Borut Juvanec
Univerza v Ljubljani, Fakulteta za arhitekturo, Zoisova 12, SI-1000 Ljubljana
Institut vernakularne arhitekture, Prijateljeva 11, SI-1000 Ljubljana
borut.juvanec@stoneshelter.org

Adriatic drystone constructions in corbelling

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Excerpt

Stone is a natural and very usable building material. The drywalling technique can be built into a plain wall but corbelling is the only possibility of constructing a room. Creating the shape of an object in this unique building system is a matter of personal knowledge and inspiration, with particular shapes being typical of different geographical locations. Stone shelters were used to facilitate the transhumance economy: nowadays this branch is almost dead. The article starts with descriptions of corbelling in the northern part of the Adriatic Sea, on the Italian side from Friuli-Venezia Giulia, over Abruzzo to Apulia/Puglia and on the other side from Slovenia, Croatia, Herzegovina to Montenegro. The objects are mostly shelters for herdsmen, but wells and ice huts can also be found. The most important object – because it is still in use – is a *trullo*, others are more or less abandoned and neglected. Drystone architecture in corbelling is valuable and from cultural heritage point of view an interesting architectural construction principle. In all the Adriatic area must be preserved for future generations. At least brief information is important for young people, who cannot remember old structures once used by their predecessors, which still exist in this architecturally interesting area.

Izvadak

Kamen je prirodan i iznimno primjenjiv materijal. Tehnika suhozida može se primijeniti prilikom izgradnje običnoga zida, no prostoriju je jedino moguće izgraditi pomoću nepravoga svođenja. Stvaranje oblika tim jedinstvenim sustavom izgradnje pitanje je osobnoga znanja i nadahnuća, dok su određeni oblici karakteristični za različita geografska područja. Kamena skloništa koristila su se sa svrhom provođenja ekonomije transhumance; danas je ta grana gotovo izumrla. Članak započinje opisima nepravoga svođenja na sjevernome dijelu Jadranskoga mora, s talijanske strane od regije Friuli-Venezia Giulia preko Abruzza do Apulije/Puglije te od Slovenije, preko Hrvatske i Hercegovine do Crne Gore s druge strane. Objekti su

uglavnom skloništa za pastire, no ima i bunara i ledenica. Najvažniji objekt – jer se još uvijek upotrebljava – je *trullo*, dok je ostatak objekata uglavnom napušten i zapušten. Suhozidna arhitektura nepravoga svođenja značajna je u sklopu kulturne baštine kao zanimljiv princip arhitektonske gradnje te kao takva mora biti očuvana za buduće generacije diljem Jadrana. Za mlade, koji se ne mogu sjećati starih građevina kojima su se koristili njihovi prethodnici, a koje još uvijek postoje na tom arhitektonski zanimljivom području, važne su barem osnovne informacije.

Key words: Adriatic, stone, drystone, corbelling, Italy, Slovenia, Croatia, Herzegovina, Montenegro
Ključne riječi: Jadran, kamen, suhozid, nepravo svođenje, Italija, Slovenija, Hrvatska, Hercegovina, Crna Gora

1. Introduction

Stockbreeding is an important part of the peasant economy. Daily pasturing can be done only close to the homestead; seasonal transhumance moves cattle from valleys to the hills in search of better fodder on remote grasslands, while nomadism moves entire tribes from place to place. Some decades ago, transhumance was still vital as an important economic activity; today, only a few limited locations with this type of farming activity can be found, and, of course, some tourist attractions with an ethnological focus.

Both the Italian and eastern sides of the Adriatic are rich in stone, with various structures, levels of hardness, and possibilities for acquirement. Walls can be built from it easily, but corbelling is the only option for constructing a room. Creating the shape of an object in this unique building system is a matter of local knowledge and inspiration, with particular shapes being typical of different geographical locations.[1] Stone shelters were used to facilitate the transhumance economy; nowadays, this branch is almost extinct. The article begins with descriptions of objects in the northern part of the Adriatic Sea, on the Italian side from Friuli-Venezia Giulia, through Abruzzo to Apulia/Puglia, and on the other side from Slovenia, Croatia, Herzegovina to Montenegro. The objects are mostly shelters for herdsmen, but wells and ice huts can also be found. The most important object, because it is still in use and even forms the basis of three towns, is the *trullo*. Others are more or less abandoned and neglected, but are important as traces of our cultural heritage.

1 Paul Oliver, *Built to meet Needs*, Cambridge 2006, 445.

2. Methodology

Architecture, as well as material, countries, political systems, nationalities, geography and history, are incredibly varied in the area of the Adriatic.[2] The same construction material, stone, can be assembled without the help of other materials (wood, for instance) into objects only through one system: corbelling. However, the shape can be adapted to needs, possibilities, and the builder's ability. Because of the large number of objects and the multidisciplinary nature of the problem, with diverse objectives and outcomes, a range of research methods was applied in the investigation of the subject, mostly historical, comparative, and analytical. An explanatory approach was very important, rooted in prior research of the field.[3] The article provides an interesting amalgamation of selected scientific fields, explaining significant and valuable technical data, different on different locations, with the specifics of the local people.

3. Construction of drystone, corbelling

The simplest construction of a usable room in drystone is corbelling. Horizontal courses of stone overlap each other, composing a usable space: a room. This overlapping can only be made to half the length of the width, and the centre of gravity is concentrated in the lower construction. The length of the overhang is shorter and shorter with height.[4]

Gradual overlapping is the only solution for the cross section; a circle is generally used in groundplan. If the groundplan is rectangular or square, it has to finish as a circle at the top. This principle allows building without any scaffolding. The biggest well-known construction is Atreus Treasury in ancient Greece, with an almost 15 metres high inner room.[5]

2 Borut Juvanec, "Stone Shelters in Croatia", *International congress on dry stone Konavle 2021. "Dry stone perspectives: challenges after the UNESCO inscription"*, http://www.dragodid.org/kongres-konavle-2021-zbornik-radova-proceedings/ (Last access: May 25, 2024)

3 Andreja Benko – Tajda Benko, "Rakičan Manor as a Monument of prominence in Time and Space", *Podravina*, 22, 44, 2023, 33-51.

4 Borut Juvanec, "Italy in Stone / L'Italie en pierre / Italia in Pietra", International congress on dry stone Goult 2023 (Forthcoming in Conference Proceedings)

5 Idem, *Hiška*, Ljubljana 2016, 123.

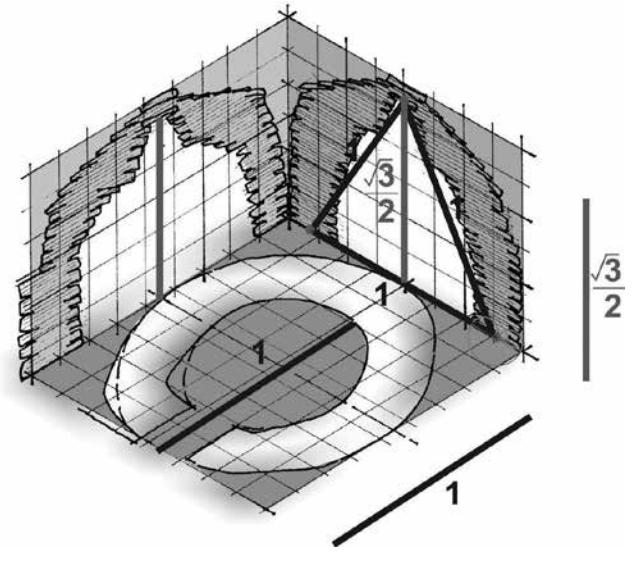

Fig. 1. The construction of a false cupola in drystone is composed with the help of an equilateral triangle with the height being √3/2, if the baseline is equal to 1. It can be simply constructed with three sticks – without any knowledge of mathematics.[6]

The entire cross-section is built with the help of the square root of three, divided by two.[7] We know this mathematical expression with theoretical knowledge today, but our predecessors composed it with the help of an equilateral triangle: if the side is "one", its height is equal to the square root of three by two. An equilateral triangle is simple to build with three sticks of the same length.

Italy has very rich architecture in stone. Some types of stone can be split into layers, which is important for achieving uniform thickness and ensuring better construction. The stone can be dressed or semi-dressed, but most constructions are made of stones just as they are found, collected from pastures, fields, or olive groves. Building with stones that have no regular shape is not easy. Skill and intellect are needed,[8] especially because of different types of stone: volcanic stone, sandstone, limestone and platy limestone.[9] In Slovenia, for instance, despite its extremely small area, limestone can be found in Slovene Istria, and drystone in the Karst region is built using several types of stone. Drystone constructions can be found in

6 Juvanec, "Stone Shelters", 5-6.

7 Idem, *Corbelling of Mediterranean*, Pisa 2011.

8 Siniša Bodrožić et al., *Gradimo u kamenu*, Split 2015, 112.

9 https://roofofrock.geo-zs.si/Publication/pages/cultural-heritage/index.html#read (Last access: February 25, 2024).

almost every region, but the types of stone shelters differ in material, shape, and stone treatment. The construction is always the same, though: corbelling with a false dome.[10]

4. Objects by type from north to south on both sides of the Adriatic Sea

4. 1. Northern and western coastline, Italy

Stone constructions along the Adriatic, on the eastern side of the Apennines, are extremely varied: in the north, small objects can be found, built just for sheltering herdsmen; in the Abruzzo mountains, they are larger, usually stepped constructions; and in Puglia/Apulia, corbelled constructions form entire homesteads, even towns. Corbelled wells can sometimes be found beneath these structures.

4. 1. 1. Triestine Karst/Carso triestino

A stone shelter on the Karst edge above the city of Trieste/Trst in the region of Friuli-Venezia Giulia in Italy and Kras in Slovenia has several names in both Italian and Slovenian: *hiška*, *hišica*, *koča*, *osia*, *casetta*[11] and the newer *casita*.[12] It appears on both sides of the border between Italy and Slovenia.

The basic objects stand alone on flat terrain with a more or less circular ground plan: the exterior is circular, though not strictly so, due to the flat front side with an entrance. Inside the huts, some furnishings can be found, stones used as benches, and the entrance normally has a flat lintel. The entrance is narrow because of the harsh karst weather (very strong wind, called *burja* or *bora*). This region is located close to the sea (in places only half a kilometre in air distance), but with a different climate, it stands about 400 metres above sea level. Like a Slovene *hiška*, this stone shelter makes full use of natural features; some lean against a rock, or are built into a karst valley, or even a cave.

10 Borut Juvanec, "Mediterranean Arch in Stone Architecture", *Journal of Civil Engineering and Architecture*, 8, 2016.

11 Adriana Guacci, *Un esempio di architettura spontanea del Carso triestino*, Trieste 1982, 303-341.

12 Elio Polli – Dario Gasparo, *Le casite del Carso triestino*, Trieste 2009, 128.

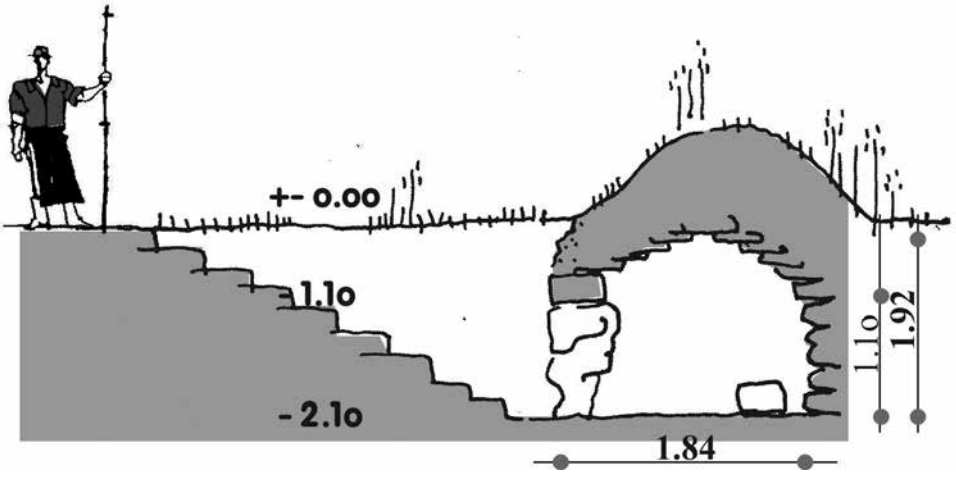

Fig. 2. Casita, a rare underground stone shelter near Trebiciano/Trebče in the Karst region.[13]

The object is no longer in use, but since 2010, some have reappeared, built anew with all the typical constructional details. Narrative decoration on the stone (bas-relief) can be found on one of the oldest houses in Trebiciano/Trebče: a classical house gable with stone columns.

4. 1. 2. Abruzzo

The shelter named *capanna* is a typical object in the mountains near the Adriatic Sea, mostly on the slopes of the Maiella Mountains, locally known as *Majella*,[14] near Pescara and Chieti. The mountains reach a height of over 2000 meters, but shelters can be found at approximately 1500 meters. The gentle slopes are very stony, offering good possibilities for using stone as building material.

The construction is typical corbelling, with horizontal courses of stone overlapping each other to form a false dome. The construction, or inner shape, is always the same, but the exterior can take on a wide variety of forms: a simple hut whose outer shape follows the internal construction, with more or less vertical walls topped by a capstone; others can be built with stepped rings, or even built into a cave with a "corall" outside.

13 Juvanec, "Italy in Stone".

14 Edoardo Micati, *Pietre d'Abruzzo*, Ascoli Piceno 2001, 104.

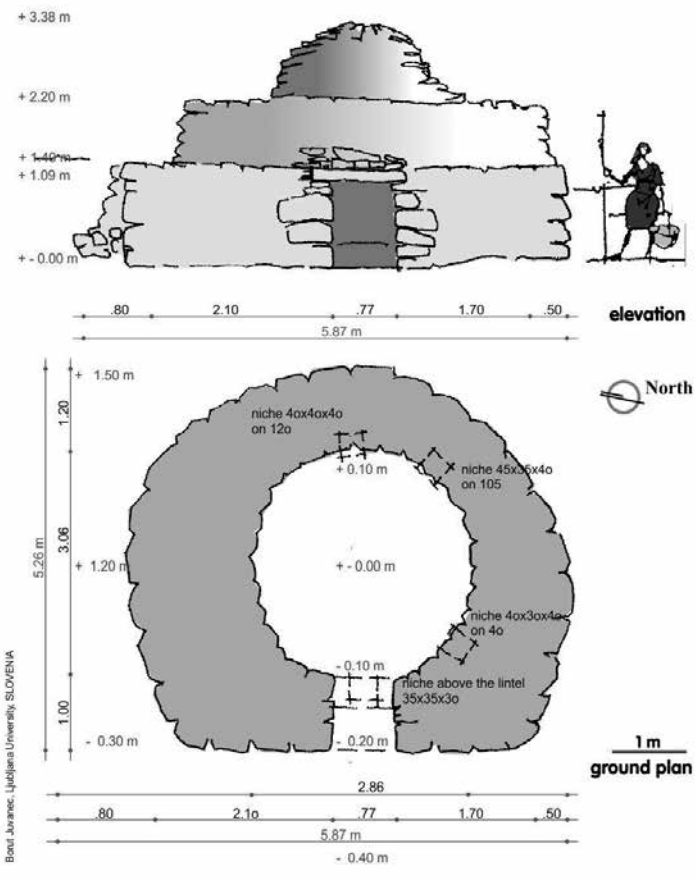

Fig. 3. Capanna on the Maiella mountains.[15]

Today, pastures on the Maiella Mountains are mostly abandoned, only a few exceptional capannas are still in use as goat houses near the rare homesteads there. Some capannas are interesting for tourists – as shelters leant against vertical rocks, high on terraces, and some underground caves are also used by hikers.

4. 1. 3. Puglia/Apulia

A *trullo* is the most typical object in Puglia, composed with the help of corbelling, but with several varieties of shapes, use, locations and local names. There are several names in use for a trullo: the oldest is *truddhu*, also *truddi*, *trullo* (singular; plural: *trulli*), *caseddhi*, *casella* and *pagliaia*, *pajare*, *paiara*, *pajaru*, *pagghiara*, *pajara*, *furnieddho* (by E. Degano), *furneddu*, *chipuro*, *casedda*

15 Juvanec, "Italy in Stone".

(by Rossi and Leserri). The first typicality is its construction, corbelling, but in several variants of appearance. Trullo means the system of construction and was rich researched by Prof Ambrosi, E. Degano and C. Zaccaria.

Several types of trulli can be found: trullo in rows in cities, trullo system as a homestead, auxiliary farm building in the countryside, auxiliary farm buildings without typical visible false dome and a pinnacle in the south, pagliaia, connected to trullo for storing straw with false dome and a hole on the top instead the pinnacle, and finaly trullo beside the beach of the Adriatic sea, which are mostly covered by concrete.

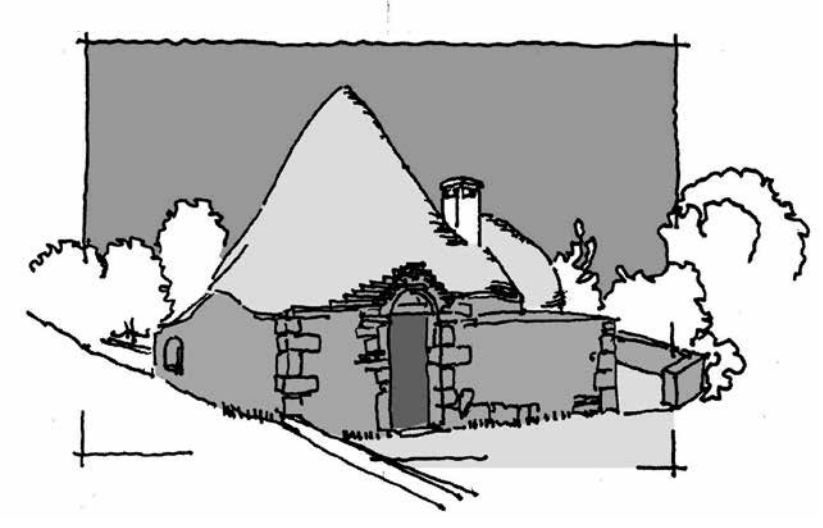

Fig. 4. Masseria Maccarone near Alberobello.

The most typical features of a trullo are its circular construction with a conical roof, covered by stone plates, with individually shaped pinnacles on top and a symbol drawn in lime on the front side of the roof. The latter are individually made and represent a typical sign of a family.

A homestead in the trullo system consists of the living trullo, a trullo for the kitchen, and others for animals (separated by height, for donkeys, swine, and chickens). This type has vertical walls, built with half-cut stone in a square shape up to a height of two meters. The corbelled false dome is overlaid on this construction, with a circular ground plan, of course. The living area occupies the entire floor, while the sleeping area is supported by a wooden structure on the first floor, above the vertical walls and beneath

the corbelling. The kitchen trullo has a massive chimney in the roof and a well in the floor, above the cistern. Water is collected from the roofs, with a gutter at the top of the walls, not reachable by animals.[16] Economy buildings consist of the yard and the largest trullo for donkeys or mules, a smaller one for pigs and the smallest, with height of 50 cm only for chickens. Threshing floor as a circular "aia" can be found in front the objects.

Trulli can be found in only three cities: Alberobello, Locorotondo, and Martina Franca, where they are squeezed together in rows, forming the streets. The principle of building is the same, but without auxiliary parts. Some trulli in the cities have terraces or small flower garden beds in front, but with minimal size. The main difference is in water collection: the streets are paved with polished stone plates, and water is collected not only from the roofs but also from the street. There are no animals in the cities, so the water cannot be polluted by animal waste.

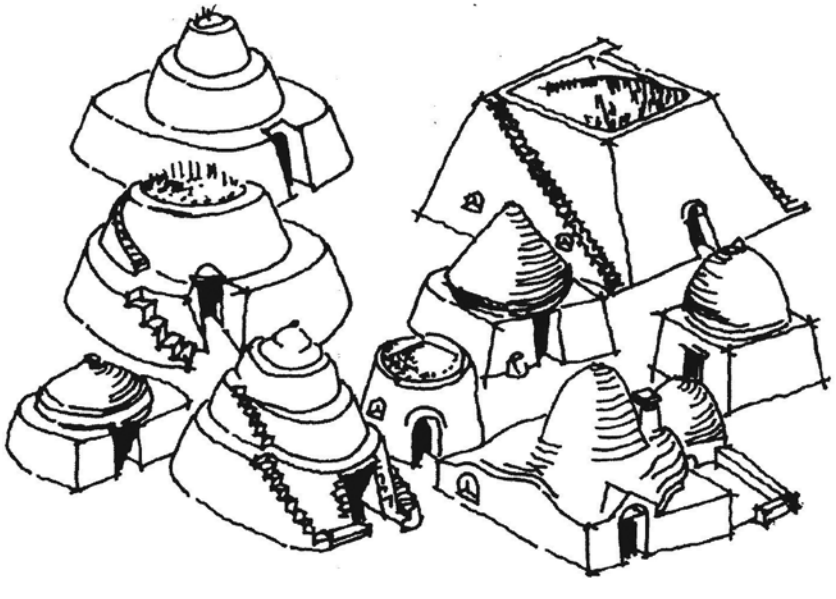

Fig. 5. Different types of shelters in south of Puglia/Apulia, near Lecce.[17]

In the south of Puglia, mostly around Lecce, another type, mostly with square ground plans, staircases leading to the top, and double stairs symmetrical around the entrance in the front, can be seen. On the top was a space for drying fruit, inaccessible to animals and closer to the sun.

16 Borut Juvanec, *Vodnjak*, Ljubljana 2017, 191.

17 Juvanec, "Italy in Stone".

Pagliaia, known by several local names, is an outbuilding near a living trullo. The basic construction is the same, but on the top there is a circular stone plate that covers the entrance to the structure, for filling in straw. It is accessible by a simple staircase, either in-built or constructed over the roof. The stored straw was taken out through the front door below.

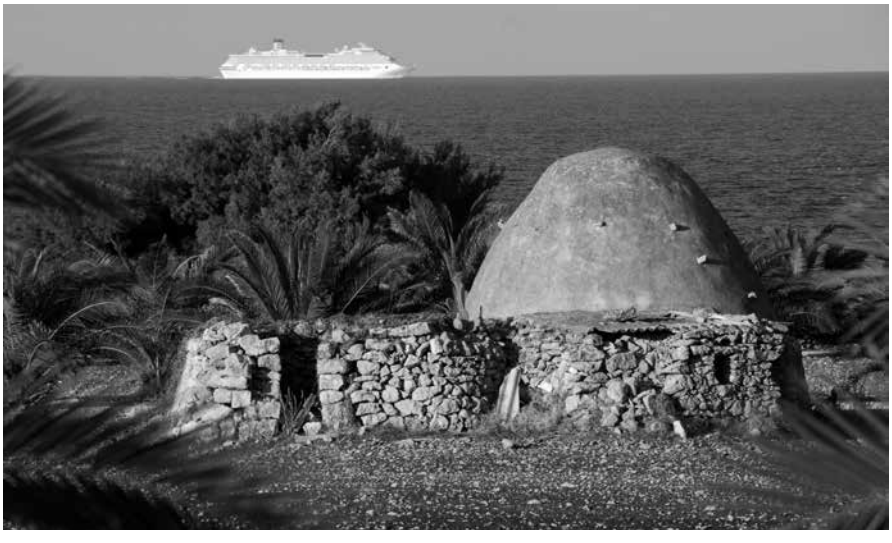

Fig. 6. Trulli near the Adriatic coast are mostly plastered, unfortunately also with concrete.

An important part of the household is the underground well at Masseria Maccarone. It is an underground cistern, and water is obtained directly from the kitchen. The most important feature of the water system is its self-sufficiency: the cistern collects water from its own roof via gutters around the corbelled domes. Some cisterns are hewn in stone; others are built using a corbelling construction.

4. 2. Eastern coastline

The eastern coast from the Karst down to Albania and Greece belongs to Slovenia, Croatia, Bosnia and Herzegovina (Herzegovina) and Montenegro. These constructions are abandoned, forgotten and mostly neglected, but still survive because of the durable material – as one of the modest and most sustainable objects of mankind. The problem today is in their visibility: when they were in use, they were located near pastures on the plains because shepherds needed a good view for the control of their flocks. Today, only rare animals can find good shade there.

4. 2. 1. Slovenia/Slovenija

Hiška and *šiška* are objects in the Karst region; *kutja* is the name of a stone shelter in Slovene Istria. They use local limestone and sandstone, which is collected during the clearing of grazing areas. Pastures have to be cleared because of the danger to livestock and to allow better plant growth. Such stones have no exact shape, so the constructions cannot be built with even walls: the roof is not separated from the body, and there are no pinnacles or other defined elements such as lintels, edges, or overhangs. A hiška uses all possible natural resources and, in some cases, leans against existing rocks or takes advantage of a natural underground cave.

There are harsh weather conditions in the Karst region, with an extremely cold, strong wind called *bora*. Local transhumance was performed twice a day: early in the morning and in the late afternoon. The mornings there are very cold, and some heating was needed. In a *cabane* (Provence, France), the fireplace is located in the middle or to the side, with a chimney opening at the top, which fills the air with smoke. In Slovenia, a more sophisticated solution can be found: the fireplace was located near the entrance, with a chimney immediately above it. This creates a "warm curtain" (well known in modern architecture as a vertical stream of air that forms a sort of insulation between spaces) with a genius effect, the warm air is kept inside.

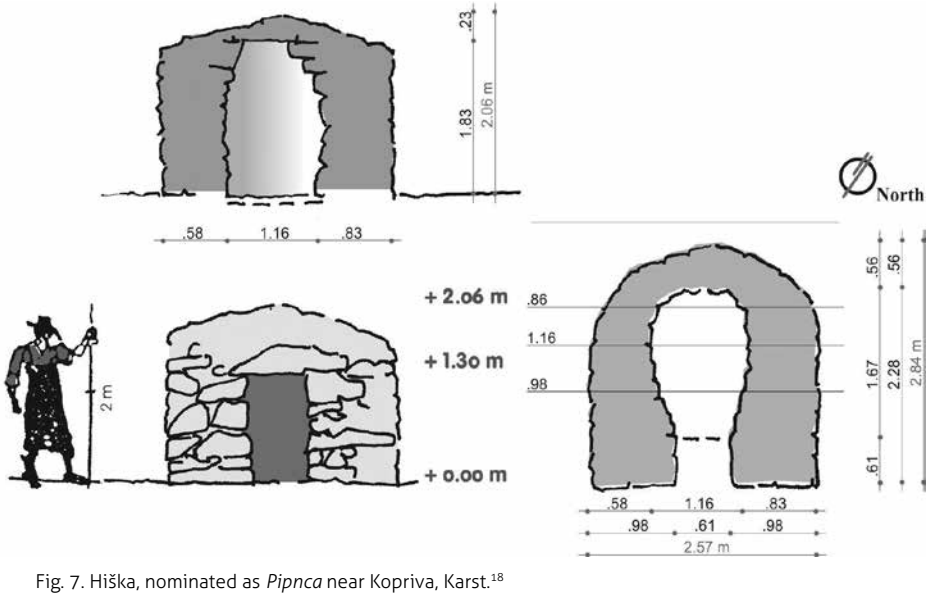

Fig. 7. Hiška, nominated as *Pipnca* near Kopriva, Karst.[18]

18 Juvanec, *Hiška.*

The ancient *pil*, a stone shrine almost a thousand years old, must be mentioned in Krkavče as a monument carved from a single piece of stone, decorated with religious elements. Stones are also well known from ancient times as milestones (in Šepulje, as signposts).

A natural source of water in the Karst is a *kal*, a sort of pond. A *kal* can also be man-made, with a paved bottom and a drystone wall around it. In the Karst, water is obtained from wells built as drystone vertical cylinders with a spiral staircase. In Slovene Istria, "underground wells" can also be found: the visible part is the staircase, while the water is collected in the corbelled false dome inside. Such wells are still in use for watering fields. The well in Lokvica is not a corbelled construction but simply a circular cylinder with stone stairs leading to the bottom.

Ice huts are similar stone constructions in the shape of a circular cylinder, but in Slovenia they are covered with a wooden roof structure, thatched or covered with clay tiles (Lipica, Kačiče).

4. 2. 2. Croatia/Hrvatska

Kažun is a typical stone shelter on the Istrian peninsula. More than a thousand of them can be found. Kažuns serve as herdsmen's shelters, with rich stone fittings: benches, tables, fireplaces, shelves, and dormers. They are rarely used for animals, but some sheep can be found in abandoned huts, seeking shade. A few of them are built with two storeys, but this is an exception. Near villages, they are devoted to animals and stand in rows of three or even four. They are normally well maintained, some of them by experts in stone architecture.

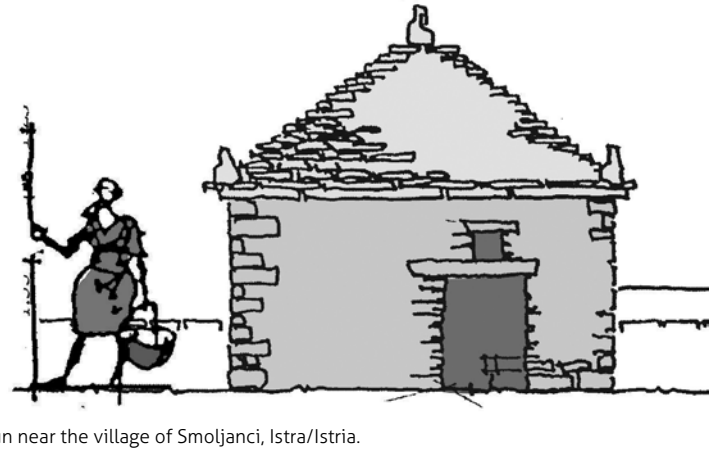

Fig. 8. Kažun near the village of Smoljanci, Istra/Istria.

Kažun is a typical vernacular shelter, built of split stone plates. Because the elements have the same thickness, it can be constructed very precisely: it has vertical walls, a roof with overhangs, and pinnacles. The cross-section can be found in a proportional system based on the equilateral triangle, both as a whole and in detail. This includes the use of the square root of three, divided by two, if the inner diameter plus the width of the wall is "one".[19] This composing of a false dome is characteristic of corbelling.

The island of Krk in the Kvarner archipelago has rich stone architecture: permeable water wells, stables, *mrgari*, and finally *komarde* (plural; singular: *komarda*), herdsmen's shelters. They are built of unhewn stones collected from grazing areas. Their construction features a typical false dome, built using corbelling; the outer shape cannot be exact, unlike a kažun, for instance. Today, they are abandoned and largely disregarded.

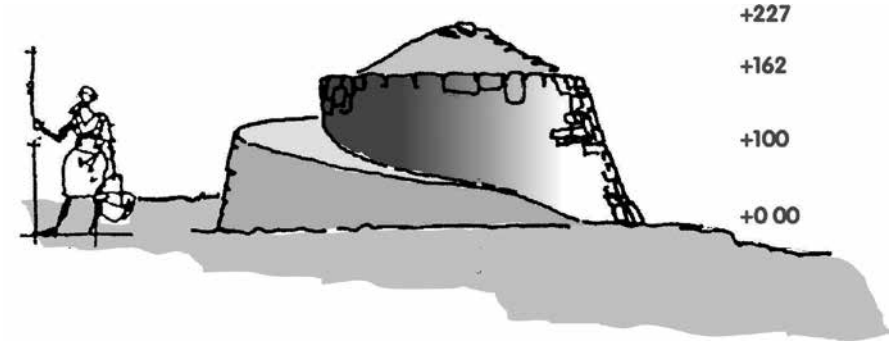

Fig. 9. *Komarda va Starih Frušćeli* not far from Punat.[20]

Bunar means water well, located above the village of Draga Baščanska. Grazing areas are far from the village, and shepherds need access to water. They cut basins, which are covered by a corbelled false dome. The roof collects water, and the entrance is accessed via a staircase with a narrow opening, allowing sheep to enter. Several water wells of this type can be found on the mountain plateau; Berislav Horvatić identified 14 of them. Other wells, especially those closer to the sea, are open and have vertical walls with a staircase leading to the bottom.

19 Borut Juvanec, *Chozo de Extremadura, joya en piedra*, Cáceres 2008, 120.

20 Juvanec, "Stone Shelters", 11.

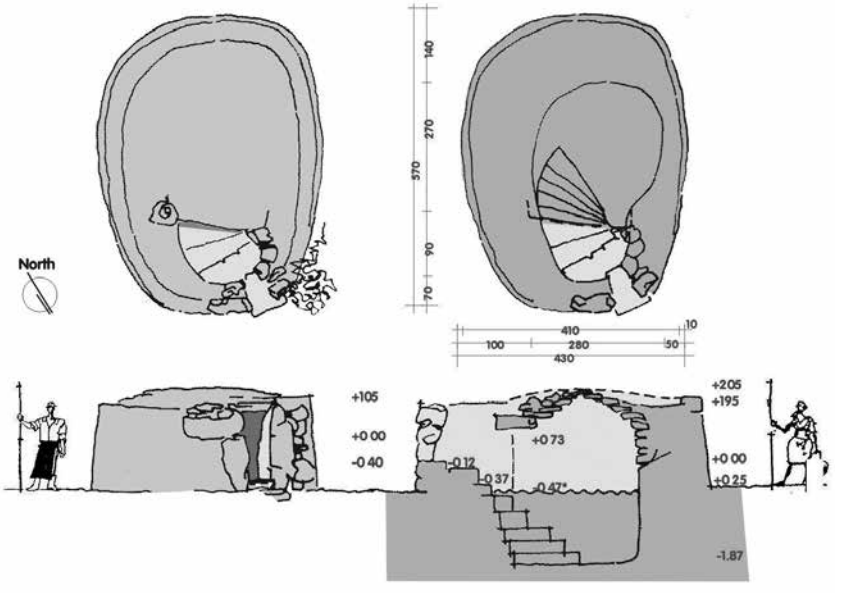

Fig. 10. *Bunar navrh Vala,* south of the island Krk, above the village of Baška.[21]

Mrgari is the organizational system of sheepcotes with vertical walls, built in the shape of a flower (Horvatić named them as "flower shaped sheepcote"[22]) for collecting, organizing, selecting, and controlling sheep flocks. It includes a funnel for gathering the sheep, a main hall for selection, and individual cells.

Bunja is the common name for these structures in Dalmatia and on the islands, though they are also known by several local names, such as *poljarica* (according to Iveković)[23] They are beautifully built near Šibenik and often include several cells on the islands. The structures near Šibenik are larger and used for all-day transhumance. On the islands, herdsmen lived in them with their animals throughout the season. The most important structures there are built as multi-cell constructions, with the largest cell for people, smaller ones for sheep, and the smallest for their young. Some of them are built into the walls or composed of several concentric rings of stone.

21 Idem; Juvanec, "Italy in Stone".

22 Berislav Horvatić, "Mrgari – Flower-shaped Dry Stone", *Deset let naporov: 10. Konferenca o vernakularni arhitekturi Alpe Adria*, zbornik povzetkov / *Ten years of efforts: 10th Conference on Vernacular Architecture Alps Adria*, proceedings, Gozd Martuljek, ed. Borut Juvanec, Ljubljana 2000, 17-21.

23 Ćiril M. Iveković, "Bunje, čemeri, poljarice", *Zbornik kralja Tomislava*, Zagreb 1925, 413-429.

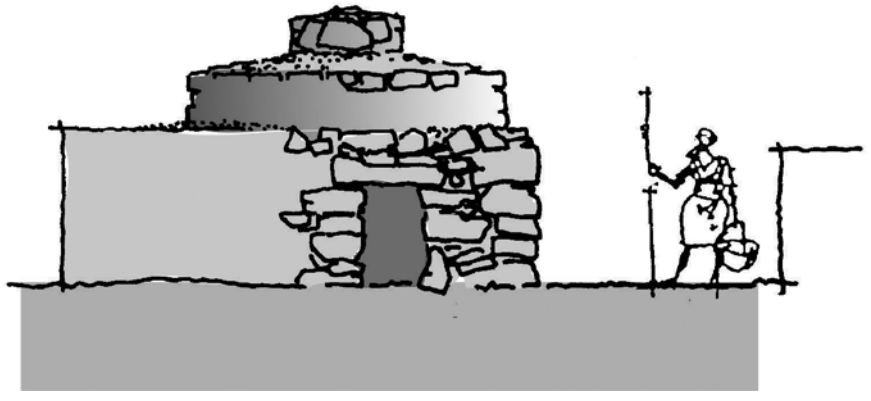

Fig. 11. Bunja on the island of Žirje near Šibenik.[24]

Iveković identified the shelter *Šuplja gromila* as a hajduk's shelter, but it appears to be a religious object. It has a rectangular ground plan in the proportion of the golden section (1 : 1.61 approx.) and a barrel vault constructed with corbelling. The main gable wall has carefully cut edges (unlike other economic structures), which emphasizes its importance, perhaps as an altar wall. The entire structure is built into a wall, with an underground entrance through a small tunnel. As a secret shrine, it was well hidden and was not destroyed over time.

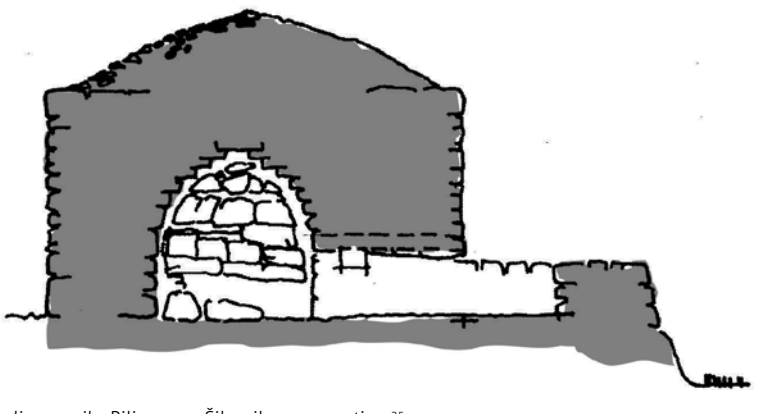

Fig. 12. *Šuplja gromila,* Bilice near Šibenik, cross section.[25]

Trim: Hvar is an island between Split and Dubrovnik. Large shelters can be found there, built with a stepped construction and equipped with

24 Juvanec, "Stone Shelters", 12.

25 Borut Juvanec, "Najstarejši sakralni objekti v korbelingu vse do krščanstva", *Bogoslovni vestnik*, 77, 1, 2017, 214.

stairs. On the Ager (*Starogradsko polje*) in the Stari Grad plain, they are used mainly as temporary structures in vineyards and are part of a protected area under UNESCO. The buildings are used for living and storing tools; outside, there are benches and tables for work, as well as fences and bowls for preparing insecticides. The vineyards have been known since Roman times, and some are still in use today.

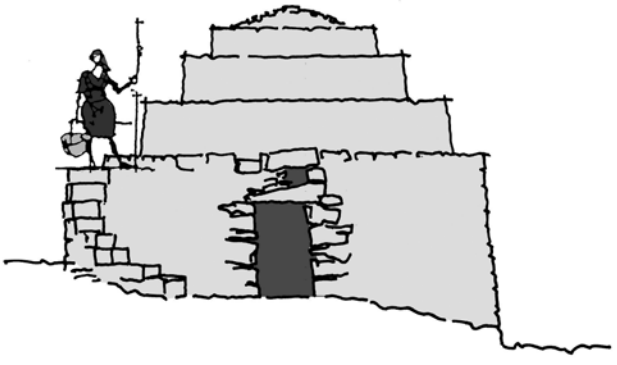

Fig. 13. Trim on Jurkovica, Hvar, Starogradsko polje.

A lime kiln, *japjenica*, is not a shelter but a kiln. Lime must be burned at a high temperature and then slaked; hydrated lime is used for mortar. Mortar is a very important building material for sealing, connecting, and protecting a wall. Large structures were built to obtain this material from raw

Fig. 14. Japjenica, lime kiln on Hvar (photo Dr B. Horvatić). Author of this article is there collecting data for the documentation.

limestone. The problem lies in the material itself: stone can only be used for this purpose a few days after being quarried. All of the stone, both the main structure and the stone inside, was burned, but only a few days after exposure to the sun. The contents and the construction were burned together, and the entire structure disappeared. Existing traces (in the case of Hvar Island) are a matter of coincidence: the builders were enrolled in the army during WWI and had to leave the lime kilns unfinished. After some time, the kilns became unusable, but they remain as monuments of former times.

A *naplov* is an enormous stone area used for collecting water into underground cisterns, where water must be used very carefully.

Two types of shelter can be found on the island of Korčula: *vrtujak* in the western part of the island and *toreta* in the eastern part. The name *vrtujak* explains the construction, meaning "roundabout"; singular: *vrtujak*, plural: *vrtujci*. These are beautiful structures, built very precisely, with vertical walls, roofs, overhangs, and pinnacles. Stone furniture can be found inside, and an underground cistern is part of the structure. This indicates human use, vrtujak is not an economic object for livestock. They typically have a circular ground plan and a conical roof; one of them even has a tower in the shape of a truncated cone, for better visibility of incoming boats on the sea.

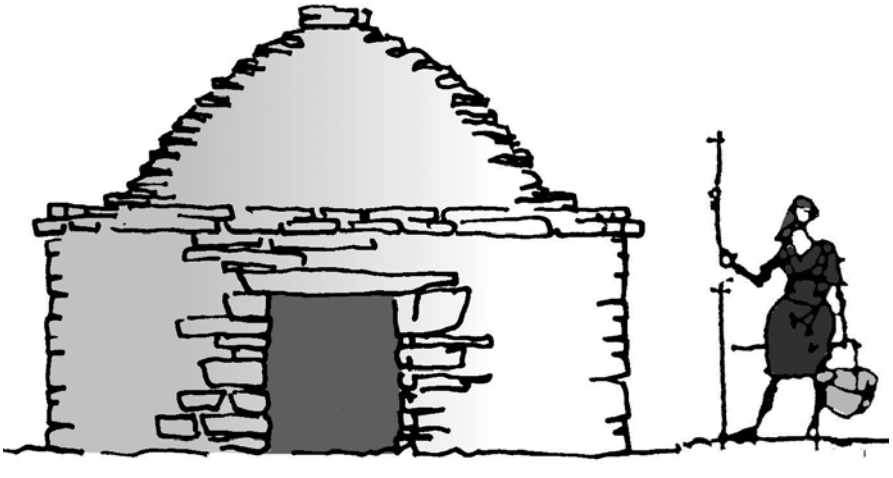

Fig. 15. *Vrtujak* on the location Strmena, north of Vela Luka.

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

Italian word *torre* means "tower", and toreta is the local name for a small tower. Toreta is indeed a tall structure and is clearly visible on the high plateau. Today, the toretas are abandoned but technically intact.

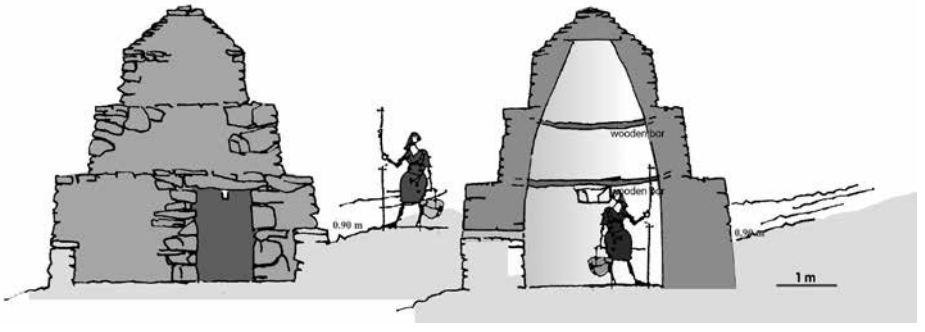

Fig. 16. Toreta on Salapućeva njivica 1: front elevation and cross section.[26]

Konavle is a karstic region on the border with Montenegro, where the Dubrovnik airport is also located. *Kućarica* or *kućerica* is the local name for a shelter there. The ground plan is typically circular, and the corbelling is made of uneven stones. This is difficult work, but some examples have perfect corbelled false domes. When the airport was built, a number of these structures were destroyed, but today they are being preserved by local craftsmen, who have relocated them to other sites.

Fig. 17. Kućerica above the airport Ćilipi (Dubrovnik) in 2005.[27]

26 Juvanec, "Stone Shelters", 15.

27 Idem, 17.

4. 2. 3. Herzegovina (the southern part of Bosnia and Herzegovina)

Shelters in southwest Herzegovina, near the border with Croatia at Dubrovnik and Boka Kotorska in Montenegro, are locally called *poljarica*. This name is also used for similar structures in Dalmatia.[28]

Herzegovina is a very stony country, and stone architecture can be found in all remote mountain villages, though with wooden roof constructions, also used for transhumance. Drystone shelters are not often found; a few can be seen west of Popovo polje, mostly as shelters built into walls, but featuring the typical false dome construction. These structures are very small, only for one or at most two shepherds. A poljarica is located laterally on the grassland, while in the middle of a pasture, many structures can be found as deposit constructions used only for storing redundant stone, such as *griža* or *grublja* in Slovenia, or *le clapas* in Provence, without any other function.

Fig. 18. Poljarica in the wall.

The watermills on the Trebišnjica River must also be mentioned, as an intellectual culmination in the use of a fluctuating river with high flows and karst inflows. Exceptional architecture can be seen in Popovo polje, where cylindrical drystone structures are used as watermills.[29] They are located

28 Aleksandar Freudenreich, *Kako narod gradi na području Hrvatske*, Zagreb 1972, 181.

29 Borut Juvanec, "Popovo Polje, a different View", *Acta carsologica*, 45, 3, 2016, 275-284.

above underground caves, and some of them use water power with wooden propellers, turning in both directions, functioning as *estavelles*.

4. 2. 4. Montenegro

Close to Montenegro, on the Croatian side of the border, *kućarice*, stone shelters for herdsmen, can be found. On the Montenegrin side, the agrarian economy focused on vegetable production for delivery to larger towns, mostly Dubrovnik. Circular corbelled shelters cannot be found there; instead, rectangular huts thatched with straw are typical.

The only exception is a well. One of the most interesting is a self-sufficient well called a *poćuo* on Lovćen Mountain. This is a complete agglomeration, with a cistern covered by a false dome to protect the water from pollution, and a roof that collects water and directs it into the cistern. Around this system is a wall that protects it from animal waste.

The most important idea is the self-sufficient system for collecting, storing, and protecting water within the structure, something essential for living beings on the slopes of Lovćen Mountain. Similar constructions can be found in the village of Ramljane near Knin (Croatia).

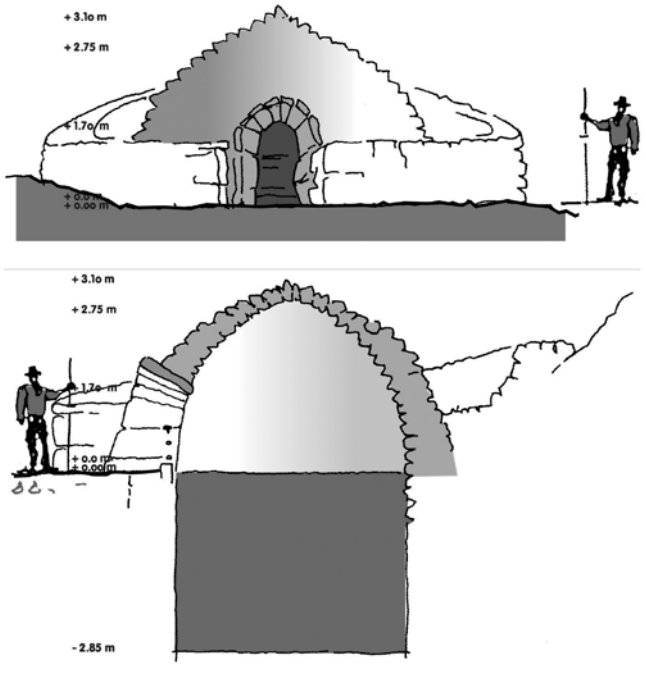

Fig. 19. Interesting stone waterwell or reservoir, named *ubao* on Bižaljevac, Lovćen mountain.[30]

30 Juvanec, *Vodnjak*.

Regions of Montenegro near the Adriatic Sea are stony, with only a few areas having rich soil. Mountain settlements use all available natural resources, and some villages have their fields in higher locations. Rain is very useful, though rare, and necessary. Water streams downward, and the surplus flows into the villages. However, this rainwater also carries away valuable soil from the already poor fields.

An intelligent drainage system follows the paths between the houses, but in some places, there are intermediate basins where the soil settles. The soil from these basins is periodically removed by village women and returned to the fields.

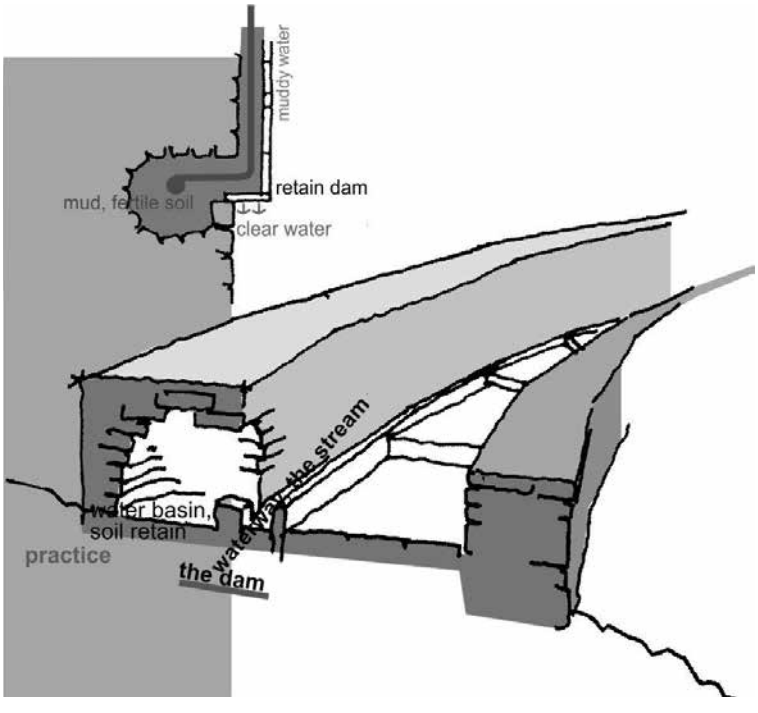

Fig. 20. The dikes follow paved paths, and the basins are covered with tiny corbelled false domes. The entrance ensures access to the collected soil.[31]

A threshing floor must also be mentioned, as a very common object near a house, built in stone. It is not a corbelled construction, of course.

31 Borut Juvanec, *Gornja Lastva. Architecture between Rural and Urban Elements*, Cetinje 2002.

5. Considerations

Stone is a very good building material; it is readily available and, in some cases, can be worked with simple, hand-held tools. It is not a heat insulator (it conducts heat) but the air between the elements does provide insulation. As a material, it is extremely durable; its static properties are very useful, and it is almost eternal. It cannot burn, and it is very safe. Some ancient structures can still be found that are several thousand years old, preserved in their original shape, appearance, or use.[32] It is a natural material and can also be reused after its original purpose, following the decay of the initial structure. Therefore, it is a sustainable material.

Simple architecture, such as vernacular architecture, is rarely used for religious buildings[33] or for castles and manors, which are the result of professional work.[34] Hewn stone can also be used for pretentious constructions. In *espigueiros* and *hórreo* (corn sheds in northern Portugal and Galicia, Spain), almost wooden-like details can be seen. The same details in wood require separate binding elements, such as pins or three-dimensional edge joints, stone does not need these, due to its mass and external shape. It is a durable material that does not change its properties, surface, or color in the sun.

The simplest construction in stone involves arranging one stone next to another, with overlapping in each subsequent layer. All vertical openings must be covered. It is important to understand that stone supports vertical loads well but not horizontal tension. In the case of a lintel, the stone cannot be too long, as it cannot bear axial loading.[35] All this is used when building a wall.

Intelligent solutions have produced several key architectural details: the first is corbelling; the second is the arch; and, in terms of volume, the vault and the dome. These building techniques enable the construction of the largest structures.

32 Frank Braemer et al., "Le bronze ancien du Ramlat As-Sabatayn (Yemen)", *Paleorient*, 27, 1, 2001, 21–44.

33 Juvanec, "Najstarejši sakralni objekti", 201–219.

34 Benko – Benko, "Rakičan Manor", 33–51.

35 Filip Šrajer, *Model za inventarizaciju, monitoring i evaluaciju suhozidnih gradnji u Hrvatskoj na primjeru Starogradskoga polja na otoku Hvaru*, PhD thesis, Zagreb 2019.

6. Conclusion

Drystone walls and buildings are a construction technique that is technically becoming forgotten. These stone-only constructions, however, when placed in the natural environment, become an inevitable part of the cultural landscape. With their vital organisms, plants, animals, and animal habitats, as well as the connections between such places over time, they are also important for human beings.

The condition of this built heritage today is of utmost importance. Without maintenance, it can collapse within a few decades. Conservation consists of monitoring, repairing, reconstruction, and renovation. The theoretical part can only be carried out by professionals, educated individuals, so education and qualifications are essential. For physical conservation and maintenance, local craftsmen are also of great importance.

Research work consists of listing, documenting, evaluation, renovation and reconstruction, and finally education at all levels, with licensing of masters in drystone. Elements for this important research work are as follows: inventorying, as listing objects with all relevant data; documenting, which has to be placed so as to be available to the public (ICOMOS principles); evaluation, which follows standards in all involved fields, such as architecture, archaeology, ethnology, anthropology, history, etc.; maintenance as physical repair; reconstruction where this is needed; renovation when

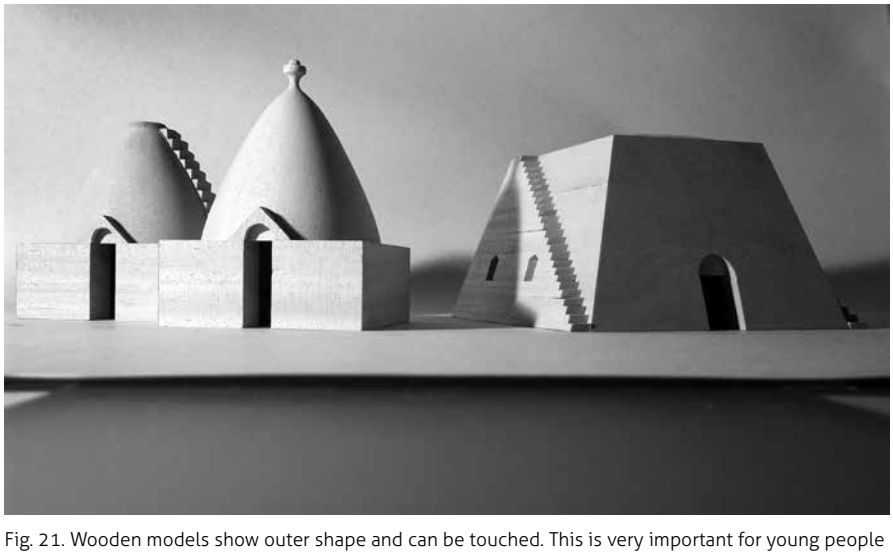

Fig. 21. Wooden models show outer shape and can be touched. This is very important for young people (typical trullo of Alberobello and economy shelter near Lecce, two absolute different types of shelters in the same region).

reconstruction represents a danger or is impossible; education as the spread of knowledge of this forgotten culture, with formal licensing of experts. Slovenia started an official system of licensing for stonemasons through the governmental agency CPI, Centre of Vocational Education, in 2021, as an NPK (National Professional Qualification) with the designation "drywaller 7488784011", Klasius-P16 (Civil Engineering 0732), as an official education level for drystone workers. Education is of extreme importance, with simple explanation of the problem, construction, and appearance in the space.

Stone is timeless, yet functional, modern, beautiful, and close to man; it is a perfect material for architecture. Stone, as an extremely suitable building material, is important for the future. It was long the building material of kings, the gods, and the dead, used for the rich and prestigious, and less for the ordinary man. Solid stone replaces the use of cladding, whereby the construction is slightly different, and stone thus provides both protection and appearance. Conservation is very often also a symbolic act, demonstrating pride and appreciation toward the present and the future. We have to know stone and understand the architecture that uses it as an important culture of our forefathers.

The Adriatic, on both sides of the sea, may seem to be a small appendage of the Mediterranean. It is not, because of its history and preserved elements of human culture, especially in stone, it is an important part of Mediterranean culture.

Abstract

Stone is a natural building material, used similarly to clay and wood. The drywalling technique utilizes stone, either as found or shaped, with quarry stone being the most practical due to its even layers, which enable precise construction of walls, roofs, and details like windows and corbels. While stone can be used for walls, corbelling is essential for building rooms. Stone shelters were historically used in transhumance, a near-extinct practice today, though remnants exist in remote regions, such as the *chozo* in Extremadura, Spain, used by herders and even families. This article focuses on corbelled structures in the Adriatic region, spanning Italy, Slovenia, Croatia, and Herzegovina. Most of these buildings were shelters for herders, but there are also wells and ice huts. The *trullo* in Italy, still in use today, is the most prominent example of corbelled stone structures. Across the Adriatic, each region boasts distinctive forms of corbelled stone structures. In Slovenia, small, irregularly shaped huts like *hiška* and *šiška* are common. In Croatia, examples include

the *kažun* in Istria, the *bunja* in Dalmatia, and the *komarda* on Krk. On Korčula, the *vrtujak* and *toreta* are notable structures. In Herzegovina, small, now-abandoned stone shelters were built into walls. Wells built using corbelling, such as those on the island of Krk and on Montenegro's Lovćen Mountain, are also significant. The preservation of these drystone structures is crucial, as they represent important cultural heritage across the Adriatic region. Architecture transcends borders, and these buildings must be remembered for future generations.

Jadranske suhozidne nepravo svođene građevine

Sažetak

Kamen je prirodan građevni materijal koji se koristi poput gline i drva. Tehnika suhozida koristi se kamenom, bilo prirodnoga oblika ili oblikovanim. Kamen iz kamenoloma je najpraktičniji kamen zbog svojih ujednačenih slojeva koji omogućavaju preciznu izgradnju zidova, krovova i detalja poput prozora i nepravih svodova. Dok se kamen može rabiti za zidove, tehnika nepravoga svoda ključna je za izgradnju soba. Kamena su skloništa tijekom povijesti korištena u transhumanci, praksa koja je danas gotovo izumrla, iako njezini ostatci postoje u zabitim regijama, poput *choza* u Extremaduri u Španjolskoj kojim se koriste pastiri i čak neke obitelji. Ovaj se članak bavi nepravo svođenim strukturama diljem jadranske regije, od Italije, Slovenije, Hrvatske do Hercegovine. Većina tih građevina bile su skloništa za pastire, no uz njih postoje bunari i ledenice. Talijanski *trullo*, koji se koristi dandanas, najistaknutiji je primjer nepravo svođenih kamenih struktura. Diljem Jadrana svaka regija ima istaknute oblike nepravo svođenih kamenih struktura. U Sloveniji su uobičajene malene kolibe nepravilnoga oblika poput *hiške* i *šiške*. U Hrvatskoj primjeri uključuju istarski *kažun*, dalmatinsku *bunju* i krčku *komardu*. Na Korčuli su poznate građevine *vrtujak* i *toreta*. U Hercegovini malena, sada napuštena, kamena skloništa bila su ugrađena u zidove. Iznimno su značajni i zidovi izgrađeni tehnikom nepravoga svoda, poput onih na otoku Krku i crnogorskoj planini Lovćen. Očuvanje tih suhozidnih struktura je ključno jer predstavljaju važno kulturološko nasljeđe diljem jadranske regije. Arhitektura nadilazi granice i te građevine moraju ostati zapamćene za buduće generacije.

Le costruzioni in pietra a secco con pseudo cupola sull'Adriatico

Riassunto

La pietra è un materiale di costruzione naturale, utilizzata allo stesso modo dell'argilla e del legno. La tecnica della costruzione a secco utilizza la pietra, sia nel suo stato naturale sia lavorata. Il tipo di pietra che si è dimostrato più pratico per le costruzioni a secco è quello ricavato dalla cava perché i suoi strati uniformi consentono una costruzione più precisa di muri, tetti, finestre e cupole. Mentre la pietra può essere utilizzata per la costruzione dei muri, la costruzione di pseudo cupole è essenziale per la costruzione di stanze e locali. I rifugi di pietra erano storicamente usati durante la transumanza, una pratica che oggi si è quasi estinta, anche se è possibile ancora sempre riscontrarne qualche traccia in alcune regioni remote. Un esempio ne sono i *chozo* che si trovano in Extremadura, una regione della Spagna in

cui vengono utilizzati da pastori e addirittura da famiglie. Questo contributo si propone di analizzare le costruzioni in muratura a secco con pseudo cupola, spaziando dall'Italia, Slovenia, Croazia fino all'Erzegovina. La maggior parte di questi abitacoli era stata costruita come rifugio per pastori, ma esistono anche esempi di pozzi e ghiacciaie. Il *trullo*, ancora sempre in uso in Italia, è l'esempio più significante della costruzione a secco. Nell'Adriatico, ciascuna sua regione vanta una forma distinta di muratura a secco. In Slovenia sono comuni piccole capanne dalla forma irregolare chiamate *hiška* e *šiška*. In Croazia, troviamo esempi di kažun in Istria, *bunja* in Dalmazia e *komarda* sull'isola di Veglia. Per l'isola di Curzola bisogna invece menzionare il *vrtujak* e la *toreta*. In Erzegovina invece, piccoli rifugi costruiti in pietra, oggi abbandonati, furono incastonati nei muri. Sono però significanti anche esempi di pozzi costruiti con la tecnica del muro a secco, come quelli che si trovano sull'Isola di Veglia e sulla montagna di Lovćen in Montenegro. La tutela e la conservazione di queste costruzioni è cruciale poiché rappresentano un patrimonio culturale importante in tutta la regione dell'Adriatico. L'architettura può superare i confini nazionali e queste costruzioni devono essere conservate per le generazioni future.