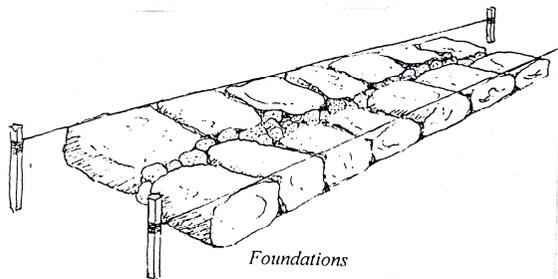
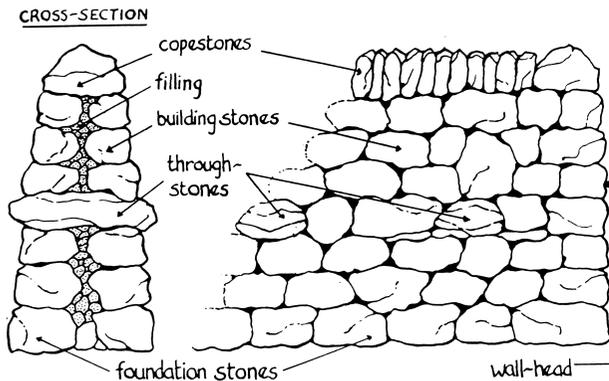


**DRY STONE WALLING ASSOCIATION
OF GREAT BRITAIN**



**A Guide to the
Commissioning,
Inspecting and
Assessing of
Dry Stone Walling**



INTRODUCTION

A dry stone wall is a stone wall built without a binding agent such as mortar. The stones are held together by gravity and friction, and the wall relies on good craftsmanship to ensure stability.

This guide is intended as an aid to those who commission or specify work, and especially to those who inspect the work to be acceptable for payment. It describes the basic techniques of construction and the common faults which occur in dry stone walling. Much of the strength of a wall is internal so that there is no substitute for inspecting work as it progresses. However, many faults can be assessed from the outside and guidance is given on how to recognise these. Since even good wallers create an occasional fault, inspection should look for multiple faults which indicate overall bad technique.

Variations in local practice, geology and the resulting stone type mean that there is a large variation in what can be expected. This booklet looks at standard 'doubled' dry stone walls; that is walls with two independent faces separated by a core of much smaller stone. Brief mention is made of retaining walls as these relate closely to the standard double wall. For the less usual walls such as single walls, Galloway dykes where there is a single sitting on top of a double, and structures with an earth core such as Cornish hedges and Welsh cloddiau additional advice should be sought.

There are more detailed publications on dry stone work given in the reference section. An understanding of the craft is best obtained 'hands-on' and branches of the Dry Stone Walling Association of Great Britain (DSWA) run training courses at all levels. Attendance at one of the major walling competitions will illustrate how the same stone can result in different quality walls depending on the skill of the craftsman.

In the case of disputes involving dry stone work, the DSWA has list of recommended assessors who can undertake inspection. Details of this service can be obtained from the Association, without obligation.

SPECIFICATIONS

Variations in local practice and stone type mean that it is not possible to develop a single specification for dry stone walling. The DSWA has free technical specifications leaflets for some of the more common wall types available online at <http://www.dswa.org.uk/Leaflets-g.asp>. These include basic information which might form the basis of a specification, however different stone types demand different techniques. For any particular project it is always advisable to have expert local advice. The DSWA can suggest suitable contacts.

Clear written specifications should include information on all aspects of the work. The generic aspects probably exist within big organisations and include timescales, groundwork, site access, health and safety, traffic management, public access and payment scheduling. The practical aspects of stonework such as the wall dimensions, type and source of stone, walling style, finish, line, batter, tightness, the number and coursing of the throughs, the style of the top stones should be drawn up in consultation with suitably knowledgeable local wallers. A beginning point for these details should be to follow the local style and especially that of the neighbouring walls, if these are of high quality. Heritage walls need to be identified from their appearance or documentation and retained, repaired or rebuilt as appropriate.

Where replacement stone is used, this should match the stone of the immediate area in order to maintain the vernacular. The appearance of reused wall stone, broken stone, stone from old buildings, sawn faces and fresh quarried stone can be very distinctive. If there is not a perfect match, then the new stone should be used in complete sections to full height rather than in patches. On occasion a concrete foundation may be allowed, with all the stonework above ground being dry stone. Where vandalism is a problem it might be necessary to mortar the top stones.

The Dry Stone Walling Association operates the only nationally recognised, tiered, certification scheme. Details are given later. A register of DSWA members who are contractors, with their standard of craftsmanship, is also available.

WALL CONSTRUCTION PRINCIPLES

A distinction is often made between more utilitarian walls, such as those on farms, and highly visible projects, such as roadside, show and garden walls. Whilst different degrees of craftsmanship are expected between such projects, this relates to the neatness of finish rather than the structure. All walls should be built structurally sound regardless of their function. A good craftsman will produce a wall which has been built soundly, will last longer, be better value for money; and also looks neat.

As well as damage by outside forces, such as trees, stock, vehicles or people, walls fall down as stones move or crumble. Most failures occur due to movement as the wall settles differently between adjacent sections or from one side to the other. This depends on the firmness of the ground. The strength of a wall depends on the selection and placing of the stones. The techniques of wall building described here have evolved to control the effects of this movement and will be covered in rough order of construction.

FOUNDATIONS

Inspection of foundations during construction is important since it is impossible to assess them once the wall has been built. In new walls the foundation, or footing, should be laid in a levelled trench with all vegetation and loose soil removed down to bedrock or firm ground. This might be 10-20 cm deep.

If an old wall is being repaired, the foundations should be reset if they have moved or tipped. 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.

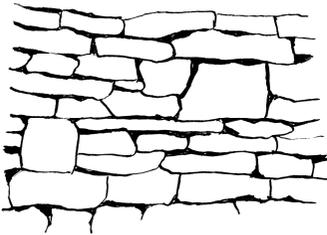
Each foundation stone should butt up tightly to its neighbours. The foundation course should be of an even width along the length of the wall, with as level and flat a top surface as is practical with the available stone. The biggest stones available should be used since the weight will then be spread more widely. Small stones or traced stones (see LENGTH INTO WALL later) should be avoided. Any gaps should be well packed with suitably sized stone (see FILLING later).

In some areas, the foundation stone course projects a few inches beyond the main body of the wall in what is known as a scarcement. This spreads the weight of the wall over a wider area and decreases settlement on soft ground. Generally stones should be set to the horizontal rather than following the slope of the ground once the angle gets over about ten degrees [about 1 in 6]. On slopes it is necessary to step the foundation in order to maintain setting to true horizontal.

GRADING AND COURSING

Grading is the placing of larger stones towards the bottom of the wall and smaller stones to the top. In coursed walls the stone is set in regular layers of very similar heights. In random walls, where there are no distinct courses, the stone size generally decreases with height. In a well structured wall not only is stone graded according to height it should also have an even distribution in size along a wall.

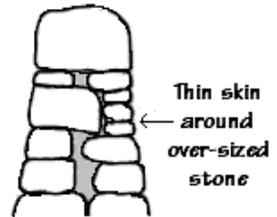
Any very large stone should be used in the footing, unless its length and shape are such that it will make a suitable throughstone (see THROUGHSTONES later).



In some styles, which have regular stone, the coursing is broken by a jumper, a large stone, which jumps up two or sometimes three courses. These are acceptable provided that they are well placed. That is: they have good length into the wall, they are not traced or set vertically on edge, they do not result in a thin and unstable opposite face, and there is good stonework above and below.

LENGTH INTO WALL

A key aspect in a wall's strength is the placing of stones with their longest axis pointing into the wall. In general any single stone should reach at least a third of the way across the wall. If it reaches too far then there is inadequate space to place the stones of the far face securely.



Stones placed with their long axis along the line of the wall are known as "traced" stones. Tracing is a frequent fault since traced stones usually make a wall look good and complete the face of the wall faster. They are also easier to place rather than trying to fit them lengthways into the wall when the stones on the opposite side of the wall will be difficult to fit and make stable.

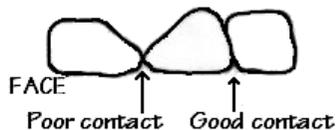
The weakness caused by the relative instability of the traced stone is compounded by the fact that, because of their length, they do not always sit securely on all the stones below. This problem usually referred to as the problem of '1 on 3' (see in CONTACT later). Traced stones can suggest that the stones have not been selected, graded and sorted well. Even worse, a traced stone might have been more suitable to have been used as an important stone, such as a through stone, elsewhere.

Traced stones can be most easily assessed through inspection as work progresses. From the outside it is not always possible to determine that the stones are traced. However, if the length of the stone's face is more than about half the width of the wall at that height the stone is likely to have been traced.

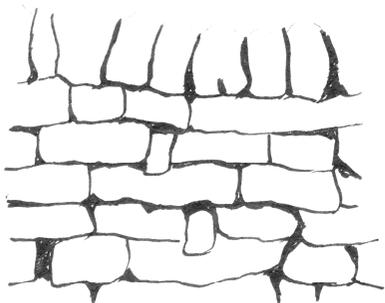
CONTACT

How well the stones fit together in the face of a wall is referred to as 'tightness', with 'slackness' as the opposite. A tight wall has less potential for the stones to rotate or move during settlement since there is a good area of contact and larger friction between the faces of adjacent stones.

The amount of tightness that can be achieved can vary with stone size and type. Stones should be butting against their neighbours over as large a surface as possible. Thus a wall built of regular/flat bedded stone can be made tighter than one built of irregular stone, and rounded stone is likely to appear slacker than squarer stone.



Good contact should be achieved on both the vertical and horizontal faces of each stone. The contact on the faces of the stones inside the wall should also be good with firm hearting within any internal V shaped voids.



Where a stone fails to sit with a significant part of its weight on any one of the stones below then a 'letterbox' results. This is often the result of a single traced stone or a wide throughstone bridging three stones and is also more frequent if the stones are not graded or well coursed. However the middle stone can sometimes be held, although not visibly, when the upper stone rests on the back of the apparent floater. It is advisable to check, by pulling, the solidity of all the stones under a '1 on 3' stone.

CROSSING JOINTS

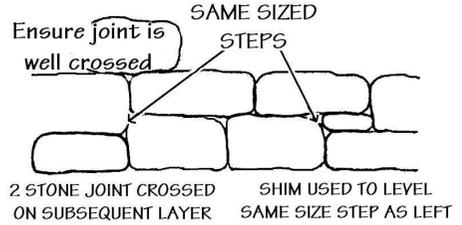
Stones should have a good bond to distribute forces and tie stones together, similar to brickwork. One stone should sit on two, and two on one, with significant overlap and good weight and friction distribution at each point of contact. Where stones are set so that there is no bond between courses they produce a 'plumb' or vertical joint. An occasional plumb joint through two layers can be accepted. Plumb joints through three or more courses are referred to as a 'running' joint. These joints are a severe weakness, creating a seam in the wall which is likely to widen as the wall settles.

Not all running joints have joints clearly above each other. Vertical joints can be only slightly crossed, with each stone only just lipped on to the one below. Such a joint can run to the same side in successive courses, diagonal, or alternate left and right, zipper.

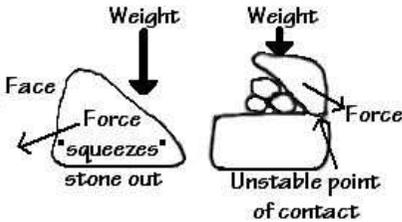
STONE PLACEMENT

The way stones are placed affects subsequent building. Stones with badly sloping or rounded top surfaces can tend to create later problems, as they try to shed the next stone placed on them.

'Plates' or 'shims' are thin stones used to level off a small step in a course, allowing the placing of the next building stone without it rocking. They are acceptable if they sit well, are firmly held, have a good length into the wall and do not proliferate.



As a general rule stones are set flat rather than on edge, with their largest surface forming their base. Occasionally, relatively thin stones are set on edge to fill a narrow gap between two stones. Stones placed this way are less stable than those laid flat and they are usually letter box stones.



Where any cross sectional part of a stone is triangular or wedge shape this end should be set as the stone's face. If the triangular cross-section is set within the wall the weight of the stones above will act to force the stone out of the wall. This can only be assessed during construction.

'Pins' are small stones inserted firmly into the face to wedge the stones and present a smoother face. Pins can work loose and so should be infrequent but firm.

FILLING

Filling, or hearting, is the small stone used to fill voids in the centre of a wall. Filling the voids reduces the potential for the wall to fall in on itself during settlement. It also prevents the movement of any internal wedges used to lift or stabilise the tails of the building stones. Hearting should be completed during the placing of each course of the face stones to provide sufficient support under the tail of any longer stone placed into the wall on the next course.

The hearting should be firmly packed in flat by hand. The largest stone possible should fill any given gap with as much contact with the building stones as possible. Angular stone is best and small round fill is unacceptable since the stones can get under a face stone and act like ball-bearings.

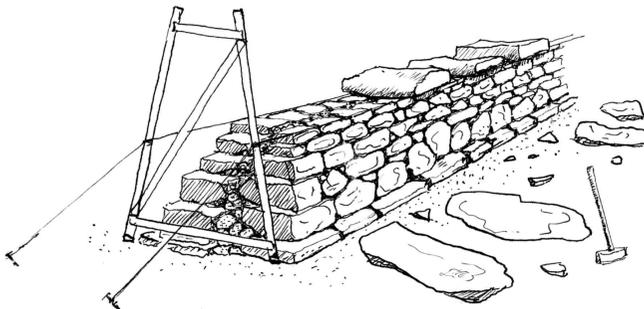
THROUGHSTONES

'Throughs' or throughstones are single stones which completely traverse the width of a wall to connect the two faces. The style and spacing of throughs varies with local tradition and the availability of suitable stone. They can form a continuous course or be spaced. Where the throughs form a continuous band they should interlock closely with their neighbours. If spaced, they will normally be at regular centres of about a metre. If the style is one row then this should be around half way up. For taller walls (over 1.2m plus coping) there may be two courses of throughs at about $\frac{1}{3}$ and $\frac{2}{3}$ height, with the centres of the throughs staggered from the lower to upper course.

Where the style is for the throughs to project, they would normally all be at the same height to emphasize the through course. Stones seen to be protruding from a face are not a guarantee that they are actually throughstones since it is not unknown for building stones to be deliberately poked out to maintain a pattern of throughs. This can be best detected during construction, although comparison of the front and back faces at a suspect point may indicate the deception. The projection should only be around 5-10cm to prevent damage by stock, or climbers. Where the practice is to set throughs flush with the face of the wall they should still be evenly distributed along a course.

All throughs should be set at right angles to the face and be level. A particular problem is to get them to sit securely on all the stones under them; as in the '1 on 3' problem seen earlier in CONTACT. They should hold all the stones underneath securely. The top of the face stones completing the through course should be even with the top of the through stones.

If throughs of sufficient length are not available, then '¾ throughs' should be used. These should ideally be laid in sets of three where the tail of one stone is held in a 'pincher grip' by the tails of a pair of stones, above and below, on the opposite side of the wall. Apart from this case, it is probably better that they are slightly shorter rather than longer so that there is adequate room for a good width of face stones on the far side.



TOP STONES

The coping, or cope, stones are the wall's top stones and serve to seal the top of the wall and hold the final course of each face in place and bind them together. Each cope stone should sit solidly on its own base, the top layer of both faces of the wall and fit tightly with each stone placed to maximise contact with its neighbours. Very many styles and regional variations of coping exist. The style should fit with that of the surrounding area. Most styles comprise upright or sloping stones or sometimes with alternating taller and shorter stones. In some styles, slabs are set flat on the wall top and these are known as covers which always completely span the wall top. In many instances, boulders or vertical stones sit on the cover. As with throughs care is needed to prevent the 1 on 3 problem. The top of the wall and the top of the copes are best set level using a line.

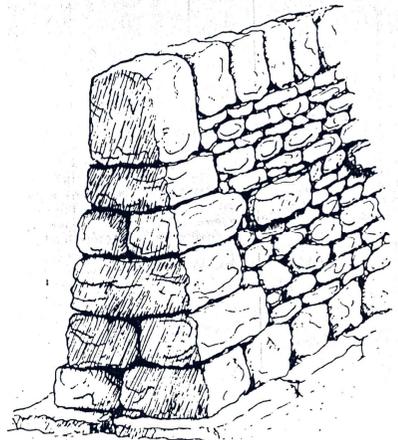
In some areas there are insufficient suitable cope stones so the coping does not stretch across the wall. It then requires two rows, usually alternating the larger stones on opposite sides interlocking the tails wherever possible. Where the top stones are long, the stones are sometimes set to one side of the wall, generally the lower side or the side with the stock, and project by 3-5cm.

All coping stones should be checked by trying to gently rock them from side to side and front to back. There should be no movement.

WALL ENDS and RETAINING WALLS

Wall ends, also known as cheeks and heads are very visible and susceptible to damage. They comprise alternate course of headers, which reach right across the wall, like throughs, and stretchers which tie the end back into the wall. In areas with a lack of well shaped stones the end is constructed by a series of L shapes on alternating sides.

Retaining walls are built across slopes to support or protect earth banks. Either a free-standing wall is back-filled with stone, or the wall is built with a good outer face and a rough second internal skin with the fill placed like well organised large hearting. Since water or fluid soil pressure can push the wall over, there should be no soil in the hearting or the back-fill. To allow for any pressure or soil movement, a retaining wall might be built with slightly more batter than in a similar free-standing wall.



INSPECTION DURING CONSTRUCTION

The strength of stonework is largely inside the structure so the quality of a wall can be difficult to assess from the external appearance, therefore inspection during the construction is important. Particular aspects of the wall that can best be assessed by inspection during construction are the foundations, traced stones, triangular cross-section stones, throughstones and the filling.

Inspection during the work is also common in order to assess adequate site practice, such as health and safety. Such periodic visits give insight into the waller's working practices. For example, building up several courses on one side before changing sides is a bad practice since the hearting cannot be packed in properly. An indicator of good practice is the selection and laying out of the cope stones and throughs before building commences. The use of frames and lines varies although the final result is the real requirement. However these are most valuable where the stone has a smooth rectangular face and is well coursed. Lines should be used for the foundations, the through course, the top of the wall and the top of the copes.

FINAL INSPECTION

Conformation to the specifications should be checked. Indications of the care in the workmanship are the uniformity along the length of the wall, the straightness and smoothness of the face along its length, and 'batter', from bottom to top. These qualities do not merely make the wall look good, but will add to the wall's durability and any deterioration of the wall can be seen more easily. The adequacy of the hearting is best assessed during construction but some indication can be obtained afterwards. If you squat and look directly at the face you should not be able to see any daylight through the wall. Clearing of the spare stone should be complete.

ROUTINE MAINTENANCE OF WALLS

Periodic inspection of dry stone walls is essential if they are to have a long life. Regular replacement of fallen top stones and the repair of any larger damage is essential, since a damaged wall decays rapidly.

Trees and walls do not mix. Trees should have been removed during a rebuild. Part of the maintenance should be to remove branches which are close enough to touch the wall, especially in a high wind. Tree seedlings or shoots within a metre of the wall should be removed. Where there is an existing tree which needs to be retained then the wall should be built well away from the trunk and roots. The wall can bend around the trunk or a gap with good ends can be left to be made stock proof with hurdles or fencing.

REFERENCES

- Brooks, Adcock, Agate. "Dry Stone Walling, a practical guide." BTCV, 1999
- DSWA, "Dry Stone Walling Techniques & Traditions". DSWA, 2004

The present leaflet is a concise version of Adcock. S. "STONEWORK", North Wales Branch of DSWA, 2012

"STONEWORK" is also available electronically in the "Standards" section of www.dswales.org.uk where an associated photo gallery of examples of faults can be found. Printed copies are available free of charge (plus postage) from the North Wales Branch.

DSWA CRAFTSMAN CERTIFICATION SCHEME

The DSWA recommends that only suitably qualified wallers are employed on projects to which end it operates the only national, graded, practical skill tests for walling - the *Craftsman Certification Scheme*. Current qualifications have been specifically designed in conjunction with Lantra Awards and sit within the Qualifications and Credit Framework (QCF). As well as being stand alone qualifications, they also form the technical certificate for the modern apprenticeships.

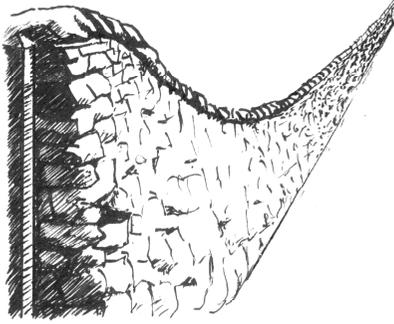
The Craftsman Certification scheme has four levels:

- Initial - ability* - Able to undertake minor works, having demonstrated their ability to rebuild gaps in free-standing dry stone walls.
- Intermediate -* Able to undertake most general walling work to a good standard, and have demonstrated their ability to construct a sound, free-standing dry stone wall which includes a cheek-end.
- Advanced -* A level indicating high technical skill. Have a proven ability to build set pieces of work with an emphasis on finish and quality including construction of retaining walls, curves.
- Master Craftsman* A high level of quality and technical expertise. Have a proven ability to produce quality work to a high standard in a variety of commercial conditions including the construction of a full range of features, e.g. steps, stiles, pillars, arches, etc.

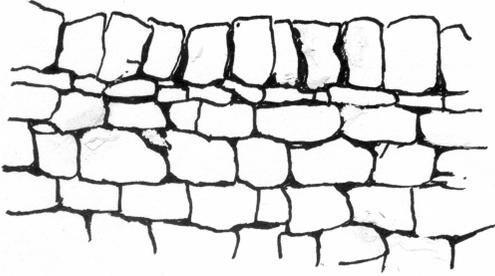
More detailed information can be found in "*Craftsman Certification Scheme*" online at <http://www.dswa.org.uk/UserFiles/File/CCS%20booklet.pdf>.

The Initial, Intermediate and Advanced levels parallel the levels 1, 2 and 3 of the LANTRA awards scheme, further details of which can be found at <http://www.lantra-awards.co.uk/training/drystonewalling1.aspx>

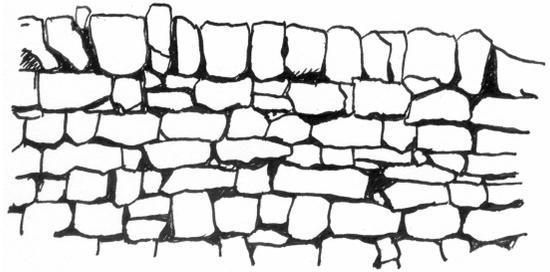
The DSWA keeps a register of the certification level of its professional members. This is available on line at <http://www.dswa.org.uk/Professional-Services-g.asp>.



Smooth line and batter



Tight wall



Slack wall

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