



TIMBER CLADDING
IN SCOTLAND



SCOTTISH EXECUTIVE



CONTENTS

The publication and wider dissemination of this Scottish Executive-funded research has been made possible with the support of the following organisations:



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Published by ARCA Publications Ltd
Manifesto, 18 Blantyre Terrace
Edinburgh EH10 5AH
Tel: 0131 455 2808

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Cover: Govanhill Millennium Space, Glasgow – garden shed structure by Christopher Platt Architect. Cover photography by Kenneth Bayne.

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This publication should be cited as:
Davies, I., Walker, B., Pendlebury, J., 2002. Timber Cladding in Scotland, ARCA Publications Ltd. ISBN 1 904320 00 7

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This publication contains research commissioned from Highland Birchwoods by The Scottish Executive, Central Research Unit.

The authors of the original research were Ivor Davies, Bruce Walker and James Pendlebury.

Peter Wilson, of ARCA, the Journal of Scottish Architecture has edited the text for publication and contributed additional material in the form of case studies.

Highland Birchwoods acknowledge with gratitude the support of the project steering group, the information and advice given by experts in several countries during the course of this research, and the co-operation of all those who have given permission to use illustrations of their buildings and designs. Unless otherwise stated, all illustrations are by the authors.

Further copies of this publication are available from:
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HIGHLANDS & ISLANDS PARTNERSHIP PROGRAMME
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THIS PROJECT IS BEING PART-FINANCED BY THE EUROPEAN REGIONAL DEVELOPMENT FUND UNDER THE HIGHLANDS AND ISLANDS PARTNERSHIP PROGRAMME





Gavin Fraser



INTRODUCTION

There is no easy explanation why timber-cladding has not been widely used in Scotland. There are suggestions that there are special climatic factors; a combination of wind and rain, that suitable indigenous wood could not be obtained at a competitive price, that there are not the skilled workers to carry out the work, that building societies are unenthusiastic about the technique and insurance companies are also reluctant to cover its use. The evidence is anecdotal and some of it can be easily discounted...⁽¹⁾

External cladding is the outermost envelope of a building and normally carries no loading beyond its own weight plus those loads imposed by rain, snow and wind. It is thus mainly a protective and decorative envelope for the structure and contents of a building, and can be constructed from a variety of different materials including metal sheets, pre-cast concrete slabs, uPVC, tiles, masonry, and timber. In principle, each is interchangeable in terms of its cladding function, allowing several different cladding materials to be used side by side on the same building.

Most people in Scotland today are unfamiliar with external timber cladding, a fact compounded by the lack of published research on the historical use of timber in Scottish construction. Yet there are strong historical precedents throughout our urban and rural environments for the use of external timber cladding - it was an important exterior wall covering in medieval Scotland's royal burghs, for example, and continued to be used in urban Scotland until the 17th century. During the 18th and 19th centuries timber cladding was still used on a wide range of non-domestic buildings as well as occasionally on housing, particularly in remote rural areas. During the 20th century, timber cladding was extensively utilised on social housing and, over the past five years, a small but significant growth in the use of external timber cladding in Scotland has been evident. Providing it is designed for durability, it can achieve a performance comparable to that of timber cladding in similar maritime climates abroad (e.g. western Norway or Canada) where its use is widespread. And yet, perhaps because of uncertainties and information gaps, many people - including some planning authorities - remain reluctant to recognise timber cladding as either a traditional wall finish or as a cladding material for Scotland's wet, windy climate.

The historical material contained here is only a preliminary review of the evidence of

external timber cladding in Scotland and is necessarily wide in range and containing many uncertainties. The authors hope archaeologists and architectural historians will be encouraged to carry out further work on the subject.

Being the area where most difficulties arise, the technical sections of this publication focus on the management of moisture due to wind-driven rain. Other issues (e.g. fire) are not dealt with in any depth since, although impacting upon the design of timber cladding, they are already well understood and fully incorporated within the Scottish Building Regulations. Current best practice in the specification and detailing of timber cladding is also reviewed, and is based upon a comparison of current practice in the exposed coastal climates of British Columbia, western Norway and Scotland. The scope of the technical parts of this publication is limited to the cladding of low-rise buildings in Scotland and not all of the issues raised are necessarily relevant to taller buildings or to the requirements of the Building Regulations in England and Wales. Moreover, some of the points discussed are an interpretation of the Scottish regulations and other interpretations are possible.

Sustainability is a key factor driving current interest in timber cladding in Scotland. Consequently a distinction has been sought between standard practices which - while widely accepted and well proven - do not always minimise the use of wood preservatives or high energy consumption, and those other practices which not only comply with the regulatory framework but also aim to minimise the use of preservatives and promote better energy use.

Recent growth of interest in external timber cladding has brought all of these issues to the fore, and the Scottish Executive recognises that further development may be constrained by a lack of accurate information specific to Scottish needs. This publication therefore aims to provide accurate and up-to-date guidance for architects, self-builders, planning and building control officers, contractors and cladding manufacturers. By describing, illustrating and interpreting its historical and contemporary design, it is hoped to stimulate further discussion on the future potential of timber cladding in Scotland.

LEFT
Shaped and profiled iroko boarding to Hawthornden School, Bonnyrigg, by Ungless and Latimer Architects.



Kenneth Bayne



Chris Morgan

THE BENEFITS OF EXTERNAL TIMBER CLADDING

Timber cladding can offer a unique combination of benefits of value to both urban and rural Scotland:

□ Improved energy efficiency

Timber framed, timber-clad houses can deliver real energy cost savings combined with good performance. When lightweight external claddings (e.g. timber) are used, heavy and bulky masonry walls can be eliminated from the outside of the building. Lightweight cladding, when combined with lightweight roof coverings and lightweight wall structures, can produce significant weight savings, allowing foundation depths and widths in a typical house to be reduced, with up to 20-40% savings in below-ground costs^(2,3). Money saved can be used to increase the building's insulation so that, for no additional cost relative to masonry cladding, a more energy-efficient building envelope can be created. On the principle that building construction should not include costs that do not add consumer value, this potential combination is compelling.

ABOVE

Timber cladding, slats and shingles are collaged onto the 'garden shed' in Glasgow's Govanhill Millennium Space, by Christopher Platt Architects.

ABOVE RIGHT

Timber cladding adds to the simple elegance of a new house at Linfall in the Borders by Simpson & Brown Architects.

□ Promotion of good design and siting

Timber cladding complements current thinking on rural housing design. Market forces in rural Scotland are already delivering keenly priced, flexible and quick-to-erect housing and timber cladding offers considerable advantages in this context: it can reduce costs, introduce colour and - because it is relatively easy to modify - is suited to the kind of long-life, loose-fit approach currently advocated through the 'lifetime homes' approach to housing design.

□ Encouraging originality and innovation

Timber cladding can have a bright and vibrant finish or, alternatively, a natural appearance which complements many other materials. It offers considerable design flexibility, and is easily adapted to both traditional and contemporary styles of building.

□ Overcoming the disadvantages of remoteness e.g. high building costs

Timber cladding's light weight offers lower transport costs than masonry cladding and is not so weather-dependent to erect, both of which are considerable benefits in remote rural areas.

□ Stimulating the prudent use of natural resources

Timber is a renewable and environmentally friendly raw material, and UK woodland management standards are comparable to those of most other western European countries. Providing the felling operation has official approval, home-grown or European timber is generally accepted as a low environmental impact raw material in terms of its production and compares favourably with non-renewable raw materials such as stone, metals or plastics.

□ Supporting local economic development

Customers will favour environmentally sound or locally sourced products providing their price and quality match existing alternatives. Although there may not always be a cost premium available, there is a potential market share advantage for those environmentally-sound or more locally-based suppliers able to capitalise on it. Timber cladding is manufactured in Scotland and, as the market expands, local economic opportunities can grow.

□ Increasing the use of local raw materials

Historically, the majority of timber cladding used in Scotland was imported and this continues to be so today. There is growing interest in buying locally manufactured products, thereby minimising energy consumed in transportation whilst contributing to the local economy and culture. European larch cladding is particularly popular and can be sourced in Scotland, as can European oak and some other timbers (European Larch is the trade name for the species *Larix decidua* and European oak is the trade name for the species *Quercus robur* and *Q. petraea*).

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TIMBER CLADDING IN SCOTLAND TODAY

THE CURRENT MARKET

Timber products occupy almost 50% of the total UK weatherboarding market, but increasing use of cellular uPVC weatherboarding in the private housing sector continues to impinge upon timber's share of the market. The UK market for timber weatherboarding currently amounts to around £45 million per annum at factory gate prices and - presuming 5-10% of this is in Scotland - the market here for this product is probably worth between £2 million and £4.5 million per annum⁽¹⁾. There is, however, little quantified market research on timber cladding in the UK, with most studies focusing only on the type of low-value weatherboarding distributed through conventional supply chains such as timber and builders' merchants. Omitted from these studies is any investigation of the increase in demand over the past decade for the higher-value and more specialised timber cladding products sold directly to main contractors.

The current market for timber cladding in Scotland divides easily into six segments:

1 SOCIAL HOUSING

In recent years, housing associations in Scotland have moved away from heavy masonry construction towards lightweight timber frame houses, and over 90% of their new buildings now use this technology. Accompanying this has been a significant rise in interest in external timber cladding, a change driven mainly by Scottish Homes' (as the principal funding agency) increasingly specific policy on sustainability. Housing providers now seek long-term durability and local sourcing of raw materials, with the former factor more critical than the latter since it reinforces an existing requirement to minimise maintenance costs - a big issue for housing associations since their funding is based on the initial building procurement cost plus subsequent running costs over 60 years. Where timber cladding is

used, the trend is towards durable woods such as western red cedar which need no painting, although painted (but generally untreated) Scandinavian redwood and whitewood (Norway spruce) have also been used. Affordable, flexible and quick-to-assemble accommodation such as school classrooms and small rural offices are also sometimes clad with timber and, as with social housing, there appears to be growing interest in the use of timber cladding on these types of buildings.

2 LEISURE, COMMERCIAL AND PUBLIC BUILDING

This market is unlike most others for timber cladding, as it is mainly driven by changes in architectural style. Until recently, architects largely ignored timber as an external cladding material, but during the early 1990's it featured strongly as a fresh and exciting cladding material in an increasing number of UK buildings - Darwin College Study Centre in Cambridge by Jeremy Dixon and Edward Jones (1994), was clad with flush oak panels, while Henley Rowing Museum by David Chipperfield (1996) featured open-jointed horizontal cladding of unseasoned European oak. Although previously used in Europe, Chipperfield's building was undoubtedly the seminal project which established this latter cladding method amongst UK architects and their clients.

Occasionally timber is used as the dominant cladding material on new leisure, commercial or public buildings, but it is more commonly used as an infill panel in combination with other materials. In the UK, the current trend in this sector of the cladding market is for relatively-flush panels as opposed to what are perceived to be more 'traditional' board-on-board designs. Flush timber cladding panels were first developed by (amongst others) Walter Gropius, but a great deal of current work reflects the aesthetic



Keith Hunter

Iroko cladding is used on Rick's Hotel, Edinburgh by Malcolm Fraser Architects.

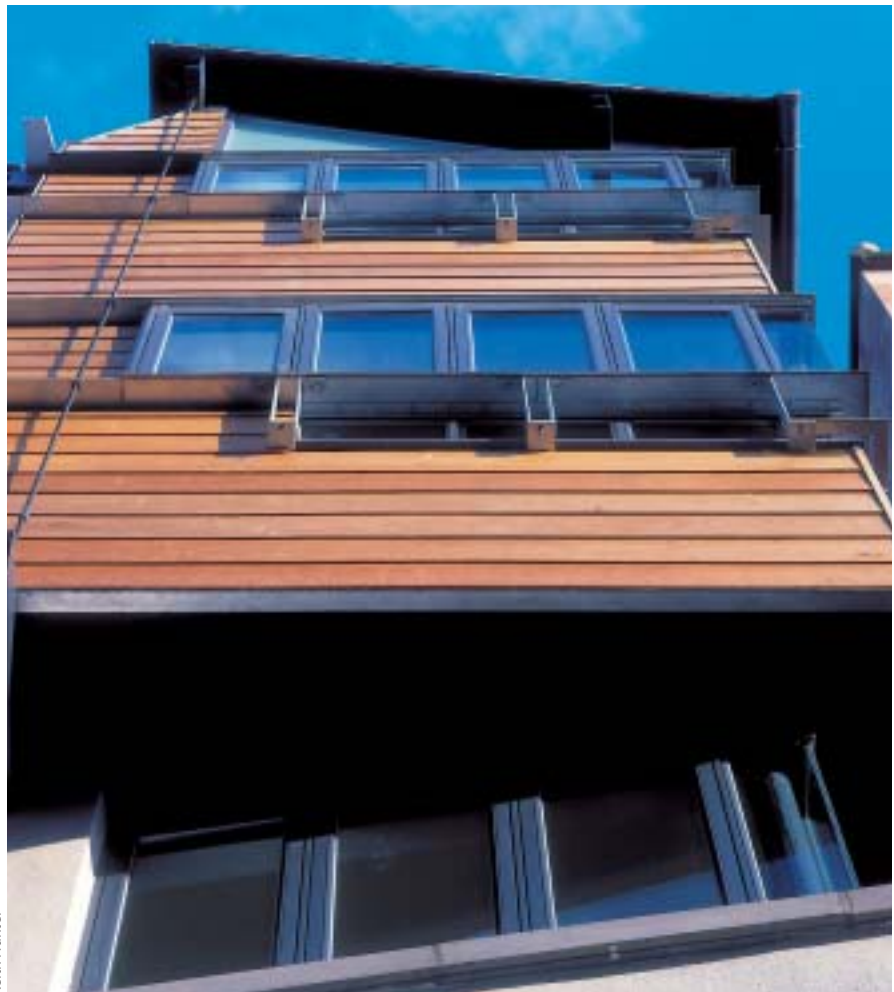
Whinhill Housing, Greenock by Chris Stewart Architects.



of American architect Louis Kahn in which he accepted the processes of weathering on the external skin of his buildings, a radical departure from the mainstream of Modernism. This appreciation of the ever-changing qualities of 'natural' materials can increasingly be seen in new architecture in Scotland, with much more use being made of western red cedar as a cladding material. Its use, however, is not always well informed:

- ❑ It is often selected because it weathers to an attractive silver-grey, but all relatively durable timber species will eventually attain more or less the same bleached effect. Western red cedar bleaches quickly and reliably, but some other timbers can be used to equal effect, with similar durability and often less cost.
- ❑ Being soft, western red cedar is vulnerable to vandalism and incidental damage. More hard-wearing timbers are more appropriate in damage prone situations.
- ❑ Increasingly questions are being asked about the sustainability of western red cedar from some sources in British Columbia. In a recent report ⁽²⁾ commissioned by Greenpeace in the Netherlands it is argued that much of the western red cedar exported from British Columbia is not coming from sustainably managed forests and as such its use should be questioned on environmental grounds.

Currently, the main alternative to imported western red cedar in Scotland is home-grown European larch which, although not quite as durable, is still perfectly suitable for many cladding applications. Home-grown European oak is also available and, when used 'green' (i.e. unseasoned) is often comparable in price to imported western red cedar. Other relatively durable imported timbers such as iroko are also sometimes used. Like western red cedar, iroko also has questions surrounding its sustainability.



Keith Hunter

Housing by Richard Murphy Architects in Edinburgh's Canongate makes use of western red cedar in its reinterpretation of the mediaeval timber architecture of the Old Town.

BELOW LEFT
Western red cedar should be avoided in situations where there is a risk of impact damage or vandalism.

BELOW
Iroko cladding in Dublin celebrates the bleaching effects of rain and sun, creating a patina that enriches the architectural effect.



3 PRIVATE HOUSING

During the 1960-80's, homeowners in Scotland largely avoided external timber and its use was restricted to small decorative infill panels, porches and cladding which protected the gable triangle. With timber again becoming fashionable, its use as cladding over all - or most of - the house is on the up. In part this can be attributed to increasing failures in uPVC cladding which, along with greater affluence, has made higher quality and more environmentally-friendly products such as timber attractive and affordable.

Growth of interest in timber cladding amongst private housebuilders spans new-build homes, renovations and extensions. Whole-house cladding - formerly the domain of people with a strong environmental agenda -

is now becoming more mainstream. Western red cedar is the most commonly used whole-house cladding material, but European larch is becoming more popular. Where only part of a house (e.g. a gable) is clad, European whitewood remains the most popular choice. Most cladding is coated with a translucent stain, although there is a small but increasing trend towards leaving western red cedar and European larch uncoated and allowing them to weather naturally. There is still a tendency, however, among private housebuilders or owners to use a restricted palette of dull brown colours on their properties.

Although timber frame is an enormously successful construction method here, with considerable performance advantages over traditional technologies, many owners of this type of house are unaware that a timber frame

supports their roof or that the primary function of the outer blockwork is as a protective rainscreen cladding. As a result, house-buyers are often resistant to timber cladding since they perceive timber-clad and timber-framed homes to be somehow inferior to 'traditional' masonry-clad, timber-framed houses. Other concerns include misconceptions about increased fire risk, poor durability and difficulties with insurance or mortgage companies. The reality is that, providing the designs comply with current Building Regulations, timber-framed and clad houses are no more vulnerable than any other forms of house construction. Maintenance is also a common concern and many people prefer to live in new-build houses which they do not expect to have to maintain (indeed, over 50% of new home owners have no experience of maintenance).



David Somerville

House at Lewiston by David Somerville Architect.

Holiday chalet in Achnasheen.



4 AGRICULTURAL BUILDINGS

There is little overlap between this sector and other parts of the timber cladding market. Tied to the fortunes of the agricultural industry, it is largely dependent upon the various grants or loans available to farmers and crofters, and building design is often managed by a specialist unit at the Scottish Agricultural College. The dominant factor in this sector is cost, with preservative-treated whitewood the main cladding timber. Farmers occasionally hire in mobile sawmills to process their own timber into cladding, but this is rarely competitive with cladding purchased from specialised suppliers.

5 STABLES, GARDEN SHEDS AND GARAGES

Poorly-designed, or maintained, temporary buildings such as stables, garden sheds and garages have tarnished the reputation of timber cladding. Design is driven by large DIY merchants and some specialist suppliers and, in this price-sensitive market, ongoing maintenance is virtually unheard of. In this sector better-designed timber-clad buildings are exceptionally seen and it may be that a niche market can be created. The recent growth of garden office structures are an example of this type of more up-market temporary building. European whitewood is the most common cladding timber, with western red cedar being used for more up-market structures.

6 CHALETs

As with agricultural buildings and garden sheds, timber-framed and clad chalets are low-cost and often temporary structures which have impaired the reputation of timber cladding. A part of the tourist industry, they are often linked to farm diversification, but with both of these industries currently financially-challenged, the chalet market is extremely price-sensitive. European whitewood and western red cedar (used either as boards or shingles) are the most commonly-used timbers.

Scottish planners are being asked to accommodate an increased use of timber cladding where previously masonry materials would predominate. New facilities at Crookfur Cottage Homes, Newton Mearns, by Davis Duncan Architects.



Keith Hunter

ATTITUDES TO TIMBER CLADDING IN SCOTLAND

The use of timber cladding can provoke strong and wide-ranging opinions in Scotland. The principal viewpoints can be summarised as follows:

PLANNERS

Scottish planning authorities are often perceived to be opposed to the use of timber cladding, but the evidence for this is inconclusive. Many planning officers - while acknowledging their lack of familiarity with timber cladding - will consider well-designed proposals. Responses vary across the country, however, with a number of issues and inconsistencies standing out:

- Planners invariably aim for continuity with an area's dominant forms and materials. This often implies 19th century materials which necessarily include mainly masonry construction and an across-the-board assumption that - irrespective of the materials involved - the colour of walls should be 'stone like';
- Some planners regard timber cladding as desirable, but consider it easier to introduce in the countryside than towns. The prevalent assumption is that, if timber cladding is permitted in urban areas, opposition will emerge from heritage and amenity groups who prefer continuity with a limited palette of late 19th century materials;
- It appears that some planners tend to under-estimate the amount of timber-clad buildings actually present in their area;
- Some planners consider timber cladding to be acceptable in wooded environments but not elsewhere, yet timber-clad buildings exist all over Scotland and restricting their use to wooded areas has no basis in historical or local precedent;
- Many planners prefer timber to be painted a dark colour, although this too has little historical precedent;
- Planners tend to be cautious about unfamiliar building materials and their statutory responsibilities demand proper scrutiny of their introduction. This is sometimes seen as a rejection of timber cladding
- Architects or other building professionals experienced in negotiation are more likely than private self-builders to present successful cases for innovative or non-standard building materials;
- Protracted negotiations with planners can cause delays and it is often simpler and cheaper for architects or developers to use masonry cladding.



Late 19th century timber-clad fisherman's store in Stromness, Orkney has been painted a light, bright colour, a more traditional finish in Scotland than dark colours.

One of the few research studies to examine these issues in detail was carried out at the Robert Gordon University⁽³⁾. Based upon a 60 mile sample transect running west from peri-urban Aberdeen to extremely rural Braemar, the line was selected to provide a sample from a relatively affluent area that retained a strongly 'traditional' character. The dominant wall and roofing materials of all buildings were characterised at six mile intervals along the transect and the findings compared to the main published architectural guides to the area^(4,5,6,7,8). The study argued that commonly-used definitions of traditional forms tend to under-represent the extent and diversity of the cladding materials which actually exist, since:

- The architectural guides focus on certain building types and under-represent the diverse vernacular buildings in the area. Old and/or large buildings are over-represented, as are slate-clad pitched roofs;
- Masonry walls are over-represented by a factor of two, with masonry buildings forming 80% of the images in the guides, whereas in the sample, only 40% of the buildings had masonry walls, of which only half were un-rendered stone.
- Only 3% of the buildings in the published accounts are timber-clad, whereas timber is the most common wall finish in 38% of the sample.

The authors concluded that:

These then are the images of buildings in the countryside which are passed into the collective psyche. Or rather, these are the images which, we are persuaded, constitute good, appropriate design. There is little to define this

appropriateness other than that the precedents exist and those which do not fit the historical view are glossed over or ignored...⁽³⁾

Although the evidence for the widespread historical use of timber cladding in Scotland exists, it has often been ignored or left unrecorded - in part because it does not fit within the prevailing canon of acceptability, and also because definitions of what is acceptable take a long time to change. Growing awareness of sustainability is stimulating change, however, and recent Scottish Executive planning guidance has brought the subject to the fore. The National Planning Policy Guideline paper (NPPG1) states:

The Scottish Executive is committed to integrating the principals of sustainable development into its policy agenda. The Scottish Ministers expect the planning system to support and inform this wider policy agenda linking principals and actions to enable sustainable development. Co-ordinated action between different programmes and priorities is essential to increase effectiveness and value.⁽⁹⁾

While advocated at a national policy level, there is as yet little evidence of local planning advice including criteria for sustainability and the subject is not generally of a very high priority. Were this to change and (as recommended in NPPG1) the consideration of economic, social and environmental concerns to become a more formal part of local planning processes, the use of timber cladding would most likely increase.

At local levels, elected council members are an important, and sometimes critical, influence in the planning approval process and future promotion of timber cladding needs to respond to their perceptions and win their active support.

BUILDING CONTROL

Building control in Scotland has existed since around AD 1119⁽¹³⁾ and the legislation, now as then, sets the minimum acceptable technical standard for construction work. Under modern regulations, a building's design must demonstrate fitness for purpose and, in the case of external timber cladding, has to demonstrate that it is sufficiently durable for its intended service life and that it will perform satisfactorily in a fire. Building Control Officers seek good design and detailing to achieve these aims and are generally sympathetic to the use of external timber cladding providing these technical issues are properly addressed. Compliance with the Scottish Building Regulations is achievable in several ways, depending upon the particular building design or product being proposed⁽¹⁰⁾:

- By meeting the requirements of the relevant British Standards or equivalent standards of another member state of the European Union;
- By Agrément Certificate coverage or equivalent approval issued in any member state of the European Union;
- By meeting the requirements of a technical approval issued under the European Construction Products Directive;
- With test evidence from an accredited laboratory;
- With evidence of a material's satisfactory performance in similar environmental conditions;
- By compliance with an EC Directive.

No Building Control Officer is likely be familiar with how these compliance mechanisms affect every material in every instance, and there may be occasions where the compliance process is protracted.

The Scottish Building Regulations differ in important respects from those in England and Wales, but since much of the available technical guidance is produced for England there are sometimes discrepancies between designs proposed and the recommendations of Building Control Officers in Scotland.

DEVELOPERS

Some developers privately recognise that moving to lightweight structures and cladding is desirable, but this is only slowly being translated into building practice. This may be because developers are risk averse when it comes to design and have very limited capacity for in-house design and innovation. It could also be that some developers consider timber cladding a potential impediment to securing planning approval and, because delay in obtaining permission can result in significant additional costs, they prefer masonry cladding. Because they are reluctant to experiment with their own product, more demonstration projects could help to influence developers.

MORTGAGE PROVIDERS

Difficulties in obtaining mortgages for timber-clad, or in some cases, timber-framed homes existed in the 1970's and '80's, but in the past decade this problem has largely disappeared. There now appears to be little difficulty in securing a mortgage on a timber-clad house, with High Street lenders such as the Halifax 'lending on the person not the product'. A cause of some concern, however, is the policy of two well known lenders who have recently published guidelines indicating that they will not lend on timber-framed, timber-clad houses.

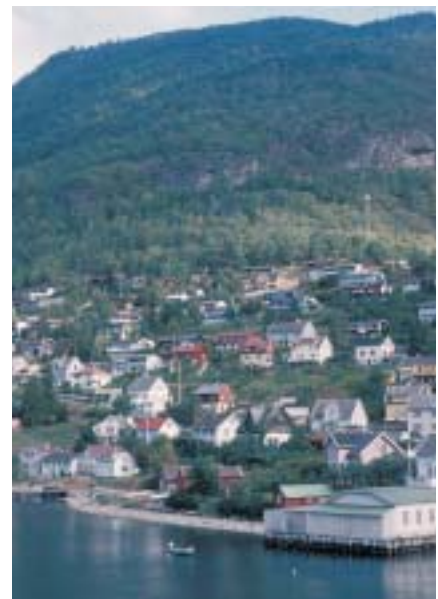
CLADDING SUPPLIERS

Construction industry buyers seek consistency in supply and well-informed technical support from suppliers⁽¹¹⁾ - basic market requirements sometimes missing in the case of timber cladding. External cladding production in Scotland is currently restricted to sawing and/or machining of imported timbers, usually by large specialised sawmills linked to importers or the small-scale sawing and machining of home-grown timber cladding - usually by small sawmills. Generally, the quality, drying and machining of the timber cladding produced by importers is good. Unfortunately, the same cannot be said of smaller Scottish suppliers where - in some cases - standards of timber grading, drying and processing require improvement. Similarly, considerable variation exists in the quality of technical support available from suppliers.

PUBLIC AND PRIVATE OWNERS

Maintenance costs are a key issue affecting most public and private property owners. Minimising expenditure is a natural concern of owners everywhere, but low maintenance seems to be a peculiarly British pre-occupation - in Scandinavia regular paint maintenance is regarded as an opportunity to freshen-up house exteriors every ten years whereas in Scotland the cost of the same task is often seen as prohibitive. The perception of high maintenance costs are undoubtedly a

significant barrier to greater acceptance of timber cladding in Scotland and this is true for both individual homeowners and for housing associations. Sometimes, however, these difficulties disappear - some private clients accepting the need for regular maintenance and, in the case of Hjelatland Housing Association in Shetland, painted timber cladding is used because no cost-effective alternative exists (the local stone offering only poor quality aggregate for breeze blocks). These are exceptions, however, and several stakeholders believe a substantial design and marketing push is required for external timber cladding to gain wider consumer acceptance in Scotland.



ABOVE
In Scandinavia regular paint maintenance is regarded as an opportunity to freshen up house exteriors.

BELOW
Locally-grown western red cedar cladding was used on the Ardross Millennium Project, near Alness by David Somerville Architect.



David Somerville

SUSTAINABILITY AS A MARKET DRIVER

Sustainability is one of the most important factors driving the recent market growth for timber cladding in Scotland, but a wide variation in the understanding of this issue makes for even greater diversity in its practical application. Interest in sustainability is growing in Scotland because of increasing environmental concerns amongst some specifiers and clients, reinforced by recent published guidance from Scottish Homes and the Scottish Executive^(9, 12). The impact of Landfill Tax is also increasing demand for long-life, repairable products, or for materials which on disposal will not be classed as toxic waste.

In practice, sustainability is often sacrificed in the face of the severe cost pressures which affect much commercial development. People are frequently prepared to pay a slight premium for products such as safe food, but there is little evidence in the construction market of either an environmental or a Scottish (i.e. local) premium. Customers will, however, favour environmentally-sound or locally-sourced products if their price and quality match existing ones, and a potential market-share advantage is available to those environmentally-sound and/or local producers capable of capitalising on this⁽¹³⁾. To do so, however, specific issues need to be addressed:

New publicly funded buildings are increasingly emphasising sustainability. This new visitor centre at Glencoe by Gaia Architects avoids the use of timber preservatives and sources all of its timber in Scotland.



Michael Wolchover

1 ENVIRONMENTAL SOUNDNESS

Assessing the possible environmental impacts of a building material during its complete life cycle from raw material sourcing through to its eventual, re-use, recycling or disposal is known as life cycle analysis (LCA). In the context of timber cladding, this includes:

- **Raw material sourcing** - the production of timber as a raw material is a woodland management issue and LCA's require evidence of sustainable management;
- **Embodied energy** - the energy consumed in transporting and processing raw material and timber products (the embodied energy) can be quantified and compared with other products;
- **Wood preservation and other chemical additives** - many preservatives, glues and coatings may have adverse environmental impacts associated with their manufacture and use. Their presence in a timber cladding product can limit the options for the material's re-use, recycling or disposal.

2 LOCAL SOURCING

Buying products that have been manufactured locally minimises the energy consumed in transportation, and helps sustain local economies and cultures. However, the definition of what constitutes local can vary enormously because the availability of materials and manufacturers is not uniform - a wide range of locally-made products can be found in large cities whereas in some parts of the Scottish Highlands the nearest manufacturer of certain building products may be hundreds of miles away. Local sourcing is therefore a four stage process: regional; Scottish; European; global, but two additional factors can limit its applicability:

- **European Procurement Rules** - In order to promote a Europe-wide market, European Union legislation can sometimes preclude local sourcing. With procurement thresholds set at 200,000 Euros on materials-supply contracts and 5,000,000 Euros for full building contracts, it is arguable that European rules work against sustainable construction.
- **Conventional supply contracts** - In an international market place affected by fluctuating foreign exchange rates and other variables, local timber products may not be as competitive as imports, and have cost penalties which may be resisted by contractors and quantity surveyors responsible for the procurement of construction products. Such resistance inevitably results from the way in which many conventional construction industry supply-chains are structured - to secure best value, contracts between clients and main contractors are often arranged by competitive tender with several firms competing against each other on price. Although architects and clients may advocate local sourcing, they are not in reality the people who can deliver it. As the main links in the supply chain, suppliers and subcontractors to the main building contractor are the ones who can actually deliver local sourcing but - with huge pressure to reduce costs - they have the least personal interest in the issue. This problem may be reduced or avoided by current trends towards supply chain partnerships on large contracts, but such arrangements still rarely apply to smaller contracts.

Sourcing of timber in Scotland has to date been most successful in situations where local products are able to compete on cost or performance against imports or where the person paying for the building is committed to using specific products and either stipulates their use or purchases them direct from suppliers. Alternative structures to conventional supply chains need developing, e.g. within design-build companies or the self-build sector⁽¹¹⁾.

FUTURE OPPORTUNITIES

With timber cladding now achieving respectability in Scotland and able to compete on its merits against other external cladding materials, two major opportunities exist for its future development:

- **Increased use of lightweight timber cladding on housing -**
Timber cladding offers cost, performance and sustainability benefits, particularly when used in combination with lightweight roof coverings and structural systems to form integrated, energy-conscious designs. These benefits are equally relevant to private housebuilders, developers and housing associations.
- **Increased use of timber as a high status cladding material -**
Timber cladding can compete on cost, performance, and sustainability grounds in large budget architectural schemes. It is a viable - and desirable - alternative to other prestigious cladding materials (e.g. pre-cast concrete, stone, stainless steel or glazed brick) and can co-exist alongside other claddings. Properly promoted, this use of timber could prove attractive to architects and their clients, particularly in the leisure, commercial, and public building sector and for architect-designed private housing.

Unfortunately there is no quantified research available on emerging market niches for timber cladding in Scotland and gathering such information would be very beneficial.

Suppliers of timber cladding - particularly home-grown - need to provide the level of information, technical support, product quality and consistency that customers expect. One solution is to establish a timber cladding association able to set minimum quality standards and provide technical assistance to customers. The Lead Contractors' Association is a useful model: industry funded, it provides high-quality technical information and has set demanding quality targets as a condition of membership⁽¹⁴⁾. By aiming high, it has succeeded in gaining widespread industry trust to the extent that some building contracts are now open only to members of the association. To be successful, a UK timber cladding association would require similarly high standards.

Producers could also benefit from research into timber cladding made from Scottish oak, including designs utilising shingles and short board lengths of 'green oak'. A market opportunity may also exist for the large softwood sawmilling sector to supply Scots pine, spruce or other homegrown softwood timber cladding, and more research into the suitability of these species is required as well as into the application of defect cutting technology.



Scottish Poetry Library by Malcolm Fraser Architects uses uncoated European oak in its sliding screens and doors.

- Industry-led marketing and promotion could also be helpful in:
 - Re-designing cladding to reduce ongoing maintenance requirements to a minimum;
 - Re-branding to reduce the association of timber cladding with low-cost temporary buildings and garden sheds;
 - Making timber-clad housing appear more 'ordinary', thereby achieving wider market penetration with buildings that look plain, symmetrical and unexceptional on ordinary suburban streets;
 - Conversely, making timber cladding appear bright, light and desirable, perhaps mirroring the type of designs seen in Scandinavia or the Faroe Islands;
 - Promoting uncoated timber cladding. At present this finish does not have wide customer acceptance, although it complements natural stone walls and copper roofing and is often associated with more 'up-market' buildings;
- Demonstrating life cycle costing advantages. Maintenance costs for timber-clad buildings are higher than for those with masonry cladding, but initial build costs and ongoing heating costs are lower. Masonry-clad timber frame costs 2-3% more than conventional construction but if bricklaying and plastering trades are removed, time & money can be saved. The use of a lightweight cladding (e.g. timber) can reduce the foundation depth and width of a typical house⁽¹⁵⁾, and the resultant savings can be spent on increased insulation - an attractive advantage to owners such as landlords, or sheltered housing providers who seek to minimise costs over longer time scales (perhaps 60 years);
- Promoting timber as a lightweight cladding in situations where - to improve thermal performance - external insulation is applied to the outside surfaces of solid masonry walls.

In addition to industry-led initiatives there are opportunities where other key stakeholders could assist the development of timber cladding in Scotland:

POLICY MAKERS

As climate change reduction measures assume ever greater importance in Scotland, the role of lightweight cladding systems looks set to grow as a part of the search for energy-efficient and cost-effective building design. Unlike Canada and Norway, there is limited information available in Scotland on timber cladding in exposed maritime conditions. What is published tends to be written mainly for the UK's southern climatic conditions, and contains standard details which do not comply with Scottish requirements. In some cases this results in the use of inappropriate details, and technical guidance on timber cladding specifically focused on Scottish conditions and the Scottish Building Regulations is needed.

Best practice in timber cladding specification may not be fully reflected in current British Standards and a specific British Standard for external timber cladding is needed. The National Building Specification for timber weatherboarding would also benefit from revision and expansion to reflect current best practice.

There could be benefits for sustainability if European Procurement Rules were modified to enable greater local sourcing of building products.

Key stakeholders such as planning and building control officers, architects, developers and suppliers need more opportunities for open and positive dialogue on timber cladding. In controlled conditions, demonstration projects can promote building innovation in timber-clad housing, particularly where affordable and energy-efficient designs suitable for developers and social housing providers are explored.

ARCHITECTS AND OTHER BUILDING DESIGNERS

Although currently producing attractive and original designs using timber cladding, Scottish architects need more information on the subject via seminars, Continuing Professional Development programmes and publications since variable detailing standards are apparent in the use of what is still a relatively unfamiliar and quite specialised product.

ARCHAEOLOGISTS AND BUILDING HISTORIANS

Considerable evidence exists for the historical use of timber cladding in Scotland, yet little information has been recorded, analysed or published. Current practice could be informed by more research into, for example, the impact of early fire control legislation in the royal burghs, the evolution of the Scottish timber trade, and the development of 19th century timber cladding in Scotland.

RESEARCH AND TECHNOLOGY ORGANISATIONS

A wide range of historical timber cladding survives around Scotland. These buildings provide a resource which can help in the assessment of timber cladding's expected service life when used in similar situations today, and greater use could be made of this empirical evidence.

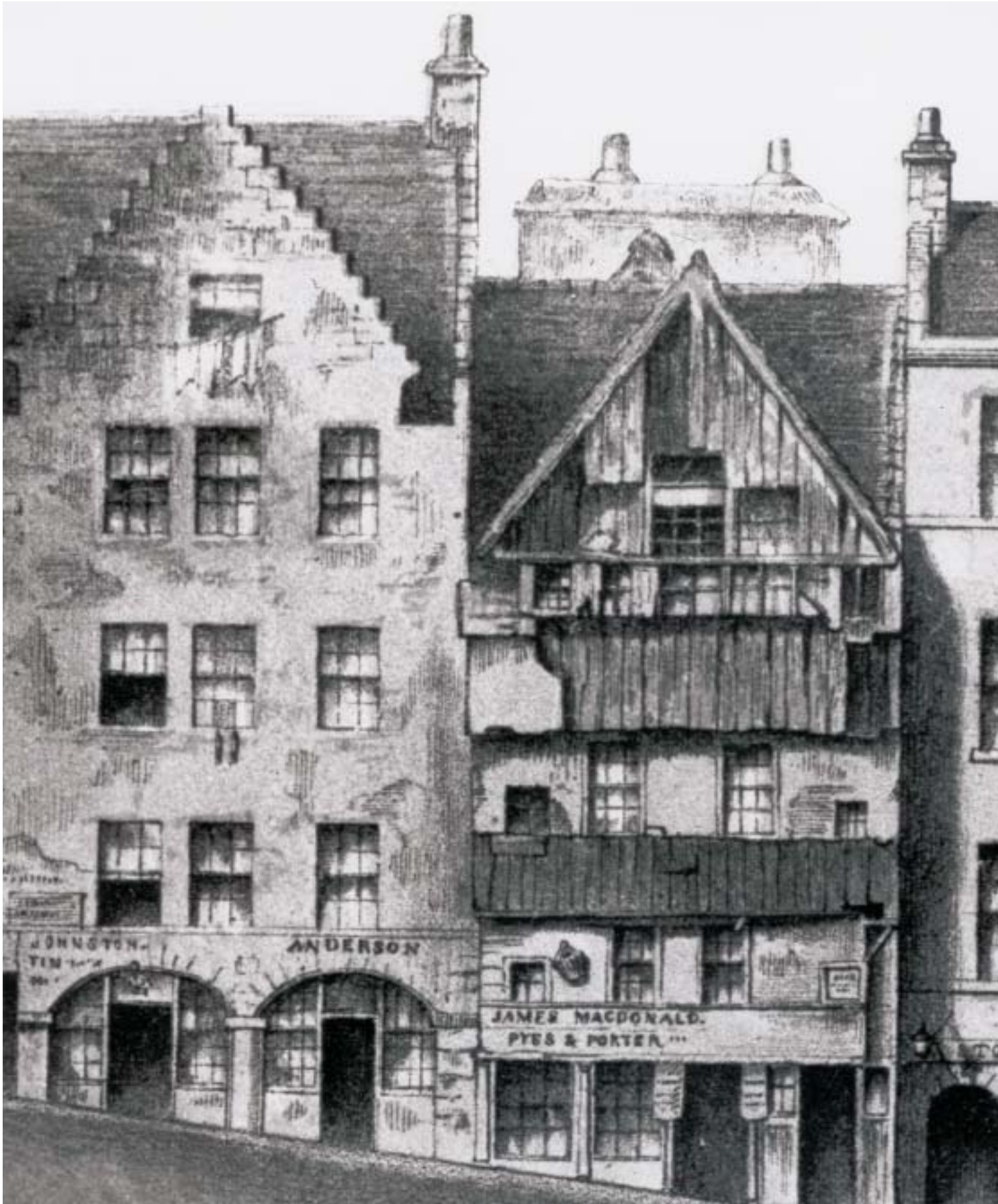
The growth of interest in cladding has highlighted uncertainties in the choice and specification of external cladding timber which could, if the wrong choices are made, give rise to building envelope failures. Further research is needed into these issues. For example, the transferability of cladding designs from sheltered to exposed maritime climates raises a number of uncertainties. Scotland-specific research and publication of such information would be useful but, at the very least, any UK-wide detailing guidance should include detailing examples for the full range of climate exposure classes (this is already provided for some other cladding materials but not for timber). Similarly, the suitability of open-joined timber cladding designs for exposed sites has been questioned and in-situ performance monitoring of a representative sample of designs already built would be beneficial.

SOCIAL HOUSING PROVIDERS

For local sourcing of timber cladding to become significant in Scotland, more focus needs to be placed on the structure of the timber supply chain and on alternative models such as design-build. And, given the evident enthusiasm amongst housing associations and some local authorities for sustainable-building measures, further discussion, demonstrations and exchanges of good-practice using timber cladding as a model are required.

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TIMBER CLADDING BEFORE THE INDUSTRIAL REVOLUTION

Many misconceptions surround the early history of building with timber in Scotland. The popular view is that masonry has always been the dominant walling material and that timber was used only for roofs, floors, stairs, internal partitions and finishings. While incorrect, this perception remains influential because of:

❑ THE SURVIVAL OF A REMARKABLE RANGE OF MASONRY MONUMENTS.

The Orkney monuments, together with many medieval castles and other stone buildings throughout Scotland, can be easily visited, leaving an impression in the public's collective memory that such monuments were much more typical than was actually the case. In fact these masonry structures were remarkable even at the time of their erection, since they stood amongst a range of more commonplace timber structures built to various standards, from the extremely elaborate to the purely utilitarian.

❑ THE SHORT-LIVED USE OF STONE FOR ALL CLASSES OF BUILDING IN THE 19TH CENTURY.

The 19th century was a period of unprecedented affluence in Scotland. Before then the use of stone was mostly restricted to upper class (or at least upper middle class) buildings and most other construction in rural Scotland was in timber and earth. Only at the end of the 18th century did wealthy landowners begin to introduce stone farm buildings and cottages. Whilst this movement spread throughout the country during the 19th century, leaving its mark in virtually every parish, the resulting 'traditional' stone steadings and other buildings we now associated with the Scottish countryside are unrepresentative of most of Scotland's building history.

❑ THE ROMANTICISM INTRODUCED BY WRITERS SUCH AS SIR WALTER SCOTT.

Following the Union of the Parliaments in 1707, Scottish intellectuals began to search for a new national identity to re-assert 'Scottish-ness'. This gained impetus during the National Romantic Movement that swept Europe in the 19th century, with North Britain reverting to its earlier name of Scotland. Romantic writers such as Sir Walter Scott went out of their way to depict the Scots in a superior light by highlighting the considerable range of early stone structures whilst at the same time playing down the role played by more common building materials such as timber and earth. The inheritance of this view still continues, as is evidenced by the under-representation of timber buildings in recent histories of Scottish building.

Together, these three factors have created an historical fiction which, although frequently repeated, is nonetheless incomplete. Study of archaeological reports together with contemporary descriptions, images, documents, and modern survivals clearly demonstrates that timber is a central part of Scottish building tradition. The historical importance of timber construction in Scotland is not restricted to one area or one class of building but holds good for all types of structure throughout much of Scottish history. Even during the major masonry building period of the 19th century, large numbers of timber buildings continued to be built for a wide range of purposes.



Engraving of Mahogany Land, West Bow, shows traditional timber construction of housing in Edinburgh's Old Town.



© NGS

ABOVE West Bow, Lawnmarket, Edinburgh.



Milne's Court, Lawnmarket, Edinburgh.



Wooden gallery on a house at 77 Saltmarket, Glasgow.

SOURCES OF EVIDENCE FOR EARLY TIMBER CLADDING

Although timber structures in Scottish towns were clad in timber boarding until a very late date, this was often ignored in the late 19th and early 20th century when the surviving buildings were demolished. This is because the cladding was, at the time of demolition, generally covered with a lime render and it is this material that is most often recorded in contemporary descriptions and illustrations.

TIMBER CONSTRUCTION'S INFLUENCE ON THE AESTHETIC OF LATER MASONRY STRUCTURES

Scotland is one of very few European nations where a distinctive national expression in masonry is based on earlier timber building traditions. The other obvious example is ancient Greece, where the Orders of Architecture developed in limestone and marble were based upon the arrangement of columns and entablature of earlier timber structures. By contrast, in Scandinavia, log construction was often roughened on the surface and pegged with dowels to provide a key for the hair-lime render used to make the log structure resemble ashlar masonry. This attempt to make a commonplace material look more expensive was the more normal approach. The evidence of timber architecture influencing the aesthetic of later masonry structures is everywhere in Scotland:

- Pictish standing stones from the 8th and 9th centuries are clearly carved representations of basketwork structures. Rather than setting out the patterns geometrically, the sculptor carefully copied the basketwork prototype including the curves and offsets necessary to weave the patterns with willow rods;
- The aesthetic of cantilevered timber hoardings on top of early defensive walls is repeated later in the stone wall-walks and attic storeys of Scottish keeps and towerhouses;
- The jettling of floors, common in half timbered construction, is reflected in the corbelling of the face of masonry walls in towerhouses and tall 'lands'.

The resultant aesthetic, in which corbel courses run across the facade in imitation of the jettling of timber floors and the castellated wall-walks imitated the hoarding at the top of castle walls, provided a distinctive signature to 15th and 16th century Scottish upper-class domestic architecture. Claypotts Castle, near Dundee took the corbelling even further by placing a rectangular attic over a three storey circular drum.



Historic Scotland

Corbel courses run across the upper façade of Stirling Castle's Great Hall in imitation of the traditional jettling of timber floors.

SURVIVALS

There is a broad relationship between the survival of buildings and their social status. High status buildings dating from the 14th century have survived in Scotland whereas surviving middle-status buildings from before the 16th century are rare, and few low-status buildings from before the 18th or even the 19th century still exist. Survivals are therefore an uncertain guide to building history, and are particularly unrepresentative of the lower-status buildings that, throughout history, formed the majority in Scotland's towns and countryside. Timber and earth were the two most common construction materials, and so the surviving buildings under-represent the amount of timber that would have been present. A further difficulty is that surviving timber buildings are generally entombed within later masonry walls and it is often impossible to investigate the timberwork without risking damage to subsequent layers of construction. Although there are no mediaeval timber-clad buildings surviving in Scotland in anything like intact form, it is possible to infer what such buildings might have looked like by examination of building survivals abroad:

- **TIMBER CLAD BUILDINGS IN THE LOW COUNTRIES OR NORWAY.**
Because these were significant trading partners with Scotland, technologies and cultural ideas were often imported along with raw materials. The Bryggens area of Bergen in Norway still contains timber-clad buildings that were contemporary with this trade.
- **BUILDINGS CONSTRUCTED ABROAD BY SCOTTISH ADVENTURERS AND ECONOMIC MIGRANTS**

Mediaeval Scotland was a poor country, and the lack of economic opportunity at home resulted in a considerable number of Scots emigrating to seek their fortunes in trade or military service. The Scots mercenary settlement at Gurro, Valle Cannobin, in the Piemonte region of Italy is a fascinating example of timber clad construction by Scottish emigrants.

ARCHAEOLOGICAL RECORDS

Archaeological excavation is an important, but often fragmentary, source of information on timber building. Over archaeological timescales, timber tends to rot in the ground in all but the most waterlogged sites, and timber stains in the soil are very easily disturbed by subsequent building operations. Most urban sites undergo continuous redevelopment, and there is a considerable degree of luck involved for good evidence of timber to survive.

DESCRIPTIVE DOCUMENTS

Descriptions may incorporate inaccurate terminology and cannot always be taken at face value. Descriptive evidence always requires consideration in a wider context. In addition, the nature of the infill and/or cladding is often not specifically mentioned and needs to be inferred from the records of materials purchased to construct or maintain the building.

IMAGERY

Visual evidence for timber-clad buildings in Scottish towns survives in prints, drawings, paintings, book illustrations and architectural surveys. Lamb (1895) illustrates and describes a number of timber 'lands' surviving in Dundee until the 1890's⁽¹⁾, and the same type of evidence survives in other towns, for example in folios of drawings showing the streets and closes of Edinburgh^(2,3,4,5). Unfortunately, whilst evidencing timber-fronted buildings, these drawings seldom show constructional details.



Surviving timber-clad buildings were often subjected to an external lime plaster in an effort to appease adjoining owners worried about the potential spread of fire. Fleshmarket Close, Edinburgh.

FACTORS IN THE EARLY DEVELOPMENT OF CLADDING

Timber cladding in Scotland appears to have developed as the result of the constraints of the timber trade combined with cultural and economic forces:

THE TIMBER TRADE

WOOD PROCESSING

Prior to the industrial revolution the wood-processing industry was entirely different to that of today. Logs were converted into beams and boards either by splitting, (either by cleaving the logs into thin boards with mallets and wedges or by squaring the logs into beams with axes and adzes) or by slowly, and with great effort, sawing the logs by hand using either a large pit- or frame-saw. Water-powered frame-saws were introduced in the Netherlands and Norway in the 1590's, and it is likely that they also appeared in Scotland around the same time. Thereafter, muscle-powered and water-powered sawing co-existed until the 19th century.

TIMBER SUPPLIES

Prior to the growth of rapid trans-Atlantic shipping in the 19th century, building timbers were restricted to locally available native species, or to timber that could be floated down major European rivers and shipped across the North Sea to Scotland. Large scale sawing of timber commenced in Amsterdam in the 14th Century and records exist of timber imports from this period onward. The two construction timbers in most common use were European oak and Scots pine.

EUROPEAN OAK (*Quercus robur* and *Q. petraea*)

In mediaeval Scotland, as in much of Europe, oak was the preferred structural and finishing timber. Converted into boards by cleaving the log along its length, this technique required straight-grained and knot-free timber, with the board lengths determined by the distance between knots. The log was split into wedge-shaped segments, with the central core and sapwood removed (the width of each board had to lie within the radius of the log, making allowance for the removal of the centre of the log and the sapwood). It therefore required a log of at least 750mm (2ft 6in) diameter to produce a 300mm (1ft) wide board. Oak shingles appear to have been a popular roof covering on high-status buildings in Scotland until the late 17th century, and were produced by cleaving in the same way as boards⁽⁹⁾.

Scottish builders, in common with those in most parts of Europe tended to use cladding boards vertically. Each board was dressed to be roughly rectangular with a slight thinning to one side which was inserted into a check or groove in the thicker edge of the adjoining board. The oak available in Scotland appears to have been more knotty than English oak - in many of the illustrations of timber cladding, two lengths of board form a storey-height rather than the single length seen in European and English illustrations. Some of the architectural surveys that were occasionally undertaken prior to the demolition of a building describe oak cladding - in one Edinburgh example, a fragment of vertical boarding survived under a later lime render and was recorded in section by the surveyor. The boards vary in width from 150mm (6 inches) to 300mm (12 inches) and were 18mm (3/4 inch) thick at the widest part.

SCOTS PINE (*Pinus sylvestris*)

The use of European oak for external cladding in Scottish towns gave way to Scots pine in the late mediaeval period. Exactly when this occurred is uncertain, but new trade developed with south-west Norway around 1500 and this is likely to have been an important factor. The 'Scottish Trade' (Skottahandelen) with Norway was a direct trade between the skippers of Scottish ships and the local farmers in the Ryfylke region of Norway. It was a barter system: the Scots traded cereals for timber (mainly redwood but with occasional pieces of oak), whilst avoiding the customs duties of Stavanger, the trading port. The Scottish Period 'Skottatida' lasted from c.1500 to 1717 when Stavanger managed to impose a ban on the Scots and other foreigners sailing up the fjords to trade. Other districts included in the Skottahandelen were Møreord Trøndelag to the north and other areas outside the main forestry region which ran eastwards from Agder⁽⁷⁾. Half the Scottish ships came from Fife and a quarter from Tayside, Dundee providing the largest number from a single port. Homegrown Scots pine was also utilised when available, although supplies were intermittent.



© Byggforsk

Sawing logs by hand using a large pit-saw.

Scots pine was recorded under a number of trade names which were mainly derived from either the region of growth (e.g. Baltic fir, Scots pine), the port of export (e.g. Riga pine, Memmel pine), the colour of the timber (e.g. redwood, yellow deal) or some combination of these (e.g. Kara Sea redwood). Nowadays BS 7359 requires that the import of *P. sylvestris* timber from the continent of Europe be called 'redwood', while UK-grown timber be specified as 'Scots pine'. Unlike oak, Scots pine was mainly sawn on account of the larger number of knots which made cleaving long lengths difficult, although this method was employed in the manufacture of Scots pine roof shingles.

CHANGES IN THE TRADE

The use of oak and Scots pine reduced in importance throughout Europe in the late mediaeval period due to a general shortage of timber and a move towards stone or brick construction. The latter change was probably due to increasing affluence, improved overland transportation, and the introduction of a more Italianate-style of building popularised by the works of Palladio. Tropical timber imports began to appear in the 18th century, albeit on a very restricted scale at first.

Example of a fragment of oak cladding from Edinburgh

CULTURAL AND ECONOMIC INFLUENCES

POVERTY

Early travellers' accounts give an impression of mediaeval Scotland. One of the best collections of pre-1700 travel notes was assembled and published by Hume Brown⁽⁸⁾, in the preface of which he stresses that comparing Scotland directly with rich countries such as England or France is misleading and that it should be compared instead with lesser north European nations such as Norway or Sweden.

Much of the housing would have been of a temporary nature. Jean Froissart, accompanying a French army to Scotland in 1385 and reporting on the Scottish attitude to English invasions, states:

If the English do burn our houses what consequence is it to us? We can rebuild them cheap enough, for we only require three days to do so, provided we have five or six poles and boughs to cover them.⁽⁸⁾

DUTCH INFLUENCES

Prior to the Union of the Crowns in 1603, at least 90% of Scottish exports were to the Low Countries. The Scottish base was at Veere and Scottish buildings from this period were remarkably similar to those in Belgium and the Netherlands. Timber buildings appear to develop in tandem between Scotland and the Low Countries until, in the century following

the Union of the Crowns, trade with the Low Countries virtually ceased. Thereafter Scotland (or North Britain as it then became known) grew increasingly under the cultural and technological influence of England. Instead of continuing to build in timber, the Low Countries gradually moved towards brick and tile, whilst Scotland moved towards stone and slate.

LEGISLATION

The towns of mediaeval Scotland were overcrowded, resulting in a progressive introduction of local and national legislation to control the risk of fire. The impact of this legislation was the most significant factor in the eventual disappearance of timber cladding in urban Scotland.

Mediaeval Scottish towns were organised through an administrative system of royal burghs which were set up by the Crown with a range of rights and privileges to provide them with income. The first royal burghs were established by King David 1 in the 12th century, with each administration controlled by a Dean of Guild who was responsible for introducing legislation including the banning of various flammable materials from dwellings and building construction.

Early legislation appeared in response to specific incidents or disasters in a particular

burgh. Occasionally legislation stemmed from decisions reached by the Convention of Royal Burghs but not every burgh within the convention adopted every recommendation. Generally building legislation in Scotland followed north European models. This happened in a number of stages:

- 1 A complete timber structure with an 'eaves drop' i.e. a space between adjoining buildings on to which water dripped from the eaves. (The space was not wide enough to be used as a passageway but did provide a convenient place to secretly listen in on conversations within a building. Hence the phrase 'to eavesdrop');
- 2 A non-combustible 'fire-safe' was added to the rear of the property to protect valuables from fire (eavesdrops and firesafes can still be seen in the Bryggens area of Bergen, Norway). Early fire-safes tended to be square on plan and multi-storey (as can be seen in the towers of San Gimignano, Italy). Gradually the fire safes adopted squatter forms and by the 17th century had become long, low, rectangular structures. A number of fire-safes still survive in Scotland, albeit in altered form - Abertaff House in Inverness being the best known example;
- 3 Eaves drops were subsequently infilled with a non-combustible party wall of masonry or brick;
- 4 Non-combustible rear walls were next;
- 5 A requirement for a complete non-combustible core to the dwelling followed, although timber galleries on the principal facade were still allowed;
- 6 Lime pargetting or rendering over the timber facade gave the appearance of harled masonry. Building legislation in Edinburgh banned the construction or rebuilding of timber structures, and neighbours registered complaints every time replacement boards or timbers were introduced as part of routine maintenance of existing timber buildings on the grounds that this constituted rebuilding. Lime rendering may thus have been a reaction to those claims of rebuilding lodged by neighbours when maintenance was necessary.
- 7 Finally, by the 17th century, completely non-combustible facades and party walls were required.



Prior to 1603, Scottish buildings were remarkably similar to those in Belgium and the Netherlands, as in these two examples from Malinas, Belgium and Mahogany Land, West Bow, Edinburgh.



THE HISTORY OF EARLY TIMBER CLADDING

The gradual evolution of timber cladding is reflected in different types of buildings:

RELIGIOUS BUILDINGS

Some of the earliest evidence for timber cladding in Scotland comes from accounts of religious buildings. Saltzman⁽⁹⁾ quotes the Venerable Bede (c.673-735) in part of his statement:

Until the 11th century it was exceptional for even a church to be built in stone. Finan, in about 655, built a church at Lindisfarne, not of stone, but, in the Scottish fashion of cleft oak.

This could refer to the type of cruck-framed, hog-backed structure depicted in the hog-backed tombstones of that period, while the 'Scottish fashion' suggests the techniques used by the Scots who moved out of Ireland into Southern Scotland (the name of the monastic settlement of Iona may be derived from the Irish name for a yew tree on account of the buildings being clad with Irish yew shingles). It is not until the 12th century that timber gave way to masonry in the most important ecclesiastical buildings, but many smaller churches and monastic settlements were still built and clad in timber long after this.

DEFENSIVE BUILDINGS

A similar situation existed with castles and other defensive structures. Macgibbon and Ross⁽¹⁰⁾ described the gradual change from timber to stone castles:

It is curious to trace the history of the use of wood in the construction of defences of mediaeval castles. At first we find the whole of the erections in the castle, with its dependencies and enclosing palisade, constructed entirely from wood. The first change was the introduction of stone for the construction of the keep, or chief stronghold, which was thus rendered secure against fire. Then it was found desirable to prevent the enclosing fortifications from being easily destroyed by fire and a stone wall substituted for the wooden palisade. Wooden defences are still adhered to but they are now raised to the top of the walls in the form of hoards ... by and by the engines of attack became powerful enough to throw missiles which destroyed these hoards, and fire-balls which set them on fire. It then became necessary to make the hoards of stone; but this change is introduced very gradually. First stone corbels are used instead

of wooden putlogs to support the wooden stays, then larger corbels are substituted for the wooden struts ... and finally the hoarding or parapet itself is built with stone. This last change did not take place till about the beginning of the 14th century.

Stokesey Castle on the Welsh borders gives some idea of what 14th century Scottish fortified houses might have looked like. These were the castles of the upper echelons of the nobility, however, and it took a long time for masonry construction to become the norm even amongst the lesser nobility and rich merchants. It might be argued that there is no evidence for large timber structures surviving at any of the major castle sites in Scotland, but of those plans of surviving structures which carry a date, very few are from before the 16th century. Kincardine Castle, for example, while formerly important, has almost nothing surviving above ground level, suggesting it was abandoned before masonry building was introduced. Similarly most of the existing structures at Edinburgh Castle were constructed after 1540, and records show that the predominant building material used prior to this was timber.



ABOVE
Stokesey Castle's wooden defences are raised to the top of the wall in the form of hoards, and give some idea of what 14th century Scottish fortified houses might have looked like.



RIGHT
Threave Castle, Dumfriesshire still shows positions for putlogs to support timber wall walks.

MUNICIPAL BUILDINGS IN THE ROYAL BURGHS

Tolbooths and bellhouses are the earliest municipal buildings in Scottish burghs, and the fact that many of the surviving buildings date from 1591 suggests they were constructed as the result of a Scotland-wide decision of the Convention of Royal Burghs. Although all the buildings erected in or immediately after 1591 comprise stone towers, none of the burghs appear to have purchased ground on which to erect the tolbooth. Similarly, when town houses were added to tolbooths in the 18th or 19th centuries, there was no purchase of land, suggesting that these masonry structures were replacements for timber buildings which had previously occupied the sites and served a similar purpose. Surviving tolbooth towers were probably originally built as fire safes for tolbooth complexes, with council rooms replaced by masonry structures in the 18th or early 19th century. Following the 1591 rebuilding there are no later records of municipal buildings constructed of timber. Many of the surviving tolbooth towers retain small areas of timber cladding some of which could be the original timber and, if so, almost certainly amongst the oldest examples of timber cladding in Scotland.

ABOVE RIGHT
Timber-fronted land, Nethergate, Dundee.

BELOW
Partly timber clad belltower on the Tolbooth, Moffat, Dumfries-shire.



DOMESTIC BUILDINGS IN THE ROYAL BURGHS

Scottish mediaeval burghs followed the same general pattern as medium-sized burghs in northern Europe. Regularly laid out, the tenements or building plots were on long narrow strips of ground running at right angles to the street. In the case of the larger burghs, the buildings (known as 'lands') were multi-storey structures in multiple occupation: the principal owner lived at first floor level, with other families being progressively poorer the higher they lived. In Edinburgh, additional lands were constructed to the rear of the principal land, while in Scotland generally, the period of major change from timber to masonry construction in both upper and upper-middle class urban dwellings appears to have occurred in the 17th century, such as in the Royal Burgh of Dundee where prior to the English invasion of 1547:

Many of the houses had wooden fronts supported at the ground floor upon pillars, within which were open piazzas, (the Scots name for arcading) sometimes used as the workshops of craftsmen and often as the booths of merchants.⁽¹¹⁾

Following destruction by the English, these houses were rebuilt in the 1550's with timber fronts, and it was the beginning of the 17th century before legislation finally prohibited further timber buildings in Dundee. This did not cause an immediate change - in Dundee 200 years later:

The buildings were generally of wood. There were not then above half a dozen of stone houses in the High Street or Market place.⁽¹²⁾

At the end of the 18th Century, The Statistical Account for Scotland⁽¹³⁾ recorded no more than four stone houses in the centre of Dundee. These were probably the townhouses of landed gentry who were displaying their exceptional wealth by building in masonry.

Hume Brown's late 19th century collection of early travellers accounts gives a flavour of the building types in a late mediaeval royal burgh. For example, John Ray who visited Dunbar in 1662 commented:

They have a custom to make up the fronts of their houses, even in the principal towns, with fir boards nailed one over another, in which are often made many round holes or windows to put out their heads.⁽⁸⁾

Many of the records in Hume Brown's collection describe the transition from timber cladding to stone in the royal burghs, with Fynes Moryson describing the houses of Edinburgh in 1598:

The houses are built of unpolished stone, and in the faire streete good part of them is of freestone, which in that broade streete would make a faire shew, but that the outsides of them are faced with wooden galleries, built upon the second story of the houses; yet these galleries give the owners a faire and pleasant prospect, into the said faire and broad street, when they sit or stand in the same.⁽⁸⁾

Another account from Hume Brown states: *Their old houses are cased with boards, and have oval windows (without casements or glass), which they open or shut as it stands with their conveniency. Their new houses are made of stone.⁽⁸⁾*

By the 1700's, the intellectuals of the Scottish Enlightenment were responding to new cultural influences and this, combined with increased affluence, meant that the 18th century building boom in Edinburgh was realised in stone. The older timber-clad houses in the royal burghs were progressively demolished or incorporated within new masonry walls and while there is no evidence that new timber-clad houses were built, it is likely that other types of timber-clad buildings (e.g. workshops and stables) continued to be constructed in the royal burghs.

RURAL SCOTLAND

Rural Scotland encompasses everything outwith the royal burghs. The majority of rural buildings were under the control of one or other of the landed estates. These estates ranged in size from about 75 acres in the case of Flatfield at Errol, Perthshire, to several thousand acres of rich arable land at Glamis in Angus, and to tens of thousands of acres in the larger Highland estates. In rural Scotland the estate factor took on the mantle of the Dean of Guild in imposing building control at the behest of the landowner.

VERNACULAR BUILDING TYPES

The range of Scottish vernacular building types has never been fully defined and to do so more 17th, 18th and 19th century rural sites need to be excavated. Unfortunately, it was the poor end of the social spectrum which survived until recently that has been recorded by students of vernacular building, but glimpses of interiors and exteriors of Scottish rural houses in the works of the genre painters of the late 18th and early 19th centuries suggests a much wider range, both of structural types and external

finishes. Using the structural system as a means of classification, there are four main types of timber structure known in rural Scotland: the cruck frame (sometimes called a 'couple' in Scotland); the post and longitudinal beam; the post and cross beam; and aisled construction. Because each of these systems transfers the loads to the ground without the need for structural external walls, it is possible that - where timber was available - it may well have been used for cladding these buildings.

The cruck frame typifies rural vernacular building in Scotland. Although a better class of cruck frame is known in England, the system appears to have developed in Scotland and Ireland before being exported South. Cruck frames offered several types of external building form for dwellings. One type had the roof oversailing a vertical wall while, at the other extreme, the roof stopped near the inner face of a broad turf wall (in the same manner as the roofs of surviving Hebridean blackhouses). Between these two extremes many other variations existed. Cruck-framed houses continued to be built in the Highlands until the 1920's and timber-clad cruck frames survived in Strathspey until the 1980's.



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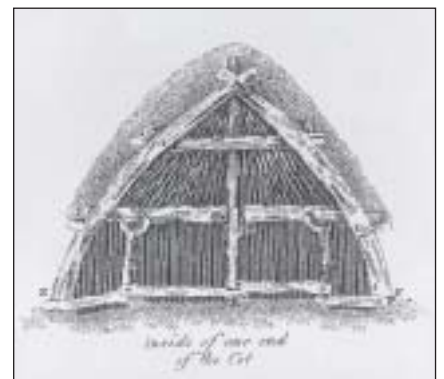
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LEFT

Timber cladding between the masonry base and eaves on a cruck-framed cottage at Kinchurdy, Strathspey.

BELOW

Cruck frame used in a Highland sheep cot.





TIMBER CLADDING AFTER THE INDUSTRIAL REVOLUTION



Towards the end of the 18th century a series of technical and social changes began which, in the coming decades entirely transformed the lives of most people in Britain. The Industrial Revolution introduced a period unlike any other in the history of the British Isles and, by the mid-19th century, 80 years of industrialisation and agricultural change had seen Scotland's population double. The impact was immense:

- Agricultural reform and improvement transformed much of rural Scotland;
- New trade with the colonies brought unprecedented affluence and new raw materials;
- Urbanisation grew rapidly as the population expanded. Glasgow, as one of the great engines of the Industrial Revolution, increased its population twelvefold during this period, with Edinburgh, Aberdeen and Dundee also experiencing dramatic growth;
- Technological change and improvements in transportation reduced costs, displaced handcraft production and gave birth to industries inconceivable a few decades previously;
- The new availability of books and pamphlets facilitated a growing interchange of ideas.

The industrial revolution created new markets for timber cladding, and new types of cladding to supply those markets. Scottish building would never be the same again.

Herring gutters huts stand in front of Scalloway Castle, Shetland.

SOURCES OF EVIDENCE AFTER 1780

Evidence from the post-Industrial Revolution period is less circumstantial than from previous centuries, with information on various types of construction appearing in books, official reports, patent records, newspaper advertisements, trade catalogues, textbooks and contemporary photographs. There are also a large number of extant timber-clad buildings, although most of the 19th century survivors in Scotland date from the latter half of the century and have yet to be fully studied or recorded.

Historical photographs taken by some of the pioneer photographers show timber buildings, sometimes in unlikely situations. A photograph of Scalloway Castle, Shetland taken c.1900 shows a row of timber-fronted herring gutters' bothies within the confines of the castle. Similarly the George Washington Wilson photographic collection (held at Aberdeen University), shows numerous timber-clad buildings in the foreground of Kishmul Castle, Barra.

Descriptions are usually linked to a particular industrial process. A typical description - backed by a series of George Washington Wilson photographs - is of the smoking chimney brace (the large timber structure in which the fish are hung) used in the production of 'finnan' haddocks in Aberdeen.

OPPOSITE
Swiss Cottage, Fochabers, c1820 is probably clad in homegrown Scots pine from Strathspey.

FACTORS INFLUENCING TIMBER CLADDING AFTER 1780

THE IMPROVERS

Scotland underwent progressive transformation from the late 18th century. The 'great rebuilding' of rural England had taken place in the 17th century but Scottish law had prevented a similar movement in Scotland. Some Scottish landed estates, particularly in the Lothians, began to 'improve' their buildings in the early 18th century but it was not until the 1770s that the law was changed to allow 'improvements' on a grand scale. In the countryside new towns were established in the Highlands and new estate villages were created. During the early 19th century this movement spread throughout central Scotland and up the east coast and by the mid to late 19th century most of the Highlands had been transformed. The stone cottages and farm buildings that are now so characteristic of rural Scotland are the inheritance of this period.

NEW TRADE AND URBANISATION

In the 18th century the growth of trade with England re-oriented the commercial outlook of the country away from the North Sea and Baltic trade towards the Atlantic and the Caribbean. New timber species began to be imported and this increased during the 19th century as rapid trans-Atlantic shipping became possible.

In 1800, only 20% of Scots lived in towns of 5000 or more people, but by 1861 this had risen to 40% and by 1901 was almost 60%. Although many small towns were affected by this growth, it was the cities which were most transformed. By 1911 Scotland was the second most urbanised country in the world, exceeded only by England.

In the 19th century the legislative building control process initiated seven hundred years earlier by King David 1 reached its conclusion with new Scotland-wide regulations prohibiting the use of timber for external walls. This was supplemented by improvements in town planning which provided ample opportunity to force demolition. As a result, timber buildings in Scottish towns were demolished in a systematic way throughout the 19th century and advertisements regularly appeared in the local press offering timber from old houses or asking for tenders for demolition contracts. The royal burghs, formerly clad in timber, were now being completely reworked and, as the urban areas expanded, the character of Scotland's built environment switched to masonry.

The introduction of new wood processing technology enabled the rapid growth of timber framed and timber clad buildings such as this mid 19th century railway station at Nairn.

TECHNOLOGICAL CHANGE

While the 18th and 19th century building booms were sweeping away evidence for earlier timber building traditions, technology was introducing new opportunities for timber construction. Prior to the Industrial Revolution, only muscle power (or in exceptional cases, waterpower) was available for converting trees into timber. Consequently trees had either to be split or hewn to shape or slowly sawn with large two-person pit saws or water-powered frame saws. All this changed when English naval shipyards invented the circular saw in the 1780s, and mechanised planers were developed around the same time. Almost overnight, new processing technology - combined with the introduction of steam power - transformed timber construction, the best known development (initially in north America) being that of timber frame buildings using relatively small section sawn timbers fixed together with mass-produced nails.

In common with many other building materials, mechanisation resulted in the lower cost and greater availability of sawn softwood cladding boards. These newly available timber claddings were used in the production of temporary buildings, or permanent ones where the speed of erection of a prefabricated structure had distinct advantages. The London Evening News carried illustrations of prefabricated buildings being used in the Crimean War and the patent records of the early 19th century contained many examples of prefabricated timber-clad buildings designed for export to the colonies. These products

were, however, quickly challenged by the introduction of metal claddings such as corrugated iron which came into use soon after the introduction of rolling mills for the production of iron and steel plate and sheet.

PATTERN BOOKS AND OTHER PUBLICATIONS

During the 18th century, the cost of producing printed books dropped dramatically. This was seized upon by architects and others wishing to exploit the potential offered by the 'great rebuilding' of the Scottish landed estates and the opportunities offered by colonists establishing themselves in the developing British Empire. Improvements in the printing process in the 19th century made it possible to produce elaborate publications and this, combined with a growing interest in Scotland in agricultural improvements, resulted in a further increase in books of building designs. Some of these 'pattern books' were small pamphlets dealing with a particular aspect of planning or construction, while others were collections of design drawings ranging in size and complexity from the factor or estate manager's house down to labourers cottages and bothies. Many included designs for half-timbered or timber-boarded dwellings and steadings. Possibly the most influential pattern books were produced by horticulturists and estate managers working with architects - the Scot, John Claudius Loudon (1783-1843) for example produced his *Encyclopedia of Cottage, Farm and Villa Architecture* in 1833 on the back of a series of other encyclopaedias on farming, gardening and horticulture.



19TH AND EARLY 20TH CENTURY SURVIVALS

A large number of timber-clad buildings survive in Scotland from the 19th and early 20th centuries and while mostly unrecorded, include examples serving almost every purpose:

SHOOTING LODGES

The demand for shooting lodges increased in the mid-late 19th century, and several were constructed with timber frames and cladding. Fires caused most of these buildings to be lost and Forest Lodge at Abernethy in Strathspey is perhaps the most impressive of those that remain. Interestingly, this building was originally insulated with sawdust.

FISHING INDUSTRY BUILDINGS

The late 19th and early 20th century herring boom saw a large number of timber-clad buildings constructed for work and for accommodation. A number of these survive in Caithness at Puctneytown, Wick and Thurso; whilst on the islands former herring gutting huts exist at Gremista and Lerwick on Shetland, and Sanday on Orkney. On the Western Isles, the large whaling station at Tarbert on Harris retained both timber-clad factory buildings and workers' accommodation until the 1950's.

In addition to the buildings created to service the mainstream fishing industries, small utilitarian timber buildings were constructed in many of the fishing communities around the Scottish coast. Surviving examples include several distinctive high-gabled sheds in Avoch; black tar-coated storage sheds at Buckie and Redpoint, and a fine painted store in Stomness.



RAILWAY STATIONS AND SIGNAL BOXES

Originally developed in America, industrial timber frame construction lent itself to prefabrication and rapid erection and so was well suited to the needs of the railway companies in locations remote from major towns. Oban Station (demolished in the 1970's) was perhaps the most elaborate of these buildings, although many other fine examples still exist, particularly on the Highland line.

The coming of the railways in the mid 19th century probably helped to popularise timber-framed and -clad housing in rural Scotland. The chimneys of many of the surviving timber-clad buildings in the Scottish countryside date them to the period when railways carried bricks to areas remote from any brickworks.

SERVANTS' HOUSING AND STABLE BLOCKS

In the late 19th century, ancillary buildings to the rear of a large house were often constructed in timber frame with vertical timber cladding. These buildings survive throughout rural Scotland with numerous examples in Strathspey and Deeside dating from the mid 19th century to around 1910. The largest collection is probably on Balmoral Estate. Generally built to a high standard in a style broadly similar to the railway stations, virtually all these ancillary buildings have been painted with light coloured paint.

ABOVE RIGHT

Forest Lodge, Abernethy, 1880 is the largest remaining 19th century timber-clad shooting lodge in Scotland.

RIGHT

Mid 19th century ancillary buildings such as these Balmoral Estate examples typify a building type found throughout much of rural Scotland.





These brightly painted pre-fabricated houses were erected in many parts of the Highlands in the mid to late 19th century.

TEMPORARY OR LOW-COST DWELLINGS

Millworkers, hutters, cotters, and agricultural workers all required low cost dwellings and these were frequently constructed of timber. The structure of these buildings varied considerably and included cruck frame, timber frame and other types of construction. Like many other vernacular buildings, the construction method was often determined by the availability of low-cost materials. The cladding of many of these buildings was made from sawmill offcuts or 'mill backs' (the low value outer boards first cut from a log). Although no longer standing, photographs of the mid 19th century gold-mining village at Kildonan on the River Helmsdale show typical examples of this type of building which, unlike the higher status servant' dwellings already mentioned, were coated with tar oil instead of paint.

Prefabricated timber-clad dwellings were also imported into the Highlands and the Western Isles as shepherds' accommodation. Corrugated metal or timber-clad examples can still be seen around the Highlands and similar types of buildings are still used around the Scottish coast as beach huts and holiday accommodation.

PUBLIC BUILDINGS AND RECREATION HALLS

Many social buildings (e.g. village halls, huts for youth organisations, yacht clubs, sports pavilions, etc.) were clad with timber. This was not uncommon in cities either and the Empress Ballroom in Dundee and the Chalet Ballroom in Broughty Ferry were good examples. The Drill Hall at Golspie is perhaps the largest surviving example, but others include the recently refurbished village hall at Arisaig, the pavilion in Strathpeffer, and the fine servants hall behind Haddow House.



Swiss Cottage, Fochabers, c1820 was built to the pattern book designs of John Claudius Loudon and is one of the oldest surviving timber-clad buildings in Scotland.

BOAT HOUSES

Timber-framed and -clad constructions were ideal for boat houses, and these distinctive little buildings are still relatively commonplace throughout rural Scotland. A particularly fine example was the two storey boat house at Loch Brora (sadly destroyed in the 1980's).

COMMERCIAL BUILDINGS

A wide range of commercial structures from village stores, post offices and other small scale enterprises, to large granaries and warehouses were timber clad. In the 1950's, a large timber granary existed near the lifeboat shed in Arbroath, and small timber-clad shops still exist in villages throughout rural Scotland, Ardersier in Nairnshire having several examples.

HOTELS

Occasionally hotels and guesthouses were constructed in timber frame with timber cladding. Robert Lorimer designed the Clousta Hotel on the east Mainland of Shetland in 1894 as an anglers hotel (unfortunately later destroyed by fire). The St Magnus Bay Hotel on Busta Island, Shetland was erected in 1900 for cruise passengers from Leith. This building was imported as a prefabricated structure from Norway. Other examples exist in north-west Scotland.

PATTERN BOOK HOUSES

Sometimes pattern books or collections of drawings can be linked to buildings that still survive, but not all were constructed in strict accordance with the designs. A set of early 19th century drawings for half-timbered farmhouses and steadings are held at Rossie Priory Estate in Perthshire, and some small scale examples - usually in the form of half-timbered gables or dormers - survive in the estate village of Knapp.

The majority of the buildings erected from these drawings followed the plan and section but changed the external walls to a vertical boarding finish. One of the oldest timber-clad buildings in Scotland is the Swiss Cottage near Fochabers, built c.1820 for the Duke of Gordon to a Loudon pattern book design. It appears to be clad in relatively fast-grown Scots pine and, since it is known that Loudon advocated the use of Strathspey pine for other buildings in this area, it is quite likely that the cladding is of homegrown timber.

GAZEBOS AND OTHER ORNAMENTAL BUILDINGS

Picturesque landscaping works from the late 18th to the early 20th century included small ornamental timber buildings, and the now sadly-neglected boating house at Rosehaugh Estate on the Black Isle is a fine example. Quite a number of rusticated timber cottages still survive on the Taymouth Estate at Kenmore, on Altyre Estate near Forres and at Balmoral. Similar rustic aesthetics are employed on buildings in the villages of Birnam, Kingussie, and Golspie.

INDUSTRIAL BUILDINGS

Timber cladding was used for many industrial purposes where large span buildings were required, but worries about fire resulted in the earlier timber cladding being replaced by corrugated iron or some other form of profiled metal. Timber-clad boat-building sheds survived at St Monans in Fife until the 1960s, and many sawmills were timber-clad structures, the best known surviving example being the bucket mill at Finzean in Aberdeenshire, built in the 19th century and still functioning, albeit as a woodworking museum. Other fine examples are the elm-clad estate buildings at Achfary, Sutherland.

MILITARY BUILDINGS

Timber-clad permanent, temporary and portable structures played a major part in the housing, hospitalisation, recreation, education and spiritual needs of the armed forces as well as providing storage facilities for much of their equipment. From the Crimean War onwards, the military tended to use timber or metal-clad structures in preference to tents but, even earlier than this, massive ship-building sheds sheltered the construction of Men-of-War. This tradition continued to the newer branches of the armed forces, and timber aircraft hangers still survive at Montrose Aerodrome in Angus. On a smaller scale, the many temporary airfields of World War II created a legacy of timber huts, many of which are still in use as scout huts, stores and workshops.

FORESTRY COMMISSION BUILDINGS

In its early years the Forestry Commission built forest crofts in remote parts of Argyll and elsewhere in the Highlands, and it continued to build timber-clad forest workers accommodation and offices throughout Scotland, with many of these buildings still in service today.

LOUVRED OR OTHER WELL-VENTILATED BUILDINGS

The introduction of sheep farming to the north-west Highlands created a need for large well-ventilated barns. A few of these buildings with their characteristic louvred or wattle-filled panels can still be seen at Applecross and on the way to Kyle of Lochalsh. Other examples of this type of building were seen at tanneries and as drying sheds at potteries such as the Blackpots Brick and Tile Works at Whitehills, Banffshire. On a smaller scale timber was the perfect material for constructing the louvred walls of the deer larders and seed drying kilns still seen on some Scottish estates. Another surviving building is the recently restored ventilated oar house in Cromarty.



An Arts and Crafts-style timber-clad church on Altyre Estate near Forres.

MOBILE BUILDINGS

Roadworkers, foresters and showmen all required well-built mobile dwellings suitable for year-round accommodation. A few of these have been preserved by enthusiasts or museums and at least one - a forest worker's van - is still inhabited by its original occupant. Railway wagons were perhaps the most common mobile buildings with timber exteriors and many of these found a second life as temporary farm buildings when sold off by the railways.

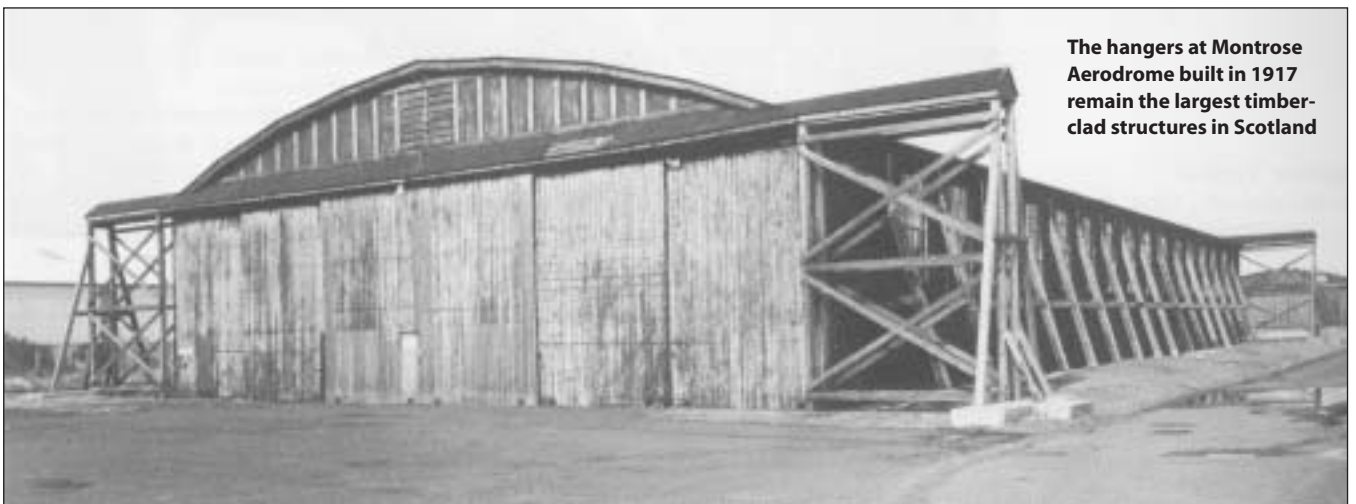
CHURCHES AND SCHOOLS

With the expansion of urban centres during the Industrial Revolution, the Church turned to prefabricated timber buildings to serve its new congregations. Sometimes these became permanent, but were more often demoted to church halls when the congregation built a larger masonry or brick structure. Occasionally a permanent church was commissioned in

timber and one surviving example is the late 19th century estate church at Altyre near Forres. A few rural schools were also constructed with timber cladding, perhaps the largest being the elm-clad school at Achfary, Sutherland.

PORCHES AND ARCHITECTURAL DETAILS

19th century stone-built estate cottages often incorporated timber-clad porches. The knotty pine columns supporting the roof of some of these are reputedly hollow (to prevent the log from splitting as it dried), and if so were probably a by-product of the boring mills which made wooden waterpipes. Many 19th century buildings have small timber clad details including carved barge boards; waney-edge elm weatherboarded gables; and timber clad panels on doocots and church steeples. These were often finely-made and illustrate that, with good design and regular maintenance, even quite intricate detail can perform well in many parts of Scotland.



The hangers at Montrose Aerodrome built in 1917 remain the largest timber-clad structures in Scotland

TIMBER-CLAD HOUSING

Although the majority of 19th century house building was in masonry, timber-clad houses continued to be built in rural areas for specific purposes, including:

- Pattern book housing;
- Prefabricated dwellings for the fishing and agricultural industries;
- Self-built housing for temporary workers;
- Accommodation for servants;
- Decorative panels and porches on masonry buildings;
- Mobile homes.

These were of course the exceptions, and by the late 19th century, 'traditional' house construction in Scotland was mainly defined in terms of the masonry construction techniques introduced during the previous 150 years. These techniques are most characteristically expressed through:

- The unified 'terrace' of identical dwellings as popularised by Robert Adam;
- Ashlar-faced Glasgow tenements;
- The improved farm buildings of the rural estates.

It took until the 1920's before the merits of the timber-framed, timber-clad house began to be reassessed.



1970's social housing at Kyle of Lochalsh uses preservative treated western red cedar shingles.

THE RE-EMERGENCE OF TIMBER-CLAD HOUSING

A revolution in Scottish house building began with the growing shift away from the free market towards the state during the period of crisis following World War I. As the public sector began to assume importance as a housing provider, the combined pressures of growing demand and a shortage of labour and materials encouraged city corporations to experiment with new 'non-traditional' methods and materials. Prefabricated timber-framed construction with masonry cladding was thus introduced to a generally sceptical building industry. Timber frame itself was not new in Scotland, nor was prefabrication - the novelty lay in the degree to which prefabrication could be applied to mainstream housing and in the use of masonry claddings. Prior to the early 20th century, timber-framed buildings had generally been clad with timber boarding, slate or corrugated metal, but in order to gain acceptance alongside 'traditional' construction, timber frame was now given a non-structural masonry cladding.

Founded in 1937 as a 'Keynesian' state intervention to stimulate recovery from the depression, the Scottish Special Housing Association (SSHA) embarked on an ambitious building programme of 5000 new houses including solid-walled Canadian cedar houses in Lanarkshire designed by Basil Spence and William Kininmonth. At the same time, timber-clad Scandinavian kit houses were introduced into Scotland - between 1920-44 the SSHA built 350 timber-clad houses and bungalows, Dundee Corporation built 556 timber houses and Aberdeen Corporation constructed 76 timber-clad houses. These buildings were adjudged to be successful and, by the end of World War II, the SSHA had ordered several thousand prefabricated timber houses from Sweden for erection throughout Scotland and rural parts of northern England. In this way the SSHA reintroduced timber cladding into the Western Isles, Orkney, Shetland and many other areas where its use in housing had virtually ceased. The importation of these kits from Sweden was ordered by Robert Matthew, Chief Architect in the Department of Health for Scotland. Matthew had been stranded in Scandinavia until VE day, and while there designed the kits to conform with the recommendations of the 1944 UK government report 'Planning our New Homes':

Usually the lower storey walls consisted of 2 inch tongued-and-grooved vertical boards, lined externally with wind-proof paper. The external finishing consisted of vertical 5/8 inch boards and cover strips... the upper storey walls were of 4 x 2 inch studding clad externally with 2 inch diagonal boarding, wind-proof paper and horizontal weather boarding.⁽¹⁾

The official consensus in the post-war years was once again that 'non traditional' and prefabricated construction methods were essential to overcome severe labour and materials' shortages. Although these technologies had been commonplace until the masonry boom of the 19th century, they were resisted by many in the construction industry. Andrew Mickel, the owner of a leading Scottish building firm made his views clear:

Both the Scottish climate and the Scottish character are against prefabrication. Let us get our brick and concrete works going and our skilled men back from the Services. With organisation and continuity, I am sure that we can keep pace with the building programme - and provide the solid, long lasting homes which Scotsmen want.⁽²⁾

At the same time the firm was hedging its bets by patenting a timber frame system clad with roughcast concrete blocks. This was prudent because after World War II the timber frame market grew throughout Britain, albeit as a niche within the wider 'traditional' housing market. In the 1960's and '70's, however, the stagnation of the private housing market combined with the move towards tower blocks meant that very little timber-clad housing was built in Scotland. The exception to this was Shetland, where the mid '1970's oil boom had stimulated a large housing demand. This was met in part by the SSHA through the import of more Scandinavian kit houses such as the Norwegian timber clad kits at Brae (1973-4). Aberdeen County Council also imported nearly 1000 Norwegian and Swedish kits at around the same time, as did the SSHA and several private developers for sites in Ross-shire and around Inverness.

During the early 1990's the Building Research Establishment surveyed many of the timber-framed, and often timber-clad, housing systems built between 1920-75:

... the incidence of timber decay in timber frame dwellings built between 1920 and 1975 is slight. However, in a few dwellings decay has occurred in particular parts of the construction because of inadequate maintenance ... Provided that regular maintenance is carried out, and that repair or rehabilitation work meets accepted levels of good practice in design and construction, a performance comparable with traditionally constructed dwellings of the same period should be maintained ...⁽³⁾

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THE DURABILITY OF TIMBER CLADDING



As the moisture content of the cladding has increased, the lack of expansion gaps in this western red cedar cladding has resulted in the boards bulging off the wall.

With adequate design, construction and maintenance, timber clad buildings can perform perfectly satisfactorily in Scotland. Virtually all the performance problems of timber products in buildings occur because either the timber was installed at the wrong moisture content for its intended use or because the timber subsequently became wet due to poor maintenance or detailing. In such circumstances, timber may be subject to movement and can also be at risk from fungal decay and insect attack.

THE EFFECT OF MOISTURE ON TIMBER CLADDING

MOISTURE IN TIMBER

Timber is hygroscopic, i.e. it absorbs or loses moisture until it is in equilibrium with the amount of water vapour in its surrounding environment. For any given combination of air temperature and relative humidity, wood has a specific moisture content known as the 'equilibrium moisture content'. Properly maintained and well-detailed exterior cladding has a typical equilibrium moisture content of about 16%⁽¹⁾. It will however fluctuate from around 12% on a hot summer's day to 20% or above during periods of driving rain. Accordingly, BS 1186-3: 1997 recommends that exterior cladding timber is dried to a moisture content of 13-19% before it is installed. The only exception to this is where unseasoned timber such as 'green oak' is deliberately used for cladding.

MOVEMENT IN TIMBER

The cells of wood fibres shrink or expand when they lose or gain moisture. These movements occur mainly across the width of the cell and are usually minimal along the length. Consequently shrinkage or swelling movements along the grain are negligible but can be significant across it. This shrinkage or expansion only occurs when moisture levels change below a critical value known as the 'fibre saturation point'. For most species this value is around 25-30% moisture content. The normal seasonal range of moisture contents experienced by cladding are less than this value, and movement will therefore occur throughout its service life. Different timber species have different movement characteristics and it is important to consider these when selecting a suitable species for cladding; normally described in relative terms, different species are classed as small, medium or large movement timbers. The latter require particular care and attention to detail if used for cladding. In a recent publication, TRADA expressed these movement classes as follows:

| TRADA MOVEMENT CLASSIFICATION | | SOURCE: HISLOP, 2000. |
|--|----------|--|
| Across the grain dimension change within a moisture content range of 5 - 30% | Movement | Examples of species |
| 1% for every 3% change in moisture content | Large | Karri, ekki |
| 1% for every 4% change in moisture content | Medium | European oak, European redwood and Scots pine, Norway spruce |
| 1% for every 5% change in moisture content | Small | European larch, sweet chestnut, iroko, western red cedar |

For most purposes, this TRADA classification provides all the guidance required to design for movement in cladding boards. There are two exceptions to this:

- Some types of cladding design - such as close-boarding - are more demanding because there is less capacity to absorb large changes in board width. In these instances, a more careful assessment of movement is required, possibly requiring specialist advice.
- Unseasoned oak with a high moisture content is sometimes used for cladding. This can save around 25-30% on the timber costs but the detailing must allow for shrinkage.



A converted warehouse in Trondheim, Norway is supported on wooden piles which are exposed to attack from marine borers and specialised fungi (Hazard Class 5). The timber cladding, although close, is at much less risk of biological degradation (Hazard Class 3).

ALLOWING FOR MOISTURE MOVEMENT

In addition to drying cladding boards to a moisture content of 13-19% before installation, movement can be further reduced by limiting the width of the boards. If possible, the heartwood side of the board should be installed to face outwards on the building, to ensure that - even if the boards undergo further in-situ drying - the cladding joints remain tight. This arrangement is particularly important on the outer board of board-on-board assemblies⁽²⁾. The fixings should leave the board as free as possible to move across its width. Where boards overlap, it is particularly important that nails never go through both boards. Where unseasoned green oak is used, special details such as oversize screw holes should be drilled to accommodate shrinkage.

BIOLOGICAL DEGRADATION

Timber is at risk of attack from a range of organisms if it remains damp or wet for extended periods - various species of fungi and insects are the principal risks in buildings in the UK. Fortunately these risks are manageable and, with proper specification, detailing and maintenance, should be preventable. There is little risk of fungal decay if timber is dried to, and then maintained at, a moisture content below around 20%. The risk of attack in the UK by wood boring insects is also relatively minor at low moisture contents.

FUNGI

Fungi require a suitable combination of moisture, air and temperature to grow. Different species of fungi have slightly different moisture requirements but, in general, wood decaying fungi require a wood moisture content of at least 20% for an attack to start, and most decay fungi will become inactive and eventually die if the wood moisture content drops below this for extended periods. Scotland has low winter temperatures and fungal activity in external joinery generally ceases when temperatures fall below about 5°C. That said, it is possible the fungal activity period may in future be extended due to the higher winter temperatures brought on by climate change.

INSECTS

In Scotland, the common furniture beetle or woodworm (*Anobium punctatum*) is the only insect to regularly attack softwood timber at moisture contents below the fibre saturation point. Damage is usually restricted to the sapwood of certain susceptible timber species.

The two other beetles that pose a significant hazard in the UK are the death watch beetle (*Xestobium rusovillosum*) and the house longhorn beetle (*Hytotrupes bajulus*). The former species rarely occurs in Scotland while in the UK, the latter is restricted to the south east of England⁽³⁾. Powder post beetles (*Lyctus sp.*) can be problem in oak sapwood but as this is normally removed from oak cladding *Lyctus* attack is not a significant threat.

The optimum moisture content for woodworm is between 18-30%, but it may colonise any susceptible sapwood contained in external timber cladding at moisture contents as low as 12%. The rate of colonisation tends to be slow at this level and, if the moisture content does not increase over time, the infestation will tend to die out. Temperature is also an important factor and rates of growth are 50-75% less at 10°C compared to 24°C⁽³⁾. As a consequence, woodworm is generally only a minor problem in external timber cladding in Scotland.

CLASSIFYING BIOLOGICAL DECAY HAZARDS

European Standard BS EN 335-1:1992 groups the end-uses of timber according to the biological decay hazard they are exposed to, thus providing a useful framework within which to summarise the decay risks described above. Like all exterior joinery, timber cladding is normally in Hazard Class 3 and as such, likely to be exposed to some risk of fungal decay and possibly insect attack. However, providing cladding is well designed, regularly maintained and made from suitable timber, the occurrence of rot or insect attack is often preventable. Conversely, very poor detailing or maintenance can significantly enhance the risks and place parts of the cladding in Hazard Class 4.

| HAZARD CLASSIFICATION FOR WOOD | | | SOURCE: BS EN 335 PARTS 1 & 2: 1992. |
|--------------------------------|--|----------------------------|--|
| Hazard Class | Environmental characteristics where the wood or wood-based product is situated | Moisture content of timber | Biological hazard In addition to those listed, termites may be a severe problem in all hazard classes in some parts of Europe, but not in Scotland. |
| 1 | Under cover, fully protected from the weather and not exposed to wetting This class describes the typical conditions inside a building | Permanently below 20% | Beetles are the only biological hazard. The risk is generally not severe at the low moisture contents found in a modern centrally heated house. |
| 2 | Under cover and fully protected from the weather but located where environmental humidity can lead to occasional but not persistent wetting. This class mainly describes specific parts of a building such as sole plates or sarking that may be exposed to condensation. | Occasionally above 20% | Beetle attack predominates, fungal decay (especially moulds) may occur if high moisture contents are sustained. |
| 3 | Not covered and not in contact with the ground. It is either continually exposed to the weather or is protected from the weather but subject to frequent wetting. This class describes most exterior joinery and structural timber including cladding, windows, decking and bridges. | Frequently above 20% | Brown rot and white rot fungi can cause problems particularly if the timber is unable to dry out following periods of wetting. Beetle attack can also occur. |
| 4 | In contact with the ground or fresh water and thus permanently exposed to wetting. This class includes fencing, canal lock gates and transmission poles. | Permanently above 20% | The main decay organisms are soft rot fungi. Other decay fungi and beetles may cause problems at the soil/air interface |
| 5 | Permanently exposed to salt water. This class describes all marine uses such as dock work. | Permanently above 20% | Marine borers are the principal decay organism although specialised fungi are also present. |

UNDERSTANDING NATURAL DURABILITY

Different tree species have evolved different degrees of resistance to biological degradation and these are described in the relevant standards. When interpreting natural durability statements, three points should be kept in mind:

- ❑ **Heartwood and sapwood**
 There is a difference in natural durability between the inner part of a tree known as the heartwood and the outer sapwood zone. In most species the heartwood is a darker colour than the sapwood due to the presence of various organic chemicals known as extractives. These extractives make the heartwood of some timber species more resistant to fungal or insect attack. In contrast, sapwood does not contain as many extractives and the sapwood of virtually all timber species is classed as being of low natural durability.
- ❑ **Moisture content**
 Timber with low moisture content is not prone to fungal attack and the risk of insect attack in the UK is also relatively low. Providing it is kept dry, even timber classed as 'not durable', can thus last for many centuries in the UK without serious decay problems.
- ❑ **Relative durability**
 Classifications for durability are mainly derived from long term trials in which heartwood stakes are buried in the ground. In other words, the classification is a description of relative durability performance under Hazard Class 4 conditions. The durability of a particular timber species in other hazard classes may be different. In the case of cladding, the environmental conditions used in such trials are far more aggressive than would normally be found in external cladding.

Sapwood is less durable than heartwood. In this sweet chestnut log, although the heartwood is classed as durable, the outer sapwood has started to decay after only a few months in a damp environment.



CLASSIFICATION OF THE NATURAL DURABILITY OF WOOD AGAINST FUNGAL ATTACK

SOURCE: BS EN 350-2: 1994

| Durability class of heartwood | 1 very durable | 2 durable | 3 moderately durable | 4 slightly durable | 5 not durable |
|-------------------------------|-------------------|--------------|-------------------------|-----------------------|------------------|
|-------------------------------|-------------------|--------------|-------------------------|-----------------------|------------------|

European Standard BS EN 350-2:1994 groups timbers into five durability classes based on the natural durability of their heartwood against wood-destroying fungi.

Although the principal of durability classification is relatively simple, it can in practice be quite confusing when applied to specific situations. The natural durability of solid wood depends to a large extent upon the species and upon the presence of heartwood or sapwood. In some cases natural durability may not be sufficient for the particular situation, and improved durability may need to be conferred on solid wood by the use of chemical preservatives forced into the timber. In some

circumstances even superficial coatings that help shed water from the timber surface can be important. Moreover, different timber species have varying degrees of permeability to moisture and this can, in some circumstances, also affect their service life. Scope for confusion is further increased because the relevant British Standards are in the process of being integrated with new European Standards. European Standard BS EN 460:1994 broadly integrates the different timber durability specification practices throughout Europe and provides a general introduction to the determination by Hazard Classes of the need for natural durability or preservative treatment.

THE NATURAL DURABILITY OR PRESERVATIVE TREATMENT NEEDED FOR RESISTANCE AGAINST FUNGAL DECAY

SOURCE: BS EN 460: 1994

| Durability Class \ Hazard Class | | Durability Class | | | | |
|---------------------------------|--|-------------------|--------------|-------------------------|-----------------------|------------------|
| | | 1 very durable | 2 durable | 3 moderately durable | 4 slightly durable | 5 not durable |
| Hazard Class | 1 Above ground and covered (dry) | 1 | 2 | 3 | 4 | 5 |
| | 2 Above ground covered (risk of wetting) | 1 | 2 | 3 | 4 | 5 |
| | 3 Above ground, not covered (periods of wetting) | 1 | 2 | 3 | 4 | 5 |
| | 4 In contact with ground or fresh water | 1 | 2 | 3 | 4 | 5 |
| | 5 In salt water | 1 | 2 | 3 | 4 | 5 |

KEY

| | |
|--|--|
| | In these conditions natural durability is always sufficient and there is no requirement for preservative treatment. |
| | Natural durability is normally sufficient in these conditions, but for certain uses where condensation may be severe, preservative treatment is advised. |
| | Natural durability may be sufficient in these conditions, but depending on the wood species, its permeability and end use, preservative treatment may be needed. |
| | Preservative treatment is normally advised in these conditions but natural durability may be sufficient in some cases. |
| | Preservative treatment is always necessary in these conditions. |

WOOD PRESERVATIVES AND COATINGS

Providing it has sufficient natural durability, the heartwood of a timber species can be used without preservative treatment even where a biological hazard exists. Sometimes, however, the natural durability of a particular timber may be insufficient for the Hazard Class in which it will be used. If so, the designer may have to switch to a more durable timber, or increase the durability of the timber through the use of a suitable preservative to avoid the risk of subsequent decay or insect attack.

DEFINING THE RISKS

Sustainability is currently a significant market driver for timber cladding in Scotland and so any discussion of wood preservation involves the recognition of two - sometimes conflicting - risks, the balancing of which is not always straight-forward:

□ Environmental risks

Like all other pesticides, timber preservatives are biocides that carry environmental risks throughout their life cycle from manufacture through to eventual disposal. Consequently, when wood preservatives are used in a cladding assembly one could argue that sustainability may be reduced and this might limit its market acceptance.

□ Risk of product failure

Within the confines of construction contract management, product selection will be partly determined by quantifying the risk of each product's failure and subsequent reduction of the risks - either through redesign or, more commonly, through transferring any associated liabilities to the supplier or contractor. Thus whilst sustainability-related issues may be important to the designer or the client, implementation will be limited to those situations where the designer, main contractor or supplier is content to underwrite any contingent liability. This tends to engender a conservative approach, and whilst designing for durability can minimise the risk of premature failure, many in the construction industry will still require to reduce the perceived risk of failure by using the 'insurance' of wood preservation.

USING WOOD PRESERVATION APPROPRIATELY

Depending on service location, many timber products are susceptible to biological degradation from fungi and insects. It is therefore essential that - when used in a particular location - timber products have a durability appropriate to the performance required of the component. European standards provide a decision-making sequence for selecting the level of natural durability or wood preservation required in a particular situation:

- 1 The desired performance and the Hazard Class of the component are decided first, taking into account the cost of failure (e.g. health & safety; replacement costs etc). This assessment is described in BS EN 335 parts 1 and 2:1992;
- 2 The timber species is then selected using the timber properties guidance in BS EN 350-2:1992;
- 3 The durability of the chosen species is then assessed against the performance and Hazard Class using BS EN 460:1994. The options are either: that the timber has sufficient natural durability for the envisaged use; or that the durability of the component needs to be increased either by using a more naturally durable species or through preservative treatment;

Where required, the performance of wood preservatives are then specified by taking into account the biological agencies against which protection is required. With some timber species it may be impossible to achieve the

appropriate preservative specification, in which case a different timber species should be selected or the design changed to reduce the decay hazard. Guidance on the specification of wood preservatives is given in BS EN 351-1:1996 and BS EN 599-1:1997. The draft standard DD 239:1998 provides additional information and, along with BS EN 460:1994, gives a general introduction to the specification of naturally-durable or preservative-treated timber.

Preservatives can be applied in several ways. Some methods (e.g. brushing, spraying and dipping) will only result in a surface deposition of preservative and are therefore relatively ineffective. Deeper penetration and distribution of the preservative chemicals in the wood generally require industrial vacuum or pressure-impregnation methods. Some wood preservatives are prone to leach from the timber and where this is a risk, either the timber component is given a water-repellent coating (as is common with window joinery) or the preservative chosen should be resistant to leaching.

It is vital to ensure that the quality of wood preservation practice is consistent with the requirements of the European Standards. For example, inappropriate preservative or poor site practice may lead to situations where the level of durability conferred by timber preservation may be much less than that required by the Hazard Class. Consequently, where preservative treatment is specified, care should be taken to ensure that the preservative chosen, its depth of penetration and retention, as well as the subsequent handling and installation of the component, are appropriate to achieve the level of protection required. This is a complex process and there may be benefit in adopting formal quality assurance procedures to ensure compliance with the relevant standards.

On this exposed site on Shetland the housing designers chose to pressure-treat the softwood cladding with a leach-proof preservative before applying a decorative surface coating.



Richard Gibson



This batten has had to be cut to length on-site which has exposed untreated timber. In order to preserve the 'envelope of protection', the joiner has followed best practice by liberally coating the endgrain with a recommended preservative.

The main function of a surface coating is decoration and should never be seen as a substitute for good detailing, natural durability or timber preservation.



If a designer wishes to avoid using preservatives then both the design and the timber species need to be chosen with care using the guidance given in the standards. The designer also needs to be confident that the subsequent maintenance programme is suitable and that, should a component fail, it would not constitute a danger to persons or property; that it could be easily replaced; and that the owner of the building is prepared for the possibility of replacement.

It is always worth being cautious with timber preservation. Adherence to environmental criteria for selection or avoidance should be rigorous, and emotive arguments and rationale avoided. The discussion of wood preservation is littered with ill-informed good intentions and so performance requirements, fitness for purpose, and risk of failure should always be the guiding principles. Designers should always ensure that any supplier's claims in relation to preservative performance can be backed-up, especially under service conditions which reflect the design's intended end-use. Boron-based preservatives are, for example, frequently advocated as having less environmental impact than other systems. Yet while suitable for some applications, the fact that boron preparations are water-soluble and can therefore leach out of the timber generally limits their use to Hazard Class 2 applications, unless the timber is subsequently painted with a water-repellent coating which is then regularly maintained.

Oak external joinery with the remnants of a transparent coating which has failed after a couple of years. It would have been better not to have used a coating at all.



HEAT TREATMENT OF TIMBER

Because of growing environmental concerns about some wood preservatives there is increasing interest across Europe in the potential for the use of thermally modified wood for cladding. To date there are four commercially available technologies: the Finnish THERMO WOOD; the Dutch PLATO WOOD; the French RETIFICATION and the German OIL HEAT TREATMENT. Timber cladding using these products is beginning to be available in Scotland.

According to a recent review of such technology, all four modification treatments are based on controlled heating of solid wood to temperatures close to or above 200°C for several hours in an atmosphere with low oxygen content in order to modify the wood's inherent properties. Whilst such treatments reduce some mechanical properties they also increase the dimensional stability and *biological durability of the wood without adding outside chemicals/biocides to the wood*⁽⁴⁾.

However, it should be noted that the use of heat-treated timber is not recommended in Hazard Class 4 or 5 situations (e.g. in ground contact) and it is not yet supported by a body of long term in-service performance evidence. Because of these and other uncertainties careful selection of timber species and process are critical if adequate in-service performance is to be achieved and hard evidence should always be sought from suppliers as to the appropriateness of their treatment for the timber species concerned and its intended end use.

COATINGS

Manufacturers of surface coatings sometimes use confusing terminology such as 'preservative coatings', but the preservative ingredients contained in their coatings are mainly intended to increase coating life and in most cases do not in themselves confer significant additional durability to the timber substrate⁽⁵⁾. There are, however technical benefits from coatings which, in some circumstances, can be important:

WATER SHEDDING

In Hazard Class 3 conditions a superficial coating which is water-repellent may slightly reduce the speed of water uptake by the timber and will consequently tend to:

- reduce the susceptibility to fungal decay;
- reduce the amount of moisture-induced movement in the timber;
- protect susceptible wood preservatives from leaching out of the timber.

All of these effects depend on an intact coating being maintained.

UV PROTECTION

Timber exposed to sunlight and not protected by some kind of coating will quickly bleach to grey due to photo-degradation of its surface by ultraviolet light. Surface checking and splitting can also occur. In some circumstances these effects may be desirable but, where bleaching of the timber is not acceptable, it is necessary to provide some kind of surface protection. Beyond the bleaching effect, timber damage from UV light is not in itself a significant degradation issue under Scottish conditions.

SELECTING A COATING

There are two key points to remember when selecting a coating for use on external joinery:

- ❑ **Relatively opaque coatings are more durable than non opaque coatings -** While UV degradation of timber is not in itself a major problem, UV damage to the timber surface is a problem if it occurs under a surface coating. This can cause the adhesion between the coating and the timber substrate to fail, resulting in the coating peeling off. Only coatings that offer long term resistance to UV penetration are suitable for use on cladding and a high degree of opaque pigmentation is generally the most effective long-term UV protection for the coating. Some less opaque coatings use UV absorbers, but these tend to be used up quite quickly and may only offer limited protection. For this reason, exterior varnishes and low-build woodstains should generally not be used on timber cladding. There are no completely clear coatings that will maintain the original colour of the wood over the service life of the cladding.
- ❑ **Exterior coatings need to be moisture vapour permeable -** The use of a moisture-vapour-permeable coating that allows any moisture accumulating in the wood to evaporate away without causing damage is generally considered beneficial. The more impermeable conventional gloss paints should be avoided on exteriors and a specialised timber coating used instead.

The generally accepted minimum service life of the best modern coatings is about 6 years in most conditions, with less opaque coatings having a shorter service life. Claims of service lives of 10 or even 15 years for particular coating products should be treated with extreme caution.

ENSURING THE MAXIMUM SERVICE LIFE OF AN EXTERIOR COATING

Timber coatings are often resisted because it is argued they create an ongoing maintenance cost. This can be minimised through the use of the following measures:

- ❑ Opaque moisture-vapour-permeable coatings can more than double the life of the coating when compared to using a semi-transparent stain.
- ❑ Application of a primer and a first top-coat to timber cladding before it is fitted onto the wall avoids any uncoated areas becoming exposed should the boards shrink even slightly after installation;
- ❑ The use of design details that protect endgrain from wetting is very important, otherwise moisture will be absorbed, resulting in premature coating failure;
- ❑ Coatings tend to weather better when applied to timber that has been pressure treated with a preservative;
- ❑ Rough-sawn boards hold coatings longer than smooth boards. Although rough boards initially absorb more of the coating, their use can extend the life of most coatings by several years;
- ❑ Avoid sharp edges or arrises on profiled cladding, as the coating is always thinner and less durable on a sharp edge. TRADA recommend a radius of 3mm on profiled sections⁽⁹⁾;
- ❑ Avoid timber that needs to be coated on very exposed elevations. Protect eaves with metal sheeting or use the heartwood of a durable or very durable species that needs no coating;
- ❑ Channel water off the wall by using flashings at regular intervals;
- ❑ Avoid exposed horizontal or near horizontal timber surfaces, as these are vulnerable to moisture;
- ❑ Coating timber under properly controlled conditions always gives a more cost-effective and durable finish than site application. Factory coating is well established for window joinery and would also be of benefit for cladding;
- ❑ External cladding boards that will be coated should be separated from other materials by a gap of 10mm. This makes the coating much easier to apply as less care is needed at the junctions.

The alternative to using a coating is to allow the timber to weather naturally to a silver-grey. This approach is only suitable for timbers of moderate durability or better, and will not be visually acceptable in all circumstances. The use of uncoated timber offers particular qualities of surface and is increasing in Scotland.

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CLADDING DESIGN IN MARITIME CLIMATES

It is sometimes asserted that external timber cladding is unsuited to the wet maritime climate of Scotland. The inaccuracy of this statement can be illustrated quite simply by pointing to timber-clad buildings that have performed quite satisfactorily for many years in some of the wettest places in Scotland.

Unlike Norway and Canada, where its use is commonplace, timber cladding in Scotland has a poor reputation for durability in some people's minds. This can be ascribed to a combination of factors:

- **Limited examples of good practice -**
Well-designed timber clad-structures are comparatively rare in modern Scotland. Timber cladding is most frequently seen on garden sheds, barns and temporary low-cost housing where little attempt has been made to design, construct or maintain for long term durability. As a result their performance has sometimes been poor.
- **Lack of skills -**
Because there is little recent history of timber cladding in Scotland, design and construction skills are often poorly developed. Even in countries like Norway where timber cladding is commonplace, designers and builders regularly make mistakes. Poor design, detailing or site practice are more common problems than any with the material itself.
- **Maintenance -**
The UK tends to have a culture of poor building maintenance. Timber is intolerant of poor maintenance and where failures occur, the material may be blamed when once again poor practice is the culprit. Timber external joinery has consequently lost out to uPVC which, because it requires little maintenance in the short term, gives the illusion of being maintenance-free. Properly-maintained timber external joinery will easily outlast uPVC products, but since the plastics industry has been more effective at marketing its products, timber has acquired a poor reputation as an external cladding material.



A late 19th century deer larder at Loch Hourn, one of the wettest places in Scotland. Well-designed and well-maintained timber cladding is suitable for our most maritime climates.

CLIMATE COMPARISONS

Contrary to popular perception, the main rainfall variation in the UK is not north-south but east-west. The drier eastern half of Scotland has an average rainfall of 250mm over the four summer months, a figure closely matching the drier eastern parts of England and Wales. In contrast, the west of Scotland has much higher rainfall, exceeding 1600mm per annum in many areas and paralleled by the wetter westerly regions of England and Wales. In Scotland the number of days per annum with heavy rainfall (over 10mm in 24 hours) range from 20 on the east coast to over 80 in most of the western Highlands. The highest figure is 120 days of heavy rain per annum around Fort William. Again, these figures are paralleled in the wettest areas further south⁽¹⁾. The west of Scotland thus has a very wet climate though, because of the coastal influence, it is also relatively warm for the northern latitude. Thus Scotland's climate is broadly comparable to other temperate maritime climates such as western Norway and British Columbia in western Canada.

The three areas have very similar climates in the Spring and late Autumn. There are however two significant differences:

- During Winter, Bergen's maximum temperature is below 5°C, the minimum threshold for fungal activity. In contrast, the maximum temperature in Onich and Vancouver may at times rise above this threshold. These differences may slightly affect how early fungal activity commences in the Spring.
- Bergen and Onich have broadly similar rainfall patterns throughout the year, whereas Vancouver is significantly drier in the Summer and early Autumn.

As a result of these differences it could be argued that Onich is at a slightly greater decay risk than Bergen or Vancouver. Temperature and rainfall are not, however, the only factors - wind exposure is also very important. Being close to, or on the path of, the Atlantic weather fronts, the frequency of strong winds is greater in Scotland than in less exposed climates such

as England and Wales⁽¹⁾. Broadly similar weather patterns are found in the narrow coastal zones of the Pacific north-west of America, southern Chile and Argentina, southern New Zealand, Japan and parts of the extreme western seaboard of Europe. In these areas wind speeds are strongest near coasts and over high ground and so there is a strong gradient from coast to inland exacerbated by surface roughness and mountains. Wind speeds in coastal British Columbia are, for example, much higher than those further inland. Similarly, winds are more extreme in northern Britain than in most of Scandinavia except for the coastal zone centred on Bergen in western Norway⁽²⁾. It is this combination of a large number of days of heavy rain combined with the strong winds that is characteristic of the weather over much of Scotland and the western coastal zones of Norway and British Columbia. The frequency and intensity of wind-driven rain tends to reduce the importance of the slight temperature and Summer rainfall differences. The three areas are thus broadly comparable in climate, with western Scotland and western Norway being the most similar.

CLIMATE CHANGE

A recent study commissioned by the Scottish Executive⁽³⁾ predicts that by the end of this century there will be the following changes to the Scottish climate:

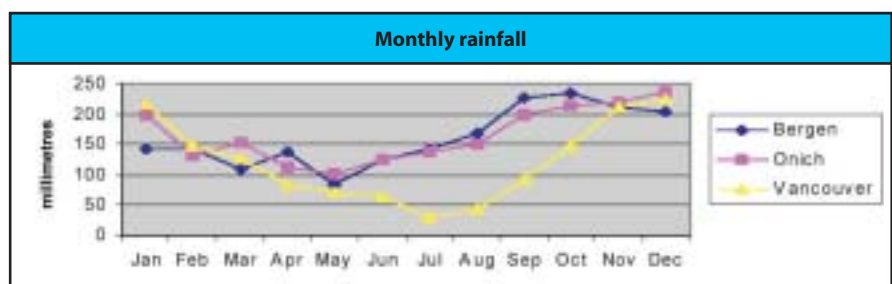
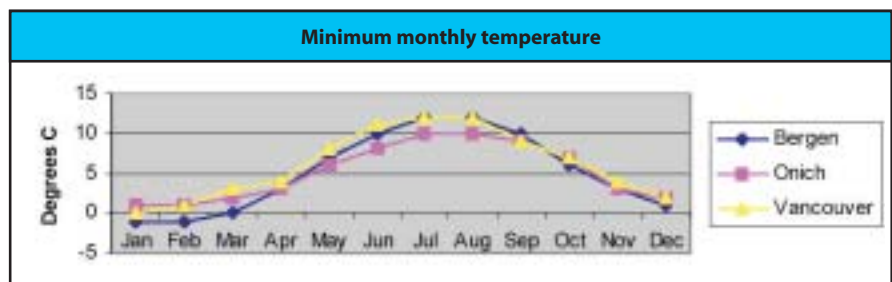
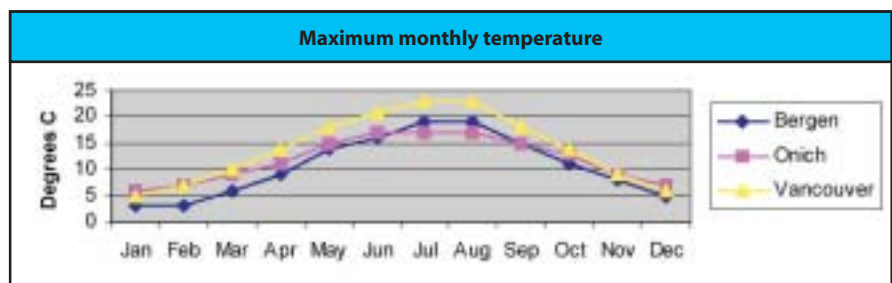
- An average temperature increase of 2° - 3°C will occur and precipitation will increase by around 20%;
- The coolest individual years in the period 2080 - 2100 are likely to be comparable with the hottest of recent years, e.g. 1990;
- Wind speeds are likely to increase throughout Scotland during all seasons, with corresponding increases in precipitation intensities.

Consequently it is anticipated that more of Scotland will be regularly exposed to periods of severe wind driven rain and the higher temperatures will result in conditions where fungal growth and insect activity could be sustained for a longer period of the year.

Fungal decay and insect attack on timber cladding in western Norway. This area has very similar decay and insect attack risks to Scotland.



CLIMATE COMPARISONS BETWEEN BERGEN, ONICH (NEAR FORT WILLIAM) AND VANCOUVER SOURCE: WWW.ONLINEWEATHER.COM





SPECIFICATION AND DETAILING COMPARISONS

The design of external timber cladding varies considerably between different countries. The most important technical difference is whether the cladding is designed according to rainscreen principles with a drained and ventilated cavity behind the exterior boards, or if the boards are simply fixed directly onto the underlying structure without any intervening cavity. In maritime climates, the control of wind-driven rain penetration into the wall is the most important technical consideration in cladding design. Rainscreen cladding achieves this through a two stage approach:

- 1 An outer rainscreen layer deflects most of the driven rain;
- 2 Behind this is a ventilated and drained cavity at the back of which is an air seal (the breather membrane).

Rainscreen claddings are used in areas exposed to heavy driving rain, while non-rainscreen cladding is generally restricted to use in drier climates. The rainscreen approach is not new and has long been used intuitively in many countries (including the UK). In the early 1960's, Norwegian and Canadian researchers made serious investigations of wall leakage and proposed solutions that are still the basis of current rainscreen cladding design^(4,5).

In the foreground, an open-jointed rainscreen cladding is used to protect the trusses of a timber bridge in Trondheim, Norway while, in the background tight-jointed rainscreens are used to protect the buildings, many of which are of log construction.

THE ACTION OF RAINWATER ON TIMBER CLADDING

Timber is a relatively porous material, and when rainwater continually strikes timber cladding it will tend to be absorbed until finally, when fully saturated, a film of water is formed on the surface. When the rain stops, this surface film dissipates and the absorbed water dries out through evaporation. Where rainfall continues, the surface film of water will - under the combined effect of gravity and wind action - tend to migrate down the boards and also laterally until the flow is concentrated at places where irregularities (such as joints) occur. Consequently the flow of water at vertical joints is much greater than the average flow down the wall. Additionally, near the top of windward-facing elevations, the wind may force rainwater upwards and into horizontal joints. At lower levels on the wall, heavy flows of rainwater can be sufficient to fill horizontal joints. The end result of all these movements is to concentrate the rainwater flowing down a wall at the joints, the most vulnerable point in the external cladding assembly⁽⁶⁾.

JOINT LEAKAGE PROCESSES

Five main processes force rainwater through joints or defects in the rainscreen⁽⁶⁾:

- 1 Kinetic energy - drops of rainwater may have enough momentum to carry them through open joints either directly or by splashing;
- 2 Surface Tension - water can adhere to and run across the underside of horizontal surfaces;
- 3 Gravity - The force of gravity will pull rainwater downwards through any openings;
- 4 Capillary attraction - water is drawn into narrow gaps that are bounded by wettable surfaces;
- 5 Air-pressure differentials - the most common form of joint leakage is due to wind-induced differences in air pressure. When pressure on the outer face of a wall cladding is greater than that acting on its reverse face, rainwater will be forced inwards.

Over the 40 years since these mechanisms of joint leakage were first described, the rainscreen approach to preventing moisture penetration into a wall has developed into two distinct techniques:

THE DRAINED AND BACK-VENTILATED RAINSCREEN -

This is the more common and less technically demanding technique. It is based on the assumption that, although most rain is deflected at the outermost surface of the cladding, there will always be some wind-driven rainwater penetration through joints in the rainscreen and this is removed by cavity drainage and ventilation. In its simplest form, drained and back-vented timber rainscreens consist of a series of planks fixed to support battens which are designed to allow uninterrupted drainage and ventilation of the cavity. The joints between the boards are generally quite tight, and are designed to obstruct the passage of wind-driven rain droplets. Due to the combined effects of gravity and wind-induced pressure differentials, the joints do not prevent leakage. Thus, during periods of heavy driving rain, relatively large amounts of water may penetrate the joints and run down the reverse of the cladding boards. Successful design depends upon preventing this water from reaching the inner leaf of the cladding assembly. In other words, the claddings are allowed to leak to some extent and no deliberate attempt is made to minimise the effects of wind by pressure equalisation. Instead the cavity is drained and ventilated in order to remove moisture⁽⁶⁾.

THE PRESSURE-EQUALISED RAINSCREEN -

This more demanding technique seeks to eliminate rain penetration through the cladding, not by tightly sealing the joints, but by leaving some or all of them open to the passage of air but not water. This is achieved by controlling kinetic energy, surface tension, gravity and capillary attraction through careful joint design, using similar principals to the drained and vented cavity approach. Rain penetration caused by pressure differentials is controlled by pressure equalisation of the cavity. Pressure equalisation is enabled by incorporating sheltered openings of adequate size within the rainscreen combined with compartmentalising the cavity into separate vertical spaces. Splitting the cavity into separate spaces prevents lateral air movements which would reduce pressure equalisation. Full pressure equalisation is impossible to achieve in practice and minor leakage will still occur. This is drained and vented away using the techniques for the drained and back vented approach^(6,9).

Both the drained and back-vented rainscreen and the pressure-equalised rainscreen incorporate a cavity behind the outer cladding. Confusion arises between the two because, whilst pressure-equalised rainscreens are designed in other materials they are difficult, if not impossible, to achieve in timber. In spite of this, various pressure-equalisation claims are regularly made for timber cladding that have little empirical basis. Anderson & Gill⁽⁶⁾ caution that:

... very little is known about the wind response characteristics of rainscreens. When designing the cladding assembly, no account should be taken of the fortuitous effects of cavity pressurisation unless the results of adequate research are available.



RECOMMENDED BEST PRACTICE ON THE WEST COAST OF CANADA

In the exposed coastal climate of British Columbia, a number of building companies are currently the subject of litigation claims concerning the failure of various external cladding materials. In Canada these failures are popularly known as the 'leaking condo' problem. The failures have been appearing since 1985 and as a result the federal government's housing agency, the Canada Mortgage and Housing Corporation, instigated a comprehensive research programme to identify and develop solutions to the problems.

Many of the cladding failures discovered in the coastal climate of British Columbia were caused by building details designed for a sheltered climate being introduced to more exposed conditions⁽⁸⁾. The use of non-rainscreen cladding (i.e. cladding without a drained and ventilated cavity) was a particular problem.

In addition to careful design that promotes drainage and ventilation of the cladding, Canadian researchers also recommend that all inaccessible structural and non-structural timber outside the breather membrane should be pressure-treated with a suitable preservative unless it is of a high natural durability. Canadian researchers do not believe that a surface coating will provide adequate weather protection to timber species with low natural durability⁽⁷⁾. While spruce and lodgepole pine claddings are treated with preservative, Douglas fir is used without pressure treatment but is given a surface coating. Western red cedar cladding is not treated when used for cladding, but pressure treatment is recommended for roof shingles⁽⁹⁾.

In British Columbia the current recommendations for timber cladding generally involve drained and back vented designs. However, on very exposed coastal sites it is argued that these types of design may not give sufficient protection against driving rain penetration. In such situations, the use of pressure-equalised timber cladding has been proposed though these proposals are hedged with caution:

Very few of these assemblies have been constructed, so construction detailing has not yet been fully developed⁽⁷⁾.

Watermarks on the inside face of external timber cladding. Wind-driven rain will tend to penetrate through joints and run down the rear face of cladding boards. This is removed by cavity drainage and ventilation.

RECOMMENDED PRACTICE ON THE WEST COAST OF NORWAY

In Norway, as in the rest of Scandinavia, virtually all external timber cladding is made from either European redwood or, more commonly, European whitewood (Norway spruce). No attempt is made to remove the sapwood and the use of preservative treatments are only recommended on coastal sites exposed to the full force of wind driven rain⁽¹⁰⁾. Less than 10% of Norwegian cladding is preservative treated and the detailing of most timber cladding there is generally very plain and follows established convention. Considerable emphasis is placed on cladding being well drained and ventilated and thus able to rapidly dry out after periods of wetting. Throughout Scandinavia this type of timber cladding is given a service life of 50 years in most conditions although poor detailing can reduce this figure considerably.

Norwegian timber cladding is almost always coated, generally with a fully opaque moisture vapour permeable coating. It is also well maintained through, for example, repainting the coating every 5-10 years, and replacing any boards that are damaged or starting to decay. The moisture-shedding properties of coatings are not, it is believed, as important in defending against moisture problems as adequate drainage and ventilation.

Both the heartwood and the sapwood of Norway spruce are relatively resistant to the uptake of moisture and for this reason whitewood cladding is preferred to the more permeable redwood. Norway spruce is also less

resinous than redwood and so less prone to resin staining on a warm, south facing wall.

Technical standards for timber durability and preservation are harmonised throughout Scandinavia. Thus, although Norway is not a member state of the European Union, its technical standards could be expected to be broadly in compliance with the European standards quoted in this study.

In contrast to the UK, Norwegian recommendations stress the importance of relatively tight cladding designs that seek to minimise the gaps where wind-driven rain can penetrate the outer rainscreen. It is believed open-jointed designs may put an undue reliance on the water shedding qualities of the breather membrane. This is because - even allowing for the best of modern breather membranes being very reliable - such designs are vulnerable to:

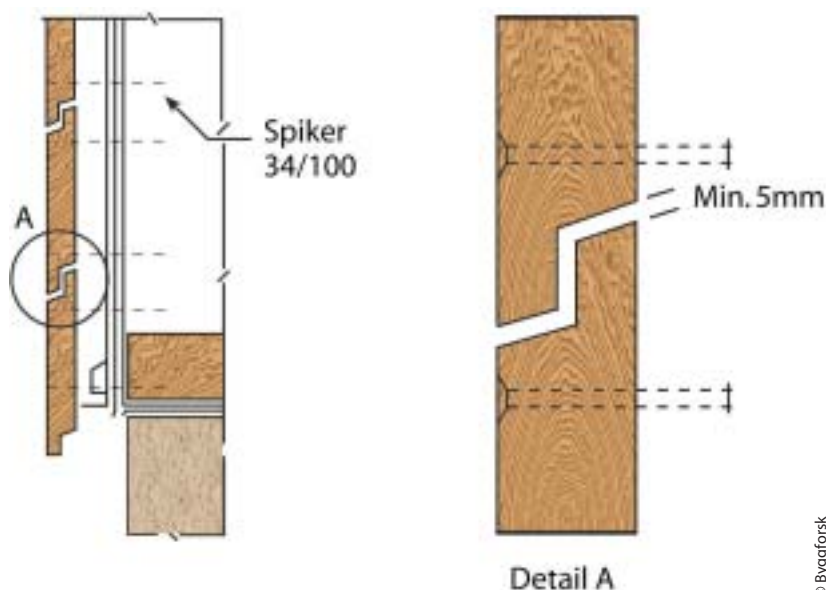
- Poor installation practice;
- Damage caused by vandals pushing sharp objects through the cladding joints;
- In extreme cases, particularly with open jointed vertical cladding, sunlight may penetrate the joint and cause UV degradation of the breather membrane.

Vertical open-jointed designs are not accepted at all because these can allow sunlight to reach the breather membrane leading to UV breakdown of the membrane. Current Norwegian guidance only includes one type of horizontal open-jointed cladding and this is only recommended for sheltered conditions⁽¹⁰⁾.

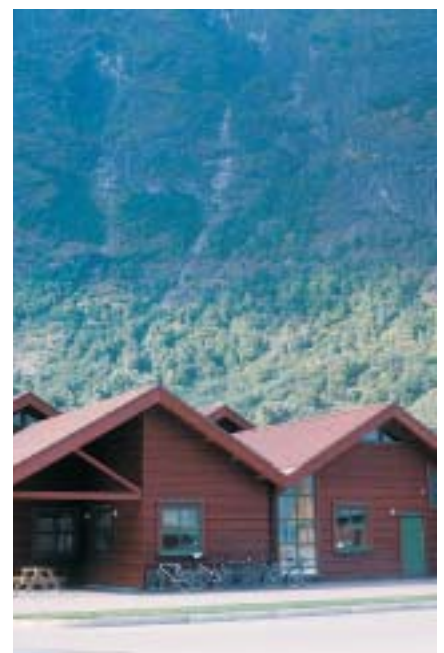


No attempt has been made to remove the (lighter coloured) sapwood of newly installed redwood cladding in Stavanger, western Norway. This cladding would subsequently have been painted with an opaque moisture vapour permeable coating.

An open-jointed cladding design recommended for sheltered sites in Norway. As with all open-jointed designs, it is not suitable for use as vertical cladding. This type of open-jointed design can be adapted for use with invisible clip systems, such a system is currently being marketed in the Netherlands.



Brightly coloured opaque coatings add vibrancy to buildings on the west coast of Norway.



Open-jointed, drained and vented cladding can take many forms. This visitor centre at Mount Stuart on the Isle of Bute by Munkenbeck and Marshall Architects uses horizontal timber louvers which, although they allow a considerable amount of rain to penetrate, will protect the breather membrane behind from UV damage. Open-jointed cladding appears to be suitable for sheltered sites in Scotland providing that it is understood that the breather membrane is required to do more work than would be the case with tighter cladding designs.



Keith Hunter

RECOMMENDED BEST PRACTICE IN SCOTLAND

In the UK, TRADA currently recommends that where cladding timbers are classified as being less than moderately durable, or where they contain sapwood, the timber should receive preservative treatment by impregnation⁽¹¹⁾. This view is essentially the same as Canadian guidance but contrasts strongly with Norwegian recommendations.

The requirements of the Building Regulations in England and Wales correspond to TRADA's recommendations. However Part B 2.2 of the Scottish Building Regulations corresponds more closely to Scandinavian practice in that the regulation permits timber of low natural durability to be used without preservative treatment providing the boarding can be readily replaced. The regulation states:

Materials, fittings, components, and other manufactured products or parts thereof whose suitability depends upon proper maintenance or periodic renewal must be readily accessible, or positioned so that replacement is reasonably practical⁽¹²⁾.

Under BS EN 460:1994, both approaches appear to be consistent with European standards. This standard reconciles the two approaches by putting the onus on the designer to decide what level of decay risk is acceptable for a particular cladding job. Where only a minimal risk is acceptable, or the site is very exposed, the specifier has little alternative but to specify an appropriate preservative treatment or a relatively durable timber. But where safety and economic considerations indicate that minor remedial action is acceptable, preservative treatment could be avoided, and even timber classed as being not durable might be used in many situations. It should be emphasised that:

- the low durability option requires that the owner of the building is aware of and accepts the possibility of greater ongoing maintenance;
- the cladding is designed so that the most vulnerable components are readily replaceable should the need arise;
- this approach presupposes a much higher standard of detailing, construction and maintenance than is common in the UK construction industry.

In contrast to Norway, current UK recommendations for timber cladding include designs for relatively open-jointed drained and back-vented claddings. These designs have a long history in sheltered continental climates^(10,13) and were first used in the UK on the Henley Rowing Museum (1998). Open-jointed designs such as Henley assume the cladding itself is not fully resistant to water penetration, and so the use of a high performance breather membrane behind the cladding cavity is essential to resist water penetration into the wall assembly. These types of cladding appear to be acceptable on most sites providing it is recognised that rain penetration through open joints places increased demands on the breather membrane. Indeed, they offer the advantage that, because they can accommodate a degree of timber shrinkage, green (i.e. unseasoned) oak can potentially be used. Green oak can be considerably cheaper than seasoned oak and may permit the use of homegrown oak in situations where it might otherwise be too expensive to use for cladding.

'Behind the Wall' in Falkirk by Zoo Architects uses green oak sourced from forests in the Trossachs for its exterior cladding.



Andrew Lee

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British Standards

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Housing at Graham Square Glasgow by McKeown Alexander Architects makes use of western red cedar cladding in an urban environment.



Keith Hunter

BEST PRACTICE IN SPECIFICATION AND DETAILING

SPECIFYING TIMBER SPECIES AND QUALITY

The National Building Specification for timber weatherboarding⁽¹⁾ cites BS 1186-3:1990 as the appropriate standard for specifying timber cladding and its fixing. This standard does however have several limitations:

- The timber quality grades in the standard are quite complex and are intended for timber sections to be moulded to fine tolerances. The grading requirements of cladding boards are not usually so demanding and in many cases even ordinary sarking timber is suitable for use;
- The timber cladding sections recommended in the standard are inconsistent with modern best practice requirements, e.g. the tongues are sometimes too small to be suitable and so some sections are more appropriate for internal wall linings;
- Some of the timber durability information given is inaccurate (e.g. the durability of home-grown Douglas fir), and the durability and wood preservation advice is not fully consistent with the European standards.

The following notes are intended to supplement the guidance in BS 1186-3:1990, providing points of clarification on timber species and quality grading.

SPECIES

Timber species from a wide spectrum of durability classes can be used quite satisfactorily for external cladding, and specifiers are sometimes unclear as to why such a wide durability range can be employed.

Three broad approaches exist to deciding the level of natural durability or preservative treatment required. These are implied in the European Standard BS EN 460:1994, although there are considerable difficulties in interpretation. The approaches are:

1 USING NATURAL DURABILITY

Providing the sapwood is removed, timbers classed as moderately-durable or above generally have sufficient natural durability to be used in Hazard Class 3 conditions without preservative treatment.

The service life will vary as a result of both design details and the natural durability of the timber. Poorly drained and ventilated designs will reduce the service life while more-durable timbers will tend to last longer. The draft European Standard DD 239:1998 quotes a minimum 60 year service life for durable or very-durable timbers in Hazard Class 3 conditions and good detailing could be expected to extend this. Moderately-durable timbers might be expected to achieve a similar service life when carefully detailed for

| DURABILITY CLASS OF THE HEARTWOOD OF SOME COMMON EXTERNAL CLADDING TIMBERS | | | | | | |
|--|-----------------------------------|--------------|-------------------------|-----------------------|------------------|--|
| Durability class of heartwood | 1 very durable | 2 durable | 3 moderately durable | 4 slightly durable | 5 not durable | |
| Species used for cladding | Opepie | | | | | |
| | Iroko | | | | | |
| | European oak | | | | | |
| | Western red cedar | | | | | |
| | European, hybrid & Japanese larch | | | | | |
| | Douglas fir | | | | | |
| | European redwood/Scots pine | | | | | |
| | Norway spruce | | | | | |
| | | | | | | The sapwood of all these species is classed as being not durable |

SOURCE: BS EN 350-2: 1994

durability⁽²⁾. Where detailing is poor, however, DD 239:1998 cautions that the minimum service life is only 30 years, and it would be prudent to use a durable or very-durable timber for exterior structural uses or where a component would be very difficult to replace or might constitute a health and safety risk if it failed. Alternatively, preservative-treated timber could be used.

From a durability viewpoint, surface coatings are not necessary with these timbers. If the timber is to be left uncoated, however, building owners must be prepared for the inevitable - and sometimes unpredictable - surface changes that will occur as the timber weathers. With correct practice, the use of naturally-durable timbers can give reliable results but this approach is vulnerable to poor timber grading (e.g. failure to remove the sapwood) and to inappropriate species selection.



2 USING TIMBER PRESERVATION

It is accepted practice in the UK that where timbers used in Hazard Class 3 are designated as less than moderately-durable, or where they include sapwood, the timber should receive preservative treatment by impregnation to the specifications in the European Standards. Where best practice is followed, the Draft European Standard DD 239: 1998 states that preservative treatment can provide a reliable service life of 60 years.

Where preservation treatment or site practice do not conform to European Standards, however, adequate durability cannot be guaranteed from the use of preservatives alone. Stringent quality control is therefore essential at both the preservative treatment and construction stage and, if in doubt, it should be ensured that compliance with the requirements of the European Standards can be demonstrated.



TOP

Approach 1 - using natural durability.
Oak shingles on the Koldinghus Museum in Denmark.

CENTRE

Approach 2 - using timber preservation.
Preservative treatment has been used on roof and wall cladding at Stavanger, western Norway as the roof is exposed to a considerable decay hazard.

RIGHT

Approach 3 - using careful detailing.
Redwood cladding in Stavanger, western Norway. In common with most cladding in the area, the boards are well-detailed for drainage and ventilation and have been given a water-repellent but moisture vapour permeable coating.



3 USING CAREFUL DETAILING COMBINED WITH MEASURES THAT REDUCE MOISTURE UPTAKE

An alternative (but much more controversial) approach to using timber of low natural durability in Hazard Class 3 conditions is to avoid using wood preservatives and instead to use careful detailing in combination with a water-repellent but moisture vapour permeable coating which is regularly re-applied. The use of timbers with relatively impermeable sapwood (e.g. Norway spruce) may also be beneficial. This approach is widely used in Scandinavia (including the western coastal zone). In Scotland it is used by some window manufacturers and is surprisingly commonplace with timber cladding. Indeed it is probably the most common approach to specifying timber cladding on housing. Although this approach is implied in BS EN 460:1994 it is not explicitly described in any of the current standards and there are many uncertainties and anomalies surrounding its use. Consequently the comments given here are only intended to highlight the approach and the uncertainties surrounding it. Further research is needed and, until this becomes available, these techniques should be used with caution.

In this approach the use of careful detailing to promote drainage and ventilation is the most important factor, and where such detailing for durability is not present, surface coatings by themselves do not provide sufficient protection against biological degradation. Consequently, this approach requires a much higher standard of detailing, site practice, and maintenance than is common in the UK construction industry.

Where detailing is poor, the service life of the component will be very limited. The draft European Standard DD 239:1998 quotes a minimum service life of only 15 years for slightly-durable or not-durable timbers used in Hazard Class 3 conditions without preservative treatment. This is probably correct when poor detailing and site practice is in evidence, but in western Norway the service life of cladding designed for durability and suitably coated is generally accepted as being around 50 years, even where slightly-durable or not-durable timber is used. Severely exposed coastal sites will reduce this service life and in such conditions the use of other approaches (i.e. preservative treatment or naturally-durable heartwood) is recommended.

This approach is generally acceptable under Part B2 of the Scottish Building Regulations providing that the cladding is designed to be easily repaired or replaced should decay occur and that, were a component to fail, it would not pose a structural or health and safety hazard. Where structural or health and safety considerations exist, preservative treatment or naturally-durable heartwood should always be used.

There are a number of useful questions which help identify the most suitable species or group of species for use in specific timber cladding situations:

- What cost is acceptable?**
Hardwood cladding timbers and western red cedar are usually two or three times more expensive than most softwood cladding timbers. Less expensive timbers are perfectly suitable for many applications;
- What is the anticipated maintenance regime?**
Regular maintenance allows a wider choice of species and finishes to be used. If maintenance is likely to be poor, it would be prudent to use a relatively-durable or preservative-treated timber;
- What is the desired service life?**
The service life of external cladding is difficult to predict since many factors affect it. However, preservative treatment or a durable or very-durable timber should always be chosen for buildings requiring particularly long service lives;
- How exposed is the site?**
Sites prone to severe wetting may require a more-durable timber than sheltered sites. Alternatively, preservative treatment by impregnation might be specified to protect the timber;
- How easy or acceptable is it to replace boards that have started to decay?**
Durability may not be so important if building owners are happy to undertake repairs, should they become necessary;
- What type of detailing is used?**
Simple traditional details generally cause fewer decay problems. Other types of detailing may require preservative treatment or more-durable timber. Movement is an issue, as some types of detail can more easily accommodate shrinkage and swelling than others which may require the use of a low movement class species;
- Will timber be coated or left to weather naturally?**
All uncoated timber eventually weathers to a silver-grey colour, with the speed of weathering varying between species. If cladding is to be left uncoated, then the heartwood of at least a moderately-durable species should be used. Alternatively, the timber could be impregnated with a preservative that is immune to leaching;
- Will cladding be exposed to vandalism or incidental damage?**
Low-density timbers such as western red cedar are easily damaged and should never be used on sites prone to vandalism or accidental scrapes. Denser timbers such as European oak or European larch should be used instead;
- Is preservative treatment acceptable?**
Where preservatives are acceptable, only timbers of low natural durability generally need be used. However, where preservatives are not acceptable then either a more durable species should be used, or the cladding could be detailed to allow ready-replacement of boards if there are problems. In such instances, designers should ensure that building owners are aware of - and accept - the potentially greater risks of timber decay and increased maintenance costs.
- Do you wish to use home-grown timber?**
The principal moderately-durable or durable timbers which can be sourced in Scotland are European larch and European oak. A wide range of lower-durability timbers are available and in some circumstances these may be suitable for use as cladding.

| SELECTING A SPECIFICATION APPROACH ON THE BASIS OF TIMBER PROPERTIES AND PRICE | | | | | | | | | |
|--|---|------------------------------------|--|---|----------------|--------------------------------|---|--|------|
| Common name Plus origin where important | Durability class Of heartwood against fungal decay | Movement class | Density range & mean density Kg/m ³ | Treatability class ¹ | | Relative price ² | | | |
| | | | | Heartwood | Sapwood | | | | |
| Opepe ³ | Very durable | Small | 740-750-780 | Moisture permeability is not generally important when these species are used as cladding | | High | | | |
| Iroko ^{3,4} | | Small | 630-650-670 | | | | | | |
| Robinia ⁴ | | Medium | 720-740-800 | | | | | | |
| Sweet chestnut | Durable | Small | 540-590-650 | | | | Moisture permeability is not generally important when these species are used as cladding | | High |
| European oak | | Medium | 670-710-760 | | | | | | |
| Western red cedar North American | | Small | 330-370-390 | | | | | | |
| Douglas fir North American | Moderately durable | Small | 510-530-550 | | | | | | |
| European larch ⁵ | | Small | 570-600-650 | | | | | | |
| Western red cedar Home grown | | Small | 330-370-390 | | | | | | |
| Redwood/Scots pine ⁴ | Moderately durable or slightly durable | Medium | 500-520-540 | 3-4 | 1 | Low | | | |
| Douglas fir ⁴ Home grown | | Small | 470-510-520 | 4 | 2-3 | Medium | | | |
| Lodgepole pine ^{4,7} | | Small | 430-460-470 | 3-4 | 1 | Low | | | |
| Norway spruce | Slightly durable | Medium | 440-460-470 | 3-4 | 3 ⁹ | | | | |
| European elm ⁸ | | Medium | 630-650-680 | 2-3 | 1 | High | | | |
| Japanese or hybrid larch ^{5,7} | | Slightly durable or not durable | Small | 470-600-650 | 4 | 2 ⁹ | Low | | |
| Western hemlock ⁷ Home grown | Small | | 470-490-510 | 2-3 | 1 | | | | |
| Sitka spruce ^{4,7} | Small | | 400-440-450 | 3 | 2-3 | | | | |

| KEY | |
|--|--|
| Using natural durability | Approach 1 The heartwood of these species is generally suitable for use as external cladding without preservative treatment or a water repellent coating. Sapwood should always be removed. |
| Using timber preservation | Approach 2 The standard approach to using these species for external cladding is to pressure treat the timber with a suitable preservative. Sapwood is not removed. Species that can be easily treated with preservatives are preferred. |
| Using careful detailing combined with measures that reduce water uptake. | Approach 3 An alternative, but more uncertain, approach is to use careful detailing to promote drainage and ventilation, combined with a water repellent, but moisture vapour permeable, coating. The sapwood is not removed and so the use of a species with relatively impermeable sapwood may also reduce moisture uptake. Regular maintenance is essential with this approach. |

NOTES ON THE TABLE

- 1 Treatability is used here as a broad indication of the moisture absorbing characteristics of a timber. Although originally intended as a description of how easily a timber can be penetrated with preservatives, treatability is also used in BS EN 350-2:1994 to describe the permeability of timber in service. In this standard easily treated timbers are therefore assumed to be highly permeable to moisture and vice versa (It should be highlighted that treatability does not directly equate to permeability to moisture and that this is a complex issue in need of further investigation) The classification used in BS EN 350-2 is as follows:
- Class 1** easily treated
Class 2 moderately easy to treat
Class 3 difficult to treat
Class 4 extremely difficult to treat
- 2 The following figures indicate the relative prices of cladding timber:
- High** These timbers are expensive and, in 2000-2001, were generally priced at between £20-£35m² when sold for cladding.
- Medium** These timbers are about half the price of durable or very durable timbers and, in 2000-2001, this cladding was generally priced at £10-£15m²
- Low** These timbers are about half the price of moderately-durable species and, in 2000-2001, cladding from these timbers was generally priced at £5-£7m².
- Elm cladding boards cost around the same as durable timbers such as oak. This may seem anomalous, but until the mid-20th century elm was considered a low-value utility wood. Availability has declined since then due to Dutch elm disease;
- 3 Tropical species may be protected under the Convention on International Trade in Endangered Species. If in doubt, proof of independent forest management certification should be requested;
- 4 Where the durability of a species spans two durability classes, designers generally have no alternative but to assume the timber is in the lower class. This is a common problem with Douglas fir where homegrown timber is incorrectly assumed to be of equivalent durability to that originating in North America, see BS EN 350-2: 1994
- 5 The standards do not distinguish between the durability of the three larch species, all of which are grouped as moderate- to slight-durability. The separation between European larch and the other larch species given in the table is based upon anecdotal trade experience in the UK⁽⁴⁾;
- 6 In addition to the low-durability class identified in the standards, anecdotal information suggests that homegrown western red cedar tends to be more knotty than North American timber and may be prone to drying problems;
- 7 In Scotland or Scandinavia, there is little experience of using these species for external cladding. Inclusion in this table is based upon their timber properties or on their use for external cladding in North America. Until more experience is gained in using these species for cladding in Scottish conditions it would be prudent to assume a limited service life or to impregnate the timber with a suitable preservative;
- 8 Where waney-edged elm boards (i.e. boards with sapwood) have been used for cladding it is likely that the boards were given a superficial coating of tar oil;
- 9 The sapwood of these species have variable treatability characteristics.
- The main information source for the above table and these notes is BS EN 460: 1994.
- Additional points of interpretation are drawn from:
 BS EN 350-2: 1994;
 DD 239:1998;
 TRADA, 1997⁽⁴⁾;
 Hislop, 2000⁽³⁾;
 Byggforsk, 1998⁽⁵⁾;
 Hamilton, et al., 1993⁽⁶⁾;
 and E & FN Spon, 1992⁽²⁾.

TIMBER QUALITY

Specifiers should always state the required quality of the finished cladding in order that suppliers know what level of defect is acceptable. The selection of suitable timber then normally happens in two stages - the supplier first selects suitable boards taking into account the species, whether it is to be painted or not, and whether sapwood is acceptable. This is then delivered to site where a further selection is made as the boards are being fixed. Where there is any uncertainty as to the timber quality required, the National Building Specification recommends specifiers request advance delivery of a small sample of the cladding boards so that a final quality specification can be agreed. To avoid subsequent dispute, the sample should include examples of the lowest quality which will be supplied.

BS 1186-3:1997 gives limits for the size of knots and knot clusters and, largely on this basis, grades timber into four classes: CSH, 1, 2 or 3. CSH grade is the most expensive as it limits the knots to a maximum of 6mm diameter. The other grades set varying limits on knot size depending upon the width of the board:

CSH - Not generally relevant to cladding as it is mainly intended for the grading of very small profiled sections. It is, however, suitable for very prestigious flush cladding panels made from tropical hardwoods or carefully selected European oak;

Class 1 - Suitable for most cladding designs where planed and flush jointed panels are used. It is generally available in imported Douglas fir and western red cedar, plus all the main hardwood cladding timbers, except elm. Where cladding boards are within normal sizes (i.e. circa 100-150mm wide) this class limits the diameter of sound knots to 22.5mm;

Class 2 - Generally considered suitable for unpainted boards in homegrown European larch. Many timbers of low-durability are also available at this grade. Where cladding boards are within normal sizes (i.e. circa 100-150mm wide) this class limits the diameter of sound knots to 35mm;

Class 3 - Generally considered adequate for painted cladding boards. Where cladding boards are within normal sizes (i.e. circa 100-150mm wide) this class limits the diameter of sound knots to 50mm, or no more than 35% of the board width.

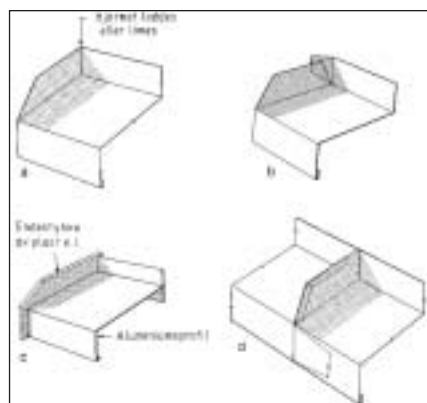
The standard distinguishes between the exposed and concealed surfaces of boards. Dead or unsound knots are permitted on exposed surfaces providing they are not loose. No limit is placed on the size or tightness of knots on the concealed face of boards. The standard also places limits on other features such as splits, resin pockets and grain angle. Sapwood is the most important of these, and the standard requires it be removed from the exposed faces of cladding boards unless the timber is to be pressure-treated with preservative. As already noted, the Scottish Building Regulations may permit this recommendation to be relaxed in some circumstances, providing sufficient care is taken with the detailing. Sapwood should, however, always be removed from more durable timbers such as European larch or European oak (there is no point in incurring the additional costs of using these timbers if removal of the sapwood is not insisted upon).

DETAILING FOR DURABILITY

All too frequently, exterior joinery such as cladding is designed with water traps and other details which put too much reliance on natural durability or preservative treatment. This should be avoided and the principals of detailing for durability should always be the first line of defence against decay. The principles of detailing for durability are⁽⁷⁾:

- ❑ To prevent wetting of the timber wherever possible;
- ❑ To ensure rapid drainage and adequate ventilation in situations where it is impossible to avoid wetting;
- ❑ To use naturally-durable or preservative treated timber in situations where wetting will be persistent.

In the context of external timber cladding using a drained and back-vented rainscreen approach, these principles can be expressed as the four D's: Deflection, Drainage, Drying, Durability⁽⁸⁾. The rainscreen serves to deflect most of the rain that would otherwise get blown into the wall. Any water that does get blown into the cavity is able to drain harmlessly away, aided by the drying effect of a cavity which has unrestricted airflow to the exterior. Finally, all the materials used to construct the rainscreen should be sufficiently durable to resist damage from moisture. The four D's provide a useful framework when considering the detailing of external timber cladding in exposed maritime climates.



ABOVE
Norwegian and Canadian recommendations stress the importance of good flashing design above and below windows.

Note the use of vertical upstands at the back and sides.

DEFLECTION

Using architectural features (such as eaves) to control water sources by deflection can have enormous benefits in a maritime climate. If most water is diverted before it impacts on, or is able to wet, the wall then the requirements for drainage and drying mechanisms are considerably reduced.

OVERHANGS

A survey of building failures in the coastal areas of British Columbia⁽⁹⁾ identified a direct relationship between the frequency of problems and the width of the eaves overhang. Large eaves could be beneficial on low-rise buildings in Scotland, though this recommendation requires cautious interpretation when applied to very exposed sites (e.g. the Western Isles) where uplift forces due to wind acting on a building can be severe. The provision of large eaves is not generally a part of 'traditional' building practice in Scotland, however, and there may be planning issues where such details are proposed in close proximity to more traditional buildings. Interestingly, 19th century railway stations in Scotland have large eaves.

TOP FLASHINGS

Where large eaves are not appropriate, it is still vital to protect the top of a cladding panel, with a flashing used to deflect water off the wall and protect any endgrain that might be exposed to wetting. The normal UK recommendation is for the flashing to project from the wall by 50mm. Any intermediary flashings at storey height should have similar projections⁽¹⁰⁾.

SPLASHLINES

A common detailing failure occurs where timber cladding has been taken too close to the ground or other horizontal surface. The base of a wall is always subject to splashes of water and serious wetting can occur if the timber is not kept above this 'splashline'. In the UK and Norway, the recommendation is a gap of at least 100mm where the splashing risk is minimal, though a gap of 150mm would be preferable in most cases. A gap of 250mm or more is required below any exposed walls where the risk of splashing may be high^(3,5).

SHELTERED OPENINGS

If moisture problems are to be avoided, the detailing of windows and door openings through the cladding requires particular care. Air leakage and penetration of driving rain at the sides and base of windows are the greatest problems. In exposed conditions windows and doors should be set well back in the wall section and fixed to the inner leaf of the building in such a way that they will be sheltered and not exposed to water running down the inside of the cladding^(5,11). These details are recommended in Scotland, but are much less common in England and Wales where windows are often set forward in the outer leaf of the wall section. Unfortunately, because much of the technical guidance available in Scotland is produced for English conditions, it is sometimes difficult to find window and door details suitable for exposed sites and, as a consequence, inappropriate window details are frequently used. By contrast, Norwegian recommendations⁽⁵⁾ provide examples of window openings in timber-clad buildings designed for the full range of Scandinavian climate conditions and their approach should be adopted in the UK.



Timber should be kept above the 'splashline' - in this case the minimum 100mm has been used, although in most cases a larger gap of up to 250mm offers better protection.

**FAR LEFT**

Watermarks indicate water is flowing down the back of the cladding during periods of driving rain. This should be allowed to drain away, but in this case the cavity has been closed at its base, with consequent potential for decay problems.

LEFT

Support battens create a well-drained cavity. Note the insect mesh at the base of the cavity.

DRAINAGE

Any rainwater not deflected from the cladding will tend to be drawn down the wall by gravity. The volume of run-off increases with the height of the building, but the path of any run-off is not always straight down, since wind will tend to push the water sideways. While the external face of the cladding should be able to deflect most wind-driven rain, it must always be assumed that some water will penetrate through it. Detailing should enable this to drain down the cavity and out through unrestricted openings at the base. In the UK, the cavity width for drained and back-vented cladding is recommended to be at least 19mm⁽¹⁾. This is a minimum width and, in general, the principle is that the more open the cladding joints, the wider the cavity required.

A WELL DRAINED CAVITY BEHIND THE CLADDING

Water penetrating through cladding joints tends to run down the back surface of the boards where it can be intercepted and drained back to the outside. The cavity is maintained through the use of spacing battens and these should be designed to enable water to drain freely - battens are generally spaced at 600mm centres to give adequate support to most types of timber cladding. Where movement-prone timber (e.g. 'green' oak) is used, however, the spacing should be reduced to 400mm to provide additional support⁽²⁾. Care should be taken to ensure that horizontal battens do not block cavity ventilation. This usually requires the use of separate counter battens behind the horizontal battens. The base of a drained cavity should always allow free drainage and airflow, and all openings into the cavity should be fitted with an insect mesh.

BREATHER MEMBRANES

A separate breather membrane is normally required behind the cavity, functioning both as an air seal to prevent wind penetration into the wall structure, and as a second line of protection against water penetration. Because of this dual role, the membrane should always be a high performance material not prone to tears or to wicking of moisture. TRADA⁽⁴⁾ recommend that only membranes classed as Type 1 under BS 4016: 1997 be used.

FLASHINGS

Water flowing down the back surface of the cladding boards should be drained out of the wall assembly through the use of flashings. Poor flashing details are a major cause of moisture problems in timber cladding. One of the most common detailing mistakes is the failure to maintain a sufficient gap between the base of cladding boards and the flashing. This gap is vital for drainage, ventilation and to prevent the timber (particularly the endgrain) absorbing moisture due to contact with a wet, impermeable material. In the UK, this gap is recommended as 10 mm in most cases⁽³⁾. Flashings may be needed at the base of walls, at storey height horizontal breaks, and above and below openings. Flashings should always be sloped to the outside and wherever one is interrupted it should have end dams to prevent water running off the ends.

WINDOW AND DOOR FLASHINGS

As with timber cladding, the detailing of windows and doors against wind-driven rain should always incorporate a two-stage approach in which the primary rain screen is separated from the secondary wind seal by a drained and vented cavity⁽⁵⁾. The junction

between the frame and the cladding should be protected behind a cover board (the 'check reveal') which overlaps the frame by 10-20mm⁽¹¹⁾. In this case, wooden window sills are insufficient to span the 80mm or more required to reach the outer surface of the cladding, and consequently separate sills are required which - in the case of a timber-clad building - are normally achieved through the use of metal flashings. It is easiest to achieve a wind and watertight seal around the window when the upper edge of sill flashings (where they tuck under the window frame) is flush with, or slightly outside of, the breather membrane that provides the air seal on the wall. Flashings around openings should project from the wall by a minimum of 50mm⁽⁵⁾.

Detailing of flashings around openings requires particular care, and these details are poorly described in most UK literature. Norwegian and Canadian recommendations state that window sill flashings require vertical upstands of at least 20mm at the back and sides to control water leakage^(5,8). Both countries recommend corner joints be made waterproof. Flashings can be made from galvanised or stainless steel, copper, lead, aluminium or plastic and - depending upon the material - the corner junction could be waterproofed by welding, gluing with epoxy resin, folding without cutting, or the use of special end pieces. Gluing with silicon does not give long term protection^(6,11). The base of timber cladding boards forming the window jamb should be in front of, and overlap, the vertical upstand of the flashing. They should, however, be stopped so that the endgrain is separated from the flashing by a gap of at least 6mm in order to avoid endgrain take-up of moisture^(5,12).

These details describe best practice from a detailing-for-durability viewpoint. Unfortunately there appears to be a conflict in the Scottish Building Regulations between the need to maintain unrestricted cavity drainage above a window or door, and the requirement (under Part D of the regulations) to provide a cavity barrier around an opening. The intention behind this requirement is to restrict the spread of smoke and flame from the room of fire origin into the cavity and to restrict the fire spreading between cavities.

In the case of low-rise housing, the requirement for cavity barriers above openings in timber cladding may be relaxed in practice. This is probably because (providing other parts of the structural fire regulations are adhered to) the risk of fire spreading into the cavity is outweighed by the risk of timber decay due to inadequate cavity drainage⁽¹³⁾. Where the requirement is relaxed then the accompanying window details are consistent with the detailing advice given here, however these details are not definitive and their use would need to be approved with local Building Control officers.

In some cases, cavity barriers above openings will be required and, where this occurs, the durability of the cladding assembly could be compromised. A possible solution to this problem is to use cavity barriers made from 50mm thick wire-reinforced mineral wool which should permit a minimum level of drainage and ventilation⁽¹³⁾. Further research and guidance on this issue would be beneficial.

OVERSAILS

In many circumstances, an alternative to flashings is to ensure the cladding oversails the surface below. Once again, a suitable drainage and ventilation gap needs to be maintained.

AVOID HORIZONTAL SURFACES IN EXTERNAL TIMBER

Exposed horizontal, or near-horizontal, surfaces in external joinery such as windows or cladding drain slowly and therefore, prone to wetting, should be avoided or protected by a suitable flashing. Some species (e.g. oak) are particularly vulnerable because the timber is prone to staining if it remains wet for extended periods.

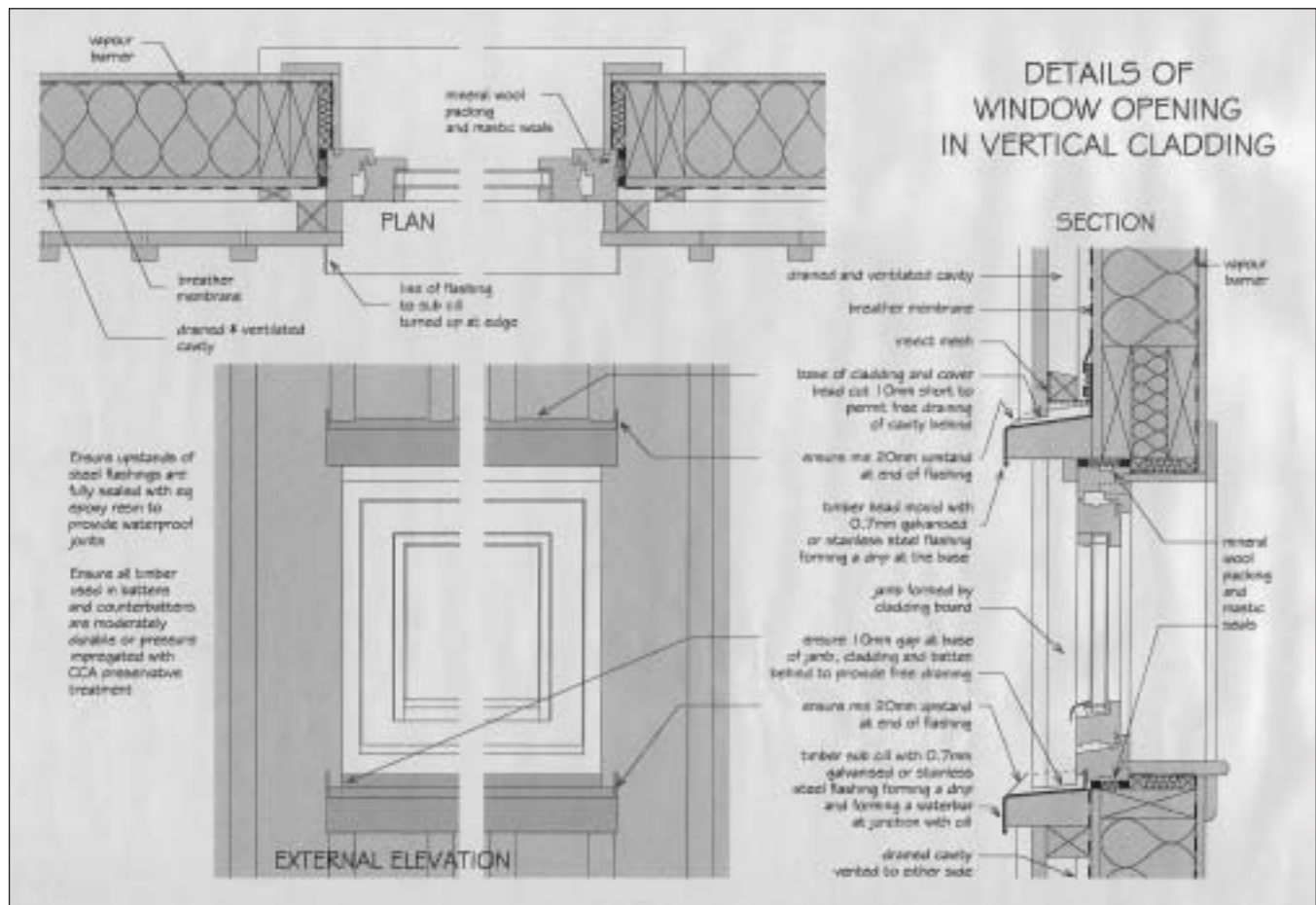
AVOID WATER TRAPS

Some types of detailing create watertraps which can lead to decay problems, and the use of diagonal cladding is particularly prone to this. Complicated or over-fussy detailing can also lead to problems and should be avoided in exposed maritime conditions - simple conventional details generally work best and have helped to inform the plain Scottish aesthetic

KNOT ORIENTATION

Many 19th century softwood-clad buildings in Scotland demonstrate a conscious attempt to arrange the boards so that the slope of the knots through the boards went upwards from the outside to the inside of the cladding assembly. This reduced the potential for water leakage through the knots. Assuming (to control movement problems) the heartwood side of the board closest to the pith is installed towards the outside of the building, the root-end of the board requires to be pointed downwards on the wall. Victorian buildings were erected in the days before rainscreen cladding design was introduced in Scotland, and so maintaining a leak-proof cladding was very important. This technique would have significantly reduced the amount of water able to penetrate the cladding, but with outer cladding nowadays drained and back-vented, this is less important. Nonetheless, it is still identified amongst the board grading options in current Norwegian recommendations⁽⁵⁾. Such techniques are impossible with horizontal cladding boards (which may be slightly less durable as a result) and are not relevant to hardwood cladding because of the smaller number of knots.

Schematic window details for use in exposed Scottish conditions.





Elm cladding oversails the brick plinth to provide a gap for drainage and ventilation.

DRYING

The breather membrane providing the inner air seal should be kept as dry as possible. In principle, the provision of adequate ventilation behind the cladding will increase the capacity for drying and thus reduce the amount of water reaching the inner surface of the cavity. There are two schools of thought regarding the degree to which cavities should be vented at the top. In the UK and Norway it is recommended that a gap of 6mm be maintained at the top of a cladding cavity. This increases the volume of air passing through the assembly and thus the potential to dry the cavity through evaporation. Conversely, in British Columbia it is argued that venting the top of the cavity - particularly at the top of a high or exposed building - may result in a negative air pressure being created within the cavity which will tend to draw water into cavity from outside. Because of this risk, Canadians take the view that cavities should not be ventilated at the tops of walls⁽⁸⁾. The main points to note are:

VENTILATION GAPS

Providing there is an adequate drainage gap at the base of the cladding cavity, adequate ventilation will also exist. Following Norwegian experience, it is important that further ventilation is provided higher up the wall. This must happen at points where wind-driven rain does not reach. Depending upon the building design, such points generally include: below and above windows; at horizontal storey-height wall flashings; and under the roof overhang. Cladding of one storey-height or higher must be ventilated at the top and the bottom, whilst cladding over only part of a storey-height can be ventilated at the bottom only. In severely exposed areas, cladding should be detailed so that water can exit at each storey level. Where openings are not provided below windows, the air cavity requires connections to allow free air movement into the areas to the side which may otherwise be blocked by the vertical support battens^(3,5,8).

PROVIDING FOR SHRINKAGE AND EXPANSION ACROSS WIDTH OF BOARDS

Timber cladding changes dimension slightly as it gains and loses moisture. For tongue and groove or other profiles that have little capacity to accommodate movement, the maximum board width recommended is 100mm, with 150mm the normally recommended maximum width for other boards^(3,5). Narrow boards are less prone to movement problems and, where tongue and groove boarding is to be used, the boards should be no more than 100mm

wide. The tongue or overlap should always be of sufficient width to accommodate possible shrinkage without becoming disengaged. Generally, tongue-widths should not be less than 9mm, and commercial profiles which provide tongue-widths of 6mm or less should be avoided. Board-on-board designs are the most suitable where boards over 100mm are being used, though, providing there is sufficient thickness, a 20mm rebated overlap may be used on boards up to 150mm width. To minimise water penetration through the joints 100-150mm wide cladding boards normally need to be detailed with joint overlaps of 15-25mm. A 2mm expansion gap should normally be provided between all cladding boards. Board thicknesses are between 16-22mm depending on the profile used.

Where possible, cladding should always be installed so that the inner heartwood side of the board is facing outwards on the wall, thereby minimising movement problems should the boards dry out in-situ. Where board-on-board designs or rebated overlaps are used, nailing through two overlapping boards should always be avoided as this restricts board movement and increases the danger of splitting^(3,5).

When used as cladding, green oak (i.e. unseasoned oak) will shrink by at least 7% across the board width as the timber dries. During the first year this can equate to 10mm or more over a 150mm wide board. Detailing needs to accommodate this and the options include overlapping boards, oversize holes around fixings, and open jointed designs.

SUPPORTING BOARDS ADEQUATELY

Boards are fixed to support battens to create a drained and ventilated cavity. A continuous air gap is essential and, with vertical cladding, counter battens will usually be needed to ensure cavity ventilation is maintained. Some types of board-on-board claddings have a sufficient gap behind the outer board and, in such cases, counter battens may not be needed on moderately sheltered sites. In the UK, no more than 600mm between support battens is recommended. However, where very movement-prone timber (e.g. unseasoned green oak) is used, this distance should be reduced to 400mm⁽³⁾.

COATING BOARDS BEFORE FIXING

If boards are to be given a coating, the primer and at least one top-coat should be applied before they are fixed to the wall. This avoids the problem of boards shrinking in-situ and exposing uncoated surfaces. It is also desirable to coat the rear of boards at the same time as this reduces the risk of wetting due to water running down the inside of the cavity.



Vertical cladding installed below a window opening.

Note: The rear board has been coated before installation to allow for subsequent shrinkage of the outer board. The outer board is installed so that the inner heartwood side of board is facing outwards on the building. The boards have good overlaps. The fixings have been placed so as to avoid going through both overlapping boards. Counter battens are not generally needed with this type of cladding as there is adequate ventilation behind the outer board.

DURABILITY

Timber cladding can become saturated during periods of driving rain. Moreover, the high rainfall and relatively mild climate in parts of Scotland can lead to very high levels of relative humidity occurring, particularly in the winter months. Consequently, although cladding assemblies may be well drained and vented, there may still be a risk of the timbers being damp for extended periods. In such circumstances there may be an increased risk of fungal decay and insect attack whenever the temperature is warm enough. There are also corrosion risks with ferrous metals and aluminium, as well as weathering risks due to moulds and UV light. The two main durability points to remember are:

- 1 All inaccessible structural and non-structural timber outside the breather membrane needs to be either pressure treated with a suitable preservative or be made from the heartwood of at least a moderately-durable timber. Under the Scottish Building Regulations, if the cladding boards are easily replaceable - and would not constitute a health and safety risk if they failed - this requirement need not apply to the cladding itself. On exposed or coastal sites, however, cladding boards should always be pressure-treated with a suitable preservative or made from at least a moderately-durable timber. Support battens in drained and vented cavities cannot be easily replaced without considerable disruption to the cladding, and so should always be of naturally-durable or preservative-treated timber
- 2 At moisture contents above 20% all timbers are acidic due to the breakdown by water of wood cellulose into acetic acid. No wood species is immune to this process and, as a result of the corrosive effect of acetic acid, both mild steel and galvanised mild steel fixings can cause unsightly staining on timber cladding. More corrosion resistant materials such as stainless steel are preferable for embedded fixings and should always be used with uncoated cladding. Stainless steel fixings are readily available from specialist suppliers. Only austenitic stainless steels have sufficient corrosion resistance for use in cladding, with type 1.4301(304) stainless steel recommended for most cladding applications, and the more durable type 1.4401(316) recommended for coastal sites⁽¹⁴⁾. Non-ferrous fixings such as silicon bronze could also be used and are sometimes supplied with western red cedar cladding. They are also readily obtainable from marine chandlers.



A durable timber such as European oak or imported western red cedar is essential in situations where maintenance would be prohibitively expensive.



Galvanised steel fixings are not suitable for use with uncoated external timber cladding - only two weeks after galvanised steel fixings were embedded in unseasoned European larch cladding, unsightly black stains have occurred.



Because the support battens behind the outer cladding are difficult to replace, they should always be preservative-treated or be of moderately-durable timber.

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Keith Hunter

HOMEGROWN EUROPEAN LARCH

CASE STUDY

SCOTTISH SEABIRD CENTRE, NORTH BERWICK SIMPSON & BROWN ARCHITECTS

In the short time since it opened, the new Scottish Seabird Centre in North Berwick has proved to be one of Scotland's most successful visitor attractions. The building is connected by video links to islands in the Firth of Forth, bringing live action of Fidra's puffins and the Bass Rock's huge gannet colony onto screens in the Centre. Given its environmentally-sensitive purpose, it was entirely appropriate that the design concept should set out produce a 'green' building, using natural materials where possible, and local ones where obtainable.

Perched on a rocky promontory (the former site of the 1930's Harbour Pavilion), the building's unusual shape is formed from three materials: stone, timber and a swooping asymmetrical copper roof. The architects gave careful consideration to the environmental impact of each of the materials used and the north and west elevations, formed from a battered, drystone rainscreen, rise steeply from

sea level in echo of the coastline's rugged form. The east elevation, by contrast, sits in the shadow of the roof's deep eaves and is a carefully-articulated curving wall of vertically-arranged timber cladding.

The vertical cladding is formed from ex 25 x 100mm square-edged European larch (heartwood only) boards centre-fixed to timber battens and counter-battens with 30mm stainless steel ring-shanked nails. The timber was specified to meet BS1186 - 3: 1990.

A moisture content of 13-19% was required in the timber at the time of fixing, and a high-performance breather membrane was used. No coatings were applied to the timber cladding, the architects preferring it to weather to silver-grey. From the outset, the architects' accepted the potential for the natural timbers used to warp and twist slightly, and have detailed the building accordingly.



Keith Hunter

HOME GROWN DOUGLAS FIR

CASE STUDY

**RENEWABLE ENERGY OFFICE FOR NATURAL POWER,
DALRY, DUMFRIES AND GALLOWAY**

NEIL SUTHERLAND



Neil Sutherland

The recent winner of the Association for the Protection of Rural Scotland's 'Creative, Native and Innovative' Award, Natural Power's new 20 person eco-office is a consummate exercise in the use of home-grown timbers. All of the wood employed - with the exception of a few pieces of Oak handrail obtained from mainland Europe - was sourced in Scotland, with around 60% of it coming from nearby woodland owned and managed by the client.

Three softwood species (Norway spruce, European larch and Douglas fir) and two hardwood were selected for their practical characteristics. The softwoods were chosen from 45 year old stands of trees and the resulting 120 tonnes of logs were converted using a portable mill in the estate yard. The converted timber was stacked there and seasoned over the summer of 2000. A small quantity of Douglas fir (some 5 cubic metres) was kiln-dried locally for internal fit-out purposes.

Exposed posts and trusses made from large section Douglas fir form the building's mortise and tenon jointed timber frame (with steel connectors and steel wire used for the tension members). The 25 x 150mm vertical cladding is formed from Douglas fir heartwood, with the same material used for soffits, barge-boards

and fascias. Although homegrown Douglas fir is classed as being less durable than imported timber this is not seen as a problem in this case because the cladding is carefully detailed for drainage and ventilation and because it is painted with a water-repellent surface coating. The horizontal counterbattens behind the cladding are however made from European larch heartwood, chosen because water was likely to lie on them and because the support battens are more difficult to maintain than the outer cladding. The moisture-repellent coating used was transparent and so it is expected that this will have to be maintained every two years. It will also serve to slow down the rate at which the timber surface weathers to grey although it will not prevent it eventually occurring.

Apart from its use as counterbattens, European larch was used for sole plates, with the less durable Norway spruce utilised for all secondary purlins, floor joists and framing. No timber preservative was used anywhere on the building. The external balcony is constructed from green oak because of its particular exposure to the Dumfries and Galloway climate. Internally, the staircase was fabricated locally from oak and sycamore, with Scottish sycamore also used for the upper floor and associated finishes.



Neil Sutherland

IMPORTED EUROPEAN OAK

CASE STUDY

SCOTTISH POETRY LIBRARY, EDINBURGH MALCOLM FRASER ARCHITECTS



Keith Hunter

European oak was selected for the Scottish Poetry Library because of its associations with landscape, its material character and, not insignificantly, its limited maintenance requirement. The timber cladding is combined with glass as infill to a simple steel frame, with large timber-framed screens sliding to transform the building into a timber box at the end of each day.

The River and Rowing Museum at Henley by David Chipperfield had just been completed at the time the Library's detailing was being developed. Unlike the green oak used by Chipperfield's office, however, the cladding at the Scottish Poetry Library was dried to a moisture content below 19% to avoid the large shrinkage associated with green oak as it dries.

European oak from France was selected for the Poetry Library. The practice has since made efforts to specify Scottish oak for large external sliding doors and windows, but sawmills, industry experts and ironmongery suppliers have all recommended against its use for these specific applications (While it is suitable for many cladding and other external joinery purposes, homegrown oak is not generally suited to designs in which movement is not easily accommodated. Also, homegrown oak is

usually too expensive to be used as cladding except for green oak designs).

The cladding was specified as 2300mm long vertical tongue and grooved boards with 19 x 175mm profiles machined from 22 x 200mm sections. Lateral movement and board fixing were the practice's principal detailing concerns and - working to the rule of thumb 1% movement for every 3% change in moisture content - the tongue and groove profile was determined. Fixed with stainless steel self-tapping screws with stainless steel and rubber washers, each board's weight is carried by the screw head/washer and not by the screw shank, which is fitted through an over-sized pre-drilled hole. In principle, each board can move unconstrained by its screw fixings.

The specification precluded the use of sapwood and tolerances for knots, cracks and splitting were indicated, as was the need for temporary protection of the fixed boards. Intriguingly, the practice was advised to use diluted Toilet Duck(!) to clean off the black stains caused by acetic acid corrosion of mild steel shavings left in the drilled holes (a 5-10% solution of oxalic acid would be the more normal recommendation).



Keith Hunter



Keith Hunter

NORWAY SPRUCE

CASE STUDY

HOUSING AT GREMISTA SHETLAND
RICHARD GIBSON ARCHITECTS



Richard Gibson

Overlooking the north side of Lerwick harbour, the project at Gremista on Shetland is the largest development undertaken by Hjaltland Housing Association. It consists of 66 flats and houses as well as two buildings providing residential accommodation for people with special needs, and has proved very popular with residents, with nearly 50% of the houses occupied through a shared-ownership scheme.

The rainfall at Lerwick is not excessive (c.1171mm per annum), but high wind speeds make the risk of wind-driven water penetration into the wall fabric of buildings a serious problem. This is compounded by the unsuitability of the stone available on Shetland for the manufacture of high-quality concrete blocks. The combination of these factors gives harled blockwork cladding a tendency to leak, leading to moisture problems in the wall fabric

and a consequent increase in maintenance costs. Because of these problems, Hjaltland Housing Association analysed the ongoing performance and costs of conventional blockwork cladding against timber cladding and found the latter to be the more cost-effective alternative in the long term.

Hjaltland Housing Association already owns 100 timber-clad houses which it purchased from Scottish Homes. Constructed 25 years ago by the Scottish Special Housing Association, they still perform well and are similar to earlier timber-clad kit houses on Shetland which were imported from Norway and Sweden in the 1940's and which also still give dependable performance. These precedents afforded the Association confidence in the durability of timber-clad housing in the local exposed conditions, and vertical

board-on-board cladding was selected since it appeared to offer the most resistance to wind-driven rain penetration. The preservative-treated softwood cladding was carefully detailed for drainage and ventilation and was given an opaque water-repellent coating.

The bold use of colour on the cladding unifies the scheme and gives it a bright appearance even in the middle of winter. This brightness contrasts strongly with a neighbouring local authority housing scheme constructed of harled blockwork, and even though the coatings will require maintenance every five or six years, the Association remains confident that timber will prove to be more cost effective than alternative cladding materials.



Richard Gibson



Gökay Devici

HOMEGROWN NORWAY SPRUCE

CASE STUDY

VAN MIDDEN HOUSE
GÖKAY DEVICI ARCHITECTS

Designed and constructed as a result of a research programme on 'Affordable Housing Projects' at The Robert Gordon University, the Van Midden house prioritises affordability and ecological sustainability and demonstrates that truly 'affordable' housing need not be inconsistent with good, responsible, sustainable design. The basic design concept rests on the cost savings which arise from the utilisation of a simple geometric plan form to maximise the space/envelope ratio. Further savings were achieved by centralising the living space thereby minimising the circulation and by using a simple modular structure.

The structure and cladding materials are predominantly of timber construction, and the resultant savings in weight also considerably reduced the cost and work involved in the substructure. Lightweight timber 'I' beams were used for the wall and roof members, a strategy which permitted the inclusion of 220 and 300mm thick recycled newspaper insulation in the walls and roof respectively and helped reduce the house's energy requirements to a minimum. The wall cladding is homegrown Norway spruce and this lightweight and very cost effective cladding material - used in combination with lightweight corrugated steel roofing - further reduced the construction costs. The house has deeper than normal eaves in order to shelter the external cladding.

Materials throughout the six-bedroom house were selected for their low embodied energy and, wherever possible, recycled materials were used (the majority of the materials were sourced locally, with the embodied energy estimated at 1.4GJ per square metre compared to 6.5GJ per square metre for a traditionally-constructed dwelling). By using a breathing wall construction, the need for vapour barriers has been eliminated. The wall and roof panels were designed to be prefabricated and with a trussless roof structure employed, the resulting space was freed-up to provide additional storage and play space.

In the context of external timber cladding this house is notable both because it uses lightweight timber cladding and structure as part of an integrated design approach, and because the cladding is made from Norway spruce. In common with standard practice on the west coast of Norway there has been no attempt to remove the sapwood and the timber has not been preservative-treated. The cladding, however, is carefully detailed to promote drainage and ventilation and has been given a water-repellent surface coating. This approach suggests considerable potential for the use of homegrown sitka spruce and although there are many uncertainties which require further research, this cladding market could be attractive to Scottish sawmills in the future.



Gökay Devici



Gökay Devici

IROKO

CASE STUDY

ST MAGNUS CENTRE, KIRKWALL, ORKNEY
GORDON FLEMING IN ASSOCIATION WITH ARP LORIMER & ASSOCIATES



The St. Magnus Cathedral in Kirkwall dates back to the 12th Century and forms the centrepiece of a group of new and existing buildings which are now collectively known as the 'St Magnus Centre'. A new upper floor has recently been inserted into the volume of the Victorian church hall, with the resulting function hall below able to operate independently. The newest building sits perpendicular to this, creating a new south-facing entrance court as well as a series of flexible function rooms inside.

In selecting materials for the building, reference was made to the relationship between Orkney and Norway and the significance of timber structures in Norwegian

traditional architecture. Additionally, the use of timber cladding emphasises the non-loadbearing function of the upper clerestory by separating its steep monopitch roof from the roughcast masonry walls which enclose the accommodation below.

The principle criteria in species selection for the timber cladding was that it should have a long service life, and for it to weather to a silver-grey colour without any surface coating. European oak, imported western red cedar, and iroko are all classed as durable timbers and so each fulfilled these requirements. However, because the

architects had uncertainties about the staining effects of western red cedar and European oak, it was decided to use iroko even though this is a tropical hardwood.

The horizontal timber cladding was fixed to vertical, preservative treated, softwood battens on a breather membrane on sheathing ply to a non-loadbearing timber stud background, with insulation, vapour barrier and birch-faced ply to the interior. With each board drawn onto large-scale elevations, the architects' established rules on spacing and the arrangement of fixings to ensure a regular pattern of screw-heads. Stainless steel screws and washers were countersunk into the face of the board by the depth of the washer.



WESTERN RED CEDAR

CASE STUDY

BIRNAM INSTITUTE, BIRNAM, PERTSHIRE
MACMON ARCHITECTS

The use of timber on the new extension to the Birnam Institute contrasts well with the prevailing stone and slate Victorian architecture of the small town and of the Institute itself. The original building has been owned and managed by the Birnam Institute for more than 100 years, providing the community with a hall and a lending library, and a fully glazed, double height 'link' now connects it with the new facilities. A new foyer and cafe, multi-purpose hall, arts' workshops and mezzanine gallery have been created.

There are very few standard details or wall conditions to the new building: it has a steel frame, with timber frame infill forming the inner leaf and supporting sheathing ply and membranes (at one stage the architects considered a specification utilising breathing wall principles, but the construction's complexity and discontinuity mitigated against this). The support framework for the timber cladding is formed from 38 x 38 mm battens and counterbattens, with the vertical western red cedar (class 1 to BS1186 - 3:1990) curved around the radiused ends of the new block. The timber has not been coated in any way as it is intended that it should progressively weather to a silver-grey colour.

The tongue and grooved ex 135 x 25mm vertical boards are twice nailed at approx 600 centres, with one secret fixing and one face-fixed. Having consulted with TRADA and followed the recommendations in its Cladding Manual, the architects used a TRADA nail-fixing specification. The contractor offered an alternative 'brad nail' specification (as proposed by their nail gun supplier) which offered equal performance, pull out strengths etc, but nevertheless considerable time was expended by all parties on this issue as there were concerns about the possibility of the boards splitting and on the visibility of the nail heads.

Once commenced, however, the application and fixing proved to be relatively straightforward, although the radiused plan did cause some problems in respect of the groove width 'opening up', and the architects chose to reverse the boards to achieve their visual preferences. The work was carried out on a less-controlled basis than they would have liked and in future they intend to include a requirement within their specifications for early stage samples of workmanship.



Peter Wilson



Peter Wilson

HOMEGROWN EUROPEAN LARCH AND DOUGLAS FIR

CASE STUDY

THE FIELD OF DREAMS, FINDHORN FOUNDATION

Founded in the early 1960's, the Findhorn Foundation near Forres describes itself as an international spiritual community. It has a current size of up to 150 members with several hundred individuals or families living in or associated with the Foundation and its related activities and businesses. The initial living accommodation was necessarily temporary in nature but an increasing amount of new permanent housing and community buildings are being built. This work has gained momentum over the past decade culminating in the current development of 50 houses, mostly timber-clad, on the aptly named 'Field of Dreams'. The Foundation now contains perhaps the largest collection of timber-clad bespoke housing in Scotland, and possibly even in the UK. It is also one of the longest-running large-

scale demonstrations of ecological building practice in the UK, and stands comparison with the Centre for Alternative Technology in mid Wales.

Originally informed by the German 'Building Biology' or 'Baubiologie' movement, the early building work at the Foundation was technically innovative and often experimental and it continues to be inspired by a strong environmental ethos today. But although the timber-clad buildings at the Foundation are sometimes seen as being unconventional, the 'Field of Dreams' is now notable for the ordinary, suburban character of much of the development. While 'suburban' is often a pejorative description, it is not intended as a criticism in this case - it is only when timber cladding becomes ordinary, conventional and

unexceptional that it will be able to deliver the full range of benefits that it is uniquely capable of.

Several designers and builders are actively involved in the development of new houses at the 'Field of Dreams'. All of the houses use local materials and suppliers wherever possible and actively seek to avoid materials or building practices that have an adverse environmental impact. Locally sourced timber is an indispensable part of the technological mix in this building approach and, with the range of different species used (mostly home-grown European larch and Douglas fir) and variety of cladding techniques employed, the overall development forms a valuable demonstration project. *The house illustrated is designed by Northwoods Construction of Ullapool.*



Peter Wilson



Peter Wilson



HOMEGROWN DOUGLAS FIR

CASE STUDY

**HOUSE AT MAULD, STRUY NEAR BEAULY
SIMPSON & BROWN ARCHITECTS**

Most of the recently designed timber-clad buildings in rural Scotland are inspired by ideas and fashions from outwith their local area. German, Scandinavian or north American practice tends to predominate in 'ecological' housing while the timber cladding design seen in the mainstream kit house market emanates from purely suburban examples. To date, there has been relatively little attempt to utilise the indigenous timber building traditions of Scotland.

The house at Mauld near the village of Struy, south west of Beaulay, is significant because its simple design draws upon the Scottish timber-clad house-building traditions that existed in rural Scotland prior to World War One. These redwood or whitewood-clad servant's houses and railway stations are still surprisingly common throughout the Highlands, and although some of the temporary buildings are coated with creosote, virtually all of the permanent houses or other buildings have a light-coloured lead paint coating and simple conventional detailing well-suited to a maritime climate. Yet, despite this demonstrable inheritance, the owners and

the designer of the house at Mauld still encountered resistance to this 'unconventional' approach.

Structurally the house has a conventional timber frame, and while better insulated than most, is otherwise technically little different to standard rural kit-houses. The difference lies in its proportions and in the use of brightly-painted softwood cladding which has been carefully detailed for Scottish conditions. Local timber and suppliers have been used wherever possible.

The house is one of a range of designs trying to identify and establish an approach to rural housing which is appropriate to the needs of today. These are adaptable, deliberately unselfconscious designs, and intended to be constructed at mainstream prices. Different specification options are available which can add to or reduce the costs. Each design in the range make considerable use of passive solar design and, because they are well insulated, they are very easy to heat. In this particular example, the house is situated on a small organic farm and will be heated solely from timber harvested from the owners' own land.



HOMEGROWN EUROPEAN LARCH

CASE STUDY

GLENCOE VISITOR FACILITIES
GAIA ARCHITECTS

The new National Trust for Scotland visitor facilities at Glencoe comprise a series of buildings containing cafe, kitchen, shop, toilets, interpretation centre and education room. Boardwalks connect these with administration buildings, storage and on-site staff accommodation. A steel framework raises the whole complex off the ground to allow ventilation beneath the floors and to ensure minimum disturbance to the ground and its waterways.

Timber-framed and using 'breathing' wall construction, the entire complex is fabricated from home-grown woods. None of the timber is preservative-treated, and various measures have been taken to ensure acceptable levels of durability and maintenance. All boards and supporting battens are of European larch (heartwood), with 144 x 25mm vertical cladding boards set 6-8mm apart on 44 x 25mm inner battens. The supporting horizontal battens are fixed at 600mm centres on vertical battens over a high performance breather membrane. The boards are face-sawn with planed edges (whether to plane or saw the cladding boards was a moot issue - by reducing the amount of

surface presented to the atmosphere, planing might reduce moisture ingress. Conversely, sawn surfaces may permit moisture to evaporate much more readily, and could reduce the time boards spend saturated). No coatings of any sort have been used.

Screwing the boards proved too expensive and so each is nailed, with torque carefully gauged to prevent nail heads penetrating too far into the timber's surface (ideally, they should be flush with the surface to avoid creating mini-collection points with exposed end grain). Screws would have facilitated ease of replacement of boards, but nailed connections were accepted by the design team once it was agreed that boards would only be removed when they were unlikely to be useful for other applications. Nails are applied centrally, allowing for any amount of movement to either side.

Differential weathering between boards is a disadvantage of vertical cladding - the lowest 150-300mm can suffer 'splashback' whilst higher areas protected by eaves stay in good condition. To avoid replacing whole boards when only their lowest parts are in



Michael Wolchover



Michael Wolchover

poor condition, a detail was developed using a 150mm horizontal board to take the brunt of the weather whilst the vertical boards above remain in good condition.

Untreated European larch boards have also been used to clad the roof. While this is contrary to recommended practice in Scotland and Norway, the wider environmental remit of the building precluded the use of preservative treated roof boards. The designer and client accept that the roof timbers will require regular maintenance and have detailed it accordingly.



Michael Wolchover



Michael Wolchover

The increasing popularity of external timber cladding in Scotland has created a need for accurate historical and technical information specifically relevant to Scottish conditions, and the Scottish Executive has commissioned *Timber Cladding in Scotland* to provide an invaluable reference for policy makers, architects, engineers, self-builders, planning and building control officers, contractors and cladding manufacturers.

External timber cladding offers a unique combination of environmental, social and economic benefits of value to Scotland's built environment, and planning and building control systems are increasingly sympathetic to its use. The technical risks of using timber cladding in Scotland's exposed maritime climate are manageable and no greater than in similar climates, such as the western coastal zones of Norway and Canada, where external timber cladding is widespread. There is also evidence of strong historical precedents for external timber cladding throughout urban and rural Scotland.



Ivor Davies is a product designer and timber technologist. He worked for eight years with Highland Birchwoods and now operates independently as a timber research consultant specialising in product development and external timber cladding.

Dr. Bruce Walker is an architect and architectural historian. A former lecturer in the School of Architecture at the University of Dundee, he was seconded for several years to Historic Scotland, initially as a district architect and then as a technical author. He has published widely on the history of building construction in Scotland.

Dr James Pendlebury is a wood scientist specialising in timber durability and preservation. He has worked internationally with a wide range of timber research organisations, including TNO in the Netherlands, TRADA and Highland Birchwoods. He is currently employed with Forest Enterprise.

Highland Birchwoods is a charitable company promoting the sustainable management and use of forest resources. The company runs research, development and demonstration projects in partnership with a wide range of organisations in Scotland and further afield.

