

REFLECTIONS ON EQUILIBRIUM

I was fortunate to have been introduced to stonemasonry in the south of France, in an area replete with stone-built structures: houses, outbuildings, boundary walls, and retaining walls. Instructive examples of the stonemason's craft, good, very good and not-so-good, were everywhere, and there was plenty of work available, transforming ruinous old farmhouses into rustic villas for Parisians and their ilk from elsewhere in Europe who were discovering the charms of life in the French countryside. I lived in a small village and worked as a stonemason for several years.

Then, I visited the island of Mallorca and found myself face to face with walls very unlike those I had been familiar with in France. Not the walls of the houses which were not that different from the walls of French houses, but the many retaining walls forming the agricultural terraces that so articulately modified the stony, hilly landscape. There was something, well, disturbing about these walls, but what, exactly? Eventually it dawned on me.

The stones were not at rest!

In France I had learned to build in horizontal courses with jumpers between courses, to place each stone in a stable position, to form a stable mass. There, all walls were built in this way, house walls or terrace walls, mortared or dry laid. But in these Mallorcan walls there were no horizontal courses and the individual stones were set on their ends rather than laid on their long sides, placed vertically or diagonally rather than horizontally—except for the corners of the walls and the vertical columns that occurred at regular intervals in the body of the wall, like structural parentheses.

If rectangular, the stones were oriented on the diagonal, herring-bone fashion, but the common stone shape was that of a polygon, in the case of fieldstones an irregular, even shaggy, rudimentary hexagon. Imagine, if you will, that a roughly hexagonal, individual stone in the wall has the shape of the human torso (some fat, some skinny.) What might then be referred to as the hips of one stone would be exerting pressure downward diagonally against the shoulders of the two stones immediately below it—just as pressure is being exerted upon it, upon its shoulders, by the hips of the two stones above it. This is graphically apparent in the regular (or irregular) honeycomb structure of walls constructed with carefully tailored stones, but the principle is at work as well in rougher walls made with un-worked fieldstones that are more like angular ovals than polygons.

All those stones actively wedged together, pushing against each other, create a web of tension throughout the body of the wall.

That tension, a cohesive force, infuses the mass of the wall and in so doing forms a stronger bulwark than mass alone against the lateral pressure of the earthen terrace behind it.

The instinctive intelligence at work here deserves respect—more than respect, admiration. Later, when Miguel Ramis made me aware of the interlocking arches built into the fabric of the *marges*, and how they function to enhance structural stability, my admiration grew.

EQUILIBRIUM is a state of balance. Masons, it might be said, are agents of structural equilibrium; the lesson this mason took from these Mallorcan terrace walls was that there are two types of structural equilibrium:

STATIC EQUILIBRIUM occurs in well bonded, horizontally coursed masonry with the stones laid in a stable position. It is an effective way to build and is adequate for house walls or free-standing fences where masonry has only to accommodate bearing weight. But when the masonry structure must resist lateral pressure, or is subject to earth movement either through subsidence or seismic upheaval, DYNAMIC EQUILIBRIUM serves best. The two types of equilibrium are well illustrated in Joe Kenlan's article on bonding (page 61.)

In houses and larger buildings, the two are often combined, for instance in the use of arches, as Joe points out. A relief arch, incorporated into the fabric of a wall over an opening and deflecting the weight of the wall to the sides of that opening is an excellent example of a dynamic masonry element in a static masonry context.

Inertia, as it relates to construction, is the tendency to resist induced movement. Equilibrium contributes to inertia. Static style masonry accomplishes its work through the inherent inertia of its mass. Dynamic style masonry also possesses inertia, but inertia enhanced by the masonry being in tension.

The antecedents of contemporary Mallorcan builders evolved styles of masonry that served their various needs. In the thousands of kilometers of *marges*, or terrace walls, interwoven with ramps and roads and watercourses, we see the most ingenious manifestation of their instinctive technological savvy.

Landscape design professionals and contractors, stonemasons and those who seriously pursue stonework as an avocation would all benefit from an understanding of Mallorcan style walls. That is why we organize the workshops, and why I've asked Miguel Ramis to write the following article.

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ADAPTIVE INTELLIGENCE

DRY STONE WALLS OF MALLORCA

by Miguel Ramis

Mallorca is the largest island (1,405 square miles, slightly larger than Rhode Island) of the Balearic archipelago. Due to its strategic location in the western Mediterranean it has been densely populated throughout its long and colorful history. The successful agriculture-based economy that evolved there made territory an important cultural issue.

The flatlands were obviously the most desirable areas and these were possessed by the most important families, the descendants of the noblemen with King James I who defeated the Moors and took control of the island in 1229.

The forests were slowly transformed into cultivated land by the landed gentry and the religious orders, especially the very organized Cistercians. Trees were cut, water channels, mills and cisterns built and the forests physically adapted to suit economic ends. The mountainous areas, with hardly any soil, remained wild. The poor people, called *roters*, (ro-TAIRS) started to establish agreements with the landlords: for the right to inhabit and cultivate a section of hilly terrain they would give the landlord half of what they were able to make the land produce—the practice known elsewhere as sharecropping. The wealthy landlords had nothing to lose, and the poorest people had the opportunity to make a living.

Thus, the hills began to change. Retaining walls, called *marges*, tamed the stony landscape step by built step. Erosion was checked and the soil was held in cultivable terraces on which crops like olives, grapes and onions were grown, produce that had been exported since Roman times. The Sierra Tramuntana is a mountain range in the northwest quadrant of the island; in this area alone over 10,000 linear miles of *marges* were built over time.

After generations of hardscrabble life the most resourceful and hard working *roters* had been able to earn the means to buy the land and the territory started to change from large estates to small farms or *fincas*. Social revolution was the by-product of the transformation of the natural landscape.

Once the erosion was controlled, agriculture in the mountains became possible. Vineyards, olive trees and other plants brought a green carpet to the mountains. Greenery attracts rain, and rain abets the development of a successful agricultural economy.

The dry walls are a home for many creatures: snakes, insects, and especially *caracoles*, or snails, which were an important source of protein in the meager diet of the poor folk and are a delicacy still in Mediterranean cuisine.

DRY STONE WALLING WORKSHOP

DEIA, ISLAND OF MALLORCA, SPAIN
SEPTEMBER 21-26, 2009

THE STONE FOUNDATION
AND ARTIFEX BALEAR

registration is limited, apply soon. for information:
www.stonefoundation.org www.artifexbalear.com



The last decades have witnessed an increasing trend for tight stone fitting. This was never traditional in the past. It is nothing a *marger* could not do, but simply illogical in terms of efficiency. Furthermore, smaller joints mean the snails would not be able to house in the *marges*, thus blocking the possibility of gathering them.

To clarify, we are talking here about countryside agricultural terrace walls. There are tight fitting walls dating from 19th century, civil works, such as the roadway walls ordered by Queen Isabel II. These civil works started a trend towards tight fitting that is basically urban.

THE EVOLUTION OF SKILL

Agriculture has always been the proving ground of the art of the stonemason. The ingrained habit of using stone to build non-mortared walls evolved into a traditional building art form, the principles and aesthetics of which were passed from generation to generation of craftsmen capable of conceiving of and executing more demanding and technical stonemasonry designs such as roadways, bridges, water channels and reservoirs, flooring, pavements and, ultimately, sculpture.

DISTINCT FEATURES OF A MALLORCAN WALL

Dry Stone Walls, Polygonality and Arches

In general Mallorcan walls, are comprised of pentagonal and/or hexagonal shaped stones. In rural walls stones are usually placed in the wall as they are found, with little or no shaping, so they tend to be only rudimentary pentagons or hexagons. In more urban or formal settings the stones tend to be tailored polygonal shapes.

As indicated in the detail of the photograph of Mestre Biel and as can be seen in the other photographs, the Mallorcan *marge* is a complex mesh of many interwoven arches. In a well-built *marge*, most stones are surmounted by an irregular arch of other stones—and are themselves elements in one or more other arches.

With rectangular coursed stonemasonry, if a stone is taken out of the wall, a natural corbelled arch is formed by the stones in the courses above it. With polygonal masonry, what you get is a true arch formed by 3 or more stones. The wall would not even notice the missing stone since the arch will be in tension. Because



A scene from the Stone Foundation's dry stone walling workshop last summer in the village of Deia, Mallorca: Mestre (master) Biel Estela, 76 years old, is assisted by workshop instructor Lluç Mir as Michel Giannesini works nearby and Donna Hasbrouck looks on. Mestre Biel has been working with stone since he was 13 years old. Building such walls has become second nature with him and he is probably not conscious of the interlocking series of arches that he is incorporating into the structure of this one (see detail). Note the rudimentary but effective Mallorcan scaffolding which can be easily removed and repositioned: two planks resting on two stout pieces of rebar inserted into crevices in the wall (the soda can is a safety measure.)

wall system evolved. The Mediterranean historically is also a seismic zone, so the technique could well be a universal anti-seismic solution.

Paret en sec versus Paret en verd

In Mallorca there is a clear distinction between the *paret en verd*, a horizontally coursed house wall built with lime and earth mortar, and designed to take top-to-bottom bearing weight, and the *marge*, a dry wall with non-horizontal courses, designed to withstand the lateral pressure of the earthen terrace behind it.

Capginyes

The *capginya* (see photo next page, top) is a vertical column of sizable stones placed at regular intervals within the *marge*. This simple and effective design is, in fact, an integral pilaster or in-built corner that, in the event of a collapse on one side, limits the damage and sustains the other side until the repair is made.

It is no wonder that in Japan and Peru, areas subject to earthquake, a polygonal



You can find the same design, again Roman, replicated in the walls of the houses.

The Backfill

The backfilling uses 100% of the spalls, chips, rubble and otherwise worthless stone to occupy the space behind the external face of the *marge*. So the dry stone wall absorbs all the scraps; nothing is wasted (unused wall stone is removed or neatly stacked nearby for future use.)

The spalls are not just thrown in, but carefully placed, even wedged with a hammer (or with another stone if the hammer is not to hand) in order to create tension throughout.

Here and there at the back of the *marge* a second wall is often built, the *braó*. This is a way of using the round boulders that would require too much energy to shape. The *braó* ("biceps" in the Catalan language) is a "muscular" reinforcement, a parallel wall section that augments the inertia of the backfilling and helps to better withstand the lateral pressure of the earth terrace behind.

C & C & C

Coping, Capginyes and Corners

When the *marger* begins to work, he normally spends a day shaping the stones and placing them in three piles: the larger ones are saved for the corners, *capginyes* and coping, the largest for use in the first course, those remaining will be used in the body of the wall. A typical mistake for beginners is to use the stones as they come without saving large stones for the coping or corners. The result is an ugly wall with very small stones at the top and inadequate corners. Such a wall is as weak as it looks.

There is very practical logic in differentiating stones by size—it is inefficient to lift a

big stone higher than hip level. The place for such a stone is at the bottom of the wall, where it is most needed.

Through-Stones

The extensive use of cement mortar to make "dry" walls has made it possible to break one of the basic rules of building a solid wall: that the front face of the stone, the one that is seen on the outer surface of the wall, should NOT be the largest face.

It is best if the tail of the stone extends deeply into the infilling. Since this is not always possible, at least one stone in four or five should be a through-stone, that



The collapse of this wall (even well-built walls are subject to failure) shows how it was constructed. Note the 'brao' of large, odd-shaped stones at the rear of the wall.

extends from the face well into the fabric of the wall. Visualize the wall like the upright bed of the fakir: the nails are the through-stones that effect a better contact with the rest of the wall.

Freestanding Walls

These structures, usually perimeter or boundary walls, are generally wider in proportion to their height than *marges*. Why does a freestanding wall need to be so wide if it is not working to retain earth? The answer is utilitarian; the countryside freestanding wall is not just a boundary wall, but also a way to store stones cleared from the fields. (see *claper* below) On the neighboring island of Minorca walls are nearly a foot wider than in Mallorca; one reason for that is there are a lot more field-stone in the soil. Another reason is that the most common livestock in Mallorca are sheep, but in Minorca there are more cattle and a thinner wall could be damaged by the larger-bodied cows.

Claper

This is another type of dry stone structure, a circular, sometimes oval, dome-like cairn of stacked field stones. Its purpose is to clear the arable land and it is designed to occupy the smallest possible amount of soil. The *marger*, usually the land owner/farmer, incorporates empty spaces within the *clapers* and tunneled entries which invite rabbits to make dwellings inside, thereby providing another source of protein by hunting or snaring them in the future.

Rutló

The *rutló*, an indented space that interrupts the plane of a *marge*, is a good example of the "savvy" of the farmer/dry stone waller. As any agriculturist knows, a tree that is "born" naturally is always stronger and grows quicker than another planted by man. That is because seeds thrive best at places where the conditions are most favorable. So when the *marger* builds a wall and finds a small tree, instead of unrooting it, he modifies the design of the *marge* by creating a *rutló*, a semicircular "cove" that interrupts the wall plane order to give it a better chance: the stones will retain the moisture and in winter capture the solar heat to warm the soil.

At other times the *marger* incorporates a *rutló* in the wall because he has spotted a deposit of fertile earth which, if covered by the *marge*, would be unproductive. The *rutló* enables the *marger* to plant a tree here and at the same time avoid an unstable foundation since the softer earth might subside beneath the weight of the wall, leading to its collapse.

The Energy Equation

In terms of results gained from energy expended, the *marge* is a very practical enterprise.

A rustic *marge* can be built at a rate of nine or ten square feet per day and it will last a minimum of 50 years without any maintenance work.

A collapsed section of a wall is normally twelve to seventeen feet wide at the most, which means that it can be rebuilt in one or two days since the stones are already shaped and on site. Walls typically collapse in winter, in the rainy season, a time when the farmer conveniently has no urgent jobs to do.

So, as a matter of agricultural routine each generation dedicates a couple of months per year to the building and repairing of dry walls, usually in the winter. It was in essence a part-time job for the farmer and something a shepherd could do 'on the side' as the sheep grazed.

Economy of Style

The less the stones are "tailored" (from the French, *tailler* 'to cut') the more natural the wall looks. In Mallorca, on a building site, an old dry stone waller, even if not seen, can be recognized: The rarely-heard hammer is a sign that an experienced master at work. He visualizes the space for the next stone then locates it in the pile. He finds rather than "makes" the stone. Less work, quicker work.

Muscularity

The dissipation of muscular strength during the life of a person is compensated (by and large) with a more efficient use of force. An old master can easily keep up with a

younger *marger* even above 60-70 years old. Those who participated in the 2007 dry stone walling workshop know this from watching the 76 year old Mestre Biel at work. (see photo p56)

The Team

The best team is comprised of 3 persons, a master, a younger master and an apprentice/helper. The master directs the job and, with or without words, teaches the young master the different, subtle ways of facing each technical problem. The young master lifts and places the stones; the master only finds and fits them. The young apprentice breaks the stones, brings them to the wall to be placed and provides the backing. The young master does the hard job, the apprentice the hardest. The master does the lightest work, but he is the one able to speed up the job by selecting the right stones at each moment.

An old dry stone waller once told me "every stone is useful." For a basic dry stone wall you hardly need to shape any stone. There's a place for every stone and a stone for every place if you have "the eye." It is a pity to spend time and energy shaping a stone when one that would work is there to be found.

Spatial visualization is an essential tool of the stonemason and something that every stonemason needs to develop.

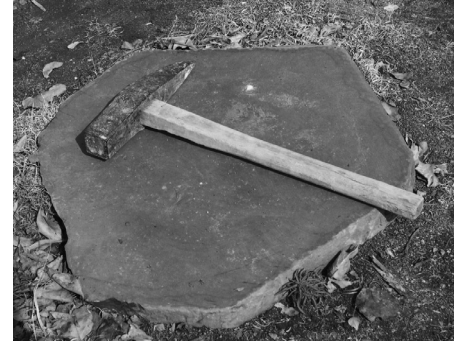
The Stone

The kind of stone available is crucial to the development of dry wall technique. The Balearic Isles are home to several varieties of excellent limestone of moderate hardness (5.5-6.5 at the Mohs scale) which respond truly to tools. There is no need for

carbide tools, good carbon steel is enough.

The Mallorcan Hammer

The local answer to the Swiss knife design, a three-in-one tool that makes hammer and chisel work unnecessary. The shape of the Mallorcan hammer is an untouched Roman design, 2000 years old.



(If enough people request this hammer from Trow and Holden [see ad page 32] they may be persuaded to produce it).

Its most distinctive features are the concave depression in the head and the point at the other end that effectively transforms the hammer into an array of several tools.

Instead of a hammer head, what you have in fact are four chisels or, better said, four hand-sets. Using only one hand (or two if a stronger blow is required) the *marger* strikes the stones with precision on either left and right sides, as well as bottom or top edges. Striking the top edge of the stone with the bottom edge of the hammer endangers one's fingers and requires some care, as one quickly learns when doing this.

The other end of the hammer does the work of a point chisel. Its curved shape follows the arm's natural swing movement, hitting inward towards you like an adze, instead of the outward movement of the pointed chisel at work.

The weight of the hammer is more important than the strength of the arm wielding it. The arm remains relaxed, using only enough energy to lift and launch the blow. Mass and momentum do the work.

If you study the depictions of medieval stonemasons you realize that almost all work (including mouldings) was done with picks and pointed hammers. The hammer and chisel technique was used more for detailed sculpture carving.

Our traditional Mallorcan tools, which evolved from Roman designs, follow this rule. The curved saw with the backwards orientation of the teeth allows you to cut

wood by pulling instead of pushing, using the weight of the body. Other traditional Mallorcan tools utilize the same principle: the curved sickle to cut the grass, the adze of the boat-maker, the triangular shovel/hoe used to move earth and rubble. The reason is that you work more efficiently with biceps and pectoral than with shoulder and triceps. The use of these muscles allows you to work longer and tires you less.

There is always a lesson to be learned when confronted with vernacular building techniques: Nothing is casual. There is a reason for everything. Like an onion, traditional procedures keep a number of subtle secrets in successive layers. Revisiting them with attention can only make us better artisans, proud and conscious and appreciative of this great gift—the heritage of the old masters. ■

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(Look for the arches embodied in these walls.) above: Holding pond, former domain of Luis Salvador, Archduke of Hapsburg, Austria center: Urban wall building site.

marger, Miguel Forteza below left: Terrace walls, ramp. Note *capinya* at extreme left. The stones in the base course appear smaller than they actually are because the ground surface has been raised. *marger*, Lluç Mir below right: Quasi-herringbone masonry. Not a particularly handsome wall, but effective. And instructive. Here the anonymous *marger* had to deal with shortish pieces of sedimentary limestone. He tilted each one on the diagonal so they push against each other, creating tension. If these stones had been laid on level courses, the wall would probably not be standing.

next page:
upper left: author's diagram of *marge*.
upper right and lower left, *marge*, four meters (13 feet) tall. Excellent work by a respected past master, Mestre Gorra de Lloret
lower right: *marge*, ramp, detail.
marger, Lluç Mir



THE MALLORCAN 'MARGE'

