

Dry Stone Walls

of the

United Kingdom



*with a focus on construction
methods and techniques*

Dedication:

*This study is dedicated to my parents who have
been so supportive of my education and passion
for dry stone walls.*

Written and Illustrated by

Brian Post

*State University of New York College of Environmental Science and Forestry.
Landscape Architecture Off Campus Program.*

Fall Semester 2005

Faculty Advisor: Professor Emanuel Carter

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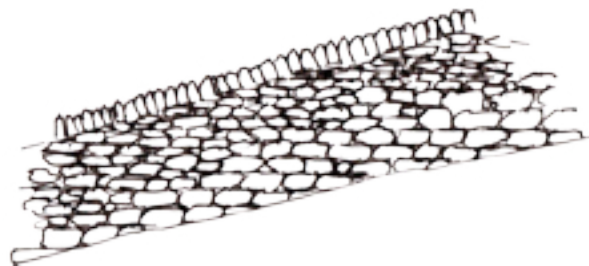
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Introduction

Origins of the Study

I first became interested in stone walls at the age of 13. I am not sure what sparked my fascination with walls, but I remember that I liked the feeling of history that the walls had. I grew up in the rural wooded hills of Barnard, Vermont, and there were old farm walls running along the roads and through the woods of the land surrounding my home. I built my first true wall in the summer of 1998 (age 14) after reading a book given to my family by an elderly neighbor: *The Forgotten Art of Building a Stone Wall* by Curtis P. Fields. Reading this book ignited my desire to build stone walls.



Standing with my dog Abby by the first wall I built.

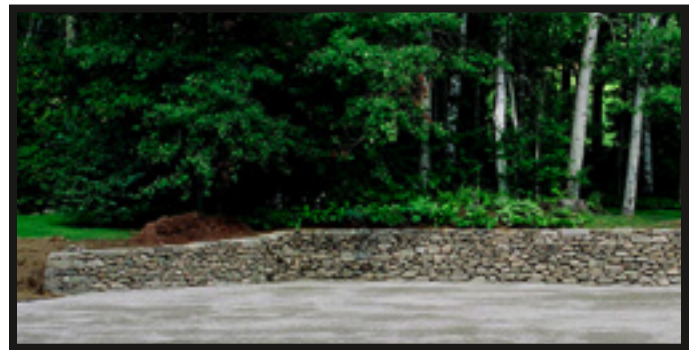
Over the next two years I built several walls on my family's property and my skill and confidence continued to grow. In the summer of 2001 I began to work for several neighbors rebuilding the old farm walls near their houses. This continued the following summer and I expanded to working for several other people as well. Over these two summers I built over 500 lineal feet of wall.

These early walls were of good construction considering the limit of my skill and knowledge at the time. However, looking back I see construction faults and weaknesses that I was unaware of at the



A wall built during the summer of 2003

time. In the summer of 2004 I began to work for Terrigenous, a landscape design/build firm based in Chester, Vermont. Co-owner Scott Wunderley is a skilled waller. Scott not only taught me much more about building a strong wall, but also stimulated my desire to learn more about walls and how to build them to the best possible standards. Working with Scott, I improved my skill and speed. I also realized that he knew a great deal about walling that was not in any book I had read. I was interested in learning the detailed and advanced techniques that he had either learned from other wallers or figured out himself. When the opportunity came for this off-campus study there were few topics that I found more interesting or intriguing than dry stone walls. I found it to be the obvious subject for my study.



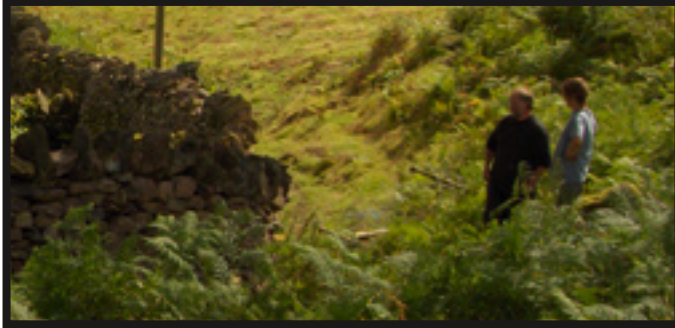
A retaining wall that I worked on with Scott Wunderley and Scott Bowman while working at Terrigenous

Building on my experience with Scott Wunderley, I understood that each waller has a bed of knowledge that he or she works from, and I wanted to learn this knowledge. Thus I directed my study so that I could learn and record some of the different techniques and styles used in the UK.

One key to this study would be working alongside skilled wallers to observe what they did, discuss it with them, and try it myself. Thus, I sought several wallers with whom I could spend one or two weeks working. Through the Dry Stone Walling Association (DSWA), I was able to make contacts and arrange to work with three wallers in England and one in Wales.

An Introduction to the Wallers I Worked With

Jerry Gavins was the first waller that I worked with. I spent the last week in August and the first week in September walling with Jerry and his co-waller, Vanessa Good. They are based out of Ulverston and build walls throughout the southern Lake District.



Jerry and Vanessa inspecting a wall they just built.

Jerry first became interested in dry stone walls when he was working as a lineman for the railroad. One of the responsibilities of linemen at that time was to maintain the walls that prevented livestock from coming onto the rails. However the rail company did not provide any training for the rebuilding of walls. After becoming frustrated that his repairs did not last, Jerry began to read and learn about walling and became a skilled and confident waller. He also became involved with the British Trust for Conservation Volunteers (BTCV), which runs training courses and other walling events.



Jerry at work building a wall.

By 1979 Jerry found he was more interested in walling and it was better paying than his work as a lineman, so he started to wall full time. Since 1986 he has also been teaching training courses

in drystone walling. He has trained hundreds of people in the basics of walling over the past 19 years.

Jerry is not a member of the DSWA because he takes issue with several of their policies and standard specifications. He expresses his opinions without hesitation and usually makes a valid points.

Vanessa became interested in dry stone walls through the BTCV, and learned walling from the courses Jerry was teaching in 1993. For a while she walled on her own, but then joined forces with Jerry, and they have been walling together since.

The vast majority of walls that Jerry and Vanessa build are field walls. Jerry does not like to get involved in garden and landscape walls because there is too much time spent muddling with the design and clients. Jerry much prefers rebuilding field walls where the job parameters are straight forward and clear.



Vanessa putting the finishing touches on a section of wall

Jerry tends to be more focused on structure when he walls, although neatness is still a consideration. Vanessa tends to build slightly neater walls and is perhaps just slightly slower. Both build all walls in courses. They are often working with the irregularly shaped stone that is typical for much of the lake district. They have a reputation for producing good walls out of the worst stone, and will take jobs that have been turned down by other wallers. Their clients are often farmers who wish to maintain their walls and the National Trust. On a typical day Jerry and Vanessa will build at least 6 linear meters of wall, with a height of about 1.5 meters.

The second waller that I worked with was Andrew (Andy) Loudon. I spent the middle two weeks of September working with him. Andy is based out of Coniston and does the majority of his work in the Lake district.

Andy had been a carpenter in building construction. He became interested in the stone cladding that was being done on the sites where he was working. Although Andy was keen to give working with stone a try, the stone mason on the crew was protective of his craft. Eventually Andy got his chance. When the stone mason was off work due to illness, Andy offered to take over the stone work. He quickly found that he liked this craft and continued working with stone. Although his first stone work was mortared, he soon shifted to dry stone walling and the DSWA.

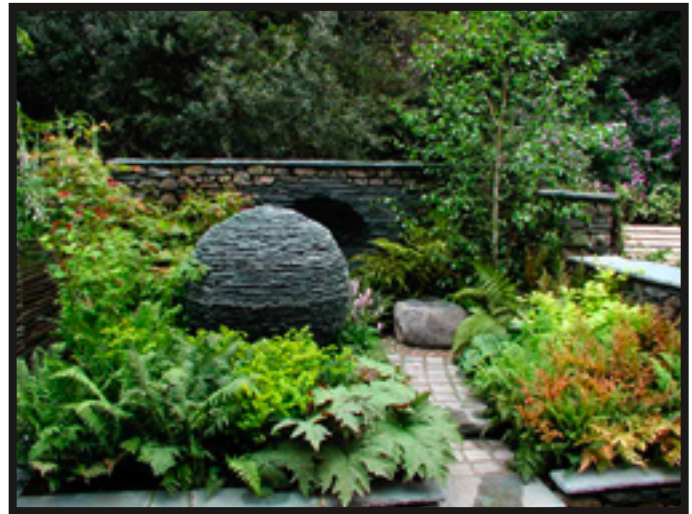
Andy has been walling professionally for the past 15 years. Throughout his walling career Andy has been active with the DSWA. He has participated in competitions and demonstrations for many years. He holds master craftsman certification from the DSWA as well as being a walling examiner. Currently Andy is the only professional waller on the DSWA national committee.



Andy, with his dog Tod in front of a wall being built.

In his competitive walling career Andy won many local competitions and performed well at the national level. He told me that he has found competitions to be one of the best ways of improving his skill because of the opportunity to work next to wallers who were more advanced than he was.

Nearly all of Andy's work is with landscape and garden walls. While he enjoys rebuilding field walls, he prefers the better earnings from building garden walls. Andy has built gardens for several competitions, including the 2005 Chelsea Flower Show, where his garden placed 2nd. On several occasions, he worked for Andy Goldsworthy, a renowned artist in walling, and he has built feature walls in the US and mainland Europe. Andy is one of the top wallers in the UK.



Andy's 2005 entry in the Chelsea Flower Show, featuring a dry stone sphere in the foreground and a wall with the negative space of the sphere at the back.

(Photo: Andrew Loudon, 2005)

Andy works with a wide range of stone types, from random field stone to finely shaped sandstone. He has a reputation for building dry stone features which require a great deal of shaping. He usually builds dry stone, but will build mortared walls when they are called for.

As Andy's business grew, he employed wallers to work for him and at one point had 8 employees. But then he was doing virtually no walling himself, and spent all his time driving around inspecting projects and managing his business. With multiple wallers working for him, Andy found it difficult to maintain the high standards he wanted. Finally Andy cut back to one employee so he could return to walling himself. As it turned out, his employee was on vacation while I was working with him, so I worked with Andy alone.

I spent the first half of October working with Andy Chapple, the third waller that I walled with. He is based in the village of Chedworth in the Cotswolds, and does nearly all of his walling in Chedworth and the surrounding villages.

Andy worked in farming until he was in his early twenties. During this time he built some stone walls as part of the farm upkeep. However, after that he went into the technology industry working for the BBC and Orange, both in Bristol. Nine years ago he moved to Chedworth, but continued to commute to Bristol. While living in Chedworth he became interested in the surrounding countryside and walls. He gradually began learning about walls and started to do some small odd walling jobs. He eventually became interested in starting to wall full time, but was reluctant to lose the security of his current full time job.

In 2002, due to his wife, Catherine, being diagnosed with cancer, he needed to work near to home and with more flexible hours. This was the impetus that he needed to start walling full time. Catherine has since recovered, and Andy has continued to wall.



Andy stripping out an old field wall.

Andy's work is roughly equally divided between rebuilding farm walls and building landscape garden walls. Cotswold stone is a level bedded limestone that is quite soft and easily shapable. Andy builds his walls coursed, as is traditionally done in the Cotswolds.

In addition to walling Andy also does some work on the side salvaging and reselling stones. Some stones can be quite valuable, such as old quoins, (corner stones on buildings) so this can be

reasonably profitable. Although this is a small part of his income, it has become part of his work.

Because Cotswold stone has a tendency to deteriorate relatively quickly, weathered stone is expensive and hard to come by. Thus newly quarried stone is often needed when rebuilding old walls, in addition to building new walls. Because of this frequent use of quarried stone, Andy has developed a relationship with the local quarries, and was able to arrange for us to take a tour of Huntsman Quarry.



A tall freestanding wall built by Andy.

Andy is not a member of the DSWA because he does not feel that it holds any advantages for his business. Andy learned to wall independently and has been getting plenty of work without any certification. Therefore he is quite happy to continue walling independently from the DSWA.



Andy and myself in front of one of the walls we worked on together.

Sean Adcock was the final waller that I worked with. He is a DSWA master craftsman and a very skilled waller. I worked with him during the last week of October and the first of November. Sean is based near Bangor, Wales, and builds walls throughout North Western Wales.

Over the years Sean has been very active in the BTCV, working as a volunteer and an employee. He has set up and taught courses and worked on many projects for the BTCV.

Sean became self employed in 1986. At that time he was primarily doing forestry work and fencing but some walling was included. Gradually walling contracts increased and other work decreased until he was walling full time.



Sean, standing in front of a tall freestanding wall that he built several years earlier.

Starting in the early 1990's Sean became active in the DSWA. In 1993 he achieved his Master Craftsmen certificate from the DSWA. Between 1993 and 1998 he was one of the few people active in the North Wales Branch of the DSWA. He started and produced, and was the main contributor to the branch magazine Stonechat (Adcock, 2001).

He has written numerous articles on walls, and related issues. He wrote the *Specifications for Traditional Welsh Cloddiau* leaflet published by the DSWA. Sean was also one of the authors of *Dry Stone Walling: A Practical Handbook*, published in 1999 by the BTCV. This is the most detailed and comprehensive book on dry stone walls that I have seen. Although no longer active in the North Wales branch of the DSWA, Sean is still a member of the branch, and the national DSWA.

Sean has had a very successful competitive walling career. He has won the North Wales Professional Championship six times between 1993

and 2000. He also placed first in the Grand Prix, a national walling championship, in 1992 and 1997. Additionally Sean has won numerous competitions throughout Wales and England. Since 2001, however, he has semi-retired from competitive walling (Adcock, 2001).

Sean does a combination of landscape/garden and field walls. Typically he prefers to do field walls in the winter when the weather is worse, and the added complications that often occur with garden walls can be avoided.



An arched niche incorporated into a farm wall built by Sean.

Sean is dedicated to walls. He walls more for the sake of building the wall to his best ability, than for the income. He can talk about walls more than anyone I have met. Sean is very skilled at evaluating the construction and has even written a number of formal reports on walls that have been poorly built.

Sean is very skilled at working with difficult irregular stone and in difficult conditions. He also maintains very high standards even when working where there are difficulties. Working with Sean can be challenging because he has a very critical eye, but due to this I was able to learn a great deal from Sean.

The History of Walling in the UK

Nearly everywhere in the world where stone was plentiful it has been used as building material. Dry stone walls are found throughout the world. The British Isles, however, have one of the richest drystone histories. Dry stone structures have been discovered in the UK that date back more than 5000 years, and the building techniques used then are remarkably similar to those used in modern drystone construction.

Early Dry Stone Walls.

The earliest known dry stone constructions in the UK are the Neolithic dwellings in Orkney, Scotland. The oldest is Knap of Howar dating back to 3500 BC. While these early dwellings are different than the modern walls of today, the construction principals are virtually the same. (Noonan, 2000).



Knap of Howar dwelling.
(Photo: Noonan, 2000)

Much more impressive dry stone structures appear in the form of Scotland's numerous Brochs. Brochs are circular dry stone towers, the majority of which date from between 200 BC to 200 AD. Each brochs is thought to be the "defended residence of a locally powerful lord" (Noonan, p14).

Ingenuous methods were used to build brochs in excess of 35 feet high. The walls were very thick at the bottom and tapered inward as they went up, much like the batter on today's farm walls. Unlike farm walls, however, the walls were hollow. They were build as two separated walls connected with long flat slabs, leaving space in the walls that contained stair ways and other rooms. If anyone ever argues that tall drystone walls won't last, Scottish Brochs are excellent proof to the con-



Mousa Broch, Shetland, still stands more than 40' high.
(Photo: Noonan, 2000)



Dun Troddan, one of the brochs of Glenelg, shows the hollow wall construction.
(Photo: Noonan, 2000)

Dating agricultural walls is notoriously difficult. Walls eventually fall and are rebuilt, so there can be walls in a location that date much farther back than when the present wall was constructed. Some of the earliest walls built for agriculture are thought to be in Cornwall and are estimated to go back two or three millennia (Dry stone Walls: The national collection, 2002).

The next oldest walls were built around church yards and monasteries in the early medieval ages. Circa 1200, monasteries began to build walls enclosing larger areas of land. The objective was to clear the land as well as enclose the monasteries' pastures. These walls were "massively built though with little refinement of technique. They consisted of wide high walls of simply piled stone that ran for

miles with no concession to any steep slopes” (Dry Stone Walling Techniques and Traditions, 2004). Despite the lack of refinement, these walls are the earliest large scale dry stone field enclosures in the UK.

Agricultural Walls.

The vast majority of the walls that cover large areas of the UK were built in three stages between 1400 and 1900. These walls were built for agricultural reasons, primarily the retention of livestock.

The first stage of agricultural walling was begun in the 15th century and mainly consisted of tiny enclousres near small villages. They are indicative of a shift away from communal farming toward individual land holdings. The walls were often massive, lacked refinement, and had no specific layout. It is thought that these early enclosed fields were used for growing crops, and pasturing was still done on common land (Garner, 2005).

The second stage of walling came with the increased demand for wool in the 16th century. With increased flocks of sheep larger enclosures were built for pastures, and in some cases for increased crop production. Although still small by today’s standards, the enclosures of the second stage were substantially larger. The enclosures were still of irregular shape, but the walls from this period tended to be built in straighter segments, and the field shapes from this period indicate some thought went into the layout. The walls of this time period were still built by the farmers, but the level of refinement in the construction was increasing. Such walls were primary built in valleys and more readily farmable areas, still close to villages but farther out than the original enclosures. The practice of enclosing these small fields with walls continued until the second half of the 18th century when the Parliamentary Enclosure Acts began to be passed.

The field enclosures that took place up to this point did so because commoners were legally allowed to enclose their allotment of land. This was made possible by small and local independent enclosure acts. However this was nothing compared to what was coming with the Parliamentary Enclosure acts.

The Parliamentary Enclosure Acts were a series of more than 1000 separate acts allowing land to be enclosed. The Acts began around 1750

and each one legalized enclosing a specific area of common land. The Acts were pushed forth by the wealthy. Primarily the Acts stripped away the land needed by commoners to survive as farmers, and gave it to the wealthy to serve as vast private grazing lands. The enclosure acts were socially very unpopular among the lower classes and forced many farmers into poverty, while the new land owners became wealthy. (Turner, 1996).

In 1801 the Enclosure Consolidation Act was passed in an attempt to clean up the previous Acts. In 1845 the General Enclosure Act made further attempts to clarify previous enclosure legislation and allowed the further enclosure of land without Parliamentary Acts. Over 7 million acres of land, 21% of England was enclosed during this time (Enclosure Act - Wikipedia, 2005).



Enclosure walls on a north Welsh Hillside.

Enclosures in Scotland and Wales also took place during this time period. It is important to realize that the UK was not enclosed uniformly nor was it simultaneous.

Although the social and economic results of the enclosure acts can be deplored, the effect on walls and walling was profound. Land owners now required their land to be enclosed and walls were a favored method. It was during this time that walling first became a profession. Most enclosure acts required that the land be enclosed within a time period of a year or two, and often there were many miles of wall to build. At this time, teams of professional wallers were employed to build huge quantities of walls in short periods of time. Some wallers were local and others were nomadic, traveling from one project to another.

Enclosure era walls were surveyed so they run perfectly straight paths, sometimes for miles. They are the walls seen high up on hillsides, fells and moors. Standards for construction were es-

established to guarantee the walls were built to last. These are the standards still used today, concerning the placement of through stones, thickness and height of wall, and cope (Brooks, 1999). Also for the first time quarrying was done for walling stone in some areas, rather than just digging stone up near where the wall was being built. This was particularly true in the case of through stones which in some cases were transported long distances to areas where suitable through stones could not be located. However it was still most common for walls to be built from stone that was from the immediate area. This can be seen when looking at a wall running up a hillside where the type of stone changes on the hillside; the stone in the wall will usually change in the wall as well.

The Fall of Walling.

By 1900 walling activity had greatly decreased, and in many areas was nearly non-existent. The era of Enclosure Acts was done, and there was very little reason to build new walls. The majority of walls were still of recent construction and did not need repairing, so walling was on its way to becoming a forgotten art. Other new forms of barriers such as wire fences on wooden posts were also gaining popularity because they required less labor.



Derelict enclosure walls in the in the Lake District.

Rebirth of Walling.

Through the first two thirds of the 20th century there was little interest in walls. Few were built or maintained during this time. However beginning in the 1970's there was renewed interest in walling.

The increased interest in walls and walling can be attributed to a variety of factors. Perhaps the most important was that value was being placed on maintaining the traditional British agricultural landscape (Brooks, 1999). In addition, increased tourism to rural

areas meant that many more people were exposed to walls, and this led to greater interest as well. What has resulted is that as part of the greater traditional farming landscape, "walls have been given a value far above their straight economic importance" (Brooks, 1999).

The Rise of Walling Organizations.

With the renewed interest in walling a number of groups, local and national, began to provide training and information on walling technique. At the national level such groups included the British Conservation Trust for Volunteers (BCTV), the Agricultural Training Board (ATB), and perhaps most importantly the Dry Stone Walling Association (DSWA). At the local level it was groups such as the Friends of the Lake District (FDL), and the Costwold Area of Outstanding Natural Beauty (AONB). These groups all promoted walling through training, volunteer work, public policy, publicity, and grants.

The Dry Stone Walling Association. The Dry Stone Walling Association of Great Britain (DSWA) has been a driving force in the walling community since it was founded in 1968. The national association was initially formed by the members of the Stewartry of Kirkcudbright Drystane Dyking Committee which was formed in the 1930's in the Galloway region of Scotland (Clark 2001).

Since its formation the DSWA has been organized and run by and for its members, and is set up as a registered charity organization. There is a national organizational body to which people are elected. Local branches of the DSWA are then organized in prominent walling areas. (About DSWA, 2005)



The DSWA logo.

The DSWA is run by volunteers at the branch level and primary so at the national level as well. However the DSWA does employ Alison Shaw as the Office Administrator at the National Headquarters in Cumbria. The national committee includes a representative from each of the local branches as well as those serving in management of the national organization.

The DSWA "seeks to ensure the best craftsmanship of the past is preserved and that the craft [of dry stone walling] has a thriving future" (About DSWA 2005). The DSWA is actively working to improve the knowledge and understanding of dry stone walls. "It produces a series of information leaflets, practical

books on the craft and promotes walling competitions.” (About DSWA, 2005). In addition the DSWA has produced several instructional videos, and sets up walling training courses, competitions, and demonstrations. The DSWA also produces a magazine, *The Waller and Dyker* on a quarterly bases which is sent to all members.



The DSWA offices in Cumbria

There are five membership options in the DSWA. Membership fees are on an annual basis and are used for administration and organizational costs. In the Summer of 2001 the DSWA reported having over 1200 members including 250 professionals. Professionals are defined as people who make a majority of their income from walling. In addition to membership at the national level, each local branch also has a separate membership. There are currently 19 branches within the UK, and 4 international branches, one in Canada, one in Australia, and two in the USA, one in Vermont and one in Kentucky. The map shows the geographical locations of the branches within the UK.



The DSWA UK branches.
(Image: DSWA Branches, n.d.)

The 1990s was perhaps the DSWA’s most active decade thus far. During this time walling competitions were very popular, and an annual national Grand Prix competition was organized. This involved wallers competing in a number of competitions around the country. The scores would be added up from all the competitions to choose the final winners. This was run from 1991 until 1999 when interest had declined. Over the past 6 years there has been a decline in walling competitions in much of the country. The outbreak of foot and mouth in 2001 can be partly to blame for this as it limited unnecessary movement of people onto and off of farms, preventing access to many walls. However it was mainly due to a decline interest in competitive walling. That said, there are still many local and regional competitions occurring each year, and there are signs of renewed interest of competing at the national level. Walling competitions are judged on quality rather than speed, although there is a set time period in which the walling must take places. The exact specifications and rules vary with the location, however they are all relatively similar.



A display of information about drystone walls inside the DSWA offices.



*A walling competition underway.
(Photo: Clark 2001)*

Another important function of the DSWA is the administration of a certification scheme that helps to maintain high standards in walling. There are four levels of certification, initial, intermediate, advanced, and master craftsman. Certification is based on a practical demonstration of the applicant's skill to build a wall in the presence of an examiners. Certification is based on quality and speed. Recently this certification process has been recognized by Lantra Awards, a national job training and education organization. Certification is not compulsory, and there are excellent wallers who hold no certification. Few contracts require that wallers be certified, however certification does help to establish credibility. Some contracts are now beginning to specify that the work must be overseen by a certified master craftsman, but this is still unusual.



*A nearly finished Initial level test wall.
My section is in the center.*

Certification does help to establish standards for the craft. However it has not been without its own problems. Dry stone walls are incredibly variable due largely to the stone being used, but also due to the local style. The fact that certification is based on a nationwide standard makes it difficult to apply to all locations. There are some allowances for these variations within the system, but there is still a tendency to build

to a national pattern, rather than to local styles.

The DSWA is an unusual organization in that it represents both amateurs and professionals. More unusual still there has been a recent trend toward professional wallers contributing less to the policy and administration and the amateur and hobbyist wallers doing most of the work needed to run the organization. Indeed only one professional waller, Andrew Loudon, is currently on the national committee. This pattern is not surprising in that the DSWA is run by volunteers, and those earning a living from walling have little time to donate. However this situation has led to something of a rift forming between DSWA and the professional wallers. Many of the professional wallers are unhappy with current policies of the DSWA. How this situation will play out in the future is yet to be seen.



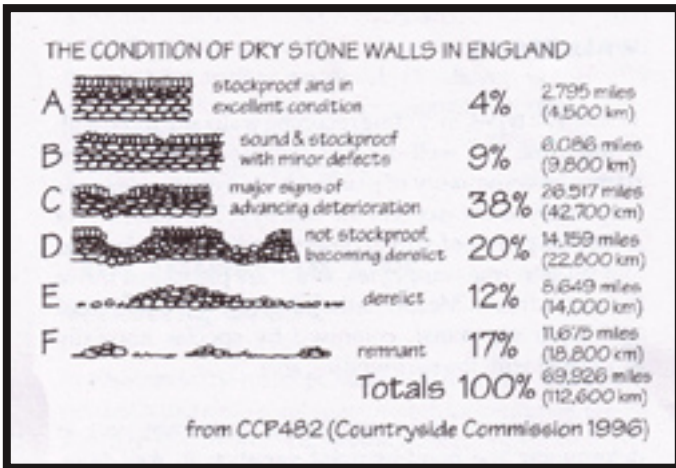
*The DSWA booth and demonstration wall,
Westmorland County Showground. The
demonstration wall was built by myself, Andy
Loudon, and several others.*

It is clear that the efforts of the DSWA over the past 38 years have greatly increased the interest in walls and walling. The DSWA has developed a wealth of knowledge, standards and information about walls and walling. This information and continued efforts by the DSWA has made the UK the place to come for people interested in walls. There are fantastic examples of dry stone walls around the globe. But largely because of the DSWA there is far more accessible walling knowledge and information available in the UK than any other location.

Modern Walling.

Walling in the UK since the second half of the 20th century is somewhat different than it was before. Nearly all walling that is done now is either the rebuilding of existing walls, or building new walls for aesthetic reasons rather than agricultural function.

A 1994 survey by the Countryside Commission (now the Countryside Agency) evaluated the condition of the walls in England. It found that the majority of the walls in the UK are in poor condition. The table below shows the details of this survey (Brooks, 1999).



The results of the Countryside Commission's evaluation of the condition of English walls. (Image: Brooks 1999)

The process of rebuilding a wall takes much the same amount of labor as the initial building, with the exception that at least most of the stone needed is at hand. With so many walls in need of repair, it is not surprising that much of the walling activity in the UK is simply the rebuilding of existing walls. However, labor is not cheap as it was in the time when the walls were first built. Thus funding the rebuilding of walls is by far the most limiting factor. In areas that have been designated as having historical importance or natural beauty grants are available for the reconstruction of walls. However these grants do not cover the full cost of rebuilding the wall. Thus the farmer or landowner must still put up money in order to have the walls rebuilt. Most farmers do not have the ability to pay out money for wall repair, so much of the rebuilding of agricultural walls is taking place on land owned by the National Trust, or other organizations.

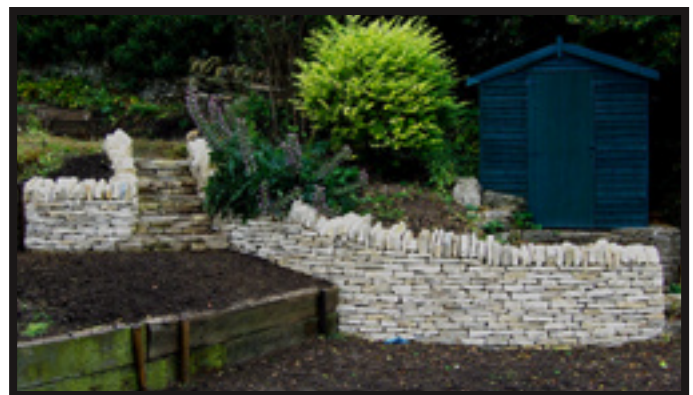


A Lake District wall, not yet fall, but in need of rebuilding.

There are no stipulations as to the quality of construction required to receive grant money, because the grants were intended to encourage farmers to repair their own walls. However few farmers take advantage of this, preferring to hire out the walling. This has resulted in many walls being poorly rebuilt by wallers who are not adequately skilled, but are willing to work for less money.

Walling for aesthetics has become quite popular over the past 40 or so years. Walls are built for gardens and included in many landscape designs. Walls are also being built along new roadways where they go through walling areas.

Garden and Landscape walls have become the best paying walling projects around. On garden walls, high profile wallers, such as Andy Louden, charge more than three times the going rate for field walls. Other wallers also find that they can charge more than what is available for rebuilding agricultural walls. Building walls used for landscaping is definitely a direction that will continue to expand as long as people have money to spend on their landscapes.



A garden retaining wall built by Andy Chapple.

There are virtually no new walls being built for agricultural purposes. In most locations there is little need, and fences are much cheaper alternatives. The nearest thing to field walls that are built are walls along new roads. These can sometimes stretch for miles. Unfortunately they are usually built by the lowest bidder so the quality is often very poor.



A five year old roadside wall in Anglesey Wales. The wall was very poorly built and sections have already fallen, as shown in this picture.

In addition many road designers have a dislike of dry stone walls because the strength depends on the quality of construction. For this reason many new roadside walls are built with mortar. This unfortunately rarely matches the surrounding walls, which was the reason for building the walls in the first place, so that the new road would fit into the landscape. It is a troubling problem that the money needed to build the walls is a tiny fraction of the cost of the road, but the government won't slightly increase this tiny fraction to ensure the walls are well built.

Why Dry Stone Walls?

Throughout history drystone walls have had a number of distinct advantages over other forms barriers or structures. Stone is a very hard wearing material. It last for ages, and will not be affected by decay or fire as wood is. These properties of stone have been the main contributors to the use of stone over the centuries.

The earliest dry stone structures, such as the Scottish Brochs were presumably built for defensive purposes. Thus stone was the natural choice. They were dry laid because mortar was not yet invented in that area.

The walls built between 1500 and 1900, which account for the majority of what is presently seen, were built because stone was the most suitable or most readily available material in those locations. In areas where hedges could be grown, this was often the preferred method of enclosure. However it is impossible to grow hedges in windy exposed sites, or where there is little soil. Wood was not a plentiful resource in the UK at this time. Wood also rotted quickly in the wet environment. In addition wooden fences must have posts driven into the ground. In stoney upland areas this could be nearly impossible. In other locations land was cleared of stone so that it could be tilled. Building walls out of the stone at the field edge was the most practical means of waste disposal. It also had the added advantage of protecting the planted crops within.

The UK is not uniformly covered with dry stone walls. They occur only in areas where they were the most practical means of enclosure. In areas where stone was not immediately available walls were not built. The boundary between areas with walls and those without can be quite defined.

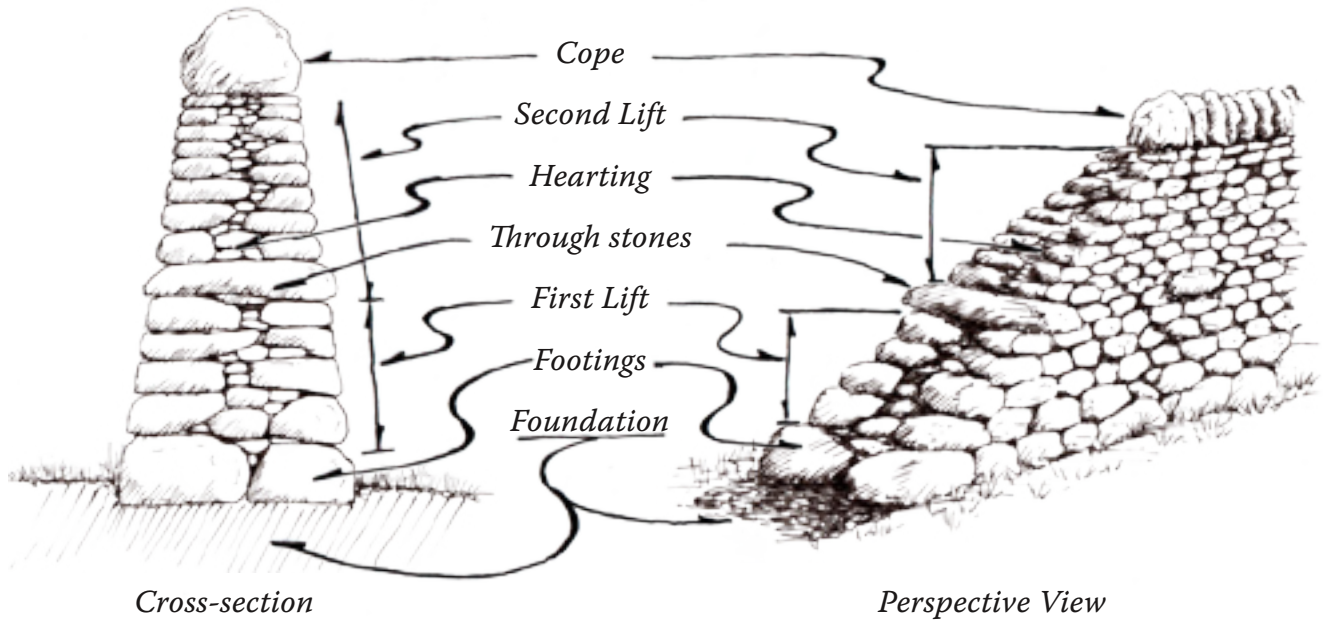
Dry stone walls also have the advantage that they provide protection for sheep from the wind. In cold wet weather this can be very important to the survival rate of lambs. While a mortared wall might offer similar protection, mortar was not easily available until the 20th century, and even then was too costly to use in field walls.

Building walls always has required a great deal of labor. Thus the vast majority of walls were built when labor was cheap. At certain times in the past wall building was also used as a means of relieving unemployment.

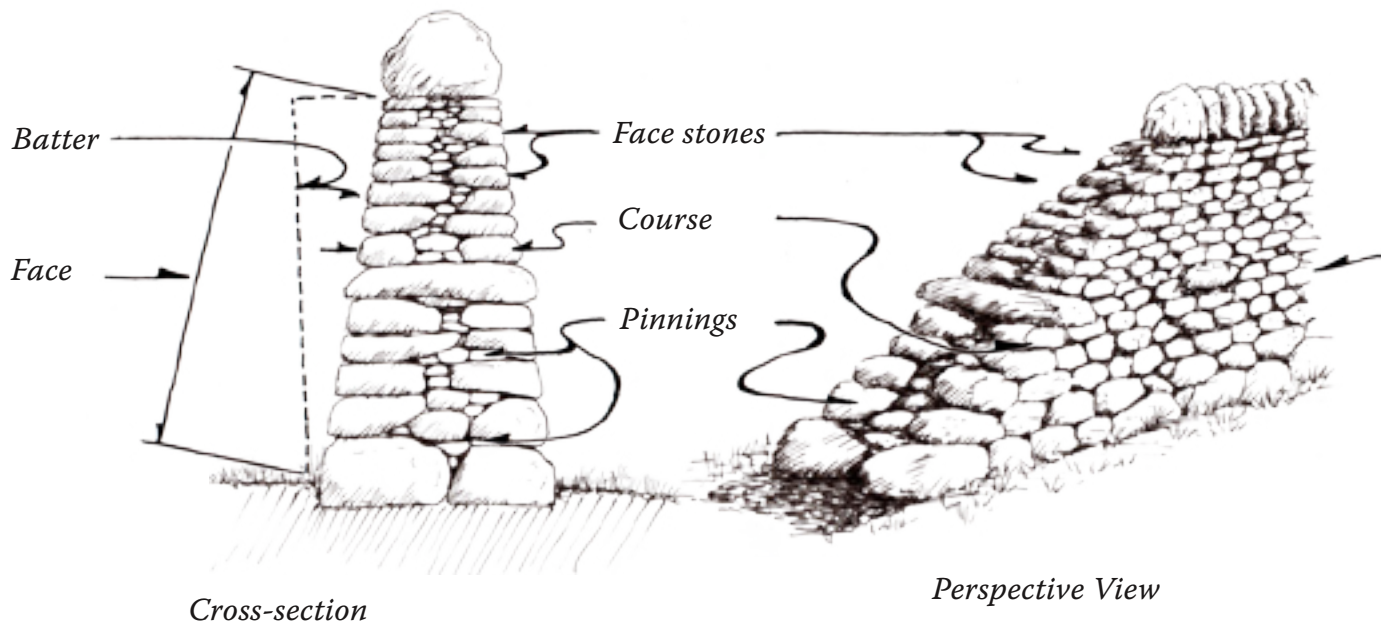
Walling Basics

Anatomy of a Wall

Walls have a number of distinct parts. While there is considerable variation in some styles of wall, most are similar to the one labeled below. The parts of the wall are described in detail on the facing page. Other types and styles of walls are described in the Advanced Walling section.



There are also several other terms that are important to know when discussing walls, as labeled below.



Foundation: This is what the wall is built on. For field walls it is often the native soil with the turf removed. Landscape and garden walls may be built with a bed of crushed stone or in some cases concrete.

Footings: The footings are the stones that make up the bottom layer, or course, of stone upon which the rest of the wall sits. The stones that make up the footings are commonly called foundation stones. The footings are usually the largest stones in the wall. The footings may be partly or entirely below ground depending on the conditions in which the wall is being built. In some cases the footings are called foundation stones or collectively referred to as the foundation.

First Lift: This refers to the lower portion of the wall, from the foundation to the level of the through stones. This includes the face stones, hearting and pinning. The first lift is made of larger stones than the second lift.

Through stones: These are stones that extend through the wall, connecting the two sides. They are typically set roughly every meter along the wall and are halfway up the height of wall. The purpose is to prevent the sides from separating and are absolutely crucial to building a sound wall structure.

Second Lift: This is the top half of the wall, between the through stones and the cope. Like the first lift the term is inclusive of the face stones, hearting, and pinning. The stones are typically smaller than those in the first lift.

Cope: These are the top stones on the wall. There are numerous styles used for copes, but they all basically serve the purpose of adding additional height and capping of the wall in a structurally sound manner.

Batter: Batter is the term used to describe the angle of the face of the wall. In other words the wall is narrower at the top than the bottom so the sides are angled inward. This angle is the batter.

Hearting: Hearting are small stones used to fill in the gaps between the face stones in the wall. Hearting is scaled, like the face stone. Larger hearting is used near the bottom of the wall and smaller pieces near the top.

Pinning: Pinning stones are used to hold the face stones in place. They are very similar to hearting and could be considered a part of the hearting. But pinning stones are specifically chosen and placed to wedge the face stones in place, where hearting stones are only roughly placed to fill in gaps.

Course: A course is the term used to describe a layer of face stones in the wall. Some walls are built without courses, which are referred to as random walls. In many walls however the stone is arranged into courses. The courses may be more or less rigid depending on the stone, walling style and the waller.

Face: The term face can refer to the wall collectively or to individual stones. In both cases it means the side(s) that can be seen. In other words the side of the wall is called the wall face. But, the side of a stone that is visible in the finished wall is called the face of the stone.

Face stones: Face stones are the stones that can be seen in the side of the wall. The face stone make up the majority of the volume and structure of the wall. They are sometimes referred to as 'wall-stones'.



*Coursed vs. Random.
The wall on the left is built in rigid courses. The wall on the right is build randomly.
Both walls are built with the same type of stone.*

Understanding Stone

A basic understanding of stone is important to walling efficiently. Some stone is easy to work with, and other stone is very challenging.

Stone can be divided into two basic categories for walling: level bedded and irregular. Level bedded stones are called such because they split along the beds into layers so that the top and bottom of each stone are parallel. Level bedded stones are most commonly sedimentary, such as sandstone, gritstone and shale. Some limestone is level bedded as are some metamorphic stones, including some slate and shists. Some wallers will also refer to level bedded stone as regular.



An old field wall built of level bedded sand stone.

Irregular stone accounts for all stone that is not level bedded. It can be angular or rounded. Irregular stone does not have flat parallel sides, and will not split so that it does. However stone ranges from being completely level bedded, somewhat level bedded, somewhat random, and completely random.



A wall being built of Silurian Slate, which is very irregular and difficult to build with.

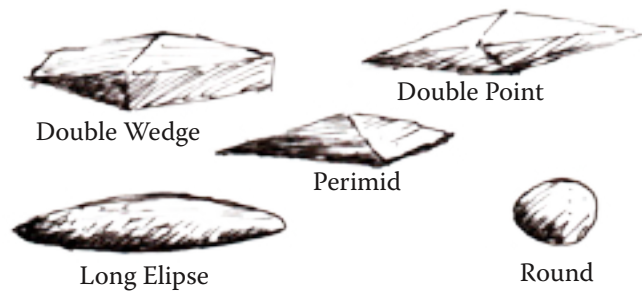
The shapes of irregular stone are highly variable, but there are some that are more useful than others. Stones that have one or more sides at roughly 90° to another side are useful shapes as they tend to make good face stones. Stones with only sharply acute and obtuse angles are much harder to work with.

Rounded stone is not overly difficult to work with, so long as it is not completely round. Most rounded stone still have flatter areas which become the top, bottom, and face. Rounded stones which have flatter areas at 90° to each other are reasonably easy to work with. Rounded over triangles can be quite difficult.

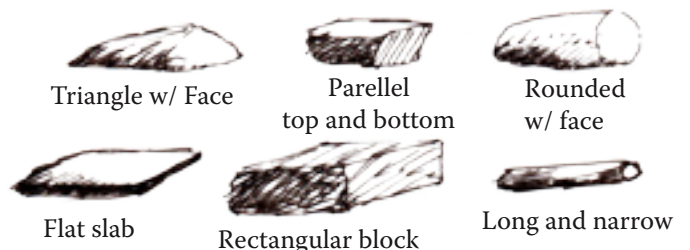
Walls made with level bedded stone tend to look neater and more refined. Walls of random stone tend to look more rustic. Both have their own beauty and both can be built well or poorly.

Some of the common shapes of stone are illustrated below.

Common shapes that are difficult to use.



Common shapes that are easy to use.



Tools of Walling

In its most basic form walling can be done entirely without the use of tools. However, there are many tools which make walling faster and easier. Additionally, the ability to shape stones gives much more flexibility in what can be built. Shaping stones will tend to lead to a tighter, more refined look. A description of the tools commonly used for walling and their use follows.

Hammers: A hammer is the most basic tool used for walling. A common walling hammer is between 2 and 4 pounds in weight and has one square end and one wedge shaped end.



A common walling hammer.

There are a variety of walling hammer styles available. Walling hammers are also called mash hammers, trimming hammers, and striking hammers by different manufacturers. There are variations in weight, balance, and handle length. The shape of the head and orientation of the wedge end is also variable. Every waller seems to have their preference, and much of it depends on what type of stone they commonly work with.

Generally the cost of the hammer reflects the quality of the steel that makes up the head. Inexpensive hammers are made with softer steel that will round over quickly if used often, and can be virtually useless if working with hard stones. At the other end of the spectrum are carbide tipped hammers which are exceptionally useful when working with hard stone such as granite.



A walling hammer with a carbide-tipped head.

Using Hammers:

Hammers are used to trim and split stone. Trimming is breaking off a small part of the stone so that the remaining shape is of the desired size. Usually this is done using the square edge of the hammer, swinging it down onto the stone. If possible it is best to avoid holding the stone that is being trimmed with one hand while striking with the other. This sends a shock impact through the wrist and arm which can result in injury. It is far better to wedge the stone on the ground so it does not need to be held at all, or to use one foot to hold it in place. Trimming is most often done against the grain of the stone. If trimming off a substantial amount, it should be started at the edge of the stone and then gradually worked in until the desired dimension is reached.

Splitting is a means of shaping stones with the intension of using both of the remaining pieces. It is most often done with the grain of the stone, but may be done against the grain in some cases. Splitting is done using the pointed end of the hammer and striking repeatedly along the line of the desired split. If splitting with the grain, this will eventually result in a crack which can be further opened with continued strikes, until the stone splits in two.

When splitting against the grain, it is important to properly support the stone being split. There are two effective ways to support the stone. The first is to support it directly under the location of the desired split, so that a pitching force is caused when striking the stone. The other method is to support the stone at either end and not below the desired split line. When the stone is struck, it applies a bending force, which will split the stone.

When shaping stones it best to wear safety glasses as stone chips can fly in all directions. It is also not advised to shape stones already placed on the wall, or to use the wall as a table on which to shape stones. Both of these practices will often shift other stones already built in the wall. Skilled wallers will occasionally do both of these practices; they should be avoided by inexperienced wallers. An experienced waller can not only judge when stones are unlikely to shift, but also has the eye to see when stones do shift and thus need to be shifted back.

It can take many years to become skilled at shaping stones. While it can be relatively straight forward with some stone types, others stones can be very tricky to break with any accuracy. With experience a waller can learn to 'read' the stones and know whether a stone is likely to break in the desired manner or not. Most wallers try to keep the shaping of stones to a minimum, as it takes time, and slows down the building of walls. However virtually every waller is going trim or split an occasional stone.

String lines:

String lines are one of the most simple and versatile tools, and also the most complicated to used. A standard walling string line has a flattened pin at each end that can stuck in the ground or wedged between stones. The string can be shortened or tightened by winding it around the pins.



String line and pins.

String lines are used to keep the wall straight and the faces even. They can also be used to keep courses level, and when working with a team of wallers, to keep everyone even. String lines are usually used in conjunction with stakes or a batter frame.

There are several different ways to use string lines. The most common method is the one recommended by the DSWA. This method uses one string line on each side of the wall. The string starts near the ground and the wall is built up to it. Once the wall is built up to it, the string line is then moved up, usually about 8" and the wall is built up to it again. This process is continued until the wall is up to its final height.

This method helps to keep a straight and even face on the wall, because there is always a string near by to act as a guide. It is also useful because it is easy to judge horizontal off the strings and thus align the stones to be level.

On the other hand, string lines can be used very wrongly and the results can be appalling. Because the wall is battered, some stones are actually placed slightly outside of the lines. If all the stones are placed directly underneath the string, the wall face will be stepped instead of an even plane. This not only looks terrible, but is usually not stock proof because sheep can clamber up the steps.

Another common flaw when using string lines is to have them set up properly, and then not follow them. If string lines are being used then they need to be followed. Simply having them up will not make the wall right.

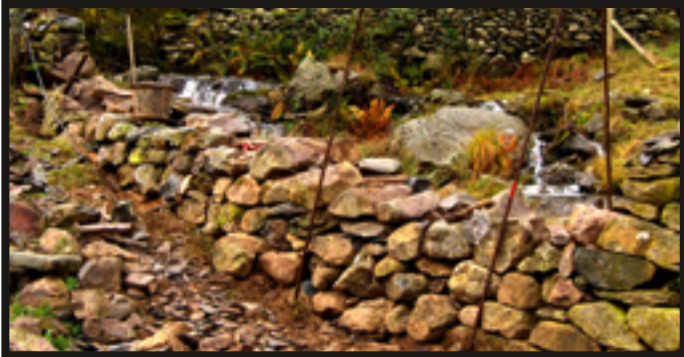
String lines can also be set up incorrectly. They can be in the wrong place, the batter can be off, and they can be out of alignment. Additionally sting lines can shift as the walling progresses. String lines should be checked for accurateness repeatability as the wall is being built. In particular, watch out for tripping on the string lines, pushing the string line out of alignment with stones placed on the wall, and stones hitting the stakes or batter frames.

Stakes and batter frames both have advantages in different settings. Batter frames keep an even batter on both sides of the wall and tend to be more sturdy than stakes. However they are not very flexible. A batter frame has specific dimensions and can only used for building a wall of those dimensions. So a new frame is necessary for almost every wall. The other problem is that batter frames don't work well on uneven ground because the legs have to blocked up or dug into the ground to keep the wall even.



A bater fram in use. Once the wall is built up to the frame, as in this picture, the frame is then moved back, and another section of wall is built

Stakes are much more flexible in terms of how they can be used. The big disadvantages are the fact that stakes have to be driven into the ground, and that the stakes are much easier to bump out of position when building the wall.



Using stakes to hold the string lines, which are too fine to be visible in this photo.

A good compromise can be to use stakes with adjustable wooden crosspieces to add extra stability.

Another way to use string lines is to use four string lines, two per side. One string is put at the base of the wall and one at the finished height. Using this method allows one to sight between the two strings and line each stone up precisely. This technique allows the plane of the wall to be perfectly straight. However it is absolutely critical that the string lines don't shift during construction when using this method. So the stakes or string lines should be set up in as sturdily as possible.

Walls can also be built without string lines, or only using them minimally. Walling without string lines is a very good skill to have, because there are situations where string lines can not be used, such as on curved walls. Some wallers find that not having string lines is more difficult, and others find it easier. Many wallers find using string lines speeds up the process of walling because less time needs to be spent judging if the wall is going up straight and even.

Jerry Gavins is a waller who uses string lines very minimally. He uses a line to make sure the foundations are in a straight line, and then once the wall is nearly finished, he will sometimes use a string to make sure the top is even. Working in this manner takes a different eye than one accustomed to using string lines, but it is just as effective.



A wall built by Jerry and Vanessa with minimal use of string lines.

Other Tools:

There are many other tools that are helpful in building walls. These include crow bars, a mattock or pickax, a shovel or two, a few buckets, a level, a tape measure, and several additional hammers and chisels.

Crow bars, also called pry bars are no more than long bars of steel with at least one pointed end. They are exceptionally useful for shifting and placing large foundations. Several different lengths are available. Six foot bars are the longest commonly available and are the most useful. However a 4 foot bar that can be easily used one handed is also useful. Crow bars are used to lift, and slide large stones.

A good pickaxe is another very useful tool. Its primary use is in stripping out. Stones that have fallen off the wall and become buried will be quickly found when digging with a pickaxe. The pickaxe is also very useful for removing foundation stones, and digging new foundations. A mattock, is a variation of a pickaxe which has an axe-like blade instead of a point. This is designed for cutting tree roots and is very effective at this. However it is less useful than a pickaxe for other tasks. A true pick, with point and chisel shaped ends, is useful if there is no pickaxe available, and will make a good match with a mattock.



A typical pickaxe.

Shovels are used primarily for digging foundations. I prefer a long handled, round pointed shovel and a short handled square bladed spade. This combination provides good versatility for most conditions. Shovels are not pry bars, and generally should not be used as levers. A few plastic farm buckets of 3-5 gallon capacity are very useful for moving excess soil away and for collecting hearting.

Levels are handy for checking to make sure that courses and stones are horizontal. A straight four foot spirit level is the best for this. A small six inch spirit level that can be set on top of stones is also handy. In addition a piece of wood can be cut to form the angle of batter of the wall. This can then be attached to the level, and used to make sure the face of the wall is being built at the correct batter. This is especially useful when building where string lines cannot be used.

Tape measures are fairly straight forward, and are very useful for making sure the wall has proper dimensions. Walling is a very hard environment for tape measures to survive in, so buy cheap

ones and replace them fairly often. In some cases a stick with notches cut in it can be a longer-lasting alternative to tape measures.

Besides a basic walling hammer, there are many of other hammers that are very useful when walling. When using a hammer it is best to use a weight that will result in the desired break in one to five strikes. Therefore small hammers are used for making small breaks, and large hammers are used for large breaks.

The common brick hammer is very handy when working with soft stone, or when working with small stones. In these cases, one strike from a 3 or 4 pound hammer can completely decimate a stone. Brick hammers are typically 16-20 ounces, and are hardened, so they should never be used as a chisel, and struck with another hammer. Brick hammers are also used as a claw for digging stones out of the ground, and as a small lever for lifting stones.

Bull hammers have a similar shape to walling hammers, but are intended for a different purpose. Striking hammers are used to hit the rock directly and have hardened edges. Bull hammers are intended to be used as a chisel, held against the stone and struck on the back by a second hammer. While the pointed tip of a mash hammer is hardened, the square back end is not, thus preventing the head from chipping or cracking. Bull hammers are a very effective tool for splitting stones, and in some cases for trimming. Bull hammers can be used as walling hammers, but walling hammers should never be struck by another hammer. Bull hammers range in weight from 3 to 25 pounds, although under 8 pounds are hard to find. Larger hammers should be used for larger splits. Bull hammers are often preferable to chisels when making large, but precise splits, because the handle keeps hands out harms way, and they can be struck with far more force than a chisel. Using a bull hammer takes two people to use, one to hold the bull hammer in position and one to strike with a sledge.

Sledge Hammers are heavy and long handled. They are most commonly found with a double round head, although they can be bought with a walling hammer type head. Sledge hammers are used for breaking large stones, especially when the exact location of the break is not critical. They are also very useful for breaking stones up to use for

hearting. The round headed variety is also used for striking bull hammers. Weights are typically found between 6 and 16 pounds.



An eight pound sledge hammer.

Chisels are most useful for splitting with the grain and for precise shaping of stones. They can be used for nearly all shaping with stones, but it is usually faster just to use a walling hammer. Chisels are rarely used when building farm walls, but when creating a tight and even garden wall they can be very handy for dressing face stones.

There are different chisels used for different jobs. Tracers have a very acute tip that is best for splitting with the grain. A standard chisel has a wider angle tip that can be used for general trimming and splitting. A pitching, or offset, chisel is best for dressing stones.



A three pound lump hammer with a tracing chisle and glove for scale.

Lump hammers have a double round or square head and are used to strike chisels. They can be used to strike rock directly, but they are generally less effective than a good walling hammer.

A Word on Safety

Dry stone walling does include some elements of risk. By being safety conscious one can dramatically reduce the risks associated with walling.

Wearing the appropriate safety gear is important when walling. Steel toed (steel toe capped) boots are critical. It takes a surprisingly small stone dropped from a low height to inflict a great deal of damaged.

Safety glasses are recommended especially when shaping stones. Chips of stone tend to fly in all directions when shaping stone, so it is important to protect your eyes.

Gloves are used by some wallers and not by others. Some wallers prefer to feel the shapes of the stones as they build because they find it makes it easier to build. Other wallers prefer gloves to protect their hands. I find fabric gloves covered with rubber work very well. Leather work gloves give added protection but reduce one's dexterity which can be problematic when working with small stones. Leather gloves also cost more and wear out quicker.

Lifting heavy stones should be done with the legs, not the back. Lifting with the back can lead to back problems. Also avoid hold stones while shaping them. This sends vibrations through the wrist and elbow, that can eventually lead to problems

It is also important to keep your work area clear of trip hazards and make sure you have good footing when lifting heavy stones.

Setting Up to Wall

Before walling can begin, it is important to get properly set up. If rebuilding an old wall this includes clearing a working space, stripping out the old wall, and often relaying foundation stones.

If a new wall is being constructed this will include clearing vegetation from the walling area, and often digging a trench to place the foundations. Additionally stone must be acquired and brought to the walling site.

Setting Up to Rebuild a Wall:

Setting up to rebuild a wall is often much simpler than when building a new section. The following is the procedure that is commonly used.

Clearing the working area:

Before beginning to wall it is important to clear the area you're going to working in of tall or dense vegetation. Tall grass and bracken should be cut or knocked down. Woody brush should be cut and removed. Tall thick vegetating can hide stone and be a trip hazard. The vegetation should be cleared at least 6ft back from the wall on both sides, and if possible 10ft. However if this is not possible, clear as far back as is possible.

Stripping Out:

This is the process of taking down the old wall. When the old wall has already completely collapsed, it can better be described a picking stone up off the ground.

Stripping out begins by deciding how large a section to take down. If repairing a gap, it is fairly obvious that the wall should be taken down back to sound wall.



A section wall stripped out and ready for rebuilding.

If rebuilding a long section of wall, it usually makes more sense to strip out and rebuild the wall in sections. The ideal length of the section depends on the stone and conditions. It usually makes sense to work on sections between 4 and 20 meters long. Shorter sections help keep the work area tidy. Longer sections give a greater opportunity to find the one perfect stone to solve a particular problem. On the other hand one can end out spending a lot of time searching for stones instead of building with what is at hand. The other advantage to stripping out long sections is that it aids in straightening crooked sections of wall.

Stone should not be left on the ground for more than a few weeks or vegetation can start to cover it up and hinder the building process. Therefore avoid taking down more than can rebuilt in a few weeks. If working with a stone that deteriorates quickly such as Cotswold limestone, this is particularly important.

When stripping stone off the wall it is important to keep things relatively organized, but also to work quickly, and not get hung up on precisely sorting the stone. Generally the stone should be spread so that the stones used in the top of the wall are the farthest away, and the stones used in the bottom are closest.

Since the large stones that make up the bottom of the wall take great effort to move, they should be put nearer the wall when stripping out. This also means that you will not be working on top of stones not used later in the construction.

When building it is very useful to always have hearting within reach, so it should be piled near the wall at intervals of 2-3 meters.

The stone should be spread equally on both sides of the wall wherever possible. Basically the premise is to lay the stones out in a way that makes it as easy a possible to build the wall.

Stones that have especially useful shapes should also be placed in separate piles, especially when working with random stone. In particular, thin flat stones and long narrow shapes are very useful for getting out tricky situations, and thus should be saved for these situations.

Finally, pay attention to the shapes of the stones you are moving. This is your chance to get a feel for the stones you will be working with.

Evaluating the Foundations: If there are foundation stones that are in good positions and sitting solidly there is no need to remove and relay them. Stones that have settled into position over the last hundred or more years are generally far more stable than anything that can be placed in a day. However one of the most common reasons for walls falling is due to foundation stones that have moved into unsuitable positions to support the wall above. Therefor the existing foundations must be evaluated carefully.

Stones that have a top surface that is sloping significantly to the outside of the wall are highly unsuitable as the wall above will tend to slide off. It is best to have a relatively level top surface on foundations, however stones slopping side to side or into the wall are generally acceptable.



Existing footings in need of resetting. The large stone near the center has a top that slopes steeply outward. The stone behind it was set on its edge and is now leaning outside of the plane of the wall.

Often foundation stones may not be in line with the edge of the wall and will thus need to be shifted. String lines are often used to determine the exact location of the wall.

Stones that stick out past the line may be left if the majority of the stone is still under the wall. However the wall will have a neater look if they are moved into line. Foundation stones that do not come out to the line do need to be shifted, as it is nearly always unacceptable for the wall to overhang the foundations. Some walls will require nearly every foundation stone to be relaid, while other walls only the odd one will need to be shifted.

Setting Up to Build a New Wall:

Setting up to build a new wall often requires more planning than rebuilding an old wall. Once the location of the new wall is decided upon, vegetation should be cleared from the area as when rebuilding old wall.

Acquiring Stone: One of the key differences when building a new wall is that stone must be acquired and brought to the building site. If the builder of the wall is gathering the stone him/herself, then the opportunity exists to spread and sort the stone as is done when stripping out.

It is far more likely however that the stone will be coming from off site, such as a quarry or other source of stone, in large trucks and will be dumped in large heaps near where the wall is being built.



This has several disadvantages. The stone has no order, so it is impossible to judge what sizes and shapes are present. Additionally much of the stone is covered by other stones so it can not be seen. There is also a tendency for the small hearting and pinning stones to end up at the bottom of the pile and therefore be inaccessible. If stone is delivered in this manner, one solution is to sort it out as though stripping out. However this can feel like and be a lot of unnecessary work. If you choose to work from heaps of stone, expect to spend more time running around trying to find the right stones. Also don't expect the size of the stone in the built wall to be as neatly scaled with larger stones in the bottom and smaller ones at the top.

Preparing for New Foundations:

There is some disagreement as to the best way to prepare new foundations. The purpose, location and climate are all factors that should be considered. It is often acceptable for field walls to settle more than landscape or garden walls, therefore a less substantial foundation is often required.

According to the DSWA, when building a new wall, a trench should be dug down to firm subsoil, in which to build the wall. A wall should not be built on top of turf or topsoil, both of which are prone to varying amounts of compaction.

On the other hand the trench can end up acting like a drainage ditch, and trap water in the footings of the wall, or wash the soil out from under the footings. If water is trapped amongst the footings and freezes on a frequent basis, it can dramatically shift the foundation stones, and cause the wall to collapse. Therefore in places where water is likely to collect or cause erosion it can be better to not dig any foundation at all, and to build directly on top of the turf.



Footings set on grass for a new section of curved feild wall.

For landscaping and garden walls there is usually a much smaller tolerance for settling so a more substantial foundation is often made, using crushed stone or even concrete. However this also requires substantial drainage considerations. Whenever a trench is dug water will have a tendency to collect there. Thus it is usually necessary to run a perforated drainage pipe in the foundation. This is especially useful in a climate where there is a deep ground frost line.

Placing New Foundation Stones:

Placing the foundation stones properly is very important. If the foundations are poorly laid, the wall will be inherently unstable.

To begin, run a string line at each edge of the wall, just above the ground level. Typically the width of a wall should be about 30", but for more information on dimensions see the section on Wall Design.

Foundation stones should be the largest stones available and be placed so that a face lines up with the string. Each foundation stone should be placed with the largest flat side down. This spreads the weight of the wall out as much as possible. Ideally the foundation stones should have decent faces and a level top surface. Often not many stones that fit within this ideal, so compromises must be made. Foundation Stones should also fit together well and each one should have substantial contact with the stones on either side of it.

Hearting stones should then be securely wedged in any gaps between the foundation stones. If there are any air spaces under the foundation stones, they should be filled with hearting, although such gaps should be minimal if the foundations stones are properly placed. Foundation stones should not be propped up on small stones, as this does not spread the weight of the wall effectively, and the small stones will tend to be pushed into the soil below the wall, causing stones to shift.



A wall being built using unusually large footings. These footings were irregularly shaped, and too heavy to move easily, so getting a perfect fit was impossible.

The Basics of Walling: The basic rules of walling are in fact fairly simple. Jerry Gavins summed up the basics of walling with the following five rules.

1. Cross Joints. This means that each stone should be crossing a joint below it so that it is setting on two stones below it. What should not be done is to stack stones so that there are vertical joints running from one course to the next. Such joints are called Running Joints or Stack Bonds. Walls with running joints are very weak.



A well built wall with all joints crossed on the left. An extreme case of running joints on the right.
(Image: Dry Stone Walling Techniques and Traditions, 2004)

2. Keep Stones Level. This is especially true in coursed walls or when working with a level bedded stone, but applies to all walls. In coursed walls, the courses should be level, even when working on slopped ground. Level bedded stone must walled so that each stone has level top and bottom surfaces. Even when working with rounded or angular stone, the wall will look neater if each stone is placed so that it has some relation to being level.

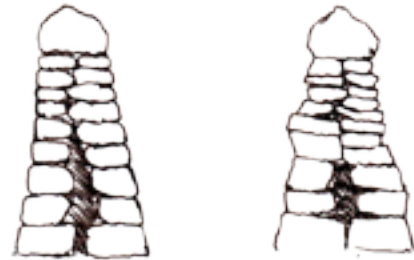


An extreme case of sloping stones. This is a very poorly built wall with lots of defects, despite the exceptionally level bedded and regular stone.
(Photo: Dry Stone Walling Techniques and Traditions 2004)



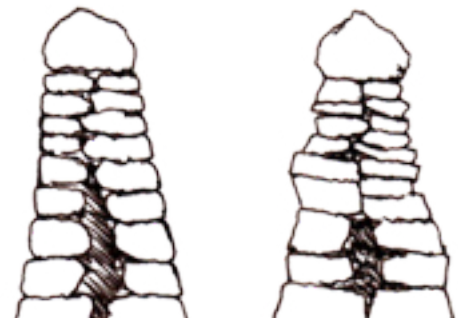
A wall with the stones kept level throughout.
(Photo: Dry Stone Walls: The National Collection, 2002)

3. Build With the Plane of the Wall. This means to align the stones so that there is an even plane to the faces of the wall. String lines are especially useful to keeping an even plane to the wall.



Wall sections: the stones are poorly aligned on the left and correctly aligned on the right.

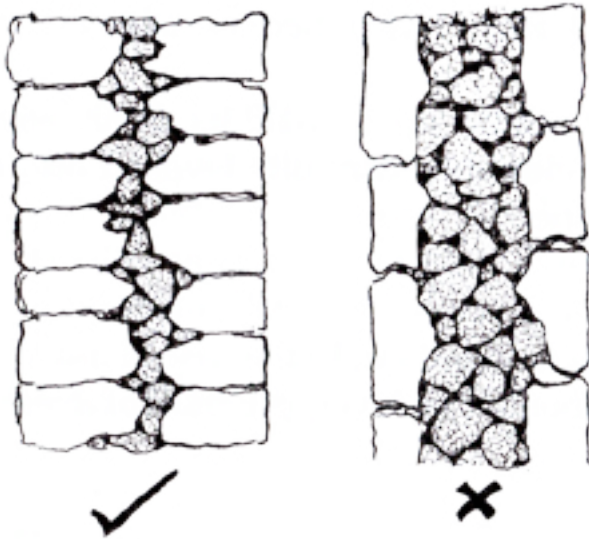
Cross-Section



Plan view of a course in two walls. The stones in the wall on the left are very poorly aligned. The wall on right has the stones aligned correctly.

4. *Set the Length of the Stone into the Wall.*

This means that the end of each stone is the part visible in the final wall. In other words the length of each stone is perpendicular to the direction of the wall. When stones are placed with the wall, so the sides are visible, it creates a much weaker wall and is called trace walling or face walling.



Plan view of a course in two walls. The wall on the left is correctly built. The face stones on the wall on the right are traced, making a much weaker wall.

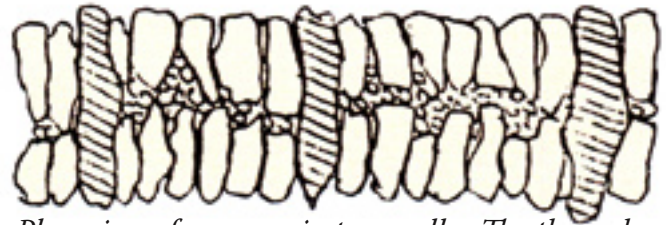
(Image: Dry Stone Walling Techniques and Traditions, 2004)

5. *Heart the Wall Tightly.* The wall should be built as solid as possible. Gaps between the face stones should be filled. The tighter the hearting the stronger the wall. However fewer larger hearting stones are much stronger than many small little bits. Anything that can be easily shoveled is too small to use for hearting. Hearting stones are much better if they are flat or angular. Rounded stones can act like ball bearings and will not work as well. Hearting stones should be placed individually, not randomly thrown in. They do tend to be placed much less precisely than face stones. Additionally, hearting takes place as the wall is being built. Hearting should be filled up to the level of the top of the face stones on the wall, before the next course of face stones are placed on the wall. Both of the walls in the image above have been properly hearted.

Through stones and Coping:

These rules apply to the majority of the construction of the wall. However there are also through stones and coping in a finished wall.

Through stones. The proper selection and placement of through stones is very important to the strength of the wall. Although there are significant regional variations, the purpose is always the same. Through stones must be long enough to show in both faces of the wall. They also must be shapes that can be built on relatively easily.



Plan view of a course in two walls. The through are properly placed and are hatched.

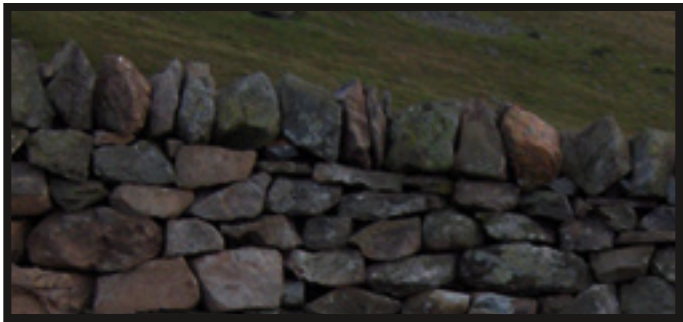
(Image: Garner, 2005)

Through stones are often quite large and heavy. Particular care must be taken when lifting and placing these stones on the wall. Placing large through stones without care can cause movement in the wall below, thereby weakening the wall.

Through stones will frequently protrude slightly from the faces of the wall. This allows stones of varying length to serve as through stones.

In some areas, stones rarely occur that are long enough to be through stones. If this is the case, bonding stones, also called 3/4 throughs are used. These stones are extra long face stones that extend past the center of the wall, with one on each side of the wall, so that the back end of one is sitting on the back end of the other. This is not quite as secure as a single through stone but it is much better than having nothing connecting the two sides.

Coping Basics. Coping is the most varying part of walls. There is a wide range of styles, both due to region and stone types. There is also a wide range of terms used for cope stones. The purposes of cope stones are to add additional height to the wall and to protect the top of the wall from being damaged. Most often copes are set on edge so that they put weight on both sides of the wall, and are wedged tightly together. How well the cope is set can have a dramatic effect on the overall appearance of the wall. If you are working with large and heavy copes, it is best to pick them up in the same orientation as they will be placed on the wall. Also care must be taken not to disturb the top of the wall when placing the copes. If the copes don't extend over the entire top of the wall, rubble should be wedged in behind the copes on the back side. For more on copes see the section on Walling Variations.



A standard cope of irregular stone. The top point of all the copes is in an even line, so that from a distance the top of the wall looks even.

Advanced Walling

Techniques and Variations

Techniques for Refined Walling

If a wall is built following the five rules listed in the previous section, it will be structurally sound and should last for many years if left undisturbed. However there are additional techniques that can be used for increased strength. Additionally the five rules apply primarily to the structure of walls, and not appearance. While this is perfectly adequate for retaining stock, often a more refined look is desired, particularly in garden settings. There are several techniques that can greatly enhance the appearance of a wall. These techniques do not weaken the wall, and often can make the wall even stronger.

The term “tightness” is often used when discussing how refined a wall is. Tightness can refer to two aspects of walls. The first is how tightly the stones that make up the wall fit together. Or rather how small the gaps are between the stones. The second use of the word tightness refers to the overall evenness and straightness of the top and faces of the wall. In other words, how tight was the wall built to the string lines.

Typically the tighter a wall is built, the more refined it looks. However tightness is also relative to stone size and shape. Level bedded stone, can usually create a much tighter wall than irregular stone. Walls built with rounded stone in particular, will tend to have larger gaps.

The size of gap that looks acceptable is also dependent on the size of the stone being used. For example: a 1/2” gap below a 1” thick stone is much too big to be considered tight. The same gap below a 4” thick stone is typically fine, and 1/2” gap below an 8” thick stone would be considered very tight.

When building a wall, the goal is for it to be as tight as possible without slowing the rate of construction down too much. Much of the skill in walling is the ability to build a tight wall quickly. The tightness of construction depends on how well the stones fit together. This is a matter of selecting the right stone for the right place on the wall, where it fits tightly with its neighbors. With square level bedded stone this is quite easy. However with irregular stone it can be quite challenging.

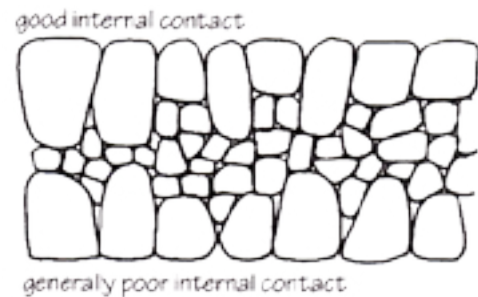
In addition to the how tight the stones actually fit together, there are techniques for making the wall appear tighter than it is.

In terms of tightness to the line, it primarily takes a well set up string line and a good eye. However there are ways of improving how tight to the line the wall appears to be. When trying to build a wall tight to a line it is important to realize that how a wall looks is largely due to how the sunlight is reflected off of it. The interplay between what parts of the wall are in sun and shadow, affects how the wall will look.

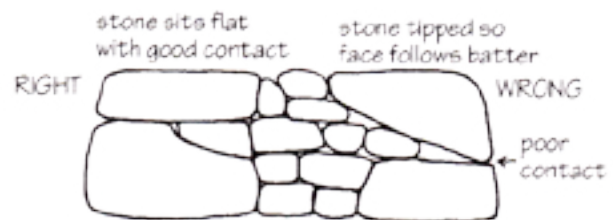
Surface contact is better than point contact.

This applies to all aspects of walling. Walls stay up due to friction between stones, and there is much more friction between two surfaces than between a surface and a point or between two points. This applies to how the sides of face stones fit together, and how pinnings fit between face stones.

While a point to surface contact sometimes cannot be avoided, point to point contacts are very weak and should be avoided if all possible. This technique applies to overall structure and stone to stone tightness.



Plan: good and bad contact between stones.
(Image: Brooks, 1999)

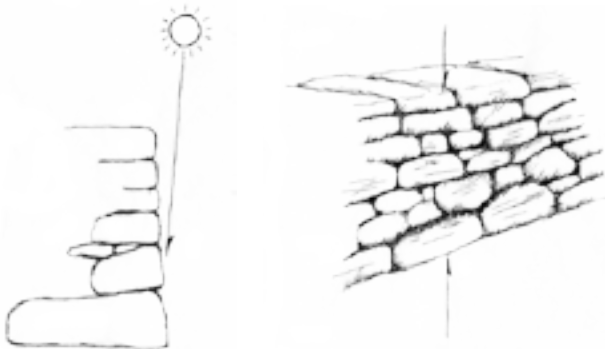


Section: good and bad contact between stones.
(Image: Brooks, 1999)

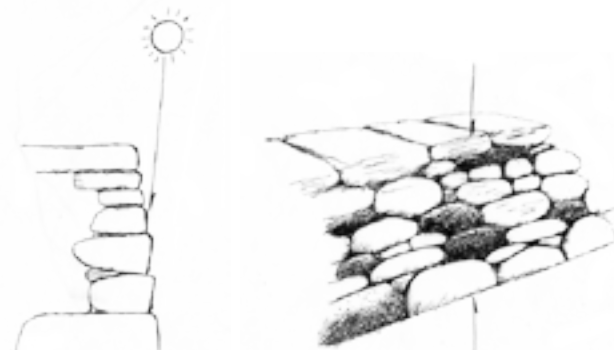
Batter the face of each face stone upward.

Face stones very rarely have a face that is exactly perpendicular to the top and bottom. Most often it is at an angle, and in some cases it may be curved or at several angles.

Ideally the face of the stone will be at an angle that matches the batter. But, it is unusual to have many stones that are like this. However, in almost all cases it is best to place the stone so that the face, or majority of the face, of the stone is angled up toward the sky, instead of down toward the earth. This rarely affects the structure of the wall, but can make a great deal of difference to the appearance of the tightness between stones, and to the tightness to the string. This is due to the fact that the sun is coming down from above and a stone which has a face angled downward will not catch the light. The resulting shadow can give the wall a mottled and poorly built appearance. In some cases the shadow can even look like a hole in the wall. It is also important to realize that the wall is typically viewed at a downward angle. So a stone whose face is angled downward will barely be visible, but the top of the stone below it will be. In addition, because of the batter, the angle of variation of the face will be closer to that of the batter of the wall if the stone is angled upward.



Section and perspective of wall with the faces of the stones corectly battered



Section and perspective of wall with the faces of the stones incorrectly battered

Keep the batter even.

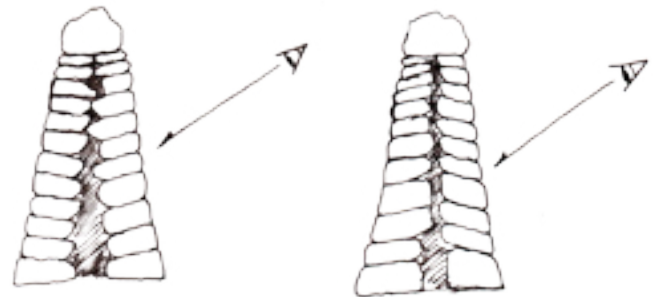
This is relatively straight forward, and means that the same amount of batter should be used along the entire wall. If it varies, when the sun is at a certain angle, parts of the wall will be in sun and parts will be in shadow. This is commonly seen on old farm walls that have settled and shifted, but new walls should not look like this.



This old farm wall has an uneven batter which results in a blochy shadow pattern.

Avoid setting face stones so the top slopes into the center of the wall.

This applies to making the wall appear tighter, and will also help the wall to shed water. This technique means that the back end of each face stone should not be lower than the face. If this is done, the wall will appear to be looser. This returns to the fact that walls are viewed looking down at the side. So if the joints between stones are angled down and in, the joint will look larger and deeper.



Sloping the face stones. Sloping inward as on the left makes the wall look looser. Sloping outward makes the wall look tighter. Angles exagorated for clarity.

Setting the stones level or even slightly sloping outward means that a person's line of sight is at a different angle from the joints between the stones, and therefore the joint will appear smaller. It is however important that stones do not slope too steeply outward.

Some wallers argue that stones should be sloped outward so that they shed water out from the center of the wall. This may have merit when working with stone that degrades quickly when wet for long periods of time, such as Cotswold Limestone. However walls are not a waterproof structure. Water that enters through the top or sides is going to flow right through to the ground. Any water that is shed down the face of the wall will end up right next to the foundation anyway.

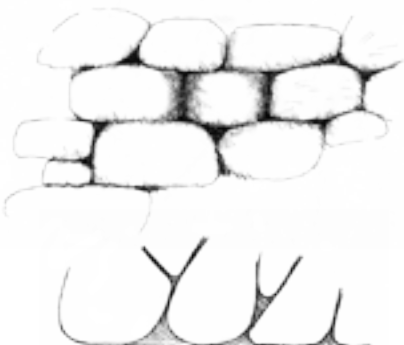
Sloping the stone outward can be slightly weaker as it is easier for the stones to slide off as the wall settles. However, if the angle is slight, and the wall is built properly, there is minimal risk of this.

Average curved faces.

When building with stones that have curved faces it is more difficult to achieve an even face. One technique to produce a more even result is to average the curve so that both corners are the same distance from the plane of the face. If the stone is rotated so that one corner is up to the line, the other will be so far in from the line that it will look like a substantial whole in the wall.

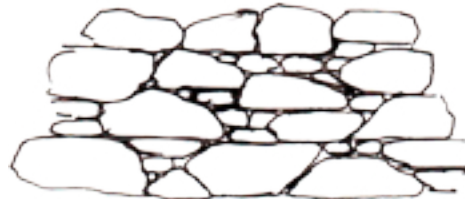


Elevation and plan of a stone with a curved face that is not aligned well.



Elevation and plan of a stone with a curved face that is aligned correctly.

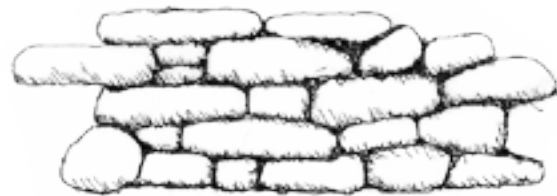
Avoid pinnings showing in the face. The faces of the face stones in a wall should fit together without leaving gaps that need to be filled by small pinning stones. Pinnings are generally unstable when they show in the wall face and will often fall out of the face as the wall settles. If the pinning was actually being used to structurally hold other stones in place, this can result in the entire wall failing. If the pinning is not structurally needed, it is usually best to just leave it out and accept the hole in the wall. But it is best to wall so that there are no gaps at all. Long pinning stones that extend deep into the wall are acceptable if properly wedged in place. Stones stuck in the face of wall can come right back out the way they came. Each stone should be set on the wall from the top.



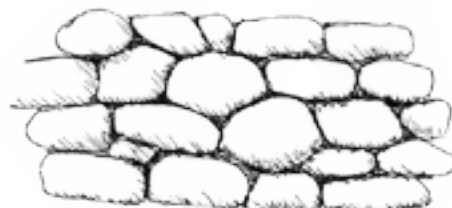
A wall with too many pinnings showing in face.

Avoid one stone sitting on more than two.

Setting stones that sit on the top of more than two is usually not a recommended practice. This is because as the wall settles, one of the smaller stones can become loose. This technique is most applicable when working with rounded stone. However, if the stone is scaled so that larger stones are on the bottom, and stones are not traced, this should rarely be a problem.

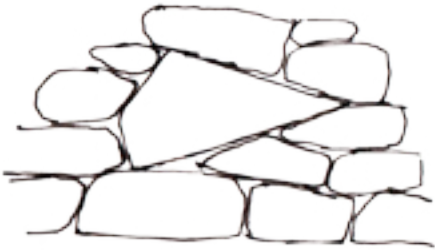


Generally not good. Too many stones sitting on three below it. This can also indicate that many of the stones are traced.



Generally well built. Nearly every stone is sitting on two below it.

Level the bottom of each face stone. This was touched on in basic rule number two, but it could use a more detailed discussion. When working with irregular stone, it is best to have the bottom surface be level in the face of the wall (this does not apply to the angle at which stones go into the wall, only the bottom edge of the face. Stones placed with the top level, and the bottom at an angle can be acceptable, but is not as preferable. Stones set with neither the bottom nor top level should be avoided. This techniques should be primarily applied to the large face stones that are dominant in the face of the wall. Smaller stones that fill in the spaces ideally will still be level, but often this is not possible. Additionally, the bottom of each stone should be the largest, flattest side.



This is incorrect, with stones set at angles.



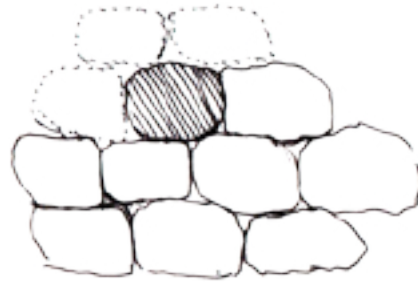
This is correct, with stones set so that the bottoms are level.

Plan ahead.

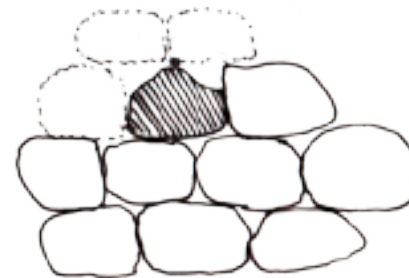
This is one of the most challenging aspects of walling, particularly with irregular stone. Each stone set on the wall solves a problem, the problem of what stone will fit there, but it also creates new problems – finding the stones to fit next to, and on top of the stone just placed. The key in walling is to pay attention to what shapes will fit against the stone that was just set. If they are shapes that are uncommon or not available, then it may be best not place the stone there in the first place as it will create more problems than it solves. Setting a stone that creates a difficult problem, but solves an even more difficult problem is generally acceptable, because a gain is still made.

The whole premise of planning ahead is

visualizing the shapes that will be needed next and then making a judgement if such shapes are available. For some people this is a difficult skill to develop, but it is critical to building efficiently.



When setting the hatched stone on the wall, one must think about how the stones not yet placed (dashed) will fit around it. In this case they fit well.



In this case the hatched stone is more problematic. The other stones available (dashed) will not fit well against the the dashed stone.

Use your eyes not your back.

When looking for the next stone it takes much less energy to look at the shape of the stones available compared to the shape that is needed, and decide visually which one will fits the best. Picking up each stone and trying it on the wall until one is found that fits, is slower and takes much more energy. This is a skill that is easy for some and can take a long time to learn for others. While this has no effect on how good the finished wall is, it has a great effect on how much wall can be built in a day, and how tired the waller is at the end of it. Moving and lifting stones takes time and energy. If every stone is tried on the wall three times, the amount of energy it took to build the wall is nearly the same as if the wall was built three times, or if three times more wall was built.

There is an old saying that a waller will put every stone he picks up on the wall and never throw it back on the ground. Every waller I have talked to says that this is utter rubbish. However it is true that skilled wallers throw fewer stones back on the ground than less skilled wallers.

Working with large irregular stone.

Working with large, irregular stone presents several additional complications. Large stones are too heavy for one person to place high in the wall, and usually look out of place there. Yet large stones also often don't fit together well. There are several strategies for working with large irregular stones described below.

Place large ones first. This technique is used when working with a wide range of sizes, but more large ones than can fit in the foundation alone. Once the foundation is laid, decide where large stones will fit on the wall, so they don't create running joints or other defects, and place them there. Then fill in the wall between the large stones. This is counter to normal walling where each course is laid in sequence, however when working with large stones this can be very effective. Keep walling like this until all the large stones are used up, and smaller stones can be used to build the rest of the wall.



After placing the footings, the largest stones left (hatched) are placed and then the wall is built up in between (dashed).

Double foundation. An alternative to placing the large stones first is to build a "double foundation." This is done by laying a normal foundation of large footings, and then using small stones to level off the wall at the height of the tallest footing stone. Then a second course of footing sized stones is placed on the wall, and normal walling can commence on top of that. The leveling off with small stones is done because the large stones will often not fit together well. This type of wall is common in some areas of Scotland and is occasionally built in other areas.



After placing the footings, the wall is built to a level plain. Then the large stones (hatched) are put on, then the wall is built normally on top (dashed).

Building for large problem stones. Occasionally you will come across a stone that is not only large, but that has no apparent position that it will sit on the wall. If the stone must be used because there is no other stone available, the best solution is to build a spot near the bottom of the wall that is specifically shaped to fit the stone, and then to place it there. This takes time so it is not often done, but at times this is a good solution.

When most or all the stones are large.

If the stones available are mostly large stones there are several solutions, all of which will usually require multiple people or hydraulic equipment, due to lifting the large stones high on the wall.

If there is lots of stone available one solution is to widen the wall and use the large stone as face stones. The wall will generally have a looser look, because the stones will not fit tightly together, however the weight of the large stones will keep them from shifting. This technique will result in a strong and massive wall.

Other alternatives are to build single walls or Galloway dykes, both of which are discussed in the section on Walling Variations.

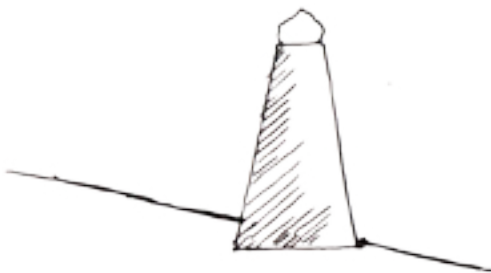
Walling on Slopes

Walling on sloped ground can dramatically complicate walling. Yet the vast majority of walls are built on slopes. There are differences in the best way to build walls on slopes compared to building on flat ground. This section discusses the best ways to approach walling on slopes.

Walls can run across a slope, up a slope, or some combination of across and up. Different techniques should be used depending on the orientation of the slope and wall. The steepness of the slope also changes the best way to wall.

Walling across gentle slopes.

Walling across gentle slopes is nearly the same as walling on flat ground. However the foundation should be dug so that the bottom is level. Through stones and coping stones should also be put on the up hill side of the wall because that way they don't have to be lifted as high and footing stones are often put on the down hill side, so that they don't have to be lifted to a higher elevation than where they will sit. If working with round stone some care must be taken to be sure it does not roll away, but other than that the wall is built as though it on level ground. If the wall is to retain stock on the uphill side it must be sufficiently high on that side, therefore the wall must be taller than normal on the down hill side.

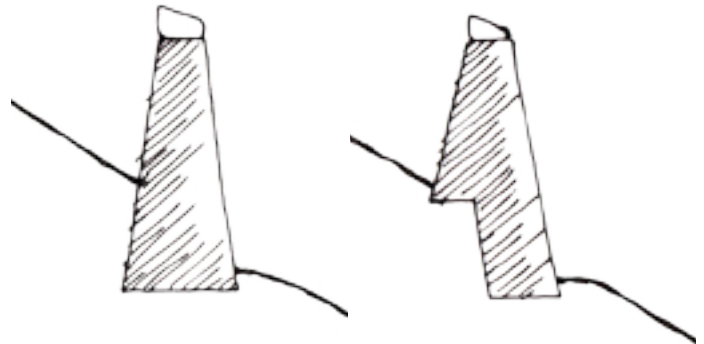


Section of a wall built across a gentle slope.

Walling across steep slopes.

Walling across steep slopes is more difficult than gentle slopes. The bottom portion of the wall will take on the function of a retaining wall, while the top will remain freestanding. There are two different ways to build the lower portion. The first is to dig down until the foundation is level just below the ground level on the downhill side of the wall. This is arguably the stronger method. How-

ever it is a lot of digging and there is a lot of stone to place below ground. The more common method is to have a stepped foundation. This reduces the digging necessary for the foundation, and is a more efficient use of stone because there is much less buried. While this is perhaps not as strong, there are plenty of walls built in this manner that are still standing after more than a hundred years, so there may be little reason to do the extra work of digging a level foundation.



The two ways of building across a steep slope: as a normal wall on the left and with a stepped foundation on the right.

When working across a steep slope great care must be taken when stripping out or delivering stone. Most of the stone should be on the uphill side because the top of the wall will be built entirely from that side. It is also much easier to move stones downhill than uphill, so it is better to have too much stone on the uphill side and move it to the downhill side than the other way around. Only a small amount of the stone should be on the downhill side. It is important to keep stones from sliding or rolling down the hill. Digging the foundation step extra deep and creating a level place to stand is generally a good practice.

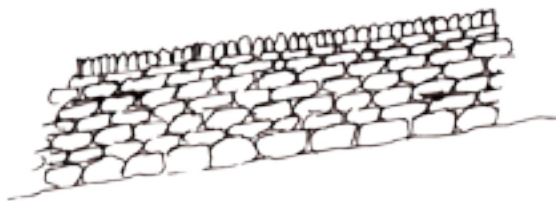
Walls running across steep slopes can start to act like dams in heavy rains, so it can be a good idea to build drains, or water smoots, in the base of the wall. See the walling features section for more information.

Walling up gentle to moderate slopes (1-20%):

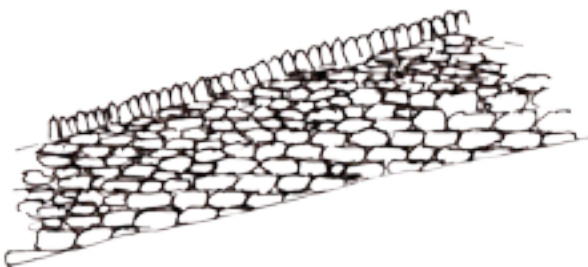
There are two approaches to walling up gentle slopes. The first is to wall as though the ground is level and build courses parallel to the ground. If this approach is used it is the same as walling on flat ground except everything is parallel to the ground, instead of level.

The other method is to wall so that all the stones are oriented level. This can be done in a randomly built or closely coursed wall. This is more challenging but produces a more refined and usually stronger result.

Building with the slope is often not acceptable on slopes over 5%. However in some areas the local tradition is to nearly always build in this manner on gentle and moderate slopes, so in these areas it can be best to match the local tradition. However, on slopes steeper than 5% and certainly on slopes over 10% it is advised to build walls with the stones in level courses, or oriented level in uncoursed walls.



A wall running up a gentle slope built with the stones oriented parallel to the slope.



A wall running up a moderate slope built with the stones oriented level.

My preference is to build the wall so that the stones are oriented level, be they arranged randomly or in loose courses. Especially on slopes over 10% I find that walling with the ground looks much weaker, even if it is still structurally sound.

If the wall is being built with rigid courses that are scaled so the larger stone is at the bottom, the courses must run with the ground. Otherwise the foundation course will eventually end out at the top of the wall.

When walling on a slope, each section that is being stripped out should be done from the uphill end to the downhill end. The steeper the hill the more important this is. Stones fall down hill, so if you start stripping out at the downhill end, stones will always have a tenancy to fall from the wall onto where you are working. By starting at the top of the section the only time this can happen is at the very top of the section, and this can be avoided by properly stepping back the remaining wall.

When stripping out, there is a tendency for the stones to work there way down hill. To counter this, face uphill when stripping out and throw the stones slightly uphill as you take them off the wall.

When building the wall, it is started from the lower end of each section. This is to keep what is already built from falling down, and because it makes it is easier to work in level courses.

Setting foundations on a wall running up a slope is the same as on flat ground if the wall is being built parallel to the ground, except that the top should be sloped with the ground, instead of level. If however, the wall is being built so the stones are level, the foundations have to be terraced or stepped. This can be done by digging a terraced foundation, or by using variable sized footings.

When using level coursing in a wall on a slope, the courses get narrower as they go along the wall because of the batter.

String lines are usually set up on slopes in the same way as when working on level ground. It can be helpful when building level courses on a slope to run an additional string that is horizontal. This gives a reference for building level.

The recommended coping for walls running up slopes is variable in different locations. In the Lake District it usually leans downhill. In other areas it will be set vertically or lean uphill. The argument for all of these styles is that if a few copes are knocked out it prevents many more from falling over. In certain situations all three styles may have merit. If walling in a area with an obvious tradition it is recommended to follow it. However if there is no precedent any method can be used. I have found that sloping the copes downhill is the easiest to build, because gravity will always hold each one where it is set.

Walling up steep slopes (greater than 20%):

Walling up steep slopes is similar to walling up gentler slopes except the stones must be kept level. Building parallel to the slope is structurally unsound, because it is very easy for the stones to slide down the wall causing the wall to fail.

All of the issues discussed for walling up a gentle become more relevant the steeper the slope. Foundations must be terraced, courses vary in width, etc. When stripping out in particular it is important to actively place stone on higher ground than where it came off the wall, and to try to avoid letting them slide or roll down the hill.

Because a wall running up a steep hill can have a tendency to fall down the hill as well as side to side, there are several methods used to increase the strength of the wall.

Tracing occasional long and large stones in the wall can actually add strength to walls on steep slopes. Such traced stones help to prevent one section of the wall from falling away, down the hill. Also in the event that a section of the wall does fall, the long traced stones act as a stop to prevent the rest of the wall from falling.

Another way to prevent the entire wall from falling down the hill is to build wall ends into the wall every so often. This creates a vertical seam in the wall that will stop a the wall from continuing to fall apart. Unlike with a running joint however, the wall ends are structurally separate.



A wall double wall end. When on level ground such as this, it usually indicates a change in ownership of the wall. (Image: Brooks, 1999)

Copes on walls running up steep slopes usually lean down hill, such that they are approximately perpendicular to the slope. Setting copes so that they stand vertically is sometimes done, but very rarely do they lean uphill, because the coping must then begin at the top of the slope and work downward, otherwise each stone will lean on a stone that is not yet placed. When coping from the top of the slope, there is a substantial risk that the

cope stones will start to slide down the wall, resulting in a looser cope.



A fine section of Lake District wall running up a steep slope. Note the though stones are a constant height above the ground.

Walling diagonally up slopes.

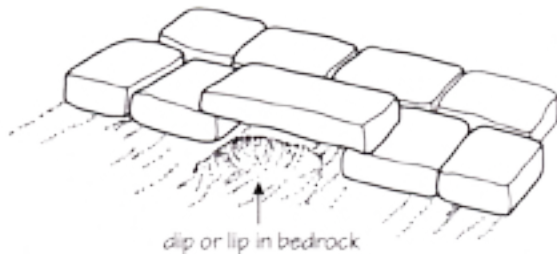
When walling diagonally up slopes a combination of the techniques used for walling across and up slopes are used. This is no more difficult than walling across or up slopes. The procedure will vary somewhat with the steepness of the slope. Most walls are at least on a slight diagonal to the slope, so it is common to combine the techniques for working across and up slopes.

Walling in Adverse Locations

In addition to slopes there are many other obstacles that occur with some regularity. Some can be walled over with a reasonable assurance of success, and for others it can be best to use an alternative type of fence or wall.

Walling on bedrock.

Walling on bedrock can make setting the footings particularly difficult, but otherwise is one of the best places to build a wall. Bed rock will not heave or shift so if it is not at a steep angle it is the most solid foundation that one can have. Unfortunately it is usually not level or smooth, so some compromises must be made when setting the footings. But because bedrock is so solid it is acceptable to do this. Small variations such as dips or ridges in the bedrock can be bridged over. Slanting bedrock can be built on by using triangular footing stones that have good surface contact with the bedrock. If the bedrock is slanting too steeply for the footings to be secure, the wall should be built elsewhere, or the bedrock will have to be broken or cut so that it has steps.



Bridging a dip when building on bedrock.
(Image: Brooks, 1999)

Particular care should be taken building the wall at the interchange between where the wall is on bedrock and on soil, because the soil will settle and shift but the bedrock will not. This means that there can be considerable strain on this section of wall and it should be built particularly carefully. Using larger and squarer stones is preferable in these areas.

Walling on uneven ground.

Walling on uneven ground is basically the same as walling up and down short hills, so care needs to be taken to be sure the footings are set level. Using string lines also needs some special care or the top of the wall may become jagged if the

stakes or batter frames are placed at the top and bottom of each undulation.

If there is enough stone available it usually looks best to build the wall so it is high enough at the rises and extra high at the depressions, resulting in an even top. If this can not be done, the top of the wall should be curved so that it matches the ground.

Walling on soft or boggy ground.

Soft or boggy ground is generally not the best place to build a wall, but if a wall does need to be built there some special considerations should be made with regards to the footings.

Footing stones should be as large and flat as possible to spread the weight of the wall and be able to take uneven settling. The footings are often allowed to stick out past the wall face to further distribute the weight.

Digging a foundation is usually a futile prospect on soft and wet ground because there will be no firm surface on which to build the wall. The firmest surface likely to be present is the turf itself, therefore placing the footings directly on top of the turf is probably the best that can be done. The wall will sink, and need rebuilding more frequently than walls on firm ground, so an alternative fence type is often more practical.

Walling over boulders.

Boulders can present a particular challenge to wallers. Existing boulders were often incorporated into old walls because they complete a portion of wall without moving any stones. However boulders are rarely the full height of the wall and are often wider.

Building on top of boulders is often difficult because they have tend to have rounded or sloped tops. Often the best approach is to big bridge over the boulder from one side to the other. This solves the problem of trying to balance stones on top of the wall. If the boulder is too big to bridge, than it must be built on as well as possible. If there is no way to build on it, then ending the wall on either side and using a wire or wooden slat is an alternative.

If the boulder is wider than the wall, sheep can use it as a way to jump over the wall. To pre-

vent this, long stones can be incorporated so they protrude from the wall above the boulder, making a jagged overhang that will deter stock from jumping the wall.

The cope may also be overhung to accomplish the same function.

Boulders that are offset from the wall can be particularly difficult. If the wall can not be moved so that it runs directly over or completely misses the boulder, bridging is often a good strategy.

Large boulders that are not steep enough to keep stock from climbing up them, need to have the wall built on top high enough so that stock can not jump over when standing on the boulder. This can lead to a very high wall just on either side of the boulder.

Walls and Trees.

As a general rule trees and walls do not mix well. Tree roots tend to cause havoc with walls and will dramatically reduce their life span. Trunks can also grow so big that they will push walls over, or hit them when swaying in the wind. If possible cut down any trees within 10 feet of a wall before building or rebuilding. If this is not possible, consider relocating the wall so it goes around the tree(s) or replacing the wall near the tree with a section of fence. If a wall must be built near a tree, cut the roots that will directly interfere with the wall. However this is not the best solution as it can inflict substantial damage to the tree. If the roots can not be cut because it will inflict too much damage to the tree, the roots should be bridged over with large stones so that the roots have room to grow. Building directly on the roots should be a last resort.

Roots not only grow in diameter but they also will flex and shift when the tree leans in hard winds. This can cause walls to fall all at once. To see proof of how damaging trees are to walls one only needs to look along a road where there is a wall and a row of mature trees. Usually the wall is damaged, fallen, or bears signs of being rebuilt near most of the trees.

Never build a wall directly against the trunk of a tree. As the tree grows in circumference it will push the wall over, so it is rather pointless, but it is also damaging to the tree because it holds moisture against the bark. This can result in rot and decay that could ultimately kill the tree.



This Costwold wall was bulging dramatically...



...and this is why. This tree root comes from the tree which is partly visible in the upper left of the picture, about 20' away.



The only damage in this wall is next to the tree!



This wall was completely knocked over due to the tree roots flexing in a wind storm.



The solution was to build the wall around the tree, resulting in this rather curvy wall.

Walling in confined areas.

Walling where there is limited space to spread out will result in slower building. The final result should not generally be affected unless the wall can only be accessed from one side.

When there is limited space to spread out the stone will end up being piled higher and more effort will have to be spent finding the right stone. If there is inadequate room to stand or kneel comfortably while building, the rate of construction will slow further. Consider head room to as well as width. There are few things more uncomfortable than walling under evergreen trees with low branches.

If the wall cannot be accessed from one side building is likely to slow down dramatically, and the side that cannot be accessed will be less tightly built.

Particular care should be taken when working on road sides. Visibility is important and stones must be prevented from rolling into the road. If approaching cars do not have good visibility of where you are working warning signs should be used.

When working in populated areas, or where there are many passers by, expect to spend some time talking about walling with those passing. This can be an easy way to get new contracts, but time is taken away from the job at hand.

Retaining Walls

Retaining walls are very commonly used in landscape and garden walls. They can also be found along roads and occasionally as property boundaries.

There are two ways to build retaining walls and both have advantages and disadvantages. The first method is to build a single faced wall that leans back against what it is retaining. The other method is to build a double faced wall that can stand on its own.

Single Faced Retaining Walls.

Building a single faced wall is much faster and uses about half the stone of a double wall. However because it is inherently less massive and relies on what it is retaining to stay up, it is a weaker structure.

When building a single faced retaining wall ample amounts of small to medium “hearting” stones should be packed behind the wall, as it is built. Flat flaky stone is best and round stone should be avoided. The soil behind the wall should be undisturbed or else extremely well packed, because if it settles much the wall will become unstable.

Trace walling is not acceptable in single retaining walls, and long “through” stones should protrude back, tying the wall face to hearting behind.

Typically it is not recommended to build single retaining walls higher than 4 ft, and only when there is no top load. However there are some locations where single walls have been built much higher and lasted over a hundred years. If using large, level-bedded stone the limits of single walls can be dramatically pushed. The angle of batter can also be increased which reduces the chances of the top of the wall being pushed out, but does not prevent the wall from failing if the wall is holding up material that can slough. When retaining unstable soil it is often best to use a double wall.



*Section of a single faced retaining wall.
(Image: Dry Stone Walling,
Techniques and Traditions, 2004)*



Building a single faced retaining wall.



Placement of a “through” stone in a single retaining wall. In this case the throughs protrude from the wall face as is common in freestanding walls.

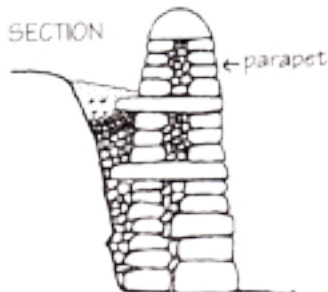
Double Faced Retaining Walls.

Building a double faced retaining wall is a much more substantial walling project than single walls. The wall is built like a normal freestanding wall except that it does not matter how neat and even the buried face of the wall is.

The building process begins by digging back into the bank the required amount. Building then commences as though building a normal wall, with two faces and hearting. The better face stones go in the side of the wall that will be seen, and the poorer stones go on the face that will be buried. The wall may be backfilled while it is being built or after the wall is completed. To prevent soil from washing through the wall, a filter-fabric type of geotextile can be placed along the back of the wall before it is backfilled. Backfilling may be soil or stone. It is best to pack firmly to prevent settling behind the wall, although this will not affect the structure of the wall.

Double retaining walls have the advantage that they are substantially more massive and do not rely on the stability of the ground behind them to stand upright. Double walls can be substantially taller and are quite capable of retaining heavy loads. Some wallers will increase the batter of the front face of the wall, and build the back face nearly vertical, however this does not dramatically change the strength of the wall.

Some wallers also like the practice of including extra long through stones that protrude back into the fill behind the wall, as is done with single walls. Such stones are generally very hard to find, and the function is debatable. While the additional weight on the back of these long stones can help prevent the wall from bowing out, if the soil settles under the back of such a stone it tip back and weaken the wall. Such an argument is generally irrelevant as there are no stones with such length to be found.



*Section of a double faced retaining wall.
(Image: Brooks, 1999)*

Coping Retaining Walls. Traditional vertical or slanted coping is not always the best way to finish retaining walls because soil has a tendency to wash through it. Vertical coping also can result in a jagged edge that will not line up with the soil well.

If vertical coping is used it should be set so that it fits very tightly together and with a neat and smooth top. Level bedded stone works best for vertical coping as the individual stones fit together very well.

The alternative to vertical coping is to use large flat stones as a cover band. Such stones are sometimes called capstones because they cap off the wall. Cap stones make a smooth line that will line up with the ground well. They also are effective at helping to prevent soil from washing into the wall.

Whatever type of cope is used it should cover the entire thickness of the wall so that soil is not above the wall itself. Soil that is above the wall will tend to wash down into the wall and collect there. This is not good because it will trap water which can then freeze, causing stones to shift, and weakening the wall.



A tall retaining wall in an abandoned North Welsh slate quarry. This wall is one side of an incline ramp used to remove slate from the quarry. Note the scale figure at the center

Walling Variations

As mentioned throughout this report there is a wide range of variations in drystone walls. This section looks at the differences, why the different styles have developed, and reasons for choosing one variation over another. It is important to realize that the majority of variations have to do with the wide range of stones that are used to build walls. Local styles and traditions have developed in order to make the strongest wall out of what was locally available. Often local styles cannot be applied to differing stone types. In other words, don't try to build a Galloway dyke out of Cotswold fieldstone, because it simply won't work.

Coping.

As had been said before, the cope stones are one of the most widely varying part of the walls. Many variations in coping are based on keeping stock from jumping the wall. Other variations give the wall added refinement or meet another need that a wall may have.

There are several reasons that most copes are oriented vertically or near vertically, as opposed to just building the wall higher. The top portion of walls are often built with quite small stones that take very little force to knock off the wall. By setting copes vertically it effectively weighs them down, putting a substantial amount of weight on the top of the wall with stones that individually are fairly light and easy to lift.

Vertical copes can also be wedged very tightly together so that the lateral friction between the stones helps to hold them in place. Also, by the time the wall is built up to under the copes, there are often relatively few stones left that make good face stones, so the cope is a way of increasing the height of the wall using otherwise unusable stones.

Finally, copes are put on edge because it is best to have them so that they bear weight on both faces. There are typically many more stones that have an edge dimension long enough to do this than the flat side of the stone.

In order to keep sheep from jumping over walls, overhanging the copes can be very useful. Often copes are overhung only to one side. This allows sheep to jump the wall in one direction but not the other. Usually the overhang is put toward the neighbors land. The idea is that you do not

want your neighbors' sheep to graze your land, but it is fine if your sheep graze someone else's land. I should add that sheep are marked so that they can be sorted out latter.

Some copes are intended to add height to the wall without building the entire wall higher. Such copes are usually crenelated in appearance, and have special names, such as "buck and doe" or "hens and cocks" Such copes may be done in conjunction with overhanging one or both sides of the wall.



An unusual buck and doe cope that uses old roofing slate which makes an excellent deterrent to keep sheep from attempting to jump the wall.



This unusually tall cope adds about 20" to the height of the wall.

Another way to add additional height to the wall is to build a double course of coping. This is usually not very strong and will fall off if the wall settles or shifts much. If an animal does try to jump a wall with a double cope, they will knock the top copes off, but the extra height is often enough to discourage animals from attempting the jump to begin with. Wedging the copes so that there is lateral friction is key when building a double cope.



A wall with a double cope.

Another variation is to use a cover band of through stones and to put coping on top of that. This can help to further secure the two faces together. This style requires flat stones that have good length, so it is typically only found in areas of level bedded stone.



A wall with a cover band.

Copes should ideally cover the entire width of the wall thus tying the two faces together. Sometimes this is not possible however and a double row of copes is used. When this is done, try to wedge the backs of the copes together so that there is some friction between the two rows of copes.

In areas with very irregular stone, rubble copes are sometimes used. These are not especially strong because they do not effectively tie the two faces together, but if small rubble is all that is available, it is what is used.



A wall with a rubble cope.

A different style of coping is to use large flat slabs, or capstones to cover the wall. This is primarily done on landscape walls. Having a smooth level top on a wall makes it easier for stock to jump the wall. However on landscape walls it can add a pleasing finish to the wall. This style of cope is more time consuming to build, but it has the advantages that garden planters, pots and other features can be set on the wall. This is also done for seat walls. Cap stones should be set so the tops are level and in a single plane.



A seat wall with flat cap stones. In this case the cap stones were mortared, but this is generally not necessary. (Photo: Garner 2005)

Mortared Copes.

Copes are often seen mortared together and to the top of the wall. Contrary to common belief, this will generally not help the wall to stay up longer, because it holds the cope rigid. The wall below will still settle and this can result in the cope no longer uniformly resting on the top of the wall. This defeats the purpose of the cope. The result is that the small face stones at the top of the wall will fall away and the wall will deteriorate and fall apart from under the cope.



A new roadside wall with a mortared cope.



A wall that has fallen from under its mortar cope.

Another variation of the same theme is to mound concrete on top of the wall instead of copestones. This is not an effective cope, as it has the same problems as the mortared cope, but is even less effective because it weighs less than cope stones.

Despite the fact that mortar can result in shortening the life of an undisturbed wall, mortaring the cope can add to the life span in some environments.

Roadside walls often have mortared copes, not because it adds strength to the wall, but to

prevent the copes from being stolen. Many garden owners like to have rocks in their home gardens and wall coping presents a convenient source. People will in fact steal the copes of a roadside wall, put them right into their cars, and take them home. Mortaring the copes together prevents this. On some roads the copes may only be mortared near pull offs and lay-byes, where stealing copes is the easiest.

Vandals also have a tendency to push copings off the wall, so walls in urban areas, near bus stops, or other places where people will be waiting often have mortared copes.

Whatever style of cope is used, some care should be taken to place the copes in an even and logical manner. The top of the cope should be relatively even, or have a distinctive pattern. Coping is not simply throwing whatever stone is left onto the wall in the order that it is picked up off the ground.

Single Walls.

Single walls are a different style of building most commonly found in areas of Scotland, but also found in North Wales and other areas. Single walls are a single stack of large stones. The overall dimensions are similar to that of a double faced wall, but the building style is completely different. The stones must be of substantial size to build in this style and lifting the stones often takes more than one person.

I have not had the opportunity to work on a single wall, so my knowledge of the construction techniques is limited, but my understanding is that pinning stones in the side should be kept to a minimum, as they have a tendency to work loose, and that wedging the stones together laterally is key to building a strong single wall.



A single wall bridging a stream.

Galloway Dykes.

Galloway dykes are a combination of a double wall on the bottom and a single wall on top. It is predominantly found in the Galloway bay region of Scotland from which it gets its name.

I have not had the opportunity to try my hand at one of these walls, but I have heard different opinions about them. Galloway dykes are an efficient way to use a combination of large and small stones without having to do much reshaping. Smaller stones are used to build the double faced wall on the bottom. About half way up where through stones would normally be placed, large stones are used to build the rest of the wall as a single stack. This means that the large stones need to be lifted high on the wall which takes a lot of effort, but in some cases it can be the most efficient way to use the available stone. Galloway dykes often have sections made as single walls for the entire height of the wall to use up additional large stone.



A galloway dyke. In this wall the double section comes only a third of the way up the wall.
(Photo: Dry Stone Walling, Techniques and Traditions, 2004)

Slate fences

Slate fences have more in common with fences than walls but they are none the less another way to build a barrier with stone. Although I did not work on one, I did get the opportunity to talk with people who did, so I was able learn a bit about them. There are two primary types of slate fences in the UK. One is from the Lake District, and in particular the area around the village of Hawkshead. The other is from North Western Wales.

Hawkshead type slate walls are made of large rectangular slabs of stone on their end and buried in a line. The vertical edges of the stones are chamfered one way at the top and the other way at the bottom so that the slabs interlock. Large slabs of slate are quite costly, so the chamfering has

to be done very carefully or the slab can break and be ruined. About 1/3 of the slab is buried below ground to keep the slabs from tipping. These walls are usually about one meter high, so a jump wire is often added above the slabs.



A slate fence made of slabs in the Hawkshead style with the slabs interlocking.
(Photo: Dry Stone Walls, the National Collection 2002)

The North Welsh Slate fences use slate that is split into long strips about 1" thick, 6 to 12" wide and 4 to 5 feet long. The slates are buried 1/4 to 1/3 in the ground with about 6" of space between the slates. Wire is then interwoven and twisted between the tops of the slates to hold the tops in line. The resulting fence looks much like the wood and wire fences used for beach stabilization. These slate fences have a very distinctive look, and are effective at retaining stock. Now, however, suitable pieces of slate for this type of fence are very costly new and hard to come by used.



A north Wales slate fence.

Walls topped with a fence.

Another variation of walls are those topped with a fence. This is done when there is not sufficient stone to build the wall high enough to deter stock from jumping. There several ways that this is done.

One of the most refined methods is the North Welsh practice of building vertical slates into the wall that come out between the copestones as fence posts. Holes are drilled in the slates and wire is threaded through to make a fence above the wall. The vertical slates are hard to firmly anchor in the wall and do tend to be a weakness, so mortar is sometimes used around the slate to better anchor it to the wall. Wood posts are sometimes used instead of slate, but this is not a recommended practice, as even treated wood will decay long before the wall will need replacing, and it is impossible to replace the posts without rebuilding the wall around each post.



*A wall with slate and wire fence above.
In this case because the wall was low and narrow,
the cope and slates are mortared.*

Walling Features

There are many features that can be built with drystone techniques. Most were developed and traditionally built for practical reasons, usually having to do with farming. These features are now commonly incorporated into walls for aesthetic reasons rather than agricultural ones.

Curved Walls.

It is surprisingly harder to build a good curved wall than a straight one. However there are some techniques that can be used to aid the process. String lines are much less useful when building curves because a taught string will always remain straight. Building curved walls is one place where wallers that have not experienced walling without string lines will have trouble.

If building a regular curve, or one that has a constant radius, a string may be used in laying out the wall, by fixing it to the ground at the vertex of the arc. For irregular curves, or those with a varying radius, string lines are of little use in laying out the wall.

String lines can be used as a guide for keeping courses level. However, there is a tendency to wall to the string line laterally as well as vertically when string lines are present, so it is often best to use a spirit level, or build by eye.

When building curves the batter has a tendency to go off because string lines cannot be used, and the curve can create an optical illusion that the wall is not battered enough or is battered too much. One of the best ways to manage this is to cut a piece of wood that is the angle of the batter and mount it to a spirit level. By checking the batter with the level frequently while building one can build an accurate and consistently battered wall.



A curved wall.

Wall Ends.

Wall ends are one of the most basic features in walling. Virtually every wall has a beginning and end. Building wall ends can be fairly straight forward if the appropriate stones are available. When working with irregular stone however, wall ends can be quite challenging.

In order to be structurally sound it is important for wall ends to tie the two faces together and tie back into the wall as well. Long stones with parallel top and bottom surfaces are ideal when building wall ends. A “text book” wall end consists of runners and tie stones on alternating courses.



A well built wall end of fairly irregular stone.

However it is common to not have enough stones suitable for such an end. Thus there are some other variations, such as large slabs that act as both runners and as a tie. If there are not tie stones available with enough length to go the full thickness of the wall, an L-shape can be used on each course with one shorter tie stone and one runner, alternating the side that the runner is on in each course.

It is very easy when building an end to not sufficiently tie it into the wall. It is important that the runners and ties are substantially different in length and width so that the end is integrated with the wall.

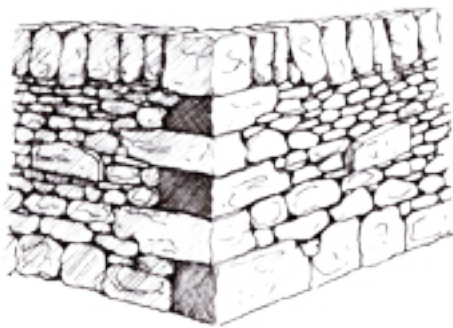
Stones that are round or triangular in cross-section do not make good runners or ties because they will not fit with the other stones in a structurally sound way.



A very poorly built wall end. The sides are not tied together and the end is not tied back into the wall.

Corners.

There are two ways of building corners, square and round. Square corners are much more common and are built similarly to a wall end, except every stone is a runner. When building a square corner all of the stones should have good length to them. Ideally they will also have a somewhat square end.



*A square wall corner.
(Image: Dry Stone Walling, Techniques and Traditions, 2004)*

Round corners are usually only built when there is insufficient stone to build a square one. Building a round corner is the same as building a very tightly curving wall. Wedged shaped stones should be used and it is important not to trace stones, or have running joints.

Lunkies.

A lunky is a hole in the wall that allows sheep to pass through. Lunkies can be blocked or gated off to form a solid barrier when needed. Traditionally, lunkies were blocked using a large slab of stone on edge, or loosely filling the gap with rubble stone. Most lunkies are about 18" wide and 24" high.



A lunky built by the author under the supervision of Sean Adcock.

A lunky is constructed by building two wall ends opposing each other, and then spanning the gap with one or more lintel stones. If large enough lintel stones are not available, corbeling can be used.

The wall ends should be built up to the same height with approximately the same number of courses in each wall end. The top course of the wall ends should be runners, unless the lintels are unusually long. This is easier said than done, and can be challenging with irregular stones.

Water Drains.

In addition to lunkies for sheep, gaps are left in some walls to allow small streams to pass through. These drains are often similar to lunkies but with different dimensions. Because these gaps are not intended for sheep to pass through, they must be smaller than lunkies. Often the drains are in pairs to allow for increased capacity.

Other drains are built with one gap above another so that if the lower one becomes blocked, or if there is too much water to flow through, it will overflow through the gap above. Such drains bear a great resemblance to lunkies except for the horizontal stone(s) in the middle, which prevent sheep from passing through.



A double water drain with two gaps in each.



A large water drain , with a piece of slate across the middle to keep sheep from passing through.

Styles.

Styles are features that are built into the wall that allow people to pass from one side to the other. The most common designs are step styles and squeeze styles.

Step styles are built by protecting long flat stones from the face of the wall so that they form steps. It is very important that the stones are well anchored in the wall. At least 2/3 of the length of the stone should be built into the wall if the stone is only long enough to make a step on one side. The preferable way to build a step style, is to use stones with enough length that they form a step on both sides of the wall. Each of the steps should stick out of the wall at least 12" and be at least 10" wide on the top surface. Typically the riser height is quite large, and only three steps are used on each side of the wall. It is important for safety that each step overlap the one below it very slightly. Otherwise people can step between the steps when climbing down the style. The stones that make the steps must also be firmly wedged with pinnings and hearting to prevent the step from shifting when stood on. It is important to avoid running joints on either side of each step, and to space the stones so that the horizontal and vertical space between each one is uniform with the rest. Where people will cross the top of the wall, large cope stones should be used that are stable enough to be stepped on without shifting.



Sean Adcock going over a style that he built.

Squeeze styles are gaps that are narrow enough to keep stock from passing through, but wide enough to let humans squeeze through sideways. The simplest form of such a style is to build two wall heads opposing each other with a gap between. The gap is narrower at the bottom than the top, tapering from about 6" to 15". Squeeze styles are effective in fields intended for cattle, however sheep, particularly the more agile breeds, can use squeeze styles to escape from the field. If building a squeeze style, be sure to use large runners and ties that will not be sifted when people rub up against them. The cope should also be blocky so that it will not be shifted.

There are many variations of squeeze styles. Vertical stones may be placed on either side, a vertical slab may be mounted in the bottom, or finely shaped stones may define the edges. Squeeze styles may also be only in the top half of the wall, and have one or two steps on either side.



An arched niche built by Sean Adcock.



*One type of squeeze style.
(Image: Dry Stone Walling,
Techniques and Traditions, 2004)*

Niches

Niches are gaps built in one face of the wall that do not extend all the way through the wall. The most common form of niches are bee bowls which were built into walls to hold bee hives kept in straw skips. Before processed sugar, honey was the only available form of sweetener, so nearly all farmers kept bees. Bee bowls are typically about 18" wide and 14" high and 14" deep. Other niches are built primarily for decoration and are found in a variety of shapes including triangular and arched.

Arches.

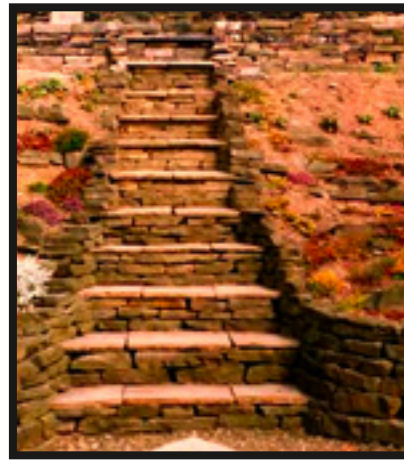
Arches take time and skill to make, but are usually well worth it when finished. Vary occasionally arches will be used to span lunkies or drains in field walls. More commonly arches can be found in old quarries and mines where they were used to support tunnel roofs and as small bridges. However, because of their complexity, arches are most commonly found in landscape and garden walls where they are desired for visual reasons. Building an arch requires a form, usually of wood, to support the arch as it is being constructed. Wedge shaped pieces are ideal for building arches, but they can also be built using flat stones with small wedges placed between them at the back. Dry stone arches can last for hundreds of years when properly built and left undisturbed.



A dry stone arched culvert at the copper mine ruins in Coniston.

Steps.

Steps are commonly found in garden and landscape settings. Ideal step construction is to use one large slab for the tread of each step. Often such stones are not available or are too large to move. When this is the case smaller stones may be used to build up the step as a small wall. It is very difficult to prevent small stones from becoming loose or wobbling when stepped on, so it can be best to mortar the stones to keep them steady. The treads on steps should be slightly angled forward so the steps will drain and water will not puddle on them.



*Dry stone garden steps. In this example each step is made from several stones.
(Photo: DSWA Picture Gallery, 2005)*

Cairns

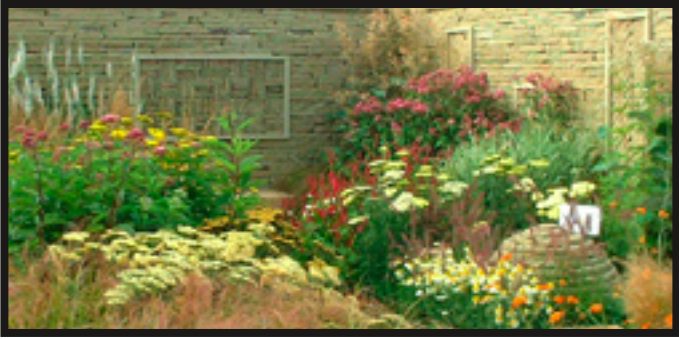
Simply put, a cairn is a pile or stack of stones. Cairns can be very rustic or quite refined. Cairns are now quite popular as monuments, and many of these are built in a refined manner. Such cairns are built as a circular wall face with a core of hearting.



*A dry stone cairn monument.
Note: the fence in front is not part of the cairn.
(Photo: DSWA Picture Gallery, 2005)*

Sculptures and features.

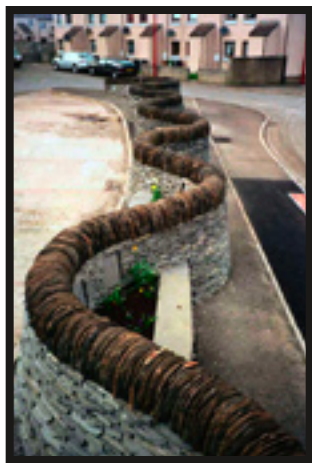
Drystone techniques are a vertical medium that can be used to make many sculptural features in landscapes. Dry stone sculptural features usually require accurately shaped stones, so building features is usually done with stone that is readily shapeable. Stone saws, in addition to chisels and hammers, can be very useful. Some features may use mortar in the core to prevent accidental damage or vandalism. However the mortar is not used structurally, or as glue. On the facing page are a few examples of drystone sculptures and decorative features.



*A wall with several inlay panels of finely shaped stone. Built by Andrew Loudon for the Royal Horticultural Society Show Tatton Park 2004
(Photo: DSWA Picture Gallery, 2005)*



*Traffic Island Sculptures
Imaginative landscape sculptures designed and built by David Wilson (Artist) for West Lothian Council at the Newpark Roundabout, Livingston.
(Photo: DSWA Picture Gallery, 2005)*



*Part of a "Home Zone" refurbishment in Ormlie Estate, Thurso, Caithness, Scotland. 2004
Built by George Gunn.
(Photo: DSWA Picture Gallery, 2005)*

Unusual Large Walls

In locations throughout the world where stone is an abundant material walls have been built. The United Kingdom is home to some very unusual dry stone walls. I had the opportunity to visit many amazing walls while in the UK. Two north Welsh walls that I saw were spectacular examples of dry stone walling pushed to its limits.

Ffestiniog Railway Bridge Wall.

The Ffestiniog narrow gauge railway was built in the 1830's to bring slate down from remote quarries in the mountains around Blaenau Ffestiniog. The railway was laid out so that it was a constant down hill slope from the quarries to Porthmadog, where the slate was then loaded onto ships. Originally horse powered, steam power was introduced in the 1840's. After carrying slate for more than 100 years, the railway is still in use as a tourist passenger service (FR History, 2005).

In order to maintain the constant grade the railway had to follow the contours around the mountains and hills. In places the contours curved too sharply for the railway to follow, and the railway grade had to be built up away from the hillside. In two such places along the railway, massive drystone walls were built to run the railway across the top.

I had the chance to see the larger of these two walls with Sean Adcock in early November. The only way to get to the wall is to walk along the railway so the visit had to be coordinated with the rail line manager.

The railway bridge wall stands 62' tall at its highest point and is 60' wide at the base. The top of the wall is about 12' wide, and it runs for several hundred feet. The wall is dry laid except for portions of the small guard walls on either side of the tracks at the top of the wall, which have been repaired with mortar. The wall is built using large roughly squared blocks of level bedded stone. The faces of the wall are not coursed. The core of the wall is something of a mystery, but it is presumed to be rubble stone. There is some evidence that buttresses were added to the wall sometime after construction, widening it to its present width. However these buttresses may have been part of the original design.

This wall is truly a testament to the strength of drystone walls. Not only is this perhaps the tallest freestanding wall in the UK, it has held up to the weight and vibrations of the trains that have run across it for over 150 years.

The other wall on the Ffestiniog railway I did not get to see, but I was told by the rail line manager it is some 40' high and again several hundred feet long. It is also narrower at the top, with just enough room for the railway tracks, and has a steeper batter. Below is a historic photo of this lower wall with a train running across it.



*A train of empty slate cars crossing the wall.
(Photo: FR Photo Library, 2005)*



Looking down the north face of the wall.

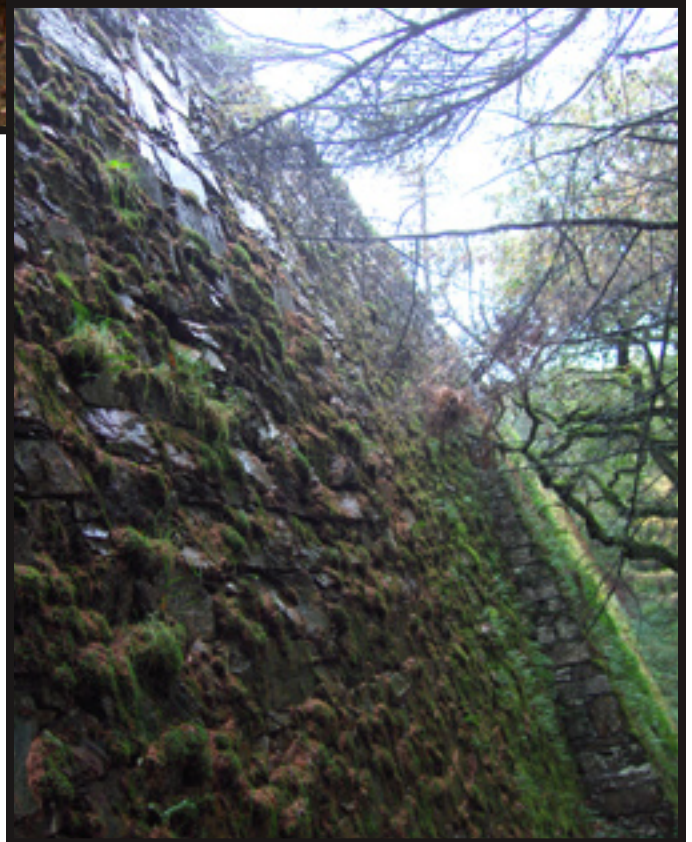


Looking along the wall from near the lower end. Much of the wall is now blocked from view by trees.

Looking up from near the bottom of the north side of the wall. Note the end of the buttress in the lower right of the photo, and the significant amount of batter.



*A historic photo of a train crossing the wall.
(Photo: FR Photo Library, 2005)*



Overhanging quarry wall.

Old quarries, with plenty of spare stone, and skilled quarry workers, are some of the best places to see massive and unusual walls. The abandoned slate quarry at the head of Cwm Ystradllyn near Porthmadog, North Wales, is an example. In fact it holds one of the most unusual dry stone walls in the UK. The wall was presumably built to protect the tramway that removed finished slate from the quarry from an encroaching slag pile. The wall is unusual because of the way the wall is corbeled to overhang the tramway below. The wall is approximately 13 feet high and overhangs as much as than 5 feet. (Brooks, 1999)



The wall from a distance, showing the size of the slag pile above.



Looking along the wall from below.



Looking up at the face of the wall.

Because of the overhang, any stone that slid down from above would fall on the far side of the tramway, rather than on it, as would happen if the wall was straight. The wall was built out of large blocks of slate that extend deep into the wall. The stones were carefully shaped to fit tightly together and have even faces, which makes this wall all the more spectacular. The distance that the wall overhangs is absolutely amazing.



Looking at the top end of the wall. Note the length of the stones used to achieve the overhang.

Designing Walls

Applications and Specifications

Dry stone walls are an excellent way to create an aesthetically pleasing wall. Dry stone walls if properly built in a practical location will outlast nearly all other types of construction. However if poorly built, or built in unsuitable locations, dry-stone walls can fall in only a few years.

While in the past dry stone walls were one of the most economical ways to enclose land or retain soil, now dry stone walls have one of the highest initial costs to construct. Where stone walls have an advantage is that they can last for more than 100 years with hardly any maintenance. Thus when considered over the long term dry stone walls can still be cost effective if they last. With that in mind, spending the money to build a wall in a location where it will not last must be called into question.

Free standing dry stone walls are suitable nearly anywhere that there is firm ground and land cleared of trees. Building on marshy or boggy ground can be done, but will decrease the lifespan of the wall, so it is often in such locations that using a length of fence will make a more effective barrier.

Trees are a particular problem for walls. Tree roots will dramatically reduce the life of walls. Dry stone walls should not be built immediately next to trees. A 10 foot space between any wall and trees is a recommended minimum, and it is ideal to stay outside of the canopy of the trees' mature size. A length of fence is an acceptable means of avoiding building a wall near a tree. It is also a bad practice to plant trees near existing walls.

Dry stone walls are strong when left alone. They do not respond well to outside forces, such as impacts from vehicles, or plowed snow. Thus it is important to leave sufficient room near walls to minimize the chances of impacts against the wall.

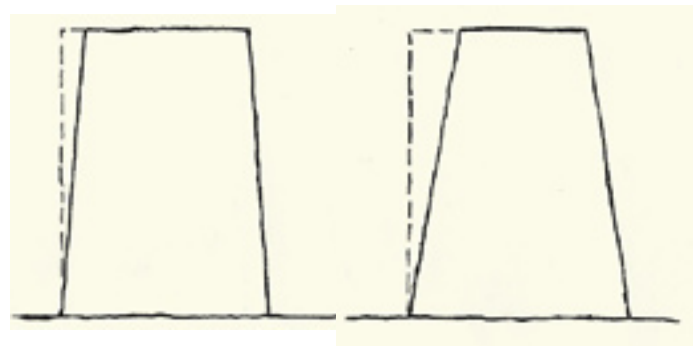
As mentioned before drystone walls are also vulnerable to vandalism. While this can be minimized by mortaring the cope, this will also weaken the wall. Thus in places where vandalism is a concern, a fully mortared wall or other form of barrier may be the best solution.

Developing standard specifications for all dry stone walls is impossible because the stone is a variable material. However there are generally recognized specifications that apply to many walls. It is important to recognize that not all stone is suited to build all walls. If the selection of stone is

limited, the design of the wall should complement the stone available. If many types of stone are available the design can be more flexible, but the stone still needs to be chosen to match the design. Depending on the stone used, the normal limits of dry stone walls can be completely inapplicable.

When considering where to build a stone wall it is important to recognize that stone walls have thickness, and that building walls too thin will substantially weaken them. Typically walls should be about twice as high as the foundation is wide. A wall three times the height of the width is severely pushing the limits of dry stone walls and will usually be unstable.

Dry stone walls should also be battered such that the top is narrower than the bottom. Standard batters are between 1:12 and 1:6. Having a batter is critical to building strong walls out of irregular and rounded stones. Walls made of level bedded stone are also stronger if they are battered. Battering walls is a more efficient use of stone. Walls cannot be made too narrow at the base, but the top does not need the same strength and thus can be narrower. This saves a substantial amount of stone.



Wall sections with a 1:12 batter on the left and a 1:6 batter on the right.

Virtually all types of stones can be used to produce a free standing wall that is 1.5 meters high, and .75 meters wide at the base. Retaining walls up to 2m high can also be made out of virtually any stone type.

Taller freestanding and retaining walls (up to 3m) can be built as long as the stone is of a medium to large size, and not excessively rounded. If the available stone is small or round tall walls can still be built if the batter is increased.

There is rarely an application for walls to be taller than 3m; however they can certainly be built

taller as long as there is sufficiently large stone, and the wall is sufficiently wide and has an appropriate batter. Level bedded stone is preferable for unusually tall walls. Retaining walls can be built incredibly high. Tall retaining walls usually require a batter of at least 1:8, and often more. The stability of tall retaining walls depends on the material being retained. Essentially all tall walls are single faced, even though they may be many feet thick. Most tall walls retain stone, such as quarry slag, as opposed to soil, which is less stable and more prone to settling.

One of the issues that must be faced when including drystone walls in landscape designs is that how a wall is built will greatly affect its strength. The best way to ensure that a strong wall is built is to choose a reputable waller. For the most part the waller's price will reflect the strength of the result. In other words, going for the lowest bid price may not be the most economical, because the wall may need to be rebuilt in a few years.

If you are considering contracting a waller that you are not familiar with, take the time to visit several of his or her past contracts, and ideally one under construction. Evaluate the wall based on the techniques listed in the section on evaluating walls. Also make sure the waller is competent using the type of stone that will be used on your project. There are many wallers who are very skilled with some stone types, but will struggle with other types. You can expect to get a wall of the same quality as those you evaluate, so make sure the walls you see are of the quality you would like to have.

If you are hiring a skilled and reputable waller, it is worth asking the waller to voice any ideas on the design that they have. Although not trained as designers, skilled wallers know the material and its limitations very well, and their knowledge should not be ignored. If you are getting feedback from the waller such as "I can build it, but it won't last" or "This is not possible with the chosen stone" they may have valid arguments and the design may need to be modified.

When hiring skilled wallers it may be unnecessary to provide dimensions for the wall, particularly when rebuilding existing walls, because a skilled waller will know intuitively what the dimensions should be. However it does not hurt to look at the wall with the waller and make an agreement

as to what the dimensions will be and to write them in a part of the contract so that there will not be any disputes later on.

If you know, or suspect, that you will have to employ a waller who is unknown to you, or known to be less skilled, drawing up detailed specifications is very important. The specifications should include the following: Depth of foundation to be dug, width of wall at the footings, height of wall, angle of batter, and width of the top of the wall. The specifications should also include the requirement to use through stones and should specify their proper placement and spacing. The style of coping should be specified. There should also be a note to prevent trace walling. One way to do this is to specify that at least a certain percentage of the stone must be oriented with the long dimension running into the wall. Depending on the stone 70% to 90% is usually appropriate. Another way is to require a certain number of bonding stones, or stones that extend into wall past the center, are in every square area of wall face. 4 to 10 per square meter depending on the stone is often appropriate. Notes should also be included that running joints are not allowable. In addition it is a good idea to specify that no face stones should shift or be able to be removed with the hands, and the cope stones should not be able to be shifted when moderate force is applied with one hand. The face of the wall should also be specified as being a flat plane, without dips and bulges. Special walling features may also require additional specifications.

It is important to realize that the specifications are nearly useless if the wall is not inspected to make sure it meets the specifications. It is often worth specifying that a certain portion of the wall, often between 2 and 5 square meters, must be inspected and approved before the rest of the wall can be completed. However, no matter how detailed the specifications and inspections, there is no substitution for a skilled waller.

Evaluating Walls

Evaluating walls is quite challenging because the quality of the stone must come into the equation. However once the wall is built it is hard to tell exactly what the stone is like. The best evaluators of walls are usually the best wallers.

When evaluating a built wall it is important not to immediately succumb to being impressed by the size or scope of the wall. Rather one must focus on answering the question “could the wall be built substantially better with the same stone?” This can be difficult to answer and can take an eye used to seeing and working with stone. However there are several aspects that even the novice should immediately notice.

The easiest defect to notice is running joints. Running joints should not be tolerated in any number, if at all. Very infrequent short running joints, between two courses, will not noticeably affect the structure of the wall. If there are more frequent running joints, or ones that continue through multiple courses, the wall should immediately come under question. Building running joints is one of the most basic mistakes made when walling, so if the wall has running joints, it is likely to have many other problems as well.



This new roadside wall is full of running joints.

The other easy test when evaluating walls is to try to wiggle or shift the face stones, especially in the lower portion of the wall. Pay attention to the small stones in particular. If more than the very occasional stone can be wiggled it means that the wall has been poorly hearted, and that the face stones have probably not been fitted together properly. If more than a very occasional pinning stone can be removed from the wall, or if face stones can be removed from the wall, it is not built

well and will not last. Also check to make sure the cope stones are not loose and have been tightly wedged together. Loose copes will tend to fall from the wall, which will allow the wall to gradually fall apart from the top down. If the coping is of a style that has rubble stone piled behind the copes this may be somewhat looser, but should still be steady enough to feel that it will stay there for many years to come.

If gravel, aggregate, or pea-stone has been used for hearting, it is usually visible in places between the face stones. If this is the case, it is a sign that the wall was not built well. Gravel, aggregates, and pea-stone are not suitable for hearting. All can settle, and leave gaps in the heart of the wall, or worse act like ball bearings and allow the face stones to move. Generally speaking do not accept a wall that has been visibly hearted with any of these materials.



This retaining wall has been filled with gravel, and has many other problems as well. Walling such as this should never be accepted.

If there were measurements for the width, height and batter of the wall included in the contract, they should be checked to make sure that they were built according to the specifications. It is also usually fairly easy to check if the faces of the wall were built reasonably in line by sighting along them. While picking up slight variations takes a skilled eye, almost anyone can notice major discrepancies.

Trace walling can be hard to judge once the wall is built. In some cases, particularly extreme ones, it can be clear that stones have been traced.

By looking at the thickness of the wall and comparing it to the length of the face it is often possible to determine if a stone has been traced. If the face of a stone is longer than the width of the wall and is not a through stone, it must be traced. If there is a substantial amount of such tracing present, the wall is most likely poorly built and should not be accepted.

Evaluating the finer aspects of walling to establish if the fit and finish of a wall is the best that can be expected with the stones that were used is virtually impossible for someone unskilled at walling with the type of stone being used, and should not be attempted. If the quality of the finish is not acceptable for the client and the waller feels it is the best that can be achieved, a highly experienced waller, perhaps with additional qualification such as a Master Craftsman certificate, may be needed to judge the quality of the wall. Such occurrences are rare but will occasionally occur.

It is best to evaluate a waller's work after a small portion of the wall is built. When the wall is under construction it is easy to see if stones are being traced or if the hearting is not adequate. It is also easier to correct without a great deal of expense if problems are caught at this point.



An exceptionally poor newly-built retaining wall. This wall displays all the features of a wall that should not be accepted.

Wallerers are usually quite proud of their work and feel that they not only do a good job, but know more about walls than other people. So in the event that a wall is determined to be unsatisfactory, it is important to be careful when bringing it to the attention of the waller. If detailed specifications were part of the contract, then it is usually

much easier to prove that the wall is not meeting the necessary requirements.

Evaluating when a wall needs rebuilding.

Existing walls only truly need rebuilding when they have fallen and are no longer serving the intended function. However entire walls do not fall down all at once. Small sections fall first, causing gaps. The term gapping refers to repairing these gaps. However, once a wall starts to develop gaps, it can be more efficient to rebuild the entire wall. Once a wall starts to develop more than the occasional gap, it suggests that the entire wall is in bad shape. This is assuming there is not a reasonable explanation for the cause of the gaps, such as trees near the wall. Each time a gap is repaired more than just what has fallen must be repaired. So if gaps are repaired over many years, eventually the whole wall will be rebuilt, but many portions of the wall may be built several times thus making gapping inefficient. The strength of the rebuild when gapping is also not as good because resetting footings is not always possible as they often extend under parts of the wall that are being left. Therefore it often makes sense to rebuild sections of wall that are still standing but are in bad shape.

A wall is in bad shape if it is noticeably leaning or bulging. However if there are no gaps in a wall displaying such characteristics it does not need to be rebuilt. A wall can stand with a substantial lean or bulge for 50 years or more. It is only when the section fails next to section that is in a bad state of repair, that it makes sense to rebuild the whole wall.

Conclusion

This document is intended to be a presentation of information that will allow readers to advance their knowledge and skill of dry stone walling. Building a dry stone wall is about making choices and solving problems. What distinguishes the masters of dry stone walling is not their ability to lift heavy stones, but their skill at making correct decisions and solving problems, and doing so quickly.

The decisions begin when the first stone is stripped off an old wall, or when the location is chosen for a new wall. The decision making will only end when the wall is complete and the last stone has been set. Problems which arise when working on a wall generally have multiple solutions. Some solutions will result in a strong wall, and some could lead to the wall failing. A novice waller might recognize a problem, and not be knowledgeable of all the solutions to choose from. A skilled waller should be able to not only identify the problems, but see the different ways in which each may be solved. However, a skilled waller may not have enough experience to determine the best choice, or may take much time in making the decision. A master waller will see the problem, see the ways it can be solved and choose the best option, before the novice has identified the problem.

A problem might involve layout, such as choosing the width for a foundation that is most appropriate for the conditions. Or a problem could involve deciding how to build on top of a difficult stone, or how to move a large boulder into place. This document describes and depicts common problems and their solutions. However, every problem and its solution will in some way be unique because every stone is a different shape and in a different environment. Thus the information provided here should be adapted to the situation at hand. Skill is gained from looking at what choices other wallers make to solve problems. The bigger your mental library of problems and solutions the more you will be able to adapt them to the problems at hand. Innovation to find new ways so solve problems is also a key becoming a master waller.

Practice is the most important key toward becoming a master waller. Working by oneself can be very useful as a way to figure solutions out individually. Setting challenges for yourself can help diversify your skill. Challenges such as building a coursed wall using irregular stone, or building

a section of straight wall without a string line are both good examples.

Working along side a waller of greater skill than yourself is also a valuable way to improve one's skill. Working along side a waller who is better allows you to see how he or she solves the problems that they are confronted with. It also encourages you to build at their speed which will give an incentive to speed up. When working by yourself there is no one to compare your speed to and it can be easy to build very slowly with out realizing it.

The first wall anyone attempts should be simple. Eliminate as many complications as possible before beginning to wall. Choose a site where the ground is level and firm and there is good access to both sides of the wall. Choose stone that is of a size you can readily move, and don't be surprised if half way through you decide to start over because you know that you can do better.

Opportunities for further research.

When writing this document I chose to focus on the construction techniques I observed during my internships with four wallers. There are several related topics that could be researched further.

The history of land enclosure in the UK is a topic that I only skimmed the surface of. A more detailed study of enclosures would include, the effect they had on the populace, and the methods of enclosures used (hedges, fences, and walls).

Stone faced earth banks, such as the clawdds (pronounced clawths) of Wales and the hedges in Cornwall are variations of walling that I collected some information about, but was not able to include in this report.

There are many other prominent areas of walling throughout the UK that I did not have the opportunity to visit. A study focused on walling in these areas, or a comparison study of walls throughout the UK would also be valuable.



A newly repaired Welsh Cawdd.

Appendix:

Evaluation of Methods

The primary method of research used for this report was to spend time with wallers. This included not only time walling, but also time evaluating walls and visiting unusual walls. Secondary methods included my own independent evaluation of walls I saw, participating in walling events, and literature research.

Arranging to work with the wallers took initiative and planning, but I knew it would be critical to spend time working with wallers for this study to be successful. This stage of planning was primarily done over the summer of 2005, before I arrived in the United Kingdom. Fortunately through the DSWA and using internet resources I was able to arrange to work with four wallers.

There were many risks to the proposition of arranging to work with people who I knew very little about. I had no idea what it would be like to work with them and I was making the assumption that I would be able to learn from them what I needed for this study.

As it turned out, it was a complete success. All of the wallers I spent time with were excellent to work with and were happy to help me in any way they could. My assumptions worked out, and I was able to learn more than I was expecting.

I found that working with the wallers was not only an excellent way to learn about walls, but also the greater culture and landscape. Someone who lives and works in a location knows far more about it and the surrounding area than any guide book or web site. Working in this manner was an excellent way to immerse myself in the local knowledge and culture.

Despite the initial work before I left, and the many unknowns, I would recommend arranging to spend time talking and working with the individuals that relate to any study subject. I found it to be a far more valuable experience than just spending-time studying on my own.

The time I spent looking at walls on my own was also valuable. I travelled by bicycle, so I had the ability to stop and photograph walls that I found to be interesting in nearly any location. This was a great way to see local variations in walls. I would also recommend cycling as a way of travel-

ing because it is slow enough that you can see, and focus on, more than just the road, but fast enough to still cover great distances.

In my proposal I listed a method of attending walling events. I was able to participate in a walling demonstration and take the test for the Initial Level walling certification, both while working with Andy Loudon. I also attended a lecture on walling features given by Sean Adcock. All three of these events were useful in expanding my own knowledge of walls, and some of the information that I learned at these events did get incorporated into this report. I found attending walling events interesting and useful. I would have liked to have attended more events but my schedule did not allow for it.

Literature research was the standard process for finding information from books and other printed sources. This was primarily done for the History of Walling in the UK section. Because of my continuing interest in walling I purchased most of books that I found on walling. Although necessary for some parts of the study, I found literature research was the least fulfilling method that I used. Most studies probably do include some literary research, but I would recommend keeping it to a minimum, because literature research can be done anywhere, and there are much more interesting and fulfilling ways of spending time abroad.

I found all the methods I used to be effective in gathering the information I wanted. Spending time with wallers was the most useful and the most interesting to me, so the majority of my research time was spent using this method. The other methods were also useful and through them I gained information that I would not otherwise have been able to learn. If I were to do the same study again, in the same number of weeks, I would use the same methods, and spend about the same amount of time on each method. What I would change if I were to redo this study would be to have a longer period in which to complete the study. There are many more topics relating to walling that I would have liked to investigate more fully, and more time to write this report would have been very useful as well.

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