

The timbrel vault (Extremaduran vault)

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Extremadura is a Spanish region located at the west of the country, border with Portugal, whose administrative capital is Mérida. In its long history, we can find a dense net of multicultural relations, from oriental (Arabian, Byzantine..) up to American (discovers' birthplace as Pizarro, Hernán Cortes or Luna de Arellano..).

It's a confirmed reality that a high proportion of this region heritage has been built with vaults. Among the authors interested in the Extremaduran architecture,¹ we can often find the term «Extremaduran vaults» although without an explicit definition, everybody could understand that this term hid something more important than a mere location adjective. In the book «Brick Vaults»² can be found in detail the constructive process, the structural analysis and the calculus of these arris vaults. The following summary about all that is offered.

DEFINITION

The first characteristic is its composed geometry. It is formed by the intersection of several simple figures; at the same time, each figure has a double curvature. The lack of spectacular works might justify the absence of detailed studies. Be that as it may the truth is that its geometry hasn't received a lot of attention and it has been defined as «arris vault», «lunetos» and other standardized geometric names. They can be classified in that way, but they have a special

difference, although it's very difficult to be seen, it's very important for its performance, it's to say «the double curvature». Let's see the arris vault, the most used out of this region, it's composed by the intersection of two cylinders while the extremaduran ones is the intersection of two torus (elliptical contour) and in this way the central keystone is higher than the keystone of the lateral arches.

The second characteristic is that it is made floating in the air; it means that it is not necessary a complete mould for all the face of the vault (although sometimes it's possible to make some auxiliary arches). This aspect is wellknown by a lot of authors.

The third characteristic is the counteract, which is relied on different elements. It is known that a vault or an arch exert some lateral thrusts on their supports that must be counteracted on order to keep the balance. Usually the one in charge of this task in the vault is the support wall but when this is not enough, other resources have to be used as the «tie», the «tail», an upper overload or the buttress.

The first of these characteristics has an effect on its mechanic, on the way it works, on how the vault strengths are transmitted to the wall, offering it a lot of possibilities and choosing the most convenient depending on the loads and the conditions. The strengths coming from the own weight of the construction and from the overloads, that have to reach the floor without violence to get a permanent stability, can take several ways; what makes this vault safer and difficult to excel, unless something wrong is done.

The second is a question of economy. When an auxiliary mean as the mould is not used, the cost of the building materials and the labour force is reduced.

The third has also an economic effect. If the counteract had to be done only by the walls, they would have to be thicker; to avoid it, the counteract is divided into several elements. This obviously has a repercussion in the final result and besides interesting spacial solutions are produced.

«RETUMBO» GEOMETRY

An arris vault with «retumbo» is the one whose central keystone is the higher point of itself and if we cut it in any direction will always offer a curve section, bigger at the diagonals direction and lesser at the parallel direction in the lateral walls.³

According to the geometry the Extremaduran vaults are all those arris vaults with «retumbo» even if they are «rosca o panderete». They are located at the Guadiana basin; towards the north up to the river Tajo, towards the south up to the Guadalquivir river, towards the east up to Castilla and towards the west up to the Alentejo Portuguese.

CONSTRUCTION WITHOUT MOULD

Most of the buildings with vaults have been made with mould, this is, an auxiliary structure, generally on wood, that supports the vault or arch during the works because till it is not finished it can't support itself. The Romans needed a complete mould, as big as the vault was. The Gothic supposed an important advance, as the mould was reduced to the ribs. The Extremaduran vault would mean the end of that evolutionary process, in the saving of auxiliary means, getting the total elimination of the mould.

J. Albarran, army captain, reported in 1883 that the Extremaduran vault could be used as a support of another upper it with an ordinary bond.⁴

COUNTERACT

The Extremaduran vault has several ways to produce the counteract:

- 1) THE WALL: sometimes this is not enough, taking into account the scarce thickness used in the domestic architecture.
- 2) THE TAIL: uses the perpendicular walls increasing the counteract mass as the weight responsible of the balance.

Tail is called to a lengthened pendentive so that the vault arris is not born in the corner formed by the two perpendicular walls but above one of them and moved back from the other at a certain distance.

- 3) Other way to increase the weight in the wall is loading in its upper part with other floor (without vault) or parapet. In this region is called parapet to a wall built along the upper front of the building that overhangs above the roof covering it and hiding the drainpipe which collects the water from the roof.

In the buildings with vaults in the South of Extremadura, the last floor is not usually built with vault but the lower ones. The more weight the wall has on the upper part, the more resistance against the overturning. And the weight not only increases by the height of the wall but by the vertical load that receives from the roof.

- 4) THE CONCEALED TIE: it is placed for the upper part of the vault between parallel walls.

The tie, either in the upper part of the vault (when it's generally placed) or in the lesser one, has a work margin between null (when the wall doesn't move) and maximum which is similar to the horizontal part of the thrust. Sometimes this is a very useful resource; the Romans didn't use it, it wasn't necessary with their concrete system. The Ghotics didn't use it either, because it spoiled their displays of willowness and lightness.

Our Extremaduran builders when they appeal to the tie, they do it in a concealed way, knowing that they are using a trick when no other alternative is left; but as the magician, the trick mustn't be seen by the audience. This resource is used on the front and above all on the corners. It is used a tie formed by a bar with a squared section (with the steel appearance it turned into a linkage threaded)

- 5) BUTTRESS: sometimes the adjacent buildings are used and if there is anything else, a simple buttress.

The buttress although is quite common in churches . . . is scarcely used in the domestic building with vault.

PERFORMANCE

As B. Bassegoda Muste said, a vault is not characterized by its shape but by its thrust. The Extremaduran arris vault due to its geometry and above all thanks to the «retumbo» can work as a rib vault or as a dome. In the first case the arris are turned into resistant ribs and the rest into supported mass. In this hypothesis the ribs transmit all the load to their respective supports, the mechanic performance would be similar to the gothic vaults.

But it can also works like a dome since by its geometry and depending on the point and on the «retumbo», may be a «baida vault» or a piece of circular cap cut by four vertical plans.

CONSTRUCTION

Once the walls have been made, the following step is to fix the starting points and the point of the vault. It's called point to the difference in the height between the starting points and the lateral arches keystone. With these references you have to design four ellipses that will be the vault sides. With the arches designed in the walls, you have to place two ropes joining the keystones from the opposite arches. The point of intersection is raised some centimetres (this's what is called retumbo). At this point a plumb is hang for the bricklayer to have a reference. The point plus the retumbo, it's to say the height between the vault starting points and the central keystone, mustn't be higher than 1'5 m, in this way the bricklayer can work easily.

Four holes have to be made at the corners where the pendentives will be. These are made with brick and mortar lime of 4 or 6 horizontal lines and the wedge forming the angle between the horizontal and the tangent to the ellipse where will be placed the first vault line.

The vault faces are built with plaster in the following way: In the ellipse designed on the wall a hole is made. Then must be done a brick arch with

plaster supported on the pendentive and on the hole. Without mould and with the references of the four lateral arches and the plumb, the bricklayer will be closing the vault with consecutive lines on the four sides.

Once the vault is closed the recesses have to be filled up to the midheight with heavy stuff (stones ..). Now the vault has in its upper part a flat surface, except on the central part, where there is a spherical bulkiness. In order to get a useful surface is necessary to fill up to the central keystone; this filling must be done with light stuff not to load too much the vault.

To sum up we can say that the Extremaduran vaults are a technical constructive and structural solution, inexpensive and with a big versatility in its performance.

EXPERIENCE

During the last years (with the help of trade schools) we have been trying to recover these antiques techniques that unfortunately were becoming extinct. As a result a great deal of square metres have been built with Extremaduran vaults and not only in Extremadura but even abroad.

Here you have some examples

NOTES

1. De la lista de dichos autores cabe destacar las siguientes obras: Luis Feduchi, *Itinerarios de Arquitectura Popular Española*; Fernando García Mercadal *La casa popular en España*; Francisco Javier Pizarro, *Arquitectura popular y urbanismo en el valle del Jerte*; Juan Carlos Rubio Masa, *Arquitectura popular extremeña*.
2. «Bóvedas de ladrillo». Manuel Fortea y Vicente Lopez Bernal. 2ª edición. Editorial de los Oficios. León 2001.
3. El «retumbo» es el nombre que le dan los albañiles a la distancia en vertical entre la clave central de la bóveda y las claves de los muros laterales. También es conocido con otros nombres, por ejemplo Alberto Gonzales Rodríguez lo denomina «resubido», y Fernando Casinello utiliza el término «arrepio». Florencio Ger y Lobe en su Manual de construcción civil editado en Badajoz en 1915, a este tipo de bóvedas las denomina «capillas empinadas o cumplidas».
4. Albarrán, José., *Bóvedas de ladrillos que se ejecutan sin cimbra*, Madrid. Imprenta del Memorial de Ingenieros, 1885.. p. 13.

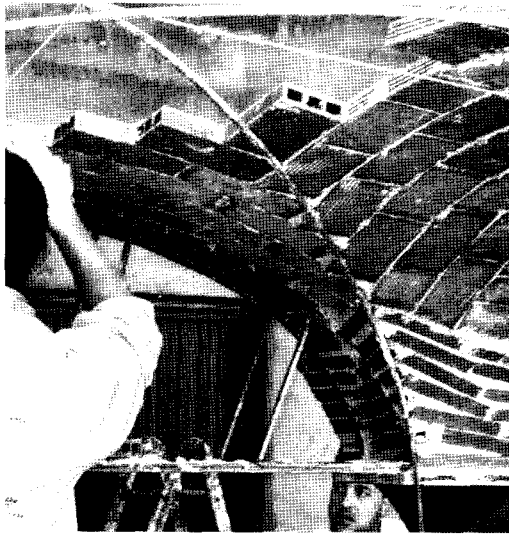


Figure 1
Construction practice without mould

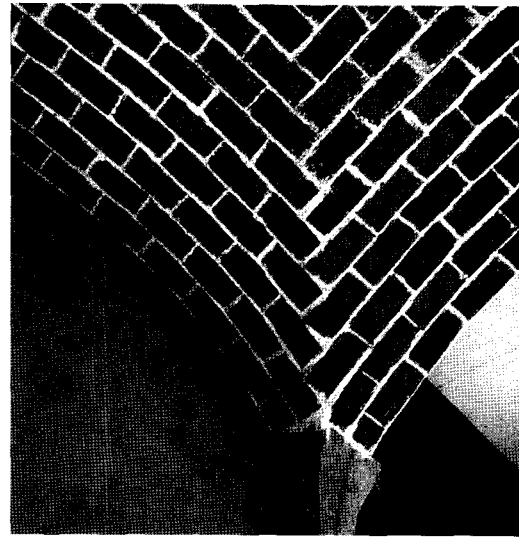


Figure 3:
A part of the bond over concrete column

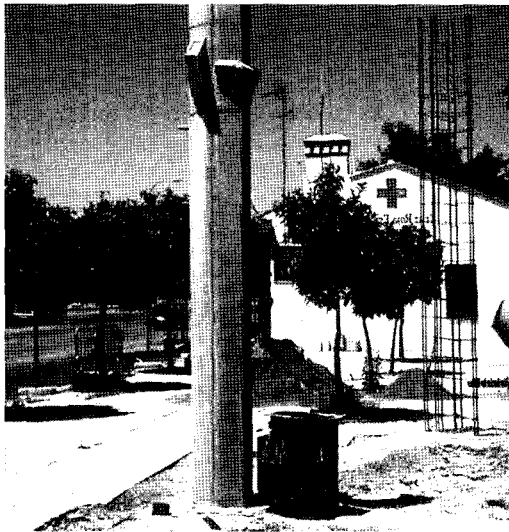


Figure 2
Concrete column with overhanging for the vault support



Figure 4
General view of the vault with 4 supporting points



Figure 5
Vault with lineal support over reinforced concrete beam



Figure 6
Vaults with different bonds over beams in double projection