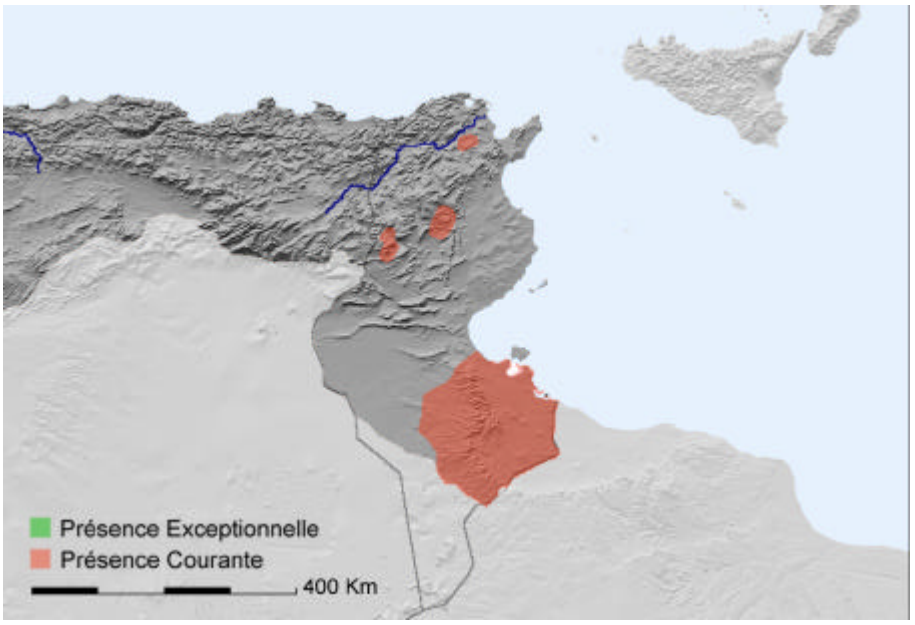
Building Techniques :

A5 – Dry stone wall

Country: Tunisie

PRÉSENTATION

Geographical distribution



Definition

Dry stone wall

- The dry stone wall is a wall built without mortar: the harmony and solidity of the construction are ensured by the weight, shape, inertia, and especially the position of each stone.

- Origin: loose stone, sometimes quarry.

- Random shape; basic re-cutting possible with a percussive tool (hammer, chisel, mallet...), or by splitting.

Environment

Dry stone masonry is an almost exclusively rural technique, in harmony with countries and social organisation where labour is abundant, and construction stone plentiful. Found in most Mediterranean countries, this technique is more often found in mountain environment, exceptionally in plains (Spain, Portugal, Tunisia) or seaside (Spain).

In Tunisia, dry stone masonry is a common rural technique, used in plain and mountain environment. It is found in various Tunisian areas, more particularly rural areas where limestone is abundant. But the most representative area for this type of wall is located in central south Tunisia, limited in the east by the low plain of Jeffara and in the west by the Large Erg Oriental cliffs. This central zone is dominated by the high plateau of Dahar which grows into a 200 to 300 m cliff. The area is greatly partitioned by many high mounts. The side is called " Djebel " or " mounts of the ksours ". The layers of the various rock beds consist of alternate soft calcareous marl and turonien limestone hard and dolomitic beds. Unless specified otherwise, the information contained in this card relates to this south Tunisian area.

Illustrations

General views :

Detail close-up :

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CONSTRUCTION PRINCIPLE

Foundations

When stone shows at the surface of the ground, as is often the case in mountainous environments, it is cleared and the wall is built directly on this stony base. This remains true on a sloped or uneven ground. Otherwise, a trench foundation is dug, about 50 cm deep. The width is generally greater than the thickness of the wall at its base, and can reach twice this width. The largest stones fill the trench, and are settled with a sledgehammer. The gaps are filled with earth, wet or compacted.

In Tunisia, no earthwork necessary, no particular foundation is associated to this type of wall.

Materials

Type and hardness :

When building with dry stone, primarily limestone and schist are used, more rarely granite (certain areas in Spain and in France) and basalt (in Greece). The stones found, either flat slabs of stone("lauses") or rough stone, are at least 4-5 on the 1-10 scale for hardness.

In Tunisia, for dry stone constructions, limestone (reported hardness: 6). The stones come from dug out caves and fallen rocks accumulated in the surroundings; they are cut and assembled with smaller modules.

Modules

In most countries, dry stone masonry is carried out without any predefined module, the builder simply uses the stones that are available and at hand. They are most often sorted out and organised according to thickness and length before the actual construction of the wall. Their weight can sometimes reach 100 kilos . The modules reported in Spain and Portugal are: length, between the 20 and 30 cm, height between 8 and 12 cm, and depth from 12 to 20 cm.

In Tunisia, the dry stone wall, called " Aïssaoui " is assembled with smaller stones as the wall gains in height : the stones are superimposed without binding material. Dimensions of the stones vary considerably: The smallest are: 20x10x5 cm; 20x15x10 cm; 20x20x10 cm; The average: 30x20x15 cm; 40x30x15 cm; 50x40x30 cm; The biggest: 70x50x40 cm; 100x70x50 cm; 120x80x60 cm.

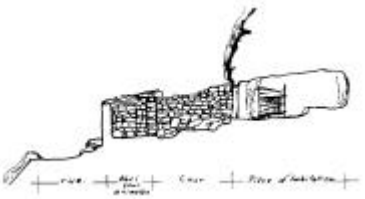
Mortar laying

Realisation :

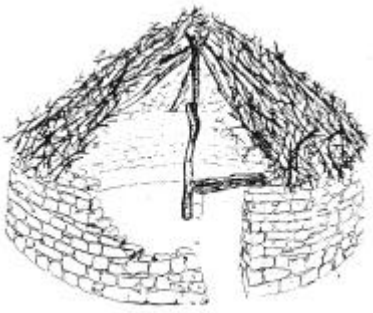
Technique without mortar.

Illustrations

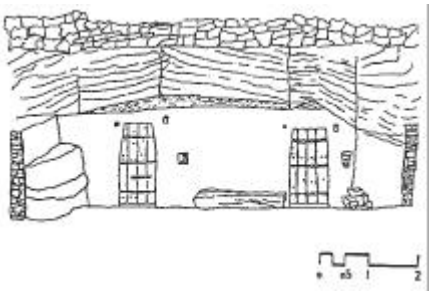
Enclosing wall – General view



Habitation at Tamezret, constituted by a dwelling part (cave dwelling) and another part built in dry stone (courtship and shelter for animals).



"Layha" : nomad shelter built in dry stone



Protection wall in dry stone on a cave dwelling at Chenini Tataouine.

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CONSTRUCTION PRINCIPLE (CONTINUED)

Thickness and Dimensions

This type of construction leads to building thick walls, from 45 to 120 cm: getting thinner as the wall gets higher. The stones are systematically laid perpendicular to the course of the wall (lengthways), the wall is generally made with two stone facings and an internal filling with smaller fragments. In all cases, each facing is linked with header binders or full stone blocks (large stone locks) that cover the whole width of the wall, and our laid regularly in the course of the wall (ideally one stone every square meter). Short of long enough stones, two header binders overlap each other at the tails, binding each other tightly.
Dry stone masonry is never used to build levels, and the walls are most often from 1.5-3 m high, and only exceptionally 4 m (up to 10 m in Spain). In Portugal, the width / height ratio of the wall is 1 to 3: this ratio seems about right for all the other study countries.
In Tunisia, with the dry stone wall technique: variable thickness, minimum 80 cm to and maximum 120 cm, thinning down in height. They are made with two not-linked facings, and their height ranges from 1 to 2,70 m.

Finishing

Dry stone masonry is traditionally left bare, and rough. It is usually not protected, with some exceptions: rendered or painted on the interior faces of the wall (Cyprus, Tunisia) or on the outside (Portugal, Turkey).
In Tunisia, the " Aïssaoui " wall is not protected. Exceptionally, when an dwelling element is built entirely or partially with dry stone, one applies a plaster pointing on the interior face of the wall. This pointing is very rare on the outside.

Tools

This technique does not require many tools, the work is mainly done by hand (with or without gloves). In most countries, a hammer is used to cut and shape the stones. The tools used to check the alignment progress of the wall are: a plumb line, a level measuring instrument, and string to limit the foundation.
In Tunisia, no specific tool was reported for the construction of dry stone walls.

Trades

This technique requires specific know how of the mason who carries out the works. It is traditionally carried out by the user himself (farmer, shepard, often helped by his family and his friends.. In certain countries, we find the assistance of a carpenter (Turkey) or a stone cutter (Portugal). In Spain, a professional - " marger " - is specialised in the construction of low dry stone walls.
In Tunisia, dry stone masonry is generally built by the user, sometimes helped by his neighbours and other family members.

Thermal and Acoustic Performance

The acoustic and thermal insulation of dry stone walls is bad: many gaps let air and sound in. To improve insulation and protection against draughts, humidity and pests, the gaps between the stones can be filled with fine earth as the construction goes along, and the inside facing can be rendered with lime mortar. Generally, shelters and sheds built with dry stones are annex constructions and/or temporary, therefore not requiring high or effective insulation conditions.
In Tunisia, the thermal and acoustic performances (> 0,025) of dry stone constructions are relatively bad.

Ageing pathology

Linked to materials used and climate conditions :
In the case of frost splitting stones, wear due to the combined actions of freezing/de-freezing and moisture disintegrate stones, and then tend to settle the masonry.

Linked to the technique:
If the fundamental rules for building a dry stone wall are not observed, then the following problems may occur: chain reaction sliding and collapse of the wall if one stone is wrongly laid, that is to say oriented outwards, in the wall course. Swelling of the facings and collapse if the core is filled with modules that are too small (the core of the wall caves in, pushing the facings outwards). Problems linked to a thrust of overhanging materials. Dry stone architecture is primarily fragile and temporary: it requires annual maintenance to replace fallen or loose stones, to stabilise or reduce abnormal settlement, counter sagging, etc.
In Tunisia, no specific pathology. This type of wall is not subject to any particular maintenance. Problems linked to construction defects occur (See MEDA).

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CONSTRUCTION PRINCIPLE (CONTINUED)

REALISATION DESCRIPTION

Greek example: (Text in French)
(Description d'après "Le mur en pierre sèche", travail réalisé par Philippe LESUEUR et Valentine SCIANDRA, Gonéa, Kotronas, Lakonie, Grèce)

Les règles pour l'édification d'un mur en pierre sèche sont simples, encore faut-il les respecter. Elles sont établies depuis des millénaires, et il serait illusoire d'y vouloir apporter des modifications ou des améliorations personnelles. C'est donc un travail qui demande beaucoup d'humilité.

Règles générales de construction :

Avec ou sans l'aide d'un engin, débroussailler et nettoyer la zone de travail sur une largeur minimale de 4 mètres. On prendra soin d'éviter de passer à proximité de gros arbres ou de grosses concentrations de taillis (ne jamais chevaucher une souche vive). Il faut ensuite acheminer les matériaux à pied d'œuvre en répartissant les tas de pierres de part et d'autre du mur et par taille, grosses, moyennes et petites. Cette précaution préalable fait gagner un temps considérable par la suite.

Deux principes essentiels gouvernent l'édification d'un mur en pierres sèches : la densité des pierres et la nécessité de convergence de celles-ci vers le centre de gravité du mur situé, naturellement, à l'aplomb du milieu de la surface porteuse (le sol). Dans cette logique, il vaut mieux qu'une pierre soit « penchée » vers l'intérieur ❶ que le contraire ❷.

Posées sur la base du sol (légèrement excave ou non suivant leur nature), les plus grosses pierres - qui sont parfois de véritables rochers dépassant les 100 kg - sont relayées plus haut par des pierres de taille moyenne, pour finir au sommet par de plus menues. L'intérieur du mur devra être comblé étroitement au fur et à mesure de son élévation et sur le même principe que les façades extérieures : au fond, à partir du sol on emploiera des pierres moyennes en prenant soin de les imbriquer les unes aux autres. Plus haut on procèdera de la même manière mais avec des pierres de plus petites dimensions, ainsi de suite jusqu'au faîtage. Ce travail particulier s'appelle : « Millioner ». Ne pas se laisser tenter, pour aller plus vite, de verser à l'intérieur d'autres matériaux comme de la terre, du sable, etc.

Que l'on choisisse de dresser chaque côté du mur simultanément ce qui suppose un ouvrier l'un en face de l'autre, ou un côté après l'autre (quand on est seul…) le problème va se poser de relier ces deux côtés l'un à l'autre le plus étroitement possible.
Pour créer ces points d'appui régulièrement répartis sur la hauteur et la longueur du mur il va falloir poser des « clefs », pierres de forme très allongée dont la longueur idéale serait la largeur exacte du mur pour apparaître en façade de chaque côté ❶. Mais il est difficile d'y parvenir tant ces formes sont très rares dans la nature. Il faut essayer néanmoins de mettre en place une « fausse clef » qui, arasant l'un des côtés pénétrera le plus profondément possible dans l'épaisseur du mur ❷. Une autre solution moins satisfaisante encore consiste à faire se croiser de part et d'autre du milieu du mur deux pierres les plus longues possibles ❸.

Une pierre quelle que soit sa taille ou son poids se pose sur sa partie la plus large, la plus dense, la plus plate. Elle ne doit jamais être en balance. La moindre tricherie est une faute aux conséquences désastreuses. Comme la forme idéale existe rarement à l'état brut – en tous cas jamais à répétition – il faut trouver à chaque pierre que l'on intègre à un mur un minimum de trois points d'appui à sa base de telle sorte qu'elle ne bouge pas une fois posée.
La cale doit être comme un coin et rester bloquée une fois en place sans risque de glissement. Il n'en est pas de même des cales « décoratives », si l'on peut dire, qu'on rajoute après coup de l'extérieur, pour améliorer le cas échéant l'esthétique d'un mur (jardin, espalier…), travail qu'on exécute en finition mais qui n'a aucune utilité mécanique.
On peut aussi tailler sommairement une pierre pour qu'elle s'adapte mieux, casser un coin qui dépasse, mais l'esprit du métier veut qu'il y ait le moins de trituration possible: il s'agit de travailler les mains libres avec le moins d'outils possible.
La pierre doit présenter son meilleur côté en façade.

Dernière opération : la pose du « chapeau » ou couverture du faîtage :
❶ On peut, soit aller en mourant ce qui donne au haut du mur une forme vaguement arrondie. Cette solution est difficile à exécuter et demande beaucoup de temps pour une solidité douteuse.
❷ Soit couvrir de grandes pierres plates suffisamment lourdes pour ne pas être déplacées par le vent ou le passage des bêtes. C'est la formule la plus courante.
❸ Enfin, couvrir avec des pierres moyennes et plates posées sur champ. Plus difficile à réaliser, mais d'un bel effet, très résistant. Le choix de cette finition reste évidemment dicté par le type de matériaux le plus facile à trouver alentour.

Une tendance actuelle est de couvrir le haut du mur, sur toute sa longueur, d'une couche de mortier ce qui simplifie certainement les choses mais a l'inconvénient, en homogénéisant le faîtage seul, de le « désolidariser » du reste de la construction et de provoquer par voie de conséquence des désordres à plus ou moins brève échéance, au lieu de les prévenir. Cette solution de facilité est donc à éviter.

Quelques recommandations :

- Essayer de ne pas travailler par temps de pluie. Les matériaux maculés de boue n'offrent plus les prises nécessaires. On ne peut plus juger correctement de leur forme.
- Poser toujours les pierres de haut en bas et lentement, comme le ferait une grue.
- Jamais de pose latérale, excepté pour les cales.
- Pour la manipulation des pierres, s'assurer au départ d'une très bonne prise pour ne pas avoir à changer de position en cours de route. Lorsqu'on travaille à deux, bien convenir de la manœuvre à l'avance pour ne pas courir de danger inutile.

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ASSOCIATED WORKS

Angles and columns

Angles: Possible processing in the technique, using the same materials

Angle edges are preferably not too sharp, and are processed using the same technique and the same materials as the body of the wall. The stones used are large, long shaped and have two faces that cross each other at a right angle (one short, one long). Start laying the heaviest stone, all the other stones will lean against it, in decreasing order in weight, make sure they cross at the head. The inside angle and outside angle are processed the same way. Many types of small constructions in dry stone are round shaped, to avoid weakening the angles.

In Tunisia, angles are not carried out, or possible in this technique.

Pillars: Possible processing in the technique, using the same materials

Besides a few exceptions, pillars are not built in this technique.

In Tunisia, you cannot build pillars and columns w ith dry stone.

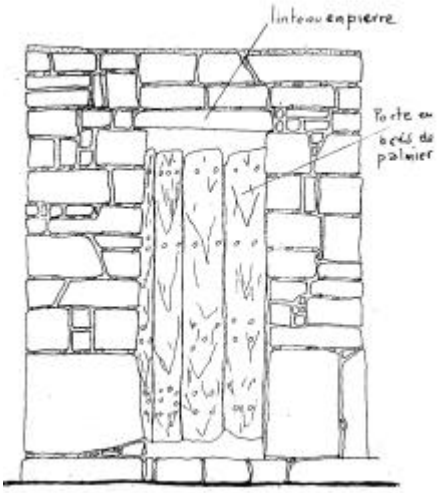
Windows and Openings

Lintels and arches

Lintels can be made of one large stone block, sometimes sculpted (not frost resistant), a piece of wood, either rough or squared (risk of rotting), it is sometimes surmounted by relief arch (France, Palestine). This arch can be made of a series of big oak branches, or two large stones placed side by side. In Tunisia, stone lintels only allow small spans ; the openings must have a trapezoidal shape, larger at the bottom than at the top.

In Tunisia, the lintels found are flat. Two kinds are possible: stone or wood. Lintel stones are monolithic, made with hard limestone coming from dolomitic layers. They is a major disadvantage: only short spans are possible, which obliges to make the trapezoidal openings, a broader shape at the bottom than the top, reducing the load of the lintel and transmitting part of the strains on the walls. The wooden lintels are carried out with olive-tree branches or palm tree beams, making larger spans possible, larger than stone lintels.

Illustrations



Angle treatment; windows and openings (i n stone)

ASSOCIATED WORKS (CONTINUED)

Windows and Openings (next)

Jambs

Jambs are processed like the walls or corners, with larger stones, long enough to link each other, often reshaped with two facings crossing at a right angle.

In Tunisia, in dry stone constructions, the jambs of the openings are built like the wall course, but they can be also laid in mortar.

Supports

Generally, the supports are non-protruding and are generally large slabs of stone.

In Tunisia, in dry stone constructions, the supports are non-protruding.

Dimensions

Narrow and not tall in most types of dry stone habitat. The width is often less than 80 cm, but in Tunisia, it can reach 150 cm at the bottom of the doors, and the height can reach 250 cm(200 cm in Palestine and Portugal). In France, it was reported that the few windows let little sun or heat in, and do not ventilate smoke well.

In Tunisia, in dry stone constructions, the dimensions of openings vary from 80 to 150 cm maximum in width and from 200cm to 250cm maximum in height.

Associated Elements

For most countries, no specific element is associated to dry stone constructions. In France, cupboards and chimneys are sometimes built in the thickness of the wall. In Turkey, projecting volumes are sometimes associated directly to the wooden ties in " dugmeli " walls.

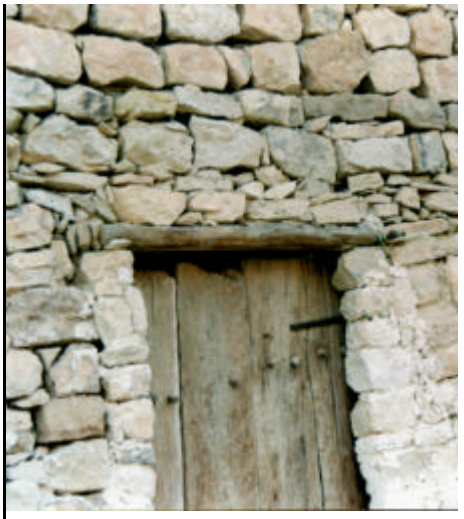
In Tunisia, no specific associated element was reported for dry stone constructions.

Wall-roof Connections

Two cases have been reported in the case of covered constructions: the vault or the roof sits directly on the wall. In certain examples, a cornice is made of two crossed rows of horizontal slabs, and serve as a gutter to avoid rain from trickling down the wall. In the case of surrounding walls, terraces, the coping answers three needs: to avoid the wall from dismantling by loading it (physical), finish the work with style (aesthetic), and possibly keep animals from passing (practical).

In Tunisia, no particular elements mark the wall-roof connection, nor is there any specific waterproofing.

Illustrations



Windows and openings : wood lintels

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USE, EVOLUTION AND TRANSFORMATION

Use

Types of buildings

This technique is used for modest housing and farm facilities, sometimes temporary or non permanent (shepherd sheds), and is very common for surrounding walls and terraces.

In Tunisia, the dry stone wall, called "Aïssaoui" is generally used to make non load bearing enclosing walls (limiting the court next to a troglodyte dwelling, for example). But also in other shapes, and particularly: - built on top of troglodytic dwellings for a protection against falling stones and strong rains – used for nomad construction, shelter called " Layha ". A light circular construction, completely carried out with dry stone, wooden roofing resting on a central mast called " Rkaya ". These sheds have been abandoned and are found periodically according to the transhumance paces and territories.

Period when the technique first appeared. Period when the technique is in use – still used today or disappeared :

In most countries, this technique is ancestral (prehistoric). Its use has decreased, and has sometimes even completely disappeared in certain countries, particularly due to industrialisation and rural migration. In other countries, dry stone is still used today, undoubtedly because of its simplicity (no tools are necessary) and the availability of materials, found on the spot. Finally, elsewhere, the trend tends towards recovery and rehabilitation, in France and Spain for example.

In Tunisia, obviously a secular technique deeply rooted in local tradition, but badly shaken under the effect of modern factors and events, mainly during the second half of the XXth century. Still used today.

Reasons why the technique disappeared or has been modified :

If the technique is still forceful in certain countries, (Greece, Tunisia) in the countryside, most countries unfortunately reported dry stone as a complex, meticulous process, that can not be mechanised, and is deeply linked to a social and economic system. Skilled labour, as it is little called upon, is growing scarce, generating a loss of know-how, from a construction technique point of view as well as maintenance. We can nevertheless still find a certain concern for the development and rehabilitation of this type of wall in several areas of the Mediterranean, particularly in France and Spain.

In Tunisia, as directly associated to housing, we can consider this type of wall has almost completely disappeared. Several factors explain this disappearing: course an invasion of modern materials (Portland cement, hydraulic lime, steel, hollow industrialised blocks... etc.) and modern techniques. But all the social, economic and cultural transformations that affected Tunisian society over the last decades have strongly contributed to the abandonment of this technique. Nevertheless, it is still used today to fence farm lands, particularly in the areas where limestone is abundant. The low cost of materials and the simplicity of the work, which doesn't require particular technical skills still encourages certain landowners to upkeep this type of wall. The illustration of a farm in the surroundings of Tunis is a very recent and young example of this survival, in these new conditions.

Evolution / Transformation

Materials

Today's trend is to cover the top of the wall on its full length with a layer of mortar, which makes the work simpler, but the drawback is that while making the coping homogeneous, the rest of the wall isn't solidified, and is exposed to damage in more or less short term. This easy solution is therefore to be avoided.

In Tunisia, domination of modern materials (Portland cement, hydraulic lime, steel, hollow industrialised blocks... etc.) and modern techniques.

Technical aspects

Few tools are necessary. Today, additional mechanical means are used for handling and supplying stones (transport, lifting): bulldozer ripraping, supply trucks from the quarries. In addition, the most significant (though not generalised) change concerning this technique is the use of mortar, and almost always cement.

In Tunisia, nothing was reported outside MEDA observations.

Evaluating materials and replacement techniques:

In most countries, new buildings are not built in the technique. In addition, a transformation is generally reported: the use of mortar, particularly on the interior face of constructions, to consolidate dry stone construction. Possible when it is built assembled according the dry stone traditional technique (see realisation). The result is much more bland.

In Tunisia, nothing was reported outside MEDA observations.

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