

# **ARCH'10**

## **6<sup>TH</sup> INTERNATIONAL CONFERENCE ON ARCH BRIDGES**

**Editors:**

**Baochun Chen, Jiangang Wei**



**Fuzhou, Fujian, China**  
**October 11-13, 2010**



**ARCH'10**  
**Fuzhou, Fujian, China**  
**October 11-13, 2010**

ISBN 953-7621-10-0



9 789537 621100 >

# Corbelling domes and bridges in Spain and Portugal: a comparative study

Fernando Vegas- López Manzanares, Camilla Mileto and Valentina Cristini  
*Polytechnic University of Valencia, IRP – Instituto Restauración del Patrimonio, Valencia, Spain*

**ABSTRACT:** Corbelling is a traditional old system to build arches and domes that consists in overhanging gradually layers of stone or bricks, rising all the way to the cap. In Spain and Portugal small primitive bridges and a great variety of corbelling domed huts mainly in vernacular architecture related to peasants' and shepherds' lives. This variety reflects not only in the dimension, shape and use of the huts, but also in the material and constructive details. These corbelling domed huts have been classified under their free-standing or grouped condition, layout, cross section related to structural functioning and type of dome, as well as their building material, building process, possible roofing, type of lintel, possible rendering. Although apparently fragile and unstable, this ancient type of arches and domes has proofed its suitability for different uses since centuries and its capability to survive without almost any maintenance.

## 1 INTRODUCTION

This essay uncovers the variability and heterogeneity of the range of constructive types of corbelling domes across the Iberian Peninsula (Fig.1, 2). Two are the main architectural features that stand out in this study: the dry bonding technique without any mortar (both in stone and adobe masonry) and its direct relationship with the roof vaulting by corbelling.

For this reason this research is focused on the dry stone bonding solutions and its transition into specific corbelling dome systems, implemented without any trace of mortar or holding up device. The corbelling technique is possible thanks to the courses' progressive approximation and it has its source into the spontaneous covering of circular or polygonal spaces.

According to archaeology the first examples of these constructions are the huts of some Middle East settlements like Arpasiyya y Tell Alaf (V Century A.C.). Whereas in West Atlantic and Mediterranean Europe corbelling system has been traditionally linked to megalith cultural phenomenon as it may be found in these big collective graves. At the same time in some Mediterranean islands the megalith building technique is expressed by monumental Bronze Age corbelling constructions. In this case, in Mallorca, Menorca o Sardinia Islands is possible to find examples of this, respectively in remains of talayots in Spain and nuraghe in Italy.

The Iberian Peninsula witnesses a geographical synchrony between the areas of expansion of megalith culture and regions with great examples covered by corbelling domes. All this suggests that the origin of these outstanding shepherds and peasants shelters dates back to several millennia ago. Therefore, it could be stated that the Iberian landscapes are dotted with these timeless constructions, as ancient as shepherds and agriculture activities.

According with this, the study reflects two different and compatible techniques applied to constructions: the dry stone walling system and, at the same time, the corbelling dome system. The walls, built either by limestone (East of the Peninsula i.e. Cataluña, Baleares, Comunidad Valenciana and Castilla la Mancha) or granites and slates (Northwest of the Peninsula i.e. Portugal, Extremadura and Galicia), are erected bonding the stones without cement or mortar. In some cases we may find adobe corbelled domes, but just in the area of Castilla-León, called Tierra de Campos, where there is a long-standing tradition of earth constructions within the world of vernacular architecture (Fig.3).



## 2 SOME CASES OF STUDY IN SPAIN AND PORTUGAL

According to the regional variations (Fig.1, 2), we may roughly mention some of the most traditional examples in the Iberian corbelling dome constructions:



Figure 1 : Distribution in the Iberian Peninsula of corbelling dome with stone (dots), adobe (rectangles) or presence of dry stone corbelling bridges (arrows)

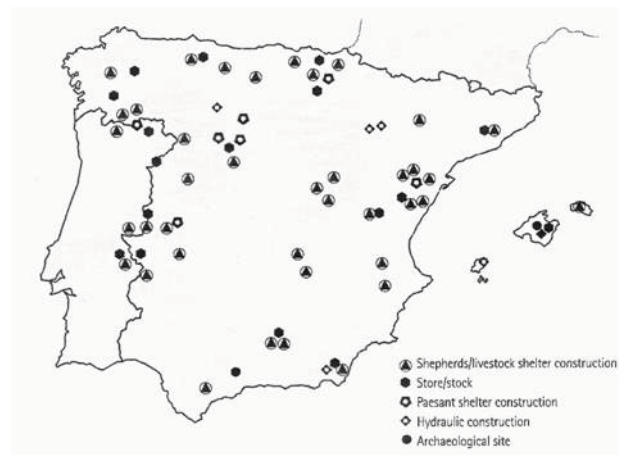


Figure 2 : Distribution in the Iberian Peninsula of the different typologies of corbelling dome

### 2.1 Chozos (Spain: Extremadura, Cantabria, Asturias, Aragón, Andalucía; Portugal: Alentejo)

These are shelters for transhumant use. According to the season, shepherds move into them for the summer and graze their sheep. During this time, these chozos shelter several people who live together in a space of a few square meters (Fig.5). Some constructions are crowned with a corbelling dome in granite or slates, while others with fired bricks. Generally, several of them have their external roof made by the same slates, while other ones incorporate a traditional ceramic tile roof or even a traditional dome, not a corbelling one. Sometimes the roofs are protected by a layer of soil or turf against the rain, and they appear as if they were green huts with grass on the roofs. Sometimes the stones walls are covered with a clay coating. Usually their section is triangular and the vault is quite conical. These shelters are especially distributed in Cáceres (Juvanec B. 2008), Oviedo, Teruel, Almería, Jaén provinces, and along the North

Atlantic Range. The name of these constructions changes practically in each province, according to regional dialects and variations (i.e. *cucos*, *monos*, *choucos*, *torrucas*, *chafurdones*, *caracoles*, *cubillos*, *tambores*, *catxerulos*...and so on).

### 2.2 *Barracas* (Spain: Inner areas of the East -Cataluña, Comunidad Valenciana and Murcia)

They are stone shelters for shepherds mainly to protect themselves and their livestock from the bad weather conditions or to control their animals. Anyway, there may be shelters specifically for agriculture in particular cases, normally built upon stonewalls that divide agricultural plots and terraces (Fig.4).The vault is a corbelling one, with almost horizontal stone layers overhanging each other. The single stones are slightly sloping outwards of the volume in order to drainage the water. Generally, on the top of the dome it may be found a top horizontal stone plate placed with the aid of some little stones. The shape outside varies a lot from an area to another. Nevertheless, it is possible to define three types according with the position of the building: free-stand volumes in brushy wood hills, shelters partially built upon dividing estates walls, shelters built with its back against a crag rock. They are typically of Cataluña, north of Comunidad Valenciana region (Meseguer Folch V. 2000, 2001, 2006) Murcia inner province and East of Aragon region (Rivas F. 2004).

### 2.3 *Pozos* (Spain: Aragón, Inner areas of Comunidad Valenciana and Cataluña, Andalucía, Tenerife and Baleares Islands)

These are stone constructions used like water wells, with traditional corbelling dome architecture, using horizontal layers of stones overhanging each other. The dry stone constructive system is perfect to gather natural water, allowing ventilation and shielding from dampness or salts arising. The shape and the dimension vary a lot from an area to another, along the dry and arid regions of Spain, like Canarias or Baleares Islands, where water is really a “treasure” for peasants and shepherds. It’s possible to define different purposes for the shelters: they are both wells, reservoirs, cisterns and so on, in some cases the constructions can be ice stores, not just water deposit, half excavated in the soil, above all in the inner rural areas of Jaén, Zaragoza, Valencia provinces.

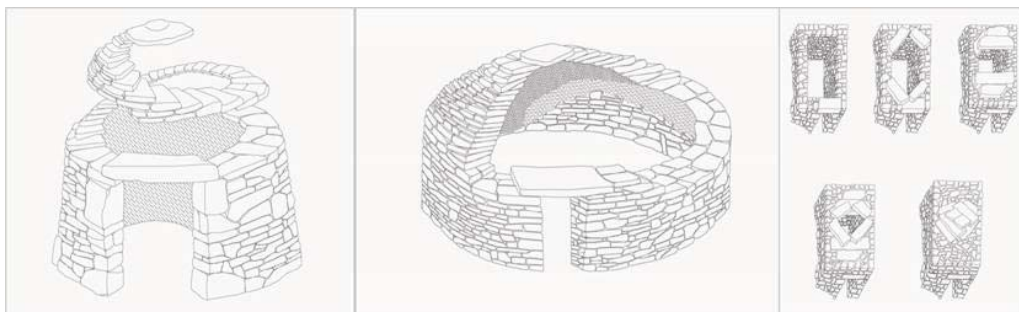


Figure 3 : Possible ways to bond up the stones for corbelling domes

### 2.4 *Ponts* (Spain: Baleares Islands)

These are shelters for shepherds and sheep and they can have basically two forms, according to the old and the more recent examples. In the inner part of Menorca there are the most ancient typologies, built unbelievably precise as half cubes with a circular ground plan and in two or three stepped heights (Juvanec B. 2001). They are made of grey stone and carry a capstone at the top or even a religious sign, a cross. Meanwhile the larger and more recent shelters are in the northern part of the plains, where they breed horses or bulls. On the contrary of the ancient structures, they are made of yellowish, dressed stone of relatively equal dimensions, perhaps smaller than the oldest buildings. Because of the larger needs, the more recent ponts are also larger, for some ten horses, they are stepped on the outside and for safety pre-dimensioned. They have a stepped form to the top and the terraces are filled with small pebbles.

The front wall is always completely flat and mangers are inbuilt on both sides of the entrance, with triangular, compound lintels. A pont always stands within an enclosure that may be a signal of their presence, as exceptional elements in the landscape Menorca Island (Balears Islands), both for their dimension and shape.

### 2.5 *Bombos (Spain: Castilla La Mancha)*

These are stone shelters mainly for shepherds. They usually have a multiple cell layout (two or three cells) and corbelled vaults that cover the space (with a final layer of gravel). There are rooms both for people and animals connected with low doors so that the shepherd may control the livestock. The final shape appears very natural as simple stone piles in the flat landscape of Tomelloso outskirts (Castilla la Mancha Region), as if they were not made by manpower. The bombo has a corbelling construction on the inside and a frame outside, and filler in between. The frame serves only to ensure that the filler does not flow out, and nature ensures that the shape is harmonious, since it depends on the natural slippage of the material. For this reason, due to the presence of the filler inside the construction is so peculiar and special in the midst of shelters typologies (Juvanec B. 2001). The shape of the external roof derives from the disposition of the stones falling naturally on the slopes of the dome. Today, the roofs are whitewashed each year with lime (Pedrero Torres J. 1999).

### 2.6 *Less famous examples built with dry stone or dry adobe techniques*

#### Almacenes (Spain: Galicia; Portugal: Montesinho)

They are dry stone constructions used as granaries with corbelling dome system (that may appear or not in the outer volume). Sometimes, due to weather conditions, the roof is covered by slates, improving the impermeability. The shape is rectangular, with a long and narrow layout. *The shape outside varies a lot from an area to another but always the base is made by two or more vertical stones and then overhanging slates (for preserving from rodents and animals). They are typically of Galicia region, on the border with Portugal, where they are known as hórreos (Caamano Suarez 1999).*

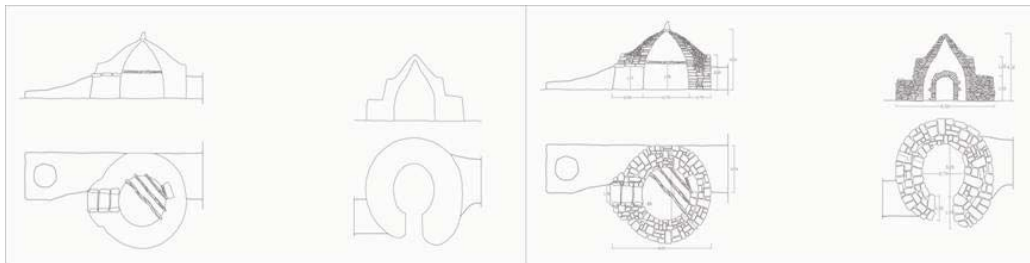


Figure 4 : Examples of some huts studied by the authors (*barracas* in C. Valenciana and Cataluña)

#### Chozos de Viñas (Spain: Castilla y León)

They are adobe constructions, usually built in the surrounding of vineyards in order to watch and control the same estate. The walls are built with adobe and less frequently, with rammed earth approximately 90 cm high. The vault is a corbelling one, projecting the adobe progressively, as in the stone shelters (Fig.5). The edges between the vault and the wall are covered and smoothed with dihedral corners to drain the rainwater. There are some constructions without the perimeter wall that start directly to corbel the dome almost from the soil, with just a 30 cm high stone basement. Anyway both constructions have a finishing protecting coating made by earth mortar, maintained every two years. Sometimes are still visible some vineyard watcher-constructions with chimney, evidence of the human dwelling inside.

#### Casetas de Pozos (Spain: Castilla-León)

They also are adobe or bricks constructions, close to a trough, employed to cover and give shelter to the well inside. The peasants and shepherds protect the curb of the well from animal pollution with these protective structures made by stones or even adobe. The vault is a

corbelling one, projecting progressively the elements. Outside of the construction but close to them, there may be found some basins or drinking troughs for the livestock, directly fed with water from the curb by a channel (Sanchez del Barri and Carricaio Carbaio 1995, Rivas 2004). Casetas de Labranza (Spain: Rioja- Navarra- País Vasco)

These buildings have quite the same constructive features of *chozos* but, in this case, the purpose of the huts is different; the peasants use them to store tools, equipment, instruments and devices... of their daily works. The inner space of the shelters, for this reason, may be divided according to the type of tools stocked. They're typically of rural north east area of Spain, like Álava province, South of País Vasco and South Navarra region.



Figure 5 : Huts with corbelling domes built either with dry stone technique or plastered adobes

#### Espigueiros (North of Portugal)

They are stone constructions used like store for drying corn (seldom grain). They usually have thatched roofs over the corbelling dome, or sometimes the corbelling vault with horizontal layers of stones appears directly to the exterior. These dry stone shelters are perfect as they permeate the wind and allow the corn to get dried. The shape outside varies a lot from circular to rectangular one. The dry stone compositions are bonded with incredible detail, as if they were not stone but wood joinery. They are typically of north of Portugal.

#### Dólmenes and tholoi (Spain: Andalucía)

Some of the oldest examples of corbelling dome architecture can be found in Magina area, in a natural park, Almeria province (Andalucía). Here we have traces of Iberian villages with some archaeological remains of *tholoi* and *dolmen* ancient structures, some of them close to caves typologies, with corbelling dome sheds.

### 3 ANALYSIS OF BRIDGES

#### 3.1 Puentes (Spain: Comunidad Valenciana, Islas Baleares, Aragón)

In the framework of constructions built with dry stone regular and systematic bonding is possible to underline some examples of bridges (Castellón and Teruel provinces as well as Mallorca island). In these examples we could value the complexity of the constructions that resides both in choosing and selecting the stone to be used and their disposition inside the



fabric. In this way, the final shape of these constructions adapts to the form of the used material and the range of possibilities to bond it. Therefore, the bridges integrate themselves into the landscape where they are located.



Figure 6: Images of the Pobleta de San Miguel Bridge, built with ashlar's masonry and dry stone

In order to negotiate little gaps and water-courses narrow dry stone corbelling bridges were built. These devices allow covering limited spans between 2 and 4 m, just with corbelling system (García Lisón M. and Zaragoza Catalán A. 2000). Frequently the bridges are linked to pebbles and cobblestone paths and dry stone walls that represent true backbones that organize the landscape (Reynes Trías and Sastre Arrom 1993). The quality and the extension of dry stone technique in the Iberian Peninsula is so remarkable that they suggest us a kind of anthropic engraving written across the centuries in the natural landscape.

If the primitive dry stone huts are born directly from landscape and appear intertwined with it, the bridges and, in particular, the bigger ones, generate with their scale a natural and aesthetical symbiosis with the natural landscape where man only intervenes to link paths and order it. We could mention the well preserved bridge of Pobleta of San Miguel. This is a small village of Villafranca municipal area (Castellón- Spain) placed on the banks of the so called river of the trouts. This medieval bridge, placed on the boundary between the provinces of Teruel and Castellón, negotiates the river with a single span of 15.40 m of diameter (Fig.6). This span is built with ashlar bonded in all the extension with lime mortar, with toothed finishing, ready to be completed by the upper masonry. This arch is surrounded by masonry bonded by lime mortar, but the rest of the length of the bridge (70 m) is built by dry stone walls, probably built with the collaboration of the inhabitants of the village itself, who have been taking charge of the repairs during centuries. In these areas, there exist some more examples of interesting medieval bridges built partially with dry stone techniques, like the one at Pont Trencat or the one at Molí la Font, so similar to the Pobla of San Miguel one that it seems to be realized by the same builders. But other many bridges in the area, erected associated with mills, towers or hermitages, also possess similar features (Rubió i Bellver J.1914; García Lisón M. and Zaragoza Catalán A. 2000).

#### 4 CONCLUSION

It may be observed how all these types of constructions are associated with a rural society where the agriculture and cattle raising were fundamental. The same farmers who worked the land simultaneously built these architectures. Traditionally peasants and shepherds piled up the



stones and bonded them with their own hands. Peasants were used to dispose the stones off their fields in order to cultivate the areas. Stones, which were never wasted, were used in all such examples that we have enumerated previously. Therefore, it is possible to value how the construction of corbelling domes without using any mortar for the union between the stones coincides with the first developments of the Iberian agriculture and building culture.

Huts or bridges are practical and functional constructions that mainly appear in livestock areas, offering shelter against inclemency and helping shepherds and peasants in their daily work. They are built with local and elementary materials, mostly stones and sometimes adobes, that become the only basic constructive components. Farmers and shepherds knew very well the building potential of these constructive elements, and knew whether this type of stone or adobe was to be used in a particular hut and how the pieces were to be bonded without mortar. So, though it seems to be simple, the dry stone constructive system reveals difficulties, since it is necessary to preview the possibilities of the materials and bear in mind the placement of irregular stones or adobes laid and joined without mortar.

All these differences and regional variations reflect the genuine technical capacity of the builders for solving the raised local problems with local materials. So these examples of vernacular wisdom built with corbelling domes or vaults to small or bigger scale, whether in primary refuges or public works, show how architecture and nature have been combined to create a unique symbiosis that defines the singular character of these ensembles. We may not forget that these constructions show a really skillful sustainable architecture that may be taken as an example and reference for contemporary architecture and engineering.

## REFERENCES

- AA.VV., 2000. Arquitecturas de piedra en seco, Actas del VII Congreso Internacional de Arquitecturas de Piedra en seco, Peñíscola, 12-14 Octubre 2000, Valencia, Centre d'Estudis del Maestrat.
- AA.VV., 1993. I Congreso Nacional de Arquitectura Rural en Piedra en Seco, Zahora, Revista de Tradiciones populares 38, Vol.I+II, Albacete.
- AA. VV., 2002a. Els Hommes i les Pedres, la pedra seca a Vilafranca, un paisatge humanitzat, Castellón, Diputación de Castellón.
- AA.VV., 2002b. Libro de la piedra en seco, Palma de Mallorca, Turismo Cultural Illes Balears.
- Caamano Suarez, 1999. As construccions adxectivas, Caderno do Pobo Gallego Ed., n.9, Santiago de Compostela.
- García Lisón M. and Zaragoza Catalán A., 2000. Arquitecta rural primitiva en secá, Colección Politécnica n.10, Ed. Institució Alfons el Magnanim Valencia.
- Juvanec B., 2001. Shelters in stone, research, short version, Ljubljana University Ed., Ljubljana.
- Juvanec B., 2008. Hut of Extremadura, Arte Ed., Extremadura.
- Meseguer Folch, V. 2000, La piedra en seco en las comarcas del norte de Castellón, Centre d'estudis del Maestrat Ed., Castellón.
- Meseguer Folch V. and Castillo J.S., 2001. El Patrimonio Etnológico agrario de Benicarló, Centre de Estudi el Maestrat, Castellón.
- Meseguer Folch V., 2006. Arquitectura popular de pedra seca al terme de Vinarós, Centre de Estudi el Maestrat, Castellón.
- Pedrero Torres J., 1999. Inventario de los bombos del término municipal de Tomelloso, Sobriet Ed., Ciudad Real.
- Rivas F., 2004. Construcciones pastoriles en la comarca de Monzón, Centro d'Estudios de Monzón y Cinca Medio Ed, Huesca.
- Rubió i Bellver J., 1914. Construccions de pedra en sec, Anuario de la Asociación de Arquitectos de Cataluña, p.35-105.
- Sánchez del Barri A. and Carricaio Carbaio C., 1995. Arquitectura popular, construcciones secundarias, Centro Etnografico Joaquin Diaz, Valladolid.