TAN 30

SCOTTISH TURF CONSTRUCTION

TECHNICAL ADVICE NOTE 30

SCOTTISH TURF CONSTRUCTION

TECHNICAL CONSERVATION, RESEARCH AND EDUCATION GROUP

HISTORIC SCOTLAND

Historic Scotland Technical Advice Notes

1 Preparation and Use of Lime Mortars (revised 2003)
2 Conservation of Plasterwork (revised 2002)
3 Performance Standards for Timber Sash and Case Windows (1994)(Deleted)
4 Thatch & Thatching Techniques (1996)
5 The Hebridean Blackhouse (1996)
6 Earth Structures and Construction in Scotland (1996)
7 Access to the Built Heritage (1996)
8 Historic Scotland Guide to International Conservation Charters (1997)
9 Stonecleaning of Granite Buildings (1997)
10 Biological Growths on Sandstone Buildings (1997)
11 Fire Protection Measures in Scottish Historic Buildings (1997)
12 Quarries of Scotland (1997)
13 The Archaeology of Scottish Thatch (1998)
14 The Installation of Sprinkler Systems in Historic Buildings (1998)
15 External Lime Coatings on Traditional Buildings (2001)
16 Burrowing Animals and Archaeology (1999)
17 Bracken and Archaeology (1999)
18 The Treatment of Graffiti on Historic Surfaces (1999)
19 Scottish Aggregates for Building Conservation (1999)
20 Corrosion in Masonry Clad Early 20th Century Steel Framed Buildings (2000)
21 Scottish Slate Quarries (2000)
22 Fire Risk Management in Heritage Buildings (2001)
23 Non-Destructive Investigation of Standing Structures (2001)
24 The Environmental Control of Dry Rot (2002)
25 Maintenance and Repair of Cleaned Stone Buildings (2003)
26 Care and Conservation of 17th Century Plasterwork in Scotland (2004)
27 Development and Archaeology in Historic Towns and Cities (2004)
28 Fire Safety Management in Heritage Buildings (2005)
29 Corrugated Iron and other Ferrous Cladding (2005)
30 Scottish Turf Construction (2006)

Guides for Practitioners

Stonecleaning – A Guide for Practitioners (1994)
Timber Decay in Buildings – The Conservation Approach to Treatment (1999)
1 Rural Buildings of the Lothians: Conservation and Conversion (1999)
2 Conservation of Historic Graveyards (2001)
3 Conservation of Timber Sash and Case Windows (2002)
4 Measured Survey and Building Recording (2003)
5 Scottish Iron Structures (2006)

Available from:

Historic Scotland
Technical Conservation, Research and Education Group
Historic Scotland Conservation Bureau
Longmore House
Salisbury Place
EDINBURGH
EH9 1SH
Tel 0131 668 8638
Fax 0131 668 8669
email hs.conservation.bureau@scotland.gov.uk

Technical Advice Note

Scottish Turf Construction

by
Bruce Walker

in association with
Christopher McGregor
Gregor Stark

Prepared by
University of Dundee

Published by
Historic Scotland

ISBN 1 900168 85 5

Edinburgh 2006

Commissioned by

TECHNICAL
CONSERVATION
RESEARCH AND
EDUCATION
GROUP

Author
Bruce Walker

In association with Christopher McGregor and Gregor Stark

With contributions by Stephen P Carter, Magnar M Dalland and Timothy G Holden

Prepared by the University of Dundee

Commissioned by:
Technical Conservation Research and Education Group, Historic Scotland

ISBN 1 900168 85 5

Design and origination by The House (5/06)

ACKNOWLEDGEMENTS

The authors wish to thank the following groups and individuals for their time, patience, ideas, skills and information.

Thomas Arres, Kelso: Mr and Mrs Boniface, Corse Croft, Huntly: Professor David Breeze, Historic Scotland, Edinburgh: Hugh Cheape, National Museums of Scotland: Olivia De Long, GUARD, Glasgow: Alan Elliot, Highland Folk Park, Newtonmore: Haraldur Helgasson, National Museum of Iceland, Reykjavik, Iceland: David Hendrie, Historic Scotland, Edinburgh: Chris Hutcheson, Historic Scotland, Edinburgh: Richard Langhorne, Stornoway Museum: Rebecca Little, Monimail, Fife: Neil Lynch, Royal Museum of Scotland, Edinburgh: Carol Mackintosh, Highland Folk Park, Newtonmore: Rod McCulloch, Historic Scotland, Edinburgh: Gordon Maxwell, Aberdour, Fife: John Philip, Head Greenkeeper, Carnoustie Golf Club: Jim Ramsay, NTS, Achnacon, Glen Coe: Ian Salmond, Carnoustie Golf Course, Greenkeeper: Hjörleifur Stefánsson, National Museum, Reykjavik, Iceland; Robin Turner, NTS, Edinburgh: Patricia Walker, Dundee: and Helen Wink, Highland Folk Park, Newtonmore.

Special thanks to Audrey Bruce, Dundee University for preparing the text for publication.

CONTENTS

LIST OF ILLUSTRATIONS

FOREWORD

Along with its many international applications, turf has long been used as a traditional building material in Scotland. From Roman times, amongst other uses, the material has formed the basis for building defensive structures, the walls of houses, creating field enclosures and been used as an underlay roofing material associated with thatch. Despite this universal application our understanding of such an important material in the context of the countries built heritage has often remained understudied and, consequently, misunderstood. It is hoped that the publication of this Technical Advice Note (TAN) will lead to a better awareness and perception of the range of turf constructions in Scotland, and the need for applied sensitivities in their future well being.

One of the major issues that the TAN seeks to address is the view which can exist that all turf is assumed to have the same properties. That is far from the case. Just as research has shown that stones have many different characteristics, this volume challenges the assumption that all turf materials are identical in composition and use, and should be treated the same. The contents of the TAN makes a significant start in developing a better knowledge of the material and, it is hoped, will also stimulate further detailed research into regional variations.

Experience has shown that a greater insight into the complexities of the traditional materials that have been used in creating Scotland's buildings has proved vital to their successful conservation. Given the comprehensive in-depth material expertly prepared and presented by Dr Walker in this volume hopefully that will now also prove to be the case where turf is concerned.

As with so many elements of our built heritage, many of the craft skills associated with turf construction have been lost and will have to be re-discovered. A grasp of the technology and nuances used in the process is vital if such structures are to be properly cared for in future. Consequently, appreciating the explanation of the differences in the materials that were used, with an enhanced awareness of the techniques by which such buildings were constructed, is essential. This TAN ably takes that integrated challenge forward.

The ultimate benefit of Dr Walkers work on turf materials and constructional techniques is to arrive at a developed consciousness of the issues involved. To assist in this process his explanation of relevant techniques is offered along with a number of detailed case studies. As with other areas of conservation, the application of such an understanding may not be easy to achieve in practice but what is presented in this TAN should go some considerable way to re-creating an appropriate basis of knowledge.

Read in conjunction with *TAN 4 Thatch and Thatching Techniques; TAN 5 The Hebridean Blackhouse; TAN 6 Earth Structures and Construction in Scotland: a Guide to the Recognition and Conservation of Earth Technology in Scottish Buildings*, and *TAN 13 The Archaeology of Scottish Thatch* the publication of this new work greatly enhances our current awareness of the importance of turf constructed buildings. The effective maintenance and appropriate protection of our rich and diverse built heritage is of vital importance to our nation. This TAN will go some considerable way towards ensuring the part that turf construction has played in its development is better understood and retained for future generations.

Ingval Maxwell OBE
Director TCRE

Edinburgh
May 2006

fig 1. Iron Age Fort, Dun Nosebridge, Islay from north-east. © RCAHMS

1. INTRODUCTION

The historical background to turf building construction is set out in Technical Advice Note No 6 *Earth Structures and Construction in Scotland: A Guide to the Recognition and Conservation of Earth Technology in Scottish Buildings* (Walker and McGregor: 1996: 7-27). The range of structures mentioned in this background history includes: iron-age forts (fig 1); the Antonine Wall (fig 2), built by the Romans to protect the rest of Britain from incursions by the Picts inhabiting the remainder of Scotland: a range of eighteenth and nineteenth century structures including field boundaries (fig 3), head-dykes, farm houses, farm steadings, ice-houses, manses (fig 4) and thatches or undercloaks to thatches. Many of these applications continued into the twentieth century including a turf walled byre built at Shader, Lewis in 1951.

The technical advice offered in TAN 6, on the use of turf, is limited, being based mainly on historical data rather than current experience. The only structures, incorporating turf construction, conserved at that time were thatches, and the Historic Scotland blackhouse at 42 Arnol, Lewis. Advice was provided in Technical Advice Note No 4 *Thatches and Thatching Techniques: A Guide to Conserving Scottish Thatching Traditions* (Walker, McGregor and Stark: 1996) and Technical Advice Note No 5 *The Hebridean Blackhouse: A Guide to Materials, Construction and Maintenance* (Walker and McGregor: 1996). In these examples the types of turf were taken from the traditional sources and presented no real problems. Work being carried out by other groups was not always so successful and this has prompted the need for further technical advice based on practical experiments, observations of the difficulties experienced by groups working outwith the control of Historic Scotland, individual expectations as to the capability of turf to waterproof roofs, and further analysis of the historic data.

Unlike other forms of earth construction such as rammed, stabilised and tempered earth constructions, there has been little practical advice offered on the uses and properties of turf, or how to select the correct turf for a particular purpose. In this respect 'turf' has been considered in the same way as 'thatch' with little consideration given to the nature, composition and varying properties. Twentieth century accounts dealing with the history of turf building in the British Isles include: C F Innocent (1916) on England: Caoimhin ÓDanachair (1945 and 1975) and E Estyn Evans (1969) on Ireland: Basil Megaw (1962), Alexander Fenton (1968) and Fenton and Walker (1981) on Scotland. All provide historic data and surviving examples but none attempts to conserve or replicate any of these structures using the historic data.

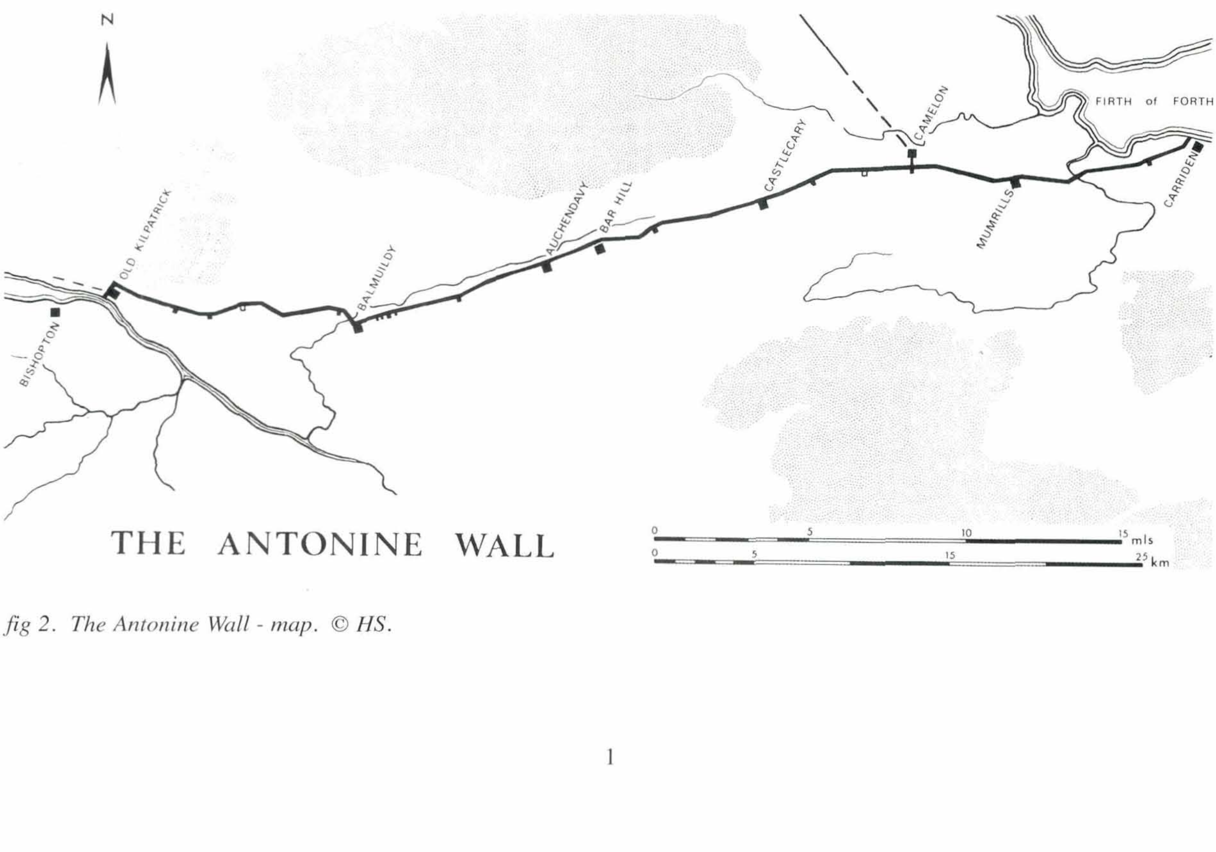


fig 2. The Antonine Wall - map. © HS.

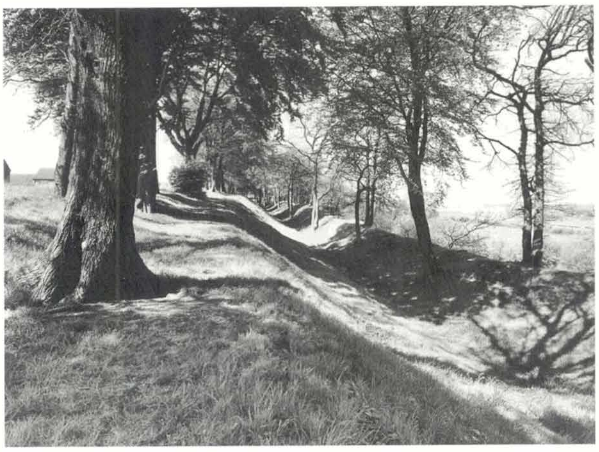


fig 2a. The Antonine Wall at Watling Lodge. © HS.

fig 2b. The Antonine Wall at Watling Lodge. © HS.

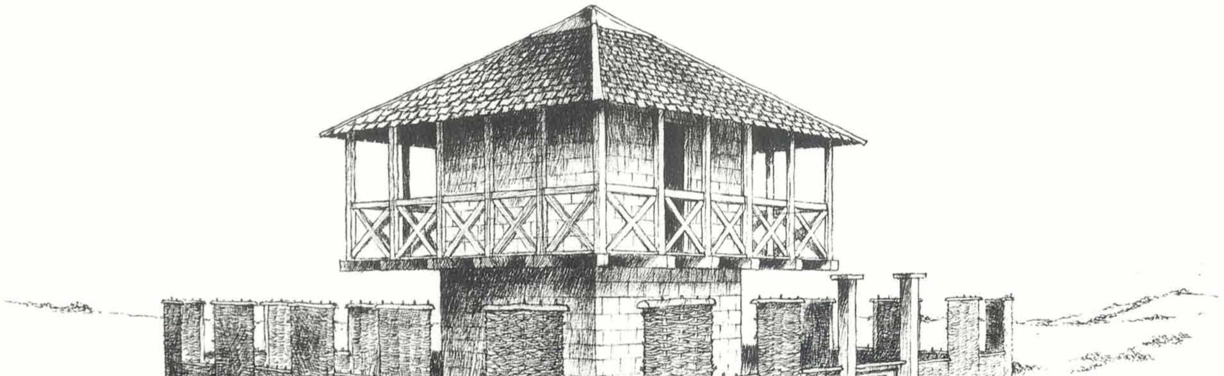


fig 2c. The Antonine Wall, reconstruction of phase II fortlet. © HS.

fig 3. Turf field boundary and replacement drystone dyke, Fair Isle, 1956. © NMS.

Similar histories were being produced elsewhere. In Nebraska, USA Everett Dick (1937, 1941, and 1966), and James Olson (1955 and 1966) produced useful histories as did Roger L Welsch (1967, 1968, 1969, 1976 and 1977) Welsch's book *Sod Walls: The Story of the Nebraska Sod House* provides a great deal of practical advice on how to approach turf building and bridges the gap between historical fact and practical advice.

Another scholar to bridge the gap between historical research and practical building is Hörður Ágústsson (1969 and 1974). Ágústsson was director of the State College of Arts and Crafts, Reykjavik, Iceland and published widely in Nordic journals but almost always in Icelandic. Not only did he observe and record archaeological and standing remains of turf structures, but also he recognised a standard range of turf blocks linked to particular names. To illustrate the exact form of these blocks he drew each one to scale within a rectangular prism. In their built form these appear to conform to some of the block types found in Scotland but as yet the Scottish turf blocks have not been fully uncovered and recorded.

Ágústsson also appears to have been the driving force behind the reconstruction of a large medieval turf house at Þjôsârðalar, Stong, Iceland. This reconstruction appears to be the largest of a series of turf structures built for archaeological-museum purposes in Europe, and contrasts sharply with the small turf-built labourer's house at the open-air museum at Arnhem, Netherlands.

It is obvious from the various published papers on turf building, and from the range of applications, that 'turf' is a generic name for a wide range of building materials, each with its specific characteristics and applications but all based on the use of vegetable fibre as a binding agent for some form of earthen block or earthen mat.

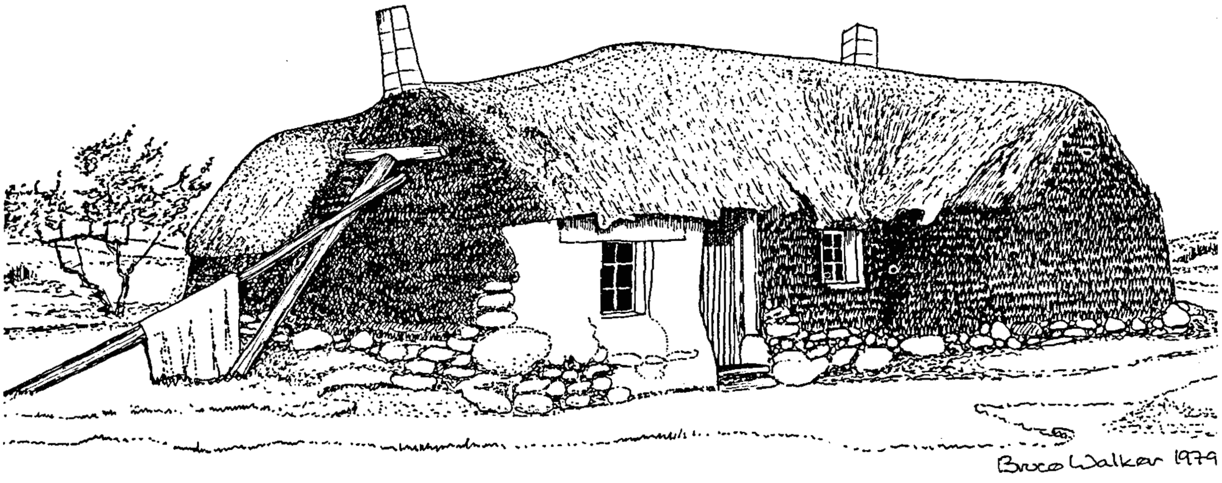


fig 4. UP Manse, Howford Bridge, Nairn, from photograph by George Washington Wilson. © Bruce Walker.

The work required to produce a definitive work on turf building is far from complete, but this Advice Note sets out to provide basic advice within a framework that is capable of expansion and development as more information is accumulated.

The terminology used in this paper when referring to building materials held together by naturally-occurring vegetable fibre (such as roots or non-decomposed vegetation such as that found in bogs) that renders the material extractable and capable of use without the need for further treatment, is that generally accepted in Scottish vernacular building construction and practice. The same terms are used in Irish vernacular building but with entirely different meanings. Throughout the rest of the English speaking world the terminology normally has a Scottish or Irish bias when describing this type of construction.

2. NATURE, PROPERTIES AND SOURCES OF TURF

The term 'turf' (Irish - 'sod') is a generic term for any building block, held together by naturally-occurring plant fibre, such as roots, which allows the block to be cut from the ground for use without the need for further treatment.

Turf, being a natural material, varies widely in its nature and properties. Not only do different grasses, or other vegetation provide different densities of root, but the time since the last disturbance of the ground also has a bearing. The longer the turf is left undisturbed, the tighter the root system, and the tighter the root system the easier it is to handle the cut turf. Similarly the type of soil also has a bearing. The turf from a sandy loam will behave differently to turf taken from a balanced loam, from a clayey loam, or from a peat bog. All have their specific characteristics, advantages and disadvantages.

Unlike modern building materials, which have predictable performance standards that can be achieved ad infinitum if the instructions are followed to the letter, turf requires from operatives degrees of understanding, experience, common sense and flexibility not normally found in today's building industry. Turfs successful use equates to the working of natural timber with hand tools, where the operator must be prepared to work with the grain, particularly around knots and other imperfections. It may therefore be necessary to follow traditional practice in finding someone who not only understands the principles of good turf construction but who also has a 'feel' for the correct use of the material. At the time when turf building was a community effort, the master turf builder was often an elderly member of the community, perhaps past the peak of physical fitness but with a reputation built up from years of experience. The master turf builder would not only source the material but would also decide when the work was to take place, how the turf was to be cut, and the sequence in which various cuts of turf would be required. He would direct the builders as to where to use the best quality turves, decide whether to accept a particular standard of turf, limit the height of daywork joints to minimise the risk of bulging or collapse, decide when to add the next lift, organise protection for the wall top between lifts, choose the style and nature of the cope, and so on. Each master turf builder knew the capabilities of the turf in his region, and would adjust the height of daywork joints to suit the type of turf being used, the condition of the turf when cut, and the weather conditions prevailing and anticipated over the next few days. In dry weather he might order the turf to be watered when laid on the wall. In wet weather he might organise protection for daywork joints. Moisture in the turf was generally considered essential, since it was hoped that the roots would continue to grow for some time and thus knit with other turves to reduce the number of shear planes in the wall. Too much moisture, particularly when the turf was cut from clayey loam, could result in slippage due to the weight of turf or the consolidation of the core of the wall. On the other hand, the use of dry turf can often result in open joints that, in addition to being a potential weakness in the structure, invite a range of creatures to occupy the void. These creatures include rodents, certain types of nesting birds, insects such as bees or wasps, or any other creature with a liking for dry cavities in vertical banks.

Ideally, turves should be used the same day as they are cut, but this is not always practical due to changing weather conditions. Cut turves should never be stockpiled for more than a couple of days since heating occurs in the stockpile, and this has an adverse effect on grasses and other vegetation.

In dry weather, turves benefit from liberal watering as they are built. This encourages growth of the vegetation and assists in the consolidation of the wall.

The nature, sources and properties of various turf types are discussed below.

2.01 Turf grown in a balanced loam

This should be avoided if top soil, but balanced sub-soil will make a good building material since the roots develop to a considerable depth and the turf can be cut accordingly; although top soil composts easily and can therefore fail. Another disadvantage appears to be the amount of good pasture that has to be destroyed to create any sizable structure.

However, according to Thomas Arres, Kelso, there are other disadvantages. A balanced loam absorbs and holds a considerable amount of water, and therefore expands and contracts as the weather changes. Similarly a damp wall subjected to a deep frost is gradually destroyed due to the expansion of water when it turns to ice. This action also tends to expel stones situated close to the edge of the turf, and gradually the material composts into a good quality loam. This is confirmed by keen gardeners such as Gordon Maxwell, who is also a leading expert on Roman archaeology.

2.02 Turf grown in a sandy loam

This is a material that can only be lifted and built in wet weather. The high proportion of sand makes handling in anything other than damp conditions impossible, and once built the rate at and ease with which the wall can wet and dry can result in rotting of the vegetable fibre. In this condition the turves are extremely vulnerable to damage and, if disturbed, collapse like the edge of a poorly-compacted sandcastle.

Sandy turves are preferred to turves cut from a balanced loam since they are less susceptible to shrinkage and do not hold water. Sandy turves were used by the Romans at Strageath, but only for the north rampart where the wall was protected from the effects of the sun by the buildings within the fort. The material is occasionally found in situ in nineteenth century vernacular buildings, usually high in the gable or behind some other finish.

One remarkable survival that may contradict some of the above statements was excavated by City of Edinburgh Council: Archaeology Service at Ronaldson's Wharf, Leith. This site on the north bank of the river yielded a series of plot boundaries dating to the setting out of this part of the Burgh in the eleventh or twelfth century. The boundary walls were built with the local sand-turf and were probably buried by sand movement soon after erection. Unfortunately, although good turf samples were removed and are in storage, it has been impossible to find funding for the scientific investigation of this turf even although its survival in sand is in itself remarkable.

Turf grown in a sandy terrain should not be confused with the thin turf that can be grown over sea sand - see section 2.07.

2.03 Turf grown in a clayey loam

This is the most substantial form of turf building block since the cut turf is similar in composition to a block made from mudwall mix: the root system in the turf performs a similar function to the chopped vegetation in mudwall. The report on the 'Turf Wall of Hadrian' (Simpson and Richmond, 1935) states that those sections of the wall built through thick woodland use mudwall block in place of turf. David Breeze points out that the east end of the Antonine Wall is constructed in mudwall block whilst the main section from Falkirk to Kilwinning is built in turf.

A grass mix for producing a strong, hard wearing clay turf is given in section 10.04.4. This turf is produced for a specific function, and horticultural advice should be sought if preparing turf for use in some other type of structure.

Ideally a turf of this type should be used while still moist, but it has been found that if the material does dry in transit or before it is time to use it, the blocks can be built using a clay mortar - see section 10.02.

2.04 Turf from the surface of a peat bog

This tends to be an excellent building material, since the vegetation is growing into non-decomposed vegetable fibre. It can be cut into very deep blocks, and has the added advantage of a high oil content which, when dried, forms a waterproof skin. The waterproof nature of this type of turf can be utilized in a number of ways including providing a waterproof thatch - see section 4.09.

2.05 Flaas

This is a form of water propagated vegetable mat, comprising sphagnum moss interlaced with the root systems of plants that have propagated on its surface, forming a thick homogeneous mat. The material forms on 'stangs' or 'strangrils' - small semi-stagnant sheets of water that have become overgrown and half solid with vegetation. It is torn from the surface in sheets and used as an under-thatch for turf or straw thatching.

2.06 Mossy turf

This is one of the poorest turf types for building, since there is little soil in the cut turves and the material is likely to shrink unless earth is packed between each alternate layer.

Mossy turf is the type of turf that may have occasioned some of the bad reports of-turf building, published in

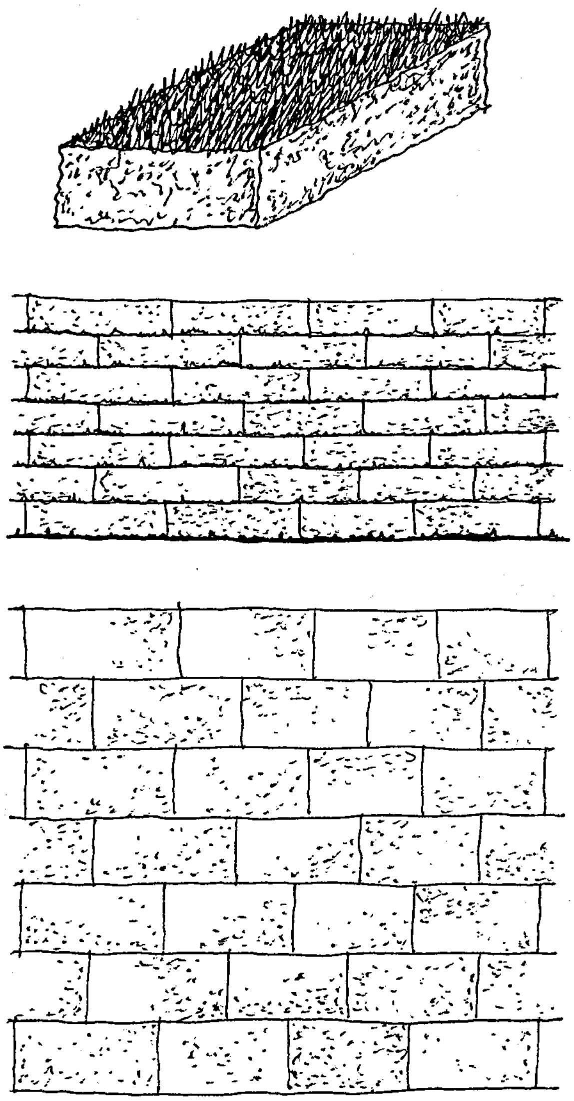


fig 5. Roman turf and system of bonding. © Frere and Wilkes

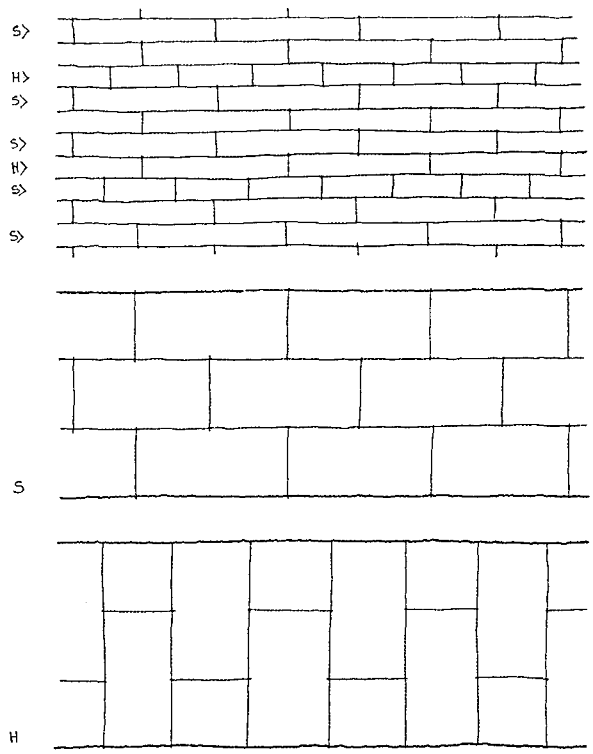


fig 6. Nebraskan turf and system of bonding, after Welsch. © Bruce Walker.

the early nineteenth century, when buildings were reported as having to be rebuilt every three to five years. It is usually found on poor quality ill-drained ground where rainwater is held on the surface of the ground and mosses develop between the other vegetation.

2.07 Thin turf propagated on sandy soil

A form of thin grass turf is found on machair ground of the Western Isles and along the coast of the North West Highlands. Here a dense root mat develops on the surface of the ground but does not penetrate to any depth. The authors have not seen this type of turf being cut, nor have they located any person who has cut it, but it has the appearance and texture of some of the hair matting sold in squares as a floor covering. The turf, even after years as an undercloak to thatch, is tough, resilient and resistant to tearing.

This is the type of material that, if sourced, it would be unwise to cut since it forms the external binding that tends to hold the sand in position and prevents it drifting into dunes.

2.08 Sedge turf

According to Icelandic sources (Gestsson, 1982, 162-172) Sedge (Carex) marshes yield the best turf. The deep root system of the sedge allows the turf to be

fig 7. Divet gabet, Greystane, Carmyllie, Angus. © Bruce Walker.

removed to a depth of 300mm (12"). There is a wide range of sedges, and what may be being described is the same type of turf as is taken from the surface of a peat bog.

2.09 Other types of turf

The authors have experience of two other types of turf, mainly through work on thatched buildings where turf is often used as an undercloak to thatch or as a ridging material in its own right.

The first is blaeberry (*Vaccinium myrtillus*, family - Ericaceae) turf which is extremely stiff and cohesive in form. Even at 75mm (3") thickness it takes time to encourage a 1200mm (4') long turf to drop 300mm (1') at either end when placed across the curve of the ridge.

Heather (*Erica*) also forms a good cohesive turf. This is less flexible than grass turf of the same size and thickness, and is capable of spanning across gaps in the supporting spars, when used as an undercloak to thatch.

Other plants must produce turf with desirable qualities but care should be taken to establish the legality of removing any turf from any source outwith an agricultural holding. In case of doubt contact Scottish Natural Heritage, Battleby, Redgorton, Perthshire PH1 3EW, ww.snh.org.uk, 01738 444177.

3. TURF SHAPES AND METHODS OF CUTTING

The terminology linked to turf shapes is often confusing and contradictory since the same names were used in different contexts in different parts of the country. The authors have adopted the following terminology as being the most commonly-used terms throughout Scotland from the eighteenth century to the 1920s, when turf building for farm houses and steadings had almost ceased. Some of the confusion may stem from the number of Irish labourers working on Scottish farms during the planting and harvesting periods: their awareness of turf building practices and terminology is likely to have been much more immediate than the Scottish farmers and labourers who abandoned the practices at an earlier date. Similarly it is the late use of turf in Ireland that possibly resulted in Irish terminology being adopted in Nebraska, USA when the prairies were opened up for settlement.

Organised groups like the Roman Army appear to have had standard sizes for their turf shapes (fig 5) whereas individual settlers on the plains of Nebraska varied the size according to the strength of the lifters and the moisture content at the time of lifting. The Nebraskan sod measures between 600mm and 900mm (twenty-four and thirty-six inches) long, 300 to 450mm (twelve to eighteen inches) wide, and 75-100mm (three to four inches) deep (fig 6) although the depth when cut may have been greater. The general rule was that the actual size was dependant on three factors.

1 the thickness of the sod

2 the strength of the lifters

3 the moisture content

Turves were cut in the morning and had to be in the wall by the end of the day, otherwise they were discarded.

3.01 Clod - *a small piece of turf*

The oldest known use of this expression in Scotland dates from between 1500 and 1512 and is considered to be a derivation of the Old English word 'clot' which can be traced back to 1398.

Clods were not specifically cut in large numbers for building purposes. The term was used to describe pieces of broken turf or a small turf cut as a packing piece used to fill an irregularity in some other form of turf wall.

3.02 Divet

A thin building turf similar in size and thickness to the turves used for gardening purposes. The oldest known use of the expression dates from 1503 when it was written as 'diffet' (fig 7).

Traditionally, divet was stripped from the ground using a flaughter spade or breast plough. The flaughter can be found with a range of blade sizes, with or without an upturned edge. This edge determined the width of the turf by cutting the divet from the remaining sward in a single action rather than making vertical cuts with a spade and releasing the base of the turf with the flaughter.

Size and cutting edge apart, the flaughter took two main forms in Scotland: those with a flat blade to make divets of even thickness, and those with a dished blade that cut a turf that was thicker in the centre than at the edges. The distribution of the two types of flaughter has not been plotted.

3.03 Fale

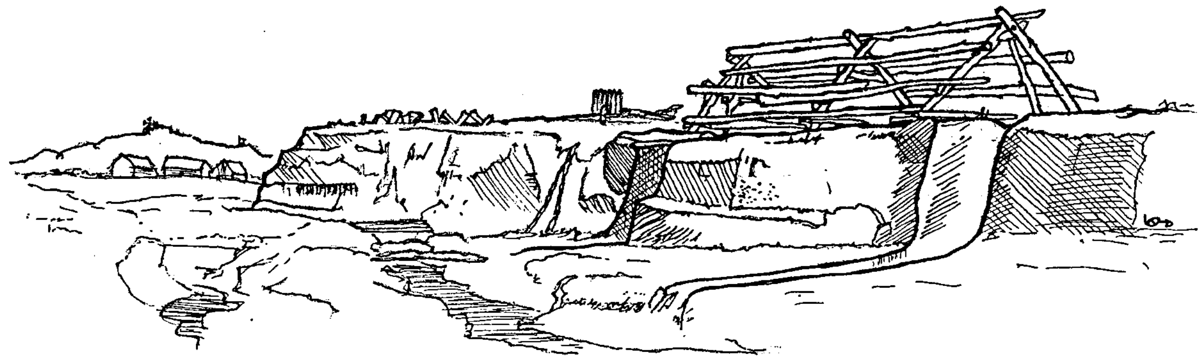
A thick building turf cut in the form of a rectangular or parallelogram-sectioned block with vertical ends. The term was in general use from 1420 onwards when it was written as 'fayle' or 'faill'. The Gaelic word 'fàl', meaning a sod, first appeared in 1513.

In 1775 it was reported that fale dykes could always be built at one quarter the cost of a stone dyke.

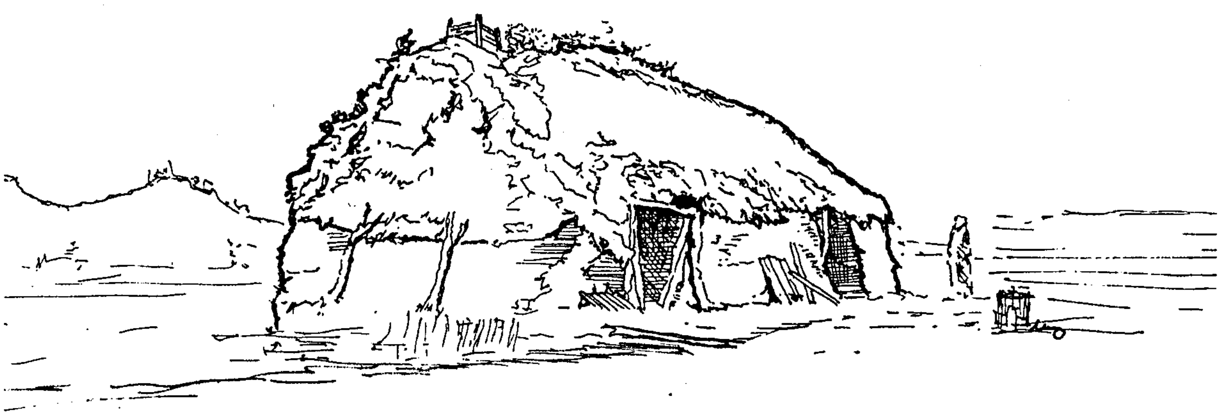
When cutting fale, the grass surface and the bottom of the block are always parallel, and the sides are cut at an angle to create a parallelogram section. The inclined sides are easy to produce using a standard spade since it is more natural and easier to insert the spade at an angle rather than vertically and the detached fale can then be levered clear of the remainder of the sward without damage to either edge.

3.04 Moss (Peat Bog)

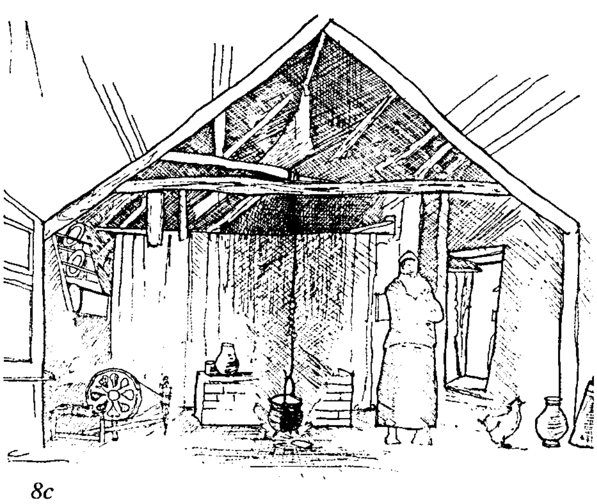
When clearing a major peat bog or moss it was reasonably common to create a house or shelter by leaving a block of living 'moss' large enough to form the entire volume of a dwelling. Drainage channels were then formed round the block and the interior hollowed out leaving the walls carved out of the



8a



8b



8c

fig 8. Moss houses, Carse of Stirling, 1792 after Joseph Farrington. © Bruce Walker.

a) Timbers being erected within moss walls.
b) Complete moss-house.
c) Interior of moss-house.

undisturbed peat or moss. Moss-houses of this type were described by Farrington (1792) (fig 8), Megaw (1962) and Walker & McGregor (1996. 9-11) and although the technique was still in use for the construction of ice houses (fig 9) in the 1880s (Herbert, 1883), no known examples survive in Scotland.

3.05 Peat (Irish - 'turf')

Peat is essentially a fuel but coarse-textured woody peat close to the surface of the bog is sometimes cut in the same way as fale and used as a building block. The test as to whether a particular peat is suitable is whether it can be carried to the wall and placed in position without breaking up or distorting under pressure when other blocks are added to complete a lift. This may be the material referred to as 'moor-faels'.

3.06 Pone (Shetland)

Two definitions are given. The first, a thin oval strip of green turf measuring about (375 x 125 x 25 mm) 15 x 5 x 1 inches, used for the roofing of houses and peat

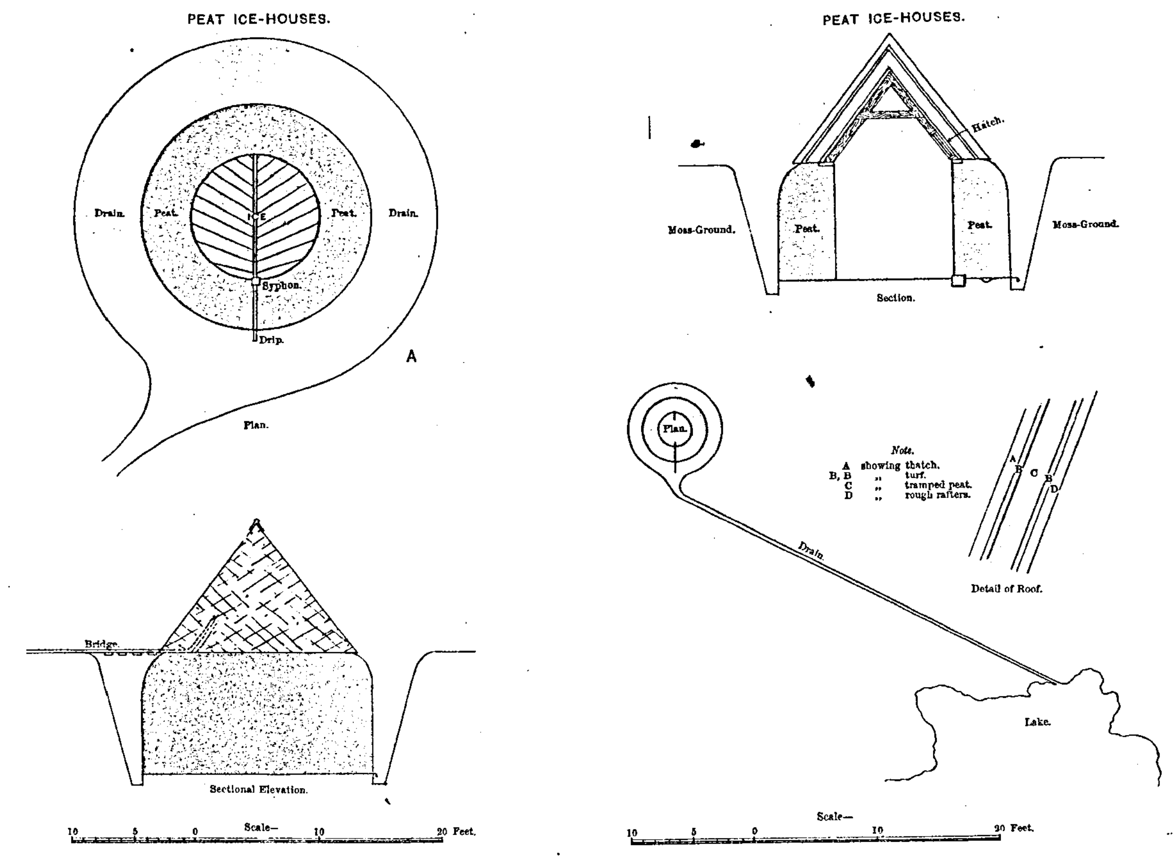


fig 9. Peat Ice House, from Herbert, 1883.

stacks. The second, swards of earth, cut very fine, upon the surface of which grows a short grass, is used for the sole purpose of roofing. Both definitions may be referring to the same material, one providing the dimensions, the other a description of the material.

3.07 Scraw

A thin turf or sod generally used for roofing: the top paring of turf removed before cutting a peat bank. These can be cut in a number of ways depending on type of sward and local practices.

3.08 Roman Turf Type

Turf construction was known in Northern Europe long before the Roman invasion of Britain. The Roman army adopted this form of construction in those countries where it was appropriate, and standardised the size of turves in their military manuals. Vegetius, in his publication on military science, wrote at the end of the fourth century using manuals that were at that time about three hundred years old (Milner, 1993).

Vegetius gives the size of a cut turf as being one-and-a-half by one foot in plan and half a foot deep (fig 5). The Roman foot is normally accepted as being 296mm. In describing the construction of a rampart, Vegetius states:

> *'The raised turves are laid out in line forming a rampart. Above it, stakes are ranged along its length'.*

The process of cutting the turves is described as:

> *'The turf is cut round with iron tools, retaining the earth in the grass roots....'*

The iron tool referred to is a half-round blade on a shaft, similar in form to a modern half-round lawn edge trimmer. Vegetius continues:

> *'When the earth is too loose to be cut out in the form of a brick, the ditch is cut in the temporary style, with a rampart rising on the inside.....'* (Milner, 1993, bk 1 chapter 24).

The 'temporary style' referred to above is described as follows:

> *'When there is no pressing danger, turves are cut from the earth, and from these a kind of wall is built, three feet high above the ground with the ditch from which the turves are lifted in front......'*

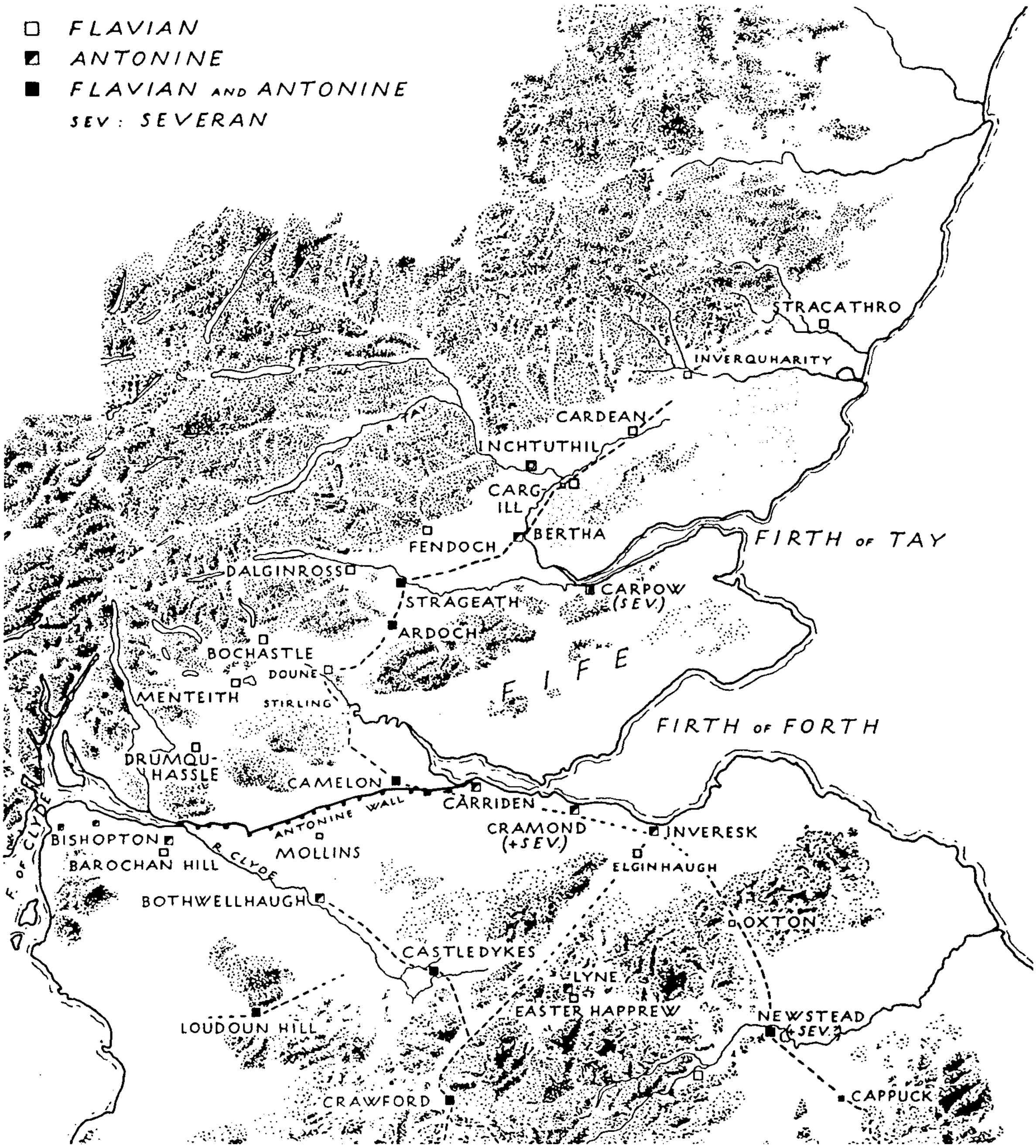


fig 10. Map showing Roman Forts in Scotland (Frere and Wilkes).

'Above the ditch, revetments are built on either side and filled with earth, that has been dug out of the fosse, rising to a height of four feet......' (Milner, 1993).

Gordon Maxwell, archaeologist, confirms the turf thickness in Roman structures in a report on an excavation at Crawford, Upper Clydesdale, where turves had been used to fill a ditch. These turves were approximately 150mm (six inches) deep, allowing for their compression over a period of almost two thousand years.

The Roman camp at Strageath, Perthshire (figs 10 & 11) was excavated by Professor S S Frere et al between 1973 and 1986. It falls into the category of Castra Æstiva (summer camp) known as a Castra Stativa (semi-permanent camp) which is generally stronger and better built than a Castra (marching camp) but less well built than a Castra Hyberna (permanent town).

The description of the defences at Strageath (Frere & Wilkes, 1989, 14-31) shows that the Romans were very particular about the types of turf used for building and fully understood the properties of the material. The east rampart is described as follows:

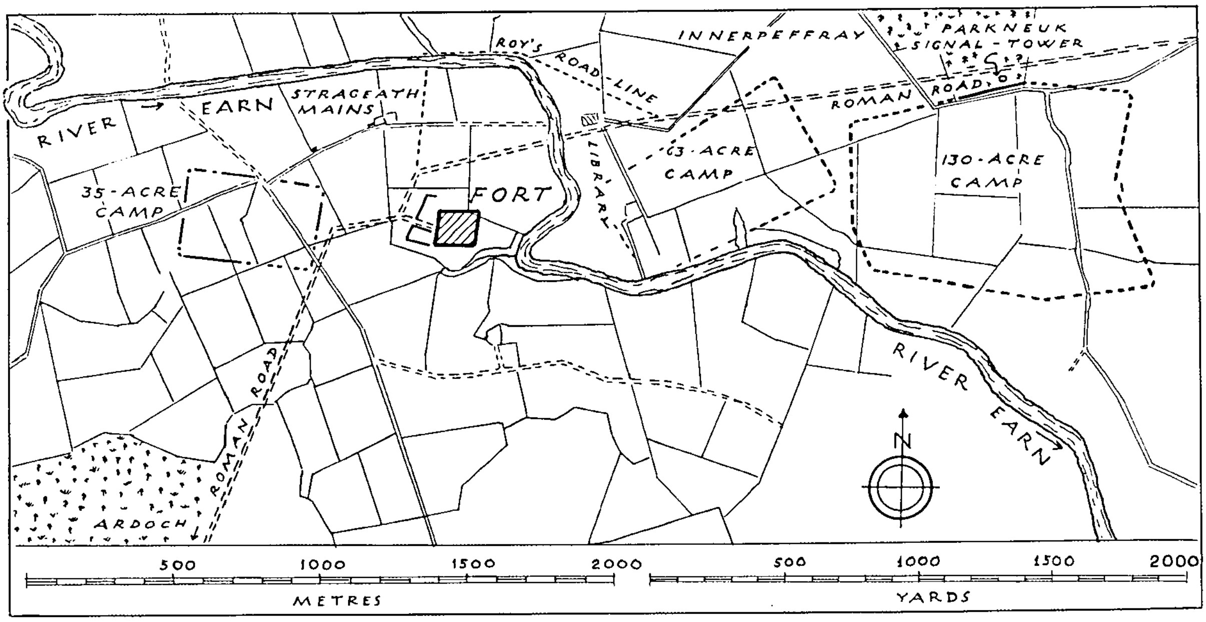


fig 11. Map showing position of Strageath and nearby marching camps. (Frere and Wilkes).

'The front of the Flavian rampart stood 9ft 6ins (2.90m) behind ditch 1; such a wide berm was perhaps a precaution against collapse of the soft sides of the ditch. The Flavian rampart consisted entirely of laid turves, and was 17ft (5.18m) wide at its base. The turves had been built on a timber strapping of small branches laid transversely on the old surface; additional layers of transverse branches were added at vertical intervals of just over 1ft (0.3m) in order to bind the structure and impede collapse. The interval was no doubt formerly greater, but has been reduced by compaction............'

'.......where measurable the largest turves in this platform were 1ft 6ins by 1ft (0.46 by 0.3m); others were 11ins (0.26m) square. This thickness varied between 1 and 3ins (0.025 - 0.076m)'.

'The old soil buried beneath the Flavian rampart was of an orange-brown sandy texture, known to soil scientists as Acid Brown Soil. When not under cultivation.......this would carry a heathland vegetation and it was evident that the thick clayey turves of the rampart could not have been stripped from the site of the fort itself......' (Frere & Wilkes, 1989. 17).

The source of these turves was identified on the slope between the fort and the River Earn about 270 metres north east of the east rampart.

'The work of carrying turves uphill this distance and delivering them unbroken must have been exacting labour' (Frere & Wilkes, 1989. 18).

'Turves of a similar character were used round the south and part of the western perimeter....... only the north praetentura, north of the porta praetoria, was a different kind of turf encountered..... the Flavian rampart was found to be built of almost black friable turves......considered to have been derived from the plateau itself' (Frere & Wilkes, 1989. 18).

This indicates that the strongest turves were being cut from the sloping ground 270 metres to the north-east of the fort. These were then carried uphill and past the north rampart to be used in the construction of the east, south and west ramparts. The poorer turf, removed from the area within the fort and from the surfaces of the surrounding ditches, was being carried in the opposite direction to be used in the north rampart. This shows that the Roman builders were well aware of the properties of the turf since turf exposed to strong sunshine and drying winds only has half the lifespan of the same turf in a cool shaded situation.

The Flavian rampart (fig 12) was refaced in later re-occupations of the fort. The Antonine I rampart (fig 13) was built using large yellow turves and grey turves from an unidentified source. The Antonine II rampart (fig 14) utilised large turves containing a high

fig 12. The 1973 trench through the east defences, looking west. Behind the two ditches lie (a) the timber strapping at the base of the Antonine I rampart and (b) the Flavian rampart with strapping at a higher level. Scales in feet. © Frere and Wilkes.

fig 13. The Flavian rampart partly cut back, with the Antonine I addition in front resting on remains of timber strapping. Scales in feet. © Frere and Wilkes.

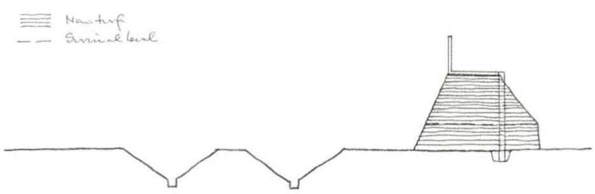


fig 14. Section through Flavian rampart, Strageath (after Frere and Wilkes).

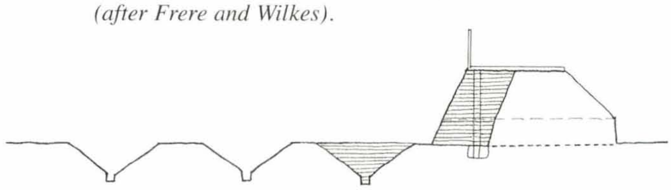


fig 15. Section through Antonine I rampart, Strageath (after Frere and Wilkes).

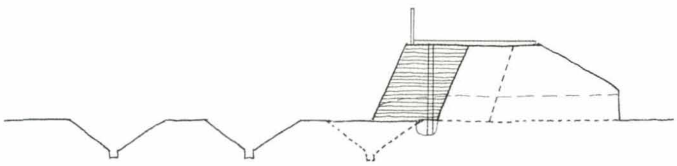


fig 16. Section through Antonine II rampart, Strageath (after Frere and Wilkes).

proportion of pebbles. The Antonine II rampart did not survive to the same extent as the earlier phases. This could be due in part to the pebbly turf degrading at a faster rate than the clayey turves, or it could be that this phase was deliberately destroyed by later farmers who wished to use the land.

William Roy's plan of the fort (fig 17) produced in the mid eighteenth century, makes it clear that the fort at Strageath had long been under the plough at that date, and that material ploughed down from the rampart had quickly formed a protective layer over the via saglaris and the edges of the adjoining buildings.

Stageath fort had turf ramparts at all three periods of its existence, and the buildings within the ramparts were all timber-framed except for the Antonine bath house. Experimental work at the Roman fort at the Lunt, Baginton (Hobley & Applebaum, 1971, 21-33 and 1975, 20-23) indicate that the ramparts to a Roman fort could be built in approximately twelve days.

'The surviving earthworks of the fort at Strageath measure approximately 468 feet by 424 feet (142.6 by 129.2m) giving an area over the ramparts of 4.5 acres (1.82 ha). The Flavian turf rampart was consistently 17-17½ feet (5.18 - 5.33m) wide at the base. The original height was probably about 10 feet (3.05m) with added parapet......... In each of the two Antonine periods the entire rampart was re-fronted with turf to provide a reliable rampart-walk and this too was supported by posts'.

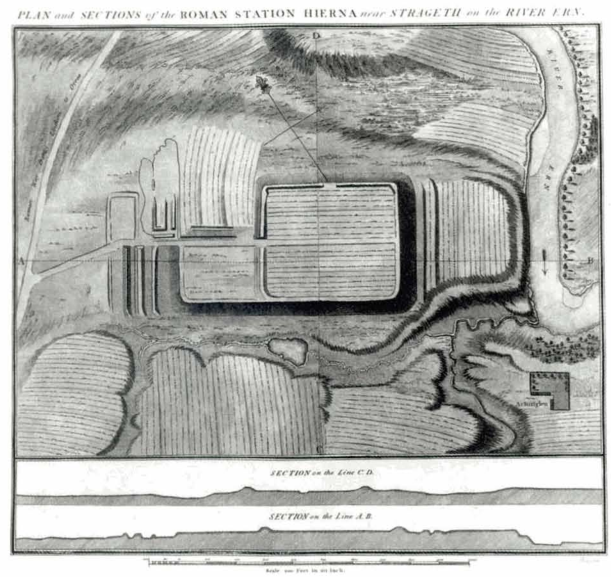


fig 17. Roy's map of Strageath.

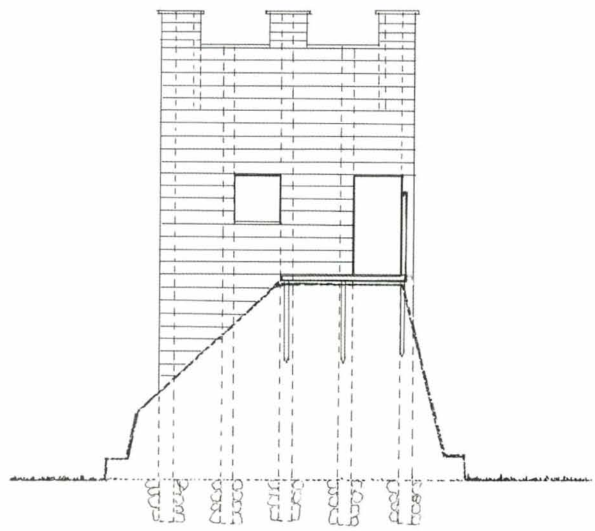


fig 18. Reconstructed section through the Turf Wall of Hadrian (after Simpson and Richmond).

The area within the ramparts remained constant throughout the three periods of occupation but the ditch system outwith the ramparts became increasingly complex, incorporating more defended annexes.

'The Turf Wall of Hadrian' (fig 18) was reckoned to take a very similar profile to the Strageath ramparts. This was erected across the north of England prior to work commencing on the Hadrian's Wall, that survives today. It took a similar, but not exact, line to the present Hadrian's Wall and excavations on the line of the Turf Wall were published in 1936.

3.09 Icelandic Turf Types

Icelandic studies of turf structures have established that the Icelandic turf builders used four distinct cuts of turf in their structures, each designed for a particular function. Ágústsson has produced a series of drawings linking each of these types to a rectangular block (fig 19). The various cuts are:

1 Klömbruhnaus

2 Kvìahnaus

3 Snidda

4 Strengur

These cuts of turf may relate to the cuts found in Scotland but as yet the Scots have only the external form on record and not the shape within the wall and the method of bonding.

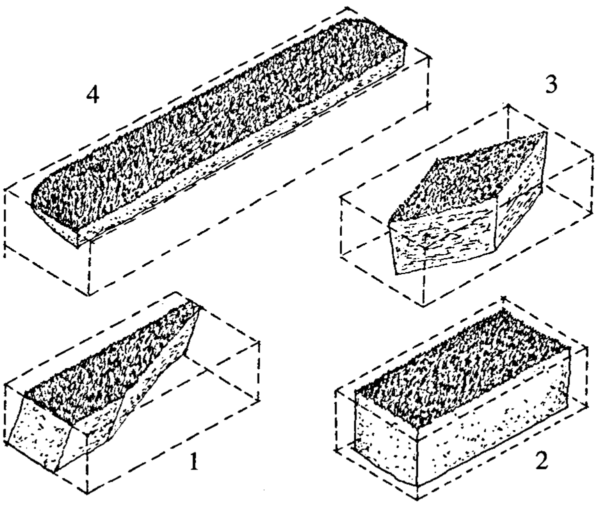


fig 19. Icelandic turf types (after Ágústsson).

3.09.1 Klömbruhnaus

This has a cross section on elevation similar to fale and the turves are cut to lean to either the right or the left to allow a herring-bone pattern to be created on the wall face. The parallelogram section is limited to approximately a quarter of the depth of the turf and the rear section is cut to a taper that results in a triangular section on the end penetrating the wall. This appears to be used to tie the turf facing into the earth core of the wall.

The klömbruhnaus was always built grass down, or leaning against the previous turf, and was often used in conjunction with alternate courses of strengur, possibly in the same way as fale and divet: again this will have to be confirmed by archaeological investigation in Scotland.

3.09.2 Kvìahnaus

This is normally a rectangular block of turf built in the turf equivalent of Flemish bond, that is, alternate headers and stretchers along the length of each course of turf.

Kvìahnaus is first mentioned in the fifteenth century but, in a herring-bone pattern suggesting that at that time the blocks were parallelogram in section when looking from the wall face.

3.09.3 Snidda

Snidda is used for outer walls either above or between layers of stone. The blocks are cut in a diamond shape from the surface and used for the outer faces of walls (fig 18). The technique is common in the rainy parts of Iceland, and the surface of the wall is soon covered with grass.

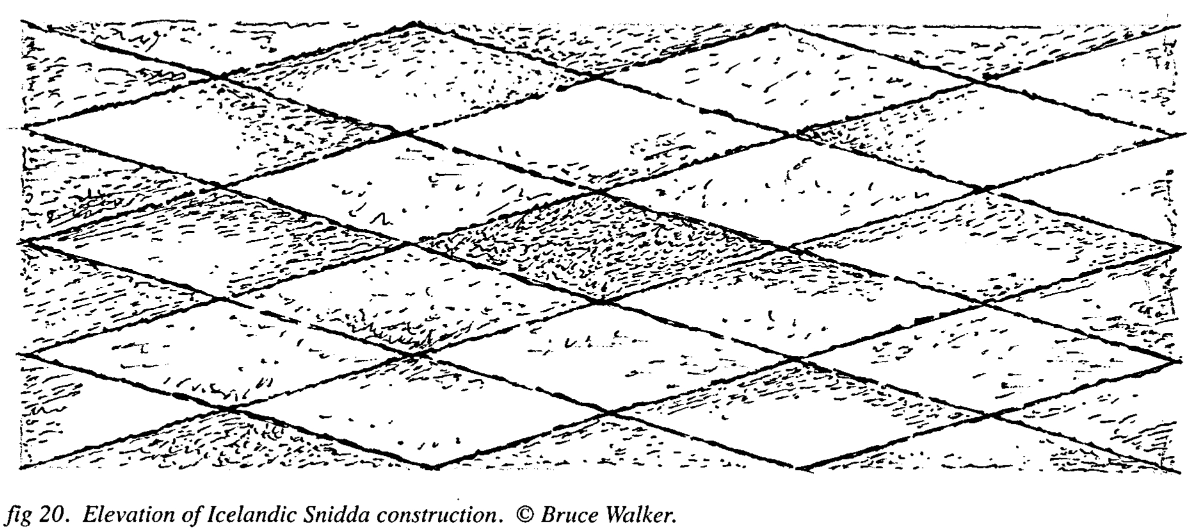


fig 20. Elevation of Icelandic Snidda construction. © Bruce Walker.

3.09.4 Strengur

Strengur is cut in metre lengths in a long strip, wedge-shaped in section. It is used both for roofing and for walls. In walls it is normally used in conjunction with klömbruhnaus, but archaeological excavations show that the oldest Icelandic turf walls seem to have been built entirely of strengur.

3.09.5 Observations

It is not anticipated that the Scottish turf types will match exactly those found in Iceland although this is possible. It is clear that there appears to be a common origin to a range of turf building types dating to around 1000 AD and found in the countries around the North Atlantic (fig 21). Survival into the eighteenth century

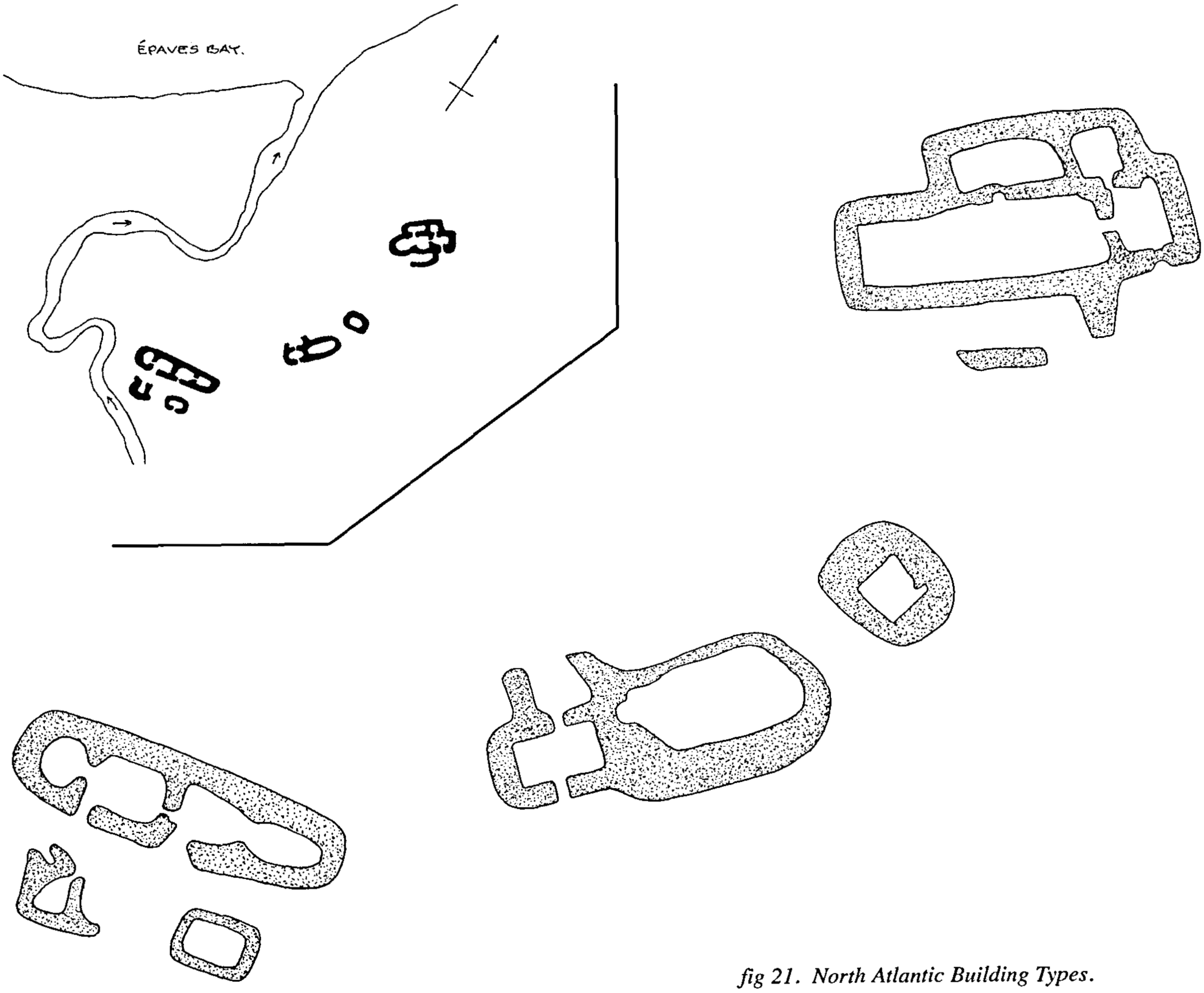
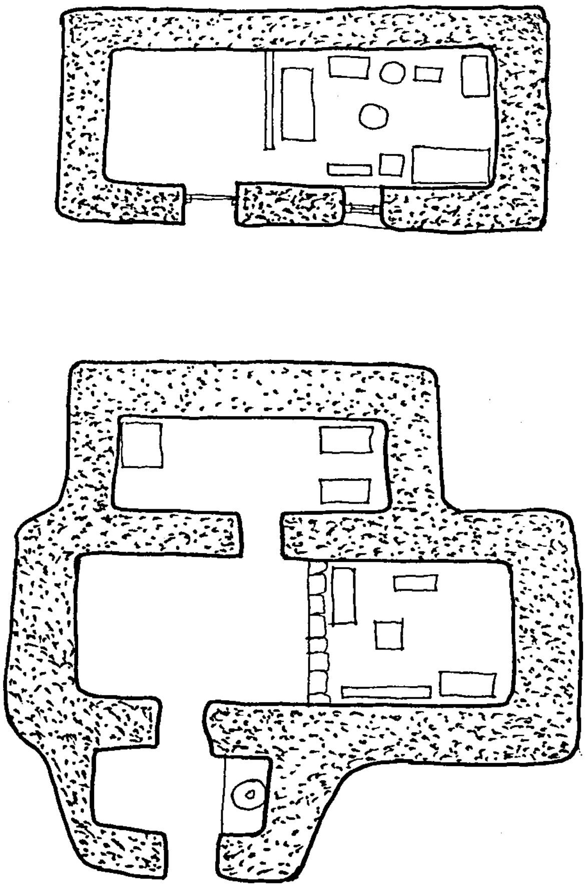
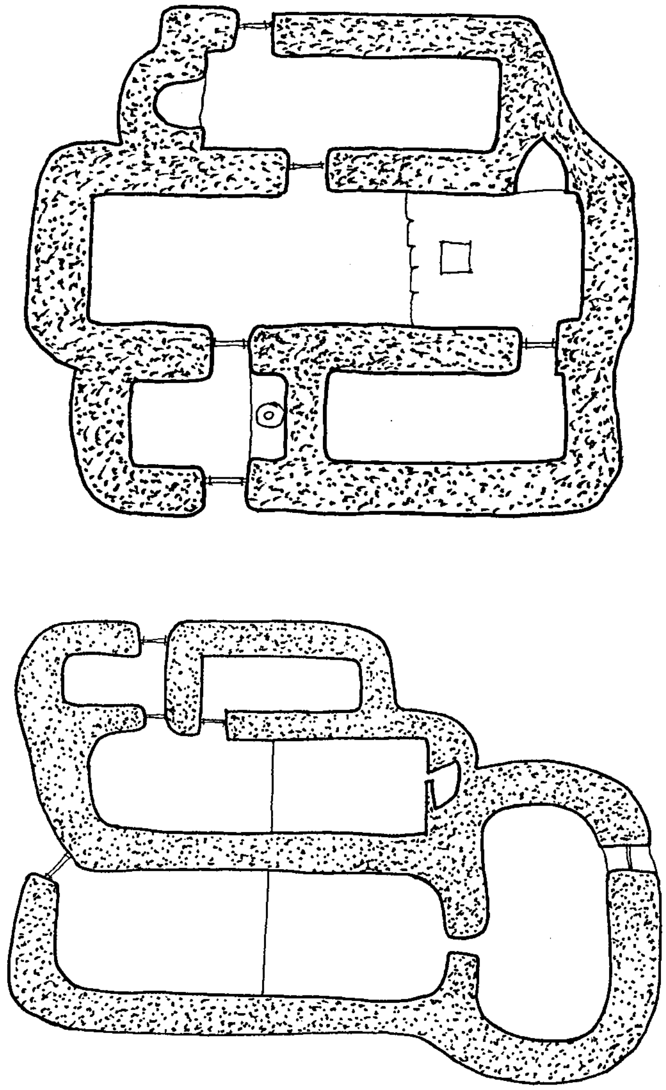


fig 21. North Atlantic Building Types.

a) Plan excavated at L'Anse aux Meadows, Newfoundland dating from circa 1000 AD. (after Ingstad).





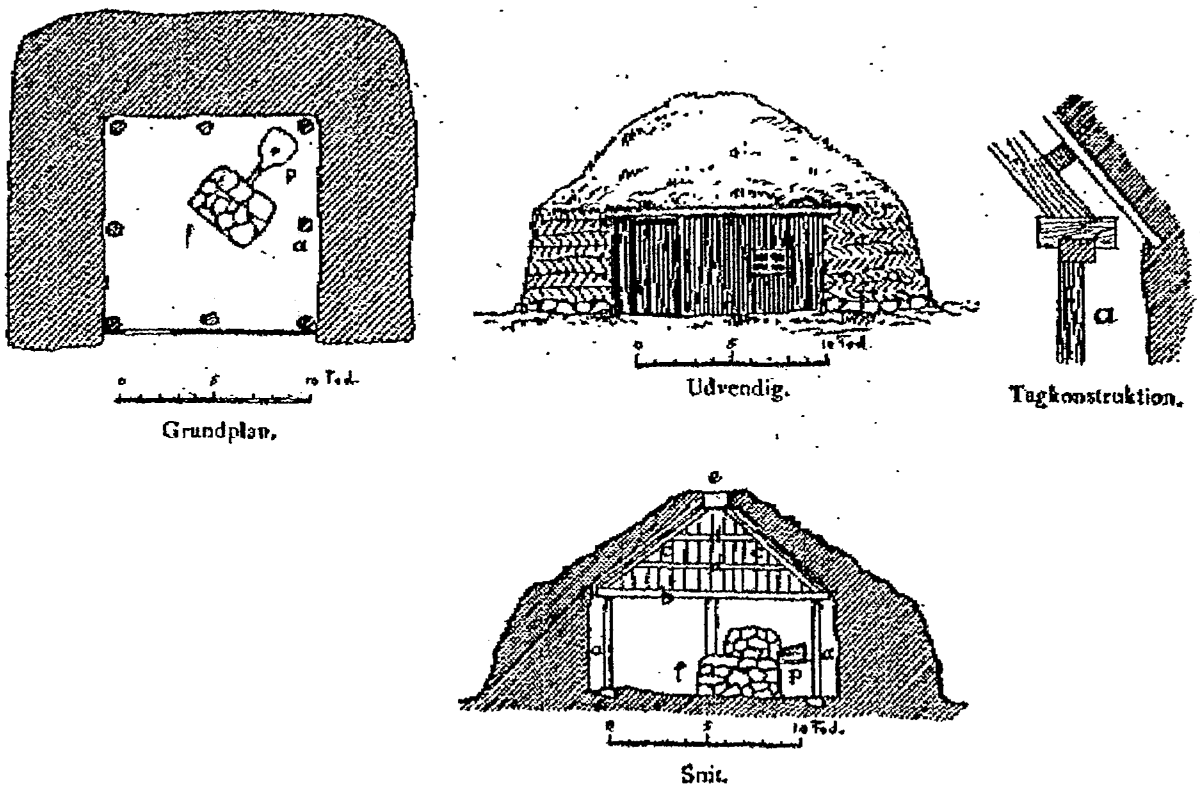
b) Plans of blackhouses surveyed by Captain Thomas in 1856 at Carloway, Lewis (from original drawings in the Society of Antiquaries of Scotland Library, Edinburgh).

is still reasonably uniform but survival into the nineteenth and twentieth centuries becomes increasingly sporadic. This spread may have been the result of Viking activity in the North Atlantic or it may be the result of some other groups such as the Irish or the Picts. Whatever the sources of the spread of turf building techniques in the Viking migration period, it must be remembered that the Romans had been building massive turf structures in many parts of their Empire a thousand years before the Vikings.

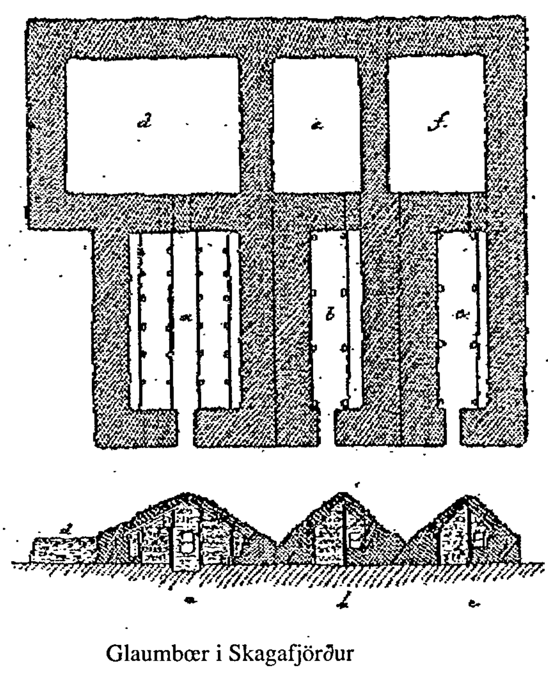
Most countries in Northern Europe will have some form of recent turf construction but the technique persisted longer in countries or regions where there was a shortage of readily accessible building stone or timber, not only in the physical sense but in economic terms. Stone is expensive to work even in areas where it is plentiful, and timber may be the property of the landlord or restricted in some other way, keeping its use to a minimum.

The purpose of this chapter is not to give a short history of turf construction highlighting its origins and influences, but rather to set out a background that will allow archaeologists to follow up clues according to the dates of the remains being excavated.

Although the Hebridean blackhouse appears to have direct links with the Sammi houses of West Finnmark, Norway, the Faeroese houses, the Icelandic turf house, and the Viking migration period houses of Greenland and Newfoundland, it may nevertheless be a response to the environment rather than a cultural phenomenon. This type of response can be seen in the development of the Nebraskan soddy where the turf construction was embraced by peoples from all over the World. It should also be remembered that a number of Indian tribes in Nebraska were already using turf construction before European settlers arrived, and that these North American Indian tribes may be linked back through the Inuit to the Sammi of Northern Eurasia.

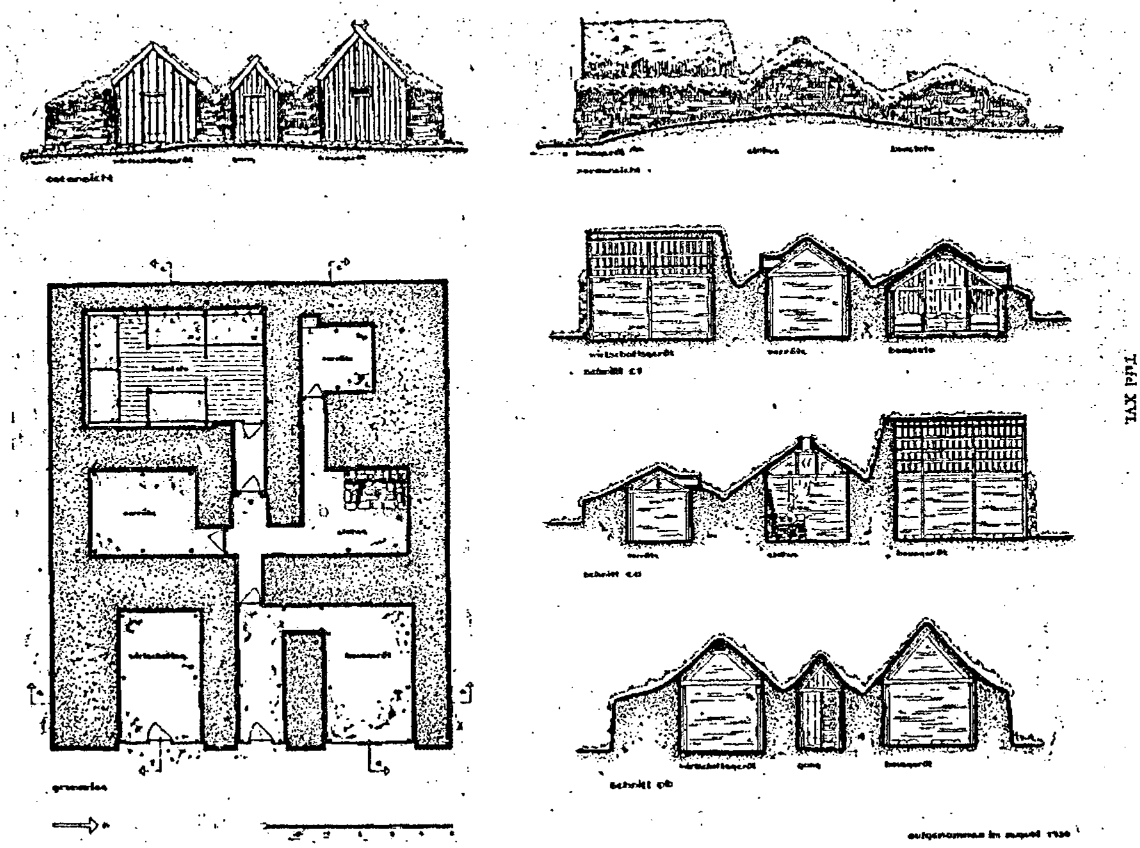


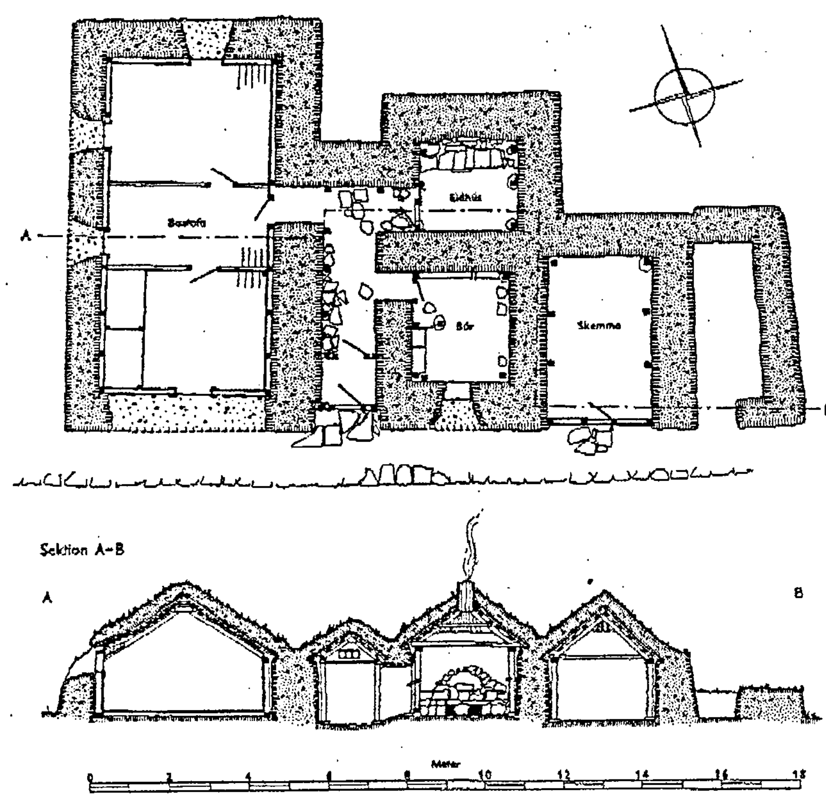
Smedje møt Spœriagpaa Gaarden Hofstaðir i Skagafjörður



Glaumbœr i Skagafjörður

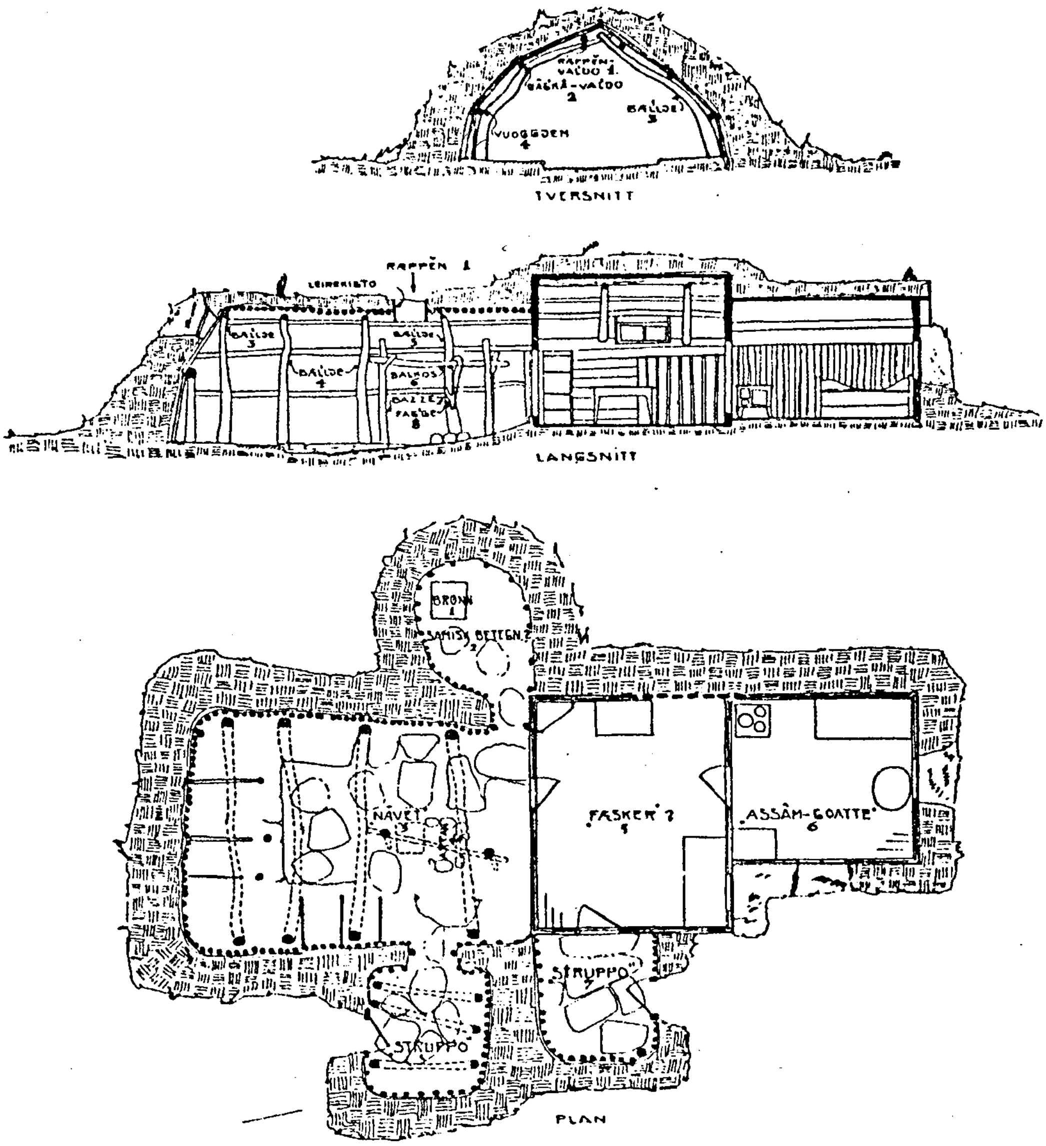
c) Plans of typical Icelandic farmhouses.





Högnastaður i Borgarfjörður

c) Plans of typical Icelandic farmhouses.



d) Plan of Sea-Sammi house, Trollbugt, lebesby, West Finnmark, Norway circa 1930s (from Vreim).

4. METHODS OF BUILDING

The ways in which blocks of turf are built and bonded together vary according to the shapes of the turf blocks being used. This aspect of the construction will be dealt with under each of the basic turf-block shapes.

Unlike building stonework or brickwork, where it is common practice to build the corners to a higher level than the rest of the wall, then to fill the intervening gap, turf must be laid in level courses. The course should be started at a corner or opening, then progressed systematically along the length of the wall, finishing each course completely before starting the next. Many accounts refer to the practice of building grass to grass and earth to earth alternately, but in Nebraska, USA, where the first buildings were being erected after the demise of turf building in the agriculturally richer parts of Scotland, the practice was to build grass-down all the time. This was also the technique favoured by RW Dickson (1805) who referred to the sods being:

> *'....laid into the fence with the grassy side undermost......the upper surface of the whole course is pared smooth and clapped down with the back of a spade for the reception of the next course......'*

This would certainly allow the wall to be fully compacted with all voids being exposed and subsequently filled before the next course was laid. The authors' experience is that working with good quality turf, the grass-side down technique is excellent, but when working with weaker turf it is not easy to pare the surface of the roots without damage to the turves already laid and the grass-to-grass turf-to-turf technique provides a substantial wall.

No mortar was used to bind the turves together but the practice of cutting the turf when wet and building within twelve hours encouraged growth in the roots that assisted the binding process. All cracks between turf blocks, holes in the turves or other voids were carefully filled with clods or soil to keep the wall solid and level during construction.

Care had to be taken to ensure that the centre line of the wall remained perfectly vertical. This did not preclude a slight batter on the outside surface, but the interior profile and centre line of the wall were always vertical.

Door and window casings were built into the wall at appropriate places, and the turf wall butted to these.

As the wall rose above waist level, a wagon could be used as a staging, or some other form of scaffolding could be erected. The faces of the wall were carefully shaved to form a finished surface which could be plastered internally and rendered externally if desired.

After a few courses had been laid the surface of the walls was pared from above to remove rough turf ends and provide as smooth a surface as possible. This assisted the builder as he was constantly reminded of the finished line of the wall and was therefore more aware of any unexpected slump or movement as the work progressed.

For many field dykes, and the walls of some black houses, the turf blocks were used to form an external skin to a compacted earthen core.

Occasionally the turf walls were partially supported or restrained by armatures of timber, wattle or whale bones. These will be discussed in Section 5.

4.01 Divet

Divet is a rectangular block (fig 22) and is usually built in a bonding pattern similar to those found in brickwork structures. Divet variations of common, English, Flemish and garden-wall bonds have all been recorded. Common bond is usual where the core is filled with consolidated earth, Garden-wall bond is more common for walls built entirely of turf, with a header course occurring every third or fourth course. English and Flemish bonds generate additional work and take more time to complete but probably provide stronger structures. Divet can also be used for roofing (fig 24).

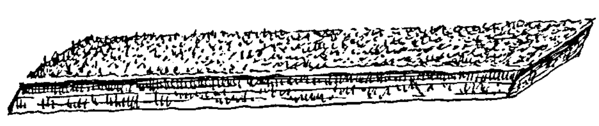


fig 22. Icelandic equivalent of divet (after Sacher).

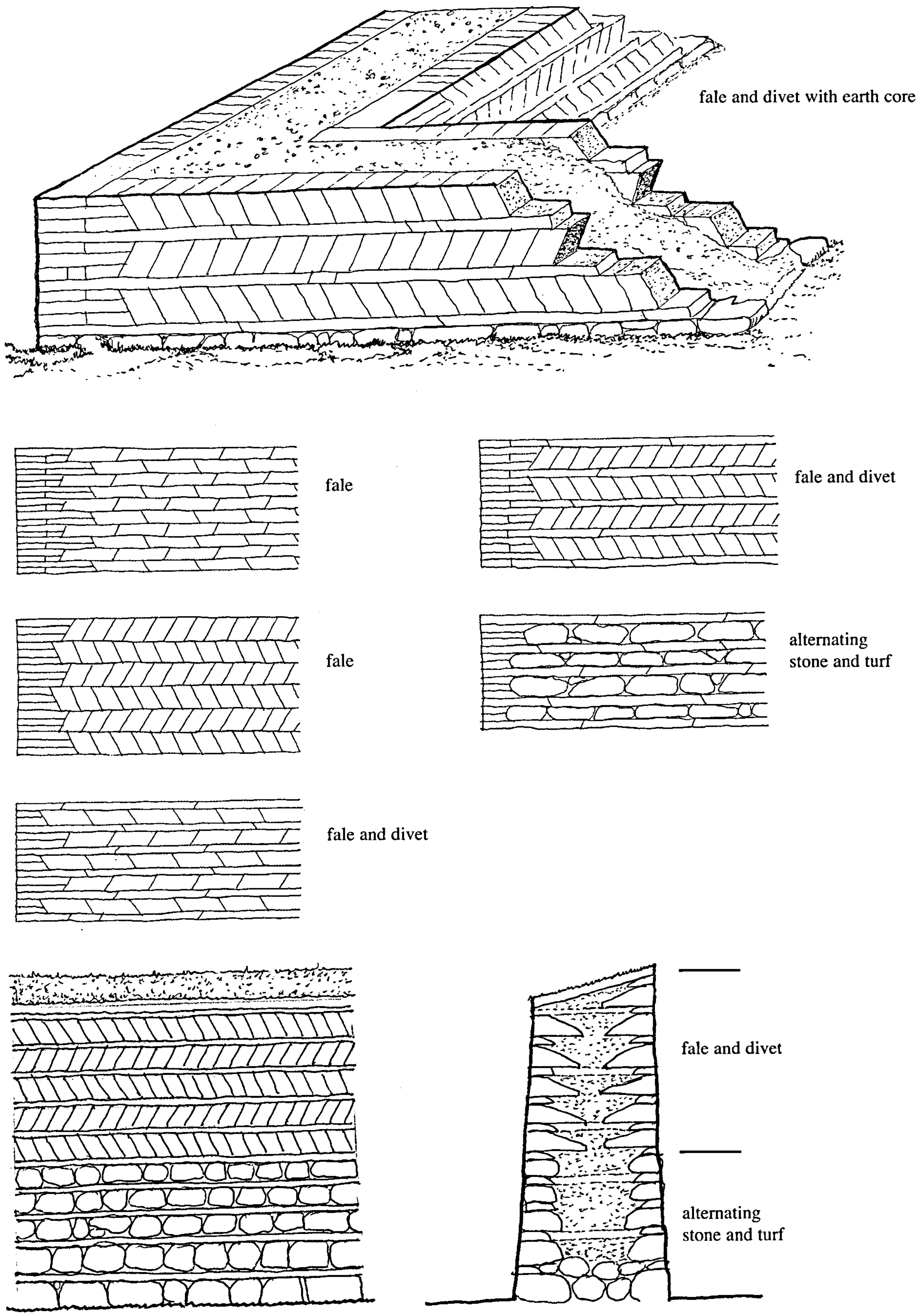


fig 23. Turf bonding patterns.

fig 24a. Divet roof to sheiling hut. © C McGregor.

fig 24c. Divet undercloak to thatch, 2 Luib, Skye. © Bruce Walker.

fig 24b. Divet roof to sheiling hut. © NMS.

4.02 Fale

Fale is essentially a thick turf block which can be either a rectangle or a parallelogram in section (fig 25). Rectangular blocks are bonded in the same way as divet but the parallelogram blocks are set in the wall herring-bone pattern. The theory behind this type of construction is that the inclined block closes under pressure from the overburden leaving a tight waterproof joint. When building with a good quality moss-fale the joints often appear to be extremely accurate.

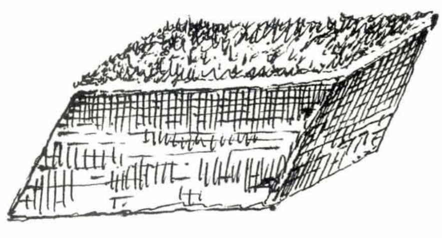


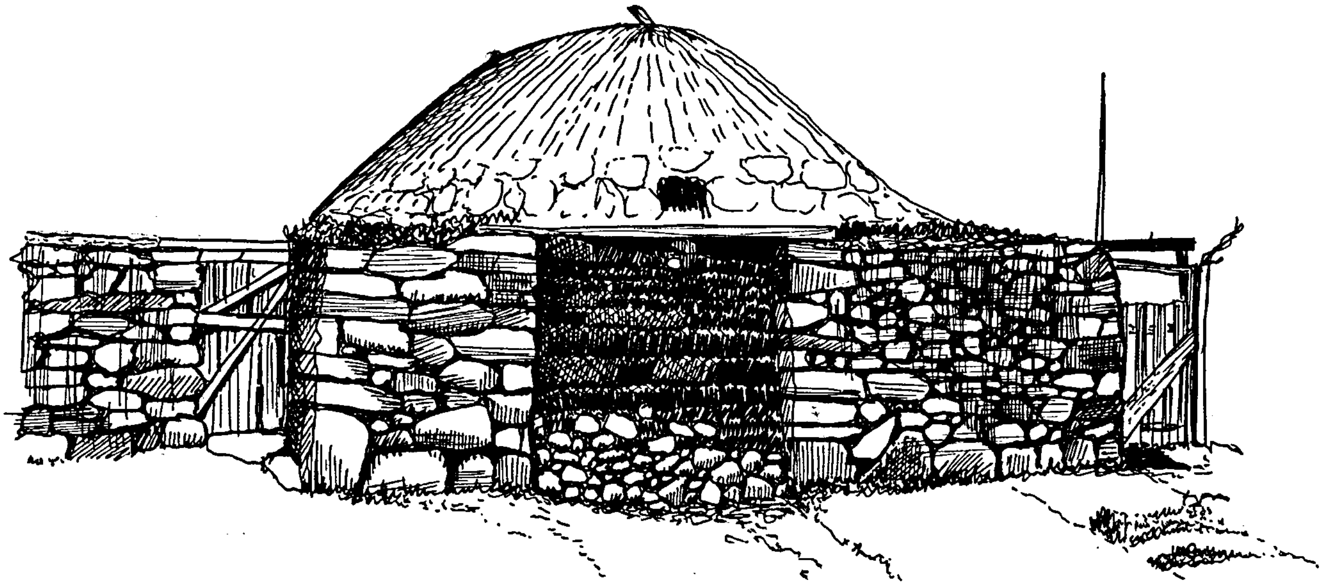
fig 25. Icelandic equivalent to fale (after Sacher).

Unfortunately little is known about the actual procedure of building. Ideally the builder should be

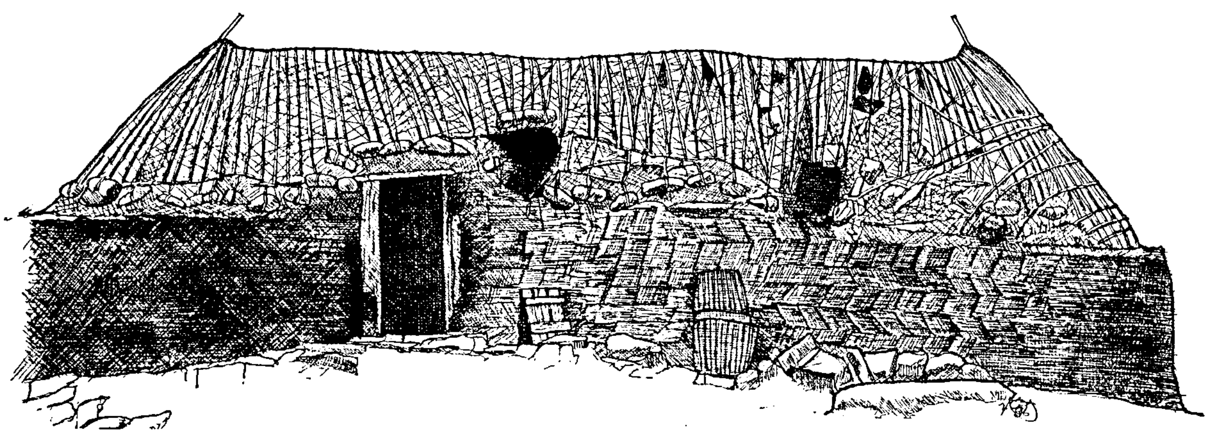
a) Wall of house, South Uist, 1886 from George Washington Wilson photograph. © C McGregor.

b) Henhouse, Lewis from photograph in NMS. © C McGregor.

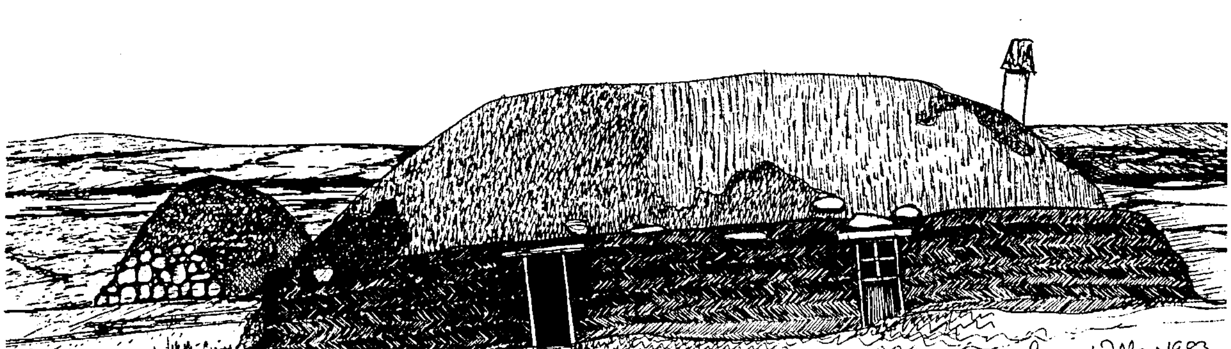
fig 26. Fale construction.



c) Fale gable to masonry faced blackhouse, Barvas, Lewis from Åke Campbell photograph. © Bruce Walker



d) House, South Uist, from George Washington Wilson photograph. © C McGregor.



e) House, North Uist from photograph held by Southern Isles Amenity Trust. © Bruce Walker.

fig 26. Fale construction.

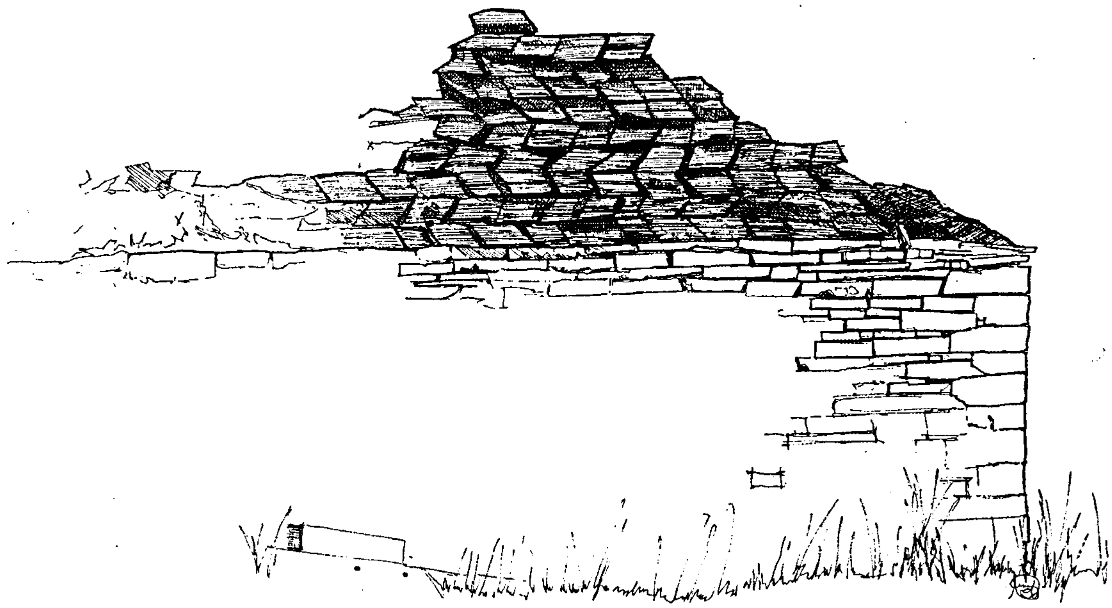


fig 27. Fale gable in Caithness from photograph in NMS. © C McGregor.

aware of when to cut the fale, how long it should dry before being placed in the wall (or whether it should be placed immediately), how to avoid distortion, and the number of courses that can be built in a day.

Experimental work with fale at Fort George used a clayey turf, and although this dried in transit to the Fort George site and had to be propped during construction due to its tendency to move under the weight of subsequent courses, it has bonded into an extremely strong wall. The Fort George experiment was unfair to the material since the contractor was trying to build the wall quickly but without sufficient length of wall to allow each course to settle and bond before the next course was added.

Some of the fale recorded in Caithness was almost certainly pure peat with no sign of surface vegetation at any of the joints (fig 27).

4.03 Fale and divet

Fale and divet utilizes the same herring-bone pattern as described in item 4.02 but with the insertion of a thin grass turf or divet between each fale course. It is assumed that the divet forms an additional tie or bond to the fale (fig 28).

In some examples the divet is placed between every second course of fale.

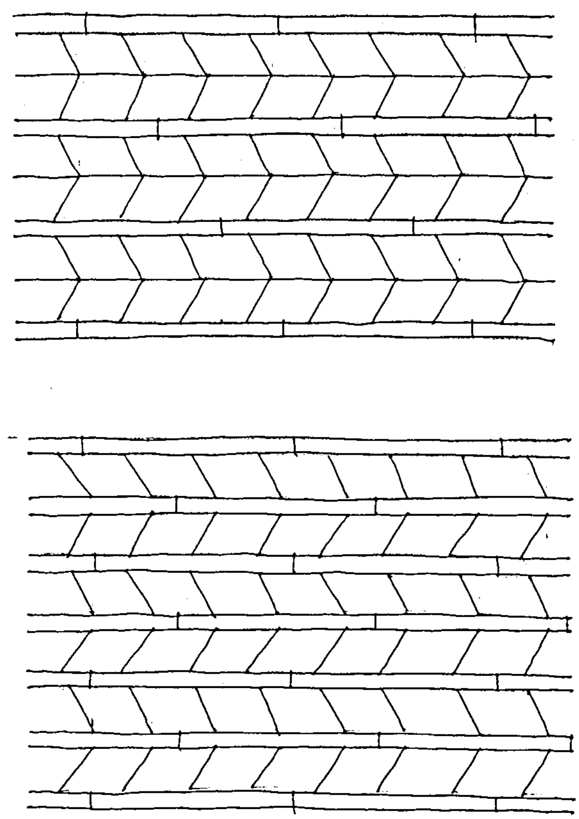


fig 28. Two forms of fale and divet bonding. © Bruce Walker.

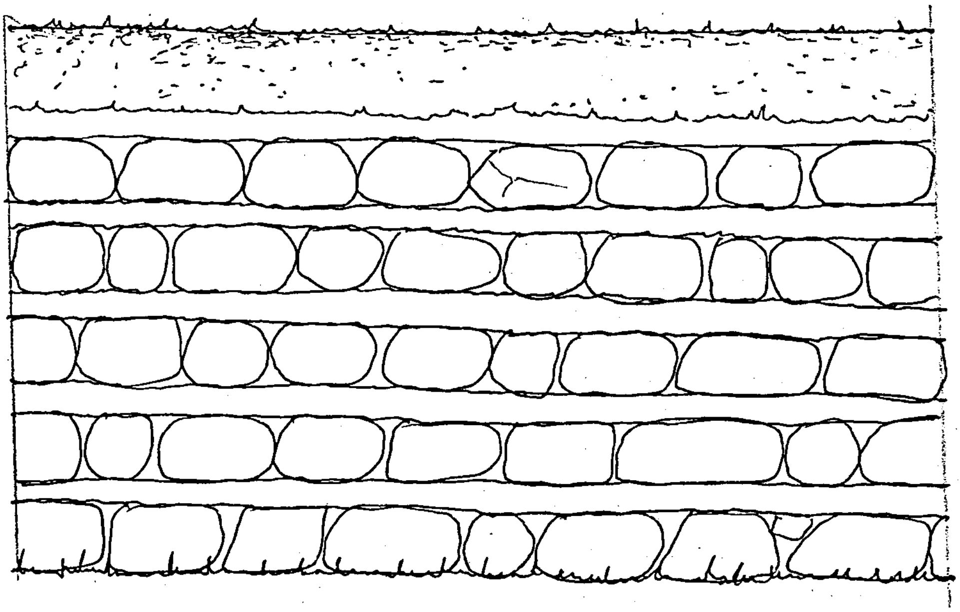


fig 29. Alternating stone and turf. © Bruce Walker.

4.04 Alternating stone and turf

The use of field clearance boulders or other irregular stones in alternating layers with fale or divet can create a sound wall (fig 29). The presence of the stones improves the wearing properties of the wall, and the fale or divet used in place of mortar accommodates the irregularities without the need to employ a skilled mason. The best results are achieved when each layer of stones is sized vertically and any irregularities are packed out with clods or an earthen mix before the next layer of turf is added.

4.05 Beam filling

Three layers of turf, usually in the form of divet, are commonly found as beam filling in eighteenth and nineteenth century houses (fig 30). Fieldwork has confirmed this as being a fairly universal finish to buildings up to the standard of large farmhouses or even small mansion houses. According to the Gaelic Society of Inverness, beam filling was known by the Gaelic name - foid-fail.

Where there are no ceilings in a house, or where the attic has a half-storey of walling and an exposed wallhead, the turf beam filling is normally encased in a mudwall plaster in the form of a neat reverse cove. A typical beam filling in a single storey house without a ceiling was sectioned at Maji Cottage, Avoch, Ross and Cromarty (fig 30).

A similarly shaped beam filling was recorded at Hilton, a small mansion house dated 1732, on the outskirts of Perth. There the same type of reverse cove ran between two different styles of ashlar post.

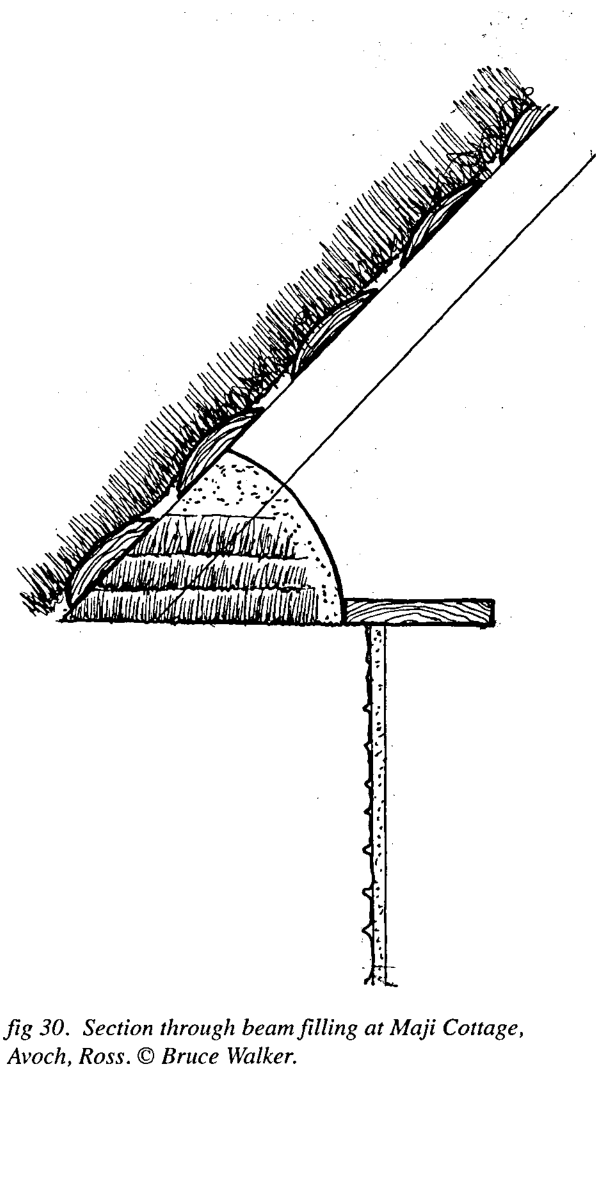


fig 30. Section through beam filling at Maji Cottage, Avoch, Ross. © Bruce Walker.

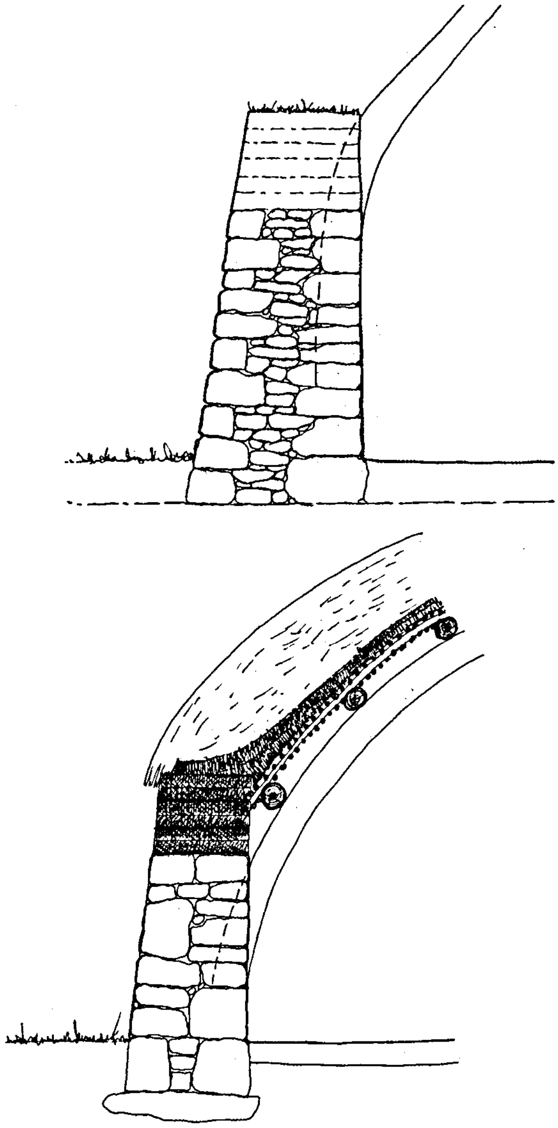


fig 31. Typical turf wall top designed to allow roping pegs to be moved to tighten the ropes. © *Bruce Walker.*

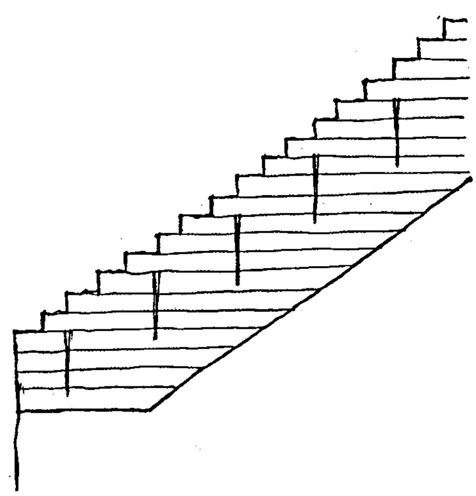


fig 32. Turf skews recorded at Drumdewan, Dull, Perthshire. © *Bruce Walker.*

4.06 Wall topping

'Three layers of turf' is also a common specification as the turf topping to drystone walls. This holds the wall top together and prevents the upper stones being dislodged, but contrary to popular opinion does nothing to waterproof the wallhead unless the turf is a dense-clay type.

Close inspection of 'turf' capping that appears to keep the mortar in the wall dry reveals that the copes to these walls are constructed of mudwall, and that the vegetation is not from a turf but rather grass and other vegetation that has seeded in moss on the surface of the mudwall cope. The roots of these plants barely penetrate the mudwall.

Many houses in crofting districts, where thatch remained the predominant roof covering until the recent past, had several courses of turf along the eaves and/or skews of the house.

At the eaves, the band of turf was used to provide a surface that would accept pegs used to restrain the cross ropes of the thatch (fig 31). The main advantage was that it allowed the pegs to be moved to tighten the ropes once they had stretched. This form of construction was eventually superseded by attaching free hanging stones or other weights to the ropes thereby providing a continual even strain on the ropes.

At the skews, the turf layer formed the vulnerable junction between the wallhead of the gable and the thatch. The turf used for this purpose was normally taken from the surface of a peat bog and therefore contained natural oils which once dried out tended to make the skew waterproof. Where waterproof turf was unavailable the gable wallhead was formed as a series of crowsteps which gave some protection from water penetration whilst providing a series of platforms to support the turf which formed the finished skew and covered the joint between masonry and thatch.

The skews at a small cruck framed house at Drumdewan, Dull, Perthshire, were recorded as the thatch under the corrugated-iron roof was dismantled circa 1975. The turf was applied in horizontal courses of divet and pegged through the courses below (fig 32). The pegs were placed in such a way that they could be covered by the succeeding course and the stepped surface was subsequently covered by skews that lapped over the joint between skew and thatch.

4.07 Turf ridges

Turf was used as a ridging material for many types of roofs including corrugated-iron, slate, stone and thatch. Since the material allowed water penetration it was used either in conjunction with some form of lapped joint or with an undercloak of clay (fig 32).

4.08 Scraw

Scraw plays an important part in the formation of many types of thatched roof. It is a very common sub-stratum over which many thatches were formed. In this use the scraws were laid on, stitched or pegged to cabers, stake and rice or thatching battens to form a complete covering; the thatch is then either laid on this surface, stobbed into the surface; or stitched through the surface.

The scraws used to form a thatch sub-stratum take many different forms and each locality or township had its own traditions. Some used dished turf to reduce problems of overlapping the joints, others rectangular blocks with inclined joints, still others were shaped at the exposed end. Many thatchers preferred turf from a peat bog since this tended to become waterproof as it dried out due to the natural oils in the turf.

Scraws were also used to form insulation under early corrugated iron roofs: they were never intended to shed water but were simply there to trap air and thus resist the passage of heat to or from the roofspace.

According to the Gaelic Society of Inverness, scraws or turf of this kind is known as *sgrathan*.

4.09 Thatch

Turf is often found as a form of thatch but, since it has normally no waterproofing qualities, it is always laid over a material that is in itself waterproof but has some other defect which makes the turf thatch desirable.

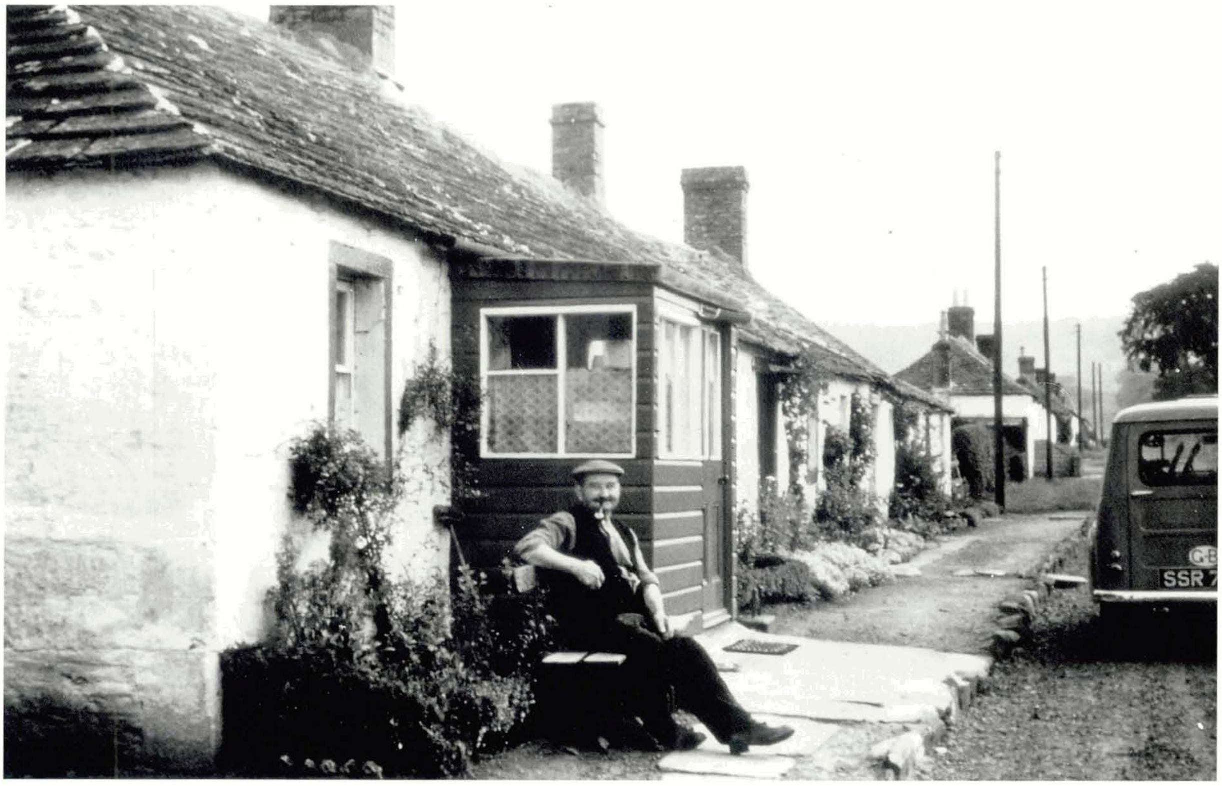
In Orkney the local flagstone looks remarkably similar to Caithness flagstone but tends to delaminate when exposed to frosts for a number of years. Turf or some other form of thatch was laid over the flagstone and roped in position. By the time the ropes had rotted the turf was well established and formed a semi-permanent external insulation layer that prevented frost causing the delamination of the flagstone.

Similarly, pantiles along the south coast of the Moray Firth tended to be blown off the roofs or have snow blown through the lapped joints into the interior of the roofspace. A thatch of turf over the pantiles solved both of these problems whilst providing additional insulation.

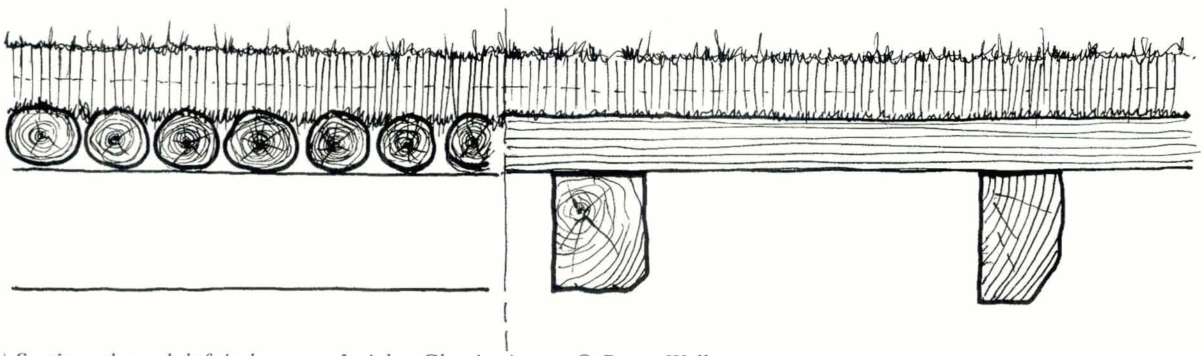
The stockstove houses of Shetland arrived in kit form from Norway and were provided with birch bark rolls to prevent water penetrating the roofs. Birch bark laid with laps, in the same way as shingles, was vulnerable to drying out in sunshine and after application, the roof was covered with soil and turf to keep the birch bark moist and thus prevent shakes that might admit water. No stockstove houses survive in Shetland but the same type of house is found in the Faeroes and Iceland.

Where a thatch appears to be formed in turf through its entire thickness the same principle applies. The underthatch is always cut from a peat bog where there is a high vegetable-oil content in the turf. The underthatch is then applied to the roof in warm dry weather and a fire lit within the building. The combined effect of the heat from the fire and the heat

fig 33. Loft-floors. a) Plank loft (after David Allan 1744-1796) © Bruce Walker.



b) House in Jericho, Glamis, Angus, built 1771-6. © NMS.



c) Sections through loft in house at Jericho, Glamis, Angus. © Bruce Walker.

from the sun dries the oils in the turf creating a waterproof material. Two thicknesses of living turf are then applied over the dried turf and this continues to function as an ordinary turf. Any oils in the upper layers may eventually leach down to the dried layer where they too will eventually dry and add to the waterproofing qualities.

4.10 Loft floors

The majority of Scottish houses built prior to 1850 were open to the apex of the roof. As chimneys were introduced in the eighteenth and nineteenth centuries, the roof space which had hitherto been full of smoke, was increasingly used as a place for storage or sleeping (fig 33). A number of mid to late eighteenth century houses have been located where the loft floors have until recently been constructed of closely spaced cabers spanning between the bottom collars of the roof trusses and covered with a double layer of divet laid root to root leaving a grass surface to both the cabers and to the loft space, thus ensuring that the toughest surfaces are exposed. According to the Gaelic Society of Inverness, loft floors of this type were known as *faradh*.

4.11 Furniture

Turf was used to form both internal and external benches. A bench or couch of this type is known as a 'fealy-sunk'.

5. ASSOCIATED STRUCTURE

Turf is often built in association with other materials which increase the structural potential and assist in stabilizing the whole building.

5.01 Cruck Couples

One of the simplest and most effective methods of transferring the weight of the roof to the ground without exerting pressure on the turf walls of a building is to use cruck couples. The cruck couple comprises a pair of curved timbers, linked by collars, that combine the function of truss and wallposts in supporting the roof without adding weight to the walls. The truss and wall-post type of construction served the same purpose, but the cruck couple was more popular in Scotland since its form suited the available home-grown timber (fig 34).

Unfortunately, Scottish builders did not distinguish between the use of cruck couples, trusses or close-coupling, using the expression 'couple' to describe the roof framing in all three.

Inspection of surviving crucks often reveals a series of peg-holes round the outer face of the frame indicating that purlins were not only used to connect the crucks at roof level but were carried down the vertical walls suggesting some form of lining on the inner face of the wall. This could be stake and rice, cabers, timber slabs, whale bones or dressed timber. Essentially the secondary structure supported by the wall purlins was to prevent the dry surface of the turf wall from being eroded by the action of animals or humans brushing against it. It also provided additional stability on the side of the wall that would most naturally dry out and shrink, thereby threatening the wall's stability. None of these linings have been found in situ in a standing building in Scotland but possible details, based on surviving Nordic evidence, are given below.

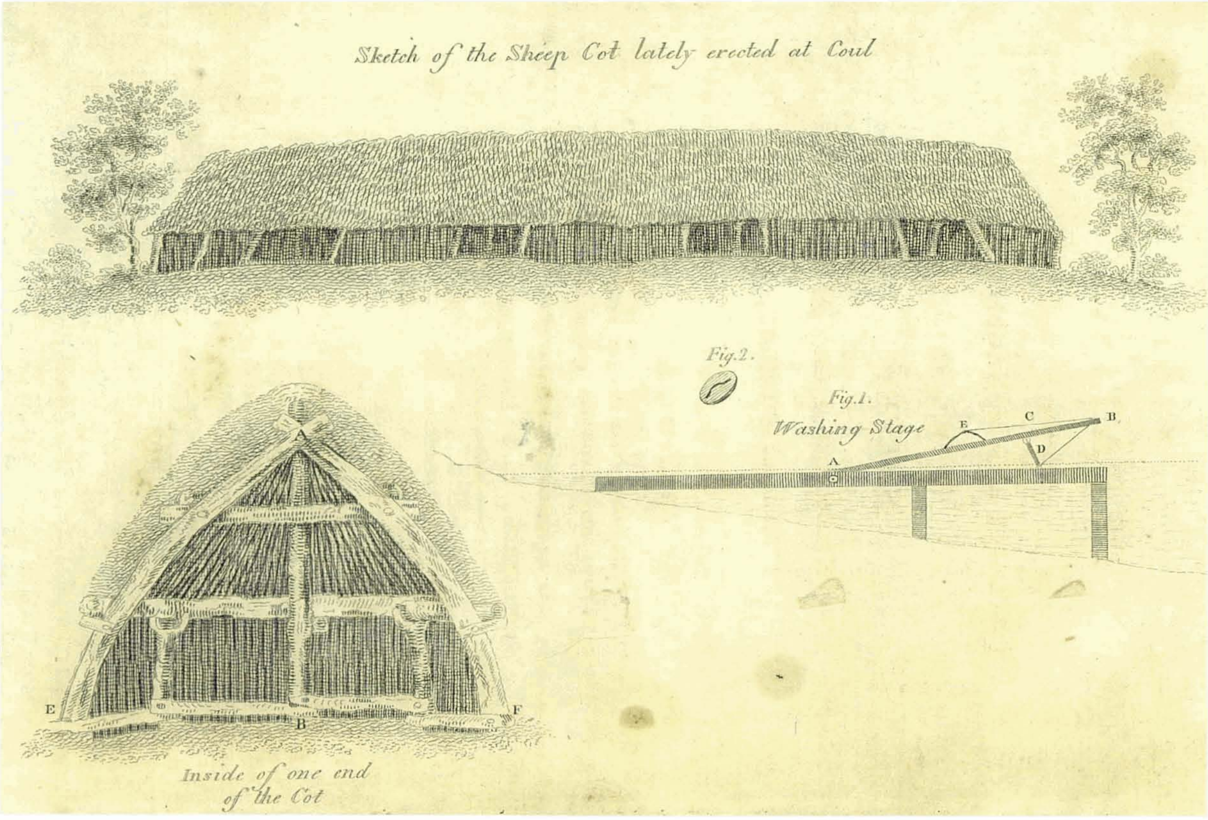


fig 34. Cruck couple structures. a) Cruck couple sheep-cot, Coul, Inverness-shire as published by Mackenzie.

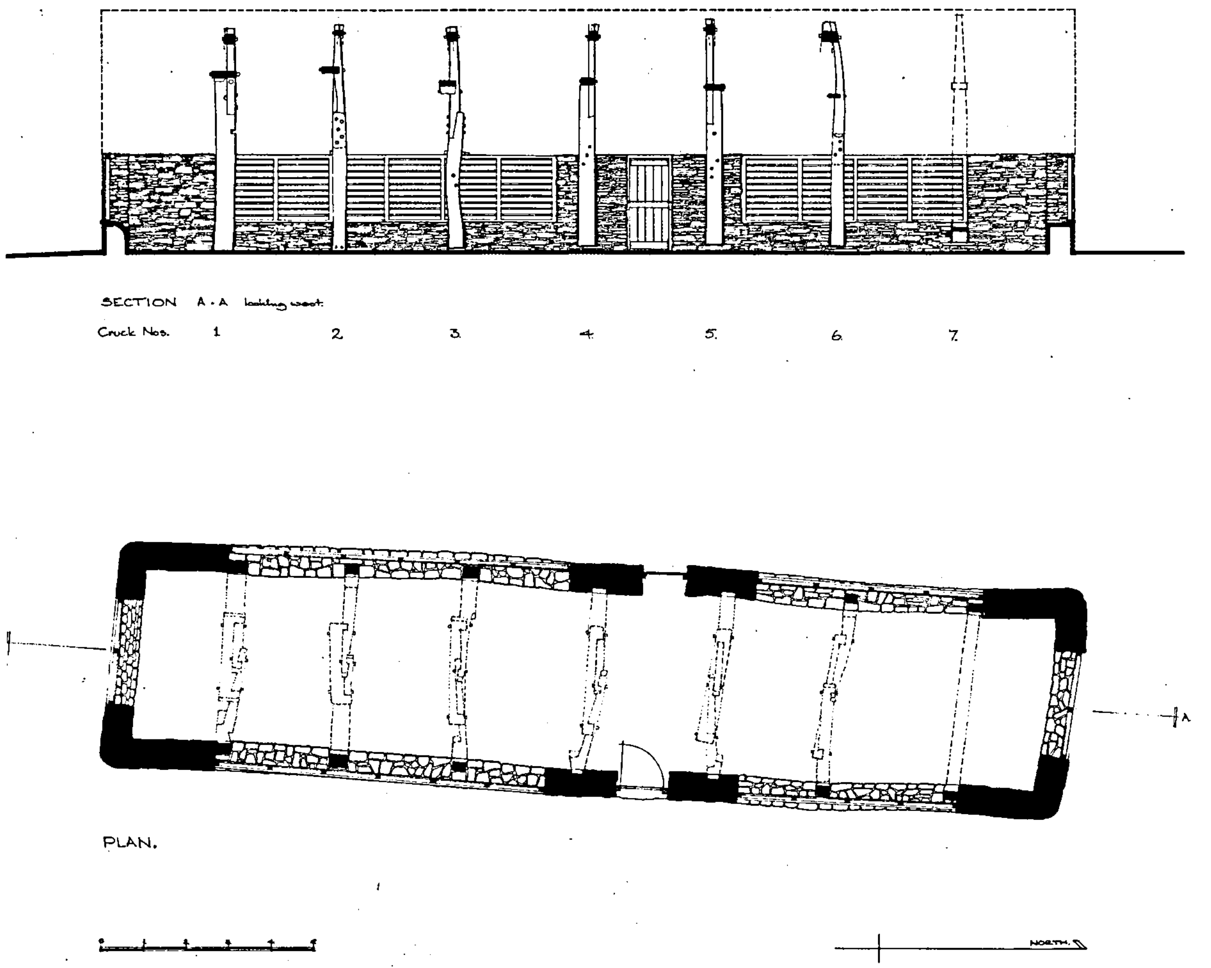


fig 34. Cruck couple structures. b) Cruck couple barn, Fernaig, Lochalsh, Inverness-shire. © Bruce Walker.

5.02 Cabers, whale bones

Cabers or whale bones can be set vertically against the outer face of the wall purlins to provide a protective barrier between the inhabitants and the dry inner surface of the turf wall, whilst at the same time providing additional support.

A series of vertical cabers form a reasonably neat finish to the interior and the gaps between the poles allow the surface of the turf to dry naturally without the need for any additional ventilation or drainage features.

Whale bones are used in the same way as cabers but, by their nature, it is less easy to provide a neat internal finish. Their use has been documented in Caithness and Orkney but the authors are certain that many other coastal districts used the bones in a similar manner. Illustrations from West Finnmark, Norway and Alaska, USA, fit the descriptions found in Scotland.

5.03 Stake and rice

Stake and rice, or wattle as it is known in England, was possibly the most common internal lining to turf walls, particularly in inland situations. Eighteenth century descriptions refer to 'creel houses' where the interior is described as being 'wattled like a hurdle' (fig 35). 'Creel' is a Scottish word for a type of basket and it was the basket-like qualities of the stake and rice that attracted comment from visitors.

As with caber or whale bone linings to turf walls, the stake and rice allowed natural drying of the inner surface of the turf whilst providing additional support on the side of the turf wall that would tend to shrink.

Another form of turf wall was also constructed using stake and rice. There the wall was defined by an inner and outer structure of stake and rice and the space between filled with turf, earth and stones which were

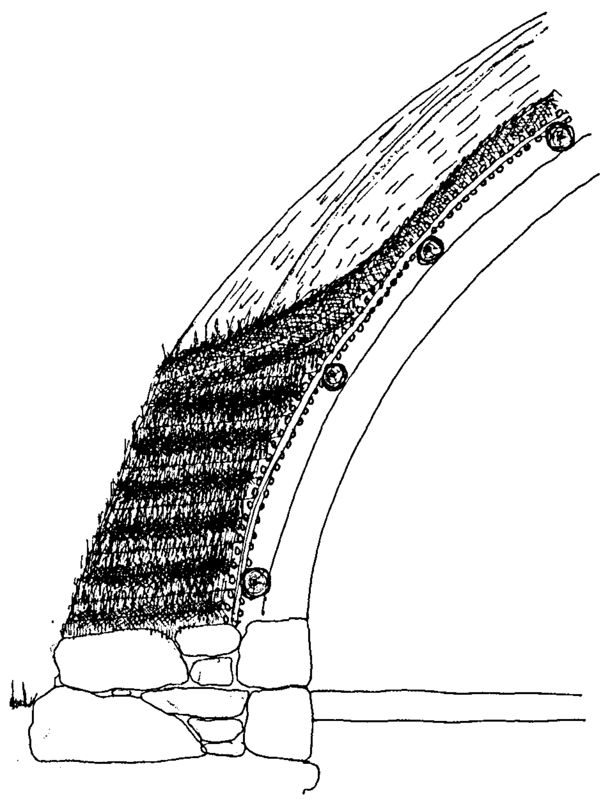


fig 35. Section through creel house. © Bruce Walker.

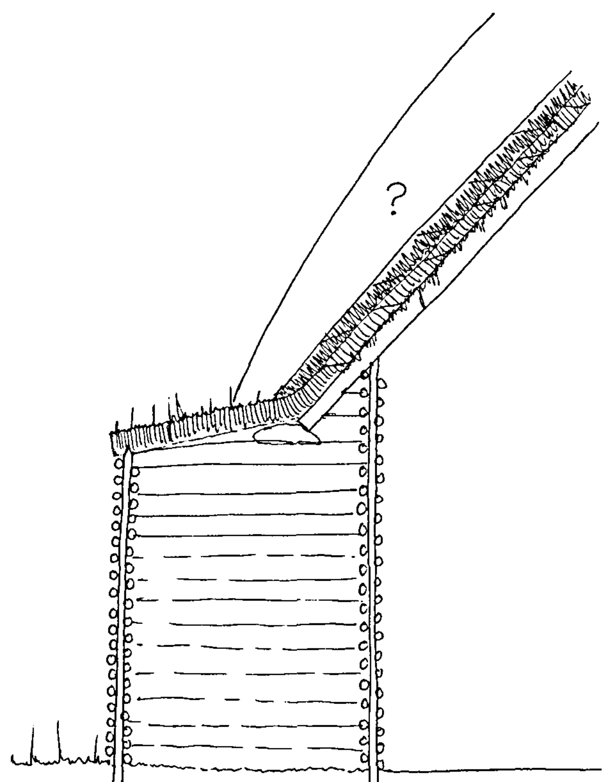


fig 36. Section through blackhouse wall constructed in turf between two skins of stake and rice. © Bruce Walker.

well compacted between the stake and rice structures (fig 36). This type of construction was ideal for building poorer quality turf where the turf pieces were closer to clods than to divet or fale. Eventually the outer skin of stake and rice would rot and break up, but by that time the clods and loose earth would have compacted sufficiently to remain as a homogeneous mass. This technique appears to be linked with the thick walls and exposed wallheads associated with blackhouse construction.

5.04 Stave construction

Stockstove houses in Shetland appear to have been built using Norwegian stave construction to form the house shell before being encased in turf. This seems to be the same construction as encountered in Icelandic houses. To prevent the back of the staves and vertical boards being subjected to rot, loose stones were placed against the timber to create a type of rubble drain the entire height of the timber. Any penetrating moisture is carried away in the drain and air circulating round the large stones making up the rubble of the drain dries the outer surface of the timber. Similar precautions are necessary with any other form of timber lining that is not ventilated to the interior of the house.

5.05 Timber lacing

Turf walls were occasionally laced with timber planks to intrease stability, especially where vertical walls were desired.

The best known example of this technique was the Gordon Haumont house, which stood 19km (12 miles) north-east of Broken Bow, Nebraska, USA (fig 37). This was a two storey turf-walled farmhouse built in 1885 by a Belgo-French family. It had a piend, shingled roof, brick chimney stacks, split door and one double window in an otherwise symmetrical frontage. The corners of the main house were built out in the form of blank turrets to reduce the effect of weathering on sharp arrises and act as a buttress to the thrust of the beam. The turf walls were laced with timber planks at ground floor sill level, lintel level (which corresponded with the bearing for the first-floor floor joists, over the first-floor joists) and at the wallhead. The result was an extremely stable structure which was still sound in 1972 when the owner drove a bulldozer through it after being refused a State grant towards its upkeep.

Timber lacing in similar positions to those in the Gordon Haumont house are used in mudwall block construction in the Republic of Macedonia to render such structures earthquake proof.

Similar timber lacing to reinforce corners is described by 'Y' in the *Dublin Penny Journal* of 1833.

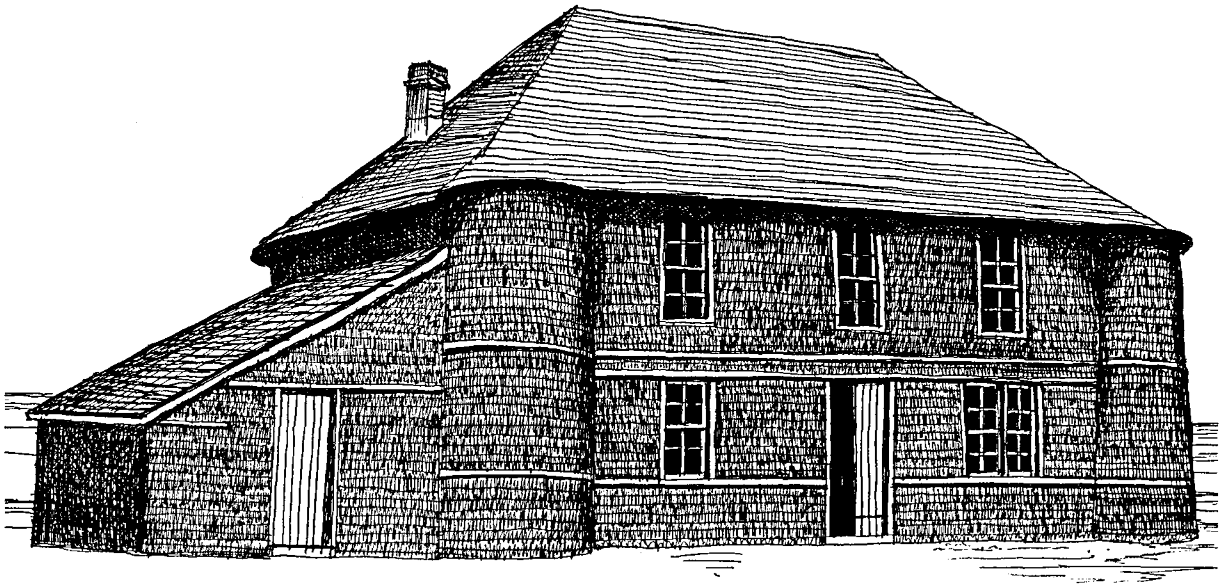


fig 37. Gordon Haumont house, Broken Bow, Nebraska, after a photograph. © Bruce Walker.

Similar stiffening of corners or in any other replacement work can be achieved unobtrusively by introducing lengths of heavy nylon fishing net between some of the courses, particularly where the turf is laid root to root.

5.06 Drystone facing

A drystone skin is often used to face the inner surface of turf (or alternating stone and turf) walls, essentially to provide a permanent wearing surface to the wall (fig 38). This is an alternative to wattle or timber, both of which are subject to attack by rot or woodboring insects.

Pennant describes houses built of turf but with an inner skin of drystone as he passes through Deeside in the late eighteenth century. Other writers repeat the claim in other parts of the country, and the present authors visited a byre in Shader, Lewis, built this way as late as 1951 in response to a shortage of conventional building materials after the Second World War.

Although the use of an inner skin of drystone as a wearing coat seems to have been a natural response to the problem of housing animals in a structure that, when dry, could be rubbed away by a beast scratching its flank or licked away by a beast trying to obtain salt, its use externally appears to be the result of estate instructions issues by landowners wishing to be able to claim that their tenants were housed in 'stone-built' dwellings.

The 'Rules and Regulations for the Lewis Estate in 1879' read :

> *'The dwelling houses to be erected by the tenants....shall be of stone and lime, or stone and clay, pinned and harled with lime, or with stone on the outer face and turf and sod on the inside.....'*

This statute ignores the reason for having a stone skin to the turf wall and the fact that many turf-walled houses on the Long Isle already had drystone faces to the inside walls. This brought about a change in the construction of these walls. The outer drystone skin, rather than protecting the outer face of the turf, held water against the surface of the turf, softening the surface and creating erosion. To counteract this problem the construction had to be changed at the wallhead by introducing a waterproof clay layer, protected by living green turf. For specific details see TAN 5 *The Hebridean Blackhouse* (Walker, McGregor: 1996b).

5.07 Drystone structure

Another form of drystone backing to turf construction can be seen in the construction of beehive sheiling buts and other structures as surviving in the Hebrides and other western districts of north-west Scotland. The main structure was created in corbelled drystone then the whole structure was covered in turf from a peaty area. The heat generated by the fire within the

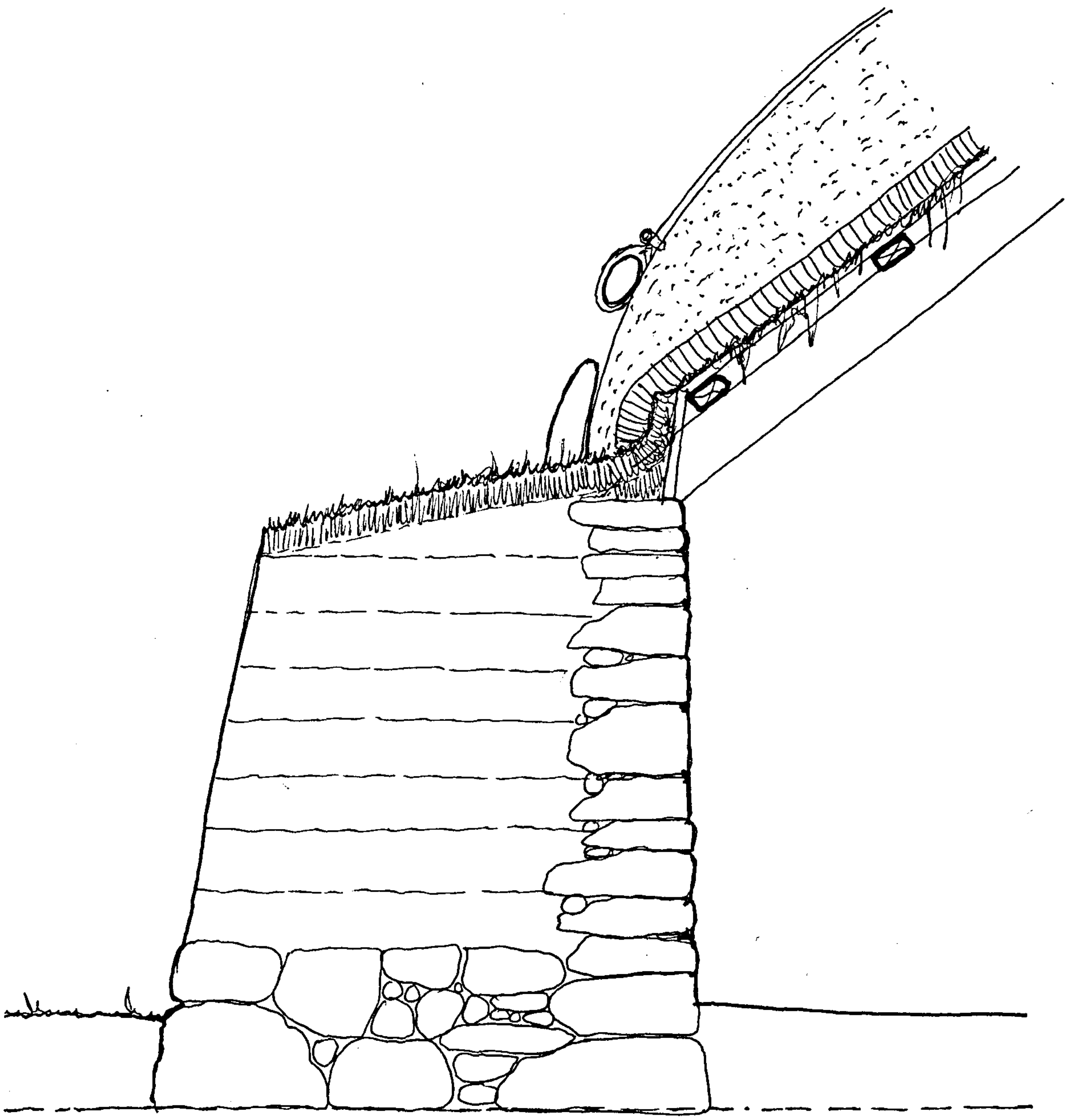


fig 38. Section through blackhouse wall with masonry inner skin. © Bruce Walker.

corbelled structure dried out the oils in the peaty turf rendering it waterproof. When peaty turf was unavailable the corbelled structure had to be created to shed surface water and the turf covering was then restricted to reducing the draught and providing insulation.

5.08 Openings

Openings can be formed in two ways and both make allowance for settlement of the structure as the turf dries out.

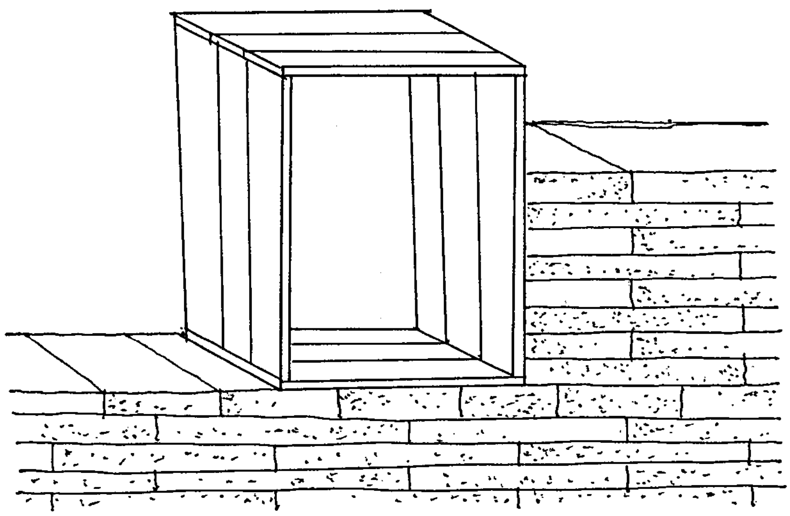
5.08.1 Slappings

One way of creating openings in a turf wall is to build the wall in solid turf all the way round the building, inserting lintels at appropriate places to allow the openings to be slapped after the settling has occurred.

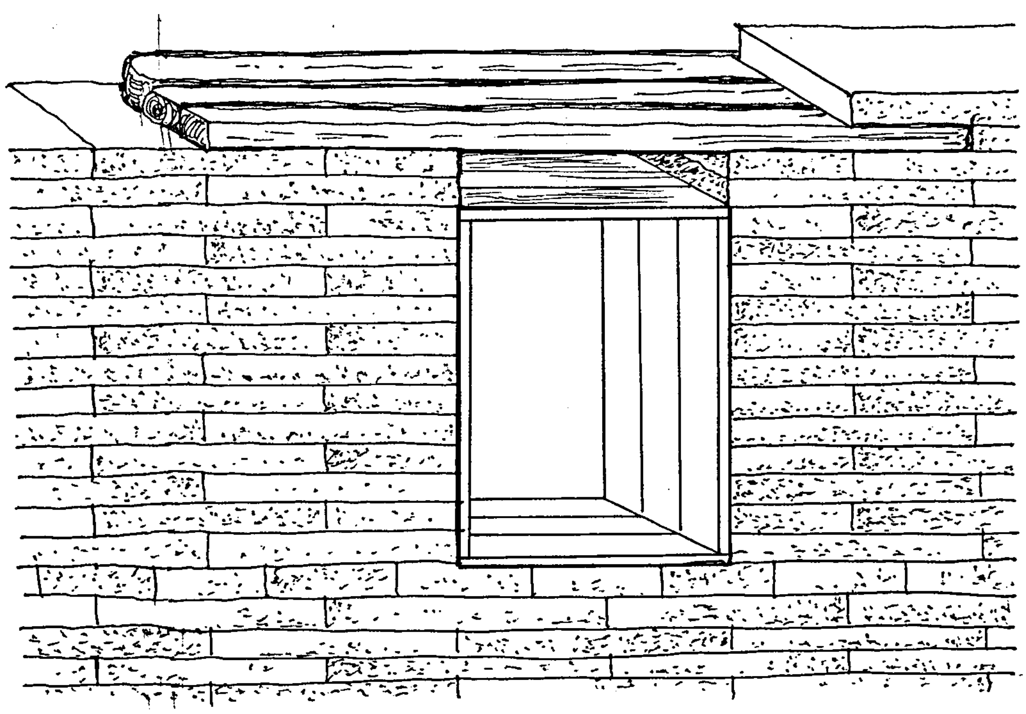
This has certain risks since the ends of the lintels will eventually rest on the turf that has been disturbed or weakened in the cutting process. The seating for these lintels should therefore be much greater than would be normal in a masonry wall.

5.08.2 Boxed Openings

Openings can be created (fig 39) as the work progresses by inserting a timber box, corresponding to the outer dimensions of the window or door frame, as the work progresses. This allows the jambs to be well consolidated by the turf builder at the time of erection. The disadvantage is that the box will not shrink with the wall as the turf dries out. To counteract this the lintel is inserted 15-200mm (six to eight inches) above the upper surface of the box. This is loosely filled with cloth or paper wadding and creates flexibility to accommodate the shrinkage of the turf.



a) Boxed opening in position in turf wall.



b) Lintel related to boxed opening showing gap left to accommodate shrinkage of the turf.

fig 39. Formation of boxed opening in turf wall after Welsch. © Bruce Walker.

6. MAINTENANCE AND REPAIR

All turf structures require regular inspection and maintenance to ensure their longevity. This need not be an onerous commitment but attention at the correct time can reduce long-term maintenance to a minimum.

6.01 Snagging

On the completion of a contract it is essential to thoroughly check the walls for voids and sagging. Bulges in the surface should be investigated particularly when these are associated with a loss of height or profile at the top of the wall.

Turf walls without a masonry base may be subject to damage by burrowing rodents, particularly in the period immediately after construction when construction works may have disturbed or destroyed occupied burrows, and the new wall presents easy access through an open joint or simply due to the turf not being fully consolidated. Problems with rodents should be addressed by a specialist, but as rodents are eradicated from the turf structure all access points to burrows should be carefully filled with mudwall mix firmly tamped into the holes.

Slump caused by inadequate compaction can be counteracted by waiting until settlement has ceased, then building up to the correct height with firm material.

Bulges caused by slippage can often be beaten back into the wall and temporarily shored until the material has bound together. The wall may have shrunk slightly in this process and this should be treated as described above.

Should it be impossible to beat the bulge back into the correct profile, it may be possible to prop it until it has stabilised, and trim off the excess material before adding more material to the top.

Provided the turf is in good condition when used for building and the work is carried out during the growing season, root binding may solve the problems without the need for large scale rebuilding.

6.02 Accidental damage

Damage caused by impact from motor vehicles or from people climbing on the wall before it has had a chance to stabilise itself properly may be difficult to remedy without dismantling a portion of the wall and rebuilding. Should this be necessary, it is advisable to insert timber ties between the old and new by driving sharpened lengths of hazel, willow or other commonly used thatching staples into existing joints before building round the protruding ends.

Although it is not generally recommended in the historical data, it may be possible to indent clayey turf into a wall of the same material by cutting a new block to size, and inserting it using a mudwall mortar. This was done at Corse Croft, Kinnoir, Huntly: see section 10.02 for a description of this work.

6.03 Inspection

After the initial snagging is agreed and completed in a satisfactory manner, a regular inspection programme should be set up to monitor the structure over the next few years. The intervals between inspections should be reasonably short at first, say one inspection every six months for the first year, then annually for the next two years, stepping up to every two then every five years.

The inspections should not take long, but the inspector should check for any unexpected movement in the walls either in the form of bulges, loss of height or signs of animal or bird occupation. There should also be a check for any recurrence of problems encountered at the snagging stage.

6.04 Instruction

This is not a subject area where clear guidelines exist backed up by British Standards, Codes of Practice, Agrément Certificates or other official certification. As a result it is essential to issue clear unambiguous instructions produced after careful analysis of the problem, discussion with other practitioners and the contractor. A clear instruction must be issued setting out as clearly as possible what is expected, how it is to be achieved, and naming an on-site supervisor.

6.05 Supervision

Turf is not a material that arrives on-site on a palette with a manufacturer's guarantee attached. It is a natural material, subject to a series of natural hazards and variations. If lifted too wet it may slip when placed in the wall. If lifted too dry it may break up or fail to bind with the adjoining material. Turves can be broken by rough treatment, accidental cutting whilst still in the soil, being too dry, and being stored prior to use. Voids may occur due to the presence of large stones that are dislodged during casting or handling. None of these faults need automatically condemn a particular turf, but careful placing and packing of voids and weak areas are critical to the stability of the wall. Work should never be left with the roots of a course of turf exposed to the air, and the line and profile of the wall should be constantly checked for bulges. Similarly the number of courses in a day lift should be carefully monitored to ensure that the wall is not being built too quickly and therefore put in danger through instability.

An experienced operator with a good track record will take all these variables into account as the work progresses: unfortunately, few people in this category exist at present.

These issues are important in new work but absolutely crucial in repair situations.

7. CONSERVATION ISSUES

The opportunity to carry out conservation work on existing turf structures has, until recently, been extremely limited in Scotland. There is still much work to be done in locating survivals in standing buildings, and the 'listings' for many historic buildings fail to mention the existence of turf as a primary component. The authors have been involved in a number of HS Advisory Reports where they have stressed the need to retain such constructional features. Unfortunately, not every client is prepared to plan his activities around the existence of a dusty relic of turf construction and a firm line may need to be taken by the conservation architect if this valuable evidence is to survive.

Archaeologists, on the other hand, are much more aware of the history that can be obtained from a turf structure. Being a material that grew just before it was cut and inserted into the structure, a piece of turf can reveal much more about the agricultural activity in the area than almost any other material other than thatch. The principles set out in TAN 13, *Archaeological Investigation of Scottish Thatch* (Holden: 1998) hold good for all types of turf construction.

7.01 Historic fabric

One of the major problems with turf construction is its recognition within the context of a standing building. Often it looks like a wall of cobwebs or an extremely dusty masonry wall, and it takes a little practice before dusty turf can be recognised at a glance. Architects and surveyors often miss the material completely, even when they are surveying manually with tape-measures.

It is desirable that some form of register of historic sites containing examples of turf construction be set up, and that as many examples as possible be recorded and subjected to non-invasive examination. This data should then be plotted to provide some indication of current distribution, since this may indicate where some of the best quality turf for building may be found. Sadly, all too many of these structures are disappearing as more and more traditional buildings fall into disrepair, then ruin, and are eventually demolished.

Historic fabric should be protected in all conservation works, and turf structures should be given particular priority due to the number that were demolished in less enlightened times, and their comparative scarcity today.

7.02 Repair or renew?

When turf construction is encountered and it turns out to be in poor condition, should it be repaired or renewed? Historic Scotland policy is quite clear in this point, historic fabric should be retained whenever possible, but where repair or renewal are absolutely necessary this should be carried out on a like for like basis.

Virtually all forms of turf construction, other than those grown in sandy soil, should be capable of being repaired.

With heavy clay turves it is possible to cut out damaged turves and indent new pre-dried turves in their place as described in section 10.02. It should be possible to repeat this pattern with lighter turves, particularly fale, by sliding thin sheets of galvanised iron into the joints above and below the damaged fale, then cutting out the damaged fale and inserting a pre-dried fale of similar composition in its place. The new fale should slide quite easily on the galvanised surface and if the bottom sheet is slightly longer than the top, it will provide a useful edge onto which the turf can be located prior to slipping it into the void. The side joints may have to be more open than normal and this can be rectified by packing the joints with a mudwall mortar.

The only turves that present a real problem in terms of repair are those cut from a sandy loam, since the roots often disintegrate leaving a loosely bonded sand which is extremely friable. If it were absolutely essential to retain a wall of this type in a position where it might be subjected to accidental damage, it might be possible to stabilise using a chemical solution, but this route is fraught with danger as has been established by efforts to carry out this type of stabilisation on friable sandstones.

Whatever the solution, repair is preferable to renewal but, should renewal be chosen, it should be on a like for like basis. The wall should be made the subject of an archaeological investigation, and the material being removed should be sent for micromorphology and other forms of scientific analysis.

7.03 Archaeological investigation

The value of archaeological investigation of turf structures that must be destroyed is considerable. Some of the potential information to be gleaned from such an exercise is practical, the rest historical.

The practical information can include information on turf sizes, shapes, uses and bonding, the existence or otherwise of internal lacing or pegging, indications of sub-soil used to pack out weak or damaged turf, the type of tool used to cut the turves, and the integrity of the turves after years of weathering.

The historical information can be even more important since it may be possible to date the turf, the vegetation making up the turf can be identified, pollen analysis of the soil within the turves can give information on different habitats and agricultural practices in the vicinity. The age of the sward at the time of cutting the turf can also be established.

To render this information more valuable, the investigation and sample removal should be undertaken by a team of skilled archaeologists who are briefed beforehand on the type of information required. This briefing should not be a one-way instruction but a dialogue that might reveal information that the conservators may not have considered possible to locate. The normal demolition crew should only be allowed access to the site after the archaeological investigation is completed.

7.04 Scientific investigation

Little scientific investigation of turf taken from Scottish buildings has been undertaken, partly because few sites have been publicised and partly due to a reluctance to disturb the integrity of the extant examples. Historic Scotland would be extremely upset if this statement resulted in a series of investigations which destroyed the remaining stock of turf structures. This makes it important to utilise every opportunity to examine turf structures that are to be the subject of partial or complete demolition. Final approval to demolish should be reserved until after the scientific investigation has been completed.

The existing investigation techniques have been developed for turves retrieved through archaeological investigation of buried remains. What is needed is an expansion of these techniques to address the requirements of investigating turves both internal and external from standing structures. This can be considered under three distinct areas of study, namely identifying, recording and laboratory analysis.

7.04.1 Recording

Existing turf structures should be recorded in detail but without any intrusive investigation.

Turf structures that are about to be demolished or partly demolished should be the subject of an archaeological investigation to establish, as far as possible:

* The shapes of individual turves in the structure
* The nature of the bond employed in building
* The relationship of the sward surface to the turf blocks in the wall
* The sequence of building
* Evidence of filling of voids in individual turves
* The nature of the wall core
* The position of each sample removed for laboratory analysis.

7.04.2 Research

A summary of known references to turf structures is given in TAN 6 (Walker, McGregor and Little: 1996) but this is far from exhaustive.

Ideally each new find should be the subject of a local research programme based on the site of the new find, the estate on which it stands and the parish in which it is situated. The site investigation should include:

* Recording - see paragraph 7.04.1 above
* Collection of oral evidence
* Known history
* Official status of building - 'listed'
  'scheduled'
* Collection of documentary evidence

Documentary evidence may survive in any of the following archives or libraries. Unfortunately, all too often, material of this type is not highlighted in inventories of papers held, particularly in relationship to estate papers, this information being lumped into the category 'General Estate Papers'.

Main sources are:

* Local libraries, particularly those having a local section
* Local museums, particularly those having a local archive
* Scottish Rural Archive - National Museums of Scotland, Edinburgh
* Highland Folk Museum, Kingussie
* School of Scottish Studies Archive, Edinburgh
* National Monuments Record for Scotland, Edinburgh

* Scottish Record Office, Edinburgh
* National Register of Archives for Scotland, Edinburgh
* National Library of Scotland
* Edinburgh Central Library
* Mitchell Library, Glasgow
* Archive Departments in the Universities of Scotland particularly those of Aberdeen, Dundee, Edinburgh, Glasgow and St Andrews.

It should be noted that in the majority of these organisations there is no category highlighting turf construction and that the chances of finding specific references to turf construction are low. This makes every such find doubly important.

7.04.3 Archaeological Investigation

The likelihood of being presented with a complete turf structure which may be subjected to archaeological investigation and sampling for scientific investigation is extremely remote, but not impossible. During the 1960s and 1970s, some local authorities in Scotland were paying a bounty on every earth-walled building demolished. This situation has now ceased but only after a major depletion of the existing building stock. Similarly, attempts to 'list' properties have in the past resulted in hurried demolition before the 'listing' became effective. Such attitudes artificially depleted an already scarce resource.

Turf walls are most likely to turn up in archaeological excavations. The excavation should be carried out over a large enough area of wall to allow the bonding pattern to be recorded. Since corners and wall ends are often built differently from the lengths of straight wall it is important to look at both situations. Corners may be built in a different cut of turf from the rest of the wall, they may be laced with timber or with brushwood corduroy mats or other strengthening devices.

7.04.4 Sampling

The size, type, location and method of handling samples should be agreed with the scientific establishment charged with the investigation of the material, and must be protected from contamination during this process. Archaeologists are skilled in this process and they should be employed whether the structure is still extant or part of an excavation.

Various lines of investigation regarding turves are worthy of investigation and several different approaches are necessary to obtain the available information.

The shape of individual turves, in both section and plan, can be used to identify the type of spade used for their extraction from the sward. These characteristics are easier to see in turves used for roofing or at wallheads, but should be recorded from several of the most complete turf samples recovered from each part of the building.

In many cases the turves will retain well preserved traces of the vegetation making up the original sward. The identification of the floristic element from a selection of turves should enable some conclusions to be drawn regarding the category of land use of the original sward and the management techniques employed before cutting. This requires that the fragments of surviving vegetation be identified by comparison with modern herbarium specimens. It is also beneficial to extract seeds from the sediments by floatation or wet-sieving in order to provide seed material that can be compared with charred or water-logged seeds from putative archaeological turves.

The vegetation study can be complemented by pedological analysis of the turves. This is best achieved by thin section analysis as outlined by Bullock *et al* (1985). This technique requires that undisturbed pieces of turf or other sediments, such as daub, be taken using standard Kubiena tins. The samples are then impregnated with resin. Once cured, a process that can take up to three months, the hardened blocks are thin sectioned. The prepared sections are thin enough that the different mineral and organic components can be characterised using high powered microscopy. Mixtures with more than one source material can be identified and data relating to the preparation of the sediments can be obtained. When taking samples for this sectioning it is essential to record the orientation of the Kubiena tin relative to the wall or roof. Any interfaces between observable strata should also be sampled.

Turf samples may contain numbers of insect and mite remains. Kenward suggests that several litres of turf be subjected to paraffin floatation in order to concentrate the remains. These should then be sorted in industrial methylated spirit. This appears to be the best option at present as it increases the number of retrievable remains by 100 per cent.

7.05 Dating techniques

The value of information gained from the investigation of turf samples will be enhanced if the turf can be accurately dated.

Various dating techniques have been used for material originating in the last few hundred years, and their value in dating turf is discussed below. Both useful and unsuitable techniques are discussed in order to provide the reader with some guidance in the techniques that are most likely to be of use.

7.05.1 Radiocarbon dating

M Dalland and S Carter

If a building can be demonstrated to be over 300 years old then it may be worth undertaking radiocarbon dating. An uncontaminated sample should be collected from the block sample in the laboratory. Each dating sample should consist of at least 5g (dry weight) of well preserved uncharred root or stem tissue from the surface vegetation in a single turf. NB. Accellerator Spectrometry dates can be undertaken on pieces of wood that are the same size as cereal grains. Care should be taken to avoid contamination during sampling and all dating samples should be immediately dried and bagged. It should be noted that the peat around the surface vegetation may be considerably older than the turf, therefore the choice of material for the test is extremely important.

The Theory

Radiocarbon dating is based on the predictable decay rate of an isotope of carbon, ^{14}C. This occurs at a rate that halves the concentration of ^{14}C in relation to the stable ^{12}C every 5730 years, which is known as the half-life of the isotope. In order to date material containing organic carbon, one has to know two parameters; the present concentration of ^{14}C in the sample and the present concentration of ^{14}C in the organic material when it was formed.

The present concentration of ^{14}C isotopes in the sample can be measured in two different ways:

Directly by measuring the ^{14}C concentration using mass spectroscopy.

Indirectly by measuring the present rate of ^{14}C decay in the sample.

None of the methods provides an exact measurement of the present ^{14}C concentration, but estimates the value normally within ± 50 half-life years. This means that there is a 68% chance that the true concentration of ^{14}C lies within 50 half-life years of the measured value. Both methods provide similar accuracy, but the advantage of mass spectroscopy is that it can date very small amounts of organic material.

The concentration of ^{14}C isotopes at the time when material was formed is worked out by measuring the ^{14}C concentration in samples of a known age, normally dendrochronologically-dated wood. From a series of dates of known age a calibration curve is built up. This curve links the present concentration of ^{14}C in a sample to calendar dates. By comparing the concentration of ^{14}C in the sample measured in half-life years with that of samples of known age on a calibration curve, the age of the sample can be estimated.

The practice

Turf contains a range of carbon-rich matter that makes radiocarbon dating a potentially useful technique. However, it is important to isolate organic matter that formed shortly before the turf was cut and this effectively limits the technique to turves with well-preserved remains of vegetation on their surface. Other types of organic matter may be hundreds or even thousands of years old. In cases where well-preserved vegetation can be identified on turves, methodological problems remain that complicate the interpretation of radiocarbon results. Laboratory determinations of radiocarbon age must be calibrated to produce actual calendrical age ranges. The calibration curve, created using wood of known age, is irregular and contains a number of reversals often resulting in more than one calibrated age range for a single radiocarbon determination. This problem is particularly acute from AD 1700 to 1950 and it is impossible to calibrate radiocarbon dates for this period without independent evidence; it is unfortunate that most surviving turf structures are likely to date from this same period.

7.05.2 Lead isotope dating

S Carter and T Holden

The dating of events within the past few centuries is generally not attempted with radiocarbon because of the problems discussed above. Instead, a short-lived isotope of lead (210Pb) is used which offers a high resolution dating of the last 100 to 200 years. This technique requires that samples are taken from a sequence of accumulating sediments enabling comparison in the concentrations of the lead isotope throughout the sequence (pers.comm. G.Cook, SURRC). It is of most use in situations such as accumulating lake sediments or peats.

7.05.3 Dated stratigraphic markers

S Carter

If particular materials can be given a precise date, they can be used to provide maximum and minimum age estimates for undated material stratigraphically above and below. So far only one likely marker has been identified: spheroidal carbonaceous particles (SCPs). These are microscopic particles produced by the incomplete combustion of coal and oil at high temperatures (Wik & Natkanski, 1900). As such, they are the product of recent industrial processes and their abundance reflects the degree of particulate atmospheric pollution. The particles are deposited on ground surfaces and therefore will appear in turves. No precise date can be given for their first appearance but they only became common at the end of the nineteenth century and increase in abundance thorough the twentieth century. Therefore their presence will indicate that a turf is no earlier than the late nineteenth century. This will assist with the interpretation of radiocarbon dates from overlying materials.

Two potential problems should be noted. Firstly, turves under thatch or exposed to the interior, frequently become coated in soot from domestic fires. This soot should not be confused with SCPs but, nevertheless, sampling from the surface of a turf protected by an adjacent turf is recommended. Secondly, because SCPs derive from heavy industry they are most common close to major industrial centres. Deposition of particles in the extreme north and west of Scotland may be too low to be detected and therefore there is a potential for a false negative result and an incorrect assumption of an early date.

7.05.4 Dendrochronology

Dendrochronology dates for associated structure or timber lacing within the turf will provide a maximum age for the turf. Care should be taken with this evidence since the re-use of timber is commonplace either from earlier structures or from the recycling of ships' timbers which is wide spread in the coastal regions of Scotland. Timber may also be retrieved in the form of flotsam or from peat bogs.

7.05.5 Documentary evidence, architectural style and oral history

Given the relatively recent date of many of the surviving turf-walled and thatched buildings, a chronological framework can be constructed using information from available documentary sources, surviving inhabitants and architectural features. The quality of this framework can vary significantly from building to building. In some cases the information is sufficient to identify when certain features were added or altered, whereas in others they may only enable us to bracket particular features or materials between two chronologically disparate events. It might be possible to identify a change from photographic evidence.

8. SPECIFICATION

Great care must be taken in the writing of a specification for the repair or renewal of any type of turf wall. It is insufficient to state that it is to be replaced on a 'like for like' basis since superficially similar turves can have very different properties.

The closest comparison is in sourcing stone where the visual match is not always geologically compatible with the original, whereas another stone with an obviously different colour and texture may prove to be an ideal geological match.

The conservation officer as the person with the overview of the whole scheme must be clear as to the requirements for any replacement turf. To achieve this the existing turf must be thoroughly examined and assessed. A description giving the type of soil and vegetation present in the original turf must then be provided to the contractor who should then seek a possible source. In some parts of the country, older inhabitants may have useful knowledge as to where turf was sourced in the past. Similarly, estate papers may refer to a part of the estate where turf was sourced for building purposes. When folk memory cannot be relied upon, soil scientists may be employed to analyse the existing turves and find some form of match in the locality. This is not always possible due to man's intervention in the intervening years, and good matches may have to be sourced at a distance from the site.

When a suitable match has been found it is essential to have trial turves cut, measured, built and monitored to establish exactly how much shrinkage there is likely to be since this will effect the detailing of the work. Generally clayey turves and sandy turves will have less shrinkage than balanced loams and peat. Mossy turves have the greatest shrinkage.

A detailed description of how the work is to proceed can be prepared only after a suitable turf has been sourced. The slipperiness of the turf may limit the number of courses that can be built in a day. The rate of drying-out in the wall and the anticipated shrinkage must be taken into account. The effect of adding wet turves to a historic fabric must be assessed, particularly when building around historic timbers. It is not uncommon to observe fungal growths, on both the turf and adjoining timbers, during and immediately after building with wet turf. Many of these growths are harmless and disappear as the wall dries. In situations like the Hebridean blackhouse, fungal growth can only be controlled by peat smoke during the building and drying-out periods, and by good ventilation thereafter.

It must always be remembered that turf is a natural material and that, if reintroduced to moisture, with or without sunlight, some form of vegetative growth will result.

Block sizes, angles of joints, rate of building, level of wetness or dryness, cohesiveness, time between cutting and building and other relevant factors must all be agreed before the contract is let if claims for extended building times are to be avoided. Quantity surveyors can obviously take part in this process, but only if fully briefed on the potential pitfalls.

Since there are no British Standards, Codes of Practice or other certified methods of carrying out the work, the responsibility for specification falls squarely on the architect or conservation officer commissioning the work.

9. TOOLS AND EQUIPMENT

9.01 Excavation

Excavation of sub-soil loam as a fill for turf construction was traditionally a job involving pick, shovel, mattock and spade. These can still be employed if labour is plentiful, but normally contract work would be carried out by some form of modern excavator.

9.02 Turf cutting

Traditionally, this would be done by hand using either delving spades, flaughter spades, peat spades, paring irons, or towards the end of the last century a flaughter plough, depending on the type of turf required. For some types of work the traditional tools are the only way of achieving a particular cut or type of turf. Where historical accuracy is less important, modern turf strippers can be employed.

9.02.1 Delving spades

A delving spade, normally simply described as a 'spade' is a tool for digging or cutting the sward. It has a sharp-edged broad metal base and a long handle. The angle of the blade to the handle varies from district to district in traditional spades, each designed to carry out a particular task in the locality where it was made. Modern spades are normally made for digging loam rather than cutting turf, and the blade might have a slight bow on its cutting edge to assist in turning soil. Traditional spades used for turf cutting normally had flat blades and a straight cutting edge. It should still be possible to purchase spades of this type in Britain, and there is a traditional spade maker operational from the Bunratty Folk Park, County Clare, Republic of Ireland. Failing this, local blacksmiths can make up a spade to the desired pattern.

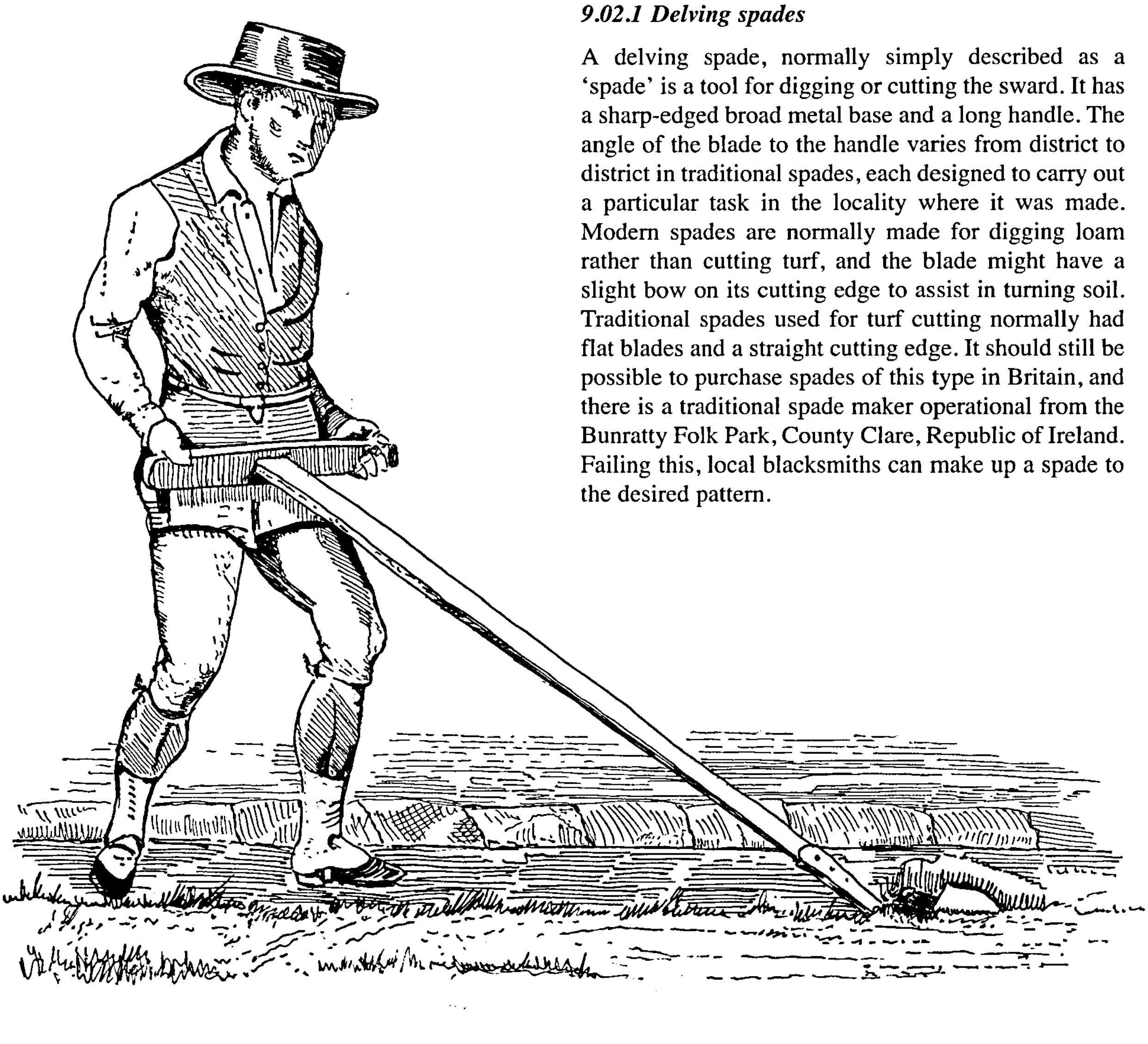


fig 40. Using a flaughter spade in the eighteenth century (after contemporary drawing). © Bruce Walker.

The various forms of traditional spade are set out in TAN 6, *Earth Structures and Construction in Scotland* (Walker & McGregor: 1996: 107-109). These would have to be consulted and adapted should the job require a turf of an unusual shape or form, to match others found through archaeological investigation.

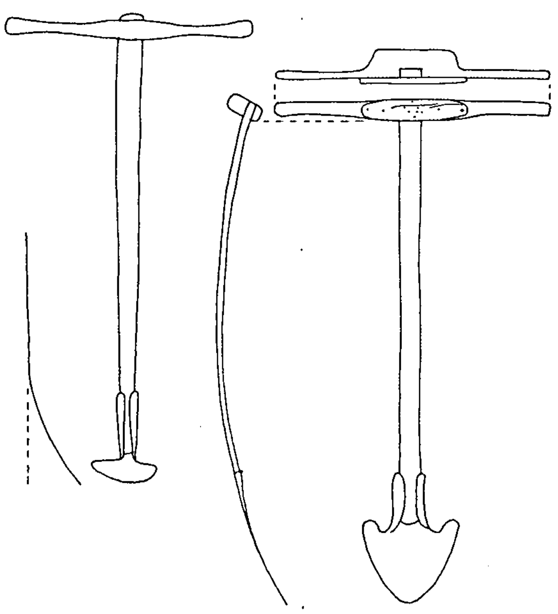
9.02.2 Flaughter spades

The term 'to flaughter' refers to the stripping of the sward from the ground and the flaughter spade or breast plough is a type of spade designed for this purpose.

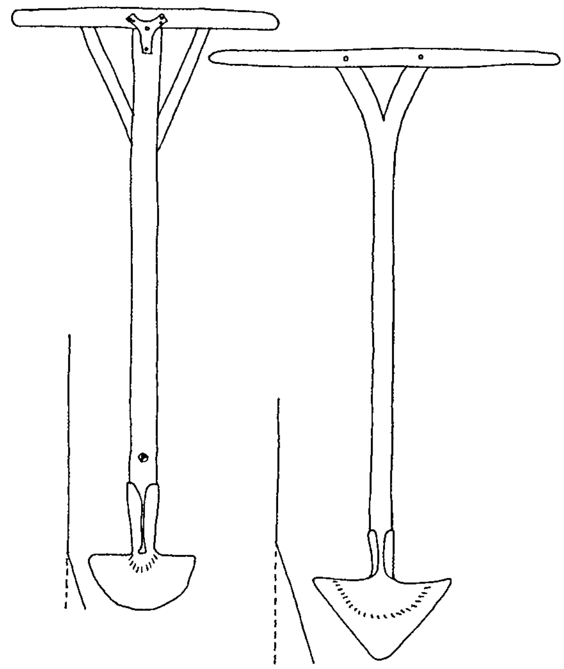
Although the English name was the 'breast plough' it is neither a plough nor had it anything to do with the breast area since it was pushed from the pelvic area (figs 40 & 41). Again the forms may vary widely from area to area depending on the type of sward being stripped and the purpose for which it is intended. Various types of basal turves for thatching are illustrated in TAN 13, *The Archaeology of Scottish Thatch* (Holden et al.: 1998: 24-25).

The flaughter spade normally has a crescent, heart or triangular shaped blade set at an angle to the shaft of the spade, so that the blade sits parallel with the ground when the handle is pushed from either side of the pelvis (fig 42).

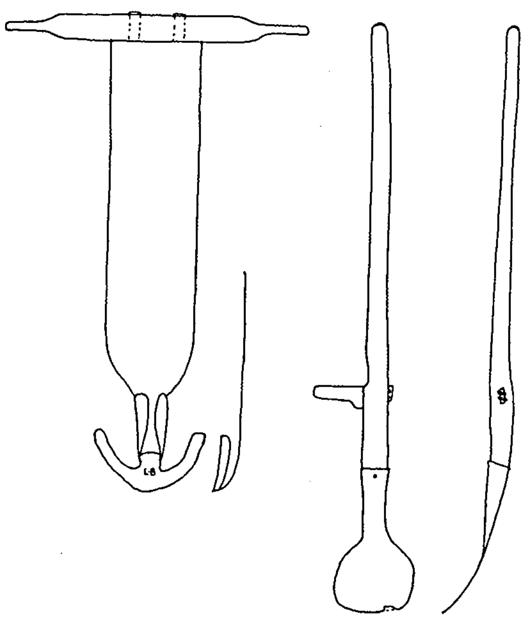
fig 41. Using a flaughter spade in the twentieth century (after Hennell, 1934). © Bruce Walker.



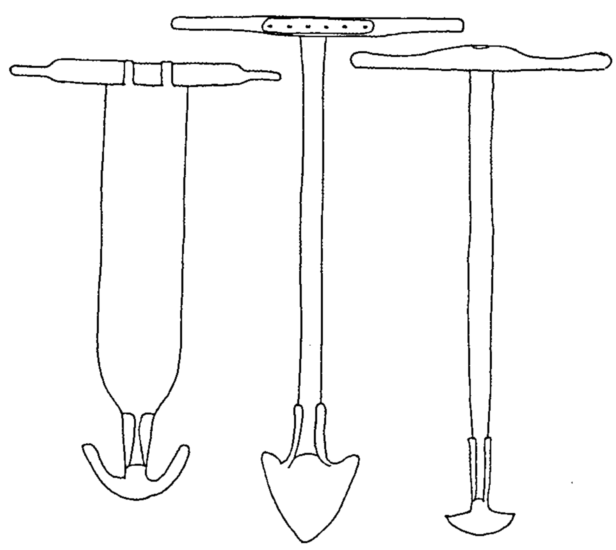
a) Flaughter spades with straight shafts (after Fenton 1970).



b) Flaughter spades with strutted shafts (after Fenton 1970).



c) Flaughter spade, Shetland and moor spade, Orkney (after Fenton, 1970).



d) Flaughter spades with different shapes of blade (after Fenton, 1970).

fig 42. Types of flaughter spade.

Many of the blades are flat, but some are dished to produce a turf tapered to each side to assist in bonding, particularly for under-thatch purposes. Traditional patterns can be obtained from local museums or may be reproduced by careful analysis of the historic fabric.

9.02.3 Peat spades

Peat spades are probably the closest type of spade to those used traditionally for cutting peaty-fale. They are normally constructed of timber, and shod with an iron cutting edge with a wing or tongue projecting upwards at right angles to the blade (fig 43).

The dimensions of the blade and tongue determine the cross sectional dimensions of the cut peats. Each area has its own preferences, some cutting almost square-sectioned peats, others rectangular section. Rectangular sectioned peats can be cut using a wide blade and a short wing, or with a narrow blade and long wing, according to preference.

More work has to be carried out by archaeologists to establish whether the peaty-fale was cut in this way or with a standard spade.

9.02.4 Paring irons

A paring iron is a sharp tool, similar in many ways to a lawn edging tool but larger, and with an offset handle that allows the blade to be pushed down from the wallhead to cut projections off the face of a recently built turf dyke or wall (fig 44).

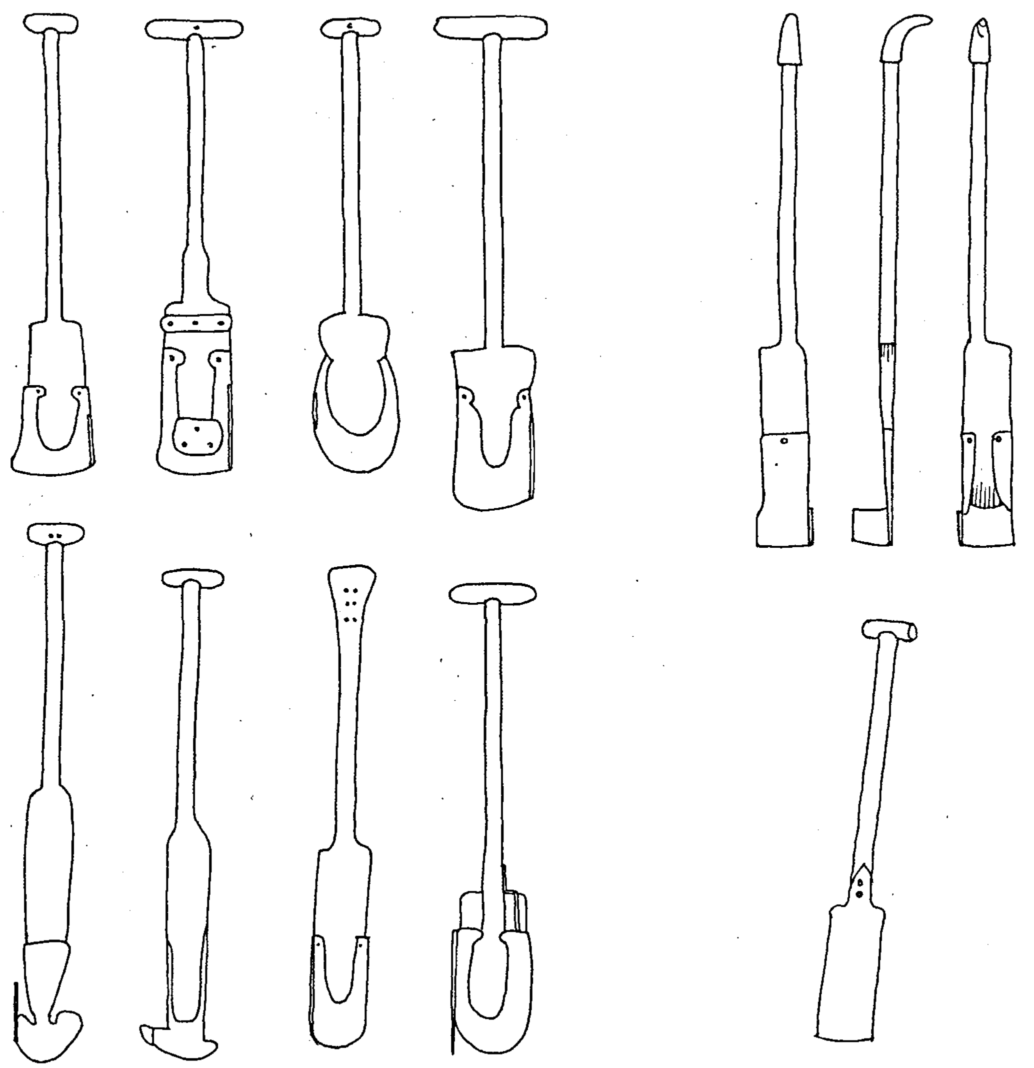


fig 43. Various types of peat spade. © Bruce Walker.

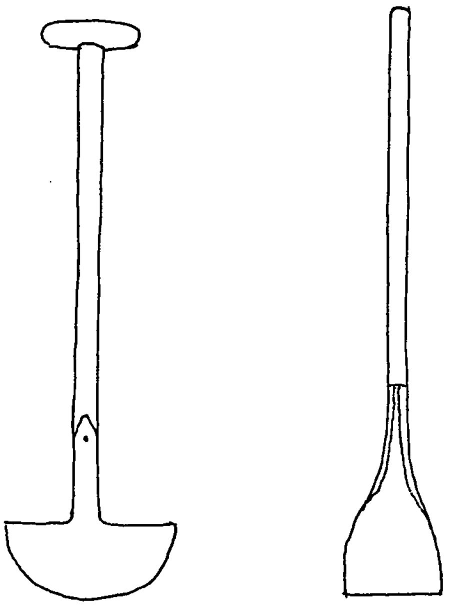


fig 44. Paring irons. © Bruce Walker.

These can have straight blades, similar to a spade but without the shoulder for purchase with the foot, or can be crescent-shaped like an edging tool.

9.02.5 Flaughter ploughs

It is uncertain whether the flaughter plough was ever used in Scotland, since the only examples known to the authors are from the plains of Nebraska, USA, but this is a logical step forward from the flaughter spade, being essentially an ox-drawn version of that implement. Oxen were preferred to horses for this work: because with their slow deliberate pace the ploughman could maintain an even continuous strip of turf. (Welsch: 1968, 40-41).

The manufacture of this type of plough was described by Randall Sargent to Irene Dewey for publication in *Pioneer Stories* -

> *'The first thing necessary was a plow with which to break the sod for their 'soddy' and the fields of corn. Since Randall had no plow, he proceeded to make one from a small water-elm trunk. He hewed out a beam about four inches in diameter and four feet long. With his brother Riley's assistance he made a rod plow [cutting plow] patterned after a little plow called "The Antelope" which they had in Iowa. The next spring he and his brother made a hundred of these plows and for a time they were hardly able to supply the demand for them'* (Welsch: 1968, 40).

The plough illustrated by Welsch (fig 45) shows a triangular flaughter blade slightly wider than the required turf. The blade rises slightly towards the rear and is attached to a series of four metal rods which replace the traditional mould board and are designed to ease the turf onto its back as the plough passes through the sward. The ribbon of turf is detached from the rest of the sward by a vertical blade or coulter attached to the flaughter blade, directly under the beam of the plough. The handle on the sward side of the plough is lined through with the beam. The other handle is offset and provides restraint for the mould-rods that turn the turf. The restraints for the rods are situated far enough back that the turf is already falling away from the mould-rods before this point and is therefore unlikely to snag.

It is uncertain whether this device would have worked on the densely cultivated lands of Scotland, but it proved an ideal tool for cutting turf from the virgin prairie of Nebraska. Descriptions of the operation of these ploughs state:

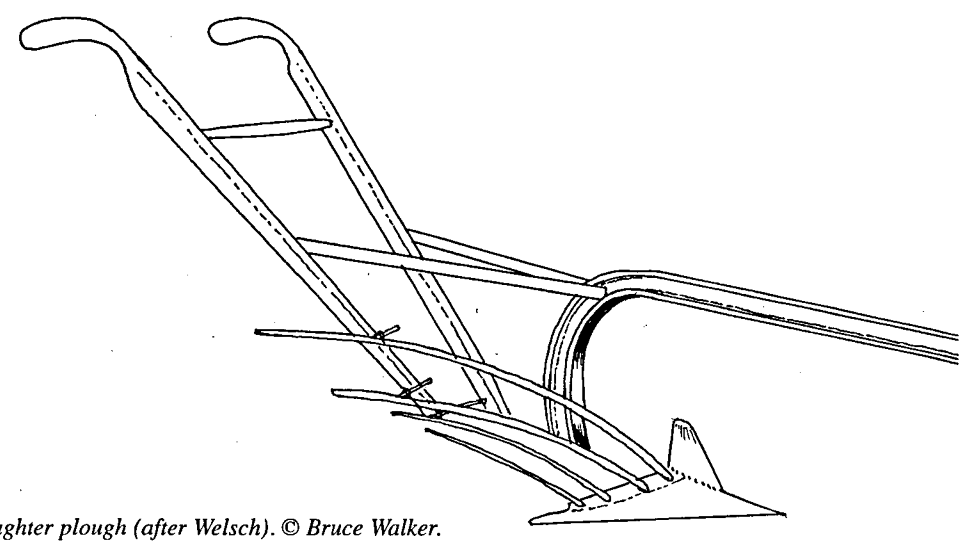


fig 45. Flaughter plough (after Welsch). © Bruce Walker.

'As the cutting plow sliced through the virgin sod, the tearing grass roots made a sound like the opening of a giant zipper' (Welsch: 1968, 40).

A 'cutting plow' allowed the turf to be cut in a long ribbon twelve to eighteen inches wide and three to six inches deep. This is the forerunner to the present-day turf stripper.

9.02.6 Turf-strippers

Various types of mechanised turf-strippers are available at present, but all linked to young lawn turf rather than mature well-rooted building turf. They will strip the mature turf, but since their maximum depth of turf is 63mm (2½ inches), these are of little use for recreating any traditional turf construction other than divet.

9.03 Transport

The transport of turves is extremely important. Turf is heavy, particularly when wet (which appears to be the desired condition) and according to Welsch it took one acre of sward to construct a 3600mm x 4200mm (twelve feet by fourteen feet) Nebraskan soddy, cutting the turves from (four to six inches) deep. This meant that even if the sward was close to the building site there was still a major transport problem.

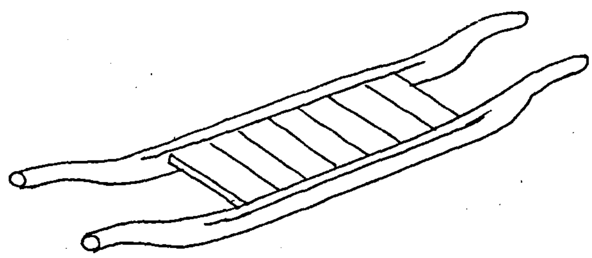


fig 46. Mason's hand barrow. © Bruce Walker.

The traditional carrying equipment such as a creel is not suitable for moving soft turves. Hand barrows are a possibility but it would require an enormous number of barrows and men to supply a team of turf builders working on a wall or building. Wheelbarrows are not ideally suited because of their shape, but some of the older wooden wheelbarrows had detachable sides making their use possible. The means of transport used in Nebraska in the 1880s was also available on most Scottish farms at an earlier date: that is, the slipe and slide-car. The slipe takes the form of a simple sledge, but with an attachment for a horse or ox. The slide-car is like a pair of shafts for a cart, extended well behind the heels of the draught animal to form an inclined platform and back. The ends of the shafts are shod with iron to prevent their wearing.

Whatever the form of transport, all the labourers agree that turf should not be lifted to any great height until absolutely necessary.

9.03.1 Barrows

A mason's barrow or hand-barrow is a form of stretcher with a plank floor (fig 46). This is useful for moving turves over a short distance.

9.03.2 Slipes and slide-cars

The definition of 'slipe' in the *Scottish National Dictionary* includes both the traditional 'slipe' and the 'slide-car'.

It is described as 'a wooden platform or drag without wheels used for moving heavy or cumbersome loads over difficult or rough places', or as 'the sliding cart or slipe which....is now in common use (fig 47). It is

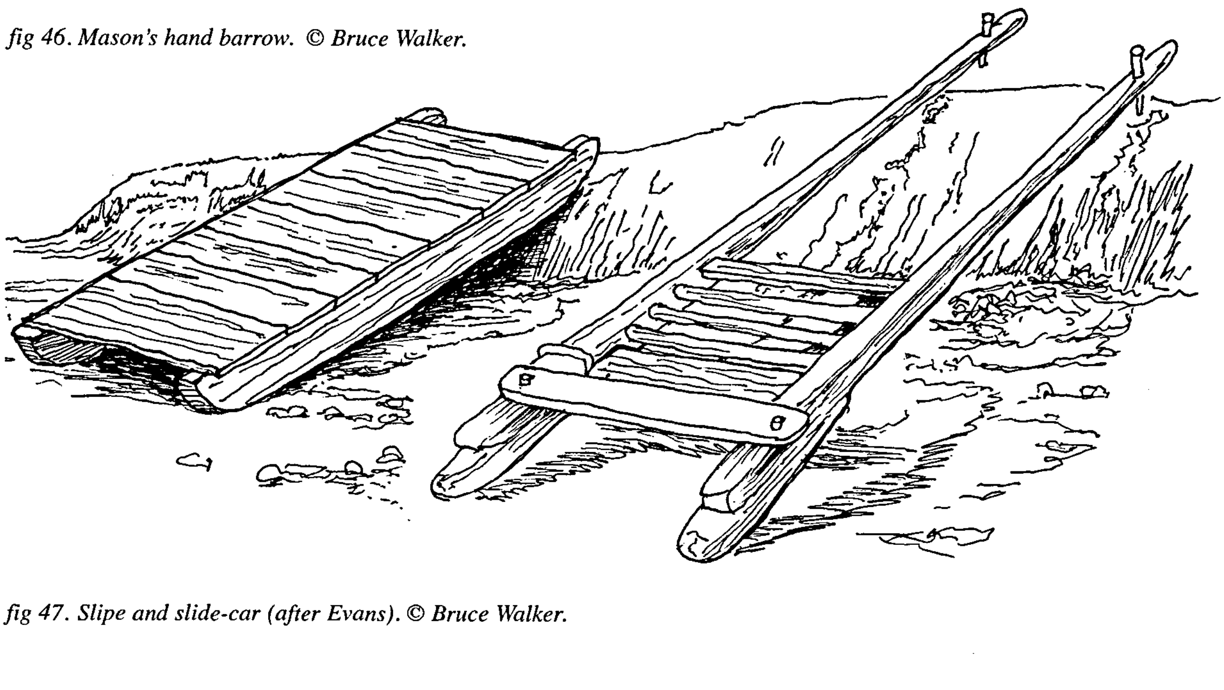


fig 47. Slipe and slide-car (after Evans). © Bruce Walker.

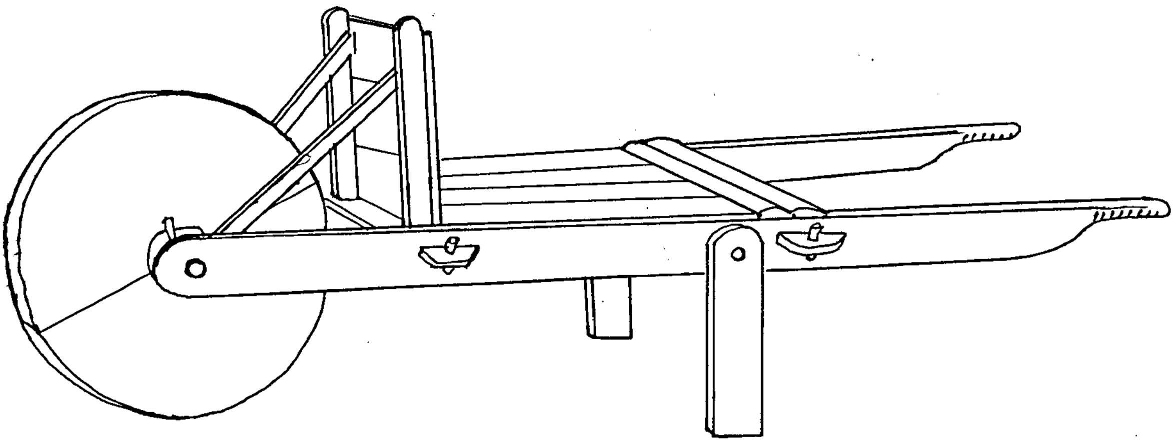


fig 48. Traditional builder's wheelbarrow or peat barrow (after Evans) © Bruce Walker.

formed of two long poles, framed together shaft-wise. The smaller ends are fastened to the hames, in the manner of other shafts, the larger ends slide upon the ground'.

The first type could be made up quite simply and pulled by a tractor. The sliding cart type may still be the best form of transport if the turf has to be brought between trees or boulders.

9.03.3 Wheelbarrows

The only type of barrow suitable for moving turf is the traditional builder's wheelbarrow, which has a plank deck with one platform-end adjoining the wheel (fig 48).

This should not be confused with the modern builder's wheelbarrow, which is made of metal but closer in form to the traditional gardener's wheelbarrow.

9.04 Building

The tools used for the actual building of the walls are minimal. They comprise beaters, rammers, paring irons, plumb-lines, and profile frames.

9.04.1 Beaters

Small timber beaters, similar to those used by plumbers to dress lead, but not necessarily as well made, are useful for compacting loose earth added to the wall to fill voids and open joints.

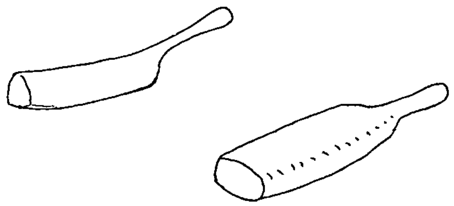


fig 49. Beaters. © Bruce Walker.

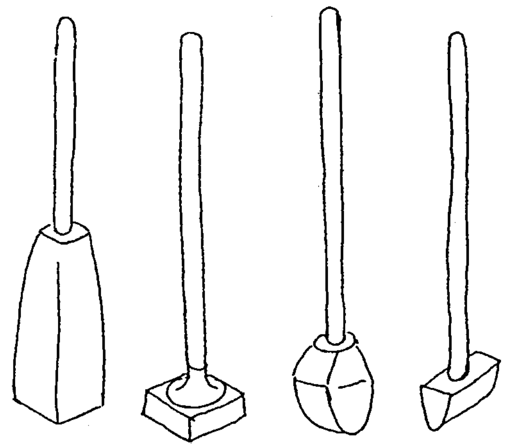


fig 50. Rammers. © Bruce Walker.

9.04.2 Rammers

Flat-headed rammers are useful and can be used as an alternative to the beater for compacting loose earth added to the turf to fill voids and open joints (fig 50). Spade-shaped wooden rammers and wedge-shaped iron rammers are useful for compacting earthen cores to field dykes or low walled dwellings.

9.04.3 Paring irons

The paring iron used to trim the face of a newly built turf wall is spade-shaped, but lacks the shoulders used to exert pressure on a normal garden spade. The cutting edge is either straight, pointed or curved. The most crucial feature is that the back of the iron (that is, the side against the cut wall surface) is flat, thus permitting the tool to be used vertically from the wallhead as the work progresses, without handles or other projections interfering with the line of the cut.

9.04.4 Plumb-lines

This is often replaced by a spirit level, but plumb-lines mounted on simple frames can form an inexpensive alternative. Ancient examples of plumb-lines for assessing horizontal and vertical surfaces are shown in the diagrams (fig 51).

9.04.5 Profile frames

When building a house or contained structure, reference points may be set up to assist the builder in maintaining straight lines and accurate sections.

When working on field dykes or other structures of indeterminate length, it is useful to have a profile frame made up to the agreed wall section to serve the same function. These are also used in masonry dyke construction (fig 52).

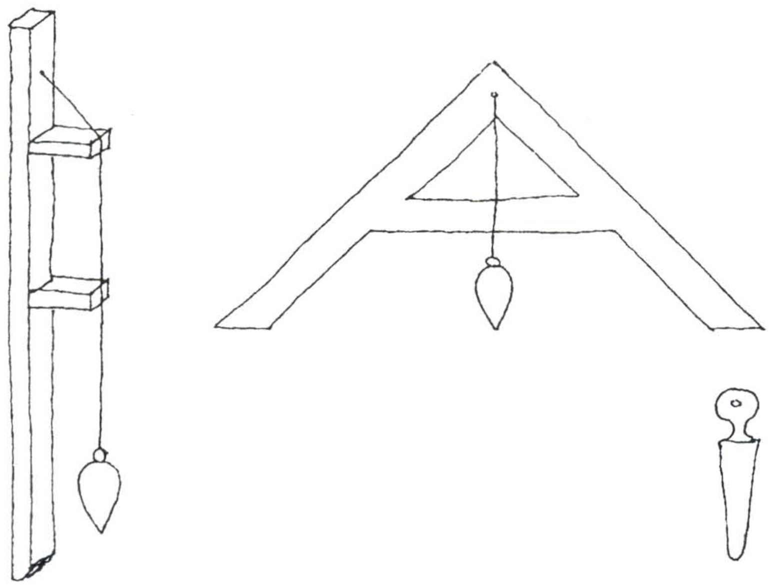


fig 51. Plumb-lines. © Bruce Walker.

fig 52. Rough profile frame used here in dry-stone walling © Scottish Lime Centre.

10. CASE STUDIES

The most prominent international case study is the report on the reconstruction of the medieval Icelandic turf-house at Þjôsârðalar, Stong, Iceland. (Ágústsson, 1969).

Within Scotland, Ross Noble of the Highland Folk Museum, Kingussie, Inverness-shire, published the results of the Turf-house Experiment carried out at the museum in the early 1980s (Noble: 1984). He was again involved in a major reconstruction of Raitts Township at the Highland Folk Park, Newtonmore, Inverness-shire. This was a major project but was not being executed in accordance with the advice given in this publication since it was based on a period of expansion when good quality turf for dwellings and other structures was difficult to obtain. It will therefore be interesting to see whether the buildings performed satisfactorily over a number of years or whether they failed in the same way as the other buildings of that period. It is likely that this project will be published in full in the near future.

Other opportunities to build in turf have been limited. The use of turf as an undercloak to thatch has been reported in TAN 4 (Walker, McGregor & Stark: 1996), TAN 5 (Walker and McGregor: 1996), TAN 6 (Walker, McGregor and Little: 1996) and TAN 13 (Holden, *et al*: 1998). A number of surviving turf structures have been recorded but only one has been repaired. This conserved structure is at Corse Croft, Kinnoir, Huntly, Aberdeenshire - see 10.02. A kailyard wall has been constructed at Burns' Cottage, Alloway, Ayrshire - see 10.01. The Leanach Enclosure, part of the Culloden Battlefield walls at Culloden Moor, Croy, Inverness-shire has been reconstructed by the National Trust for Scotland - see 10.03. An experimental fale dyke was erected by Rebecca Little, using the same source of turf as used for Corse Croft, Kinnoir, as part of the Historic Scotland: Earth Walls Experiment (Walker, McGregor and Little: forthcoming). A turf ridge to a thatched roof was recreated at Cottown, St Madoes, Perthshire (Myles and Walker: 1999).

Four case studies are given below, each carried out under different auspices and each using a different contractor.

10.01 Burns' Cottage Kailyard Wall, Alloway, Ayrshire

The Burns National Heritage Park, which comprises the Burns' Cottage and Museum, the Monument and Gardens, the Auld Kirk, the Brig O'Doon and the Tam O'Shanter Experience, was set up in 1995. This body inherited a scheme initiated by GLA Heritage Planners and Design Consultants, who had proposed that a kailyard be formed, wrapping round the west corner of the Cottage, as part of the interpretation of the site. It was decided that this proposal be implemented.

10.01.1 Nature of problem

The dyke envisaged by GLA Design was a low turf wall approximately 900mm (36 inches) high and 600mm (24 inches) broad, with battered sides and a flat top.

10.01.2 Location

The kailyard dyke wrapped round the west corner of Burns' Cottage is situated in the former fermtoun of Alloway in the parish of Ayr, Ayrshire. The Ordnance Survey national grid reference is NS 334185. The Old Alloway Kirk, Burns' Monument and Brig O' Doon are all about 2km to the south.

The kailyard, which is similar in area to the cottage and byre combined, wraps round the west corner of the cottage. It stops short of the visitors' entrance, through the barn, to the cottage. Another short section of turf dyke separates the visitors' entrance from the stackyard which wraps round the north corner of the building. The rest of the stackyard wall is built in drystone.

10.01.3 Site

The site is essentially level. The house sits on a north-north-east/south-south-west axis, with the kailyard lying parallel on the north-west side. There were no restrictions on the design of the wall other than the safety of visitors and that its height should allow visitors to sit on the walltop when the grass is dry enough.

According to the First and Second Editions of the Ordnance Survey map, part of the building turned at right angles to the road and faced onto a formal garden. This was a public house and was demolished in 1901.

10.01.4 Sourcing materials

It was decided to take the turf for the dyke from the garden ground on the Burns' Cottage site. This decision was strongly criticised by Thomas Arres senior of Thomas Arres and Son, Kelso, the contractor for the work. His opinion was that a heath and bent grass turf should have been sourced and cut in 100mm (four inch) thick turves. The soil for these turves should have been clay or peat as these would perform well for at least twenty years.

10.01.5 Construction

The construction techniques were adapted to suit the 50mm (two inch) thick turves that can be obtained from a turf stripper (figs 53-64).

The turves were 400mm (sixteen inches) square on plan and were laid grass side up with tight vertical joints. A number of half-width turves were laid alongside the first row of square turves, to give an overall width of 600mm (twenty-four inches). The joints of the half-turves were staggered to butt the mid section of each 400mm (sixteen inch) square turf.

Each successive course was constructed in the same way but with the half-turf on the opposite side of the wall to the course below. This continued until the wall height was within 200mm (eight inches) of the specified height. The sides were pared to provide a

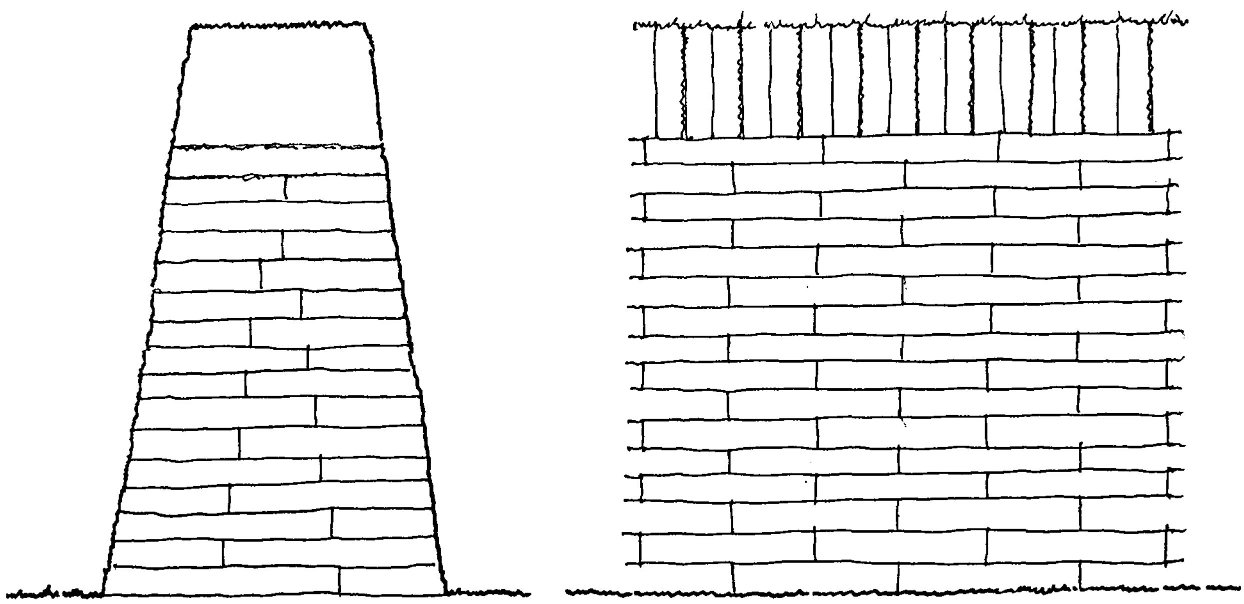


fig 53. Section and elevation of Kailyard Dyke, Burns' Cottage as built.

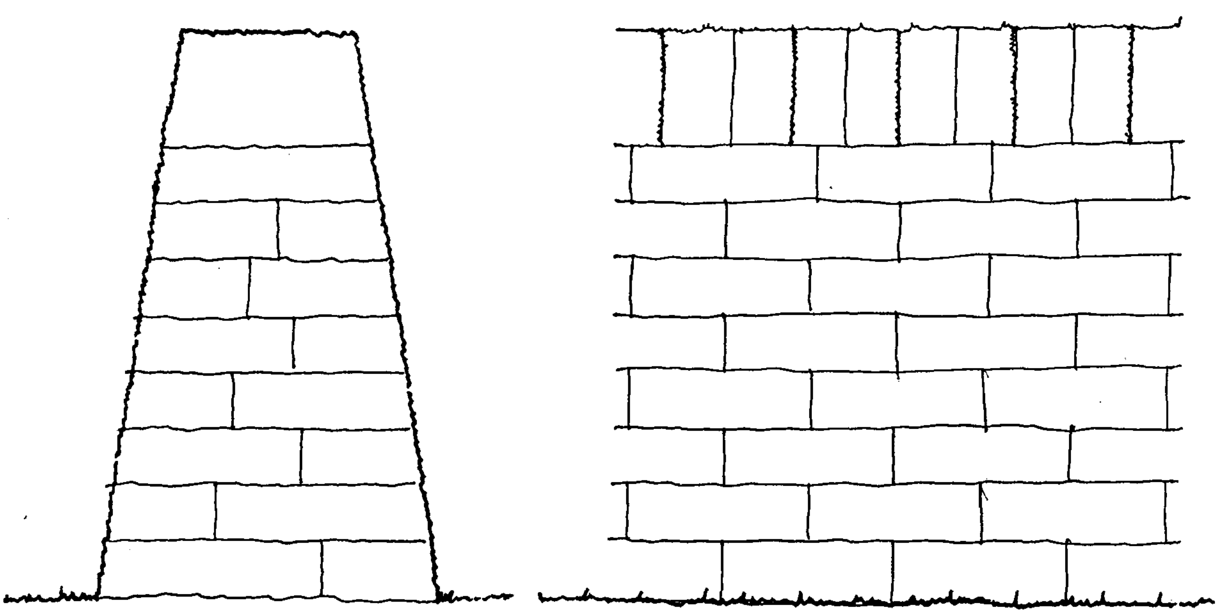


fig 54. Section and elevation of Kailyard Dyke, Burns' Cottage, as preferred by the builder.

smooth battered surface on either side, giving a width at the wallhead of 300mm (twelve inches).

The cope was then applied. This comprised a series of half-turves, laid on edge, providing a 200mm (eight inch) deep cope.

The trimming or paring of the wall surfaces and cope was carried out using scythe blades fitted with a short handle to the same pattern as those used by thatchers.

Mr Arres' criticism of the type of turf was based on traditional usage where the dyke was intended to keep out livestock and resist the attentions of domestic fowls. The dyke as built was too low to stop sheep gaining access to the kailyard. Cattle grazing the surface of the dyke tended to pull out the grass by the roots, and domestic poultry would pick the rest of the dyke apart. He was also of the opinion that the kailyard was too close to the house, and completely out of place in this setting.

10.01.6 Observations

The work was carried out in 1994-95 and in the summer of 1997 looked extremely green with a healthy covering of thick grass.

The site was revisited in August 1999 when the wall loked dry and friable, with withered vegetation. The height of the wall had by that time dropped to about 600mm (twenty four inches) from an original height of about 750mm (thirty inches).

10.02 Corse Croft, Kinnoir, Huntly, Aberdeenshire

Corse Croft comprised a late nineteenth or early twentieth century $1^1/_2$ storey croft house and an older low, single-storey, steading range standing on a 3.24 hectares (eight acre) croft. The steading range incorporated the remains of the former croft house at its southern end (fig 55).

The south gable of this early range was built of turf, with a large brick-built chimney breast against the inner face of the turf wall. The rest of the outer walls were claywall (Walker & McGregor: 1996: 70-73) and the roof, covered with corrugated-iron sheeting, contained the remains of a clay-thatch. The clay-thatch was the subject of archaeological investigation by Headland Archaeology (Holden *et al.* 1998: 67-74).

The turf gable formed part of the field boundary to the south of the croft house and steading and had been covered with ivy for many years, some of the surviving woody stems of the ivy being approximately 35 mm in diameter at ground level. The ivy had been killed off and removed from the gable without structural damage to the turf wall, and the wall stood in this condition for some time.

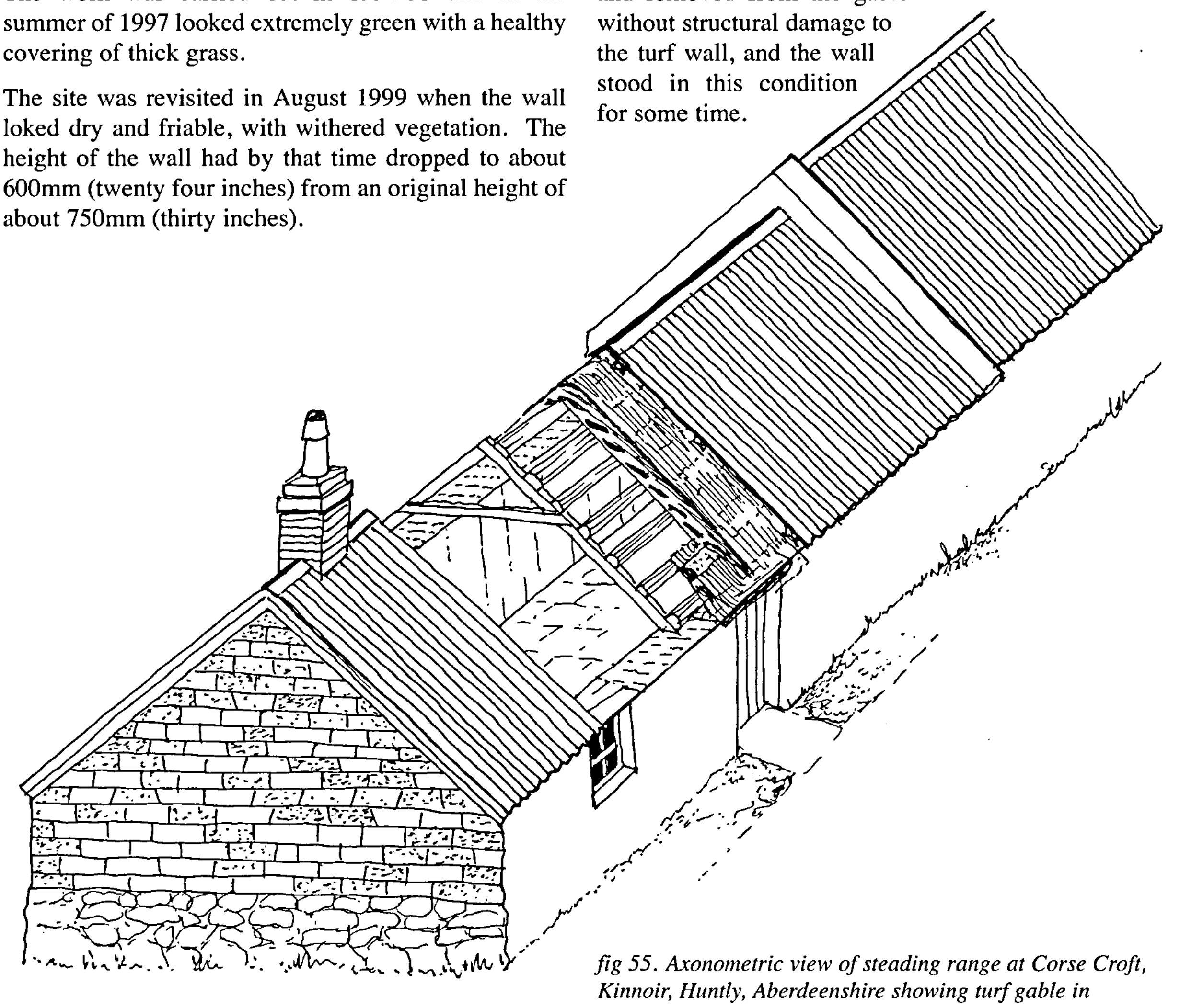


fig 55. Axonometric view of steading range at Corse Croft, Kinnoir, Huntly, Aberdeenshire showing turf gable in foreground. © Bruce Walker.

The field was then let to a local farmer to graze some young cattle, and soon after the cattle were released into the field Mrs Boniface noticed that they were lined up with their heads to the turf gable. On investigation she found that they were standing licking the surface of the turf as they would lick a salt block. Mr Boniface was called, and between them the Bonifaces erected a temporary barrier between the cattle and the wall, although not before the cattle had created a hollow across the wall surface at their head height. It is thought that these cattle were tasting salt trapped in the clay soil of the turf.

The Bonifaces knew a local member of the Scottish Vernacular Buildings Working Group, and through that contact approached Bruce Walker for advice. Bruce Walker and Christopher McGregor visited the property and assessed the situation. They suggested that Mr & Mrs Boniface apply to Historic Scotland for a Grant to Owners under the Thatched Houses Scheme.

10.02.1 Nature of Problem

The problem presented to the conservation team was how to repair the turf gable without completely destroying the integrity of the original construction. It was also decided to check on the condition of the thatch and its corrugated-iron covering, particularly where the iron was folded over the skew to protect the top of the turf gable. Some damage to the thatching slabs and the roof trusses was noted at the north end of the steading. This appeared to be the result of intensive woodwork infestation.

10.02.2 Location

The site is located approximately five kilometres north-north-east of the centre of the burgh of Huntly. The Ordnance Survey map reference is NJ 558443. The approach from Aberdeen or Huntly is by the A96 (T) road turning north approximately two kilometres east of Huntly on to the A97 to Aberchirder and Banff: about three kilometres north of this junction turn north onto an unclassified road marked Kinnoir. The croft is approximately three kilometres from this junction, about seventy metres to the west down an access road.

10.02.3 Site

The croft house and steading lie to the west of the access road. The croft house faces south into the steading court, now a garden. The former croft house steading range lies to the west, with a shorter steading range to the east.

The *Imperial Gazetteer of Scotland* (Wilson, n.d. ii. 98) describes the soil of the former parish of 'Kinore' (Kinnoir) as being of a cold clayey character. The predominant rock is granite with small deposits of limestone.

10.02.4 Sourcing materials

The turf gable was constructed of fale, each block measuring 400mm in length by 200mm in breadth by 125mm in depth. The blocks were cut with angled joints and the texture of the face is reminiscent of a fine conglomerate stone rather than a normal soil.

The turf appeared to have been sourced from two distinct sites. The bulk of the gable comprised an orange-tinted turf, similar to a sandstone with a pronounced iron content. The remainder of the gable, down the skews and at the interface with parts of the adjoining claywall was a dull grey turf. Both had the same texture.

The turf for the original structure was probably cut from the croft land (before it was improved by breaking down the clay with lime), or at a place identified by the laird as an approved source. This source remains a mystery. Rebecca Little, who had been appointed as contractor for the repair of the turf gable, talked to the owners and some of the older inhabitants of the area and established that turf of the required consistency and texture could be obtained from the site of a former local brickworks. Permission was then sought and granted to cut the required amount of turf from this source.

During renovation of the gable wall by Rebecca Little a number of turves which needed to be replaced were removed and retained. These were passed to Headland Archaeology for further study. Analysis was undertaken to determine the source of the turves and to provide information about the nature of the localities from which they were cut. Additional observations were also made on the size and shape of the turves with a view to determining the tools and techniques used to cut them.

The subsequent report by Stephen Carter et al (1997) is provided in the Appendix. This gives an indication of the potential of this type of study.

10.02.5 Construction

The turf gable was likely to be the oldest surviving structure on the site, although it is just possible that the whole of the steading range had been built in claywall and the south gable subsequently fell and was replaced in turf. Either way the precise history could only be established by archaeologically dismantling the interface of the two materials, but this would destroy the historic fabric. Walker (1979) recalled a number of claywall and masonry structures in the surrounding area which incorporated turf construction in the upper

fig 56. Turf gable, Corse Croft. © Chris McGregor.

fig 57. Close up of gable, Corse Croft. © Chris McGregor.

part of the gables, illustrating that the turf-building techniques were still alive and in use after claywall and masonry construction were already established.

10.02.6 Sequence and method of repair

Repairs to the turf gable (fig 56 & 57) were kept independent of the repairs to the remainder of the structure, the only interface occurring at the skews where the corrugated-iron roof covering protected the top of the turf gable.

The exact method of repair envisaged for the turf gable was still problematical at the time when conservation work started. The conservation team were aware of the problems of initial shrinkage of earth-based materials, and of the historical preference for building with turf which is wet. It was decided to start work at the skews, where the effects of shrinkage would be less problematical, and gain a feeling for the particular turf being used.

Sufficient turf was cut to carry out repairs at the skews and these turves were transported to the site and laid out on the ground ready for use. The weather was extremely warm, and the turves dried quickly. This was unintentional, but the dried turves had many of the properties of the mudwall blocks used to repair mudwall structures. Rebecca Little made this connection and proceeded to repair the whole wall, cutting out damaged turves and replacing them with accurately-cut pre-shrunk new turf set in an earth based mortar. Where the new turves were too large to fit the area to be indented they were cut using a joiner's cross-cut saw.

Once the structural integrity of the turf gables was re-established, slight hollows in the surface were built out in mudwall keyed to pins inserted into the joints of the turf wall. The process was slow but effective, and the whole wall dried out without any large-scale cracking either at the joints of the indented turves or in the packed-out mudwall.

10.02.7 Finishes

The turf gable was finished externally with a thrown mudwall harl and several coats of limewash.

The mix for the harl was Drongon clay: sand in the ratio 1:1. This was mixed into a sticky paste and applied thinly as a slurry.

fig 58. Completed gable, Corse Croft. © Bruce Walker.

10.02.8 Observations

This is a prime example of the complexities of building in turf. All the historical literature and archive documents refer to the need to cut the turf when it is wet, to prevent it drying out before it is incorporated in the structure, not to use turf that has been cut for more than twenty-four hours and to expect a considerable amount of shrinkage.

On this site the turf was so clay-rich, and had such a high proportion of aggregate, that it behaved in the same way as a mudwall block, and the turf wall was eventually repaired using techniques developed for mudwall repair (Walker and McGregor: 1996 and Myles and Walker: 1999). This similarity to a coarse mudwall block or to a conglomerate sandstone probably explains the considerable number of turfwall fragments recorded in this area in the 1970s (Walker: 1977) and illustrates that when working with natural materials, where there are no generally accepted standards of quality or performance, there is no substitute for experience and an inbuilt natural 'feeling' for the properties of materials. Certainly there is no logical reason for abandoning a material of this calibre in favour of claywall other than that claywall gives the appearance of being constructed in masonry.

The site was revisited on June 30, 1999 to check on the condition of the conservation work. The gable was in excellent condition, apart from two patches of limewash, one at the skews and one at the footings, where the limewash had broken away revealing the mudwall harl. The surface of the harl was cracked but otherwise sound.

These two areas corresponded to areas of repair, and may have resulted from problems created by a microclimate rather than the conservation works. The wall would have to be studied in detail, in different weather conditions, over a complete year, to see if the cause can be traced. This would be an expensive exercise to set up possibly costing a great deal more than the initial repair.

It has been recommended that the wall be re-limewashed after photography, then monitored to see whether the problem recurs.

10.03 Leanach Enclosure, Culloden Moor, Croy, Inverness-shire

The Leanach Enclosure formed part of a series of dykes on the south flank of the opposing armies at the Battle of Culloden, 1746 (fig 59).

The Battle of Culloden, between a government army led by the Duke of Cumberland and a Jacobite army led by Prince Charles Edward Stuart, was the last major battle to take place on mainland Britain. The site was a stretch of open moorland, to the south of the enclosed park round Culloden House and to the north of the River Nairn.

The opposing lines were drawn up to the north of a series of enclosures, the Park Enclosure stretching

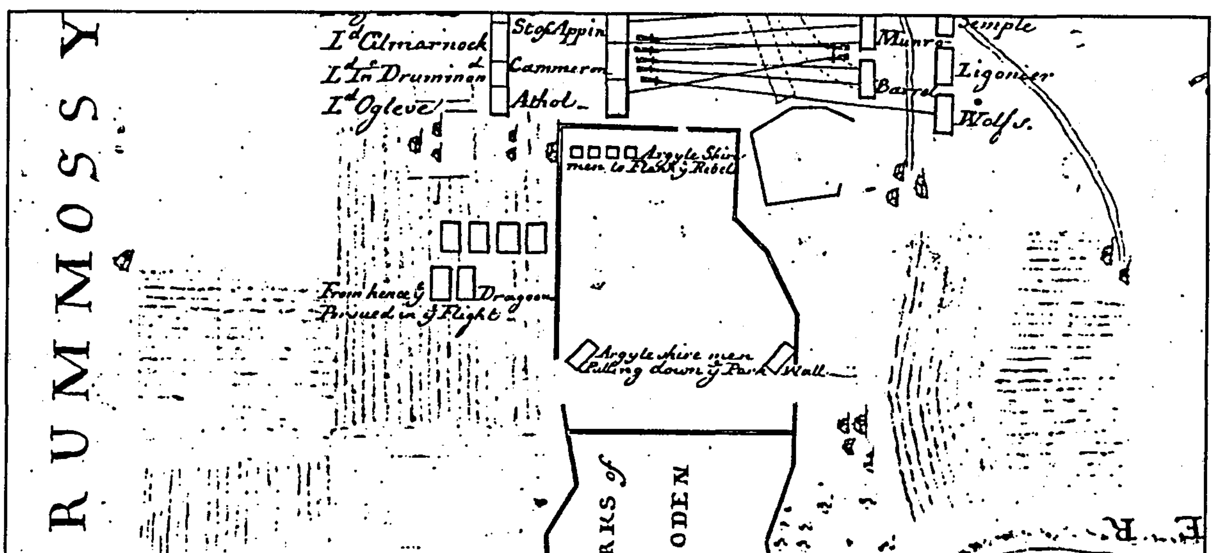


fig 59. Detail from 'A plan of ye Battle of Culloden' by Jasper Leigh Jones, 1746.

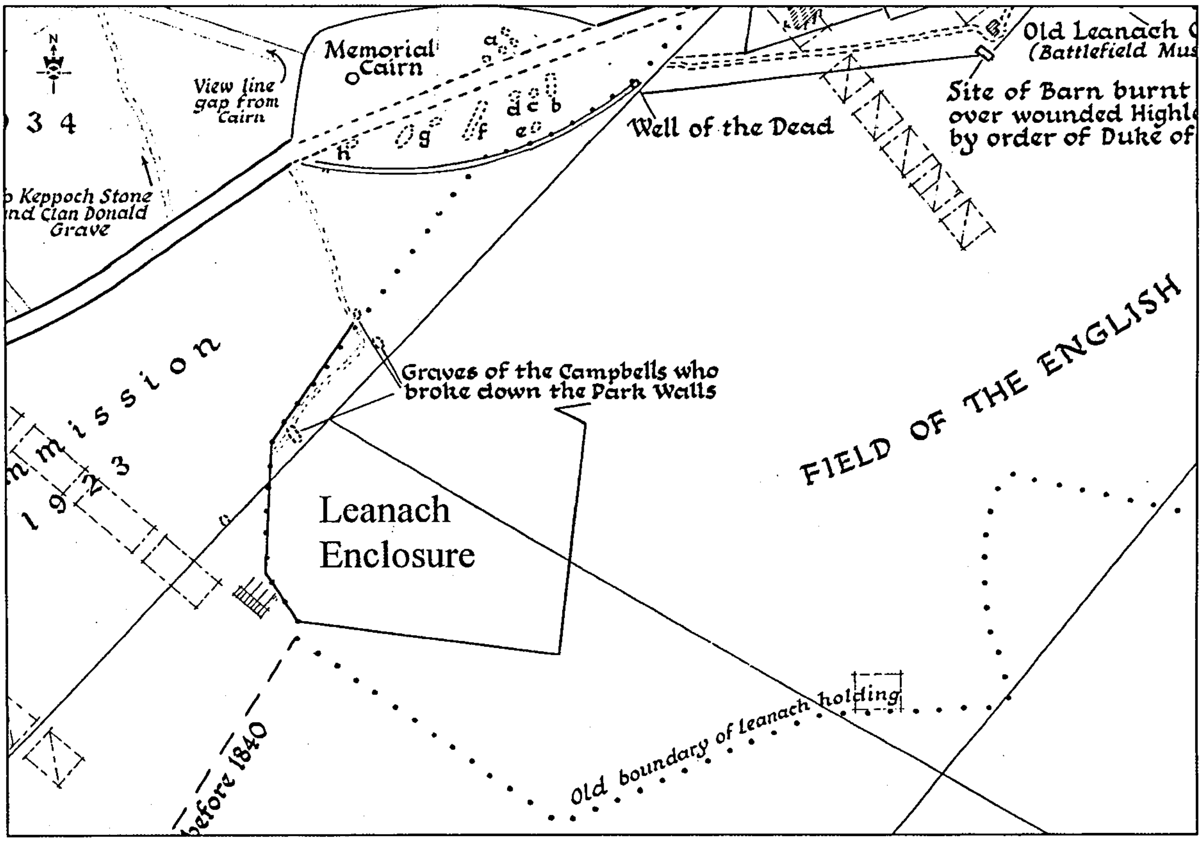


fig 60. Proposed reconstruction of Leanach Enclosure, Culloden Battlefield, showing parish boundary and location of pre-enclosures stone wall of the Parks Enclosure (dashed). © NTS.

down to the River Nairn and the smaller Leanach Enclosure which appears to have intruded onto the battlefield (fig 60).

The land on which the battle took place is now largely, but not entirely, the property of the National Trust for Scotland. In preparation for the 250th anniversary of the battle, the National Trust for Scotland committed itself to restore that part of the battlefield in their care to as close to its 1746 appearance as was possible within the framework of twentieth century communication routes and public safety requirements.

The most significant man-made feature of the battlefield appeared to have been the walls of the Leanach Enclosure and the Parks Enclosure situated to the south of the opposing armies, between the battlefield and the river.

Contemporary accounts describe the Leanach Enclosure as a turf-built dyke, whereas the Parks Enclosure was described as a larger drystone dyke, part of which was breached by the Campbells to allow the government troops to attack the Jacobite army on their south flank.

The Leanach Enclosure appears to have been demolished to make way for agricultural improvement at a later date. Since the Leanach Enclosure actually encroached on the battlefield it was decided to recreate the dykes of the enclosure on the basis of best available evidence.

The evidence was collected in three ways: by archaeological investigation, geophysical survey and documentary research.

10.03.1 Fieldwork

Trial excavations by archaeologists established that the turf dykes had left no trace in the ground. This was probably due to the contemporary practice of setting the foundations of dykes on the existing ground surface or in a shallow trench made by stripping the turf for use in another part of the dyke.

Evidence of the dykes was probably destroyed in the second half of the nineteenth century when this part of the moor was taken into cultivation. To do this the dykes would have been demolished and the stone footings lifted to allow the area to be ploughed. This was a common occurrence and the stone would have been reused in enclosure dykes or in new farm buildings.

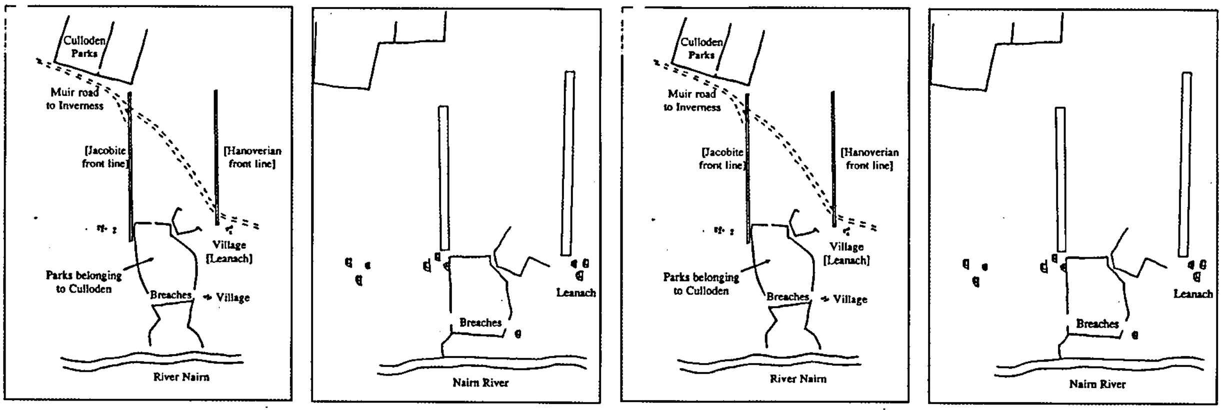


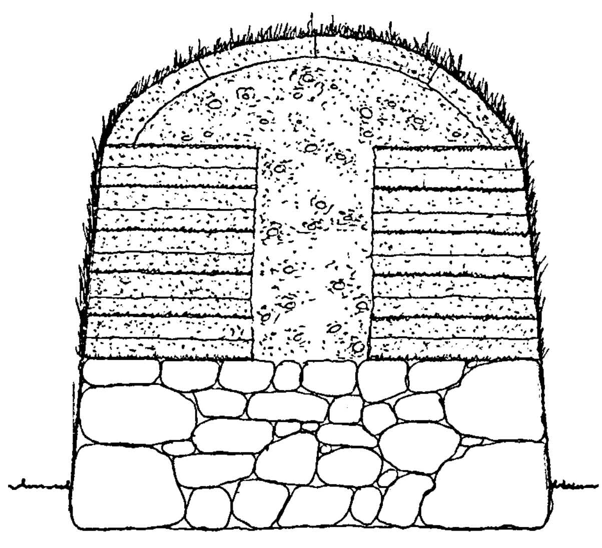
Fig. 1 Tracing of Map 43: T. Sandby, April 23rd 1746 — Fig. 2 Tracing of Map 39: D. Paterson, 1746 — Fig. 1 Tracing of Map 43: T. Sandby, April 23rd 1746 — Fig. 2 Tracing of Map 39: D. Paterson, 1746

fig 61. Some of the maps located by Kenny Aitchinson © NTS.

Geophysical surveying was also tried. It was realised that traces of the dyke could prove elusive for the reasons given above, but it was supposed that the 'English' graves reputed to be in this area might be located. In practice, no trace of the graves was found and the unusually noisy background in the magnetometer survey precluded identification of any slight anomalies that might be expected from the 'memory' of the turf dykes within the soil.

Jim Ramsay, coordinator for the National Trust for Scotland Volunteers, carried out personal research round his base in Lochaber. He measured a number of turf dykes to establish the standard range of sizes. These were checked against the remains of turf dykes in the Culloden area, and linked to descriptions in the Duke of Argyll's papers describing dykes on Mull and Tiree (Cregeen, 1964). Although the sources were scattered geographically, there was a remarkable similarity in the dykes in each area. Ramsay then produced a profile for the dyke which was approved by the National Trust for Scotland archaeologist, and this was used as the basis on which to organise the project.

Three different constructional techniques were associated with the dyke profile. These will be discussed in section 10.03.3 below



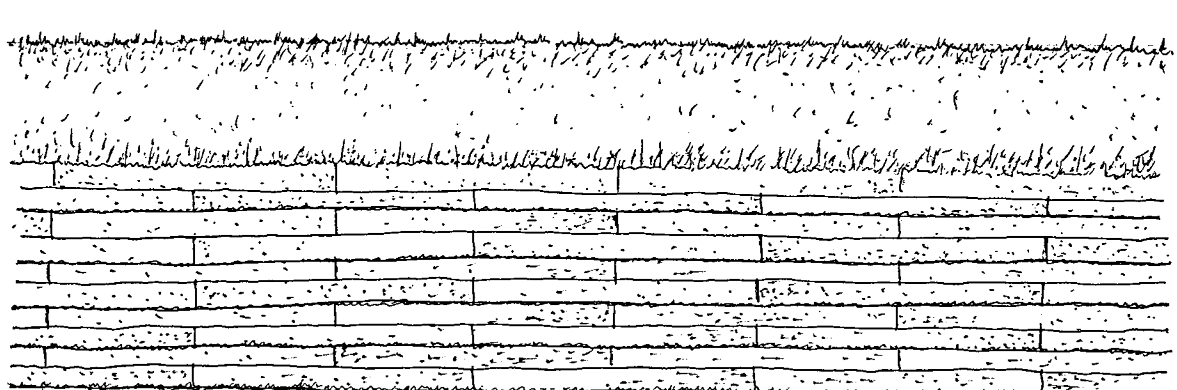
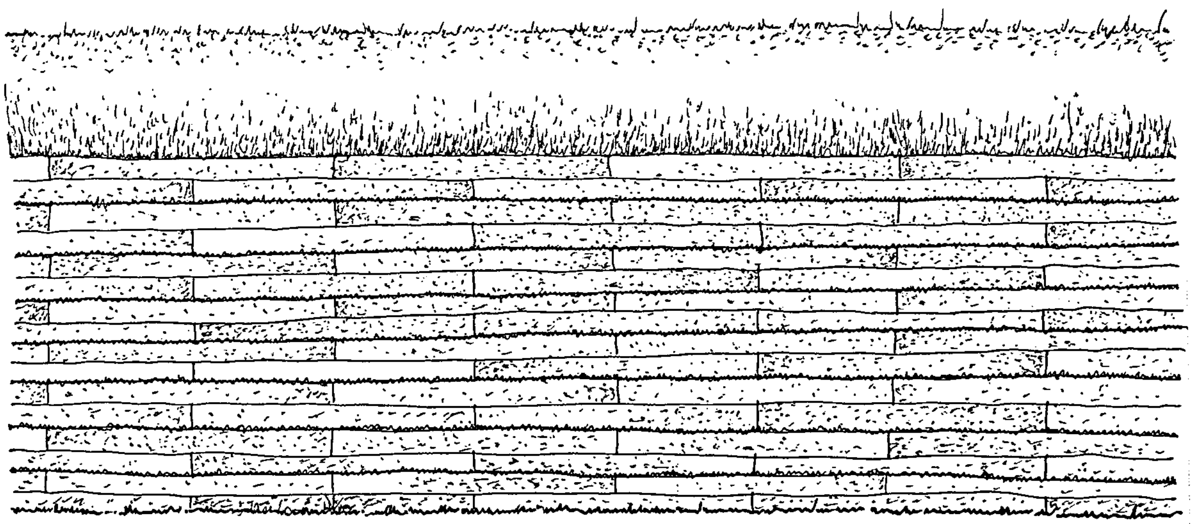


fig 62. Elevation and section through turf-faced wall on stone base (after Ramsay). © Bruce Walker.



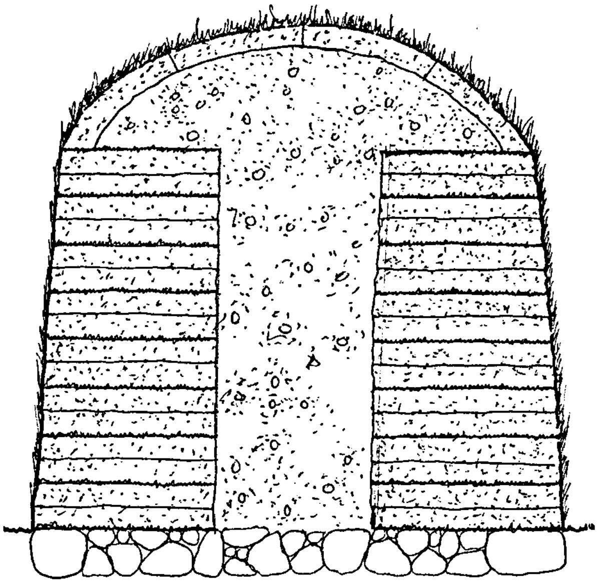


fig 63. Elevation and section through completely turf-faced wall (after Ramsay). © Bruce Walker.

10.03.2 Documentary research

A mainly map-based research programme was carried out by Kenny Aitchinson, an archaeology graduate from Edinburgh. Forty-seven battlefield maps were identified and examined, including some which had been omitted from other published lists. The resulting report (Aitchinson, 1994) considers the evidence relating to the nature and position of the Leanach Enclosure, the Muir Road and the settlement at Leanach. Aitchinson summarises:

> *'The search revealed that there were dykes and structures on the battlefield but that the exact location of these could not be pinpointed, owing to the inaccuracy of 18th century mapping. Only the general location and form of the dykes and buildings can be specified, but some information on the construction of these structures has also been discovered. In addition, details of the settlement at Leanach and of the road which ran across or near the battlefield were noted'*(fig 61).

In a summary of the project Turner concludes:

> *'It must be recognised that there is insufficient evidence on which to base the line of the Leanach Enclosure with certainty. The surviving maps disagree to such an extent that they can never match with each other and can only provide a basic guide. However, the line of the northern length of the enclosure does seem to have been preserved fairly faithfully in the parish boundary, and the elements of the rest of the enclosure from a good 'best fit' for the remaining evidence. If they still exist, the rediscovery of the two missing 1840 pre-enclosure documents (Aitchinson, 1994. maps 21 and 22) could potentially answer the questions once and for all. Until then we must rely on a combination of the contemporary maps, the existing topography, the surviving battlefield features and perhaps most importantly, the surviving parish boundary'.*

10.03.3 Construction

In 1994, three short sections of experimental turf-dyke were constructed at Culloden, each with a different form of construction. The types of wall tested were: a completely turf-faced wall with a core of compacted soil (fig 63): a similar turf-faced wall on stone footings (fig 62): and an alternating-stone-and-turf-faced wall, with a core of compacted soil, on stone footings (fig 64).

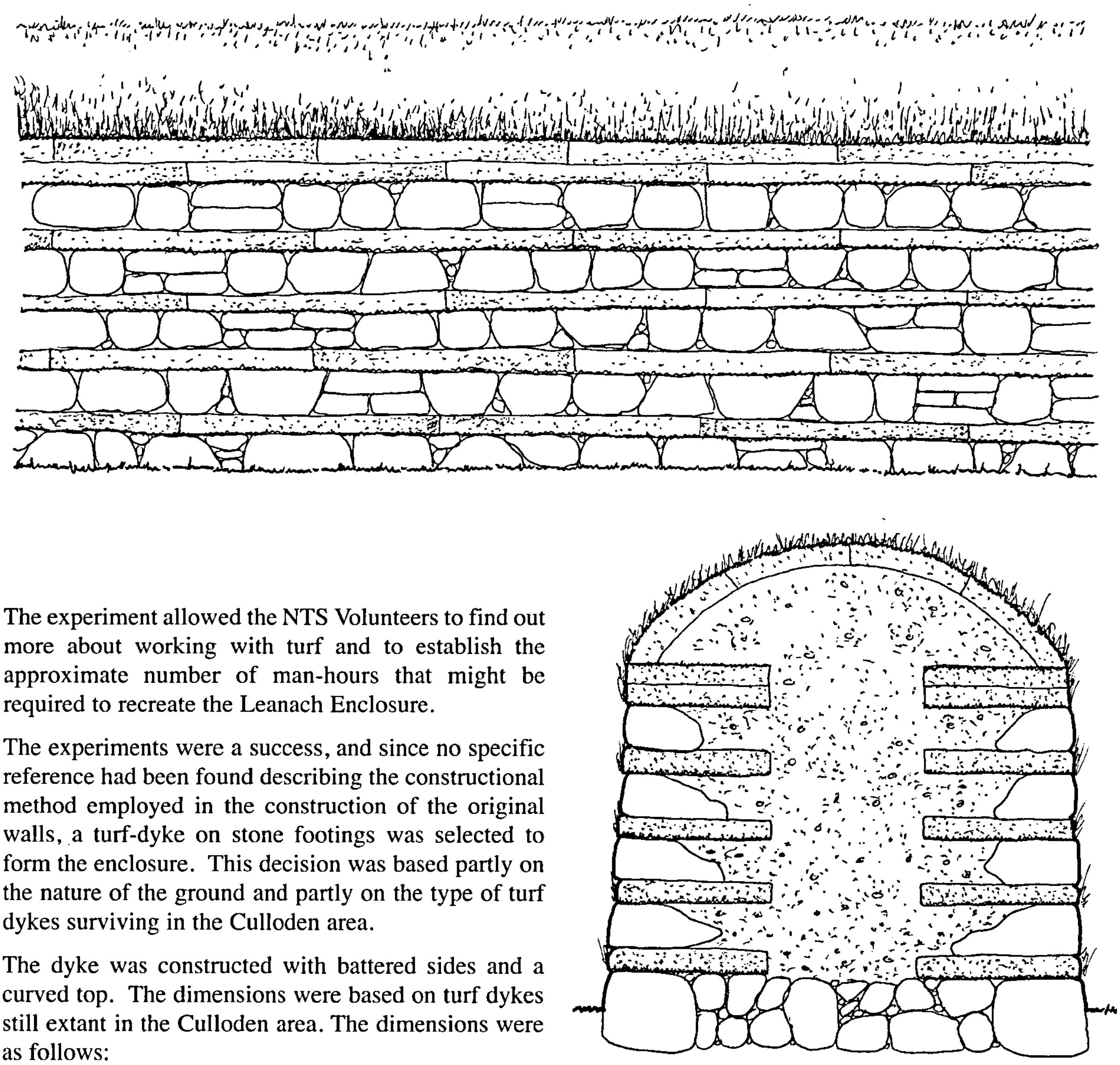


fig 64.Elevation and section through alternating stone-and turf-faced wall (after Ramsay). © Bruce Walker.

The experiment allowed the NTS Volunteers to find out more about working with turf and to establish the approximate number of man-hours that might be required to recreate the Leanach Enclosure.

The experiments were a success, and since no specific reference had been found describing the constructional method employed in the construction of the original walls, a turf-dyke on stone footings was selected to form the enclosure. This decision was based partly on the nature of the ground and partly on the type of turf dykes surviving in the Culloden area.

The dyke was constructed with battered sides and a curved top. The dimensions were based on turf dykes still extant in the Culloden area. The dimensions were as follows:

Width at base	1200mm	(48 inches)
Width at top	105mm	(4 inches)
Overall height including cope	1000mm	(42 inches)
Turf cope	250mm	(10 inches)
Stone footings above ground	300-450mm	(12-18 inches)
Stone footings below ground	120mm	(4 inches)

Other facts regarding the construction of the dykes were:

Overall length	450m	(510 yards)
Quantity of stone	255tonnes	(255 tons)
Quantity of soil/turf	125tonnes	(125 tons)
Man-hours required	4,222 hours	

10.03.4 Sequence and method of building

Jim Ramsay organised a pool of over one hundred volunteers into teams of between eight and ten: on occasion the team size reached fifteen.

The turf was cut by a turf stripper. The sub-soil fill for the core of the wall was excavated mechanically and the bucket of the excavator was used to transport both fill and turves. Even then the work could be described as extremely physical.

10.03.4.1 Foundation trench

A trench was excavated to correspond with the width of the wall at ground level, that is, 1200mm (forty eight inches) wide and 100mm (four inches) deep. The turf and soil removed from this trench was set aside for reuse in the wall.

10.03.4.2 Footings

The stone footings were constructed in much the same way as the footings for a drystone wall. The largest stones and boulders were used to establish the width and line of the wall, and the smaller stones were laid between these to create a straight outer edge but irregular inner surface. The stonework was bonded on face to keep vertical joints to a minimum, and all pinnings (required to stabilize the stones and prevent rocking or pivoting) were kept to the interior. The outer stones were positioned with the largest possible face to the outside of the wall, whilst maintaining both the line of the wall and the stability of the stone facing. The void between the two outer faces was filled with well - compacted hand-placed hardcore.

The outer faces of the stone footings were built to the height determined by the available stonework and the desire to provide a reasonably smooth bed for the turf. This height varied between 300 and 450mm (twelve and eighteen inches), and accommodated slight rises and falls in the ground surface. As the outer surfaces were created the core was filled and compacted.

The top surface of the footings was made as smooth as possible to provide a good bearing surface for the turf. Dips in the surface were filled with broken pieces of turf, or well compacted soil, immediately prior to the turf faces being constructed.

The NTS project manager estimated that the wall required over half-a-tonne of stone for every lineal metre yard of wall footing.

Laying the stone footings proved to be the most time-consuming part of the whole process of wall building. This ties in with the generally-held view that a fale dyke costs about a quarter of the price of a drystone dyke. Experience of building practice at that time suggests that the original stone footings would have been constructed on the existing surface of the ground without creating a trench although, if the turf under the line of the wall was particularly good, it could be stripped to create the topping to the soil cap of the previous section of wall. This also saved further destruction of pasture since the area of the dyke was being lost for this purpose.

Often the perceived penetration of the wall into the existing ground level is not the result of paring the turf but rather the ground level rising over the period since the wall was constructed. In late eighteenth century housing it is not unusual to find that the walls of single storey cottages are built off the undisturbed sward.

10.03.4.3 Turf and Soil

Construction in turf and soil was much easier than construction in stone, but the technique had the disadvantage of destroying grazing land which was important to both laird and tenant.

On any sward the most matted roots are found closest to the surface, and this is the most desirable material for building purposes. A thin turf cut off the surface of the sward was known as a divet. Although divets made the best building material, their removal from the sward destroyed an enormous area of grazing: the thinner the divet, the greater the area destroyed to achieve the same height in building.

In a moorland situation such as Culloden Moor, it would be advantageous to build using fale. Fale is a thick turf normally varying from 150mm (six inches) to 300mm (twelve inches) deep and cut in the form of parallelogram- sectioned blocks.

The inclined angle of the downward cut has a number of advantages. Firstly it is easier to cut since it is natural to insert the spade at an angle rather than vertically. The inclined cut also allows the turf to be levered with the spade without fear of damage to the edge of the next turf in the sequence. When the turf is placed in the wall the inclined joints tend to close naturally, reducing the effect of any shrinkage in the size of the turf. The additional thickness of the fale over the thinner divet reduces the area of ground damaged by turf cutting by up to seventy-five per cent. In moorland conditions, where the growing turf is supported on peat rather than soil, the fale blocks will remain stable even if cut to more than 300mm (twelve inches) in depth.

The method of laying fale is to lay earth to earth and grass to grass up the entire height of the wall. The result of this practice is to produce a herring-bone pattern of joints on the wall surface. The inclined joint tends to close under the weight of the material being added above and this tends to reduce the effect of shrinkage in the length of each turf but increases the vertical shrinkage. An extra course of fale over the desired wall height accommodates this shrinkage and results in an extremely sound wall.

Where the fale has less fibrous material towards the base it is sometimes combined with divet, which is used in the same way as a reinforcing mesh. Fale and divet construction tends to be more commonly found on well-drained pasture rather than on a peat bog. It was also used in any area where the turf had been disturbed in the recent past and the root system was not as well developed as the builder might wish.

Divet construction, using 75-100mm (three to four inch) thick turves cut from a sward with a well developed root base, was the ultimate in turf-building technology. Single storey houses of this type of construction were considered to last up to one hundred and fifty years, and one example of a two storey villa of this construction, built on the prairies of Nebraska, USA, stood for over ninety years before being demolished by its owner. The demolition was not the result of the structure being dangerous but was an action by the owner on the refusal of the Nebraskan State Department to provide funding for its upkeep.

The NTS volunteers had two major advantages over the original builders of the Leanach Enclosure. They were not competing with other parties for the right to cut turf and they had the use of a Ryan Junior 6hp turf-cutter which produced a continuous length of turf 300mm (twelve inches) wide and up to 62mm (two-and-a-half inches) deep. This took much of the labour out of the cutting process, eliminated the need for a flaughter spade to pare the turf and ensured that only the most densely matted part of the root system was utilised giving a high quality turf-dyke.

Traditionally the grass, or other vegetation forming the turf, was cut prior to removing the turves. This improved the accuracy of the cut and the handling of the turves. Grass cutting was found to be essential prior to using the turf-cutter, since long grass created difficulties both with the cutting and with traction.

The turves were laid grass to grass and soil to soil up the height of the wall in a common bond pattern.

To ensure that the wall had an even surface and a standard section, a batter-frame was used similar to that used for drystone dyking. Any unevenness in the surface was knocked-in using the back of a spade. The NTS estimate of materials suggests that 250 kilos (a quarter of a ton) of soil and turf were required for each 900mm (lineal yard) of dyke.

Turf should be cut from as close to the construction site as is possible. This not only reduces the time and effort used in moving the turf from the sward to the dyke, but also reduces the amount of handling, stacking and rehandling. This is important since living turf in good condition, built into the dyke when still moist, will continue to grow in its new position and the new root produced helps the bond between the cut blocks.

NTS did investigate the possibility of buying pre-cut turf to speed up the building process but this proved to be both difficult to source and very expensive in the large quantities required.

Traditionally, turf dyking was carried out in the spring and early summer, in the slack period of the farming calendar between sowing of the crops and the harvest. NTS had no such restrictions but found that March to June were the best months, followed by September and October. July and August were too dry, as the turf tended to desiccate when handled.

Building the turf section of the dyke proved to be easier than anticipated, whilst laying the stone foundations was the most time-consuming task. The months from July to October tended to be used to prepare foundations, and the actual turf-building took place from March to June the following year. A team of well-motivated volunteers could build between 4.5-9m (five and ten yards) of dyke over a weekend. The work was extremely hard, with its emphasis on heavy lifting, moving soil and compacting the core. As the turf faces to the dyke were constructed, the core was filled with soil and compacted as much as possible. This continued until the required vertical height was reached, then a cap of soil was added to the wallhead to form a rounded profile in section. Long strips of grass turf were then laid over the compacted cap, from one side to the other.

10.03.5 Durability

The subsoil fill in the first section of wall was tipped into position by the excavator. This added to the difficulty in compacting, and also resulted in a mole being introduced to the wall. The mole put up a number of molehills along the cope, then disappeared: later sections of the wall were filled and compacted by hand as the turf building progressed.

The Leanach Enclosure dyke was completed in 1997 and to date has weathered well with only a minimal amount of maintenance being necessary. There has been some shrinkage in the overall height of the wall, particularly in the first sections to be constructed, probably due to the inexperience of the operators and the earth core not being properly consolidated. This problem has not been so pronounced in later sections where both supervisors and volunteers had developed some expertise and the compaction was done by hand. Overall, the dyke has retained its structural integrity and is performing well. The main source of problems is non-traditional: the wallhead suffers from visitors climbing up onto it, to walk along viewing the Battlefield. This has resulted in the cope becoming concave along the top rather than convex. This is to be attended to in the near future.

Similar problems were experienced by Historic Scotland at the Callanish Standing Stones, Lewis, where a few notices requesting visitors to keep to the paths reduced traffic on sensitive turf areas to a level where the turf could survive.

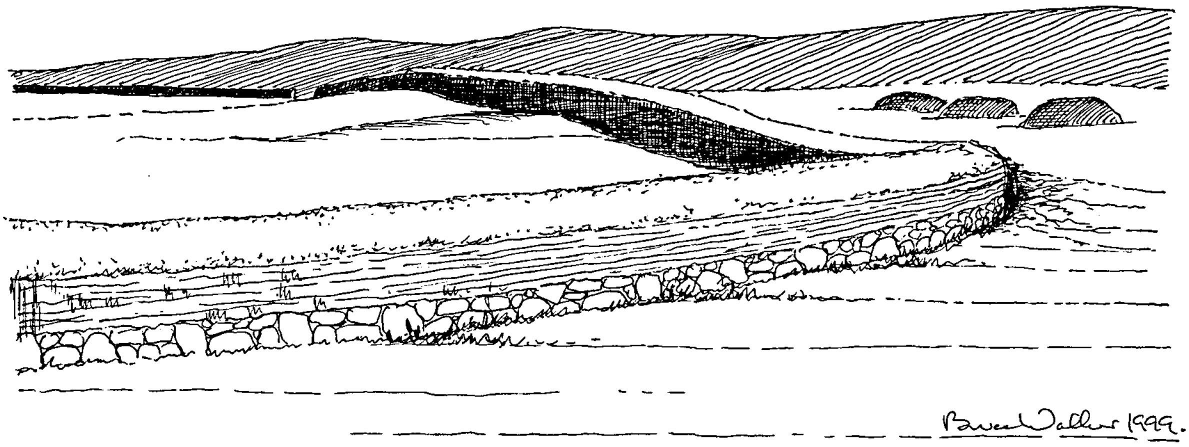


fig 65. Part of the Leanach Enclosure from the south-west corner looking east. © Bruce Walker.

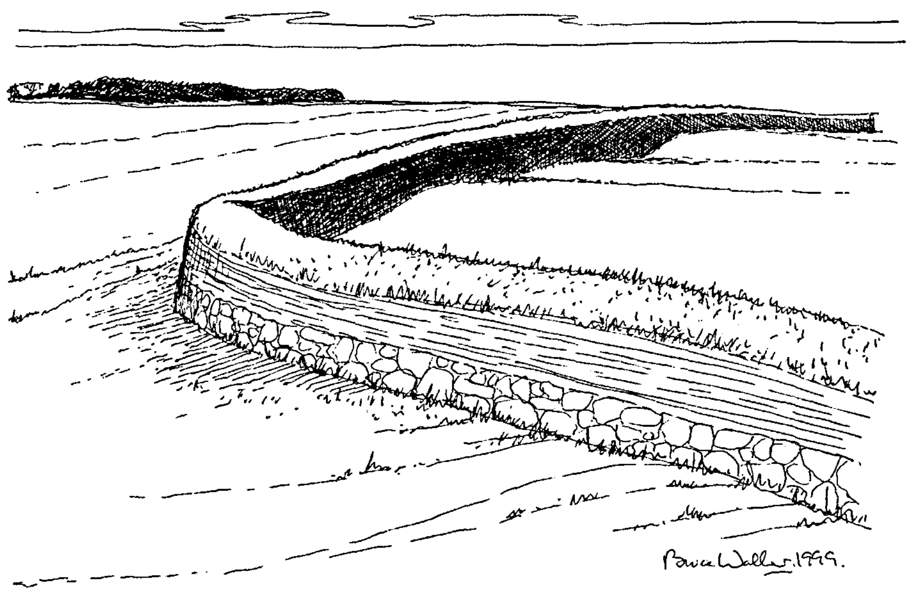


fig 66. Part of the Leanach Enclosure from the south-west corner looking north. © Bruce Walker.

At Leanach the sides of the wall had a brown, freshly-cut, earth appearance when erected. This quickly disappeared under a growth of new grass but as the wall has settled and compacted the grass sides have become less luxuriant and, although still green, no longer disguise the profile of the wall.

The Leanach Enclosure was visited again on July 1, 1999 and was found to be in good condition. No maintenance has been required to date and the only problem is the hollow in the top of the cope created by visitors walking on the wallhead.

10.03.6 Interpretation

In addition to the Leanach Enclosure dyke the NTS volunteers erected two short sections of dyke to illustrate to visitors the other two types of dyke considered at the outset of the project. This work was carried out in 1996 and both of these additional dyke types are performing well. An interpretation board illustrates the constructional details of all three types of dyke.

10.03.7 Observations

Projects of this type are not only useful in assisting the public in the visual interpretation of a site such as Culloden Battlefield, but also, if well monitored, can act as experimental structures in an archaeological sense.

The completed walls (fig 65) (fig 66) give an indication of the commitment of any estate or tenants in erecting

fig 67. Typical Carnoustie Championship Course bunker.
© Bruce Walker.

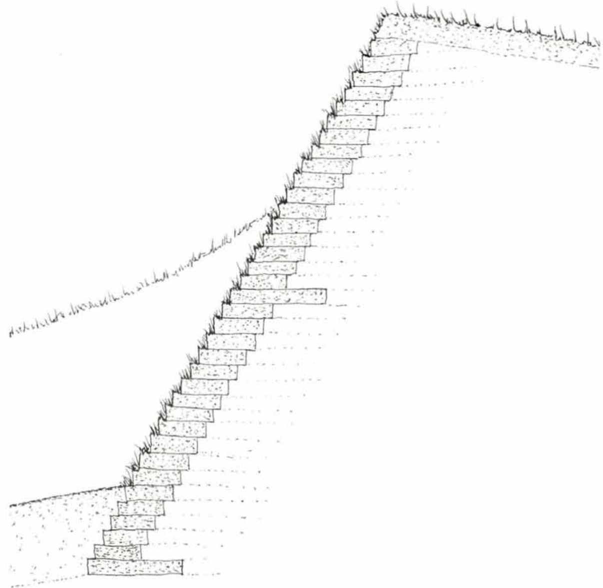


fig 68. Section through typical bare-faced bunker.
© Bruce Walker.

such a structure, the number of man-hours required, the type of structure that may have existed, the problems associated with such a structure, the type of maintenance that might have been required and eventually, the expected life-span of such a structure.

The National Trust for Scotland is to be congratulated on this project, as are the volunteers that brought the project to fruition.

10.04 Bare or Black-Faced Bunkers, Championship Course, Carnoustie Golf Links, Angus

During the televising of the 'Open' Golf Championship from Carnoustie in 1999, many commentators made special mention of the steep turf-faced bunkers round the course. These bunkers are commonplace on all links golf courses, but at Carnoustie they are particularly deep and well built (fig 67). The faces vary in height from about 600-2700mm (two to nine feet) above the level of the sand. Their function is to create a major hazard to those unlucky enough to play into them. The purpose of the turf faces is to block direct access to the green by creating a face up to 2700mm (nine feet) high.

The tradition of building turf bunker faces on links courses can be traced back to the end of the nineteenth century. Before then bunkers were natural hazards, but attempts to stabilize the links round the Scottish coast and prevent unnecessary sand movement resulted in the bunkers being formalised.

The Barry-Buddon links were covered with turf houses, occupied mainly by squatters, in the nineteenth century. The Earl of Dalhousie, who owned the land, made strenuous efforts to evict these squatters in the 1880s. This took some time to implement, and it was not until the turn of the century that all the turf houses were removed. At Tentsmuir, Fife, on the other side of the Firth of Tay, there were still around forty turf houses standing in 1900, but these disappeared before the end of World War I in 1918.

The idea of building turf faced bunkers on links golf courses is obviously influenced by this tradition, and utilized the skills still readily available at that time.

Carnoustie has some of the highest bunkers to be found on links golf courses. Some of these bunkers stand fully 2700mm (nine feet) above the level of the sand. They did not appear to be this high in the 1999 television coverage of 'The Open' since the Royal and

Ancient Championship Committee asked that the sand be swept up the face for the Championship matches.

10.04.1 Location

The Carnoustie Golf Course lies to the south of town at the north-east end of Barry Links. It is bounded on the north by the main Dundee - Aberdeen railway line, and to the south and west by the Barry-Buddon Military Camp and firing ranges.

10.04.2 Site

The bunkers are positioned at strategic points along the fairways and round the greens of the Championship Course and eighty of these were refaced for the 1999 'Open'. Some of these are quite small whilst other like 'the Spectacles' are quite extensive.

10.04.3 Nature of Problem

The steep faces of the bunkers are always positioned between the sand area and the green, or the next desirable 'lie'. The bunker faces are inclined at sixty

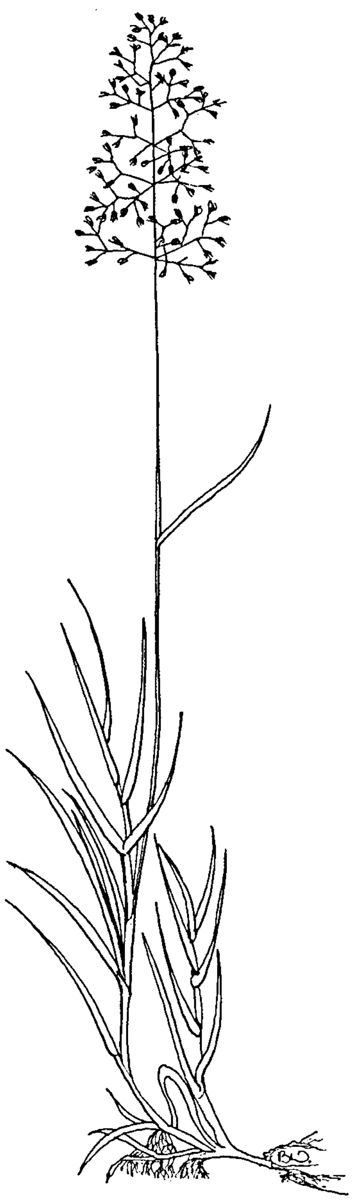


fig 69. Brown-top bent
© Bruce Walker.

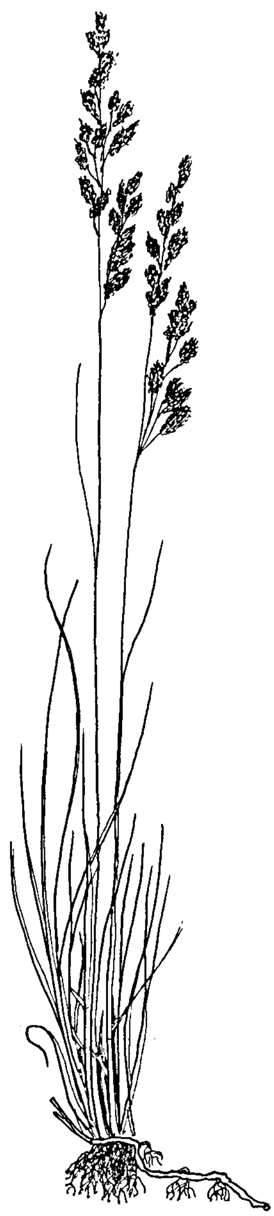


fig 70. Creeping fescue
© Bruce Walker.

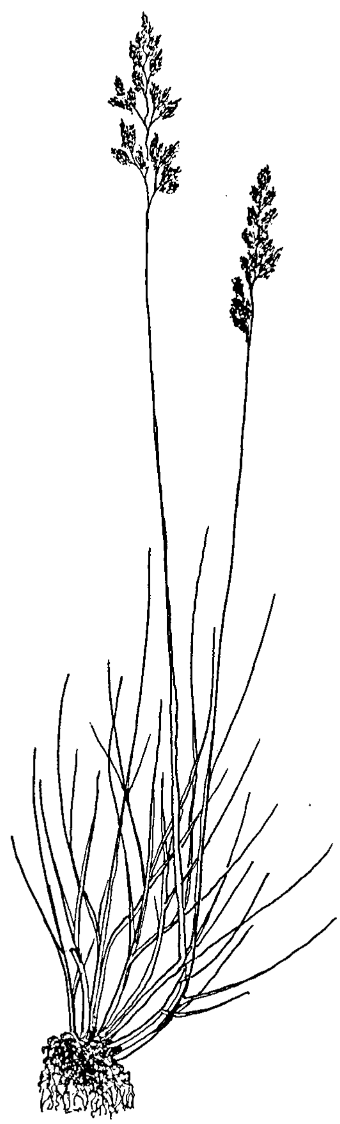


fig 71. Hard fescue
© Bruce Walker.

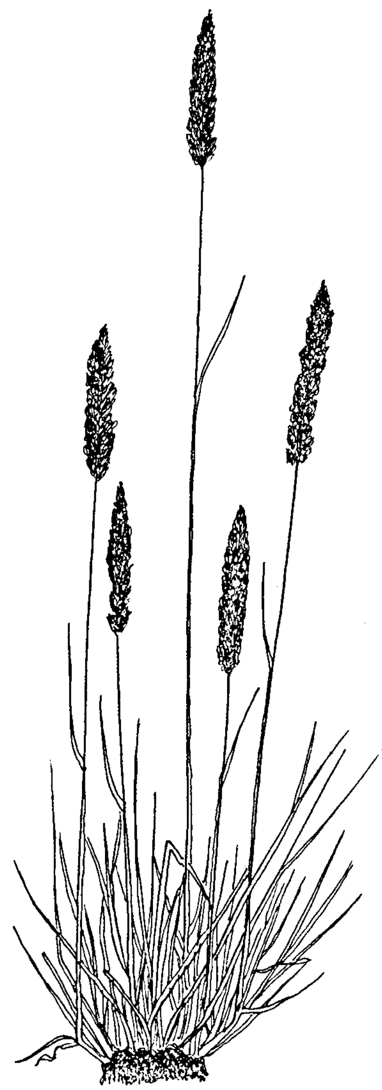


fig 72. Crested hair-grass
© Bruce Walker.

degrees to the horizontal, with the highest point in the most favoured direction of play and the lowest face back towards the tee from which the golfers have played.

The turf takes a considerable amount of punishment both from golfers playing into the bunker and from those trying to play back onto the fairway or green.

Bunkers with high faces open to the south or south-west are also affected by the drying effects of the sun, and these faces have only half the life span of those in an equivalent bunker where the high face is to the north.

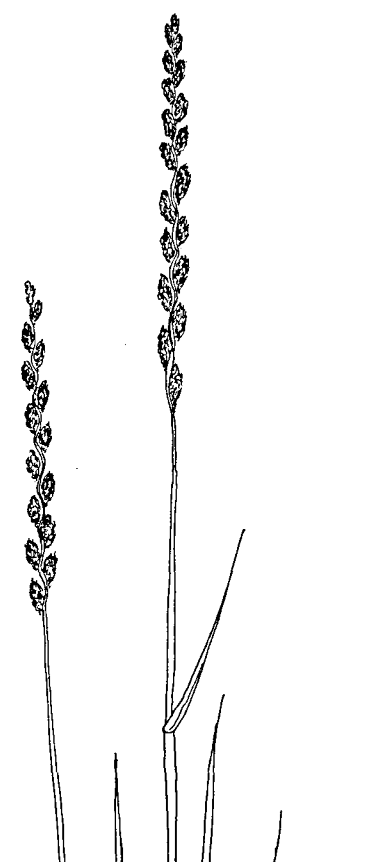


fig 73. Rye grass © Bruce Walker.

A heavily-played bunker, where the bunker wall faces south, will last for two or three years before replacement, whilst those where the wall faces north will last four to six years. Bunker faces in less strategic positions will last much longer.

The bunkers, are known as bare-faced or black-faced bunkers, but in agricultural terms the bunker faces are termed 'half-dykes' since they have only one visible revetment and a gentle slope on the other side.

10.04.4 Sourcing materials

Obviously the last thing a greenkeeper wants is to lose turf from the actual golf course. A nursery close to Barry Station is used to grow turf for the bunker faces. This turf is grown on a clay or strong loam. The soil is sown with a bent-fescue mixture of grass seed comprising:

* brown-top bent (fig 69) - agrostis canina

* strong creeping red fescue (fig 70)

* slender creeping red fescue - festuca rubra

* hard fescue (fig 71)

* crested hair-grass (fig 72) - koeleria cristata

This ensures a good tight-knit root system that will hold the turves together. The above mix is then oversewn with a dwarf rye-grass, lolium perenne, mercy (fig 73) to provide leaf growth which improves the appearance of the face of the bunker whilst giving some protection from the effects of the sun.

A modern innovation to prolong the life of south facing bunkers is being tried. This comprises a series of plastic pipes fitted with retractable 'mist' sprinklers. These work on the principle that when the water is turned on the pressure causes the ends of the sprinklers to extend about 150mm from the bunker face before discharging the water in the form of a fine spray. The nozzle retracts automatically when the water is turned off. Spraying normally takes place at night and is controlled by a computer program.

10.04.5 Construction

The greenkeepers use a mechanised turf stripper to remove a 50mm (two inch) thick turf which is 300mm (one foot) wide. The continuous strip is chopped into 600mm (two foot) lengths before being transported to the bunker. The turves are quite tough at this stage and can stand reasonably rough treatment.

When reconstructing a bunker face (fig 68) the sand in front of the wall is removed to a depth of between 225 and 300mm (nine to twelve inches). The base turf is then laid using full sized turves, that is, 300mm (one foot) wide, 600mm (two feet) long, and 50mm (two inches) deep. These are placed to the desired line of the wall far enough out from the bunker top to allow the wall face to rise at an angle of sixty degrees. The wall face is then built using half-width turves built in common bond. Each turf is set back two finger widths from the face of the turf below. As each layer of turf is laid the sand is replaced and compacted behind the turf to ensure that the wall face holds its correct line and does not sink or slump. If the wall is particularly high a full-sized turf is inserted half way up the face to help tie the face back into the sand. When the courses of turf reach the sides of the bunker the end turves are tapered from 55mm (2 inches) thick to zero, to create a more natural line to the curved top of the bunker and blend the edge of the bunker wall into the adjoining semi-rough or fairway. The turf forming the head of the bunker is peeled back at the outset to allow the old wall to be removed and the new wall constructed. The turf is folded back into its original position on the completion of the turf face. Any damaged turf round the rim of the bunker is replaced with turf taken from the practice area. This is a turf similar in composition to the rest of the links and not a clay turf as used for the bunker face.

Twenty of the most heavily-played bunkers with their turf walls facing south or south-west have been fitted with misting sprinklers as described in section 10.04.4. This is intended to help prevent damage due to the turf becoming too dry.

Two men can replace the turf wall in a small bunker in one day. The average height at the centre of the turf bunker face is 1200-1500mm (four to five feet) above the sand level.

10.04.6 Expected life-span

A well constructed but heavily used bunker face is expected to last two to three years on a south or south-west facing surface and from four to six years on a north facing surface. Less heavily used bunkers last considerably longer. As yet no figures are available for bunkers fitted with mist-spray systems.

It must be remembered that sand is a poor backing for turf since it dries out very quickly, and once the vegetation has been killed there is a danger that the vegetable fibre will decompose.

10.04.7 Observations

This is one of the few sites in Scotland where the turf building tradition has continued unbroken since the period when turf was a generally accepted building material.

The use of specially selected species of grass grown in a clay soil or heavy loam is indicative of the type of approach that should be adopted for any major turf building project, whether it be sourced naturally or prepared specially.

The Carnoustie Golf Links Greenkeepers are to be congratulated on continuing this tradition so effectively.

11. CONCLUSIONS

Turf, like 'thatch', has for all too long been considered as a single material when in fact it is a generic term for a whole range of building materials each with its own distinct characteristics and properties.

For successful conservation of turf structures, these properties will have to be recognised and, in some cases, re-discovered. Similarly, the principles behind various forms of turf construction will have to be re-established. This is not a simple task, since each new turf type will have its own strengths and weaknesses and therefore its own problems. The study must now be expanded through archive searches, archaeological excavation, literary references, scientific investigation, survey work and experimentation, to allow conservation works to be carried out without fear of destroying that which they are intended to protect.

It is no longer sufficient to work on the principle of 'like for like' in purely visual terms, since turf that has been incorporated in a structure for many years is likely to look and behave quite differently from the same turf in a freshly cut state.

The authors have been cautious in their approach but on occasion have been forced to act before the problem has been fully understood. So far they have been lucky but each new 'discovery' only serves to highlight just how lucky they have been.

Many of the nineteenth and twentieth century writers have indicated that individual estates had areas where turf was cut for building purposes, and hinted, that this was an attempt by proprietors to limit damage to the estates' wider pasturage all over the estate. The authors are now convinced that an investigation of these turf cutting areas will reveal that their soil is a heavy loam or clay soil, and that the vegetation traditionally associated with each area is of a species that produces particularly tight-knit root systems.

This document represents one step forward towards a better understanding of this ubiquitous but enigmatic material. It is hoped that it will act as a stimulus to further research and experimentation across a wide range of disciplines, and may perhaps also encourage some interdisciplinary research aimed at specific problem areas. This document should not be seen as a panacea but rather as an aide-mémoir.

12. GLOSSARY

BATTERED
Inclined towards the wallhead.

BEAM FILLING
Nogging between rafters or ceiling joists at their support used to stiffen the timbers and close the eaves.

CLOD
A lump of earth or more correctly an irregular lump of turf.

COUPLES - Cupples
The early use of this expression in Scotland refers to any pair of inclined rafters or crucks supporting part of the roof of a house or other building. More recent usage limits the term to the common rafters.

CRUCK
Pairs of large curved timbers used as the principal framing of a house or other structure. They combine the functions of rafters and wallposts. In many parts of Scotland crucks are made up of smaller timbers jointed and pegged to provide a continuous support as described above.

DIVET - Diffat, Devit, Divot
A thin flat turf, generally of an oblong form: used for covering cottages, and also for fuel.

DYKE
A low wall, especially of turf.

EARTH-CUPPLE
A turf gable used as a support for the roof purlins.

FALE - Fail, Feal
Any grassy part of the surface of the ground, as united to the rest.
A turf, a flat clod covered with grass, cut off from the rest of the sward.

FEALLY - DAEK
A Shetland name for a dyke built of turf.

FEALLY - SUNK
A seat or bench in the form of a low turf wall.

FLAA - Flaas
A thin turf or more correctly a form of water propagated vegetable mat comprising sphagnum moss interlaced with the root systems of plants that have propagated on its surface until it forms a thick homogeneous mat.

FLAUGHTER
To pare turf from the ground.

FLAUGHTER-SPADE
A two-handed spade with a broad heart-shaped blade used for cutting surface turf.

HALF DYKE
A dyke or wall with a single vertical face.

LOAM
A paste of clay and water, composed of moistened clay and sand with chopped straw or similar used in making sundried bricks, plastering and so on. A fertile soil of clay and sand with an admixture of vegetable matter.

MOSS
A morass or bog. An alternative name for peat.

MOSS-HOUSE
A house, or the walls of a house, excavated from the living peat-bog.

PEAT
Vegetable matter partly decomposed in water and partly carbonised, used for fuel.

PONE
A thin oval strip of green turf measuring about 380 x 380 x 25mm (15 x 15 x 1 inches). Used in Shetland in the roofing of houses or peat stacks. Swards of earth cut very fine, upon the surface of which grows a short grass. Used for the sole purpose of roofing.

SCRAW
A thin turf or sod, generally used for roofing.

SCRAW-BUILT
Built with sods or turf.

SKEW
Verge.

SLAPPING
An opening formed in a wall.

SNAGGING
Making good defects at the end of a contract.

SOD
A species of earthen fuel, used for the back of a fire on an open hearth.

In Ireland, a building material comprising blocks of green turf.

SODDIE
A seat of sods or turves in a cot house.

A turf-walled shack in the USA.

SPAUD
Spade.

STAKE and RICE
Wattle work.

SWARD
An expanse of ground covered with short grass, lawn-like ground, turf.

TIMBER-LACING
Timber boards built into a wall in the form of reinforcement or to spread the load of floor joists.

WATTLE
Poles intertwined with twigs, reeds or branches used in the construction of walls, hurdles and fences.

YARPHA
A name for immature peat used in Caithness and Orkney.

13. BIBLIOGRAPHY

ÁGÚSTSSON, Hörður: 1969: Det Islandske Törvhus *Byggmastaren II.* 23-29.

ÁGÚSTSSON, Hörður: 1998: Íslensk Byggingararfleifð I: *Ágrip af húsagerðarsögu 1750-1940* Húsafriðunarnefnd rikisins 57 and 437-440 (English summary).

AITCHINSON, K R : 1994: *Culloden Dykes: Documentary Research* (NTS: unpublished report).

CARTER S, HOLDEN T and McMULLEN A: 1997: *Detailed Analysis of Samples from a Turf Gable from Corse Croft, Huntly, Aberdeenshire (CSC 96)* Headland Archaeology, EDINBURGH.

DICKSON, R W: 1805: *Practical Agriculture, or a Complete System of Modern Husbandry with the Methods of Planting and the Management of Livestock,* LONDON.

EVANS, E Estyn: 1969: Sod and Turf Houses in Ireland in JENKINS Geraint (ed) *Studies in Folk Life: Essays in honour of Iorwerth Peate,* LONDON 79-90.

FARRINGTON, Joseph: 1792: British Museum Print Room - *Farrington Albums* Turf House, Carse of Stirling.

FENTON, Alexander: 1968: Alternating Stone and Turf: an obsolete building practice *Folk Life 6.* 94-103.

FENTON, Alexander and Walker, Bruce: 1981: *The Rural Architecture of Scotland,* EDINBURGH.

FRERE, S S and WILKES J J: 1989: Strageath: Excavations within the Roman Fort 1973-86 Britannia Monograph Series No 9. LONDON.

GREIFF, Constance M: 1972: *Lost America from the Mississippi to the Pacific* Pyne Press, USA 89.

HOLDEN, Timothy G, with contributions by WALKER, Bruce, CARTER, Stephen P, DALLAND, Magnar and McMULLEN, J Andrew : 1998: Technical Advice Note 13 *The Archaeology of Scottish Thatch* TCRE, Historic Scotland, EDINBURGH.

HUBBARD, C.E.: n.d.: *Grasses: A Guide to their Structure, Identification, Uses and Distribution in the British Isles* Penguin. LONDON.

HUTCHESON, Alexander: 1914: The Archaeology of Tentsmuir *Proceedings and Transactions of the Dundee Naturalist Society 1.1 1912-13* DUNDEE.

INGSTAD, Anne Stine: 1974: *The Discovery of a Norse Settlement in America* OSLO, BERGEN and TROMSØ.

INNOCENT, C F: 1916 and 1971: *The Development of English Building Construction* University Press, CAMBRIDGE and David and Charles, NEWTON ABBOT, 107-161.

MACKENZIE, G S: 1809: *Treatise on the Diseases and Management of Sheep* INVERNESS.

MACLEAN, Archibald J: 1883: 'The Best Modes of Preserving Ice' in HERBERT, (ed) *Fish and Fisheries* EDINBURGH 275-277.

MEGAW, Basil R S: 1962: 'The Moss-Houses of Kincardine, Perthshire' *Scottish Studies 6.* 87-93.

MILNER, M P: 1993: *Vegetius: Epitomy of Military Science* University Press, LIVERPOOL.

MYLES, Ray and WALKER, Bruce : 1999: Case Study No 1 *Cottown: A Scottish Mudwall Structure* TCRE, Historic Scotland, EDINBURGH.

NILSSON, Albert: 1943: 'Den sentida bebyggelsen på Islands landsbygd' *Forntida Gårdar I Island: Nordiska arkeologiska undersökningen i Island 1939* fig 175 pp293.

NOBLE, R Ross: 1984: 'Turf-Walled Houses of the Central Highlands: An Experiment in Reconstruction' *Folk Life 22* 68-83.

ÓDANACHAIR, C: 1975: *Ireland's Vernacular Architecture* CORK.

ÓDANACHAIR, C: 1945: 'Primitive Structures used as Dwellings' *Journal of the Royal Society of Antiquaries of Ireland* LXXV. 204-212.

ÓLAFSSON, Guðmunder: 1982: *Torfbærinn frá Eldaskála til Burstabæjar* Exhibition Catalogue, National Museum of Iceland. 22-25.

PENNANT, Thomas: 1979: *A Tour in Scotland MDCCLXIX* (1769) 3rd edition facsimile PERTH.

PENNANT, Thomas: 1998: *A Tour in Scotland and Voyage to the Hebrides 1772* EDINBURGH.

RAMSAY, Jim: 1999: *Notes on the Construction of the Culloden Turf Dykes* (NTS unpublished report).

SACHER, Edwin: 1930: *Die aus Grassoden und Holz gebauten Höfe und Kirchen in Island* Konrad Triltsch Verlag, WÜRZBURG, Tafel II.

SIMPSON, F Gerald and RICHMOND L.A.: 1936: The Turf Wall of Hadrian, 1895-1935. 1-18.

WALKER, Bruce : 1979: *Farm Buildings in the Grampian Region: An Historical Exploration* Countryside Commission for Scotland: Grampian Regional Council, ABERDEEN.

WALKER, Bruce and McGREGOR, Christopher in association with LITTLE, Rebecca : 1996: Technical Advice Note 6 *Earth Structures and Construction in Scotland : A Guide to the Recognition and Conservation of Earth Technology in Scottish Buildings* TCRE, Historic Scotland, EDINBURGH.

WALKER, Bruce, McGREGOR, Christopher and STARK, Gregor: 1996: Technical Advice Note 4 *Thatch and Thatching Techniques: A Guide to Conserving Scottish Thatching Traditions* Historic Scotland, EDINBURGH.

WALKER, Bruce and McGREGOR, Christopher: 1996: Technical Advice Note 5 *The Hebridean Blackhouse: A Guide to Materials, Construction and Maintenance* Historic Scotland, EDINBURGH.

WELSCH, Roger: 1968: 'The Nebraska Soddy' Nebraska History XLVIII. 4.

WELSCH, Roger: 1968: *Sod Walls: The Story of the Nebraska Sod House* Purcell, BROKEN BOW, Nebraska.

WELSCH, Roger: 1969: 'Sod Construction on the Plains' *Pioneer America* 1-2.

WELSCH, Roger: 1976: 'The Meaning of Folk Architecture: The Sod-House Example' *Keystone Folklore* XXI.2.

WELSCH, Roger: 1977: 'Shelters on the Plains' *Natural History* (May) 48-53.

WILSON, The Rev John Marius : n.d.: *The Imperial Gazetteer of Scotland or Dictionary of Scottish Topography* .....2 vols. Fullarton LONDON and EDINBURGH.

'Y' : 1833: 'On Improvement of the Habitations of the Poor in Ireland' *Dublin Penny Journal* 1:40 (30 March 1833). 316-317.

14. APPENDIX

Detailed analysis of samples from a turf gable from Corse Croft, Huntly, Aberdeenshire (CSC 96)
by S Carter, T Holden and A McMullan.

BACKGROUND

Corse Croft consists of a stone built house and a number of outbuildings located 6km (four miles) to the north-east of Huntly. Aberdeenshire (Grid ref. NJ 5577 4422). During renovation of one of the outbuildings a turf gable wall was repaired by Rebecca Little.

Oral tradition, and the presence of a gable-end fireplace, indicate that the outbuilding was originally used as a dwelling although it has, for a number of years, been used for storage as a lambing shed. Early maps such as Robertson (1822) were consulted but even though a farmstead was indicated in the general area of the croft it was not possible to identify individual buildings. The First Edition Ordnance Survey Map (1.10560) of 1874 shows there to be buildings on the site of the main house, the building under investigation and a second building, now used as a storage shed, on the southern side of the present garden. These buildings are therefore at least one hundred and twenty years old.

During renovation of the gable wall by Rebecca Little a number of turves which needed to be replaced were removed and retained. There were passed to Headland Archaeology for further study. Analysis was undertaken to determine the source of the turves and to provide information about the nature of the localities from which they were cut. Additional observations were also made on the size and shape of the turves with a view to determining the tools and techniques used to cut them.

METHODS

Each turf was cleaned to expose fresh surfaces and its original orientation with respect to the ground surface was determined. This was only possible where either vegetation or clear soil horizons survived. Orientated turfs were measured and their component soil horizons were described. Samples of the surviving vegetation were taken and, as far as possible, species were identified.

The turves were classified into different types on the basis of their pedological characteristics and one example of each type was selected for thin sectioning. Soil thin sections were produced using standard techniques (Murphy 1986) and described using the methods and terminology of Bollock et al (1985).

Table 1 - Source of turf samples

Turf label	Sample Location	Comments
A	W-facing gable	grey/brown turf from gable wall
B	W-facing gable	grey/brown turf from gable wall
C	W-facing gable	peaty turf from gable wall
D	W-facing gable	peaty turf from gable wall
E	W-facing gable	grey/brown turf from gable wall
F	W-facing gable	yellow/brown turf from gable wall

Soils and sedimentology

Pedological classification of turves

Six individual turves, or fragments of turves, contained sufficient diagnostic features to allow classification. Three pedological types of turf were identified.

Type 1 (Turves A, B and E)

The upper horizons of a peaty/humic gley intergrade soil. It comprises grassy vegetation over a dark grey brown humic/peaty A horizon, 7-9 cm deep. This overlies up to 15 cm of grey sandy Bg horizon.

Type 2 (Turf F)

A sub-surface horizon of a gleyed soil profile. It comprises up to 9 cm of yellow brown sandy BG horizon. In the absence of vegetation or horizon boundaries the orientation of this block is not known. The turf has a 1-2 cm thick layer on one surface, rich in organic components (roots and stems), but this does not appear to be a natural soil horizon.

Type 3 (Turves C and D)

The upper horizons of a peaty gley or podzol. It comprises heathy vegetation over a thin organic litter layer, 1-2 cm deep. This overlies a shallow

(1-2 cm) dark grey brown Ah horizon which grades into a sandy mineral Ea or Eag horizon at least 6 cm deep.

Thin section analysis of turves

Three turves were selected for analysis:

Type 1: Turf A (2 thin sections)

Type 2: Turf F (1 thin section)

Type 3: Turf D (1 thin section)

Analysis was focused on the mineral components of the soil which offered the best prospects for the identification of the source of the turves. The results are summarised in Table 2.

The nature of the organic inclusions primarily confirm the pedological classification of the turves and therefore have not been studied in detail. The organo-mineral layer on the Type 2 turves was examined because of its apparent non-pedogenic origin. This layer, 2 cm thick, comprises well-sorted fine sand and silt (identical to the remainder of the turf) with frequent stems of moss and monocotyledonous plants (grasses, sedges and rushes). The presence of frequent stems, which are above-ground elements of plants, mixed with a subsoil sediment demonstrates that this layer is an artificial mixture. Its possible origin is discussed below.

Size and shape of turves

It should be noted that Rebecca Little's record of the size and shape of the well preserved parts of the gable provide a more detailed record than the information presented here from a few rather eroded turves. However, sufficient variation exists to make these present observations valuable. The turves from Sample 1 can be classified into three types:

a) *Regular parallelograms* (Turves A, B and E) which, in the best preserved examples are blocks 16-18 cm wide, 8-12 cm thick and up to 22 cm deep. All three examples are from the peaty/humic gley (Type 1) soil and the grassy vegetation covers one end of the block.

b) *A rounded square turf* (Turf C), 17 x 17 cm. It is up to 5 cm thick in the centre but tapers towards the edges to only 1-3 cm thick.

c) *More or less regular cubic blocks of turf* (Turves D and F) with dimensions of 8-12cm.

Discussion of the Sediments

Sources of the turves

The three pedologically distinct turf types appear to derive from only two different sediment types.

Turf Types 1 and 2 have similar lithologies, dominated by strained metamorphic quartz with less frequent feldspars and mica. They are also both well-sorted sediments although Type 2 has a finer texture than Type 1. This high degree of sorting, combined with the evidence for sedimentary banding in Type 1, points strongly to an alluvial source for these turves. The absence of a banded fabric in Type 2 may only be the result of the orientation of the thin section. It was not possible to identify the original orientation of the turf so it may not have been cut in the true vertical plane. Sedimentary banding will only be apparent if the section was cut in this plane. The difference between Types 1 and 2 is primarily one of depth within the profile. Type 1 represents surface turves whilst Type 2 is entirely sub-surface soil. This suggests that the turves could have been cut in two spits from the same pit.

Table 2 Analysis of mineral components in the three types of turf from the gable wall

Turf type	Lithology	Texture	Fabric
1	Dominant metamorphic quartz with frequent feldspar and few mica	Well sorted sand with some silt and clay in discrete patches. Stoneless	Slight banding of coarse sand. Preferred horizontal orientation in mica
2	Dominant metamorphic quartz with frequent feldspar and few mica	Well sorted silty fine sand with some clay. Stoneless	Random
3	Common metamorphic quartz with frequent acidic metamorphic rock fragments, frequent feldspar and few mica	Poorly sorted silty sand with frequent small stones	Random

The most likely source for sandy alluvial sediments derived from acid metamorphic rocks is the current flood plain or higher terraces of the River Deveron and its tributaries. The Geological Survey of Scotland (Drift Map Sheet 86) map shows fluvio-glacial sand and gravel in the area immediately around Corse Croft but this may be generally too coarse textured and well drained to match Types 1 and 2. Less than 1 km to the south-east there is an extensive area of contemporary lacustrine sediments forming the Corse of Kinnoir. The Soil Survey of Scotland (Glentworth 1954) report poorly drained mixed clays and sands, and bedded fine sands. A peaty/humic gley soil like Types 1 and 2 is widespread in this flat, poorly drained area.

The Type 3 turves are not dissimilar to Types 1 and 2 in terms of lithology with a mix of quartz, feldspar and mica indicating a dominant acidic metamorphic source. This is confirmed by the frequent small rock fragments. The poorly sorted coarse texture of the sediment probably indicates that glacial till is the parent material for this soil. Sediments of this type occur on the lower hill slopes, only a few hundred metres to the north and east of Corse Croft (Soil Map Sheet 86).

The selection, cutting and use of the turves

Uniform-sized blocks of soil Types 1 and 2 form the bulk of the gable wall (Rebecca Little, pers. comm. and photographs). They are intermixed in the wall and appear to have been cut and used in a single build. This reinforces the impression that they were cut in spits from the same soil profile. The well-sorted, stone-free fabric of this alluvial soil provides an ideal uniform material for the cutting of a large number of regular building blocks. Clay textured sediments from the same Corse of Kinnoir lacustrine deposits were exposed for a brick and tile works at Kinnoir in the last century.

It was concluded above that the thin layer of organo-mineral sediment on the edge of the two Type 2 turves was not a natural soil layer. This suggests that it relates to the use of the turves in the wall. Possible explanations for its deliberate presence include its use as a mortar or as a repair, filling a crack in the wall. It could also have formed as a result of plants growing from weathering cracks in the wall. This latter explanation is favoured because the similarity of the mineral components suggests that the thin layer was derived by erosion from the turf. In addition, living mosses were identified on the wall (see below).

Analysis of the shape and size of the better preserved turves of Type 1 shows that they were cut as regular parallelograms. This is seen much more clearly in the well preserved examples examined by Rebecca Little. The orientation of these blocks in the ground demonstrates that they were cut as vertical slices. Dimensions of complete examples are roughly 30 cm wide, 10 cm thick and 20 cm deep. The tool used to cut them was probably a flat-bladed spade held at a steep angle, only 20-30° off vertical.

Information on the size and shape of turves cut from the Type 3 soil does not allow such a clear interpretation. Of the two substantial fragments analysed, one (Turf C) is clearly a *thin fail*, cut with a curving-bladed flaughter roughly 20 cm wide. The other (Turf D) is a blocky fragment, 10 x 10 x 12 cm. Turf D could be a wall block but the fact that it is derived from a different location means that it is likely to represent a repair to the original Type 1/2 wall. It seems unlikely that a thin fail like Turf C was used in the main gable wall, but unfortunately its location in the wall is not known. Turf C may have been used in a repair to the wall or, more speculatively, may have been part of a turf layer under a thatch which overlapped the wall head. The surviving cereal thatch lacked a turf under-layer but this could be a survivor from an earlier roof.

Botanical analysis

The preservation of the specimens was very good with whole plants surviving in some instances. Nomenclature follows Smith (1981) and Clapham *et al* (1962).

Turf A

The majority of the vegetation had been stripped from the surface leaving mainly underground parts and occasional moss fragments. The rhizome fragments would appear to belong to sedge/grass/rush. The only moss recovered was *Rhytidiadelphus squarrosus*. This is a widely-distributed moss with a broad ecological amplitude (open woodland, heath and/or grassland, for example).

Turf B

This turf retained areas of mat-grass *(Nardus stricta)* together with other fragmentary monocotyledons (grass/sedge/rush) indicating that it was taken from an area of rough acid grassland. Occasional woody roots were also encountered and could belong to nearby trees or shrubs. The moss flora includes *Hylocomium splendens* and *Rhytidiadelphus squarrosus*. These are widespread, ecologically diverse, species.

Turf C

The higher plants are represented by heath rush

(*Juncus squarrosus*) and occasional young heather (*Calluna vulgaris*) indicating that they were taken from damp heath. The moss flora includes:

Ceratodon purpureus (chlorophyllous)

Diplophyllum albicans

Hylocomium splendens

Cf Phascum sp. (chlorophyllous)

Pleurozium schreberi

Polytrichum commune

The majority of the moss species are indicative of a heath type environment, grassland, ericaceous heath or open woodland, on acid soils. The presence of *Diplophyllum albicans* and *Polytrichum commune* would respectively indicate the presence of sheltered and moist to marshy conditions. None of the species present is of a ruderal nature (ie. of disturbed ground). Evidence from areas subjected to fire clearance indicated that re-colonisation following disturbance may take up to 4 years (Southorn, 1976). It would therefore seem unlikely that the land had been recently cultivated at the time when the turves were cut.

The presence of the two ruderals *Ceratodon purpureus* and cf. *Phascum* sp. was unusual as both were in a fresh, chlorophyllous state (ie. still green) and could be seen to recover net-photosynthetic productivity on rewetting. These taxa must have been growing on the wall at the time of sampling.

Turf D

The short cropped vegetation on this sample included small quantities of heather (*Calluna vulgaris*) and tormentil (*Potentilla erecta*) indicating that the turf derives from an acid soil. The mosses include *Hylocomium splendens*, *Hypnum cupressiforme* s.l., *Pleurozium schreberi* and *Polytrichum commune*. Another heathland-type flora is represented by this sample. The presence of *Polytrichum commune* indicates moist to marshy conditions.

Turf E

The vegetation was poorly preserved and consisted of degraded grass/sedge/rush remains. A large number of stem fragments of the moss species, *Rhytidiadelphus squarrosus*, were recovered. This commonly grows in large mats reaching maximum abundance on ground which is frequently mown or grazed (Watts 1981). The purity of the sample could indicate a mown/grazed grassland as opposed to an unmanaged heath.

Turf F

Poorly preserved vegetation consisting primarily of indeterminate underground organs.

Discussion of the botanical evidence

All the species identified are common components of acid soils but two distinct patterns were observed. The first, as seen in Turves A, B and R, indicates that the turves were cut from an area of grassland with a limited moss flora. The second group, as seen in Turves C and D, were cut from an area of ericaceous heathland and a more varied moss flora is suggested.

With the exception of the chlorophyllous *Ceratodon purpureus* and cf. *Phascum* sp., which were most likely growing recently on the 'disturbed' turves, none of the species is able to rapidly colonise disturbed ground. It is therefore assumed that the turves came from relatively stable habitats, the high occurrence of *Rhytidiadelphus squarrosus* in Turf E perhaps suggesting local grazing. The presence of *Diplophyllum albicans* (Turf C) points to a depth of vegetation conferring the sheltered, moist habitat requirement of this species, indicating therefore an absence of intense grazing or frequent removal of turves (ie. $\geq$ decadal time span). The ecology of the remaining species also supports this but the procumbent growth form of the weft-forming species (*Hylocomium spendens*, *Hynum cupressiforme* sl., *Pleurozium schreberi* and *Rhytidiadelphus squarrosus*) could allow their rapid colonisation of isolated areas of stripped turf.

Polytrichum commune suggests that Turves C and D at least were derived from damp to marshy areas. The absence of its common associate Sphagnum spp. indicates that the turves were not cut from 'boggy' areas, where the bulk of the surface would constitute the active growth and decomposing stems of those species.

SUMMARY

It is clear from the above analysis that the turves from the gable wall do not all derive from a single source. The evidence is summarised in Table 3.

Two main sources of turves can be recognised. The first group represented here by Turves A, B and E consists of dark grey peaty turves cut as regular parallelograms, and makes up a substantial part of the gable wall (the darker turves on Plates 1 & 2). They were taken from an area of flood plain or higher river terraces, probably of the River Deveron and its tributaries. Material similar to that observed could be found less than a kilometre to the south-east of Corse Croft on the Corse of Kinnoir. Clay textured sediments from the same

Corse of Kinnoir lacustrine deposits were exploited for a brick and tile works at Kinnoir in the last century. The turves used at Corse Croft are therefore likely to have been specifically chosen for their building properties. The vegetation on the turves consisted of rough acid grassland. Stable plant communities are indicated with some evidence for local grazing. It would seem unlikely that the ground had been cultivated or previously stripped for turf within ten years of the cutting of turves for Corse Croft. Thick surface accumulations of organic material indicate an even longer time span. A high proportion of the turves from the gable were yellow/brown in colour, represented here by Turf F. These contrast sharply with the more peaty turves (Turves A, B and E - see Tables 1 & 2). They are, however, composed of similar parent material and are thought likely to have been taken from the same source but at a greater depth below the surface. Turf F may therefore have been cut from a second spit from the same alluvial sediments. A layer of organic-rich material adhering to this turf is thought to have derived from earth mortar or as a result of plants growing in cracks in the wall.

It is unclear exactly which part of the wall the second group of turves (Turves C and D) were recovered from, but they consist of a thin organic litter over a sandy sub-soil layer. These had been cut from an area of glacial till by two different methods. One method produced a more or less cubic turf and the other, which produced a much flatter turf, was probably cut with a curving-bladed flaughter. Sediments such as this occur on the lower hill slopes only a few hundred yards from Corse Croft. These turves do not form a large part of the standing wall and may represent running repairs to the original structure. The vegetation on these turves indicates that they were cut from much wetter ground than observed for Turves A, B and E, with more evidence for damp/marshy ericaceous heath. The moss flora from Turf C points to a relatively thick vegetation sufficient to provide a moist habitat for their growth. An absence of intense grazing, or frequent removal of turves, can be postulated.

Table 3 - Summary of results:

Turf	Pedology	Thin section	Shape	Moss	Other plants
A	a dark grey brown humic/peaty A horizon, overlying grey sandy Bg horizon	alluvium	regular parallelograms	grazed grassland	poor preservation
B	a dark grey brown humic/peaty A horizon, overlying grey sandy Bg horizon		regular parallelograms	grassland	rough acid grassland
C	thin organic litter layer over a shallow dark grey brown Ah horizon grading into sandy mineral Ea or Eag horizon	relatively thin rounded square (fail)		damp/marshy ericaceous heath	rush and heather heath
D	thin organic litter layer over a shallow dark grey brown Ah horizon grading into sandy mineral Ea or Eag horizon	glacial till	cubic block of turf	damp/marshy ericaceous heath	acid heath with heather
E	a dark grey brown humic/peaty A horizon, overlying grey sandy Bg horizon		regular parallelograms	grazed grassland	grass/sedge heath
F	yellow brown sandy Bg horizon	alluvium	cubic block of turf		poorly preserved

REFERENCES

Bullock P, Federoff N, Jongerius A, Stoops G & Tursina T, 1985, *Handbook for Soil Thin Section Description* Wolverhampton, Waine Research Publications.

Clapham A R, Tutin T G & Warburg E F, 1962, *Flora of the British Isles* Cambridge: University Press.

Dickson J H, 1973, *Bryophytes of the Pleistocene*, CUP.

Dixon H N, 1954 *The student's handbook of British mosses*, third edition. Sumfield and Ltd, Eastbourne.

Glentworth R, 1954 *The Soils of the County round Banff, Huntly and Turriff* Memoirs of the Soil Survey of Great Britain, Edinburgh: HMSO.

Murphy C P, 1986 *Thin Section Preparation of Soils and Sediments* Berkhamstead: A B Academic Publishers.

Ordnance Survey 1874 1:10560 First Edition surveyed 1871.

Robertson J, 1822, *Topographical and military maps of the counties of Aberdeen, Banff and Kincardine*.

Robertson T, Simpson J B & Anderson J G C, 1949 *The Limestones of Scotland* Special reports on the mineral resources of Great Britain Vol XXXV, Edinburgh: HMSO.

Seaward M R D & Williams D, 1976, An interpretation of mosses in recent archaeological excavations, *Journal of Archaeological Science 1*, 173-176.

Smith A J E, 1981 *The moss flora of Britain and Ireland* CUP.

Southorn A L D (1976) Bryophyte recolonisation of burnt ground with particular reference to *Funaria hygrometica*. I. Factors affecting the pattern of recolonisation, *Journal of Bryology*, 9, 63-80.

Watts A S, 1981, A comparison of grazed and ungrazed grassland in East Anglian Breckland, *Journal of Ecology*, 69, 499-508.