



Building dry stone walls

A guide for beginners



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September 2018*

Photos

All photos B Munday except for:

Cover

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P 8

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P 9 (middle)

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P 9 (bottom)

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DSWAA at www.dswaa.org.au and <https://www.facebook.com/drystonewallsaustralia>

The diagrams in this manual are adapted from a fact sheet written by Brian Post, Advanced Certificate holder, Dry Stone Walling Association of Great Britain and available on the Stone Trust website <http://thestonetrust.org>

How to build a free-standing dry stone wall



A single-skin wall

Single-skin walls are quickest to build, generally less demanding of regular-shaped stone and in their simplest form involve piling one stone upon another. But to endure they need care and skill.

Single-skin walls lack the visual finesse of double-skin walls, partly because the faces of the wall are uneven and one can invariably see light beaming through. And yet a sound single-skin requires every bit as much skill as a double—maybe more.

Single-skin walls taper from bottom to top for stability. A metre high wall probably needs to be about 750 mm wide at the base where the foundation stones sit on their flattest and fattest side (if they have one). Ideally these will be quite large stones and will need to be crow-barred into place.

The ends can be tricky which is why it is smart to finish at a post, wall or tree. If not so supported, the end stones need to be tied in with their neighbouring stones on that level. This means that the end stones should have approximately the same thickness as those neighbours. Tapering the end also assists stability.

This manual deals only with double skin walls which are generally more aesthetically pleasing.

The Dry Stone Walls Association of Australia (DSWAA) believes that there is a waller in each of us. We aim to raise awareness of the heritage value of dry stone walls and also pass on the practical skills of the craft.

Dry stone walling is both challenging and satisfying. We hope that these pages, introducing the basics of walling, will help you improve not only your landscape but also your understanding of and respect for stone. Of course there is no substitute for hands-on experience and in some instances professional advice. The DSWAA can connect you with other amateur and professional wallers.



A domestic landscaping feature can display the fine finish that only time allows, whereas a wall marching perhaps kilometres across paddocks is more about grandeur than glitter, function than finesse.

Andy Goldsworthy's well at the Adelaide Botanic Gardens is all finesse.

A double-skin wall

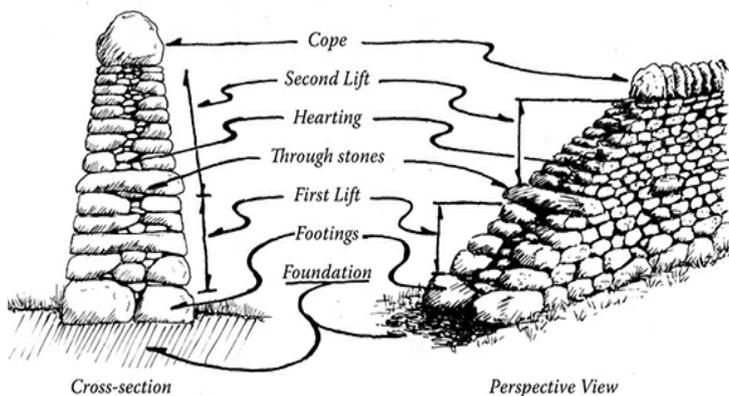
A double-skin wall is essentially two load-bearing facades leaning slightly in on each other, the structural integrity owing to the interlocking of the **building stones** along with **through-stones** at regular intervals. Voids are tightly packed with smaller stones and rubble known as **hearting**, and gaps under stones packed with **pinnars**.

In most (but not all) styles the bigger stones are at the base for stability. Along the length of the wall the two-on-one principle is used to bridge all joints as if building a brick wall. This is easier said than done when there is great variation in the length, width or thickness of stones.

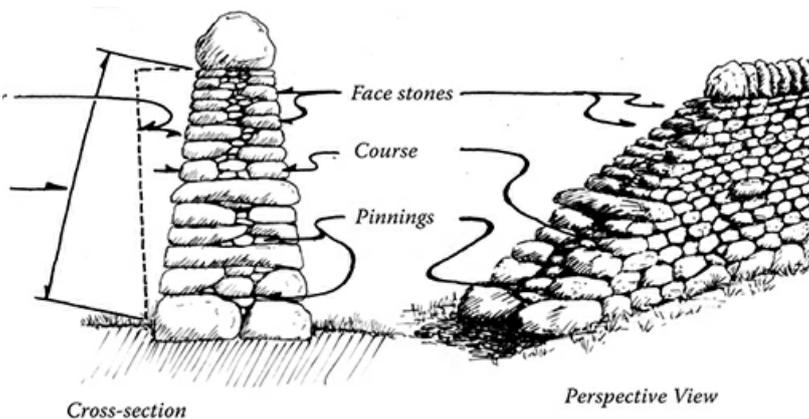
Stone fences of the early settlers (c. 1850-80) were generally built where ample stone was readily available, clearing of the paddocks an obvious benefit. In those situations a team of four (usually including two children) could build about a chain (approximately 20 metres) of fence one-and-a-half metres high per day. For that they were paid about 'a pound a chain'.

Stone walling on a grand scale was overtaken by post and wire in the eighteen-eighties when the Bessemer Process enabled wire to be drawn economically from steel.

Today when labour is not cheap, a metre-high dry-stone wall with coping might cost \$300 per lineal metre plus materials. Clearly this is seldom an option other than for landscaping projects.



Note length of building stones as far as possible into the wall, through-stones and hearting



Basic principles

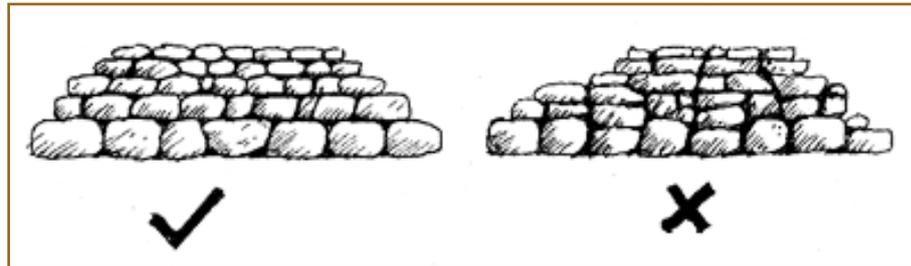


The techniques needed to build a strong good-looking wall can be condensed down to five basic rules

1. Cross all joints

Each stone should be sitting on two stones below it so that it is crossing a joint – or as they say in Yorkshire ‘Yan on twa and twa on yan’. 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, zips or stack bonds. Walls with running joints are weak, look poor and are liable to fail.

An otherwise nice wall damaged from running joints

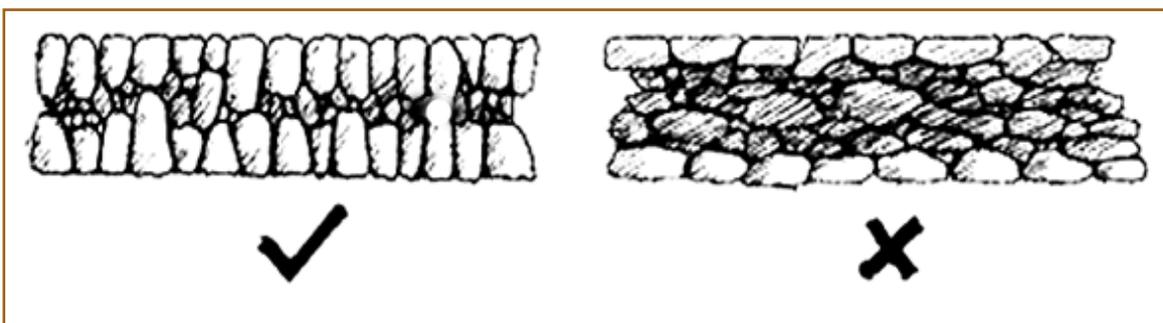


2. Set the length of the stone into the wall



The strength of a wall is very dependent on a tensile force holding the two facades together, achieved by laying the stones lengthwise **into** the wall, not along the wall. This enables the stones to interlock across the width of the wall with only the end of each stone visible in the final wall. Stones placed lengthwise along the wall create a weakness and is called trace or face walling. Trace walling is one of the most common errors, and is a primary reason walls belly-out and eventually collapse. Think of how firewood is stacked, with each piece perpendicular to the overall direction of the stack, so all you see are the ends of the pieces. A stone wall should be built the same way.

Through-stones (long stones, the ends of which show on both sides of the wall) are an extension of this rule, and should be placed every metre or so about half way up the wall to tie the wall faces together.





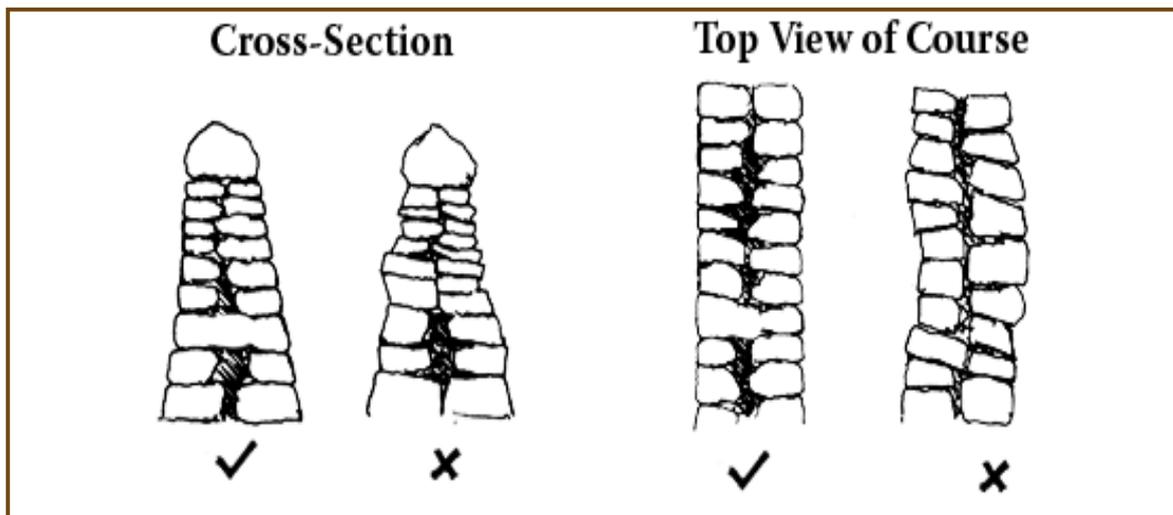
3. Heart the wall to a snug fit

The wall should be sound, with gaps in the interior of the wall, between the building stones, tightly filled with **hearting**. The voids should be filled with stones as large as possible (*see left*) followed by smaller stones that are also used to pin the building stones so that there is absolutely no wobble. Never pin from the outside of the wall as they inevitably fall out. Hearting-stones are much better if flat or angular, as rounded stones act like ball bearings. Hearting-stones should be packed individually - not randomly thrown in - as the wall is being built, making sure each course is completely hearted before beginning the next course. Not properly hearting a wall allows stones to move independently of one another, resulting in a structurally weak wall that will not last.

4. Build within the plane of the wall

This means aligning the stones so that there is an even plane to the faces of the wall. String-lines are especially useful for keeping an even plane to the wall. The outermost 'bump' of each stone is what should be in-line. The result is a wall that looks smooth and even when you stand back (*see left*). This applies both in cross section and in each course as the sketches below show. If a stone protrudes and displaces the string-line it will affect the alignment of all the stones following and the wall will grow steadily thicker.

Well packed hearting and true sides



5. Keep stones level

When a wall is built in courses it should be built so that the stones and courses are level across and along the length of the wall. On gentle slopes the courses can follow the contour of the land, but on more pronounced slopes the courses should be terraced. This is particularly so when using flat stones but applies to nearly all walls. Stones that are not level will tend to slide causing internal stress in the wall which will eventually fail as it shifts over time. While there are a few local styles and techniques that don't follow this rule (e.g. herringbone and feidin walls), it should generally be followed, particularly when you are learning to build. This rule is especially important when building across sloping ground.

Some UK text books encourage wallers to lay stone with a slight tilt to the outside to shed water. This is rarely an issue in Australia where rainfall is much less and frost less severe.



6. Finishing the wall

The end of the wall is referred to as the **cheek-end** and this deserves particular attention, requiring numerous through stones and ties back into the wall as shown in the photograph (left). Set aside suitable stones of appropriate width with square corners and parallel faces. These are too valuable for general building.

It is important to note that the stability of the wall comes not so much from the batter as from the interlocking of stones and in particular from the through-stones. Although not so critical to the strength of the wall, nice tight joints certainly enhance the appearance.

The top course of stones also contribute greatly to stability. Horizontal capping stones are sufficient in a domestic setting where walls are not exposed to undue disturbance. From a landscaping perspective they also provide a platform for garden ornaments. Again, be on the lookout for suitable flat stones and put them aside for this purpose.

Walls in paddocks with livestock should be topped with **cope-stones**. The 'copes' span the wall and tie together the facades. Standing on edge the weight of each stone bears down on a relatively small area and so applies considerable pressure – several times the pressure that would be exerted if the stone was laid flat.

When placing the copes, make sure that they do indeed bear down on both sides of the wall, using pinners if necessary, and work to a string-line between two stones of equal height about 5 metres apart. It is no accident that the most enduring dry stone paddock walls have well placed and maintained cope-stones.



Placing the copes



A garden wall with capstones



Cope-stones add strength and a nice finishing touch

These are the basic rules of walling. There are also many more techniques that will make your wall even stronger, and features that can be incorporated for different purposes and situations.

Setting Up

Setting up is important to building a wall efficiently. Setting up for rebuilding an old wall involves stripping out the existing wall, and preparing the foundation. For a new wall it includes preparing a foundation, having stone brought to the site, and organising the work site.



Rebuilding an old wall

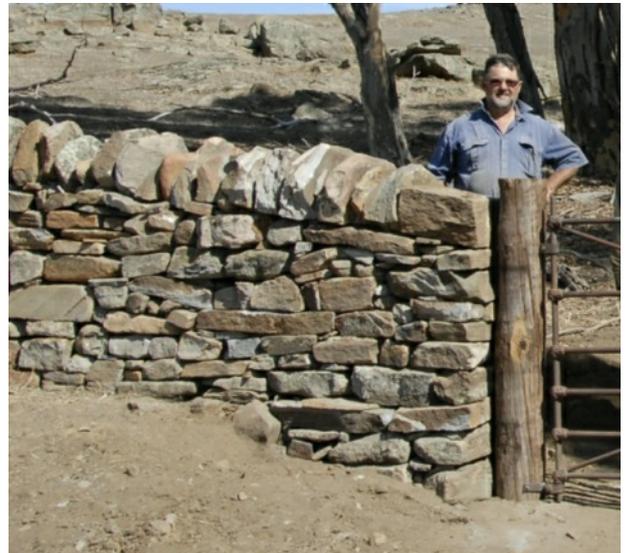
Rebuilding an old wall typically happens in sections about 3 to 8 metres. Each section will be completely rebuilt before moving on to the next section. Starting on the first section, setting up begins by clearing any brush or debris away on both sides of the wall. Ideally you want reasonably clear ground for about 3-4 metres on both sides of the wall.

Once you have clear space, begin disassembling the wall; this is called stripping. Take the time to sort the stones as you strip out. This will speed up the rebuilding. Thicker stones to be used first will be nearest the wall, and thinner stones farther away. Through-

stones should be set to the side, and cope-stones in a row farthest from the wall as they will be the last used. Stand the copes upright in a row so as to check that you have enough for the job. Small stones to be used for hearting should be placed in piles every couple of metres along the wall.

For a free-standing wall stones should be equally distributed on both sides of the wall. Remember to leave a path clear of stones about half a metre wide right along both sides of the wall. This gives you a place to stand. On retaining walls, typically all the stones should be stripped out to the downhill side. Excavated soil, hearting and cope-stones if they are going to be used can be placed on the uphill side.

Generally speaking all the stones should be removed, right down to bare dirt, when stripping out. Remove any roots or organic debris in the foundation and flatten and firmly compact the dirt. Stomping back and forth several times with your boots is usually sufficient. If the wall is going up a slope, step the foundation so you have level shelves (*as shown, right*). The foundation should typically be 50-100 mm below ground level on the lower side. Once the stone is sorted and the foundation is prepared, you are ready to set up string-lines and begin building.



Building a new wall

Building a new wall begins by preparing a foundation as described above. There should be sufficient access to have the stone delivered right next to where the wall will be built. If not, you will need to figure out a way to get it there. When stone is delivered in a dump truck it leaves a big pile, sizes are all mixed up, and hearting, if there is any, is at the bottom.

Sort through the pile before you begin building, starting on one side of the pile and sorting into rows according to thickness, not overall size. As the pile gets sorted the rows get longer. Set this up so that the rows are parallel to the wall, with the



thickest ones closest to the wall. Remember to set aside suitable stones for the cheek-end, throughs and caps or copes (as the case may be).

If you are working from palletised stone (which is usually expensive), open all the pallets and sort through the stone before beginning to build. Some palletised stone is already graded by size in which case sorting is not needed. However, these pallets are often intended for veneer, and lack the large stones you need for through-stones and features.

Determining how much stone you need for a new wall is always a challenge. When buying stone by the tonne, the quarry should be able to tell you the weight of stone you will need. If your wall is an average of 600 mm thick and 1500 mm high, one metre length will represent about 0.9 cubic metres. This could require between 2 and 4 tonne of stone, with considerable variation due to the density of the stone, its regularity and how tightly the stone is stacked in the wall, so this figure is just a starting point.



Understanding stone

A basic understanding of stone is important to be able to wall efficiently. Some stone is easy to work with, and other stone can be very challenging. Building a wall from paddock stone has its reward in the satisfaction of recognising stone with potential. This is a skill respected by farmers who also like to show that they can 'pick a good dog' or 'find good water'. Paddock stone, by virtue of its random shape and weathered surface, is more difficult to work with than quarry stone (*left*) with its regular faces and which is often dimensioned (cut to size).

Wall stone can be divided into two basic categories: level bedded and irregular.

Level bedded stones have more-or-less parallel top and bottom surfaces, and will often split into thinner stones. Slate (e.g. Mintaro, above) and shale and sandstone are typically level-bedded stones. Some limestone and schist are also level bedded. Some wallers will also refer to level-bedded stone as regular stone.

Irregular stone is not level-bedded; it can be angular or rounded lacking naturally parallel flat surfaces, and will not usually split cleanly. Granite and marble both break into irregular shapes as does some limestone (e.g. Edithburgh, right). There is a continuous range from stone that is clearly level bedded, to stone that is clearly irregular, most stone somewhere in between. Irregular stone can also be cut, or split using feathers and wedges, and some quarries will cut stone to regular shapes. Some limestone from Robe-Beachport is relatively soft and can be fairly easily tooled (*below*) to build tightly jointed walls.

Walls built with level-bedded stone often look neater; irregular stone looks more rustic. However the skill of the waller and style affect this as much as the stone. Walls built with larger stone also tend to look more rustic; smaller stones give a tidier look. While you want to build the best wall possible, don't try to force stones into a character they are not.



Stone comes in all shapes and some can be trimmed (edges or points chipped off) to improve their usability. This is particularly the case for landscaping walls where the aim is to have nice tight horizontal and vertical joints. Difficult stones can be used sporadically throughout the wall, with better stones in between, without adversely affecting the look or structure of the wall. The very worst shaped stones are often smashed into hearting. It is important to use all the stone in a consistent manner, not all the nice flat stones first then to be left with a bunch of awkward shapes at the top of the wall. This looks poor and often weakens the wall.

Breaking stones is a skill in itself. Each type of stone works differently, some break easily and some don't - layered stone such as slate or schist will often split nicely. Generally, breaking or shaping stones should be kept to a minimum; your objective is to build a wall, not carve stone. It is always easier to take corners off a square stone than to make flat sides on a round stone.

How a stone is supported often affects how it breaks as does the direction in which it was struck. Often the speed with which the hammer strikes the stone is much more important than the apparent force exerted on the hammer when it strikes the stone. The best way to learn how to break a stone as you want is to practise. Pay attention to how each stone breaks when you hit it. If it does what you want remember what you did; if not, adjust your technique.



Finding Materials

Buying stone from a quarry or supplier is expensive. Typical costs for nice quarried ledge stone run from \$250 to as much as \$360 a tonne plus delivery¹. Remember a tonne of stone is not much when it comes to building a wall. Buying stone by the pallet is typically even more expensive unless you are dealing with a very small quantity. However, if you are looking for a very specific type of stone that is not available locally, buying palletised stone may be your best option.



For projects in rural areas stone can often be gathered elsewhere on the property. Pillaging from stone fences on roadsides is absolutely unacceptable (and in some cases illegal), however there are often stone piles in paddocks. While there is a lot of labour involved to move the stone, the material may be free after asking the owner.

All types and shapes of stone can be used to build a wall and this informs the style and look of the wall. Many people think of thin flat stone as being 'good' and round or irregular stone as being 'bad'. In fact neither is true, they just lend themselves to different looks. Flat stones can be a pain to deal with because it takes so many to build a wall up to finished height and because minor blemishes stand out. Large rounder stones may build with. Smooth river stone is generally very

give a more irregular finish but can be much faster to difficult to work with and to create a strong wall.



Manicured quarry stone demands meticulous walling skills - every blemish will stand out. Boulders might appear unfashionable but they are also forgiving and can make a superb wall.

¹ Some quarries will allow you to pick over their spoils for ~\$50/t. It is time consuming but there is good stone to be had this way.

Tools

The basic tools used in wall building have remained essentially unchanged for hundreds of years. For stripping out (taking apart an old wall), a shovel, pick and crow-bar are the main tools.

When building, the basic tools are a lump or trimming hammer (*pictured*), a sledge hammer, a batter frame, and string lines and supports.



The lump hammer should be 1 to 1.5 kg although some wallers prefer a 2 kg weight. If you are just starting out and on budget, a brick hammer will work but it is too light to be efficient. Do not use carpentry hammers as they may chip when hitting hard stones.

A long handled sledge hammer should weigh about 3-4 kg. Most commonly available sledge hammers have a head that is essentially round which works fine for smashing stones into hearting.

Many wallers also use chisels and points when more controlled shaping is needed. Chisels are great for splitting stones along their natural bedding (with the grain), and can be used for trimming and other shaping. However, while they give you more control, they take more time to use, so most skilled wallers only use them when precise control is needed. Points are like chisels that taper in from all sides to leave a point that can be used for removing high spots.



Some hammers and chisels have carbide edges, useful when working with hard stones like granite, however these are expensive and require special grinding wheels to sharpen them, so only worth the investment if you are doing a lot of work with hard stone.

Batter frames (left and page 7) are not exactly tools, but they define the cross-section of the wall. They can be timber as shown here or rebar clamped as shown on page 5. For most walls the batter should be about 1-in-8 to 1-in-6. The frames should be set vertical with a plum bob or spirit level and spaced anything from 5 to 10 metres apart depending on the terrain and how many people are working on the wall. String-lines when taught provide a guide to build to, but they sag if the batter frames are too far apart.

A couple of good videos on wall building:

www.theguardian.com/money/audioslideshow/2009/aug/07/dry-stone-walling-richard-ingles

www.youtube.com/watch?V=FOlpjWGclPo



Safety

Dry stone walling does involve some elements of risk. By using safety gear, proper techniques, and being safety conscious, you can dramatically reduce the chance of injury.

Gear

Appropriate clothing and safety gear are important when walling. Steel-toed boots are important, as it does not take a very large rock to seriously crush a toe.

While some wallers prefer to work with bare hands, most wear gloves. Cloth covered gloves with the palm and fingers coated in rubber provide the best combination of protection and dexterity. Different weights are available for different temperatures. Leather gloves provide more protection, but limit dexterity and even the toughest leather gloves only last for about 50 hours on stone. Don't be tempted to use expensive builders' gloves as they only last about one day before wearing out.

Eye protection is important if reshaping or cutting stone, and really should be worn continuously. Invest in a comfortable pair of safety glasses so you are not tempted to take them off. If using power tools (drills, saws, etc.) wear ear and eye protection along with anything else instructed by the manufacturer. Avoid breathing stone dust, particularly the fine dust from running dry power saws. While limestone-based dust is not directly harmful, silica dust is. Granite, sandstone and related stones are very high in silica so it is important to avoid exposure. If you have to dry-cut stone wear a dust mask.

Practice

- Keep workspace clear of loose stones along the base of the wall, typically at least half a metre.
- Don't try to lift stones that are too heavy for you and lift with your legs, not your back. If you take your time, you can safely move very heavy stones using levers and ramps.
- Make sure any stone you are putting your hand under is secure. A light stone falling just a few centimetres can seriously crush fingers.
- Try to avoid holding a stone with one hand while pounding on it with a hammer. The vibrations up your wrist can eventually cause problems. Instead prop the stone under your boot, or in such a way that you don't have to hold it at all.
- If working with others make sure you have clear signals and a plan before you lift a heavy stone together. If machinery (tractor, excavator, etc.) is used, agree on hand signals with the operator before you start. When working around lifting equipment, make sure the operator removes his or her hands from the controls before you approach the bucket.
- Watch your hands. When you are stripping out or loading stones, keep your eyes on your hands, not on the next stone you are going to move.
- Cap stakes and rebar to protect people from being stabbed if they fall on them.
- Hi-vis socks are helpful if working with others.

Awareness

If you start to think that what you are doing might be unsafe, it probably is. Stop and find a different way to do it. Plan ahead, if you are moving a heavy stone; clear a path before you pick it up. Don't rush or try to 'get away with it this time'; that is when people get hurt.



The wall

Compared with mortared walls, dry stone walls are more resilient to impact and to reactive soils. However they are more vulnerable to vandalism, so that cope-stones and cap-stones are often mortared in public spaces.

Dry stone retaining walls drain well but can be invaded by weeds if not backed with geotextile fabric.

Nearby trees can cause damage with falling limbs, near-to-surface roots moving in strong winds or water-logged ground, and trunks simply expanding.