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Original Scientific Paper
UDC 72.031 (460 Spain)
Technical Sciences / Architecture and Urban Planning
2.01.04 - Development of Architecture and Urban Planning and Restoration of the Built Heritage
Article Received / Accepted: 25. 01. 2004./ 16. 03. 2004.

Sveučilište u Ljubljani
Arhitektonski fakultet
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Izvorni znanstveni članak
UDK 72.031 (460 Španjolska)
Tehničke znanosti / Arhitektura i urbanizam
2.01.04 - Razvoj arhitekture i urbanizma i obnova graditeljskog naslijeđa
Članak primljen / prihvaćen: 25. 01. 2004./ 16. 03. 2004.

Corbelled Stone Structures: Form

El Bombo, La Mancha, Spain

Kamene konstrukcije s postupnim konzolnim načinom gradnje: Oblik

El Bombo, La Mancha, Spain

CORBELLING
DRY STONE WALLING SYSTEM
VERNACULAR ARCHITECTURE
FRAME
STONE

POSTUPNI KONZOLNI NAČIN GRADNJE
SUHOZID
TRADICIJSKA ARHITEKTURA
VANJSKA OPNA
KAMENA GRADNJA

The elements of composition of an object are structure, frame and filler. Filler is the material filling the space between the structure and the frame. *El Bombo* is a stone shelter around Tomelloso in La Mancha province, Spain. Its composition has the construction and the frame separated by quite a few meters. In conclusion, we can say that something incredible happened there: the filler, mostly used as cheap stuffing material without any value, here makes the form.

Kompoziciju objekta fizički čine konstrukcija, vanjska opna i punjenje. Punjenje je materijal koji „puni" prazninu između konstrukcije i vanjske opne. *El Bombo* je sklonište za čovjeka i za životinju u okolici gradića Tomelloso u La Manchi, u Španjolskoj. Kompozicija ima konstrukciju posve razdvojenu od vanjske opne, a preko svega je nasut kamen. Gomila kamena. Zaključak je iznenađujući: amorfni materijal uporabljen kao punilo daje oblik.

INTRODUCTION

UVOD

I had thought that I was old enough to have already seen many things and never thought that I would discover so many new things in Spain.

While flying over the Mediterranean on my return from Valencia, where I was invited by the Univesidad Politecnica, I could hardly gather my thoughts about what I had seen. They had taken us to a landscape of gypsum, which is used there as a construction material. Not because they have too much of it, but because wood is sparse and they cannot build furnaces for burning lime, which demand higher temperatures. Back to gypsum: my colleague from Limoges, a geologist, showed us gypsum crystals, which resemble natural glass. Maybe I had seen some while in school, but my knowledge was rather deficient in this department. A surprise followed. In a typical multi-floor building we calmly reclined on the outer walls to take photographs of the interior. I was doing this until told by a colleague that the outer walls were only seven to ten centimetres thick. And they were made of gypsum! During construction their scaffolding was dragged upwards every half hour, since gypsum crystallises very fast and the wall can be finished in several hours. Afterwards I was careful enough not to lean on the walls, but still bravely walked on the floors. In the church (which has a blacksmith's shop in the basement, the village granary above it, then a horse stable and the church effectively on the fourth floor) I noticed a hole in the ground carefully covered with planks. Of course I uncovered the hole and looked six meters downwards to the stable. Then I noticed the construction itself: between the very slender girders there was a gypsum (plaster) membrane with taut, curving, almost pre-stressed scaffolding. The upper surface could be walked upon. In the middle its thickness was some four centimetres. I took a photo, covered the hole, tiptoed out and never went back to the church. There was a sign saying „no pasar", i.e. no trespassing, now I know why. All my colleagues – from Egypt to Belgium and Moscow to Portugal – agreed that they'd never believe the story if told before. Plaster is a construction material. Also. Now I know.

I would however like to talk about corbelling, construction in the dry wall technique, without binders. Not far from Madrid, in the La Mancha province, to which I travelled in sweltering heat, I found something even more amazing. Looking out through the clouds of dust rushing in through all the openings, I discovered stone shelters, called *los bombos*, whose form comes from sand, gravel and fillers. I wouldn't have believed, but here's the story:

FIG. 1 A MAINTAINED *BOMBO* IS WHITEWASHED. THE GRAVELLED ROOF OF SOME BUILDINGS IS ALSO WHITEWASHED.
SL. 1. ODRŽAVANI *BOMBO* JE OKREĆEN. POŠLJUNĆANI KROV NEKIH ZDANJA TAKOĐER JE OKREĆEN.

FIG. 2 *EL BOMBO* NEAR TOMELLOS, LA MANCHA, SPAIN. THE SINGULAR VERSION HAS ONLY ONE CELL.
SL. 2. *EL BOMBO* BLIZU TOMELLOSA, LA MANCHA, ŠPANJOLSKA. NEOBIĆNA VERZIJA IMA SAMO JEDNU PROSTORIJU.

HYPOTHESIS

HIPOTEZA

El Bombo is an object of extremely simple structure. Protecting it from ruin today without using binders is not possible.

Corbelling is undoubtedly one of the oldest construction principles for bridging space. It is more than six thousand years old as can be proved by the example from the subterranean sanctuary Hal Saflieni in Malta.[1] Such principle of overlapping above all demands a layout that is as round as possible, all the way from the ground, up to the keystone, while in the section an equilateral triangle can always be drawn. The latter ensures the construction height, which always equals half the square root of three.

By definition architectural form results from material, structure and circumstances in which elements were used. Stone shelters remerge in the medieval times, the oldest mentioned were by Degano from 1559, Horvatić from 1577 and Lassure from 1620,[2] but they are still being built today. At this point a statement and question emerge. **Corbelling** is a structure, the **frame** determines the form; the **filler** occupies the space between them. Question: can it be done otherwise? Theo-

1 JUVANEC, 2001.b: 1.a-13

2 DEGANO, 1990: 402; HORVATIĆ, 1999.; LASSURE, 1985: 9., 35

retically the answer is: no. In practice exceptions are possible. However, exceptions confirm the rule. One of these exceptions is *El Bombo*: an unpublicised but extremely interesting architecture, whose form is provided by the filler: sand and gravel. How is this possible?

Structure, Frame and Filler

Konstrukcija, vanjska opna i ispuna

In the composition of a building, the structure is the part that bears the load. The envelope, coat or membrane, mainly clothe the structure; sometimes it helps in load bearing. The filler is somewhere in between: sometimes it only fills the voids because its material is cheaper than the structure's, more often it protects – usually before heat or cold. It is therefore a stuffing used as an insulator, sometimes it helps the structure to bear the designated load (with its weight).

Filler

Ispuna

The filler is the material that occupies the void between the structure and frame. It is functional for other purposes as well: binding, insulating or maintaining constant temperature. It also provides form. In Slovenia the most widespread – but also most commonly used filler was – hay, between the source of heat and the user. In granaries there is no filler – nothing, not conveying either heat or cold.

Several Examples

Nekoliko primjera

The filler is a material ranging from „nothing" to stone (in modern architecture physical „nothing" equals vacuum, while in vernacular architecture it implies the absence of physical material, the closest equivalent being of course: air), even bound into artificial stone, concrete. The space between hosts numerous materials, used by simple builders with such ingenuity that contemporary solutions, seen as wonders upon „discovery", are today nothing more than common, ordinary and understandable.

Slovenian vernacular architecture possesses an excellent building for storing food, known as granary (orig. slov. *kašča*). It can be built, but with thick walls, thus preventing heat from entering too soon. Wooden granaries are less demanding, construction is easier, as is maintenance. The timber however also has to be rather thick, to insulate the interior. Our forefathers used a simple approach to prevent contact between the sun (heat) and sausage (sometimes also wheat, wine or other harvested goods). Between them, encased in a double wall, there was simply **nothing**. Direct contact between the source of heat harmful for the object and the object itself was thus prevented.

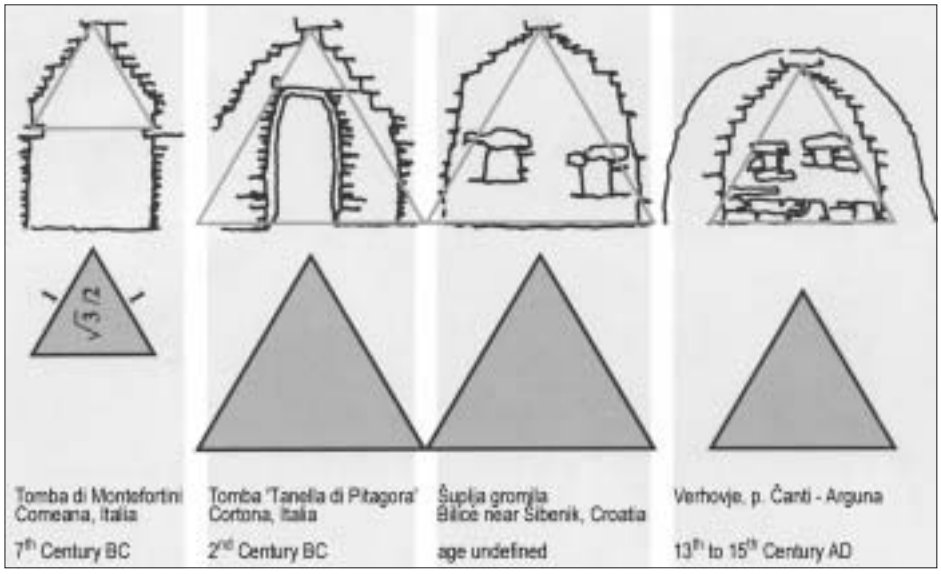


Fig. 3 Back to the history - two Italian structures, dating to the 7th and 2nd century BC. *Šuplja gromila* near Bilice, Šibenik is a fully corresponding structure, whose time frame still has to be determined. In the Caucasus similar stone structures date back to the 13th and 15th century AD.

Sl. 3. Povratak u prošlost: dvije talijanske gradnje iz 7. i 2. st. pr. Kr. Šuplja gromila blizu Bilica (Šibenik) je slična konstrukcija, koje vrijeme nastanka tek treba utvrditi. Na Kavkazu slične kamene građevine potječu iz 13. i 15. st. n.e.

Historically speaking, the physical structures of buildings are very clear: at first large quantities of material hiding the structure were used (the Romanesque for example: thick walls, small openings and small spans with small useable spaces).

In Gothic architecture only load-bearing elements formed the structure: nets, which practically carry the structure were reduced to a minimum; they are almost clear theoretical static drawings.

Filling used in walls can be almost nothing, when we have a uniform structure, single wall. When my colleague B. Horvatić told me about a single wall on Krk (an island) whose height is 1,6 meters and composed of a single layer of stone, I had my doubts. He proved to me that it can actually be walked upon and to hold without collapsing. It can even withstand the wind or rather let it through intentionally left openings...

Unjulica is a magnificent structure.

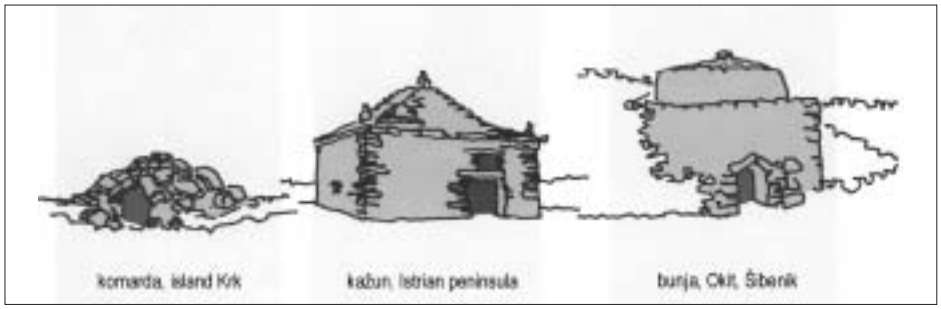


Fig. 4 The most typical forms of stone shelters are structures from Croatia: the *komarda* from the island of Krk is the simplest, with almost amorphous shape. The Istrian *Kažun* has all the elements of human dwellings: emphasised roof, projecting roof and keystones on the perimeter. The *Bunja* in Okit near Šibenik is stepped and covered with gravel on the top. The ridge stone always defines the key point of the roof, its pinnacle.

Sl. 4. Najtipičnije su forme kamenih skloništa u Hrvatskoj: komarda na otoku Krku je najjednostavnija, gotovo amorfna konstrukcija. Istarski kažun ima sve elemente ljudskog boravišta: pojačani krov, istureni krov i zaglavne kamene po obodnici. Bunja u Okitu blizu Šibenika je stepenasta i pokrivena šljunkom. Sljemeni kamen uvijek određuje ključnu točku krova, njegovu fijalu.

FIG. 5 INTERPLAY: THE ENTITY AND DETAIL, NORTH-EASTERN SLOVENIA

SL. 5. INTERAKCIJA: CJELINA I DETALJ, SJEVEROISTOĆNA SLOVENIJA

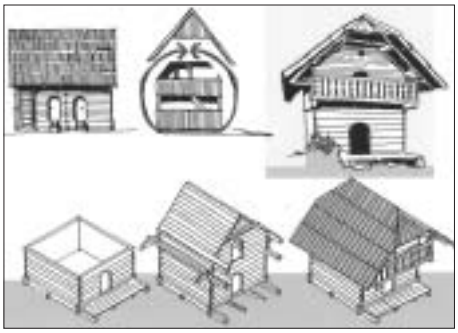


FIG. 6 THE CONSTRUCTION OF GRANARIES BY THE SAVINJA RIVER: AIR AS THE GRANARY'S HEAT INSULATOR, HIGH QUALITY AESTHETICS AND SELF-BEARING CONSTRUCTION

SL. 6. KONSTRUKCIJA ŽITNICA UZ RIJEKU SAVINJU: ZRAK KAO TOPLINSKI IZOLATOR ŽITNICE, VRHUNSKA ESTETIKA I SAMONOSIVA KONSTRUKCIJA

FIG. 7 LEFT: *UNJULICA*, TRANSLUCENT WALL ON KRK; RIGHT: DOUBLE, PARTIALLY CHISELLED WALL WITH FILLER, SU NURAXI, SARDINIJA: A DOUBLE WALL ENABLES UN-STRENUOUS FILLING-IN WITH MATERIAL

SL. 7. LIJEVO: *UNJULICA*, SVJETLOPROPUSNI ZID NA KRKU; DESNO: DVOSTRUK, DJELOMIČNO KLESANI ZID S ISPUNOM, SU NURAXI, SARDINIJA: DUPLI ZID OMOGUĆAVA LAGANU ISPUNU MATERIJALOM

In the Nuraghi village Su Nuraxi in Sardinia they have a wall that is composed of two layers of stone: the outer ones are chiselled, while the inner retain their natural, conical form.[3] If two layers are built consequently an extremely strong structure emerges. In between there is hardly any space for fillers: sand only strengthens bonds between the stones, without using other binders.

TOO MUCH STONE, A PILE OF STONES, A STONE WALL WITHOUT MORTAR

PREVIŠE KAMENJA, KAMENA GOMILA, KAMENI ZID BEZ MORTA

Too much stone is when fertile soil is caught among rocks; to cultivate a field, vineyard or orchard we have to remove them. A field's fertility doesn't benefit from the presence of stone, therefore there is too much of it.[4]

A pile of stones, which is gathered, eventually disappears – back to the soil. The problem of „too much stone" is repeated.

A stone wall without mortar, is the simplest structure. It is a system with certain rules, such as: overlapping, directing elements, exchange. A „dry wall" is generally a two-dimensional structure that mainly defines open space and often appears in combination with other de-limitation elements. Stone structures in vernacular architecture are the simplest ones. Besides stone only hands and simple tools were put to use, but above all common sense. The „dry wall" system utilises the principle of overlapping, whereby every consecutive layer covers vertical openings in the former. Rather simple, only corners are more demanding. Complications begin when we try to bridge a void.

Corbelling: If we place a stone on another and push it slightly forward, it won't move. If we push the next one in the third layer even further – but not across the common centre of gravity – we get the rudiments of corbelling.[5] Its essence is dual: the ground plan has to be as round as possible, while the section angle has to near sixty degrees.[6]

Sixty degrees is the angle seen in the equilateral triangle. The simple builder probably didn't know that the height of such a triangle was half the square root of three, although shepherds played a simple game called „three sticks". These were of equal length and could construct only one closed figure: the triangle.

Angles:

The equilateral triangle has three dimensions, three sides of equal length and three equal angles: 180 : 3 = 60

The basic angle of an equilateral triangle is sixty degrees.

Height (h):

If the basis of an equilateral triangle is **1**, its height **h** is equal to the opposite (vertical) cathetus of the equilateral triangle's half, whose hypotenuse equalling **1** and by-lying cathetus equalling ½, form an angle of 60°:

$$h^2 + (1/2)^2 = 1^2 \rightarrow h = \sqrt{1^2 - (1/2)^2} = \sqrt{3/4} = \sqrt{3}/2$$

The height of an equilateral triangle is equal to the basis multiplied by half the square root of three.

If we built a structure whose angle would be less than sixty degrees, loads would work better in the frame, but the efficiency of drainage would be lesser, especially when the eave of the upper element reclines on the drainage surface of the lower. With a lesser angle, beginning from the ground, the utility of the internal space would be diminished, if at all possible.

Stone structural elements should be of exceptional quality (no veins or cracks) and have exceptional dimensions. Such stone practically cannot be found, but an angle of

3 ZARAGOZA, 2000: 7
4 JUVANEC, 2004: 7
5 BENVENUTO, 1990: 105
6 JUVANEC, 2004: 27

sixty degrees can be built even from undistinguished stones not larger than 20 centimetres (example: *Pont* on Menorca, *Kažun* in Istria, *Hiška* in Karst).

Buildings with sixty-degree angles and, above all, circular ground plans have remained and we can learn from them. As a rule, in corbelling circular ground plans are used: the circle is the perfect figure and there are no problems with corners. The circle closes energy flows and ensures safety throughout the building phase.

Square and rectangular ground plans can also be found: generally they form higher spaces. Such spaces are usually divided into two floors. The important fact is that the construction with equilateral triangles and thus at an angle of sixty degrees begins on the upper floor (*Trullo* in Puglia, *Cabane* in France).

A point of interest is that references ignore corbelling: why, would demand a lengthy discourse. In the book Forms and Functions,[7] which is undoubtedly one of the better reviews of structural principles, corbelling is only mentioned. Twice in fact, first as a cantilever in construction[8] and then as a disburdening triangle in Greek architecture.[9]

The arch: Egyptians used upside-down grading and the ratio 3:4, Greeks only used the beam, while the Romans adopted the arch from Etruscans. This is a planar construction that uses conically cut stone, which rise across a span in an arch. Contrary to corbelling, here there are no equal values: the key and decisive points are above all the key stone and arch beds lying on the wall – the Etruscans actually visually emphasised these three points. In the spatial sense, the arch is seen as semi-cylindrical on a rectangular ground plan and cruciform on a square one.[10]

The dome: Contrary to the earlier mentioned structures this one is spatial. It uses the principle of the arch, which is spun around both horizontal axes. Even here the ground plan is circular, just as in corbelling. The difference is that in corbelling all the layers are horizontal, while in a dome all elements are spatial, each with its own axis running towards the centre.[11] After the beam, corbelling and arch, this was the first spatial architecture that allowed larger spans and defined larger spaces. Development of the dome reached its peak in the middle of the second millennium with Michelangelo and Bruneleschi, but the Pantheon built two thousand years ago was the first modern architecture.

In the structural sense the Pantheon in Rome is a perfect sphere, with a bottom cylindrical useable part and roof executed as a hemisphere with a central opening.

Buildings with Corbelled Structures

Građevine kao konstrukcije s postupnim konzolnim načinom gradnje

We can stone to construct planar (walls) and spatial elements (buildings). For the first we have to respect overlapping of composite parts, for development of spatial compositions of the latter without binders, only one solution is possible – corbelling.[12]

It represents logical development from the structure of the beam to the space: corbelling is the connecting link between large and small bridging elements, pieces of material that can be assembled.[13] Corbelling is a significant step forward and combines: the planar principle of construction and spatial composition. This sequence holds even in time: the first proof of corbelling reaches to the fifth millennium BC,[14] while the first dome was seen at the break of the millennia.

The common feature of stone shelters is use of corbelling in their internal structures. Their exteriors vary: *crot* uses chiselled stone to withstand snow and freezing in the Swiss Alps; *kažun* varies, from round to square, with emphasised to soft, almost mushroom shaped roof; *paglіaddiu* in Corsica externally almost resembles a „proper" house, but inside there is a transverse corbelling with sharp angles; *trullo* in Puglia, as we know it, with its typical round ground plan (roof), and *pinacollo* on the ridge, is only one type of the building, but there are a whole range of completely different variations.[15]

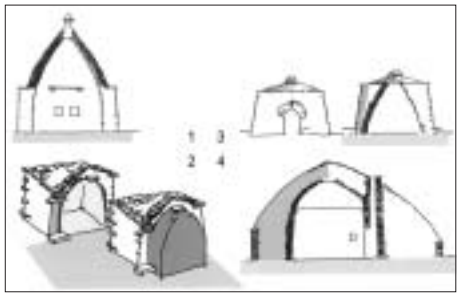


Fig. 8 Three layers: structure, frame and filler. In the first example there is no filler and the two other layers follow each other closely; in the second example there is more space for the filler, in the third example the filler dominates. the structure and frame have no immediate connection.
Sl. 8. Tri sloja: konstrukcija, vanjska opna i ispuna. U prvome primjeru nema ispune, a ostala su dva sloja usko jedan uz drugog. u drugom primjeru ima više prostora za ispunu, a u trećem primjeru ispuna dominira. konstrukcija i vanjska opna nisu neposredno vezane.

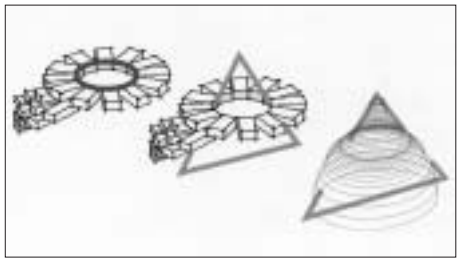
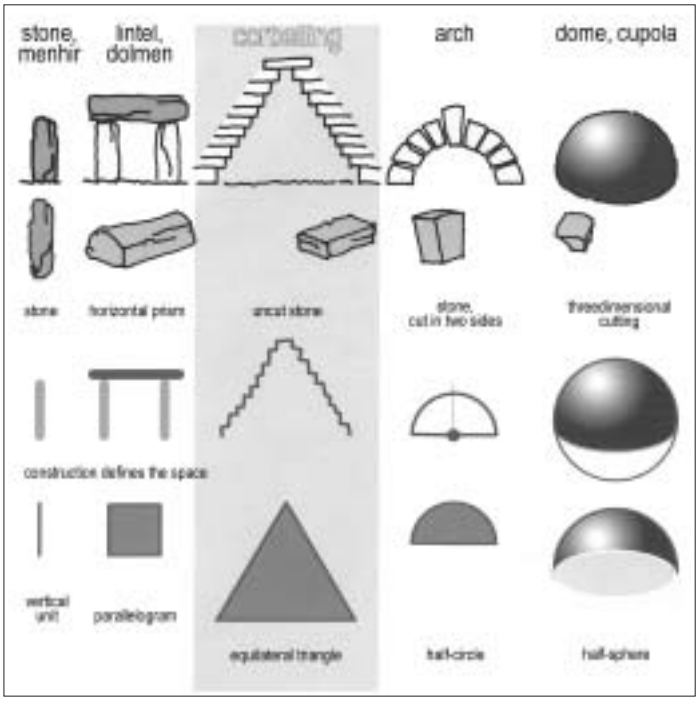


Fig. 9 Corbelling in theory: the layout is a circle, the section is an equilateral triangle
Sl. 9. Postupni konzolni način gradnje u teoriji: tlocrt je krug, presjek je jednakostranični trokut

Fig. 10 Corbelling in practise: The *trullo* in Puglia, Southern Italy; the structural layer is closely followed by the outer frame – there is no filler
Sl. 10. Postupni konzolni način gradnje u praksi: *trullo* u Pugli, južna Italija; konstrukcija je neposredno uz vanjsku opnu, nema ispune

7 Hamlin, 1952
8 Hamlin, 1952: 296
9 Hamlin, 1952: 329
10 Juvanec, 2002.d: 14
11 Tiret, 2000: 46-48
12 Fabrega, 2003: 13
13 Juvanec, 2001.a: 11
14 Juvanec, 2001.b: 1a-13
15 Juvanec 2001.a



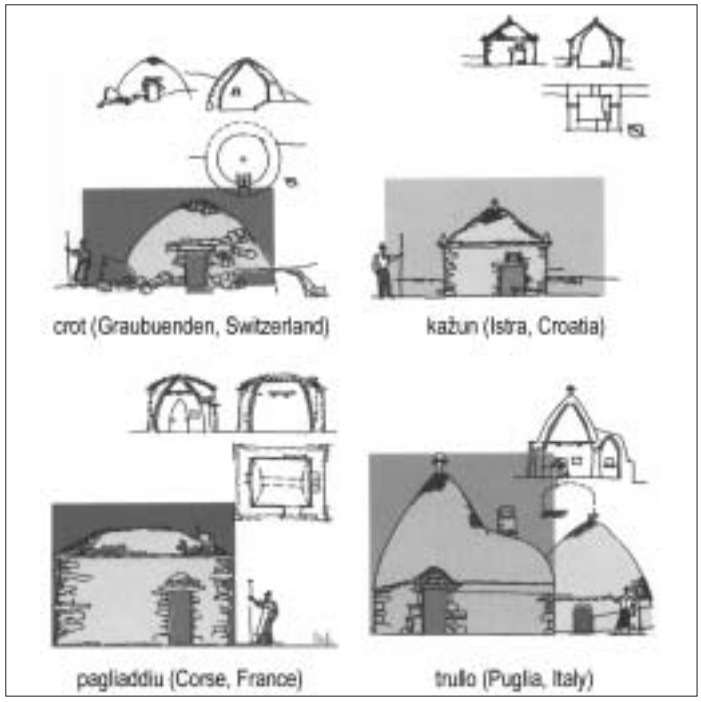


FIG. 11 STRUCTURAL SYSTEMS IN HISTORY: THE MENHIR ISN'T ARCHITECTURE, A DOLMEN CAN PROVIDE SHELTER, CORBELLING IS A STRUCTURE, THE ARCH IS A DEMANDING STRUCTURE DONE BY EXPERTS, THE DOME EVEN MORE SO

SL. 11. NOSIVE KONSTRUKCIJE U POVIJESTI: MENHIR NIJE ARHITEKTURA, DOLMEN MOŽE BITI SKLONIŠTE, POSTUPNO KONZOLNO ISTICANJE JE KONSTRUKCIJA, LUK JE ZAHTJEVNA KONSTRUKCIJA, KUPOLA JOŠ I VIŠE

FIG. 12 ONLY FOUR OF THE EIGHTEEN TYPES THAT I HAVE IN MY DOCUMENTATION: THE *CROT* IN RETOROMAN SWITZERLAND, *KAŽUN* IN ISTRIA, *PAGLIADDIU* OR *PAILLER* (CORSICAN AND FRENCH NAME VARIATION) IN CORSICA, FRANCE, *TRULLO* IN PUGLIA ITALY

SL. 12. SAMO 4 OD 18 TIPOVA IZ ARHIVE: *CROT* U RETOROMANSKOM DIJELU ŠVICARSKE, *KAŽUN* U ISTRI, *PAGLIADDIU* ILI *PAILLER* (KORZIKANSKA I FRANCUSKA VARIJACIJA IMENA) NA KORZICI, *TRULLO* U PUGLI, ITALIJA

FIG. 13 AT FIRST GLANCE ONE CANNOT DISTINGUISH BETWEEN A PILE OF GRAVEL AND THE SHELTER ITSELF

SL. 13. NA PRVI POGLED NIJE MOGUĆE RAZLIKOVATI GOMILU ŠLJUNKA OD SAMOGA SKLONIŠTA

FORM

OBLIK

Form can follow structure, but it can also be completely different. We know of semicircular forms, stepped structures, even spiral ones, forms of geometrical figures and completely amorphous, formless ones. The latter are defined by their filler, the material, which, if simply put is closest to sand or gravel.

Girna in Malta[16] and all other shelters utilise corbelling in their structure, while their exterior walls can run completely vertically. Thus a space is created between them, filled in with non-structural material – the filler. In places with no rain (Malta, Palestine, places in southern Italy) the filler is also the roofing material.

The construction and frame can be connected elements (load-bearing capacity and load),[17] they can be unconnected and the space between filled in.[18] *El Bombo* in Spain[19] is the only shelter where the construction and frame are wide apart; the filler takes on the task of providing form.[20]

EL BOMBO – STONE SHELTER FROM LA MANCHA

EL BOMBO – KAMENO SKLONIŠTE IZ LA MANCHE

El Bombo is the shelter for men and their livestock around the town of Tomelloso in La Mancha, Spain. The composition presents a structure completely separated from the frame, all of which is covered with stone. A pile of stone.

El Bombo is a one-, two-, three- or four-celled building. The living space is intended for man and has an open fireplace with a chimney (which generally doesn't exceed the height of the pile, and thus can hardly be seen) and niches to the left and right (In Slovenia we call them *leva*). The cell for livestock has a manger, built along the whole length of the back wall. The floor is compacted clay; the walls are painted with quick lime in the living space and brown clay in the space for livestock, up to the height its user can reach, between 2.20 and 2.40 m.[21] The entrance is usually on the southern side and there are no windows.

16 FSADNI, 1992; JUVANEC, 2001.a: 45
17 ROHLFS, 1963, tav.1
18 JUVANEC, 2004: 4
19 PEDRERO, 1999
20 JUVANEC, 2002.c: 4
21 JUVANEC, 2002.e: 37-46

A Pile of Stones can be a House or the most Ecological Form of Human Dwelling

Hrpa kamenja može biti kuća ili ekološka forma ljudske nastambe

I understand ecological architecture as such, which works (both its organisation and structure), uses natural materials, that are not manipulated and therefore changed, which doesn't harm nature (neither technically and technologically nor aesthetically), and which after decomposition doesn't burden nature – stone used in corbelling constructions can be built into any contemporary architecture.

The ground plan of *El Bombo* can be small or luxurious, visible also from outside. The structural part is corbelling, with ties between its cells and openings for passages (even between the living space and stable). The entrance part is the first cell and is used by both users.

Corbelling or rather, all the cells, are meticulously and carefully built, around the useable part the builder builds a fence. Between them he shovelled gravel that strengthened the inner structure.

The ecological cycle of the relation between the vine and the environment, in which it grows, is defined by the vine that grows well in fertile soil mixed with stone. Such stone is often overabundant, thus the environment itself allows only growth of vines (in flat land also olives), and hinders the growth of other field produce. Gravel as a piece of broken stone is therefore available in the place itself, while larger stones have to be brought from nearby quarries. Gravel is strewn up to the ridge and higher. Sometimes the internal structure's ridges are also shown externally as vertically planted stones.

The fence or frame of the structure is built from larger stones that also have a more constant form (they are flatter, at least on the outer side), thus the colour impression of these walls is much lighter than the filler's. At least the entrance parts of the buildings still in use today are painted with quick lime; more affluent owners sometimes paint the entire wall, so that it is white, but the structure of the wall remains clearly visible. The most ardent owners even paint the gravel, although I'm not quite sure how they do it.

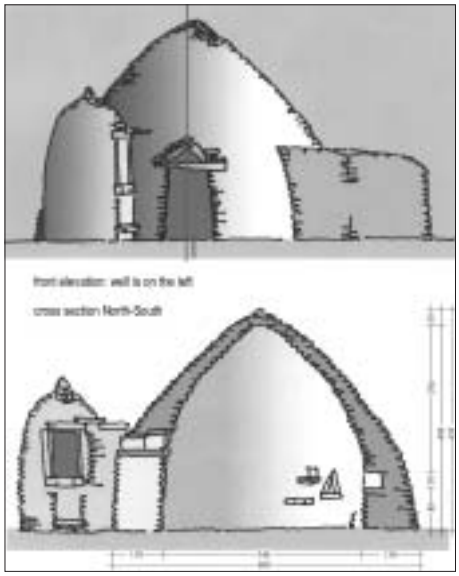


Fig. 14 St. Quentin la Potterie, Gard France, both layers (structure and frame) are tightly fitted next to each other, all the way down

Sl. 14. St. Quentin la Potterie, Gard France, konstrukcija i vanjska opna usko su prislonjene jedna uz drugu

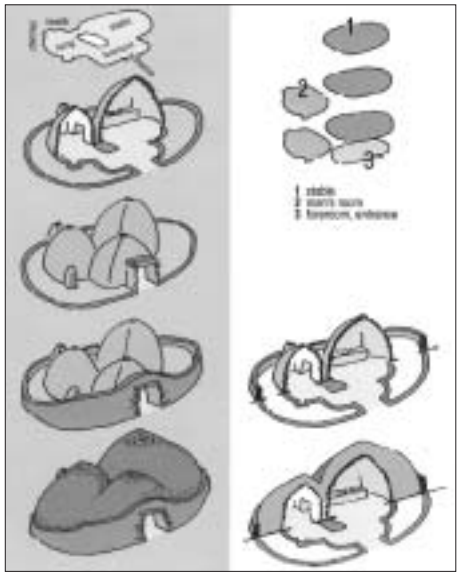


Fig. 15 A scheme of *El Bombo*: the ground plan is usually multi-cellular, always built by corbelling. The frame is only a fence, slightly raised at the doorway, generally not exceeding ninety centimetres. The filler gives the form: gravel is piled over the structure itself – refuse material is gathered and stored elsewhere

Sl. 15. Shema *El Bomba*: tlocrt sadrži obično više prostorija; način gradnje uvijek je postupni, konzolni. Vanjska je opna samo ograda, lagano izdignuta na ulazu i uglavnom ne viša od 90 cm. Ispuna daje oblik: šljunak je nagomilan preko same konstrukcije – otpadni materijal skuplja se i odlaže na drugo mjesto

Conclusion

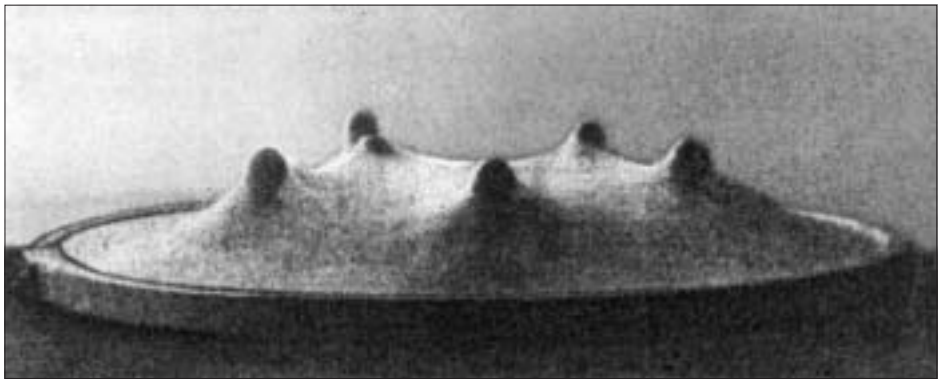
Zaključak

Los Bombos stand in vineyards, on a plane, in a circle of some five kilometres from the town, in all directions. This means that the people of the town of Tomelloso occasionally came to work in the vineyards and rode their donkeys. This doesn't mean that they stayed there overnight: because of the continental climate work was done only in the mornings and sometimes in the late afternoon. The rest of the day they spent resting in the shade of *Los Bombos*, while their animals waited there for the passage home.

When I was writing an article for the magazine 'L'Architecture vernaculaire' in Paris,[22] I made two photographs depicting piles of gravel in Tomellos. Next to the first one I wrote: „A pile of stones, which isn't a pile but *El Bombo* and

Fig. 16: „A membrane unequally supported in six places": The principle, form and use are the same, the structure differs from *El Bombo* only by the fact that *El Bombo* has a stretched outer surface, while the membrane's hangs

Sl. 16. „Membrana nejednako poduprta na šest mjesta": Princip, forma i upotreba su isti, konstrukcija se razlikuje od *El Bomba* samo po tome što *El Bombo* ima napetu vanjsku površinu, dok je ona kod membrane ovješena



22 Juvanec, 2003.a: 2

under the second, which depicts an apparently equal pile of gravel „A pile of stones, which isn't *El Bombo*, but a pile of stones".

The form is utterly natural: a pile cannot be controlled. It depends on the size and form of stones in the gravel and dictated by the angle of strewing. The form, size and structure above the ground plan, chimney and fireplace or entrance are elements, which follow each other as is best suited. The form of the pile is constant and equal to all, but the combination of spaces below and differing height of fences (the frame is determined only at the entrance, elsewhere it is almost inexistent) softly taper from the ridges, across the saddles to the edge.

Man cannot dictate such form nor control it: if too much gravel is shovelled onto a place, in time it will slide downwards and create a logical external form aligned to the internal one. The theoretical elements of such form are therefore: 1) material and its angle of strewing, 2) internal form with necessary organisation of spaces, 3) both points (1 and 2) give the final and typical form, *El Bombo*.

In architecture we say that the outer form reflects the interior.[23] However both the investor and architect much too often tend to destroy such relations by violent designing.

El Bombo takes no such liberties.

Should one ask oneself: is nature the better architect than man?

El Bombo is the only architecture I know of, that is self-regulatory in its form.

The conclusion is a surprising fact: an amorphous material, used as filler, gives a natural form to the whole composition. Good form, aligned to content, structure and the environment.

Not even man can spoil it.

(Translated by IVAN STANIČ, Ljubljana)

23 EGENTER, 1992

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ILLUSTRATION SOURCES
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FIG. 1-2	JUVANEC
FIG. 3	DEGANO, 1990: 428 JUVANEC, 2001.a: 6 MARKOVIN, 1963: 247
FIG. 4	JUVANEC, 2002.d: 4.2 JUVANEC, 2001.c: 2.5 JUVANEC, 2002.c: 5.4
FIG. 5-15	JUVANEC
FIG. 16	OTTO, 1954: 18

Summary

Sažetak

Kamene konstrukcije s postupnim konzolnim načinom gradnje: Oblik

El Bombo, La Mancha, Španjolska

Konzolni način gradnje nesumnjivo je jedan od najstarijih načina zatvaranja prostora. Koristio se još prije više od šest tisuća godina, što potvrđuje primjer u Hypogeum Hal Saflieni na Malti. Takav princip gradnje zahtijeva tlocrt koji bi trebao biti što je više moguće okrugao po cijeloj visini, dok mu je presjek jednakostranični trokut koji osigurava visinu konstrukcije koja je uvijek jednaka polovici drugog korijena broja 3.

Po definiciji arhitektonska forma proizlazi iz materijala, konstrukcije i okolnosti u kojima se elementi koriste. Kamena skloništa ponovno se pojavljuju u srednjem vijeku. Najstarije navode Degano (1559.), Horvatić (1577.) i Lassure (1620.), ali ona se grade još i danas. Postavlja se tvrdnja i pitanje. Konzolni način gradnje je konstrukcija, vanjska opna određuje oblik, a ispuna zauzima prostor između njih. Pitanje: može li se drukčije? Teoretski odgovor glasi: ne! U praksi su moguće iznimke. Ipak, iznimke potvrđuju pravilo. Jedna je od tih iznimki *El Bombo*: arhitektura o kojoj se nije puno pisalo i govorilo, a ipak je izuzetno zanimljiva. Njezinu formu čini ispuna: pijesak i šljunak. Kako je to moguće?

Konstrukcija, vanjska opna i ispuna: U kompoziciji građevine konstrukcija nosi teret. Omotač, opna ili membrana uglavnom omotava konstrukciju, a tek ponekad ima pomoćnu funkciju nosivosti. Ispuna je negdje između: katkada samo ispunjava šupljine, stoga što je njezin materijal jeftiniji nego onaj od kojeg je izrađena sama konstrukcija, a češće ima zaštitnu funkciju.

Ispuna je materijal koji ispunjava šupljinu između konstrukcije i vanjske opne. Ona ima i druge funkcije, kao što su: povezivanje, izolacija ili održavanje stalne temperature. Ispuna je materijal u rasponu od „ničega" do kamena (u modernoj arhitekturi fizičko „ništa" znači vakuum, dok u vernakularnoj arhitekturi to podrazumijeva odsutnost materijala u fizičkom smislu, a najbliži je ekvivalent, naravno, zrak) ili čak umjetnoga kamena, odnosno betona. Prostor između može biti ispunjen brojnim materijalima koje su priprosti graditelji koristili s takvom ingenioznošću da se suvremena rješenja koja se danas čine kao „otkrića" doimaju vrlo običnima i jednostavnima.

Ispuna koja se koristi u zidovima može biti gotovo ništa kad imamo uniformu konstrukciju, jedan zid. Ne mogu poreći da sam bio skeptičan kada mi je kolega B. Horvatić pričao o jednome zidu na otoku Krku, kojega visina doseže 1,6 m i koja se sastoji od jednog sloja kamena. Dokazao mi je da se po njemu može hodati bez padanja. Odolijeva i vjetru, ili ga propušta.

Na Sardiniji postoji zid koji se sastoji od dva sloja kamenja: vanjski su blokovi klesani, dok unutrašnji zadržavaju svoju prirodnu, stožastu formu.

Kameni zid bez morta najjednostavnija je konstrukcija. To je sustav s određenim pravilima, kao što su: preklapanje, izmjena. „Suhi zid" je uglavnom dvodimenzionalna konstrukcija koja najčešće definira otvoreni prostor i često dolazi u kombinaciji s drugim elementima razgraničenja.

Konzolni način gradnje: Ako postavimo jedan kamen na drugi i lagano ga gurnemo prema naprijed, on se neće pomaknuti. Ako gurnemo kamen iz trećega reda još dalje, ali ne preko zajedničkog težišta, dobivamo osnove konzolnoga načina gradnje. U osnovi, radi se o dva bitna elementa: tlocrt mora biti što je više moguće okrugao, dok kut presjeka mora biti blizu 60°.

Kao pravilo, u konzolnoj gradnji koriste se uglavnom kružni tlocrti: krug je savršen lik jer nema kutove. Krug zatvara protok energije i osigurava sigurnost tijekom gradnje.

Kamen se može koristiti za plošnu gradnju (zidovi) i gradnju prostornih tvorevina (zgrade). U prvom slučaju moramo poštivati preklapanje sastavnih dijelova. U drugom slučaju postoji samo jedno rješenje ako se želi postici prostorna kompozicija bez vezivnog sloja - konzolna gradnja. Ona je logičan razvojni slijed od konstrukcije grede do prostora. Najraniji dokaz takve gradnje potječe čak iz doba do 5000 god. pr. Kr., dok je prva kupola nastala na prijelazu tisućljeća.

Forma može proizići iz konstrukcije, ali može biti i potpuno različita od nje. Poznate su nam polukružne, stepenaste forme, čak i spiralne, forme geometrijskih likova i posve amorfne konstrukcije. Ove posljednje definira ispuna, materijal koji je najbliži šljunku ili pijesku.

El Bombo u Španjolskoj jedino je skloništе gdje su konstrukcija i vanjska opna razdvojene; ispuna preuzima zadatak generiranja forme. To je građevina s jednom, dvije, tri ili četiri prostorije. Životni je prostor prilagođen čovjeku i ima otvoreni kamin s dimnjakom. Prostorija za stoku ima jasle duž cijele dužine stražnjeg zida. Pod je od nabijene gline; zidovi su okrečeni živim vapnom u prostoru za boravak, a smeđom glinom u prostoru za stoku. Ulaz je obično na južnoj strani. Prozora nema.

Hrpa kamenja može biti kuća ili ekološki oblik stanovanja. Ekološka arhitektura koristi prirodne materijale koji nisu obrađeni, niti tehnički, tehnološki ili estetski izmijenjeni na bilo koji način. Konstruktivni dio je postupni konzolni način gradnje s vezama između prostorija i otvora za prolaze (čak i između prostora za boravak i staje). Ulazni dio je prva prostorija namijenjena korisnicima.

Ekološki ciklus odnosa između loze i okoliša u kojemu raste definiran je lozom koja dobro raste u plodnom tlu izmiješanom kamenjem. Takav se kamen često nalazi u prevelikoj količini i ometa uzgoj drugih proizvoda osim loze (ili maslina). Šljunak je stoga, kao razdrobljeni kamen, dostupan na samoj lokaciji, dok se veći kameni blokovi moraju dopremiti iz obližnjih kamenoloma.

Ograda ili vanjska opna konstrukcija građena je od većih kamenih blokova pravilnijih oblika (s glatkim površinama barem na vanjskoj strani). Boja se zidova obično stoga doima svjetlijom nego boja ispune. Ulazni dijelovi građevine, koji se i danas koriste, okrečeni su živim vapnom.

Zaključak: *Los Bombos* se nalaze u vinogradima i ravnicama unutar 5 km od grada. To znači da ljudi iz grada Tomellosa povremeno dolaze raditi u vinograde, ali ne znači da ostaju tamo i preko noći.

Kad sam pisao članak za časopis „*L'Architecture vernaculaire*" u Parizu, pronašao sam dvije fotografije hrpe šljunka u Tomellosu. Uz jednu sam dopisao: „Hrpa kamenja koja nije hrpa već *El Bombo*", a uz drugu, koja prikazuje istu takvu hrpu šljunka, napisao sam: „Hrpa kamenja koja nije *El Bombo* već hrpa kamenja".

Forma je potpuno prirodna: hrpa nije pod kontrolom. Ona ovisi o veličini i obliku kamenih komada i kutu nasipanja. Čovjek ne može kontrolirati takav oblik; ako je nasuto previše šljunka, on će s vremenom kliznuti prema dolje i stvoriti vanjsku formu povezanu s onom unutarnjom. Teoretski elementi takve forme jesu: materijal i kut njegova nasipanja te unutarnja forma s potrebnom organizacijom prostora.

El Bombo je jedina arhitektura, meni poznata, koja ima samoregulirajući oblik. Često kažemo da u arhitekturi vanjska forma odražava unutrašnjost. Ipak, često se događa da investitor i arhitekt uništavaju taj odnos agresivnim projektima. *El Bombo* to ne dopušta.

Borut Juvanec

(Prijevod na hrvatski: Neda Borić)

Biography

Biografija

Borut Juvanec, Dipl.Eng.Arch., Ph.D., Professor. He is an expert in architectural theory, in the first place principles of proportion, vernacular architecture and author of town-planning projects. He is head of the CEPUS/Vienna programme for Slovenia, and counsellor for foreign projects for the Italian and Austrian governments. He occasionally gives lectures at several European universities.

Dr.sc. **Borut Juvanec**, dipl.ing.arh., profesor na Arhitektonskom fakultetu Sveučilišta u Ljubljani, stručnjak za teoriju arhitekture, osobito principe proporcija i vernakularnu arhitekturu i autor urbanističkih projekata. Voditelj je programa CEPUS/ /Beč za Sloveniju i savjetnik za strane projekte pri talijanskoj i austrijskoj vladi. Povremeno drži predavanja na nekoliko europskih sveučilišta.