

XVII International Congress on Dry Stone

“Dry stone perspectives: challenges after the UNESCO inscription”

Cavtat, Croatia, October 1-2 2021

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Stone Shelters in Croatia

Abstract

The stone is common material and can be found everywhere in nature.

It is a perfect building material, and can be treated and composed into constructions. The first phase of construction is layering the stones, with overlapping. The space between the elements of the first course opens the possibility of composing windows and, finally, a shelter. The most important element of this construction is the overlapping. Overlapping in three dimensions, or corbelling, composes a false dome, which may be built without any connecting material or scaffolding.

The use of drystone constructions can be found in the oldest architecture, from prehistory up to today. Vernacular architecture is the art of building, performed by unschooled people. Nowadays, a drystone walling system is built by smart people, mostly highly educated.

The purposes of those constructions are very wide, including marking, monumental use, as a tomb, a wall, pavement, herdsman's shelter, residence, animal shelter, water collector, icehouse, storage place, for drying, measuring, defence, irrigation, transport, as a religious object and much more.

We have several organizations engaged with drystone walling system, but a common organization for connecting local movements on the European level is needed. Several projects as well studies have been undertaken very well, with various origins, purposes, implementation and impact on practice and theory, but more or less on a local level. Some sort of union is needed for disseminating and monitoring this important part of the vernacular heritage, by connecting the work



17th international congress on dry stone
KONAVLE 2021



of experts, lay people, civil societies with professional organizations, including ICOMOS.

This article shows drystone objects by countries, mostly in Europe and all the Mediterranean. Each record is presented by a photo and two sheets of documentation, with very short description.

Keywords: *architecture, drystone, construction, corbelling, shepherds shelter*

1. Introduction

The stone is very common material, perfect for building. It can be hewed or just found. Where is surplus of stone – pastures have to be cleaned of stones because of danger for animals, stones have to be stored. A heap of stones disappears in time: it has to be constructed. 'Le clapas' for instance in France or 'grublja' in Slovenia are firm compositions, but without any usable purpose – only for storing the stone. The simple idea: if it is constructed, it should be at least of some use, follows to composing walls and shelters. To build with even stones is relatively simple, to construct objects with heterogeneous stones are hard work. Stone masonry is professional craft and needs knowledge and skills.



p 1.1: Corbelled construction can be found in Bent pyramid – longitudinal corbelling appears in burial cells, second Millennium BC.

The inscription on the UNESCO Representative List of the Intangible Cultural Heritage of Humanity reads as follows: 'The art of dry stone walling concerns the knowhow related to making stone constructions by stacking stones upon each other, without using any other materials except sometimes dry soil. Dry stone structures are spread across most rural areas – mainly in steep terrains – both inside and outside inhabited spaces, though they are not unknown in urban areas. The stability of the structures is ensured through the careful selection and placement of the stones, and drystone structures have shaped numerous, diverse landscapes, forming various modes of dwelling, farming and husbandry. Such structures testify to the methods and practices used by people from prehistory to today to organize their living and working space by optimizing local natural and human resources. They play a vital role in preventing landslides, floods and avalanches, and in combating erosion and desertification of the land, enhancing biodiversity and creating adequate microclimatic conditions for agriculture. The bearers and practitioners include the rural communities where the element is deeply rooted, as well as professionals in the construction business. Drystone structures are always made in perfect harmony with the environment and the technique exemplifies a harmonious relationship between human beings and nature. The practice is passed down primarily through practical application adapted to the particular conditions of each place' (Intergovernmental Committee for the Safeguarding of the Intangible Cultural Heritage, 13th Session from 26th 12, 2018, **Decision 13.COM 10.b.10**). This document was realized with the help of the SPS organization.

It means that the drystone walling system is recognized as important heritage worldwide. Objects made of stone, without any cement or mortar, are not only walls: they include buildings for several purposes, with numerous local names. It is the most widespread in karstic areas. Kranjc understands karstic areas ('karstic' comes from Slovene word 'kras', Kranjc 1997: 9) to stretch from the Videm/Udine landscape, over Slovenia, Croatia, Herzegovina, Montenegro, Albania to Greece (Kranjc 1997: 17). My documentation consists of technical plans from Iceland to Yemen, from the Canaries to Palestine – but drystone architecture is much more widespread in the world.

Shelters by purpose were presented in my short presentation on the SPS Congress Konavle 2020 (Cavtat HR, 2021), but the material is too extensive for this publication. Six types of stone shelters in Croatia are presented in this paper.

2 Construction

Stone in the construction of space can only be used with intelligence. Shelters in corbelling from the sixth millennium BC can be found on the border between Saudi Arabia and Yemen (Steimer 2001). In the subterranean shrine of Hal Saflieni on Malta, it is scratched into the soft stone as a construction principle. Its model must have been even older.

The principle of corbelling requires a horizontal layer of stones, which overlap each other right to the top of the construction. In ground plan, corners and the problems associated with them are avoided with a circle but, on the outside, the composition can be completely unique: semicircular, pointed, stepped, with a pronounced roof, with stresses or without them. Only one shape is possible on the inside: corbelling creates a false cupola (Juvanec 2014).



p 2.1: Corbelling in principle appears as cross section: it can compose a room as longitudinal construction, in space it is false dome, with circular ground plan. This simple shelter has a seat for one man only, trim on island of Hvar, Croatia.

Corbelling is gradual overlapping that is repeated from layer to layer, in height all the way to the capstone (Lassure 2008). Experience suggests that the ideal internal

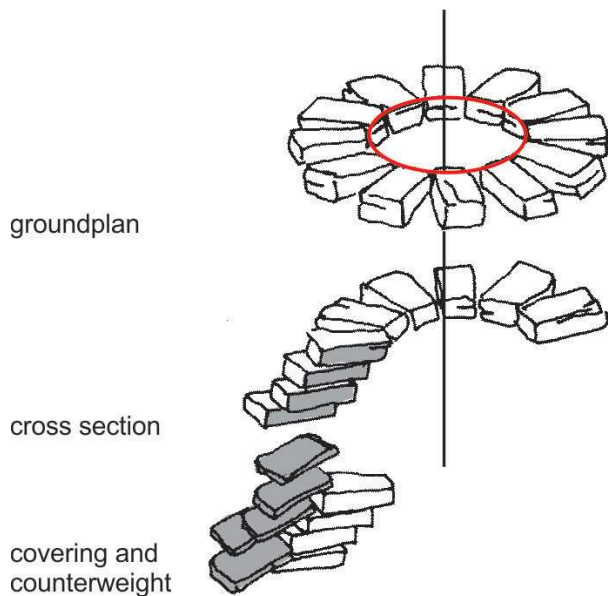
height of a construction is $\sqrt{3}/2$ of the diameter of the base plus the thickness of the wall (Juvanec 2004).

The composition of a shelter – right up to the largest, with a diameter of more than nine meters – has three elements:

- corbelling as the supporting construction,
- external frame, which leads off water,
- weighting elements of the corbelling as a counterweight. In between is filler, which fills and with volume gives weight to the composition itself.

Objects thus occur in which the corbelling and frame are almost combined and also those in which they are completely apart (Juvanec 2016d).

The external shapes of objects can be of course completely different.

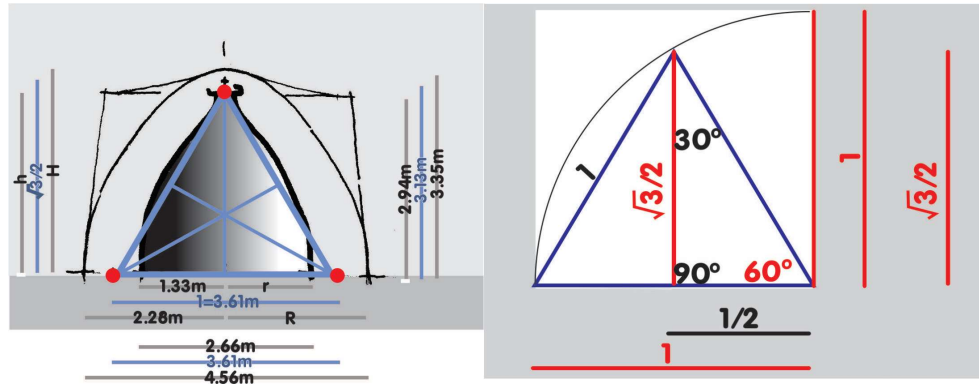


p 2.2: Theory of corbelling: a circle, overlapping, counterweight. The final result of corbelling is false dome.

In ground plan, corbelling is a construction of horizontal circles, and in cross section of overhanging layers. This construction does not affect the shape. However, three constructional elements can be observed: corbelling – the construction itself, the frame and the filling (gravel) between them.

The square root of three is the height of an equilateral triangle, if the baseline is equal to two. The diagonal of a square with baseline of one is equal to the square root of two. The mathematical order, or rule, of these rectangles (one to the square

root) is that the diagonal of a rectangle is one number higher than the number under the square root of the baseline. So: a rectangle with baseline (square root of two) and height (one) has a diagonal equal to $\sqrt{2} + \sqrt{1}$. This is $\sqrt{3}$.



p. 2.3: Height of the corbelled constructions is built with help of square root of three by two. This can be easily constructed with equilateral triangle, where is baseline equal to one. This triangle appears in cross section: from the middle to another middle of the wall. In practice, it can't be measured – but length from beginning of the entrance to the end of the room can.

In shelters, the baseline of the equilateral triangle found in corbelling is the width from the middle of one wall to the middle of the opposite wall. It seems complicated but it is not. This baseline is measured from the outer point of the wall (at the entrance) to the end of the room.

It means: $w + 2r$, where w is width of the wall (theoretically $1/2w + 1/2w = 2/2w = w$), and r is the radius of the inner room, and $2r$ is the diameter of the circle in ground plan (Juvanec 2009).

The oldest corbelled constructions can be found in Yemen, at the border to Saudi Arabia. Surveys of Tara Steimer dated them into 5th Millennium BC (Steimer 2001). Atreus treasury is the same false dome, but with hewed stones – originally covered with metal disks, from second Millennium BC. Stone shelters appeared in the oldest documents – by Berislav Horvatić – in 1577 (Horvatić 1999). Today existent shelters are not older than 200 years, only a few are elder.

3 Documentation

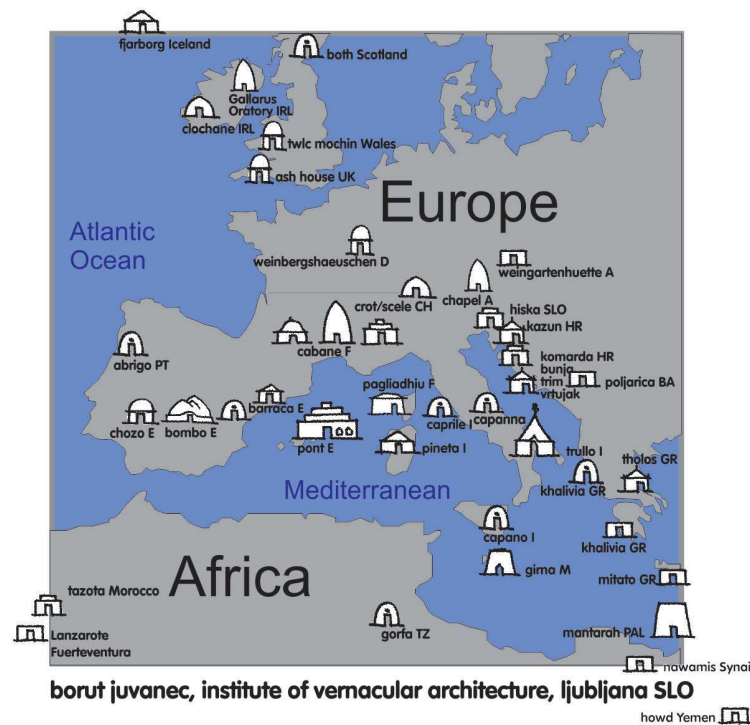
Architecture means designing the space with intentions, needs, use, building, furnishing it and managing environment – physical and psychical. Good architecture seats in environment properly and looks smaller than it is (Oliver 2006).

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An architectural object can be understood as a plain surface (elevation, ground plan, cross section, drawing, scheme) or a solid. In terms of acceptance, understanding is a matter of technical and other elements: needs, possibilities, circumstances in theory and practice. The entire problem is complex and cannot be embraced in a single step, although theory and practice are closer than we think.

The problem can be simplified as: the architect's idea, technical simplification, imagination, active thinking and practical work, presentation, explanation, understanding (Juvanec 2013).

Technical possibilities are sketch, drawing, technical drawing, 3D presentation, model, folder, working model, smart model, video, computer virtual reality with simulation of work and an active role of the user.



p 3.1: Authors documentation of stone shelters in Europe and Mediterranean. The data are missing from Sweden, Turkey, Tibet and probably a lot other (Juvanec 2016d).

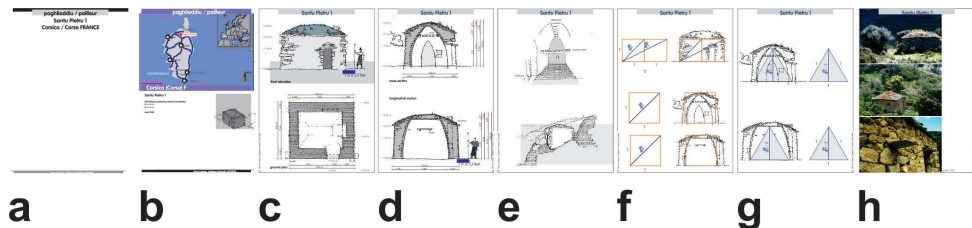
Documentation represents data: text, dimensions, technical drawings, schemes, simulations, sketches, artist's impressions, photos, videos, historical data, language, pronunciations, maps and many others.

Text of architectural documentation consists of location, text with all reachable data (historical, technical), ownership and name of informer and actors in collecting the data, date of finishing the information list.

New architecture consists of architectural and administrative documentation with all attestations and formal permissions. All historical architecture, including vernacular, haven't those documentation.

The first step to make a documentation is visit, survey, measurement, creating technical drawings, schemes, simulations and artist's impressions.

The most important are architectural drawings with exact dimensions as basis for possible restauration and further scientific treatment, including founding used proportion systems.



p 3.2: A documentation record consists of: 1 cover with basic data of object, location and author; 2 The first sheet has a plan and basic data of location (GPS, height above the sea), technical description, name of informer and supervising, author and his research organization; 3 ground plan and elevation with basic dimensions, orientation and scale (with human being); 4 Sections: cross section and longitudinal section with description of details; 5 sketches, schemes; 6, 7 proportion system found in theory and practice, their origins and implications; 8 photo material of landscape, object in whole, details (example: paghliaddju, Corsica/Corse; Borut Juvanec, (Ljubljana University) Institute of Vernacular Architecture, Ljubljana Slovenia).

4 Stone Shelters in Croatia

There are numerous stone shelters in the coastal part of Croatia. They are constructed mainly of split stone plates with the same width. This is important because the plates allow controlled and exact construction of the walls, roofs, openings, windows, pinnacles, enclosures, including inner fittings.

The objects are mainly used as herdsmen's shelters, less for animals. In some cases, there is a combination of a herdsman's cell with smaller cells for sheep (island of Žirje, Šibenik).

Kažun can be found on the Istra peninsula, komarda on the islands of Krk and Cres, bunja in Dalmatia, trim on the island of Hvar, vrtujak and toreta on the island of Korčula and kučerica in Konavle near Dubrovnik (from the north to the south of the country).

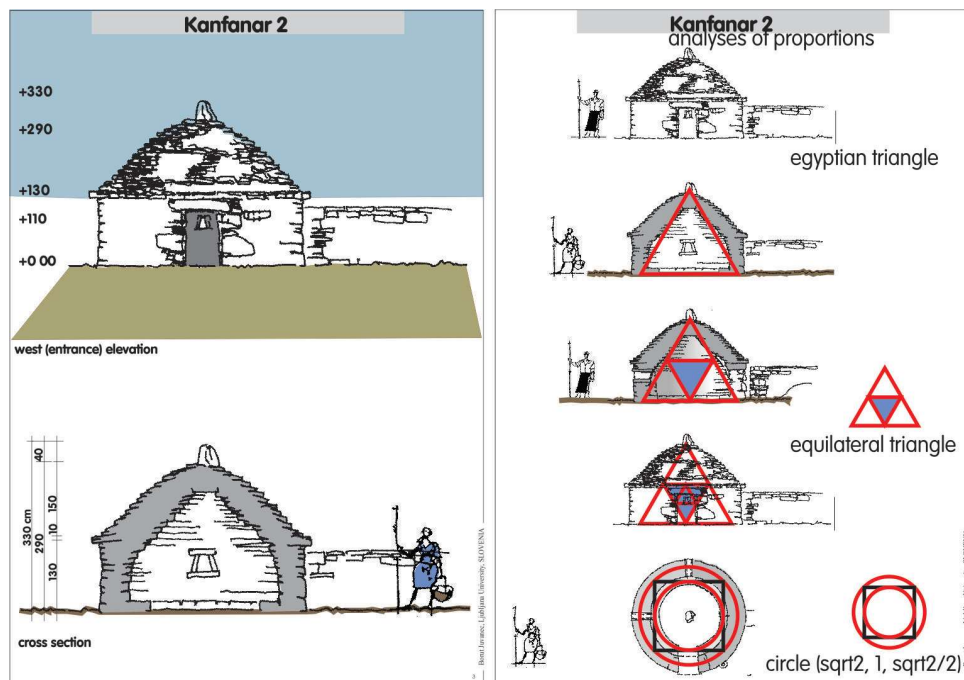
Kažun

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Kažun can be found on the Istra peninsula. They serve as herdsmen's shelters with rich stone fittings: benches, tables, fireplaces, shelves and dormers. They are rarely used for animals, and only a few of them are built in two storeys. Near to the coast and near to villages they are devoted to animals and stand in rows of three or even four.



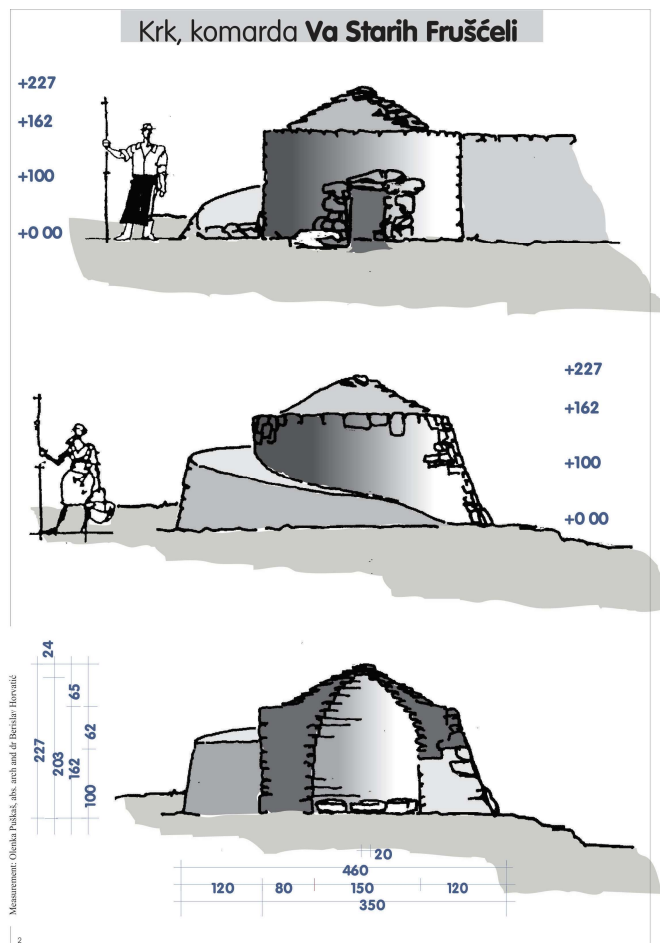
p 4.1: Kažun is a typical vernacular shelter in Istra, built of split stone plates. Because of elements with the same thickness it can be composed very strictly: it has vertical walls, roof with overhangs and pinnacles (near Kanfanar 1998).



p 4.2: Entrance elevation of the kažun. Cross section and proportion system:4 : 3; equilateral triangles as a whole and in detail. This means the use of the square root of three, divided by two: if the inner diameter plus the width of the wall is 'one'. (Kanfana 1992).

Komarda

The island of Krk has very rich stone architecture: permeable water wells, stables, 'mrgari' – sheepfolds for organizing and controlling sheep, and finally 'komarde' (plural), herdsmen's shelters. They are built of unhewn, collected stones. They can't be perfect in shape, but they are in their construction.



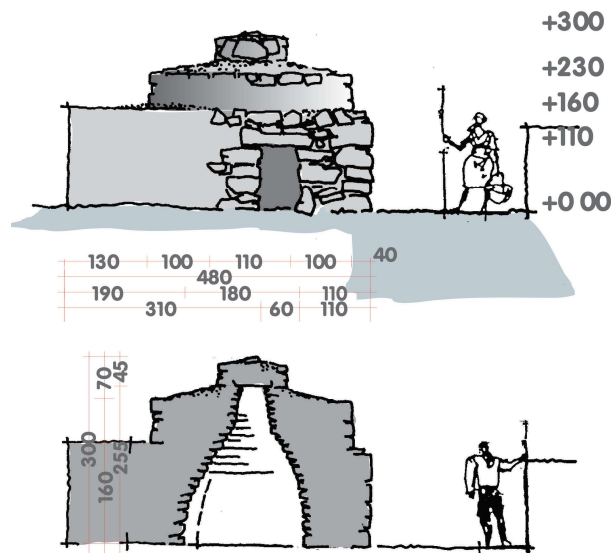
p 4.3: Documentation of komarda: front view, side view and cross section (1999).



p 4.4: In 1999 was this komarda was free of vegetation, since then, the object has become more or less covered by trees.

Bunja

Bunja is the common name for the objects in Dalmatia and islands. They are beautifully built near Šibenik, and with several cells on the islands. The objects near Šibenik are bigger and are used for daily transhumance. Herdsmen lived in them on the islands, together with the animals, throughout the season.



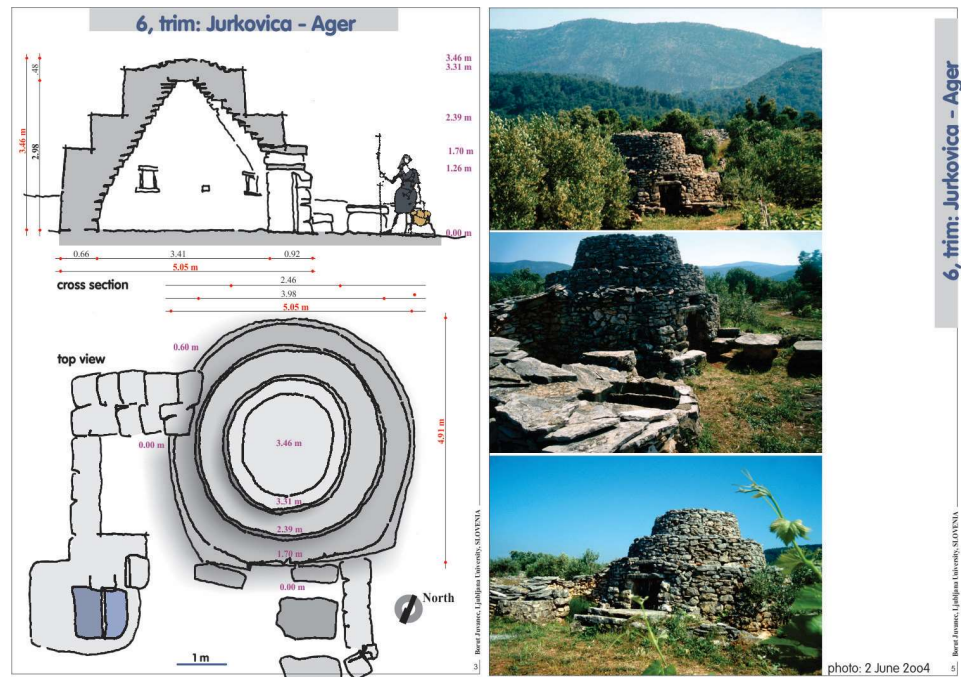
p 4.5: Bunja on the island of Žirje (near Šibenik) has a stepped construction. The cross section shows its perfect construction of a false dome, covered and filled with stone.



p 4.6: An interesting combination of a square ground plan and circular rings over it confirms its construction.

Trim

On the island of Hvar can be found large shelters, built with a stepped construction, equipped with stairs. Today they are used mainly as temporary objects in vineyards. The buildings are used for living and storing tools, outside are benches and tables for work, fences and bowls for preparing insecticides. Vineyards are well known from Roman times.



p 4.7: Jurkovicva, island of Hvar: cross section and view from above to the whole composition. Photos of the object in the landscape of Ager, ancient Roman country of vineyards.



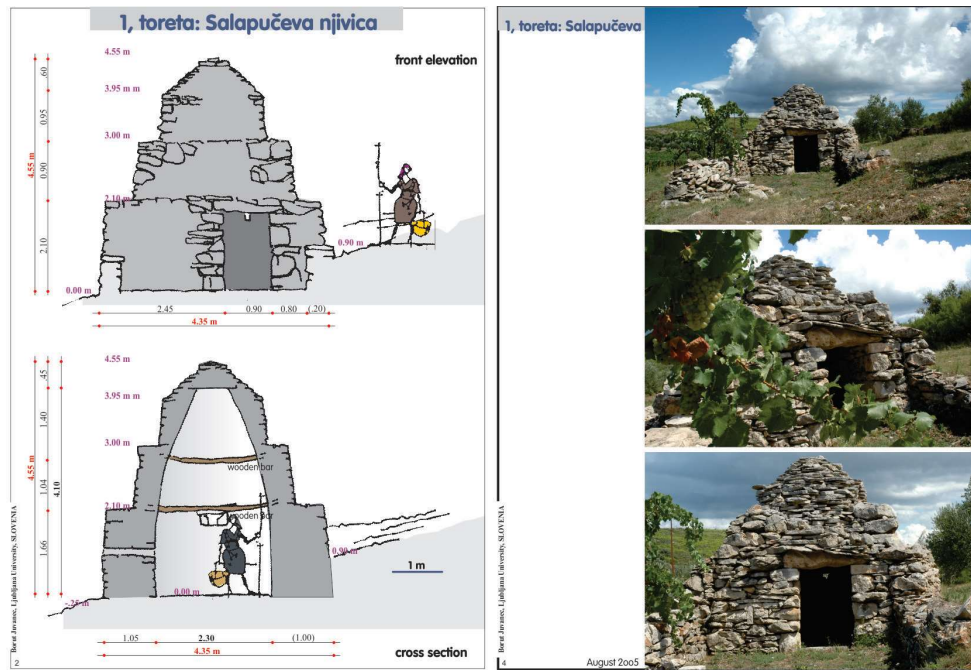
p 4.8: Shelters in Ager are equipped with outside furniture: benches, table, bowls, all in stone. Some of them are still in original use – shelter for wine-keepers. Trim on this picture is located on Starigrad plain, protected area by UNESCO.

Vrtujak, toreta

In the island of Korčula can be found two types of shelters. In the western part of the island, there is 'vrtujak' (the name explains the construction, meaning 'roundabout'; singular: vrtujak, plural: vrtijci). They are beautiful objects, built very exactly with vertical walls, roofs, overhangs and pinnacles. Inside can be found stone furniture, an underground cistern is a part of them.

Toreta in the central plain of the island is a longitudinal object, but built with a perfect corbelled construction. Cells for animals can be found beside the living part, all enclosed with a fence for security.

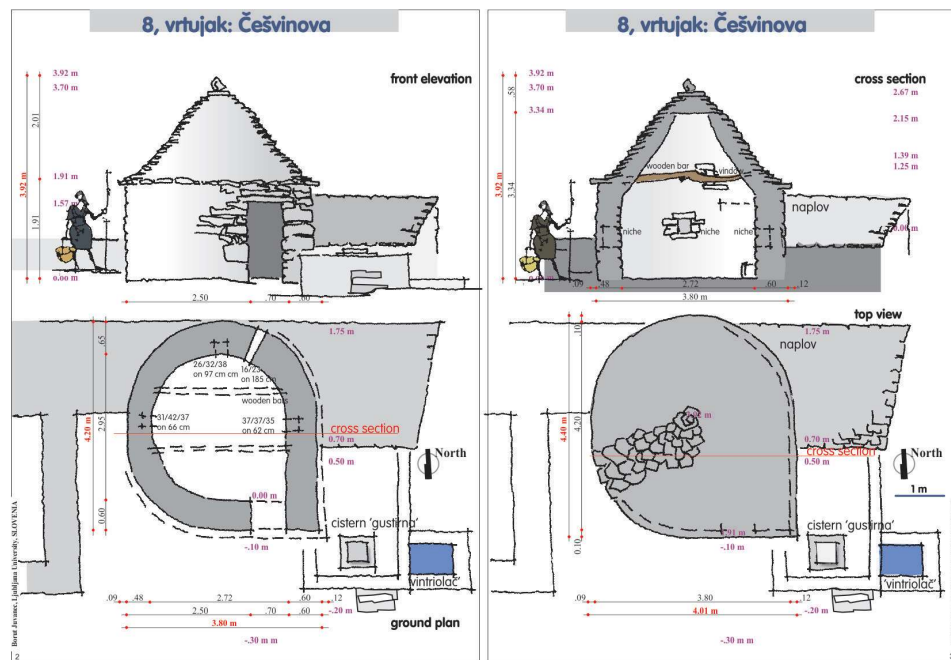
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p 4.9: Salapučeva njivica 1: front elevation and cross section.

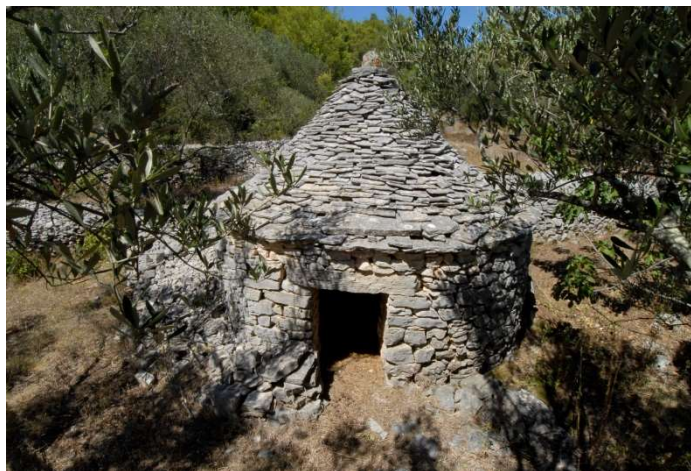


p 4.10: Longitudinal toreta is an interesting object in stone, high and equipped with yards and stone details: water bowls, lintels, openings. There are still five toretas on the high plain of Korčula island.



p 4.11: Ground plan of vrtujak with underground reservoir and water bowl for blue vitriol (against diseases).

View from above shows the interesting ground plan (Češvinov vrtujak, Korčula).



p 4.12: There are numerous vrtujci in the vineyards of Korčula. The word 'vrtujak' can be translated as 'roundabout'.

Kučerica

Kučerica is a shelter in Konavle near Dubrovnik near the airport. Local masters saved some objects by moving them to other locations. The ground plan is typically a circle and the corbelling is made of uneven stones. This is hard work, but some of them have perfect corbelled false domes.



p 4.13: Kućerica above the airport Čilipi (Dubrovnik) in 2005.



p 4.14: Some objects have been relocated by local people from the airport and stand as witnesses of the rich local culture. Some objects can be found abandoned in the undergrowth (2021).

Bosnia and Herzegovina

Poljarica

Shelters in SW Herzegovina, near the border with Croatia at Dubrovnik are called 'poljarica'. This name is also used for the oldest objects in Dalmatia (Freudenreich 1972).

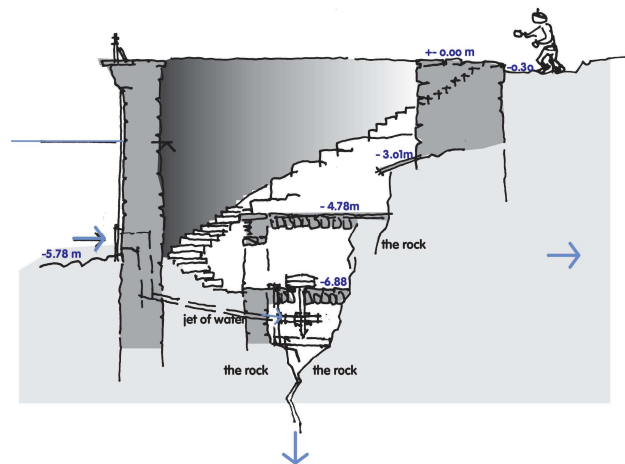
Herzegovina is very stony country. Stone architecture can be found in all remote villages in the mountains, but with a wooden construction for the roof. Shelters can't often be found. Exceptional architecture can be seen in Popovo polje, where cylindrical drystone objects are used as watermills. They are located over underground caves, and some of them use the water power in both directions: as estavelles.



p 4.15: Only a few objects in stone can be found in Herzegovina today. This poljarica is incorporated into a wall, but it is large enough to protect stool as well as some people in the case of sudden rain.

Water mills, water wheel with vertical axis

Popovo Polje is a valley on the other side of the hills between Croatia (Konavle) and Herzegovina. The river Trebišnjica flows through the plain intermittently. The mills have water wheels with a vertical axis for direct drive of the millstones.



p 4.16: Watermills (mlinice) in Popovo Polje stand in the bottom of an enormous stone cylinder, over the karst water sink (ponor). The river flows twice a year over the plain and reaches half of the height of the cylinder. It drives the mill, and the water disappears into the sink. The sinks are in some cases estavelles and the mills drive in both directions (Juvanec 2016).



p 4.17: Dimensions of the cylinders can be more than 10 metres in height and diameter (Juvanec 2016).

Close to the sea, on Ljuta river, at Konavle, there are numerous water mills. They can have millwheels with a horizontal axis, but those with a vertical axis are more common. This system needs a strong water jet: the chutes over the mills are designed for its invigoration.



p 4.18: The chutes over the mills are very narrow, but the water released after the millwheels flows in a wide riverbed. The millwheels can be seen in the corridorspace deep under the mill building (Ljuta river 2021).



p 4.19: The waterwheel is made of very hard wood. Constant moisture is needed for a long lifespan. The paddles are designed for the best effect, but are simplified because of the simple carpenter's tool. This wheel can be seen in the cold stream under the last watermill (Ljuta 2021).

5 Issues

A drystone walling system is a living organism, installed in nature with plants and serving some animals, and it is important for humans too.

The issue today is the condition of this built heritage: drystone constructions are vital organisms and need current maintenance, without which they can collapse in some ten years. Maintenance means monitoring, repairing, reconstruction and renewal. This can only be done by professionals, educated people, so education and qualifications are needed.

Research work is needed and consists of listing, documentation, evaluation, renovation and reconstruction, and finally education at all levels, with licencing of masters in drystone.

Inventorying or listing is just a list of objects, and contains all relevant data.

Documentation is professional work and contains historical, architectural, ethnographical and other data relevant for the object. Under ICOMOS Principles, adopted by the 18th General Assembly in Florence 2014, 'documentation has to be placed in a permanent archive and made publicly accessible when this is consistent with cultural and conservation objectives'.

Evaluation is an essential part of professional work. It can follow standards in the fields (architecture, archaeology, ethnology, anthropology, history etc).

Maintenance means physical repair of details. This is especially important for drystone. Drystone is a living organism, and maintenance is a part of its life.

Reconstruction is needed when and where the construction is in danger.

Reconstruction must be done in the same system, material, size and work as the original.

Renovation means reconstruction, with changing the purpose or use. This is most important in introducing new possibilities in dwelling practice: we now need greater comfort – not known in former use.

Education and licencing are also very important. Education in drystone means spreading knowledge of this forgotten culture. It is important for all countries. In the first step it should be mentioned as 'stone upon stone', as children's toys: playing dice. In higher education, individual studies can be done, with photos, drawings and vocal recordings.

Many books and manuals have been published in France (CERAV, Centre d'études et de recherches sur l'architecture vernaculaire, mostly by Christian Lasseur; and SPS, Société scientifique internationale pour l'étude pluridisciplinaire de la pierre sèche in Le Val), Spain (Patronat de Sant Galderic in Barcelona); ARTE, Asociación por la Arquitectura Rural Tradicional de Extremadura in Cáceres with an important revue *Pedras con raíces – The Stone with Roots*); Slovenia (Ljubljana University and i2: B Juvanec – *Kamen na kamen (Stone upon Stone)*, *Hiška (Shepherd shelter in*

Slovenia), Architecture in Slovenia 5, the Karst); also in Croatia (Dragodid with the booklet Gradimo u kamenu – We Build in Stone).

Permanent education is developing knowledge and skills as a second profession. This is also an important system for keeping knowledge over an entire lifespan. Licencing in Great Britain, driven mostly by DSWA, Dry Stone Walling Association of Great Britain (divided by regions: England, Wales, Scotland, Northern Ireland) is a very good example, and workers there operate strictly with those licences.

In Slovenia, the Ministry of Labour, in the frame of EU Funds, established a special education system in 2018 as NPK (National Professional Qualification) with the designation 'drywaller 7488784011', Klasius-P16 (Civil Engineering 0732) as an official education level for drystone workers, organized by CPI (Centre of Vocational Education in Ljubljana).

Unifying the professional organizations would be of great importance. There exist a lot of local organizations with important results, but in the fields of common information, organization, survey, education and licencing, publishing and especially in appearance in European Union programmes is needed a common European union, with unifying all existing organizations for better results in theory and practice in drystone art.

6 Conclusions

Man recognises all the characteristics of stone and its advantages, so he appreciates and respects it. Because it is difficult to work, it has simple forms and few decorative elements, which are therefore more considered and more effective. Its use in architecture is limited to key elements, which create the construction. When man outlines stone on plaster, it is because of the desire to have stone there, because it would be more appropriate thus and in this place.

Man has learned a great deal from stone: its hardness ensures long life. Because opposites for the most part attract, the attitude of man to stone is warm, refined and soft, he expresses gratitude for its quality. The use of stone in everyday life is not therefore coincidental (Juvanec 2013).

Stone as a building material and its future: Stone is extremely suitable as a building material in solid constructions. Its heat conductivity, large mass and the difficulty

of working it reduces its use in everyday life. Stone was long the building material for kings, the gods and for the dead, so for the rich and prestigious, and less for ordinary man. Solid stone replaces the use of cladding, whereby the construction is slightly different, and stone thus provides protection and appearance. Conservation is very often a symbolic act, demonstrating pride and values to the present and the future (Oliver 2003).

The replacement of stone by artificial stone (concrete) is possible, but not everywhere, although artificial stone is fully its equal technically. Technologies provide the shape and properties of artificial stone with suitable surfaces and, above all, better construction properties than natural stone in the case of wider spans, for instance.

It is entirely logical that, between the substitute and natural stone, man consciously and intuitively appreciates real stone more. Concrete, and above all reinforced concrete, offers much more but it cannot replace stone.

Stone is timeless, but functional, modern, beautiful and close to man; it is a perfect material for architecture (Juvanec 2016c).

Though the material is not human, the results, more or less only architecture, definitely are; but for an appreciative feeling and respect for the stone culture of our forefathers, we have to know the stone and understand its architecture – for its physical preservation as well for the human feeling to it.

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Stone Shelters in Croatia Cavtat, Croatia, October 1-2 2021 **Borut Juvanec,**
Institute of Vernacular Architecture, Ljubljana, Slovenia

Short biography of Borut Juvanec

architect, PhD, professor emeritus on Ljubljana University, current head of Institute of Vernacular Architecture.

Works in the field of theory of architecture, its origins and vernacular architecture in stone, wood and in clay.

He published a number of scientific books, published in Spain, Great Britain, Slovenia, Hungary, and some ten scientific articles.

Lectures on several European universities: **Barcelona, Florence, Malta, Moscow, Zagreb, Graz, Bratislava, Sofia, Budapest, Cerveira, Cardiff/Caerdydd, Trento, Oxford, Cagliari, Lisbon, Reykjavik, Grenoble, Valencia.**

Research work was exhibited in Alghero/I, Barcelona/E, Birzeit/PAL, Zagreb/HR, Budapest/HU, Pecs/HU, Novi Sad/RS, Prague/CZ, Vienna/A, Ljubljana/SI, he has **permanent museum exhibition** of stone architecture in Korcula HR.

Active member of ICOMOS Paris/Ljubljana (expert and votive member of CIAV), ISPROM Sassari/I, SPS Le Val/F, CERAV Paris/F, ARTE, Caceres/E, Patronat de Sant Galderic, Barcelona/E, SIS-Symmetry Brussels/B.



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