Cymdeithas Waliau Cerrig Sychion
Cangen Gogledd Cymru

Dry Stone Walling Association
North Wales Branch

Clawdd Construction

DSWA is registered as a charitable organisation (289678)

Written by Sean Adcock on behalf of North Wales Branch of Dry Stone Walling Association, April 2012.

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COVER PHOTO: Old field clawdd near Llangybi

PREFACE

This booklet is aimed primarily at those new to Clawdd construction. It is hoped that by explaining the techniques and processes involved, highlighting common problems and by describing best practice, it will also be of use to those commissioning and inspecting work. Whilst it is not possible to provide a specification covering every type of clawdd, this booklet does include a basic specification which it should be possible to adapt for a given job. Reference to the main body of the text should aid modification for a specific situation, although for any specific project it is always advisable to have expert local advice. The Dry Stone Walling Association of Great Britain (DSWA) should be able to suggest suitable contacts. For specific queries relating to the booklet please contact the author via DSWA.

Some sections of the text are based on an article by the author which first appeared in the North Wales Branch Magazine *"Stonechat"* (Issue 10, 1996) which also formed the basis for the clawdd construction section of the British Trust for Conservation Volunteer's *"Dry Stone Walling"*. (Revised edition, 1999). The author wishes to thank BTCV for giving permission to use its illustrations.

INTRODUCTION

Stone faced earth banks are found across Britain, usually on the fringes of areas rich in dry stone walls. They are most common in Devon and Cornwall, where they are known as Cornish hedges, and in Wales. In Wales they are found predominantly in the north west (notably on Ynys Môn (Anglesey) and the Llŷn peninsula) and in Pembrokeshire. The Welsh structures are known as cloddiau (plural, pronounced clo-th-ee-eye: clo as in clot and th as in them) with the singular being clawdd (Clow-th: as in clown and them), there is no widespread single term for these structures in the English Language. Strictly in Welsh, cloddiau can mean barriers in general and has also been used to describe embankments, ditches and dykes, most famously Offas Dyke – Clawdd Offa. To confuse matters further, clawdd is often used as general term for stone walls. In the context of dry stone walling it means one thing, and that is a stone structure with an earth core.

Fig.1. Garden clawdd, Penisarwaun, Gwynedd

Stone boundaries vary considerably from area to area and even within localities, depending on stone type and traditions. Cloddiau are no different in this respect. There is however one distinctive pattern which can be found throughout Wales, which along with variations on the theme, can be said to be the predominant type. This pattern involves most of the stones being set in more or less even courses with the individual stones set vertically on edge, or “book-ended” or "pitched" (set on end) rather than “flat-laid” as in a more traditional dry stone wall.

This vertically coursed/bookended pattern is found in other areas of Britain but only perhaps in parts of Cornwall (in particular the extreme north and south of the county) does it dominate the field boundaries as much as it does in North West Wales. The Cornish version is distinctive in that it is normally constructed with a concave cross-section to the face, whereas in Wales the cross-section is traditionally flat and concave faces are very rare.

Other much less common patterns include random vertical stone (mostly north Pembrokeshire and South Ceredigion), diagonally set coursing (such as around Blaenplwyf, Ceredigion), and herringbone (sporadic, but most common in the slate area of Pembrokeshire). Examples are shown on page 25.

Cloddiau are particularly valuable in terms of flora and fauna compared to most other forms of boundary. The earth core can be a haven for small mammals, reptiles, amphibians and invertebrates - more so than a dry stone wall. Insects can abound between the stones, and the stone/soil combination supports a diverse flora. They often have hedges on top, and sometimes an associated ditch. This range of habitats can create mini nature reserves within an otherwise barren landscape.

This booklet is a brief guide to the key aspects of construction, concentrating on the ‘bookended’ form. Other styles are similar to dry stone walling techniques and more information on the correct procedures for “flat-laying” can be found in good technical guides such as, *“Dry Stone Walling : A Practical Guide”* published by British Trust for Conservation Volunteers, *“Dry*

Stone Walling: Techniques and Traditions" published by DSWA and "*Stonework*" published by North Wales Branch DSWA (all available from DSWA). Aspects of flat-laying specific to clawdd construction, however, are included.

There is often a misconception as to the stability of the book-ended pattern and the nature of the coursing. As a result, an important regional style is often neglected. Where well built, the end result should be similar to the wall being built out of several layers of very tightly fitting coping. Employing the correct construction technique should produce stones which are effectively wedged together in a way that is far more difficult to achieve than with random work. This wedging introduces compressive strength into the wall, negating much of the in-built instability caused by the earth core and the insubstantial nature of much of the stone. In addition, stone which naturally does not bind as well as more regular shaped material and produces a "gappier" finish (e.g. irregular shaped or rounded), provides greater scope for vegetative growth within the face. This in turn binds the face making up for the reduced contact. Similarly, the coursing is a process which lends itself to the nature of the stone used. For most stone types, it allows for considerable variation in stone size within a course. It can be argued that as a technique it is much easier than coursing a dry stone wall and a skill that any competent stone worker should master relatively easily. Once mastered the whole process becomes relatively straightforward. Stone placement becomes much faster than for dry stone work, although correct wedging and core compaction outbalances this in terms of overall speed.

Technically the earth core of cloddiau makes them potentially unstable. Consequently considerable care needs to be taken with their construction, applying all the principles of dry stone work, coupled with careful compaction of the wall's core. Much of their strength is internal caused by the stability of the core and the internal contact and wedging of the face stones. It is however, very easy to produce a reasonably good looking clawdd which has very little internal strength.

CLAWDD CONSTRUCTION

DIMENSIONS/PROFILE

Cloddiau tend to be shorter and wider than dry stone walls. Traditionally occurring in areas with little stone, they are not used to "use-up" surplus stone from field clearance in the way dry stone walls were. In addition, there may be insufficient stone to build taller structures and whatever stone there is, is not usually suitable for dry stone wall construction. They also tend to be more widespread in the lower lying, flatter, coastal plain, areas where cattle farming used to predominate, and hence did not need to be as tall as walls needed to enclose sheep. Consequently they are rarely more than a metre high. If they need to exceed this height, especially if over 1.2m high, then more substantial stone (especially in terms of length into the clawdd), and more "batter" (slope of face), than is the norm should be considered.

Given that high cloddiau tend to be for stock-proofing against sheep any increased batter is likely to prove counterproductive in this respect. Here a concave face could prove beneficial as this would facilitate a much greater batter at the base aiding stability, whilst the relatively vertical slope higher up would add to stock-proofing. However, as noted earlier, this is rarely found in cloddiau in Wales. Commonly, the "modern day" solution to making cloddiau more sheep-proof is to erect a simple one or two strand "jump fence" with posts driven into the top of the clawdd and angled towards the field. This can of course dislodge stones and so is not necessarily recommended.

The tops of cloddiau are usually around a metre wide. They often have a hedge on top requiring a wider top than a standard wall. It is also likely that historically, a wider top facilitated

the piling of additional material for stock-proofing. Deadwood, gorse, or even additional turf, could be piled on to keep livestock out of a field turned over to crops for example.

The top width should always exceed 60cm and generally it is not advisable to reduce it much below 75cm, even if there is not to be an associated hedge. The narrower the top (and the longer the top stones into the clawdd) the harder it becomes to establish a stable vegetative cap.

An important consideration is the line (how straight/even the face is along its length) and "batter" (how even the face is as it narrows from bottom to top). Essentially, line is along and batter is up. Paying attention to these is not merely meant to make the clawdd look good, but will add to the wall's durability since the truncated 'A' (trapezoid) shape adds to a clawdd's structural stability; the more vertical a face the more likely the wall is to topple during settlement. Bulges in the face mean that it will take less for the wall to fall down, as some of the stones are already effectively part way out of the wall. Irregularities in the line and batter also dramatically increase the likelihood of stock, particularly some breeds of sheep, being able to get over the wall. Dips or depressions in the face mean that the upper part of the depression is too vertical, or that some stones are overhanging those below.

As with dry stone walls, cloddiau are battered, that is they slope in from the base narrowing towards the top. They tend to be battered more than dry stone walls. This facilitates the use of smaller stone and stone less suited to a dry stone construction (especially more rounded and relatively insubstantial stone) and compensates for the potential instability of an earth core. Batter is described by a ratio, such as one in five - written as 1:5, which means for every 50mm in height the clawdd batters in 10mm on each side. Most cloddiau will be battered at least 1:6 and typically in the region of 1:4 to 1:5. Where the majority of stones have a length into the wall of three times their face height the batter can be decreased to 1:8. Cloddiau over a metre high should not be battered less than 1:5.

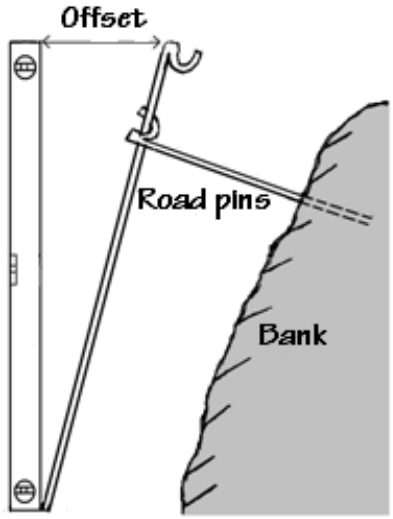

Fig.2. Setting batter on road pins used to determine profile

Profile frames can be constructed for cloddiau as for dry stone walls, however because they need to be much wider the use of profile bars is more common place. The use of frames is well covered in publications such as, The British Trust for Conservation Volunteers (BTCV) *"Dry Stone Walling: A Practical Guide"* (Available from BTCV (www.btcv.org.uk) and DSWA (www.dswa.org.uk).

To set a profile bar to the correct angle, a 1.2m spirit level is set vertically against the point where the pin enters the ground. The bar should be offset (24cm for 1:5, and 30 cm for 1:4) at the top of the level. If shorter bars are being used then mark 1m on the level and offset by 20cm for 1:5, and 25cm for 1:4.

Hooked "road pins" (sometimes called "fencing pins"), are widely available and can be useful as clawdd profiles. They are typically around 1.3m long and so can be driven in around 25cm (allowing for the hook to be above final level) for a typical clawdd. Sometimes they are not quite firm enough

this far in the ground. On repairs/rebuilds a second one can be driven into the clawdd and the pin used for the profile set into the hook (as shown in Fig.2). The bar into the bank can be driven in until the correct batter is achieved. To add stability, the two bars are easily tied together (cable ties are good for this). If longer bars are required, 16mm steel rods can be purchased to order from a local steel merchant.

Spirit levels with adjustable vials which can be set to a required angle can be used to set the profiles. It is best to set the first bar as outlined above and then set the vial to this angle. Unless using a high precision level (digital or similar), adjusting the vial to the exact angle can be problematic. Most adjustable levels work in increments of 5 degrees, although adjusting them that accurately in practice can be problematic. For reference, a batter of 1:5 is 11.3°, 1:4 is 14°, 10° is close to 1:6 (9.5°); 15° is not far off 1:4. For most practical purposes something between 10 and 15 degrees would probably suffice. Most importantly the angle should be consistent within any single build.

PREPARATION

As a lot of excavation can be involved in the repair or rebuilding of a clawdd, mechanical diggers are often used in the process. If they are employed, considerable care needs to be taken to avoid mixing stone and soil. In addition a poor wall often results if the stone is not sorted, since oversized stone gets missed, there tends to be less suitable stone readily available for each course, and height selection for each course becomes more problematic.

When repairing/rebuilding an existing clawdd it is advisable to either set out the stone in lines or piles of similarly sized stone, and to separate out stone less suited to the coursing process. In Fig.3 there is a clear delineation between stone and soil, stone has been roughly sorted into piles of “large”, “medium”, and “small” (out of shot), - although this is relative - plus misshapen and oversized (nearest bank). There is some grading of size from largest (nearer bank) to smallest within the piles. As the stone size in many cloddiau does not vary significantly, the grading can seem fairly arbitrary at times. However the piles can be “dismantled” as you assemble each course and as long as larger stone is not buried you will be ‘cherry picking’ similar sizes from the piles for each course. In practice you will need a variety of similarly sized stone rather than stone all the same size for each course. If the piles are reasonably graded (sorted by size) - say large, medium, small; then as you progress any stone left from a pile will either have been too tall – just move it along to the next section; or too short – use it on the next course. Don’t forget to save all turf for capping/re-capping. Any turf stripped in forming the foundation trench for a new clawdd should be saved for this.

Fig.3. Stone and soil separated into well delineated piles

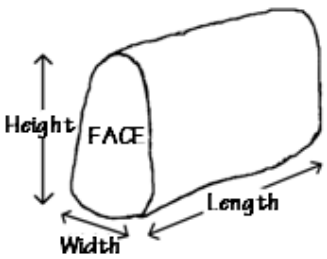

Fig.4. Typical clawdd stone

Almost any stone is suitable for clawdd construction, however larger "slabbier" stone, and more angular stone is more problematic and often requires a greater dry-stone element or pattern not dealt within this booklet. For book-ended coursed cloddiau the ideal stone is around 2-3 times as long as it is tall (Fig.4). Any stone that is at least as tall as it is long is suitable; although a clawdd should not be constructed mostly of stone which is only just longer than it is tall. The less regular the stone the longer it needs to be. Essentially, the flatter the face the better, but as noted, you can accommodate less ideal faces if you have longer stone which will sit securely within the clawdd. In a similar way, with blockier or larger stone the more regular the faces, the easier the build and the better the stone contact which can be achieved. It should be noted that the larger the stone, the less suitable it tends to be for dressing. Any height is suitable although having a preponderance of around 12-20cm tends to make for the best coursing. The blockier the stone, the more you will need of very similar sizes. The sides of the faces should be as parallel as possible, as should the sides running into the wall. Stones are unlikely to conform strictly to this and most shapes can be accommodated as long as there is a reasonable supply of good stones to build alongside them. Larger, flatter stone should be used in the footing, and oversized stone and poorly shaped stone (if of sufficient size) can be used here or flat–lain in the lower courses, as is seen below. Over-sized stones are those that cannot readily be utilised to form a course, because when bookended are too tall to fit the pattern and/or in insufficient numbers to create a complete course. In some instances it is possible to create short lengths of double height courses. Poorly shaped stones can be almost anything which does not conform to the ideal, such are those which cannot be set length in with a good face or the sides are angular and far from parallel (sides into the wall tends to be more critical than the actual face). The further from the ideal shape the less suitable the stone and the bigger the problems they present.

FOUNDATION

The foundations of a clawdd are set flat as for a dry stone wall since this distributes the weight of the stone better and reduces the chance of the stones sinking into the soil. In many old cloddiau the footing stones are set vertically; in rebuilding it is best to re set them flat. When gapping (rebuilding a short section, rather than the whole clawdd), they can be buried so any change in pattern is not visible in the face.

In new cloddiau, the foundation or footing should be laid in a levelled trench with all vegetation and loose soil removed, down to firm ground. Except for oversized stone, it is normal to dig the trench sufficiently deep that the individual foundation stones do not project above ground level. Each foundation stone should butt up tightly to its neighbours, with as level and flat a top surface as is practical with the available stone. The methods described below follow basic dry stone walling techniques and the processes involved can also be found in some detail in the books noted in the introduction.

A key aspect is the placing of stones with their longest axis pointing into the clawdd, in new constructions there is rarely any reason for placing any stones with their long axis along the line of the clawdd (known as "traced" stones) which are more likely to become displaced.

Each stone should sit on its largest surface since large flat surfaces are less likely to tip or move. However the top surface of the footing should be as flat as possible. This will of course

be partly determined by the stone size and shape: irregular stone will make a more irregular footing and boulders will lead to steps. Each foundation stone should sit solidly, secured with stone wedges rather than compacted soil. The trench should ideally be excavated to accommodate irregularities rather than using a profusion of wedges. None of the stones should wobble when walked upon and stones should not move if a force is applied to their outer edge.

If an old clawdd is being repaired, the foundations should be reset if they have moved or tipped. Many collapses of old cloddiau are the result of uneven settlement of the foundation and thinner stones set vertically, yet all too frequently the original foundations are not removed, as this is usually the single most time consuming aspect of rebuilding. The result is that the problem is merely covered up rather than rectified. However, if the original stones are solid, do not slope and are not significantly projecting from the desired line, it can be best to leave them in situ.

There are occasions when repairing the foundations of a clawdd that it is best to trace longer stones, than to disturb the earth core. In many respects the core is the key to a clawdd's stability, disturbing a compact core that has stood for many years serves little purpose (see section on CORE). Similarly, avoid excavating "tunnels" to take the "tail" of longer stones. It will be impossible to compact around these to secure them properly. The resultant tracing should be considered an exception to the rule, but avoided wherever possible. If it is necessary, then avoid tracing adjacent stones. In addition, any traced stone should be dug in sufficiently to be completely buried.

Very occasionally it might be necessary to excavate into the existing earth core to allow a stone to be set in a little. If this is done, then care has to be taken to avoid leaving voids in the core. Ensure there is sufficient space to get a hammer or punner/tamper in to compact soil.

It is often a good idea to cant the foundation slightly to accommodate the steep batter of a clawdd. This is a particularly useful technique where the first course of vertical stones is more than 150mm high, or is less rounded. In these instances, unless the stones have naturally sloping faces, it is often necessary to step the stonework in order to maintain the batter. Canting reduces this problem (see Fig.5).

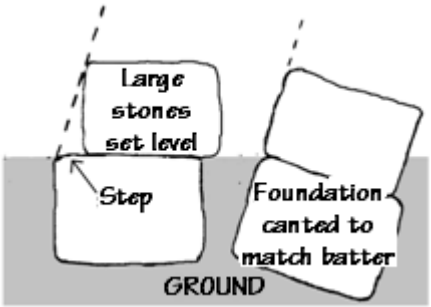

Fig.5. Canted footing

Foundation stones do not need to be enormous, preferably just deeper into the clawdd than the first course of building stone and deep/large enough that they do not become easily displaced by the weight of the stone above.

Fig.6. Flat laid Clawdd, Holyhead, Ynys Mon

DRY STONE ELEMENT (FLAT-LAYING)

Some cloddiau are built entirely (or almost entirely) as if they were a dry stone wall with an earth core (Fig. 6). In many cloddiau the stone that is not going to be suitable for "bookending", that is oversized stone, misshaped stone etc., (see description of suitable stone under PREPARATION), is used to form a small dry stone element at the base of the wall.

In areas where large boulders are present, the clawdd is often built random between the boulders until a relatively even height is achieved. It is then finished off with courses of smaller, vertical stone (Fig.7). Sometimes the vertical stones just form occasional pockets within the face, plus maybe the top course or two of stonework. Flat-lain cloddiau (ie those that more resemble dry stone walls) tend to be more common where the predominant stone is slab-like (usually laminates such as slates and mudstones; or schists), or particularly angular. In all these instances, the stone should always be set length in. There is inevitably sufficient space to accommodate overly long stones and those stones which have faces which can only be traced are better employed within the fill.

Fig. 7. Clawdd built around boulders, Llandeiniolen, Gwynedd

Stone discarded in the core is not wasted as it can help provide a more stable centre. With a new wall, perhaps 10% of the stone can be lost this way. There is a tendency to regard this as waste, but as well as helping with the core, it also facilitates better building as the structure is not compromised by using unsuitable or less suited stone in the face. It is only wasteful if good building stone is discarded in this way, something any competent waller will avoid.

Considerable care needs to be taken with filling behind the face of the wall. It is important that soil is kept off the top surfaces of the building stone thus ensuring good stone-to-stone contact. This is especially true where the stonework is flat-laid. Here the stone will inevitably sit on the soil, which can act as a lubricant, destabilising the stone, whereas as to a certain extent vertically set stone can be made to penetrate a dusting of soil as it is set in place.

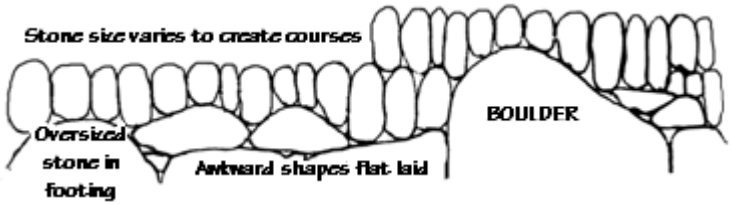

Fig.8. Using oversized and awkward shapes

Normally, the flat-laid stone is not built to a perfect level. Undulations and variations in the height of the dry stone work are compensated for in the first course of vertical stonework (Fig.8). The larger vertical stones are accommodated where the dry stone work is at its lowest.

It can help to set a line around the level you expect the first course of vertical stonework to reach. This helps to judge where to finish the flat-laying, leaving suitable spaces for taller

stones and not reducing it so that unsuitably small stone has to be used. If small dips are left, larger vertical stones can be used to reach the top of the first course of vertical stonework. If there are insufficient larger stones the dip can be levelled with smaller flat-laid building stone (Figures.8&9).

Fig.9. (Above) Misshaped stone used up in base, Tal y Bont, Bangor, Gwynedd

Fig.10. (Right)Stone more suited to a more coursed structure. Note lack of stone-to-stone contact and unacceptable soil in face

Stone Distribution

A guideline for determining where to set the lines for flat-laying is to assess the size of the stone you have for book-ending and working backwards from where you want the wall to finish. For example if the clawdd is to have 80cm of stonework and you have sufficent stone for 4 courses of say 12, 15, 15, 18cm depth that is 60 cm so you have 20cm that can be either flat-laid or bookended, and it doesn't matter if the occasional stone extends above the line as this can be accommodated as shown in Fig.8.

Fig.11. Poor flat laying and grading, with good stone set flat and oversized and awkward shapes set too high in wall

The photo shown in Fig.11 illustrates a poor execution of the concept of flat-laying. The stone is very poorly graded (stone size should essentially diminish with height) and distributed. Had larger blocks been set lower far better coursing could have been achieved. In the photo shown in Fig.12 a stone has been flat-laid on top of smaller stone, it could have been set lower facilitating better coursing. Flat-laying on top of bookended stones is also a weakness. Normally this involves setting one flat stone on top of three, or more, vertical stones. It can be very difficult to get the flat stone to sit on all the stones below it. It will almost inevitably rock on one and/or miss one or more of the others. As such, they rarely achieve a secure bond. It should also be noted, that even if the stone sits well when first built, any movement in the wall below will result in one of the lower stones no longer being securely held, unless all those under the flat stone move by exactly the same amount, which is unlikely.

The coursing in this example (Fig.13) is poor and could have easily been improved had the larger stones to the left and the smaller stone to the right been more evenly distributed, with some of the more irregular stone flat layed onto the right hand footings. This is all down to planning and organisation, with oversized stone being redistributed as work progresses. It is commonly seen on projects where individuals are working on sections and naturally work with what they have to hand in order to get their section finished, and where there is an emphasis on using all the stone rather than accepting that there will need to be reasonable wastage.

Fig.12. Right. Flat stone laid on top of vertical stones, creating structural weakness

Fig.13. Poor stone distribution and coursing

CORE

Cloddiau have an earth or earth/rubble core and are in essence earth banks protected by stone. The stone does not so much support the soil as protect it from weathering. Hence the solidity of the core is paramount. When repairing cloddiau, there is little to be gained from disturbing the core; it is unlikely that hand compaction will be as effective as 100 years worth of aging.

With new builds, particular care has to be taken to ensure that the core is sufficiently compacted. Compaction should take place following the completion of a single layer/course of stonework. Where the course, and consequently the depth, of soil is more than 100-150mm. then the compaction should be in layers of around 100mm. rather than filling to the full depth of the course. Where stone is incorporated in the fill, it is best placed as a single layer on top of the previous layer of compaction, then levelled off with soil which is then compacted.

Hand compaction should ideally take place using a punner/tarmac compactor (Fig.14) but a 14lb sledge hammer or large rubber maul (paving hammer) can be used as a reasonable substitute. Just walking on the wall or compacting by stamping, rarely produces sufficient compaction.

Care has to be taken to avoid disturbing the face stones. Compact the centre first. Work towards the face stones while placing weight on them (for example one foot), ensuring this is directly down and not exerting any sideways force. If any stones move under this weight they

were not solid enough in the first place and should be reset. Do not compact all the way up to the tails of the stone, working too close will almost inevitably displace the occasional face stone. Instead once the bulk of the core is compacted, any loose soil around the tails of the stones can be compacted using a smaller hammer. "Catchee", or axe headed, patterns are ideal for this (Fig.15).

A similar approach should be adopted when repairing/re-facing a clawdd. Here there is often little space between the stone and the bank with much of the compaction carried out with a smaller hammer. A rule of thumb, quite literally, with this compaction is that, if when pressing your thumb onto the soil its nail disappears, then there is insufficient compaction.

If the existing core is little disturbed, and most of the new stone facing is right up to the core, then to enable adequate compaction it is necessary to cut some of the core away.

Fig.14. Compacting core with tamper

With new cloddiau it is theoretically possible to form the core and then stone face it. There is a substantial risk with this (for example just forming it with a digger/excavator) that the compaction will be inadequate. One method is to overbuild the core. Make it wider than necessary, compact it with a vibrating plate in thin layers, and then cut it back to the required dimensions. It is important to leave enough space between the core and the tails of the stones to ensure sufficient soil compaction around them. It should be noted that pre-forming in this way precludes the use of waste/unsuitable building stone in the centre. As a result, there needs to be a greater acceptance that there will be waste/reject stones from the building process as it is important that unsuitable building stone is not used in the face.

Fig.15. "Catchee" pattern hammer used to compact soil

On many builds/repairs a mechanised digger is employed to help fill the centre of the wall. In these instances, care needs to be taken not to overfill the centre for each layer. If too great a depth of soil is tipped into the wall, it is unlikely that it can be compacted sufficiently. There will then be increased settlement after construction, and a greater chance that the clawdd will be less stable, even collapsing in on itself.

The moisture content of the soil fill is important in terms of how well it will compact. If it is too wet it will turn to mud, if it is too dry it will not bind. Neither state facilitates good building, nor the degree of compaction required to ensure

longevity. Hence clawdd construction is ideally avoided during particularly wet weather, or during very dry periods. In addition working during frosty weather can create problems with compaction of frozen soil, whilst freeze/thaw can destabilise and even displace recently placed stones.

Related to this is the nature of the soil used for the fill. This needs to be able to bind well under compaction (very gravelly soil is not well suited to this, finer clays and silts are). Traditionally whatever came to hand would have been used and sub soil is usually good for this but needs to be avoided higher in the wall. As noted above, moisture content is critical, as very wet or very dry soil does not compact well whatever its general structure. If the clawdd is to have a hedge it is recommended that the top half of the earth core is composed of topsoil. If the top is to be turf alone, then there should be a 100-150mm of topsoil. This aspect of construction is dealt with in more detail under FINISH.

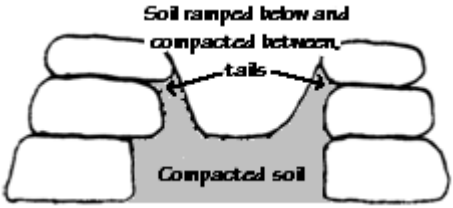

Fig.16. Ensure soil is well compacted around tails of upper courses before topsoil is added

Generally the top 200-300mm of the core is not overly compacted, in order to promote vegetative growth. Care has to be taken to sufficiently compact around the tails of the building stones, ramping some soil up as necessary (Fig.16). To allow for settlement primarily of the un-compacted fill but also the newly formed core, it is customary to fill the centre above the level of the last course of building stones (see FINISH).

There is anecdotal evidence that donkeys were used on some Cornish hedges to compact the core. How displacement of face stones was avoided is not related. Modern equivalents such as mechanical compaction via a vibrating plate, rarely works well. It can sometimes be used lower down where there is a lot of core relative to facing. However, care has to be taken to avoid contact with the building stone. There will inevitably be some sideways movement of the compressed material which might move facing stones, and vibration throughout the process is likely to loosen the face stones.

LINES & COURSING

The use of lines is crucial to coursing. For a new clawdd, it should be possible to choose a pattern and stick to it with only slight variations. With a rebuild, or gapping, the lines should be set to a height that accommodates the average size of the largest stones left. The line should be set to accommodate the available stone, not raised arbitrarily to a height and then trying to find stones that fit. Ensure that the line is set so that the height of each course diminishes as the wall gets higher. Just as in a dry stone wall the smallest stone should be used nearest the top of the wall.

In practice lines are set only 10-20mm lower with each succeeding course; or will even be set the same for succeeding courses. If the course has been built accurately to the line, then raising the line by say 150mm will mean using stones that appear on average less than 150mm high. Some stones with irregular bases will sit on irregularities on the tops of the previous course, reducing the size actually required. Consequently it is normally possible to achieve a thicker course than might at first appear.

Once in place, the line is used as a guide to help keep the line and batter, and as an aid to the height of stone required. It is only an aid and a guide; it is not supposed to determine exactly what size stone is required, for example missing the line by an average of 1cm is unlikely to pose very great problems. The key is to ensure good complimentary shapes between the tops of adjacent stones facilitating the next course. This is as, if not more important than, being exactly the right height. The creation of distinct steps between stones of different heights rather than angled transitions will create problems in subsequent building (Fig.17).

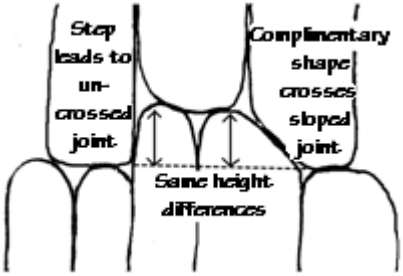

Fig.17. Problem of steps in irregular coursing

As long as there is a relatively even surface between adjacent stones, it is possible to place a subsequent building stone, and it is possible to vary the course depth quite considerably (as can be seen in Fig.9). Care has to be taken not to form a course which noticeably undulates (Fig.18). The key is learning how inexact to be. In practice, it is not necessary to have every stone exactly to the line. With experience, stone selection becomes increasingly accurate and the courses become more and more even, with a neater end result (Fig.19). This can also be affected by stone type/shape, as blockier stone both requires (and in turn facilitates) more accurate coursing (Fig.19). Bear in mind that if you keep "missing" below the line then you will need bigger stone than you might have planned for on the next course (and smaller if you are frequently above the line). Initially discovering what inaccuracy is acceptable tends to be trial and error and in this aspect there is little substitute for experience.

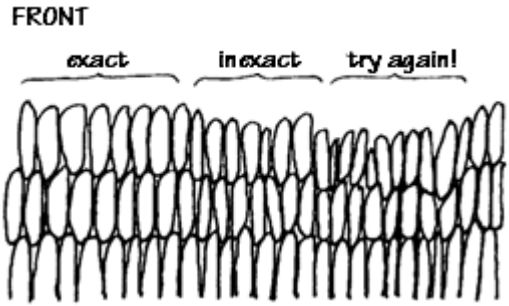

Fig.18. Degrees of exactness with coursing. Courtesy of BTCV, "Dry Stone Walling" p.80

Another consideration is the length of wall (stint) to work on. The longer the stint the greater the scope for better stone distribution and regular coursing. However longer stints tend to require more specific stone size, and if the length is too long you will struggle to complete the courses. With shorter lengths you have more scope to vary the course depth slightly to accommodate the stone sizes to hand, but you have to be very careful not to create unsightly steps or waves in the coursing between stints (as can be seen in Fig.13). With longer stints you will also have to move the unused

Fig.19. Accurate coursing with blocky stone

(oversized) stone further. In practice, something around 5 metres is probably sensible. Again, it is ultimately down to trial and error, plus experience, and being aware of the potential pitfalls. Whatever length you adopt, it can be an idea, in effect to work on two stints at the same time. Build two courses on one stint, then move onto the next stint and build a course, return to stint 1 and build the third course, then the second course on stint 2 etc. This can help with stone management and improved coursing, as you can move stone from one stint to the other, as required. It is possible that this accounts for many of the problems seen on some large projects where builders work on specific lengths and such flexibility is impossible (or at least not accommodated), and only use the stone immediately to hand.

STONE PLACEMENT/ BOOK-ENDING

Before placing any building stones, add a small layer of loose soil onto the compacted core (Fig.20). Where repairing a clawdd leaving the core intact, make a small ramp of soil just beyond the back of the building stones (Fig.21).

Fig.20. Loose soil on compacted core ready for next course

The placement of building stones is very similar to setting an upright coping on a dry stone wall.

A stone is selected for its height and set to cross a joint on the previous course. The height should be close to the guide line, but will also be in part determined by the height of the preceding neighbour (as noted in LINES). Steps between adjacent stones make the placing of subsequent stones bridging the joint particularly difficult.

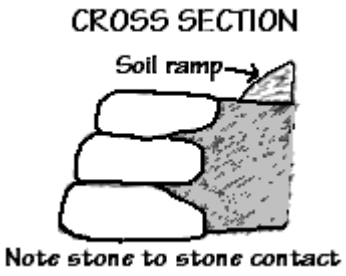

Fig.21. Soil ramp to aid stone setting

Once the height of the stone has been decided upon, there are three major considerations:

Placed length into wall (making sure they are longer than high). This rule should NEVER be broken, and stones should not be set with their longest axis upright even to maintain the coursed pattern. Ideally most stones should be twice as long as high, and the most suitable clawdd stone is three times as long as high.

Sitting on longest edge. This aids stability and in terms of compacting soil around the tails, it is best if any irregularities are upwards. Sometimes the slope of the face of the stone can preclude this. Stones with a very triangular profile present a problem as with dry stone walling. Whichever way they are set, the weight of soil and stone sitting on them will try and push them out of the clawdd (Fig.22). These stones either need to be dressed to form a suitable building stone, as shown (Fig.23), or used in the fill.

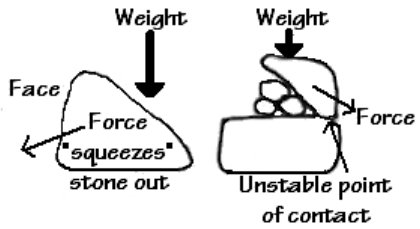

Fig.22. Problem with triangular stones

Maintain stone-to-stone contact. Stones should fit tightly with neighbouring stones both alongside and below. It is important that stones touch along as much of their length as possible and not just at the face. Larger gaps should be wedged as work progresses, (see WEDGING); however, at most, this should only occur two or three times per metre per course. Voids in the face (that is gaps as a result of poor stone contact) should be avoided. Gaps in general should be kept as small as the stone type allows. More rounded stone for example, will inevitably lead to bigger gaps compared to flat stone (see Figures 1&25). Angular stone should utilise complementary shapes to reduce voids. The size of voids is also partly dependant on stone size, as larger stone tends to larger voids. As a rule of thumb, with smaller stone, voids should never be more 25mm wide and with any stone, the voids should not exceed 60mm in any direction. Whatever the case, stone-to-stone contact must be maintained. The fewer gaps the stronger the wall.

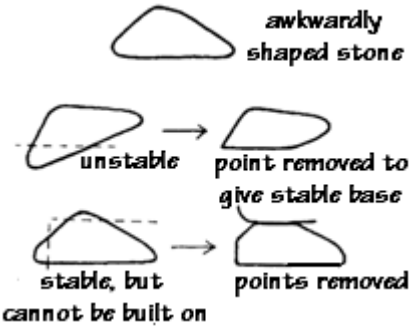

Fig.23. Re-shaping awkward stones. Courtesy of BTCV, "Dry Stone Walling" p.79

Fig.24. Voids and general lack of stone-to-stone contact

Where voids occur in the face, there is a tendency for them to be stuffed with pieces of turf. This is very wrong where it is covering up deficiencies in structural technique, but can be used occasionally where appropriate and is often specified where there is a desire to produce an instant aged look. Evidence and common sense suggest that the traditional cloddiau were built without this turf, the stone is usually very well placed to give a tight face and it is likely that the vegetation has only grown in the voids over a period of many decades. The misconception that turf was used in construction, is probably due to the proliferation of growth on roadside cloddiau, and the occasional field-wall. This growth is almost inevitably the consequence of colonisation and low grazing pressure (hence the growth roadside compared to field side) over a long period of time. It is also suggested that in the past, the face of a newly constructed clawdd was covered with cow

Fig.25. Blocky and angular stone producing tight clawdd with small gaps, but good stone-to-stone contact. Compare this to fig 1, with smaller thinner stone and next to no voids

manure. This would fill gaps with seeds in the dung, with the fertilising aspect itself, promoting vegetative development.

Care has to be taken where turf is used to plug any voids. Where too much turf is used there is a high risk that it will shrink as it dries out leading to a collapse of the wall. This is a particular risk where complete layers of turf are used, between courses of stone. This method is sometimes specified as it produces an instant aged effect and building/coursing is made much easier and thus faster and cheaper (Fig.26). However as a method, its use cannot really be recommended as it is unlikely to lead to a stable structure in the medium to long term. The importance of maintaining stone-to-stone contact cannot be over-emphasised. In practice, only the most severe of facial voids should be plugged with turf and only once a section has been completed. If the turf establishes this is a bonus and at the very least, it should provide additional matter to aid the development of natural growth.

Fig.26. Alternating layers of turf and stone nr Llangybi, Gwynedd

General placement

Maintaining a good batter/even face is easier with smaller stone. Larger stone can lead to steps. This can be alleviated by completely, or partly, canting the footing as shown earlier (Fig.5). Alternatively, trimming the top corner edge can reduce the step even if it cannot be removed completely (Fig.27). The more rounded the face the less apparent steps become.

Depending on the size of their base and the actual surface they are sat upon, not all stones set vertically will necessarily just stand there. Consequently, it is often necessary to use a small amount of soil from the ramp alongside stones or around their tail to ensure that they do not fall over (Fig.28). Avoid getting too much soil on top of the building stones of the previous course, as one of the keys to a strong clawdd is to ensure stone-to-stone contact at all times.

When learning, it is advisable to place stones in a sequence (Fig.29). Place one stone, butt another up to it, then place the one immediately next to that, etc.

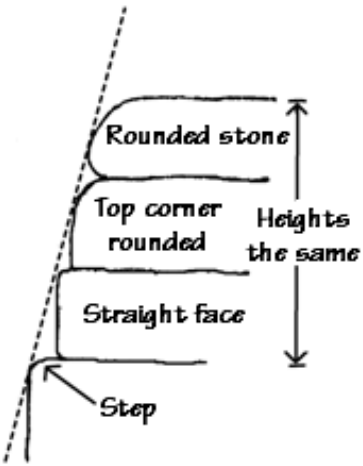

Fig.27. Large stones can lead to a stepped batter which should be avoided

Fig.28. Using soil around tail to hold a stone upright

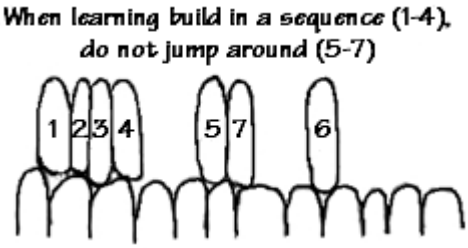

Fig.29. Until you become proficient it is advisable to work in a sequence

Care needs to be taken to ensure a good fit, and that each stone is set vertically. There is a knack to making sure the stone is sitting tightly against its neighbour and care must be taken to ensure that the stones remain tight throughout the sequence. It is all too easy to slightly slope a stone to achieve the desired height (Fig.30). This can be wrong for a variety of reasons, depending on the severity of the slope. For example, ensuring a good fit next to it can prove awkward. In addition, it is likely that the effectiveness of wedging will be reduced, especially with regard to keystones (below). The potential for torque is likely to loosen the stones in the long term reducing the compressive force introduced by keystones.

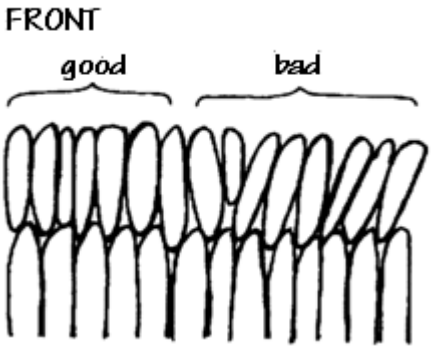

Fig.30. Try to avoid maintaining coursing by sloping stones. Courtesy of BTCV, "Dry Stone Walling" p.79

Not surprisingly given their width, cloddiau do not have through-stones. Sometimes you do find bond stones. These are stones which are over three times as long as high and where present should be evenly spaced along the length of a course rather than grouped together.

KEYSTONES

Keystones are stones which are slightly narrower at their base than their top (Fig.31). When forced down into a gap in a course the stones either side are squeezed together.

The distance between these stones will vary in practice depending on stone size and shape/contact. It is important that all the stones between them move enough to be squeezed. Experimentation is the only way

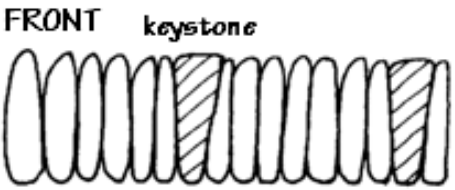

Fig.31. Tapering keystones 'squeeze' courses, tightening stone. Courtesy of BTCV, "Dry Stone Walling" p.79

to determine the best distance the keystones should be placed apart. For example if most key stones are squeezing the next 30cm of stones then they should be installed approximately 45-55cm apart (they squeeze in both directions), but this distance may need adjusting, according to observation of the results.

Having selected a keystone, place it on the wall as the next stone in the sequence (Fig.32 - a). The following stone is then selected and placed. The keystone is removed and the adjacent building stone moved slightly into the gap (b), narrowing the gap in order that when the keystone is inserted later it is a tight fit (c).

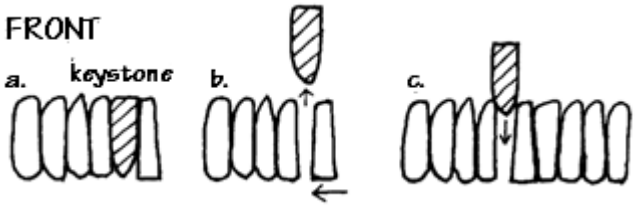

Fig.32. Keystone process.
Courtesy of BTCV, "Dry Stone Walling" p.79

The building sequence is then continued. Once there are sufficient stones either side of the gap, rest the keystone on the gap to avoid the temptation of using it elsewhere. Once the next keystone is reached (or when sufficient building stones are in place) the first keystone can be forced down into the gap left for it.

Adjusting the size of the keystone gap is very much trial and error when learning. If the gap is too small the keystone either cannot be jammed in, or when it is, it forces the adjacent stones out of line, rather than tightening them. If the gap for the keystone is slightly too wide then it does not tighten the course sufficiently. If the keystones are spaced too far apart the course will be insufficiently compressed.

In practice, keystones are used as a set of three stones. The stones either side of the keystone need good flat sides so that the keystone has something to key against. There is little point having a keystone which is tight on the face but with poor contact inside. Angular (along their internal length) keystones or abutting stones provide the potential for twisting and loosening.

It is often best to use slightly shorter (height) stone as keystones (especially if thinner than most building stones). This will result in a slight dip in the coursing, which can easily be compensated in next course. If the keystone is taller than the adjacent building stones, the resultant step is likely to create a joint when the next course is set. The use of thinner keystones tends to occur more when the course stones are set out of sequence WORKING NON SEQUENTIALLY - below), leaving gaps which have to subsequently be filled (as can be seen in Fig.9).

Once a section of wall has had the keystones inserted it is an idea to check how straight the line of the face is with a suitable (usually about 1m) length of 100x50mm timber. Place the 50mm face against the stonework, then any stones which have slightly 'popped' out of line can be knocked back in (usually by hammering on the wood). As a process, this works best before the core is filled and compacted. After compaction, the core resists the stone and it is probable that hitting the protruding stone will just loosen it and its neighbours.

NON-SEQUENTIAL WORKING

Whilst working sequentially is recommended for beginners, with experience it is possible to work more randomly.

Place taller stones in dips suited to their height. This helps get rid of bigger stones and can improve coursing by filling dips. Placing stones in dips also means a joint is naturally crossed reducing the potential for "running joints" (see JOINTS). Working non-sequentially can also help with crossing joints, as if a double joint has been formed you can ensure that a stone is placed across this, in order that it does not develop into a triple one.

It is still best to try and work essentially sequentially. Place a stone in a dip/on a joint, then work immediately either side of it. Concentrate on short lengths rather than liberally sitting individual stones along a greater length.

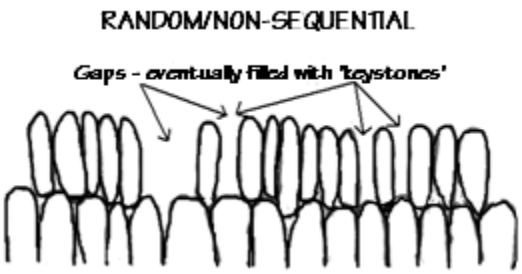

Fig.33. Working non-sequentially leads to stone clusters and gaps which can be difficult to fill

Eventually there will be a number of clusters of stones with the occasional gap (Fig.33). Start filling the gaps until they become isolated and then jam keystones into the remaining gaps. Whilst this can be a far faster and more accurate method of coursing, until the builder is familiar with the basic process it can prove more problematic. Keystones have to be found to fit specific gaps, rather than gaps being created for preselected keystones. If the stones either side of a gap are not ideal the keystone will not lock the stones. It is likely that gaps will be left for which there are no ideal keystones and a poorer key will result. It is also very easy to end up with sections that are too large for keystones to squeeze sufficiently.

One idea when working is to sort a couple of dozen stones or so from the pile/dismantled stock, choosing what appear to be the largest, and then use these. When you are down to the last 2 or 3, replenish the stock. Repeat the process until the course is complete. This can help stone distribution although you do have to be careful not to end up building/leaving short sequences which dip consistently below the line.

WEDGING

Much of the strength of a clawdd's stonework is reliant upon how well the tails of the building stones are secured. Where there are large gaps on the core side as a result of limited internal contact these will need wedging prior to jamming the keystones into place. If this is not done, there is a likelihood that the building stones will twist when the compressive forces are applied, with the effectiveness of the keystone subsequently reduced. In practice, it is best to wedge regularly. It reduces potential movement and facilitates placement through placing/locking against solid stones.

Fig.34. Wedging tails of stone

Fig.35. Compacting soil around tails of stone

Once a section is completed, including keystones, any gaps between the "tails" of the building stones should be securely wedged**,** below and between (Fig.34). Soil is then firmly compacted into all the remaining nooks and crannies around the tails. It is best to carry out this process regularly as work progresses rather than leaving long sections. If wedges are hard to come by then soil has to suffice.

When hammering in wedges, or compacting soil between stones (usually with end of a hammer handle), care has to be taken not to loosen or dislodge the building stones. This is particularly the case towards the ends of incomplete courses, or near to the gaps where keystones have yet to be inserted. Firm downward pressure should be placed on each pair of stones (Fig.34), to ensure they are not forced out of line.

Before filling the rest of the middle, all loose soil left in the centre is compacted around the tails (Fig.35)**.**

JOINTS

Just as with a dry stone wall, there should be good bonding with one stone sitting on two and two stones sitting on one, ensuring that the joints between stones are covered on the subsequent course. Two vertical stone joints are normally seen as acceptable in a clawdd, with the degree of acceptability depending largely on stone type. Where a series of joints line up this is known as a running joint. Thinner stone tends towards more joints, and since more stone is being placed there is more potential for joints. With more regular stone or wider faces it should be possible to achieve fewer joints. Bearing these factors in mind more than 5 double joints in a square metre of face would be excessive; a good craftsman should be displeased with more than 1. In addition any joints should be spread throughout the face and not grouped together.

Two-stone joints should not be allowed to develop into three-stone joints as these represent a severe weakness.

As has been noted (LINES) the easiest way of avoiding joints is to utilise any dips which form between each of the stones. Slightly taller building stones can be used in these. This can be aided by more random approach to building (see NON-SEQUENTIAL).

FINISH

Top Courses

With most coursed cloddiau there is no set coping, the top course (often of smaller stone) forming the default cope. Sometimes the top course will be thicker than the previous one, or composed of blockier stone, both aiding stability. However, it is possible to use insubstantial stone provided this is subsequently bound by good vegetative growth. Sometimes this is very small stone (50-75mm high faces), which needs very good length relative to height to sit securely. Occasionally the wall will have a more formal cope as shown in Figures 39 & 40, although this tends to be highly localised, often on a farm, or even wall by wall basis.

It is not unknown for the last course to simply comprise whatever is left over, especially on agricultural walls (Fig.36). An uneven course is built, with most of the irregularities being disguised by turfing. Practically this doesn't matter, but aesthetically in some situations it is likely to be less appropriate. Particularly oversized stones are still awkward to use and it might be necessary to flat-lay these. Care has to be taken to ensure that they sit with a minimum of rocking, which should be achieved without recourse to bedding them on soil. Bear in mind that flat-laid stones are unlikely to be bound as securely by vegetative growth as vertical ones, and should only really be used in this way as a last resort.

Fig.36. Clawdd finished off with larger random stone near Cemlyn, Anglesey

Fig.37. Double row of vertical stone set on flat-lain clawdd, Rhydwyn, Anglesey

very fragile and easily displaced. To aid the establishment, very small bits of turf are often rammed into, or onto, every joint on the top course (Fig.38). If these take, then the stone will be secured faster, if they do not, they will at least help retain soil in and around the joint promoting vegetative growth.

These pieces of turf need to be fairly insubstantial. A thick sward does not work well. Thick grass and/or dense roots cannot be forced into the narrow joints and are frequently left exposed and dry out.

Those cloddiau which are almost entirely dry stone will occasionally be finished with one (sometimes 2) courses of vertically set stone (Fig.37). Cornish hedges built flat-laid, are typically finished with herringbone (2 rows slightly sloped, top course sloped opposite to lower course). There is no tradition of this in Wales, and where it does occur is most likely the result of the Cornish pattern having been imposed on a modern rebuild/commission.

The vertical nature of the coping/vertical stonework facilitates root penetration. Once vegetation becomes established, even small stones are securely held. However, until the vegetation establishes, the stonework can be

Fig.38. Small pieces of turf being jammed into joints on top course prior to final turfing

Good length of stone into the clawdd also makes for a much more stable top, ideally you'd like to see no stones less than twice as long as high and even more for smaller heights, In practice this rarely happens and is not crucial as long as stock pressure is kept off until the vegetative layer develops. It should also be noted of course that if you have good length of stone and a narrow clawdd then you will have problems with hedge planting.

Fig.39. Flat slab cope, nr Amlwch, Anglesey

Fig.40. Sloped slate cope, nr Pen y Groes, Gwynedd

Capping

Drying out of the pieces of turf jammed into the joints on the top course is always likely to be a problem. Potentially this problem can be reduced by setting turfs to cover the stonework. In turn a thick sward used on the edges can be a problem. Generally a smaller root system can be compacted better to seal the edge. Whilst it is generally recommended that turfs are treated gently, in practice it is probably as well to hammer the edges so that roots are not left exposed.

Topsoil should have been saved for filling the top course or two of stonework to help the vegetative cap establish. This soil should not be overly compacted (see CORE) and is likely to settle; hence additional soil should be mounded above the level of the stonework. As already noted the total depth of topsoil should be around 100-150mm for a grass top, and ideally 300mm or more if a hedge is being established. It has sometimes been suggested that a dome be formed on top of the wall primarily to allow for settlement of soil within the clawdd. However provided the core has been sufficiently compacted this is unlikely to more than 50mm for most soils. Such domes frequently dry out and erode as they tend to shed water and can be more exposed to wind. The water shedding has further implications if trying to establish a hedge. Here the presence of a dished top can be an advantage (see below – 'Hedge establishment'). Whatever approach is adopted depth of soil at the edges will be a problem in terms of vegetative establishment, one reason why "turfing" each joint can be advantageous.

If no hedge is to be planted then ideally the whole top should be finished with a turf dome. Start by turfing the outside edges so these are sealed/bound. Work towards the centre. If turf is in short supply then it is more important that the edges are covered. Gaps in the turf towards the centre (topped up with topsoil if available) will vegetate over far more readily than a patch on top of the stonework. In agricultural situations additional turf can be cut from the adjacent field. Remove patches of turf randomly from a wide area rather than stripping a concentrated area. The small bare patches should re-colonise within a year or two. Scraping small turves of around 300x300mm with about 50mm of rootstock, with a mattock should be relatively easy.

Hedge establishment

There is some debate as to how commonly hedges would have been planted in cloddiau when first built. It is possible that many tops were either left bare or turfed. It is also sometimes suggested that a common practice was to mix gorse seed into the surface of the final soil layer, and hedges were allowed to develop naturally over time. Whilst many, perhaps most, cloddiau would have had associated hedges, the sporadic hedging found on many cloddiau does not necessarily mean that all were originally planted. However, trees found on cloddiau could also be the remnant of a more complete hedge that has deteriorated due to lack of maintenance and damage by livestock. Hedges on cloddiau provide additional shelter to livestock and crops and are also frequently specified for highway projects for landscaping, nature conservation and screening purposes.

Establishing a hedge in a domed top can be problematic as the transplants require well settled soil if they are not going to whip around in the wind. The dome can also shed water, a major consideration in the establishment of hedges. Current thinking is that it is best to establish the hedge on a flat or even dished top. Here it is important to ensure that the top soil around the tails of the top courses is very well compacted (SEE CORE), even if the topsoil for hedge establishment undergoes less compaction, otherwise the top courses could potentially be destabilised. The use of turf to stabilise the top course is not always appropriate where a hedge is to be established as grass is a serious problem in terms of competition with transplants.

Domed tops can offer some protection to the top course of stone during tree planting, but whatever top profile is chosen, great care needs to be taken to ensure that stones are not displaced during the planting process.

Desiccation can definitely be a problem. This can be down to a number of factors in addition to the dome. Wider banks will collect and store moisture better. It should be remembered that cloddiau are in effect large raised planters, relatively well drained, not topped up with moisture from the water table as fields are, and highly reliant on water penetration from above. Reducing the top width below a metre is highly likely to reduce the chance of a hedge establishing. The relatively exposed nature of the bank top will stress plants, hence they need to be given every other chance to help become established. The quality of soil within the top of the core is likely to be a major factor in hedge establishment; they do not need to be further stressed through planting in poor subsoil. Good quality humus-rich topsoil is essential, poorer soil can be enhanced with tree compost or leaf mould mulch.

Avoiding turfing means the top course of stonework could be more prone to displacement; it can be many years before sufficient vegetative growth develops naturally. A compromise can be to turf the outside edges, leaving an unturfed strip up the centre. This will reduce competition in the short term but can still present a problem with hedge establishment (especially on narrower cloddiau) as the grass can spread very quickly. It seems likely that in exposed locations a slightly concave/dished top may help gather moisture and gives some protection from the wind.

It is of course possible to keep the area immediately around the trees weed free by topical application of herbicide. This however can lead to problems in itself both in terms of commitment and avoiding damage to the transplants themselves

A modern “innovation” to help with the establishment of hedges has seen the use of fabric membranes to suppress weed growth, both the A499 Clynnog and A496 Abererch - Butlins schemes in Gwynedd are both good examples of how hedges can be established in windswept and harsh environments using landscape fabric. Figures 11 & 12 show a membrane “secured” with stone. The membrane is prone to lifting and damage from the wind and securing it can be

Fig.41. 20cm long pin used to secure weed suppressing membrane

problematic in windy areas. Here the edges of the landscape fabric require pinning down with landscape pegs or staples at regular intervals (usually less than 300mm). Fig. 41 shows a 20cm pin as used on A499, Chwilog, Gwynedd.

Membranes should be installed during winter months when there is moisture in the soil. The membranes reduce evapo-transpiration from the soil surface and weed competition, this seems to outweigh the amount to which they actually reduce rain penetration. Whilst they are air and water permeable they are likely to be less effective in the long term if the top is not flat or slightly dished, to aid moisture penetration during winter.

In summary, it is now generally thought that it is best to have a flat or slightly concave top rather than a dome if planting with some form of membrane or landscape fabric. Whilst there are implications for the security of the top course, where hedges are planted the clawdd is going to be fenced or in a stock free environment anyway and so less prone to damage. Once the hedge is established then grass growth is not so problematic as the hedge plants naturally suppresses the grass and self-mulch with fallen leaves. Any membrane used should then be removed, although over time many landscape fabrics will bio- or photo-degrade.

ENDS

The nature of the stone used for most cloddiau is such that there is almost inevitably a lack of suitable quoins (corner-stones) for building wall ends. Where there are the corners might be built flat-layed, or occasionally the clawdd merges with a short section of stone wall. However, even where more suitable stones are present, the width of the clawdd makes creating a stable structure difficult. As a result, a common method of ending a clawdd at a gateway is to set a large boulder in place and curve the wall gently into this (Fig.42), unless the boulder is as wide as the wall – a rarity. The specifics for construction will vary for each boulder. Ideally you need good length against the boulder to help hold the stones. However if there is much of a curve into the boulder, the length gets in the way of the adjacent building stones (see Fig.43). Almost inevitably you have to flat-lay some stones.

Fig.42. Boulder used to form end of clawdd, near Tresinwen, Pembrokeshire

Another method of ending the clawdd is to construct a curved end (Fig.45).

Set a vertical pin in the centre of the wall, bisecting two line bars. Attach a rod, such as a length of bamboo cane, to the bar. This can be done by making a loop of tape and placing this around the bar and taping the rod to the loop, tightly, close to the bar. This in effect creates a “trammel”, sometimes known as a “beam compass” - as opposed to the “dividing compass”. The radius of the wall can be marked on the rod for the level of each course as work progresses (Fig.44). The positioning of the outside edge of each stone is determined by the radius marked on the stick. Care needs to be taken to keep the trammel level as angling it can distort the curve, although generally a rod will remove most of the problems which occur through the incorrect angling or stretching of string. Care needs to be taken to maintain the correct coursing. A spirit level is useful here. This is fairly straight forward on flat ground. Where the ground is on a very slight slope, setting the end courses level around the ‘D’ will probably not look out of place. Where there is more of a slope, the level can still be used, although care has to be taken to ensure the tilt is kept relatively consistent throughout.

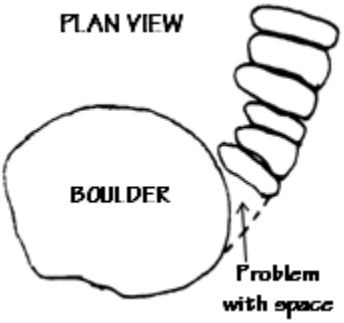

Fig.43. Curving into a boulder reduces the space available for stone

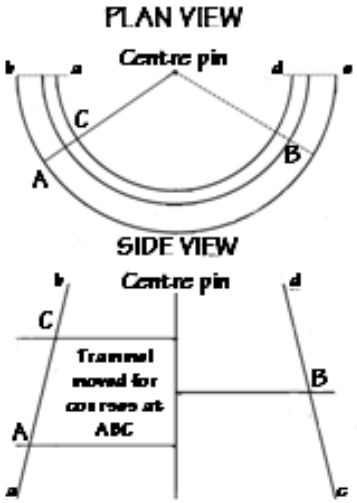

Fig.44. Trammel used to circumscribe the end

These curves are almost inevitably fragile. Nearly every stone will need to be slightly wedge shaped, thinner inside the wall than in the face in order to maintain the curve. This tends to preclude the use of longer stone. In addition, it is not always possible to wedge the tails of the stone as this tends to actually force them out of the face. Consequently they are best built utilising relatively blocky stone (as in Fig.45). These can be slightly shaped to the required wedge, and it enables some length into the wall relative to face width, whilst the nature of the stones means they sit relatively securely. Any wedging of the tails is probably best achieved just through firm compaction of soil around the tail, with the stone held securely whilst the compaction takes place. The tighter the radius the greater each of these problems, which are exacerbated further as you progress up the wall where the stone naturally needs to be smaller and the curve tightens. Once a course around the radius is completed and the tails secured, each stone should be gently tapped into the bank, tightening the course. Care has to be taken not to hit them too hard forcing them out of line relative to other stones, and/or displacing nearby stones.

Fig. 45. Curved clawdd end, Brynsiencyn, Anglesey

Sloping courses
Blaenplwyf, Ceredigion

Random vertical
near Aberteifi, Ceredigion

Herringbone, Y Ffôr, Gwynedd