bars of wrought iron would be used occasionally to tie masonry arches and domes. This use of wrought iron in tension guaranteed its use throughout the ascendancy of cast iron in the canal and railway ages, as cast iron is strong only in compression. The ill fated, first Tay Bridge was of cast iron beams tied with wrought iron. The demand for higher dynamic loads in bridges and warehouse buildings, and the ever greater spans of train sheds toward the end of the nineteenth century, led the designers of buildings to acquire the technology developed to build ships of iron, and create beams of riveted wrought iron rolled sections. By the turn of the century this had lead to buildings completely framed in wrought iron, and later steel, girder sections, and cast iron was once again relegated to an ornamental role.

Our main concern with wrought iron, however will be in its application to gates and railings, frequently given an ornamental treatment by the blacksmith.

There are wrought iron railings in Westminster Abbey from the thirteenth century, which, in essence display all the characteristics which we have come to know as "wrought ironwork", although lacking modern refinements such as symmetry and sweetness of line, but the great age of British ironwork, known as the "English" style began at the end of the seventeenth century. A French fashion for the Baroque style in gates and railings, swept the country houses of Britain, following the import of craftsmen by William and Mary, and the greater part of our national stock of good ironwork dates from the early years of the eighteenth century. After the rise of cast iron as an ornamental medium, wrought iron tended often to take a secondary role, owing to its comparative expense, each piece being made by hand, while castings could be repeated ad infinitum, once the pattern were made. Technically, however, the craftsmen of the age of machines, excelled their forbears, as indeed they must while making mechanical components, so that the ornamental blacksmithwork of the nineteenth century displays a perfection of manufacture not seen before nor since. After the introduction of mild steel, cheap because of its ability to be mass produced, wrought iron, and the craft skills associated with it, gradually disappeared in accordance with the general decline in craft standards in the twentieth century, until the last ironworks ceased production in 1974.

From 1982 Chris Topp & Co. and later the Real Wrought Iron Company, have made available a limited supply of puddled wrought iron, derived from scrap metal. The subsequent years have brought a steadily increasing demand, as the blacksmiths of Britain have slowly taken up again the ancient skills.

Identification

Wrought iron is unlike cast, in that it is not brittle, and seldom breaks. For this reason, wrought ironwork is frequently far more delicate, although years of paint can obscure this. Cast iron is most frequently identified by its repetitive nature, and forms which could be carved in a wooden pattern, but not made by hammer and anvil.

Telling wrought iron from mild steel is often more difficult, as both will bend, and not break. Frequently, however, work in mild steel is readily identified by the lower standards of workmanship often used. Look for evidence of electric welding. Also mild steel is often given away by more active corrosion, rust tends to run out of the joints in a steel gate, and stain the piantwork, where this is seldom the case with wrought iron.

Wrought iron may also be dated, approximately by its texture. Until the very end of the eighteenth century, sections of wrought iron were derived by forging of billets by hand or water power, this resulted in a more or less uneven surface texture, and very sharp corners. A foreshortened view of a bar displays well the irregularities of the surface. Rolled bars, on the other hand, produced from the beginning of the nineteenth century, are perfectly smooth, and the corners can display a small radius. Nineteenth century wrought iron is known as "puddled iron".

Alternatives

The modern replacement for wrought iron is mild steel. Many metalworkers are perfectly content to use this much cheaper metal both for new work and the refurbishment of old. I would like to suggest three reasons why this is not acceptable, while wrought iron is yet available.

1. The weathering properties of wrought iron are well known. While it does of course rust in time, with reasonable maintenance this can indeed be a very long time. The fact that so much ornamental work survives from three hundred years ago says a lot for the material. On the other hand, steel is well know for its corrodability, and the intricate forms and water traps of "wrought ironwork", only encourage corrosion. Hence it is normal practise to coat steelwork with zinc, which does indeed delay corrosion, but neither galvanising nor zinc spraying can effectively be applied to complex forms.
2. Modern conservation practise insists on the replacement of materials with like materials. When wrought iron is available for the repair and replication of wrought ironwork, why use mild steel?
3. The craft of the ornamental blacksmith, as previously practised to a high degree of skill, was virtually eradicated by the shift to mild steel, with its ready application to "high tech" techniques such as electric welding. As mentioned above, some of the blacksmiths are learning again the old skills. Only by use of the traditional methods and materials can work of an appropriate standard be produced.

Specification

There is a wide disparity in cost between the cheapest of work, and the best. Without a sufficiently tight specification, work acquired on a competitive basis will tend toward the lower order. Frequently, the term "wrought iron" is used wrongly to mean ferrous metal which has been worked. The cheapest form of ferrous metal, in these circumstances, will be mild steel. Even when "wrought iron" is actually used to describe the true material, unscrupulous contractors will sometimes take it to mean mild steel, and of course win the work with a cheaper price.

There is a need for a standard form of words which can be used to specify ironwork of the highest order. Definition of the materials is a good start, for example "puddled wrought iron" rather than just "wrought iron", which is often misinterpreted. Mention of specific techniques is important, "all welding to done in the fire" is often used, or less positively, "no use of electric welding". Assurance of quality, however can only be guaranteed by examination of the track record of the workman, or from the submission of examples.

While it is very difficult to tell apart wrought iron and mild steel in a newly finished piece of work , there are test which can be simply carried out on the bar material. The contractor should be asked to demonstrate firstly his source of supply, and then, to carry out a 'nick bend' test. This test consists of cutting through a bar perhaps 50% of its thickness, and then bending the bar at this point away from the cut. Wrought iron will demonstrate a form similar to a greenstick fracture of a bone, the material splitting lengthways away from the base to that of a softwood. Mild steel tested in this way will either snap at the cut, or more normally, bend without any form of longitudinal split.

It is also worth noting at this point, that wrought iron is supplied only in imperial sizes, and should be so specified. As mild steel is manufactured, in this country, in metric sizes only, this can act as a further test of authenticity.

Maintenance

Ironwork is commonly supposed to be nearly free of maintenance. Unlike woodwork which is religiously subjected to a stern regime of regular painting, ironwork is frequently left to rust undisturbed for long periods, so much so that the only attention that much even important ironwork receives, is periodic major overhaul, at great expense. This could be avoided by frequent small attention. Insistence on frequent inspection would be of benefit, perhaps once a year, with immediate, and usually trivial remedial work to arrest any developing problems.

Future Supplies

Since the early 1980's, wrought iron has been made available from two sources. Initially, Chris Topp and Company, published a price list in 1983, for re-rolled wrought iron bar and sheet material. The Ironbridge Gorge Museum Trust, acquired the plant from the last ironworks, and set it up in working order in the museum, as an exhibit, but also with a view to commercial production of wrought iron. In 1994, Chris Topp and Ironbridge combined efforts, under the name "The Real Wrought Iron Company" to tackle the uphill task of selling a superseded commodity in an extinct market. Subsequently Ironbridge were compelled to withdraw from the venture, which however continues to supply over 30 tonnes of iron a year from the premises of Chris Topp and Company, Carlton Husthwaite, Thirsk, North Yorkshire (01845 501415).

At present, supplies of puddled iron are derived from old material of large size, which can be rolled directly into bar form. Although, to date, such raw material has always been available, we are currently installing the plant required to process general wrought iron scrap, which by a forge welding process produces an iron of high quality. As there are nearly limitless supplies of such scrap, the future of wrought iron seems secure.

CAST IRON

Ian J Ballantine, Managing Director, Ballantine Bo'ness Iron Co Ltd

Stone and Cast Iron were the two great building materials of the industrial revolution period and the Victorian age. Unusually, my company just spans both these periods, starting some time in the 1820's. Unfortunately, virtually no records exist of the early years; it would have been quite special to give you information from the horse's mouth! However, as I wasn't around then, you'll have to settle for hearsay.

As you can see from the biographical note, I am a fifth generation ironfounder; if I were a bird, I would qualify as an endangered species! Tens of thousands of pounds a year would be sent on my well being, safety and comfort - I might even be provided with mates! Unfortunately, as a human being, I can't attract any funding. However, I am well qualified to talk about cast iron and I hope you learn something new today.

Cast iron was probably discovered when a malleable ball was overheated in a charcoal stove, the iron melted out over the charcoal, picking up carbon forming cast iron. It was a long time before the potential of cast iron was realised. Most of the early metalwork was for the military and a cast iron sword would be guaranteed first round exit from any tourney. It is a depressing fact that the hardware of the war led technological research as it does today.

Once the practical uses of iron were established, growth started; one of the earliest records is 3 cannon made in Sussex in 1510. It is interesting to see how tightly the industry was controlled during that period. In the Elizabethan era for instance, production was limited to only eight noble families licensed by the Crown.

However, this tight control broke down and by 1700, Abraham Darby was producing cast iron using coke and selling pots, kettles, and pans on a large scale. From then onwards, the industry expanded rapidly, introducing cast iron as a building substitute for stone, and as a material in its own right producing kitchen ware, seats, boilers, pipes, gutters, greenhouses, trivets, railings, lamp-posts, signposts, bollards, stable managers, water troughs, manholes, rooflights, engineering castings - the list could go on and on.

Obviously, cast iron has to have many excellent qualities to perform the various functions required by the products above. The most important qualities are:

1. It can be melted and poured into almost any shape, on a low or high volume as required. The limitations are physical - how much metal can be melted and held for a single cast - how large a casting can be handled and transported.
2. It is highly resistant to wear and corrosion giving it terrific longevity. Many of the original castings made in the 18th Century and 19th Century are still around today. Indeed, were it not for the programme of melting down cast iron in the two great wars in this century, the majority of street furniture would still be with us.
3. It has very high compressive strength, greater than steel, allowing it to be used for structural purposes, bridges, buildings - cast iron columns for industrial buildings were used in huge quantities right up to 1939.
4. It is machineable, allowing assemblies.
5. Huge deposits of iron ore exist around the world.
6. Cast iron is fully recyclable, as its wear rate is so slow. It is not unreasonable to assume 90% of most castings made could be recycled.
7. Cast iron conducts heat very well, making it excellent for cooking and heating systems.
8. Cast iron is primarily ferrous but 5 other base elements have a significant impact on its performance; they are carbon, phosphorus, silicon and manganese. They all have a weakening effect on cast iron effectively increasing the graphite flake structure which carbon forms in the metallic structure. This is the cause of cast iron's one major weakness, its lack of tensile strength. When load is applied in tension as opposed to compressively, a 1" bar will fail at a load of 12 tonnes. As the stress builds up, a crack will start at the weakest point of the casting, the crack will then leap from flake to flake and the casting breaks. Equally, when the cast iron is struck the shock runs through the casting and the crack again starts at the weakest point. This can lead to some tricky situations if the casting is struck at its strongest point, it might well absorb the shock there but break elsewhere. So if you hit a lamp-post, do hit a steel one! The person who drove into the Buckingham Palace Gate recently did exactly that; a large section of the tip of the gate broke off and went through the bonnet and windscreen of the car.

A very wide range of composition and physical properties can be obtained with cast irons. In many cases special characteristics are required such as added resistance to corrosion, heat and wear. These, and other particular attributes, can be developed in suitable base iron compositions by the addition on alloying elements. About twenty alloying elements are in everyday use, either singly or in combination. They range through the entire list of metals and metalloids from aluminium to zirconium and are added in quantities of less than 1% up to 30% or more of the composition.

It is easy to see how cast iron became so popular, and equally easy to see why conservationists would wish to use it. Few materials can offer the flexibility and life span of cast iron.

Turning to the production of cast iron, if we ignore the Factory Inspectors, the Health and Safety Acts, the Clean Air Act, S.E.P.A.'s environmental control, melting iron is very easy. A funnel, whether a steel tube, a 45-gallon drum, a ship's smokestack, a brick chimney, and old boiler, a refractory lining, a supply of air under pressure, some coke and cast iron can be melted.

Even with all today's controls, it is still easy to melt iron, just more expensive. There are more methods now with electric melting growing rapidly in popularity. Melting using medium frequency is very common now. A magnetic energy field excites the molecular structure of the iron or any metal which heats up and melts down. You or I could stand in the furnace at full power and providing we weren't wearing wedding rings, ear-rings or watches would be completely unaffected.

Now we have established that it is easy to melt and there is plenty raw material we move onto the production of cast iron.

This is much more complicated because nothing can be produced until there is a pattern. The highest skill in a foundry is patternmaking. It used to be a great bone of contention between moulders and patternmakers who was the most skilled, and in the 18th Century and 19th Century there wasn't much in it. However, the huge advances since 1945 have heightened the patternmaker's role and diminished the moulder's role.

In the building industry the role of cast iron was very ornamental with highly decorative shapes and assemblies. To make these needed the skills of a sculptor and master joiner. Today there are few foundries left with such skills. The quality of the casting is primarily dependent on the quality of the pattern.

If you are involved in a restoration project involving complex castings, the patterns are likely to be the most expensive and important part of the cast iron supply, especially if the casting volume is low. A regularly overlooked aspect of casting supply id the storage and filing of patterns; many people think that the patterns are finished with when the job is completed - not so. Some of our patterns are over 100 years old, and we have at any one time 300,00 - 400,000 in store!

Once it is established that the pattern making skills are available, manufacture follows on. Except for a few exceptions, most castings are made from traditional greensand or chemical air set sand. Basically the larger the casting of the heavier the section the better it is to make it in air set sands. However, for lighter castings and fine detail, greensand production is more suitable. It is still a source of surprise to me how few people or firms ask for samples before proceeding with production.

Not only are there good foundries and bad foundries, there are easy and difficult castings. Very often a casting which looks simple turns out to be a nightmare because of feeding problems, stress weakness or a myriad of other things. Considering the high profile of restoration work, if I were the architect or person running the contract, I would be at the foundry checking the initial castings. Oddly enough, this procedure is rigidly adhered to by all foreign consultants we deal with.

Rather than talk about the manufacturing processes, which is pretty boring, I have brought along a short video the B.B.C. made about the foundry making ornamental work . For those of you with musical leanings you should appreciate the suitability of the music! The video does convey the atmosphere of a jobbing foundry extremely well.

Cast Iron Specification

This is a huge field, but if we stay away from the more exotic end of the market, which is mostly for modern engineering applications, I have drawn up a simple chart which should cover most restoration requirements.

Cast irons for the designer

The family of cast irons can be classified in several fairly distinct groups of general-purpose materials, each group having its British Standard Specification and offering a wide range of mechanical and physical properties. For grey irons, the grade number in the BSS expresses the minimum tensile strength in N/mm^2, obtained from a cast test bar 30mm in diameter. The grades of malleable and ductile (nodular, SG) irons are expressed as two numbers in the BSS: the first is the minimum tensile strength in N/mm^2 and the second is the minimum elongation per cent.

There are also several special-purpose cast irons, some covered by British Standard Specifications, which have been developed to meet special needs - such as resistance to heat, corrosion, or abrasion.

General-purpose cast irons

	British Standard Specifications
Grey irons- containing flake graphite	BS 1452: 1990
Malleable irons- containing nodules or aggregates of graphite	BS 6681: 1986
Ductile, nodular or spheroidal graphite irons	BS 2789: 1985

Special-purpose cast irons

	British Standard Specifications. & trade names in italic
Austenitic irons* - substantially non-magnetic, containing flake or nodular graphite	BS3468: 1986. Also under trade name *Nomag, Nodumag, Ni-Resist and Nicrosilal.* These irons are used for non-magnetic, corrosion, heat and low-temperature applications.
High-silicon irons* - normally containing flake graphite	Silal (5.5-7.0% silicon) - heat resistant. BS 1591: 1975 - corrosion resistant.
White irons*- graphite-free	BS 4844: 1986 Abrasion-resisting white cast irons. Nickel-chromium grades - obtainable under the trade name *Ni-Hard.*
High-chromium irons- graphite-free	High-carbon grade (2.3% carbon, with chromium 15-30%) - wear-resistant; as BS 4844: 1986. Low-carbon grade (1-2% carbon, with chromium 17-33%) - heat and corrosion-resistant.

*Relevant British Standards contain details of compositions and properties of various grades.

Properties of different grades of grey cast iron and recommended design-stress levels.

Grade BS1452	150	180	220	260	300
Tensile strength, N/mm^2	150	180	220	260	300
proof strength	42	50	62	73	84
proof strength	98	117	143	169	195
Compressive strength, N/mm^2	600	672	768	864	960
proof strength	84	100	123	146	168
proof strength	195	234	286	338	390
Design stresses					
Direct tension	38	45	55	65	75
Direct compression	156	187	229	270	312

Maintenance

Cast iron requires care like most other materials. Coatings are a complete subject on their own. The important thing to remember is that exposed cast iron will corrode, creating rust. This will not seriously damage the cast iron for many years, but it will do shocking damage to stonework if rainwater washes the rust onto nearby stonework. The rust will stain the stonework and I am sure everyone here will have seen stone staining.

Castings should be checked annually if in an exposed position. Many paint or powder coatings will last 10-15 years nowadays, and then only need an overcoat for the same life again.

Some of the old castings we get have as much as 8mm of paint on them - that could be as much as 20 coats of paint over the years. One interesting fact which came out of stripping these old castings down was the amount of blue and green coats under the top black. Most railings were blue and green until Prince Albert died and Queen Victoria had a load of royal railings painted black in mourning. The whole country followed suit and black became the standard colour of railing for the next 120 years. Only now are blues and greens re-appearing and they look extremely good. Some railing and bridgework in Glasgow really looks terrific.

If the restoration work involves moving parts - gear wheels, valves - regular greasing is required, although some greases now, such as Copperslip, can last for several years.

The other vital area of maintenance is the prevention of water ingress into assemblies. This accounts for more damage and broken castings than any other factor. Where castings are bolted or screwed together if they are not sealed with paint, mastic or some other proprietory product, water can get in. When winter comes that water will freeze and expand; unfortunately cast iron weakens with lowering temperatures and the result can be a cracked or broken casting.

Many cast iron repairs are done in situ and I would like to issue a word of warning here - despite improvements in welding rod technology, cast iron does not weld well. The temperature in the welding process tends to set up a stress near the weld which creates a weakness in the casting which will often fail under stress. There are stitching procedures which do work, but take care that they are properly done by nominated contractors.

There are today some terrific 2-pack glues - we have done trials in the foundry where we have struck a head onto a cast iron bar and exerted pressure on it until failure occurred, the failure has been the bar itself, not the glued joint.

Supply and Demand

A little bit of bias comes in here as I am obviously an interested party. The range of castings required means that there are only a handful of foundries capable of supplying every type of casting.

At the moment the growth of the market is sucking in castings from more and more foundries struggling for existence in tough market places. Demand is being met but the supply is not consistent. The pressure on price means that the contractor is inexorably drawn to the cheapest price which seldom provides the best metalwork.

This is where the role of the architect or consultant really becomes important. When they research a contract, they should check out foundries for suitability and get budget prices. If they are satisfied the foundry they have dealt with meets their criteria, they should be specified as nominated contractors. However, the main contractor is appointed and often starts a price competition between several foundries to get the biggest cost reduction. I am not convinced that this is the best way to go about restoring our heritage for the future.

There is adequate supply to meet demand without going down market, despite the reduction in the number of foundries. To give you an idea of the scale of the reduction in the ironfounding industry; in the Falkirk area there were 114 foundries in 1945, today there is not a single ironfoundry in Falkirk and only 5 foundries in the area.

Projects usually demand a range of castings and skills. Most foundries tend to specialise within limits of size and weight. Only the bigger jobbing foundries can make the full range of castings from 7 metre one tonne lamp-posts to 1/2 kg railing heads. It is easier to control a project with a single source of castings. However, very often the contractor will buy from several sources on a cost basis.

Ductile Iron (BS2789)

The one iron not available to the industrial revolution and Victorian ironfounders was ductile or spheroidal iron which was not developed until the 20th Century.

Whilst it is not strictly speaking a traditional material, it does have a role to play in the restoration/heritage market.

Ductile iron bridges the gap between iron and steel without sacrificing iron's positive qualities. By melting carefully controlled steel scrap and adding carbon and magnesium, the graphite flake structure is changed to a nodular or ball structure. When the casting is struck, the crack goes to a nodule or ball and goes round it; it does not leap to the next ball. We therefore have an iron which can take impacts like steel or wrought iron.

Wrought iron is not freely available and ductile iron is a much better alternative than steel. The number of installations currently being ruined by the use of steel over the last thirty years are legion. Once corrosion sets in, it is seldom stopped.

Ductile iron is also an extremely good substitute for cast iron in certain locations. Where the risk of damage is high - through vandalism or whatever - I am sure you have all seen nice runs or railing marred by a few heads being broken off. Were the railings made of ductile iron these heads would still be on. It is certainly something to be borne in mind when considering city centre restoration.

The most common grade used is BS2789 420/12 where the 420N/mm^2, i.e. 27 tons tensile strength coupled with the 12% elongation minimum make this material very vandal proof.

Conclusion

In conclusion, all I will say is that the restoration business is becoming big business with all the pitfalls that entails. Cast iron has been an under-used material. Architects and specifiers have been aware of traditional cast iron but have not had much call to use it. There is a growing number of producers entering the market with little recent experience. Finally there are contractors desperately trying to make a profit. The situation is probably not unlike the industrial revolution with people feeling their way.

My advice is to use companies who have a track record and a reputation to protect; I'm not saying it's foolproof, but it does increase the chance of a good project well finished.

COPPER

Eur Ing Vin Callcut, Technical Director, Copper Development Association

Abstract

Copper is able to meet most modern challenges yet is one of the oldest of traditional materials. Having been used initially for implements and ornaments, then for cooking utensils, it soon provided material for roofing, water pipes and many architectural and decorative features.

This paper outlines the types of copper and copper alloys available, the ways in which they can be obtained and their many valuable applications. It mentions supplementary information available as books in hard copy and on CD-ROM.

Introduction

Of all the building materials being discussed at this meeting, copper is perhaps one of the most locally available, having been mined only five miles away. Up until 60 years ago, copper ore was being extracted from about 10 copper mines along the Ochil Fault that parallels the A91 road between Menstrie and Dollar, making a useful contribution to local wealth. Silver was also found and the most profitable mine was at Alva[1]. There have been other copper mines elsewhere in Scotland but unfortunately none with large reserves. In the 19th century the largest copper mine in the world was in Anglesey at Parys Mountain and Queen Victoria's largest copper port was at Morwelham in Devon.

Copper cannot now be economically mined in the UK. Our supplies of primary copper come from over forty countries in the world including, for example, Canada, Chile, Peru, Poland, Australia and South African countries. In Scotland, local foundries and fabricators are happy to make materials to suit the restoration of the most traditional types of architecture or to meet the needs and challenges of modern requirements. They can use secondary, recycled materials or primary supplies as appropriate.

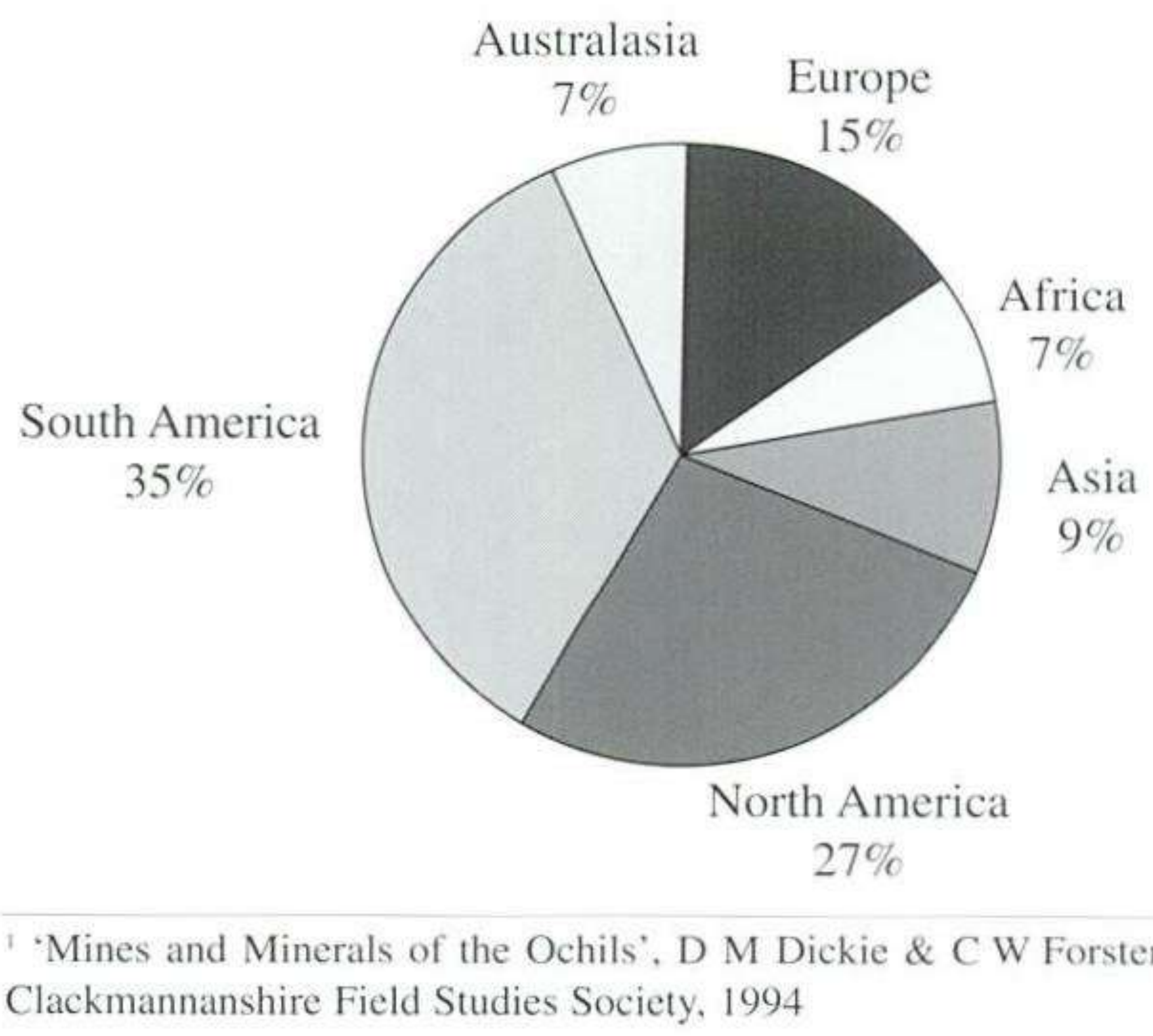
Copper itself is a relatively soft metal with excellent corrosion resistance that is ideal for fabrication for roofing of plain and intricate design. It is also, of course, the standard material for water supplies and domestic central heating. Copper's resistance to biofouling was first recognised in the late 18th century when sheet was attached to wooden hulls to prevent attack by Toredo worm. It was then found that marine growths did not adhere and that careening for hull scraping was no longer required. There was also an early lesson in electrolytic corrosion when copper sheets attached by iron nails soon fell off again! Copper nails have been used ever since.

Copper alloys are many and varied, ranging from the simple brasses with their lovely golden colour through the nickel silvers, tin bronzes and gunmetals to the aluminium bronzes, so ideal for the heaviest duty applications. Recently it has been shown that machined components can be made more economically from brass than steel and, still on the subject of money, there are an estimated 40,000 tons of bronze coinage circulating in the U.K.

Extraction

Copper is plentifully available in the deposits in the earth but only in some places is it at present economical to extract it. Most of the ores are oxides, sulphides or more complex. The original practices of refining by smelting have been much improved to make sure that copper supplies are reproducibly good quality and very economical in price. Chemical extraction techniques are now being used to make much better use of low grade ores and this, together with large quantities of recycled scrap, ensures copper supplies are ample for the foreseeable future.

World Copper Mine Production



[1] 'Mines and Minerals of the Ochils', D M Dickie & C W Forster, Clackmannanshire Field Studies Society, 1994

Availability

- Roofing copper is now rolled from continually cast cakes and is available either annealed soft or in half hard condition depending on the roofing technique to be employed.
- Copper tube is drawn from tube shells made from continuously cast billets of de-oxidised copper and can be supplied annealed half hard or fully hard.
- Copper alloy extrusions can be made as rods, rectangles, hexagons, irregular shapes and hollows to order.
- Wire in copper and copper alloys can be drawn down to very small diameters and many other rod forms are available.
- Castings for all types of applications are normally made of copper alloys rather than copper and are available in weights ranging from a few grams up to many tonnes.

There is a long tradition of good quality copper alloy foundry work in Scotland. There is also a very important copper alloy wire drawing industry at Granton in Edinburgh. Stockists for wrought materials are situated in every main city and town.

Standards

All materials can be specified to British Standards appropriate to sheet, strip, tubes, rods, sections, wire, plate and castings. All fabricators and many stockists operate under BS EN ISO 9000 approvals.

The old British Standards such as

- BS 1400 for castings and
- BS 287x series for wrought products
- BS 143x series for coppers for electrical purposes

are being replaced by standards in the BS EN series of documents prepared by the European standards committee CEN TC 133.

The new standard for copper tubes for plumbing is now BS EN 1057. This will appear on good quality tube together with the maker's identity and the BS Kitemark.

The new standard for sheet and strip for building purposes is BS EN 1172.

Recycling

The fact that copper and its alloys can be easily recycled with minimum energy input is vital to the economy. Recycling is nothing new to copper. No trace can now be found of that wonder of the ancient world, the Colossus of Rhodes. This was made of copper sheet over an armature and was reclaimed from the seabed and recycled shortly after the statue fell. Incidentally, when the Statue of Liberty was refurbished recently it was found that the copper cladding was mostly re-usable. It was the steel armature inside that had failed.

It is normal to make high conductivity copper for electrical wires from primary copper; all others contain a significant proportion of clean recycled scrap. Soldered copper, with adherent tin and lead, can be used to make bronzes and gunmetals without the need for re-refining.

Roofing

Always a popular material amongst architects, copper is frequently chosen because of the very attractive green patina that develops with age, as shown. Normally this forms within a few years and is then extremely durable and good for up to 100 years or more before replacement is needed, depending on the environment. Copper does not 'creep' on steep slopes and is light enough not to need such a strong support structure as many other materials. It is also now available pre-patinated so that the attractive look is available from day one. It is also possible to obtain solutions that can be used to patinate copper in situ.

In Roman times the domed roof of the Pantheon was covered with bronze tiles over a sheathing of copper. Copper was originally specified by Parliament for the dome of St Paul's Cathedral. Had it been fitted and set the trend for much more copper roofing in London, that cityscape would not be so grey as it now appears.

Every major city and big town has examples of good quality copper roofing. Glasgow and Edinburgh have some excellent work from which just a small selection can be illustrated. The Strathclyde University Management Building is a modern example of wall cladding and the City Chambers show a tasteful use of copper as a backdrop to the ornamental stonework.

Donaldson College in Haymarket is attractively capped with copper amongst many buildings in Edinburgh. The new Saltire Court building has a copper roof that harmonises with the adjacent Usher Hall, which shows roofing restored by first class traditional roofing techniques. The glorious copper roof on the Bank of Scotland has gained world-wide publicity on a magazine front cover.

Besides the attraction of the colour, copper is also chosen for economy, being one of the cheapest roofing materials to use on a life cycle cost basis. It is relatively light and therefore needs less expensive supporting structures. It lasts for many years without the need for continuous maintenance and, if damage does occur, it is readily repaired.

Every year, Copper Development Association organises a competition to recognise the best copper roofing design practice and many entries are received from Scotland amongst other places. In 1992 a strong entry was the roof of the new pilot station at Granton Harbour and in 1993, the prestigious winner was St Magnus Cathedral in Kirkwall, Orkney.

In response to demand,

- Roofing copper is now more readily available in both traditional and long-strip forms.
- Courses are being run to train roofers in the best roofing techniques and designs to be used.
- The Copper Roofing Advisory Service is available at CDA to give free advice.
- The annual Copper Roofing Competition recognises the best designs and workmanship.

As well as being ideal for roofing, copper is also used for wall cladding and can be excellent as a flashing material. To complement a copper or other good quality roof, traditional copper gutters and downpipes are excellent. Besides the corrosion resistance and attractive appearance mentioned earlier, copper also acts as an algaecide and fungicide, keeping growths such as moss and lichens at a minimum. Copper and its alloys are used for many decorative features such as window frames, weather vanes, urns, finials, balustrades and shopfronts.

Copper alloys are also ideal for interior uses. They make durable, good-looking handrails, stanchions, decorative panels and are suitable for heavy duty use in lift door tracks, hinges, locks and other door furniture. When specified as door furniture, copper has the advantage of being a bactericide, reducing the transmission of infections. It is therefore popular for use in hospitals and other public buildings. Note, though, that this benefit is mostly lost if the components are lacquered. Nevertheless, they still look good and do not need such frequent polishing.

Copper pans are essential furnishings for traditional kitchens. Much loved by traditional chefs because of their high conductivity and durability, provision should be made for storage racks from which they are readily available. Many historic homes have a stock of pans that dates back hundreds of years. Periodic servicing and re-tinning ensures that replacements are rarely necessary.

Joining

For roofing purposes, copper sheet is usually joined by folding. Soldering can also be used as it is for plumbing. Hard soldering, brazing and welding

Comparison of lifetime costs of typical roofing materials

Life Cycle Costs	Cost of coverings £/m²	Scrap Value £/m²	Strip Coverings £/m²	Supporting Structure £/m²	Cost to Replace £/m²	Typical Life Years	Risk, % of repair cost per cycle	Repair cost per year £/m²	Total cost to year 50 £/m²
Metal Pitched									
Copper, half hard, 0.6mm	55.15	10.99	3.00	54.00	47.16	87.5	6.5	0.04	**111.31**
Aluminium, PVF2 colour coated, 0.7mm	38.97	2.04	3.00	54.00	39.93	47	14	0.13	**139.16**
Lead code 5, standing seams, 2.24mm	80.58	10.10	3.00	61.00	73.49	85	12	0.12	**147.48**
Stainless steel, terne coat, 439 grade, 0.4mm	52.87	6.28	3.00	54.00	49.59	97.5	6	0.03	**108.59**
Zinc, bright, 0.7mm	47.19	2.96	3.00	54.00	47.23	52	11	0.11	**106.50**
Non-metal Pitched									
Tiles clay	33.97	0.00	4.00	61.00	37.97	60	10	0.06	**98.14**
Tiles concrete	24.68	0.00	4.00	61.00	28.68	50	10	0.06	**117.24**
Slate	68.61	0.00	4.00	61.00	72.61	100	10	0.07	**133.24**
Non-metal Flat									
Asphalt	14.44	0.00	6.00	69.00	20.44	20	20	0.20	**134.54**
Bitumen felt	19.24	0.00	3.00	69.00	22.24	20	20	0.22	**143.84**

Source: ECRC 1997

techniques are also readily used on copper and copper alloys where needed for fabrication of wrought items and/or repairs. Information on best practices is available in CDA and other publications.

Statues

In public places everywhere bronze statues are used to commemorate famous people and significant events. The casting of statues is one of the oldest techniques and is normally achieved using the lost wax or 'ciré perdu' process. From the original made by the artist or craftsman is made a shell, usually of ceramic, and from this is made a wax pattern. This is subsequently invested in a moulding sand with a strong binder which sets during baking. The baking process melts out the wax, leaving the most intricate of shapes to be cast using a fluid alloy such as bronze, this usually being a 10% tin copper alloy.

After cooling the mould is broken open to reveal the casting which is fettled to remove pouring sprues. Separate sections may then be welded before the whole assembly is then cleaned and polished. At this stage it is usually also toned to the chocolate brown colour most frequently preferred for statues. This finish needs occasional re-application of linseed oil to preserve it.

Two types of finish are shown in these slides, firstly of the striking Chambers statue just outside the Royal Museum of Scotland in Edinburgh. This one has been allowed to patinate to the usual green colour associated with roofing. Another example, also seen in Edinburgh, is that of Greyfriars Bobby commemorating the valiant vigil of a faithful hound. He is placed at a level where he can still be patted by passers-by. The hand-oil removes the need for linseed oil treatment.

Structural Components

For many years phosphor bronze securing bolts and anchor plates were standard for masonry fixings for heavy wall cladding. The application illustrates the strength and long term reliability of copper alloys. Correct choice of alloy and diameter means minimum sensitivity to fatigue, crevice corrosion and stress corrosion. More advanced applications include bearings for bridges and similar structures that must allow for expansion. Aluminium bronzes have been used successfully to take the entire weight of the reinforced concrete roof structure at the Physics and Mathematics Building at the University of Aberdeen. The cast aluminium bronze feet are seated in a socket made of similar material deep set in concrete, which continues to pass inspection with no problems reported.

Aluminium bronze is especially useful in marine environments since it forms an oxide skin very resistant to attack by chlorine. Its success as a standard material from which propellers and seawater pumps are cast means that there is confidence in its use for architectural applications. It has no problems whatsoever when embedded in concrete. It can be used as bearing plates with confidence.

We have also looked at the possibility of making reinforcing bars for concrete from aluminium bronze and are sure that this type of new application could be successful, if expensive.

Stained glass windows have recently been made in Aberdeen for the Oriel of Lerwick Town Hall and are supported by aluminium bronze glazing bars. The material was specified to stand up to the saline atmosphere and fierce winter storms. Inset into the masonry, it is immune to the chloride corrosion that attacks ferrous materials and causes the formation of expanded corrosion products that spall the stonework. The centre window commemorates Princess Margaret, daughter of King Erik of Norway and his Scottish wife, Queen Margaret. She was the intended for the English King Edward II but lost at sea in 1290, thus spoiling the Anglo-Scottish succession.

Aluminium bronze structural columns and roofing plates are specified for the new Parliamentary building in Westminster to be inhabited by many Scots MP's. The roof and the fourteen conspicuous chimneys for the air conditioning system are to be of patinated aluminium bronze.

Copper for Fire Safety

Copper is, of course, the standard metal used for electrical wiring throughout buildings. Conformance to the regulations of BS 7671, the 16th Edition of the IEE Regulations, will normally ensure that the operating temperatures of power cables are not so high as to cause fires. Regular inspection for damage and deterioration is naturally recommended. Modern office equipment is, however, now giving us a few surprises. Any building using large numbers of micro-processor controlled power supplies in computers, fluorescent fitting, speed controllers and timers, now has to be designed to allow for a constant flow of electricity to earth.

No longer is the earth connection merely for use in emergencies. It must not only be designed to conform to the regulations when installed, it must maintain a low impedance throughout it's long lifetime. Like all other electrical equipment it must be regularly inspected and tested. There is the growing trend away from the use of rust-prone steel armouring and conduits for earth connections, towards the inclusion of extra earth cables in power supplies.

It is also found necessary, because of the generation of harmonics by the equipment mentioned, for larger sized neutral cables to be fitted. CDA has available a variety of publications covering these topics which will be sent on request.

Fire Sprinklers

Another essential to fire safety is the installation of sprinklers to give a rapid response to the heat generated by local fires. One of the earliest systems was installed in the Theatre Royal, Drury Lane in 1812 . The system was divided into sections with manually controlled valves feeding perforated pipes and could deliver '2,000 streams of water each equal to that of a small fire engine'.

Gravity tanks and manual valves were superseded by various type of automatic valves of simplicity and/or ingenuity. The first sprinkler head was invented in 1864, being a perforated hollow brass ball with a rubber valve which operated when a retaining string burnt away.

After disastrous fires in Chicago in 1871 and Boston in 1872, the first sprinklers were installed in Chicago in 1875. From 1881 onwards, sprinklers have been fitted in Scottish buildings, starting with the Edinburgh Rubber Works and the Charles Rennie MacIntosh 1894 Glasgow Herald Building.

The use of sprinklers installed to recognise the heat from a local fire (not the smoke!) prevents extensive damage happening as fires spread. If Windsor Castle had been fitted with sprinklers it would not have needed a forty-million pound restoration.

Occasionally there is an opinion that sprinklers may cause water damage to precious heritage but, through the absence of sprinklers at Windsor Castle, it was necessary to pour nearly a million gallons into the structure. Fire hoses in fact deliver water at ten to a hundred times the rate of sprinklers. At Windsor Castle, thirty-one jets were used to provide 20,000 litres of water per minute at the height of the blaze that took twelve hours to be extinguished. If sprinklers had been fitted, it might have been contained within minutes of starting.

Codes of practice for installations in large buildings are well established. One is now being prepared for small sprinkler installations suitable for use in domestic environments using copper tube to supply brass sprinkler heads. They can be installed by suitably qualified plumbers already familiar with copper plumbing systems. If properly installed and regularly maintained, they can be relied on for many years of safe service. Because of the reduced risk of fire damage, insurance premiums should be lower.

Copper pipework has been chosen to supply the inconspicuous sprinklers and drenchers fitted to the thatched roof of the new reproduction of the Globe Theatre. The main reasons for selection were that:

- It is a traditional plumbing material
- It is easily fabricated to shape
- It is not susceptible to damage by ultra violet light where exposed above the roof.

Copper in Health

Copper is an essential trace element for the health of crops, animals and humans. Too little copper causes deficiency diseases and stunted growth. The average human in the western world is recognised by the World Health Organisation as absorbing only just enough copper to provide the minimum essential recommended for successful metabolism.

Conclusion

Copper and copper alloys have served architects, craftsmen, design engineers and builders very reliably and economically for many years in both traditional and innovative applications. They will continue so to do for the foreseeable future.

Information on Copper and Copper Alloys

CDA is mainly funded by copper producers world-wide to provide technical advice in support of applications for copper and copper alloys. It keeps in touch with recent technical, standards and market developments and has access to information available from the International Copper Association, European Copper Institute and Copper Centres in other countries.

Publications describing good practice for design and fabrication of copper for roofing, plumbing, electrical and other architectural applications are available from Copper Development Association. Some are free. Others are sold at a nominal cost to cover the provision of reprints.

Also readily available is a CD-ROM 'Megabytes on Coppers' containing the text and illustrations of 56 publications discussing coppers and copper alloys, together with their corrosion resistance, cost-effectiveness and suitability for electrical applications. It also includes 8 data programs helping to guide users through choice of alloys, availability and usage. A new version of this CD-ROM is in preparation to include all of CDA's publications on architectural subjects. If you would like to leave your name and address, we will be happy to send one free of charge to registered delegates when available later this year.

Further Information – CDA Publications

(For further details, see the 8-page list of publications, videos, posters, datadisks and CD-ROMs)

Architectural Brass

Aluminium Bronzes (five publications and a datadisk)

Automatic Fast Response Domestic Fire Sprinkler Systems

Brasses – Design Compendium

Common Power Quality Problems and Best Practice Solutions

Copper and Copper Alloy Castings

Copper in Domestic Heating Systems

Copper in Human Health

Copper in Plant and Animal Nutrition

Copper in Roofing - Design and Installation

Copper in Roofing - Pocketbook

Copper Tube in Domestic Water Services

Clear Protective Coatings for Copper and Copper Alloys

Earthing Practice

Joining of Copper and Copper Alloys

CD-ROM 'Megabytes on Coppers'

Copper Development Association
Orchard House
Mutton Lane
Potters Bar
Herts EN6 3AP
Tel 01707 650711
Fax 01707 642769

The Ankh

Pre-dynastic Egyptians knew copper very well and in hieroglyphs copper was represented by the ankh symbol also used to denote eternal life, an early appreciation of the lifetime cost-effectiveness of copper and its alloys. This was subsequently adopted by the Greeks when preparing their list of symbols for all the known metals. The same symbol was also used to represent Aphrodite, goddess of love and source of life.

The island of Cyprus is named after copper, source of supplies for both the Greeks and Romans.