

Building traditional dry stone retaining walls

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Terminology

Types and designation of the building stones

Every stone with which we build dry stone walls has different surfaces. To ease communication during work, it is useful to have a common base of terms:

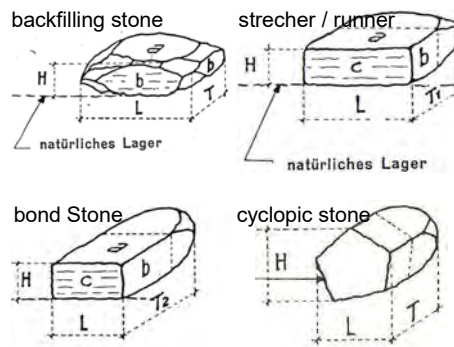


figure 1:
terminology of stone types in the wall

Legende:
L = Steinlänge
T = Steintiefe
H = Steinhöhe
a = Lagerfläche
b = Stossfläche
c = Sichtfläche (Haupt, Gesicht)
natürliches Lager = Schichtung des Steins

Backfilling stone / Core filling stone
Stone used in the backfilling. Stone which has no nice "face" and no nice surface for the use as a runner or binder.

Streicher/runner (fig. 2: "d")
Stone with a nice flat face which is inserted with its longer side along the surface.

Binder / Bond stone (fig. 2: "e")
Stone with a nice flat face which is inserted with its shorter side along the surface.

Cyclopic stone
Stone without a natural bedding

Through Stone (fig. 2: "f")
Through stones traverse the whole construction and reach from the face deep in the construction of the retaining wall. Their function is to anchor the face to the backfilling. The minimal length of a through stone is 0.6m.

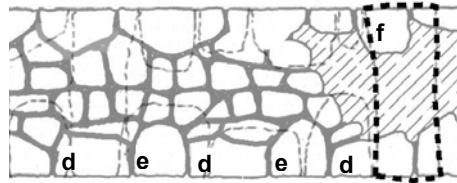


figure 2:
terminology of stone types in the wall

Steintypen

Die fünf Steintypen



figure 3:
section through a retaining wall

1. foundation stone
2. Face stone as strecher / runner,
as bonding stone
as cyclopic stone
3. backfilling stone, core filling stone
4. through stone / tiestone
5. coping stone / topstone

The golden rules for building

Paying attention to the following rules provides for stability and long life span

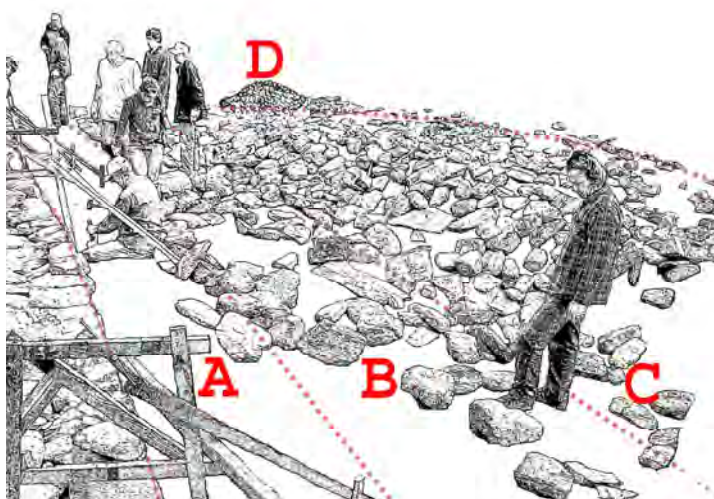
- place the stones on their natural bedding
- the stones must touch each other (important in the area of the first 5 cm from the face. The contact surface should be as big as possible).
- break or cross the vertical joints. A stone on two, two stones on one.
- the stones may not move.
- the stones may not be inclined outward.
- wedges and loose stone chips in the face must be avoided.
- use big foundation stones with their length running to the inside of the construction.
- place the core filling by hand.
- fill all gaps and cavities accurately.
- place one through stone per 0.5 m² of wall surface.
- use big and heavy coping stones.

Construction sequence

Dismantling existing walls, Sorting out the stones

figure 4:
sortation of the stones
A: keep free for circulation
B: big stones
(foundation stones,
top stones, trough
stones)
C: medium size stones
for the face
D: backfilling

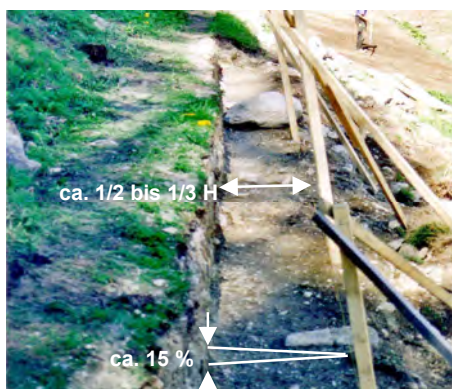
Often, the first working step consists in dismantling the old, damaged dry stone wall. The stones are sorted according to five stone types provided that there is enough place. As



soon as the stones are removed, the remaining humus is removed with pick and shovel and the foundation ditch is excavated down to the firm subsoil. Normally a dry stone wall is built directly on the subsoil or the bedrock. Nevertheless, on a marshy or clayey ground it can be necessary

to insert a grit packing to ensure an optimal pressure distribution. In addition the drainage of the wall is thus guaranteed.

figure 5:
foundation ditch



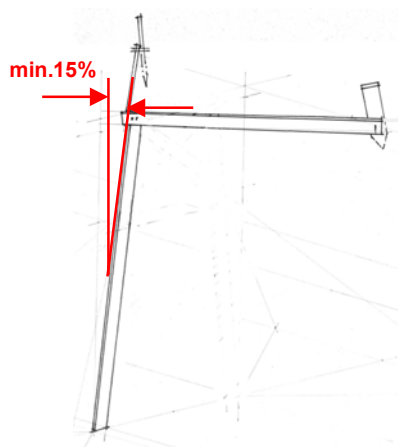
The excavated earth is deposited in a separate location for later use. The width of the foundation is about half of the final height. The foundation ditch is dug a little wider than necessary to facilitate the placing of the foundation stones. The foundation surface is inclined with approximately 15% towards the slope. Next the batter frame is built. The profile serves to

reliably define the shape of the wall during construction. The allowed tolerance amounts to ± 1 cm. The frame is constructed as light as possible using wood or metal bars. However it must withstand the rough construction time and blows and pushes may not move it out of place. After completion, the guide lines are tensed between the frames. They serve as a guide to lay the stones exactly in the plane of the face. The face of the

wall is not built vertical but leans towards the mountain. This batter must be at least 15%.

Batter frames / profiles

figure 6:
batter frame



Now we can begin to lay the foundation. The big stones are aligned exactly behind the line. The interstices between the stones are carefully filled with stone wedges. To maximize stability it is very important to place these wedges manually in the wall. If they are just poured from a bucket they are not laying stable and continue to move. While laying the foundation stones (and also throughout the construction of the wall) we try to run the stones with their length towards the interior of the wall. This increases the stability of the wall.

Foundations

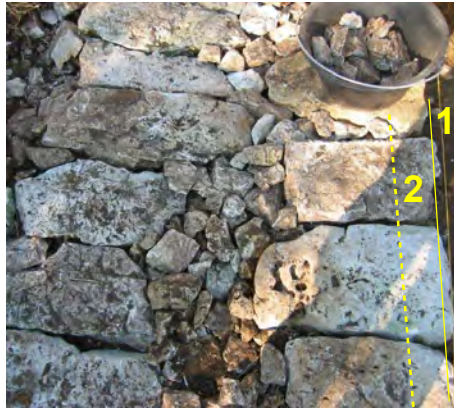
figure 7:
laying the foundation



There are two ways to build a foundation:

1. The outside of the foundation is flush with the face of the wall.
2. The outside of the foundation projects approx. 15 - 20 cm. over the planned exterior surface of the wall. The base thus projecting adds to the stability and offers protection from erosion of the foundation.

figure 8:
placing the stones as
binder.



As soon as the foundation is completed we can begin to raise the wall. The string must always be kept tense and never may touch the stones we lay. It is always shifted upwards so it is placed some centimeters above the topmost stones. The more exactly the stones are aligned behind the string, the more even will the surface of the wall be. Building a dry stone retaining wall is team work. Lifting heavy and big stones is best done by helping one another. Usually the wall is built in layers. Each layer must be finished, all cracks and interstices carefully filled before the work on the next layer is started.

Wall / Bonding

figure 09:
rising joints, bad

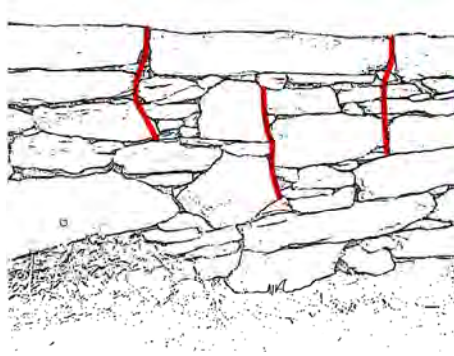


fig 10:
crossed vertical joints,
good

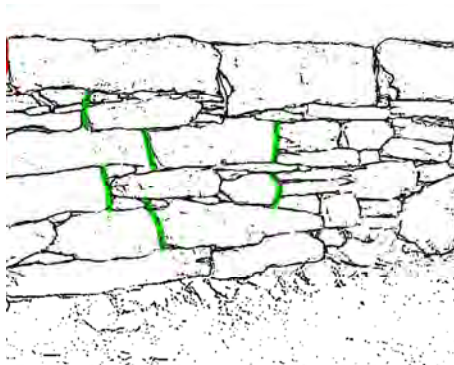
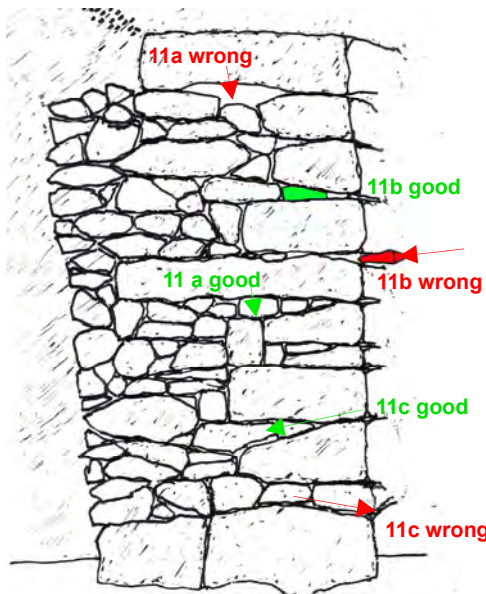


figure 11a:
filling of all cavities in
the wall

figure 11b:
wedges in the face

figure 11c:
slope of the bedding
lane



Building a dry stone retaining wall we observe the following golden rules :

- The stones have to be put horizontally on their natural bedding.
- All stones have to touch, no stone may be pulled out of the wall face.
- Vertical seams of uncrossed joints are to be avoided (cf fig.09).
- Always cross the joints, put one stone on two and two stones on one (cf fig. 10).
- stones laying on one another must touch in at least 3 points. two points near the face, one point in the inside.
- The stone may not move if pressure is applied on the outside edge of the stone.
- The surface of the stone must lie horizontally or better be inclined slightly towards the inside (cf fig. 11c).
- Don't place wedges in the face of the wall, they can be pulled out easily (cf fig.11b).
- fill interstices and cavities carefully (cf fig. 11a).

figure 12:
stones used to equalize
the height adjacent stones

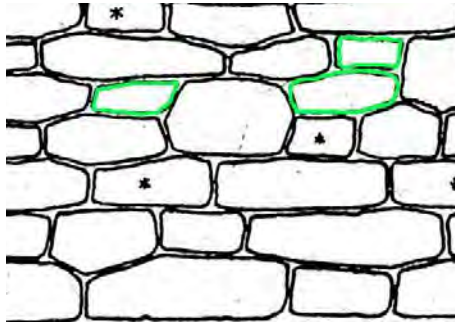


figure 13:
stones used to equalize
the height adjacent stones



In reality the breaking of the joints is not always easy. The layers of the stones are assembled of stones of different height. Thick and flat stones are placed side by side. To break a joint between a thick and a flat stone we have two possibilities. Either we search for a stone which has an underside formed like the needed height difference (which may be a time consuming job) or we equalize the height difference with a smaller stone. This gives us a horizontal surface on which we can easily place a further stone to break the joint. In this way vertical joints run at most over two stones.

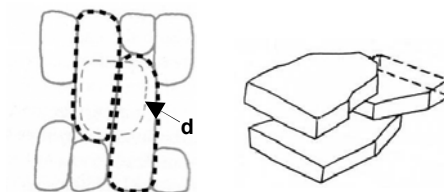
Throughstones

figure 14:
throughstones



To anchor the exterior face in the rubble fill of the retaining wall, through stones must be placed regularly. These through stones traverse the whole construction. It can be good practice to let the through stones project from the wall face. In this way the through stones can continue to act even if the wall is deformed during aging.

figure 15 und 16:
combining stones to
form a trough stone



If no through stones can be found, two smaller complementary through stones can be placed directly side by side or one on top of the other. The contact surface of these stones must be as big as possible to maximize friction. Stones can also be placed as a "pincer"-construction (cf fig. 20).

figure 17:
continue building until
approx. 40 cm under
the final height.



The space between the through stones is filled with masonry and the wall is raised to approximately 40 cm under the final height.

Coping stones / Topstones

figure 18:
topstones placed horizontal



figure 19:
first topstones with line

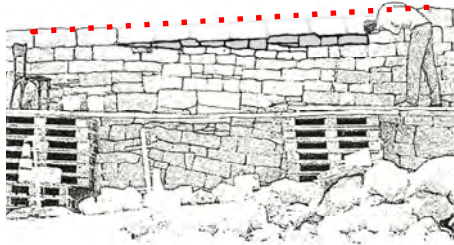


figure 20:
first topstone with line



figure 21, left:
topstone on small underpinning stones
figure 22, right:
topstone on good stones of equal size



figure 23:
joints between topstones



Wall heads, Corners

figure 24:
placing of stones in a corner



The heavy coping stones protect the underlying stones from being displaced. In addition they act as a visual upper end of the wall. The two main styles of laying coping stones is vertically or horizontally. This style is dependent on the locally available stones and the local traditions. In Switzerland standing coping stones are found mainly in the eastern part, on the freestanding walls of the Jura, in other regions of Switzerland the walls are covered with horizontal laid plates of stone. If no stones of suitable size and weight are to be found the top of the wall can also be covered with earth. The roots of the plants which grow here keep the earth in place and protect the wall.

For the laying of the coping stones the line is raised now to the final height. It indicates the upper edge of the coverstones. Now one coverstone is inserted after the other. The topstones are placed exactly under the string running on top and the remaining gap between topstone and wall is filled with a convenient stone. Underpinning the topstones with thin stones, (cf fig.25), is to be avoided. The choice of sound and big enough topstones is very important for the stability and longevity of the wall. If the topstones are placed horizon-

tally they have to be quite big and heavy so they can't be easily displaced by animals or man. There should be no gaps between topstones and the stones underneath. The topstones should be so well placed that there is no movement if we walk over the coping. Their function is to weight the underlying construction and to pin down the smaller stones underneath. The vertical joints between the topstones should be closed. It is good practise to have not only one touching point (near the face) but to have a joint which is closed over the whole depth of the joint (cf fig. 23). When all topstones are placed the joints are wedged.

Wall corners are an important part for the stability of dry stone walls. They are built with carefully selected, well placed and long enough stones. The edge bond is formed by placing the long stones as stretchers/runners. In each layer the face in which the stretcher is placed is alternated. In this manner an interlocking with the rest of the wall is achieved.