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Houses Based on Natural Stone; A Case Study—The Bay of Kotor (Montenegro)

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Received: 26 May 2019; Accepted: 9 July 2019; Published: 16 July 2019



Abstract: The Bay of Kotor, in its exceptional natural conditions, thanks to its geographical location and influenced by historical events, saw the development of rural settlements that are historically, artistically and culturally worthy of recognition. These stone settlements were acquired completely spontaneously, keeping the same pace as the settling, and transformed to some degree due to contemporary social movement and migration. Up until the middle of the 20th century, structures on the coastline in general were built by applying the same verified methods, which remained unchanged for centuries. Unreinforced stone walls as load-bearing vertical elements, coupled with wooden floor joists attached in a traditional way are typically present in the stone architecture of the Adriatic region and karst areas in general. The construction characteristics of the stone houses built in such a way meet all needs in terms of strength, thermal insulation, and are suitable for the coastal climate of this region. The fast-paced development in the past 50 years, the inadequate legal protection of residential buildings in the Bay of Kotor, poverty, and the new rich have brought about the devastation of not only buildings built in traditional architecture styles themselves, but also the urban landscape of the bay. Throughout the Bay of Kotor, buildings built in traditional architecture styles are nowadays more and more rare to see in their original shape—houses outside of cities but which display all characteristics of civic coastal houses and buildings free of rigid style rules, even though closely in contact with them. Regardless of efforts to preserve the heritage inherited by our ancestors, cultural monuments and houses referenced here deteriorate on a daily basis due to troubles and neglect.

Keywords: houses based on natural stone; architectural heritage; the bay of Kotor

1. Introduction

This research tries to investigate traditional houses based on natural stone in the Bay of Kotor over a period of 200 years and describes the basic principles of these houses. Through a review of the old traditional architecture, the qualitative and functional advantages of the building were considered.

We selected the Bay of Kotor because it is the most interesting part of the Montenegrin coast and has a very interesting historical trajectory, geological formation and rich biodiversity (Figures 1 and 2).

This paper advocates the stance that rational action in further urban development can be planned only if we understand the meaning of the phenomena processes, condition and planning strategies of this site throughout history. It also highlights the significance and necessity to preserve these houses as well as the settlements.

A new wave of urbanization makes status of these houses more endangered, both on the Montenegrin coast and in the Bay of Kotor. In most cases, urban planners “bother” objects hundreds of years old of invaluable cultural significance.

Based on the results of a previous study on 95 buildings [1,2] that discussed the typology of houses in the Bay of Kotor in the 18th, 19th and 20th centuries, two basic types of houses were formed. In the first phase, the house was a ground-level type, while in the second phase it became a single-storey house. From these two main types, other subtypes of houses were developed. The representativeness of these buildings with respect to the total is 80%.

The age of certain rural settlements in the Bay of Kotor can be accurately determined based on the archival materials of the Decree of the City of Kotor and notary books from the 14th and 15th centuries [3]. The borders of villages were defined by a regulation in the Kotor Decree in the 15th century. Border setting was done using permanent natural terrain marks or artificial signage. This is telling us that the founding of village borders was planned. Even though the Decree only mentions maintaining security measures, a large part of the settlements at the time is referenced in the cited chapter. The name of the Vrmac (Vermez) peninsula is mentioned here for the first time. Progress into the settlements was spontaneous, keeping the same pace as the settling.



Figure 1. A map of Montenegro and the Bay of Kotor [4].



Figure 2. It consisted of the bays of Kotor, Risan and Tivat [5].

In the history of the Bay of Kotor, there are four major stages for which it is possible to reconstruct the settlement organisation and the attitude of humans towards the environment:

- The appearance of village settlements in the hills, far from the shore and main communication channels (the Middle Ages)
- Consolidation of settlements on inaccessible terrain with an intense use of the territory, deforestation and landscape transformation (the Venetian period)

- (c) Establishment of settlements in the lower terrain and development of new activities (the Austrian period)
- (d) Abandonment of upper villages, growth of urban centres and degradation of landscapes (the post-war period).

The settlements, the house formations and groupings reflect a traditional lifestyle and the principles of socio-economic organisation in their relationships to each other as well as in their attitude towards the landscape.

Borders of villages in the Bay of Kotor area are uneven as a result of their spontaneous formation and terrain configuration. When looking at village locations, climate and hydrographic factors are also important.

With the beginning of the 19th century and the cease of threats, coastal strips across the bay became attractive locations for settling, and the sea grew as the most important traffic artery. Population still depended on traditional economy for endurance. Land farming was still essential for survival. It was only with the strengthening of other activities (industry) at the end of the 19th century that the conditions were set for the changing of settlement structure within seemingly traditional relationships [6–9].

The construction of a coastal road by the Austro-Hungarian authorities at the beginning of the 20th century and the construction of the highway in the 1960s significantly determined the organisational way of the settlements in this period. Those events enabled a quick development of the coastal strip, while all other areas remained neglected and left to their own decline.

Between the two world wars, with the rise of industry in this period, the need for food production was reduced, thus transforming agricultural plots into construction sites. The landscape change in the Bay of Kotor continues with increased intensity. Intensive construction entirely disregards traditional architecture.

Existing and extinct settlements with reliable historical records behind them could be divided into two groups: lower and upper settlements.

Lower settlements are located in the coastal strip. Almost all of those lower settlements are located along the coast or roads and thus had no possibility of becoming a core settlement with a central role, since they were groupings of the same or similar levels clustered along the coast.

Upper settlements are located at an altitude of 250–450 m.

2. Materials and Methods

An analytical and comparative research method was used. Data was collected using direct survey. A part of the empirical material was derived from interviews with locals. General literature, previous studies and online material have also been reviewed.

The initial phase of the research included an analysis that was based on the extensive literature review of books, articles and reports covering topics related to the architectural heritage of the Bay of Kotor. In the second phase, we included the same research for nearby regions (Dalmatia in Croatia and Paštovići region in southern Montenegrin coastline). Among the primary sources, the most important were archives, of which we will mention:

- Serbian Academy of Sciences and Arts in Belgrade
- State Archives of Montenegro in Cetinje
- Historical Archives of Kotor

In our region, only a few scientists are engaged in researching stone houses in the Bay of Kotor and those are primarily: Kojić Branislav, Korać Vojislav, Đurović Vinko, Prof. Arch. M. Zloković, Prof. Arch. Zoran Petrović, Goran Božović and Prof. Arch. Lalošević Ilija.

In his two papers entitled “Izumiranje sela u Kotorskomom zalivu i na poluostrvu Vrmac” [7] and “Seoska arhitektura u Boki Kotorskoj” [10], Branislav Kojić writes about the architecture of the Bay of Kotor. The first paper concludes that extinct villages could hardly be reconstructed due to the position

of the terrain in relation to the main roads, but the extinction of existing settlements only stop when conditions for intensive use of agricultural land are created. In the second paper, the author came to the conclusion that one of the characteristics of the rural house in the Bay of Kotor is erection of the kitchen on the highest level, which demonstrates an inclination to develop vertically.

In the paper entitled “Spomenici srednjovekovne arhitekture u Boki Kotorskoj” [8], Korac Vojislav came to the conclusion that early medieval architecture in the Bay of Kotor was almost completely unknown up to the middle of the 20th century.

Durović Vinko pointed out in the paper “O konstrukcijama kuća od XVI do konca XIX veka u kotorskom zalivu i njihovim graditeljima” [11] that old walls were not strong because they were made of burnt lime.

Milan Zloković was particularly dedicated to the subject of proportional systems. He conducted research in the Bay of Kotor, together with certain collaborators, entitled “Građanska arhitektura u Boki Kotorskoj u doba Mletačke vlasti” [12]. Numerous palaces were technically recorded (Beskuća and Verona in Prčanj, Grgurina in Kotor, as well as palace Milošević in Dobrota).

Petrović Zoran put emphasis on the upper villages of the Vrmac peninsula in his paper, “Selo i seoska kuća u Boki Kotorskoj” [13]. He concluded that the depopulation of upper villages would not contribute to the sustainability of these settlements in the future.

Božović Goran provided an overview of preserved architectural heritage in the Bay of Tivat and gave a proposal to convert them into tourist facilities in the study, “Naselja i kuće Tivatskog zaliva” [6].

Ilija Lalošević in the paper, “Svojstva istorijskih zidanih konstrukcija u seizmičkim zonama (primjer Boke Kotorske)” [14], concludes that the tall stone structures in the Bay of Kotor have significant disadvantages in terms of stability during strong seismic shifts.

In the region, one of the most important publications is A. Freudenreich’s “Narod gradi na ogoljenom krasu”, where images and drawings of house typology in the Croatian coast are shown. The architecture of this part of the coast and that of the Bay of Kotor was also explored by Croatian authors Cvito Fisković and Katarina Horvat Levaj. Their experiences are similar to those of the above-mentioned authors.

Of studies on the southern part of the Montenegrin coast, an important publication is Stanko Gaković’s “Paštrovska kuća”, published in 1979. It provides a detailed overview of the typology of houses in the Paštrovići region. This region is neglected in the literature, although it is invaluable for both the southern part of the Montenegrin coast and the Montenegrin heritage in general.

2.1. Architectural Design and Formation of the Façade of a Stone House

The position of the house on the terrain, location of the house, slope of the terrain, sun exposure, line of sight, house entrance and function are factors that determine the shape and symmetry of the house. Houses in the Bay of Kotor characteristically face the sea, be it in upper or lower settlements or on the northern, western, southern or eastern side of the slope. The sea is therefore an important factor that determined the position of the entrance to the house.

The slope of the terrain is the second factor that determined what kind of house will be built and where. A milder slope offered easier access to the house, a symmetrical, calmer façade, but also better sun exposure, while a higher slope caused the construction of a larger number of asymmetrical buildings (Figures 3–6). Cascading terraced gardens should also be mentioned. They are made of roughly carved stone in a dry stone wall. Historically, the terraces represented a complex system for managing slope dynamics (from conservation of the soil to the triple function of runoff, drainage and collection of rain water) [15].

The styling of stone house façades was more modest in the hinterland than on the coast. It depended mainly on the wealth of its owners. The front façade was richer, made using better stone in comparison with the more-modest side façades. During heavy rains, joints tend to carry moisture through the walls into the interior of the house. This brought about the trend of plastering the side façades (in some places, all of them) with red hydraulic mortar (lime mortar with added milled brick); cement mortar was used later in the 20th century.

In this area, there is an abundance of limestone, thus dictating the shape of the house and garden. Over three-quarters of construction objects in Montenegro were built using limestone, which was processed by following a centuries-old tradition. Less regularly shaped blocks were obtained by splitting the rocks. This was done manually. The houses were made of fine and rough carved gray limestone, brought from local quarries.



Figure 3. Houses in Gornji Stoliv face both the slope and the sea (Photo: Dušan Tomanović).



Figure 4. The slope of the terrain was the reason behind the construction of a large number of asymmetrical buildings—Gornji Stoliv [16].



Figure 5. Lepetani—a row of stone houses located along the coastal road (Photo: Dušan Tomanović).



Figure 6. Muo—construction of the coastal road at the beginning of the 20th century caused the destruction of the urban core settlement, which was more oriented towards economic activity related to the sea (Photo: Dušan Tomanović).

The silhouette of the house depends on the shape of the base—which was spacious in the Bay of Kotor area. The external measures are 9 to 13 m in length, and 6 to 8 m in width. The number of floors is another important characteristic that influences the architectural shape of stone houses. In most cases, these houses consist of a ground floor, an upper floor, and a loft.

The biggest changes in the 20th century occurred in the overall horizontal and vertical dimensions, in materialisation, shapes of the roofs, the design of façades and details on them. The original structural system and applied elements as well as the traditional technique were not adequately assessed in this period.

2.2. Types of Stone Houses

There are two types of stone houses typical in this region:

- A- Single-storey stone house (a house with one floor only)
- B- Multiple-storey stone house (the developed kind)

2.2.1. Single-Storey Houses

There are no primal house types proven as old in the rural area of Kotor Bay. Archival materials do not provide any information on the shape of old rural houses, thus we cannot say with certainty what the oldest types of houses looked like. The single-storey house is at the core of rural architecture of this part of the Adriatic coast because of its shape, construction and organisation, since the arrival of the Slavs to this region until today (Figure 7). It is the primary cell from which today's rural architecture has developed [10].

The interior of this house was at the same time the sole eventful room in the whole household. It was not uncommon for the building to be divided into two with a low set stone or wooden bar. The partitioning of the single-storey house represents an interior development of the same type, the barriers were added afterwards and did not change the base of the unpartitioned type. The first part was intended for use by humans, while the other was used for livestock and, at the same time, as natural fertilizer storage space. Animals lived in the same house, divided from humans by a wall plastered with mud and bovine manure (Figures 8–10).



Figure 7. The single-storey stone house is at the core of rural architecture in this part of the Adriatic coast (Photo: Dušan Tomanović).

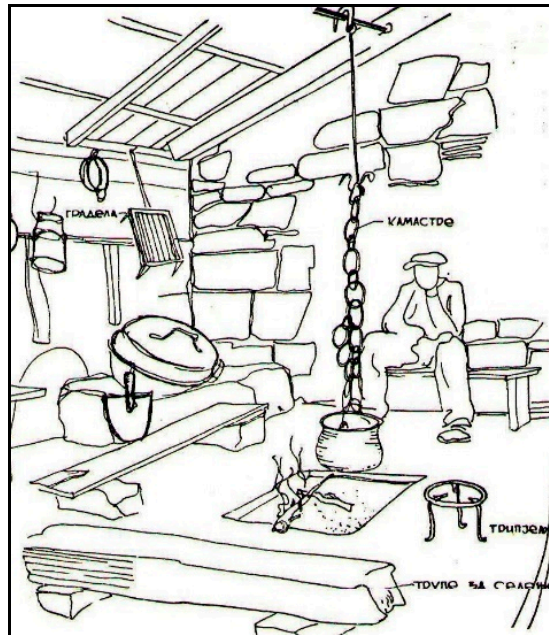


Figure 8. There was no furniture in the interior of the single-storey house [10].

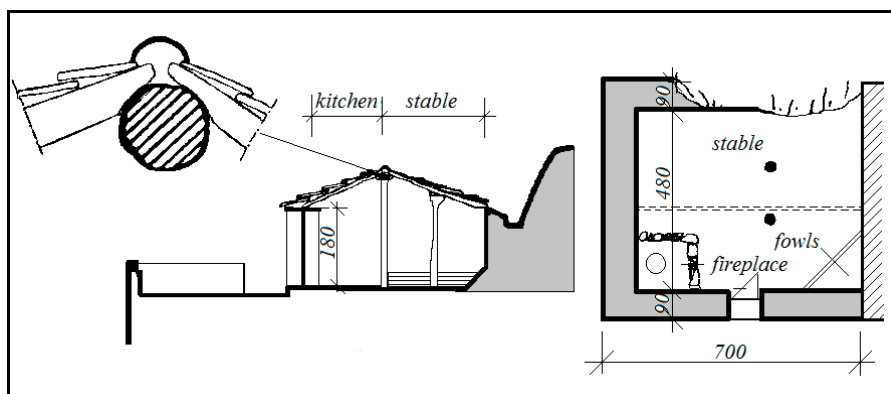


Figure 9. The plan and cross-section of an early (undivided) single-storey house [10].

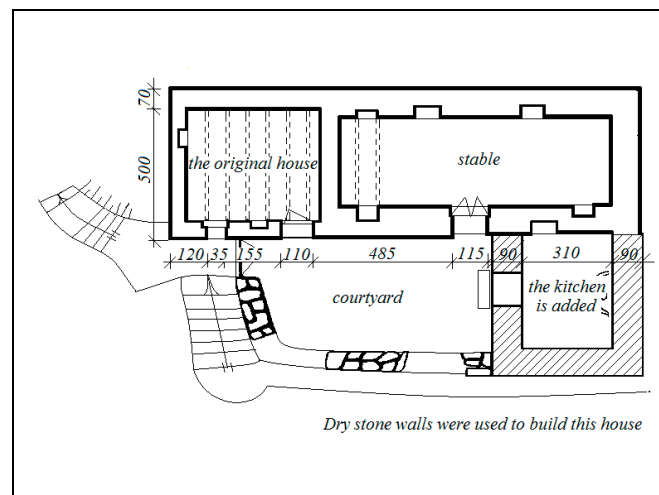


Figure 10. The area of the single-storey house extended horizontally at the beginning of the 20th century [10].

2.2.2. Multiple-Storey Houses

The multiple-storey house is a developed type of house in the Bay of Kotor area. A more rational construction stems from several reasons:

- ❖ A tendency to save space
- ❖ House compactness
- ❖ The construction is more rational (more space is obtained with the same foundation)
- ❖ Urban influences

Multiple-storey houses with ordinary lofts and kitchens located in separate buildings or outhouses in the yard can be found in the inner part of the bay. This kind of situation is typical for remote areas with low urban influence. The most common type of house consists of a ground floor, an upper floor, and an inhabited loft (Figures 11–13).

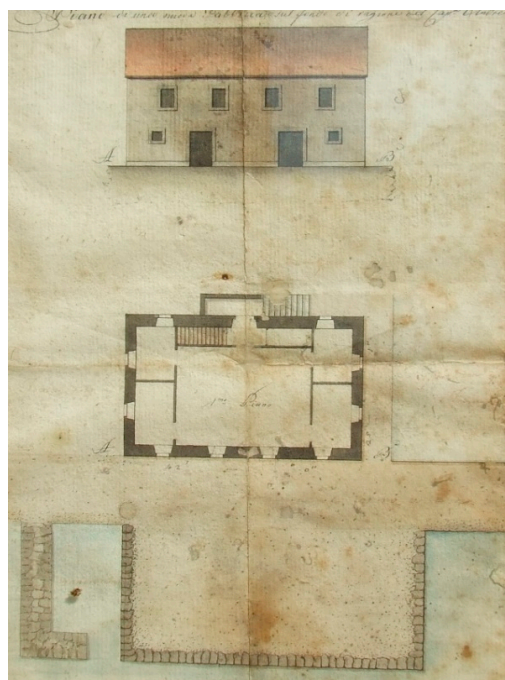


Figure 11. Original drawing (in colour) of the Tomanović family multi-storey house dating from 1826 in Lepetani (italian arch. F. Boriani) (Photo: Dušan Tomanović).



Figure 12. Typical seaside house with an upper floor and inhabited loft (Photo: Dušan Tomanović).



Figure 13. Typical multiple-storey house with an upper floor and inhabited loft in upper villages (Photo: Dušan Tomanović).

Natural factors were of essential importance when it comes to the position of the house and yard. In this case, slope was the factor, since all houses face the valley, i.e., the sea and the arable land. Cardinal directions did not play any role in the position of the houses, since they face different directions, influenced only by slope orientation of the land they were built on.

In the 18th, 19th and at the beginning of the 20th centuries, a large multiple-storey house consisted of three typical rooms: the lowest part is the *konoba* area (intended for use by men), the residential part is on the upper floor, while the loft area is occupied by a *kužina* (intended for use by women). Elevation of the kitchen to the uppermost level was the most striking feature of the vertical house development in this period.

2.3. Analysis of Construction Technique

2.3.1. Materials

Construction materials used for building houses and enclosures in the whole Bay of Kotor area, or even in a wider sense along the Adriatic coast, were locally provided, taken from nearby sites.

Natural stone has been used as a construction material since ancient times (e.g., since about 4700 BC in Egypt). Initially, these expensive materials were used for temples, tombs, palaces, civic buildings and major infrastructure as well as decoration and sculptures. Selection of stone was guided partly by suitability, but also influenced by personal prestige and social and mystic beliefs [17].

This region contains a lot of high-quality limestone. The Verige and Kamenare quarries contain plate stone, which was used then but also today for paving the floors of taverns, courtyards, city

squares, and other public spaces (Figure 14). Straight blocks of limestone extracted in Strp and Lipci close to Morinj were used for facades on the houses (Figures 15 and 16).



Figure 14. Verige and Kamenare quarries contain gray and red plate stones (Photo: Dušan Tomanović).



Figure 15. Less regular shaped blocks on the lateral façade from Strp and Lipci quarries (Photo: Dušan Tomanović).



Figure 16. Front façade walls were built using the highly regarded fine stone from Strp and Lipci quarries (Photo: Dušan Tomanović).

Limestones are massive with thick-layered types of stone, grayish brown to light brown in color, mainly of Mudstone type with layers of pellet Wackestone and Packstone, and less of Grainstone. According to Folk's classification (Folk, 1959 and 1962), these are mainly micrites, pelletiferous micrites, completely or partially recrystallized micrites of the grumous structure, and less often pelmicrites to pelsparites. Limestone contains little fossil remains, from non-skeletal components, mainly pellets, to skeletal components of myliolide and ostracods. Based on the findings of *Favreina njegosensis* BRÖNNIMANN, these deposits are from the Neocomian age (Matičec & Fuček, 1999). Microfossil structures are mainly distinguished by a micrite or a fibrous calcite diameter of 0.02–0.8 mm [18].

Manual stone extraction is painstaking work. Pin holes were done in pairs, with one person holding the rod and the other one striking it. After a row of holes was lined up, planks were inserted

between them and wedges were hammered in, one by one until the block breaks off. The oldest tools used for manual stone extraction and stone processing (levers, chisels and hammers) can be found across the whole karst region under different local names. Areas with softer stone types were easier to process with devices akin to a carpenter's tools (saw, drill, axe).

Sand for construction was brought from Meljine and Žanjic, later from Ulcinj, Cavtat, and the valley of the Neretva river [11].

There was always a lack of wooden materials in the construction of buildings on the seaside. The shore hardly contains any forests, while the modest timber did not yield adequate building material. In the 19th century, timber was imported and bought in Lepetane, and transported via direct sea pathways from Venice. After the World War II, the situation became a whole lot better. The industrialisation of a large country brought about the opening of many storage spaces and there were more diverse building materials being offered.

All sculptural elements were made of stone. They were prefabricated in local quarries or in those on the Brač and Korčula islands (Figure 17). By this, we are primarily referring to heavy house balconies borne by stone brackets (*regula*), frames around the windows and doors, small stone brackets underneath the cornices, and terrace fences made from stone balusters.



Figure 17. The Korčula stone is soft and easy to process; however, due to its lightness and brittleness, it is rarely used for construction, but only for decorating the facade (Photo: Dušan Tomanović).

When houses were being established, their roofs were covered by flagstones or by an old type of dry-layered imbrex. The oldest type of tile can still be found on some houses.

The materials mentioned here not only meet all requirements in terms of strength and thermal insulation, but also favour the coastal climate they adapt to [19].

2.3.2. Techniques of Constructing Single-Storey Stone Houses

These buildings were constructed in a primitive way. The base is square-shaped in most cases. The width and length of the building does not exceed overall dimensions larger than 3–5 m (Figure 18). Local barely regular stones were used for dry construction (with no binding agent). Dry construction (without a binding agent) is the oldest construction technique. It is still used today in the building of stone fences and retaining walls, and was being applied in traditional construction until almost the end of the 20th century.

The walls of these houses are 70 to 100 cm thick, 2–2.2 m in height. The height of the ridge is 3–4 m. In the interior of the wall, sporadic indentations (*panjega*) were left in several places by omitting a single stone in the wythes of the wall. The largest blocks were positioned at wall corners.

Blocks on the outer sides of the wall were always set first, followed by the inner ones. The outer side of the wall was built using larger and more regular-shaped stone blocks, while smaller ones were used for the inner sides, so row heights of the face and back of the wall did not match. All cavities

between blocks on the face and back of the wall were filled by small pebbles (*sovrnja*). A connective element would be placed on each square metre of the wall, connecting the outer and inner side of the wall (Figure 19).



Figure 18. The basis of rectangular houses is most commonly square (Photo: Dušan Tomanović).

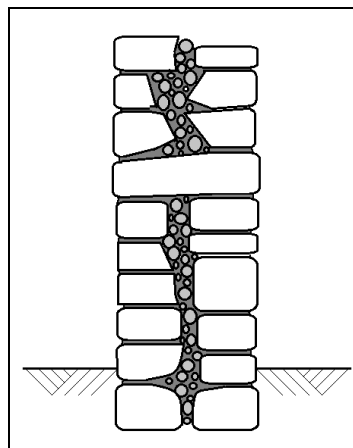


Figure 19. Stone wall without binding agent (dry construction) (Drawing: Dušan Tomanović).

In the beginning, the door was the only opening in the house. Lintels were positioned above the doors, most commonly from monolithic rock. However, there were wooden ones too (made from the hardest one—oakwood).

There were no windows on these houses in the beginning. Later, in the 19th century, windows were small in size, if existent at all, and faced the slope down towards the field and the sea (Figure 20). Windows got larger with time, so their size was about 1 m by the middle of the 20th century [13].



Figure 20. When present, the windows are narrow (Photo: Dušan Tomanović).

The kinds of openings on single-storey houses were:

- The ones which are not framed
- The ones that are framed, with “frames” made from local stone (more commonly)
- The ones with frames made from stone brought from Korčula island (less commonly)

The roof construction of these houses is very simple. It consisted of a single ridge beam stretching from the middle of one tympanum until the middle of the other one, supported by a forked pole named “soha” by the locals (Figure 21). Brotches do not lean on the ridge beam, but are simply joined at the ridge, digging into the wall at the position of the pole plate. Laths made of carved branches are thrown over the brotches and later covered with flagstones (before that, in the 18th and 19th centuries, thatch, bulrush or wooden slats and the like were used). As the brotches leaned on the inner side of the wall, the roof is slightly curved upwards at the end.



Figure 21. Roof construction is supported by a wooden forked pole (Photo: Dušan Tomanović).

2.3.3. Construction Techniques Used in Construction of Multiple-Storey Houses

The Foundation

As a rule, multiple-storey houses were built on solid ground. House foundations at the seaside were immersed in underground waters, if not in the sea itself. Nevertheless, the walls of these houses have not yet shown signs of cracking nor subsidence of any kind.

The foundations were made of flagstone or larger blocks of different sizes, and their depth did not surpass 50–60 cm. If the soil is loose, digging is done deeper than a metre, whereas foundation is not necessary if building happens on the rock. The width of the stone wall varies from 70 to 80 cm, while the binding agent used was lime mortar, sometimes also terra rossa (crljenica), known to be a good binding agent.

The Outer Wall

Walls were built using local limestone immersed in hot lime mortar or sand, clay, or sometimes even in eggs, which served as a binding agent. These walls have an outer and an inner wall 50–80 cm thick (Figure 22). Outer walls were built using the highly regarded fine stone (made from carved stone blocks) 17–25 cm in height. Side walls were built using less-regular shaped blocks than those on the front façade of the house, while their center is filled with broken and smaller stone pebbles (“sovrnja”, Lat. sauornam) and lime mortar in most cases.

The mortar was prepared by mixing fine sand and lime. Lime has been known since ancient times and the Middle Ages, and was obtained from limestone in a lime kiln. The quicklime (burnt lime), when wet developed great heat, so it was cooled for three days. For the preparation of mortar, water

was poured into the lime in shallow fenced plates. The slaked lime was mixed with a wooden tool consisting of a long handle with a stick vertically attached to its end. By the 1950s, it was done in the same or similar way.

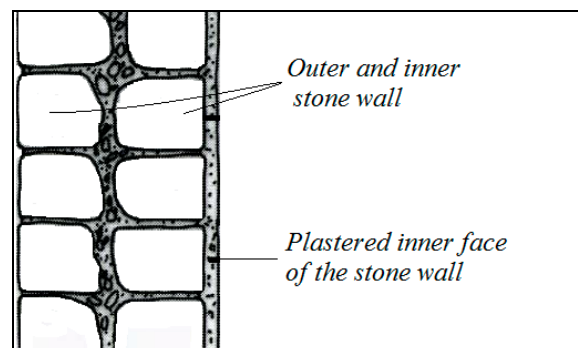


Figure 22. Stone wall with two sides (Drawing: Dušan Tomanović).

One large stone was used to connect both sides of the walls at every 2–3 m interchangeably in each row, thus fitting two walls together. This stone and procedure were called “wall binding” by stonemasons. In the corners of the house, we can see corner blocks (Figure 23). They were somewhat larger in size, more regularly processed, their colour was a darker grey, and the stability of the stone house partially depended on them. The longitudinal walls of the house were finished with wreath made of stone slabs (kotali). Gable walls are also made of stone slabs measuring 10 cm.

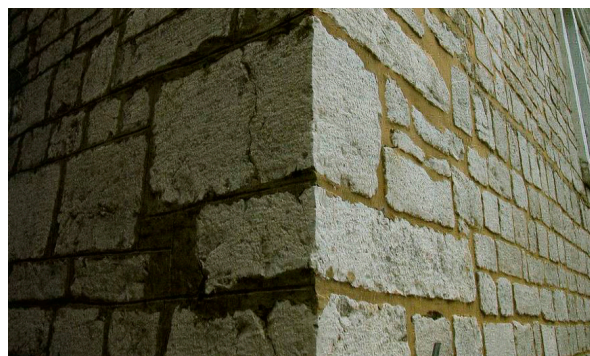


Figure 23. The corners of the house were made using blocks of greater length (Photo: Dušan Tomanović).

Thick stone walls provided lower inside temperatures in the summer months, and kept heat for longer in the winter time. During construction works on the main façade (in more wealthy owners), the local stone was substituted with the Korčula stone. It represented the height of the building’s beauty, and at the same time its owner’s wealth.

The Korčula limestone is soft and easy to process; however, due to its lightness and brittleness, it is rarely used for construction, but only for decorating the facade. The local stone is much stronger than the Korčula stone. They differ in colour—local stone is grey whereas the Korčula stone is white.

Residential buildings, aged from 100 to 160 years old, were built in straight rows up to 25 cm high. It should be noted that the width of the rows was determined only by the thickness of the layers in the quarry. Stacking the blocks into the building was done in the same position the block had in nature. This is the correct way of construction in which the joints do not come to a vertical position. In this way moisture absorption is avoided. The extraction of the blocks was done manually with wooden or steel wedges.

During the 20th century, there was a tendency for the exterior walls to be plastered to protect the house from moisture, sea and rain. In Prčanj, some houses are plastered with red plaster (most

likely made from minced bricks). Plastering with cement mortar is more present in the post-World War II period when cement became more accessible to the wider population. Humidity is, however, a difficult problem during the winter period, especially in vacant homes.

Stone was not particularly processed for inner walls, except for several flagstones above the window, where they form a mild arc. Vaults were built using 5–6 cm thick flagstone taken from local quarries Verige, Strp and Lipaca.

Joints are usually filled with mortar along the wall lines and their size varies from 5 to 7 mm. Joint processing is not always the same everywhere. Those house owners who did not find their joints along the wall beautiful or efficient enough processed them in a different way: the joints were filled up until the wall line, and subsequently the horizontal and vertical ones, protruding out of the wall lines by 3–5 mm with completely straight and sharp edges (Figures 24 and 25).

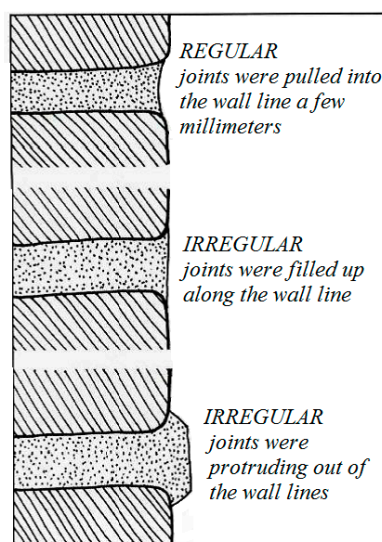


Figure 24. Types of joint processing (Drawing Dušan Tomanović).



Figure 25. An example of a joint protruding out of the wall lines (Photo: Dušan Tomanović).

Venetian feet (34.77 cm) were used to measure wall thickness. This was the unit of measurement in civil engineering until the end of the 19th century in Vrmac, in the whole Bay of Kotor area.

Some of the wall thickness measures were:

- The Verona Palace in Prčanj (built at the end of the 18th century). All outer walls are 72:72:72:65. Middle walls measure 65 cm.
- The double building Verona in Prčanj (built at the end of the 18th century). All outer walls measure 71 cm.

- The Tomanović Palace in Lepetani dating from 1846 (ground floor walls 72, upstairs 66)
- The Tomanović House in Lepetani dating from 1826 (ground floor walls 66, upstairs 60)

Walls are 72 cm (two feet) thick on some houses, while upper floors are weakened up to 66 or 60 cm.

After the 1979 earthquake, steel straps were put in place to secure the walls. They had not been used previously. Their usage began in the 19th century and was limited to tall edifices only (most commonly in the city of Kotor) [14].

Dividing Walls

In most houses in the Bay of Kotor area, dividing walls are made of wood, then plastered later (Figure 26). When property was to be partitioned, houses got divided by walls vertically, and not by floor. Dividing walls were most commonly built by vertically setting 3 cm thick planks, uneven in size, which varies between 5 and 10 cm (Figure 27). Horizontally nailed slats 3 × 3 cm in size were placed on both sides of the planks at a distance of 2–3 cm. Pre-cut planks were often used instead of slats, on the same distances. After all of this comes a 1 cm layer of lime (or later cement) mortar used to fill all cavities. The thickness of such dividing walls varies between 9 and 12 cm.



Figure 26. Dividing walls are made of wood and later plastered (Photo: Dušan Tomanović).

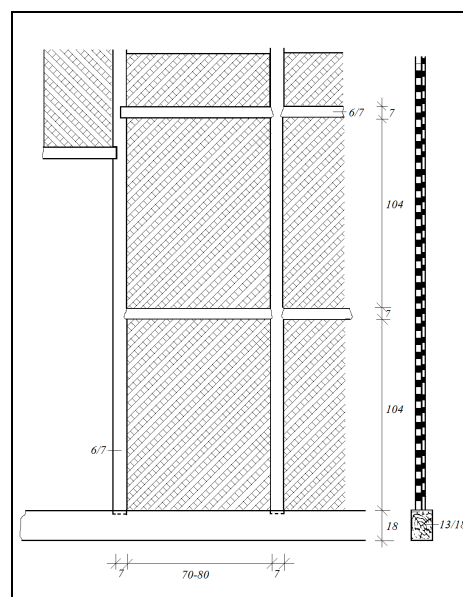


Figure 27. Cross-section through a dividing wall (Drawing: Dušan Tomanović).

Floor Joists

Mezzanine ceilings are usually made of wood. Beams are in most cases made of beech, pine or chestnut wood, or any other kind of wood available nearby. Floor joists are consisted of wooden beams 18, 20 or 22 cm in width, with significant variations in thickness: 12, 14, 16, 18, 20, 22, 28 or even 30 cm, for spans ranging from 7 to 8 m. Beams are placed at an axle distance of 70–80 cm. Floor joist beams in some houses in Prčanj (houses of the Florio and Verona families) were positioned to incline with their wider sides, which considerably reduced their load-bearing capacity.

Wooden floor joists were connected to the stone walls with tie bars. This forced them to oscillate in a harmonious way, reducing more important damages. These elements encompassed a few rows of stone on the outer side then got fastened to the joists inside and were usually set in the axle of the vertical strips of walls, where they had the most seismic effect.

Beam processing was not particularly precise. In more wealthy households, where beams were visible on the ceiling, they were finely treated, usually trimmed from both sides with slightly rounded edges.

Floor joist beams lean on constructive massive walls mainly in three ways:

- On stone teeth (Figure 28)
- On the wooden beam placed on the wall
- Inside previously prepared holes in the walls (built-in) (Figure 29).



Figure 28. The small bracket carries the floor joist beam on the inner side of the wall (Photo: Dušan Tomanović).



Figure 29. The floor joist beams are put into previously prepared holes in massive stone walls (Photo: Dušan Tomanović).

Tooths are stone brackets, sometimes made of local stone (most commonly in upper villages), sometimes of Korčula stone (on the sea), and protrude 16 cm from the wall and are 13 cm in height. They are housed in the massive outer 20–25 cm wall.

In the second case, there is a difference of 10 to 12 cm between the lower wall of the *konoba* and the floor wall, and this space is used for the wooden beam, whose function is to replace the tooths.

The third case involves floor joist beams being placed into massive walls, in previously prepared holes. These holes had the same dimensions as the beams in the axle distance about 60 cm for a 4 m span.

The ceiling heights of the *konoba*, the ground floor and the upper floor are always different; therefore, a number of heights were in active use.

In main bedrooms, the most common ceiling heights are:

$$8' = 278.16 \text{ cm}$$

$$9' = 312.93 \text{ cm}$$

$$10' = 347.7 \text{ cm.}$$

In other (auxiliary) rooms, the height is somewhat lower:

$$6' = 243.35 \text{ cm}$$

$$6'1/2 = 261.12 \text{ cm.}$$

Roof Structure

There is a wooden roof structure on all houses. The surface is covered with tiles or flagstone. Numerous remains in the villages of the Bay of Kotor point to this conclusion. Roofs are usually double sloped (swallow style), even though there are triple-sloped, quadruple-sloped (padilion style) roofs, but also roofs with multiple slopes. The roof slopes in the Bay of Kotor range between 25–32°, most commonly 28°. This is the main type of roof structure on houses in the Bay of Kotor.

2.4. Valuable Visual Design Elements

Valuable visual design elements on stone houses are:

a. Stairs, b. Windows, c. Doors, d. Eaves, e. Roof cover, f. Balconies, g. Terraces, h. Sculptural elements (Frame, Bracket, Frieze, Baluster).

(a) Stairways

2.4.1. External Stairways

At the time of creation of these houses, exterior stairways were always made of stone. They were mainly placed by the side wall of the house to the left or the right of the entrance, reinforced (filled out) from underneath. An extension 'solar', a space 2 to 3 m² in size, can be found at the entrance to the house, sheltered from the wind and rain with plenty of sunshine. It is surrounded by a *pijuo* (stone bench) with coated flagstones. Above the solar, for the main part of the 20th century, there were no eaves shielding the front door from the rain—the only protection came from the cornice. This characteristic—the lacking of eaves above the main entrance and the external stairway—is typical for the whole Kotor Bay area, and they started being added only recently.

The stairway and its elements—the tread and the front are usually made out of flagstone. The treads are uneven in size: 28 to 30 cm, while the height of the front is stable ($12 + 3 = 15$) or $13 + 2 = 15$ cm.

The fence of this staircase is stone-made, which is almost always the case. Balusters are placed in some places, while others prefer to have their fence made from wrought iron. The stone fence is 80 to 85 cm in height, the wrought iron one is $85 + 5$ for wood, while balusters come in different heights and shapes, and they are also stone-made (Figure 30).



Figure 30. The tread and fence of the external stairway are mostly made of stone (Photo: Dušan Tomanović).

2.4.2. Interior Stairways

At the beginning of the 20th century, the interior stairways were made of wood (Figure 31). They led upstairs, towards the *inglo*, and to the ground floor towards the *konoba*. Rev. Nakićenović describes them at the beginning of the 20th century: “The stairs reach the first floor in all houses, if they are in the house they are usually made of stone, while those that come from the yard, which is in Luštica usually stone-made. On the second floor they are made exclusively out of stone. Both are spacious and nicely laid, that is to say, easy to climb. Divided houses are an exception, and there, stairs would be narrow and steep because of a lack of space [20].”



Figure 31. The interior stairs are always made of wood (Photo: Dušan Tomanović).

(b) Windows

In all houses, windows have a multiple role: illumination, solarisation, ventilation and enabling visual contact with the outside. Aside from functionality, they also have an aesthetic dimension, reflected more in the exterior, but also in the interior. They are usually positioned on the side facing the slope, towards the sea.

Single-storey houses sported windows that were small or non-existent (Figure 32). Their shape and proportions are typical for the stone architecture of the seaside in general. During the 20th century, they became somewhat larger—about 1 m.



Figure 32. Openings were small on single-storey houses (Photo: Dušan Tomanović).

Larger windows appear on multiple-storey houses. Window size and proportions of the window opening were also defined by the quality of the window frame (imported or local) (Figure 33).



Figure 33. Windows on multiple-storey houses were defined by the quality of the window frame (Photo: Dušan Tomanović).

Window frames were usually made of better quality stone, which was also better processed. Holes were dug in stone frames, on the inside, to accommodate the wings later. The span of the lintel beam is slightly larger than the breadth of human shoulders. They are somewhat higher, in order to get rectangular openings of the aspect ratio 1:1.4, which are close to $1:\sqrt{2}$.

The shape of the casement is the same everywhere as a rule. These are double door windows, with each door divided by thin slatlets into two or three parts, for each door. Glass is single-layered and 4 mm thick. The windows were constructed so that quirks were integrated into it, making it into a receptacle for glass without putty. The glass is thus protected from the wind, but since it is movable, wind and rain can permeate through during particularly violent weather.

The outlet in the interior of the wall is slanted, so it is larger inside and smaller outside. This slant in the stone wall is done both vertically and horizontally. The vault which appears above the outlet, on the inside, follows the slant of the walls.

Cast iron lattice is an integral part of the *konoba*. Their main role was to protect the inhabitants from break-ins. Windows are smaller in size and enclosed in frames made of stone from Korčula.

Often, small brackets with holes, *auricolae*, could be found above windows (they were used as curtain holders in the summertime) and 'dentes' brackets (used as shutter holders or flower pots, for drying figs, etc.).

Shutters are a compulsory element of the windows. They are coloured in a characteristic green hue and protect the wood of the window frames from heavy rains and storms. Those shutters were mostly solid (made from solid wood, without any movable parts).

(c) Doors

Doors can be external and interior.

2.4.3. External Doors

External doors are different from the interior ones by their character. They are exposed to weather conditions, special functional requirements (safety, insulation), architectural and aesthetic criteria (emphasis of the entrance, singularity), which is why they differ from interior ones in terms of size, shape, materials used, construction and processing methods. External doors on the houses are the front entrance door as well as the doors on balconies and terraces.

They are sometimes also located on the stone wall fences surrounding yards of Kotor Bay houses. The openings and their number was determined by the property owner. A stone frame conditioned the dimensions of the openings, the doors were placed in different spots, and there were no irregularities.

On external walls, there are two door sizes: 5'6" (191.235 cm) and 6' (208.62 cm) with a minimum width of 3' (104.31 cm), which climbs up to 5' (173.85 cm) in half-foot intervals. The most common external door size ratios are: 6'/4' (208.62/139.08) or 3:2 and 6'/4'6" (208.62/156.46 cm) or the ratio of 4:3.

These doors have no fanlights, and they open to the inside. They are either enclosed in a better processed local flagstone or in frames made of Korčula stone $\frac{1}{2}$ of a Venetian foot in width, which is 17 cm. Lintels are positioned above the door, and there often is a relieving arch on top (Figure 34).



Figure 34. A door with no fanlights is framed with rectangular stone frames (Photo: Dušan Tomanović).

The door consisted of a frame—lintel and the movable part of the wing. There are single-winged and double-winged doors, divided according to the number of wings. In the beginning, they were

single-winged, later developing into double-winged doors. In arch doors, we can see a separate semi-circular part above the wings, but the wings themselves sometimes end up with an arched shape. They were manufactured using wood, and mostly coloured in green and white (Figure 35).



Figure 35. A door that does have fanlights is framed with arched stone frames (Photo: Dušan Tomanović).

The main entrance to the house and yard gates or fence gates were often secured from break-ins in multiple ways. On the inside of the door, in some cases, even 3–4 closing systems can be found: locks, hasps, klav, baštun (Ital. bastone), and in some cases a “pat” is often placed. A “pat” (Ven. pato) is a strong square beam that can be inserted into special holes inside walls. When being placed, it is positioned behind a closed door, thus securing the whole opening.

The hardware is made of high-quality stainless steel, the so-called arcal, arcao (from Ital. accialio-steel). This hardware’s special feature is its long durability right next to the sea shore, stretching over multiple centuries without major signs of corrosion.

Decorative elements of inner doors can be found on iron doorknobs.

(d) Eaves

Eaves form an integral part of the roof structure and their main function is precipitation protection. The ones with kotals are the most common, while grondals are far less frequent.

Kotals are flagstone blocks, mainly rectangular in shape, protruding 15 to 40 cm out of the wall, they are 2 to 3 cm thick, embedded into the wall with one side being 5 to 10 cm. They are joined with lime mortar and act as a monolith with the façade (Figure 36). The stone eaves were a very practical solution since stone was so ubiquitous. It was the only way the house could be protected from *sijavicas* (tiny rain droplets brought by the wind during heavy wind gusts such as the *bura*, the *jugo* and other types of winds). When the time came to collect rainwater from the roof and place it in special tanks, “grondals” were used instead of kotals (Figure 37). Grondals were thick flagstone stones from Korčula with a built-in gutter for draining atmospheric waters. In some cases, grondals were supported from the bottom by small stone-made brackets (*dentes*) made from Korčula stone or the local kind.

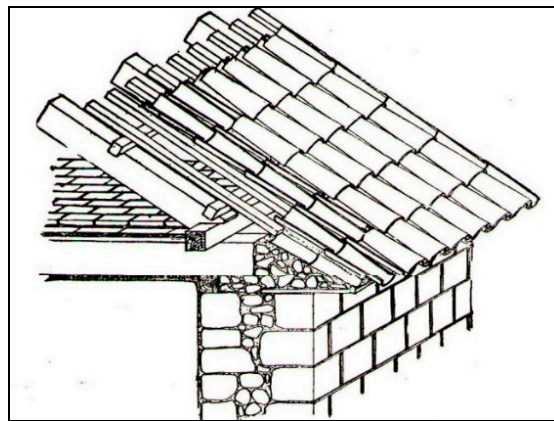


Figure 36. A detail from the loft and roof structures [11].

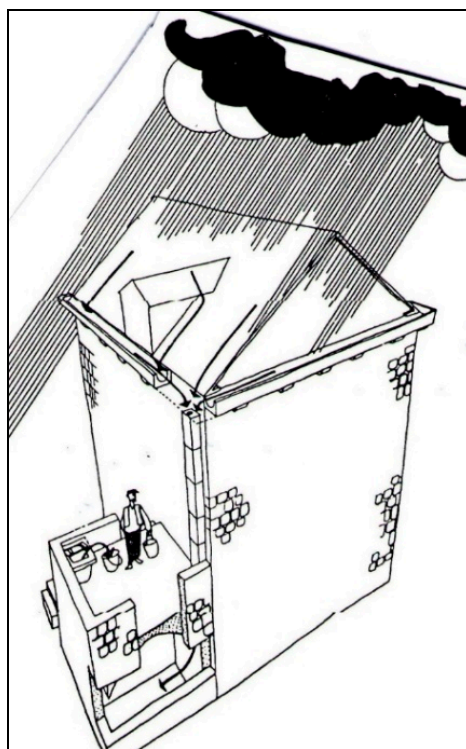


Figure 37. Grondals (stone gutter for draining atmospheric waters) [13].

(e) Roof Cover

Roofs on village houses are mainly double-sloped. Roof slope is anywhere from 28 to 32 degrees. Since the Bay of Kotor is known for its abundant precipitation, the roof protrudes slightly more with flagstone cornices (kotals). In the past, roofs were covered with flagstone blocks, found ubiquitously in the Bay of Kotor area (St. Vid, Verige, Kamenari, Strp) (Figure 38). This can be concluded after revising numerous remains in the upper villages of Prčanj, Stoliv, Veće Brdo, Gornja Lastva, Bogdašići. Before this, roofs were sometimes covered in thatch.

Towards the end of the 19th century, handmade tiles took over, and after the tile and brick factory in Krtole opened in 1907, higher quality and better processed clinker bricks were produced. They were placed between the slats, laid dry on the bottom, with a thin mortar bed being made on the upper side to adhere better in order to become impervious for any sijavica (small rain droplets brought by the rain) that may come in. An amount of effort was put into preventing the mortar from touching the

wood so as not to moisten it. Larger, much wider tiles, were used for ridges and hips. The end row is covered in tiles and forms a channel (Figure 39).



Figure 38. Flagstone roofs were dominant in the 19th century—Veće brdo (Photo: Dušan Tomanović).

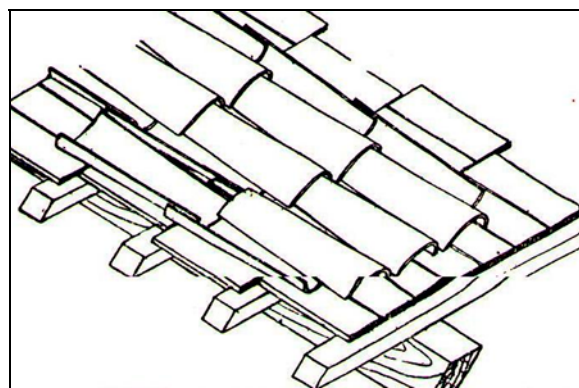


Figure 39. At the beginning of the 20th century, factory-made corrugated tiles took over [11].

(f) Balconies

The urbanistic transformation of the city during the baroque era, when the renaissance got an urban look, remained clearly recorded in the form and function of balconies in the Bay of Kotor. The majority of houses did not have balconies. Where present, they were still in good shape and being used at the beginning of the 20th century. They were built on houses by wealthy owners (captains, ship owners, merchants), which is why we almost always see them in the 17th, 18th and 19th centuries in economically prosperous places such as Prčanj, Muo, Donji Stoliv, places that also had more of these kinds of people [12]. Architect Milan Zloković says: “I think that, when it comes to special balcony deliveries, contracts were made directly between the future house owner or their representative and the main master at one of the stone workshops, determining the size of the balcony and its final processing on that occasion, on-the-spot, according to certain reputable bracket, small pillar and baluster types [12]”.

The most beautiful palaces for the noblesse were built in Prčanj in this period.

I shall cite some of them:

- The 18th century Florio Luković Palace in Prčanj, dominated by a baroque balcony on the first floor of the front façade, facing the sea
- The mid-18th century Verona Palace in Prčanj. It has a centrally placed balcony with four stone brackets and baroque balusters on the second floor

- The Beskuća Palace, in the centre of Prčanj. On the first floor of the main façade, we see a balcony with a stone fence (balustrade) supported by three stylised brackets. Two portals lead to the balcony, with arch-shaped fanlights decorated with a metal net
- The Luković Palace in Prčanj, 11 baroque urban houses in a succession with characteristic balconies

The balconies are not large in size and the question remains if they had a practical use, aside from the purely aesthetical belvedere (nice view) function. The balcony width ranged from 90 to 110 cm, with varying lengths (Figure 40). They are usually placed in the centre of the main façade, while the symmetry in relation to the façade (doors and windows) is strictly respected. All balconies are constructively supported by large stone brackets “regule”, richly stylistically decorated and processed.



Figure 40. Typical stone balconies on houses in Prčanj (Photo: Dušan Tomanović).

In most cases, balconies are surrounded by balustrades of different shapes and heights. Balustrades are surrounded by cornices from the top and the bottom, and its length as well as the length of the entire fence is divided into 2, 3 or 4 fields (depending on the length of the balcony). The fence is about 75 cm high. Later, in the 19th and 20th centuries, on some houses, stone balustrade fences were replaced by wrought iron fences (Figure 41). The upper surface of the balcony (the tread) is not covered and it is exposed to atmospheric conditions. It is coated in flagstone from local quarries. A double-winged door, which is in most cases enclosed in *voltes* (arch-shaped stone frames), leads to the balcony. As a rule, the doors open inwards. Initially made of solid wood, they were later combined with glass. Sometimes, the part where the arch starts and ends is being glazed, while the lower part is made from wood and glass, or solid wood.



Figure 41. At the beginning of the 20th century, balcony fences were made from wrought iron (Photo: Dušan Tomanović).

Influences from the whole Bay of Kotor area can be recognised in the shapes of the balconies, which are adapted to the measures and needs of the local environment in an original way.

(g) Terraces

Terraces are almost always present in upper villages, and significantly less in the lower parts. Depending on the slope, they are usually located in front of the house at ground floor level or at the first-floor level (Figure 42).



Figure 42. Terrace on the ground floor (Photo: Dušan Tomanović).

When placed on the first-floor level, a stone *volte* bears its load. The terrace is plate paved with rectangular stones brought from local quarries on both the ground floor and the first floor. It is surrounded by a “pijuo”, a stone bench with a seat and a backrest (Figure 43).



Figure 43. Terrace on the first floor (Photo: Dušan Tomanović).

Wealthier families would make *bistjernas* on the ground floor of their terrace. These *bistjernas* were used to collect rainwater with the help of a stone gutter (*grondals*, *gurla*). Poorer families would keep livestock in that same area (under the terrace), and in that case the *bistjerna* was located in front of the house or behind it, in the yard.

(h) Sculptural Elements

Frames around doors and windows, frieze beams and stylised eaves above the openings, balcony components (brackets, blocks, little pillars and balusters), external stairways and their fences are all

made of limestone brought over by sea from famous quarries on the Vrnik island next to Korčula known by the name *korčulanac*. This is probably due to the fact that it was not possible to find a stone easy to process in a precise way anywhere around. Thus, the inhabitants of the Bay of Kotor ordered stones processed in the finest way through their merchants and sailors and built it into their new homes.

Sculptural elements on stone houses are: the frame, the bracket, the frieze and the baluster.

2.4.4. The Frame

While houses in the Bay of Kotor were built using local stones, frames for openings were made from stones that were easier to process, brought over from the Croatian islands of Vrnik and Korčula. These frames had standardized measures, which in turn determined the dimensions of the openings themselves. Feet were used as a measuring unit up until the mid-19th century (the Venetian 34.8 cm foot was divided into 12 ounces ($1'' = 2.9\text{ cm}$)) [21].

On external doors, the stone frames also served as door jambs onto which wings could be attached. The width of the frames was 17 cm or $\frac{1}{2}$ of a Venetian foot, while the size of the opening dictated its height and length. In single-storey houses and in most houses in upper villages on Vrmac, door jambs were made of home-made monolithic stone whereas they used to be made of wood in older times.

On the Vrmac, openings (frames) on multi-storey houses can be:

- a. With enclosures, i.e. “frames” made of local stone (Figure 44)
- b. With frames made of Korčula stones and without stylised lintel cornices
- c. With frames made of Korčula stones and with stylised lintel cornices (Figure 45)

Frame faces were well processed, while inner parts were done more roughly. Stone enclosures around openings (frames) play a constructive role, aside from being aesthetically pleasant. Door openings influence the door shape and determine its dimensions. Such openings could be finished in a straight or arch-shaped way. With straight frames over larger spans, a relieving arch is added to avoid cracking.

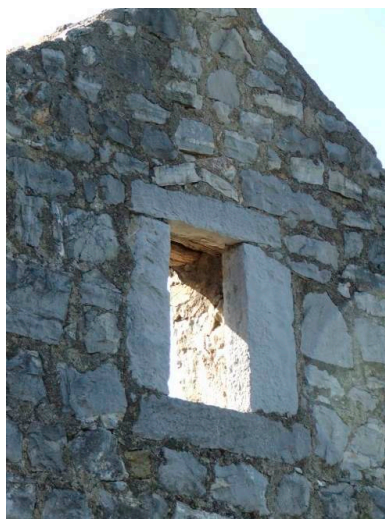


Figure 44. Window and door frames in the hinterland are mainly composed of monolithic stone with no stylised cornice (Photo: Dušan Tomanović).



Figure 45. Frames made from Korčula stones with stylised cornices (Photo: Dušan Tomanović).

Frames over arch-shaped doors and windows (volates) are somewhat more specific and wide. They are manufactured in two parts, and connected by a decorative bracket with a frieze on top (Figure 46).



Figure 46. A stone frame above an arch-shaped door, connected by a decorative bracket at the top (Photo: Dušan Tomanović).

In external doors and windows, the frames serve as door jambs or window frames, respectively, with the possibility to accommodate wings.

2.4.5. Brackets

Stone brackets find multiple usage on houses in the Bay of Kotor area. A few types were used, and those are:

- brackets with a hole (auriculae) (Figure 47)
- brackets underneath the lower window frame (dentes) (Figure 47)
- brackets bearing heavy stone balconies (regulae) (Figure 48)



Figure 47. Brackets with a single hole “auriculae” (above) and “dentes” brackets (below).



Figure 48. The regulae support heavy balconies (Photo: Dušan Tomanović).

Brackets with holes (auriculae) supported the curtains from the outer side and protected the inhabitants of the house from sunlight during the summer. Their dimensions are 30/25 cm and they are placed under the lower line of the upper lintel frame. Their width ranged from 5 to 7 cm. They exist in variations with one and multiple holes.

In the second half of the 20th century, brackets with holes (auriculae) slowly lost their primary function—to protect house inhabitants from the sun in the summer. On some houses, they were entirely removed, while some others saw them decay over centuries of use.

Brackets (dentes) come in multiple variants. They are built below the lower window frame or at the same level, to the left and to the right, in pairs. Their role differs, in some places they are used as shutter holders, while some dry their figs on them. We can also find them on the façade below the roof cornice, bearing *kotals* (stone blocks), but they also carry floor joist beams on some houses. Their dimensions are 40/20 cm, and they are mainly encountered on houses in Prčanj, Donji Stoliv and Donja Lastva.

Regulae are brackets bearing heavy stone balconies. The largest load they receive comes from the balusters. They are being placed in rows of two, three or four, depending on the balcony length. The more luxurious regulae were imported from Italy because those made on the island of Korčula were much more modest.

2.4.6. Frieze

At the beginning of the 20th century, friezes have been subsisting for more than two centuries on some houses. Despite this fact, they did not show any signs of weakness or damage because of the compact way they were manufactured in. They are mainly found on houses at the sea. They do not exist in villages in the hinterland.

They are placed above the window, the door, or gates (Figure 49). Their dimensions vary and depend on the size of the opening above which they are placed. Stonemasons from Korčula standardised them, and the largest number was bought in their workshops. Their lower part leans on the upper window frame and the door. Aside from the aesthetical function, they had a practical one, which was to prevent rainwater from entering through the openings, since rain would be falling from the roof directly onto the floor.



Figure 49. The frieze leans on the upper door and window frame with its lower part (Photo: Dušan Tomanović).

A rich frieze means a rich house owner. Special attention was given to friezes above arch-shaped doors with a small decorative bracket at the top (Figure 50).



Figure 50. A frieze above an arch-shaped door with a small decorative bracket at the top (Photo: Dušan Tomanović).

2.4.7. Balusters

The appearance of balusters is not consistent with the tradition of folk architecture, but they did announce the gradual formation of the local architecture language and its dialects. Balusters, or stone pillars, are used to fence not only balconies, but inner yards and atria as well. They appear sporadically on the coast, while they are not present in upper villages (Figure 51). This shows us that they started being used in later stages, since all lower settlements were created afterwards. They are most common in the following places: Perast, Orahovac, Mula, Prčanj, Donji Stoliv, Donja Lastva. It was probably sea men who brought balusters from their numerous trips around the world, into the cities at first, around the 17th and 18th centuries (for example, balconies on the 17th-century Gregorina Palace in Kotor or the mid-18th century Dabinović Palace in Dobrota), and later into nearby cities sometime in the second half of the 19th century.

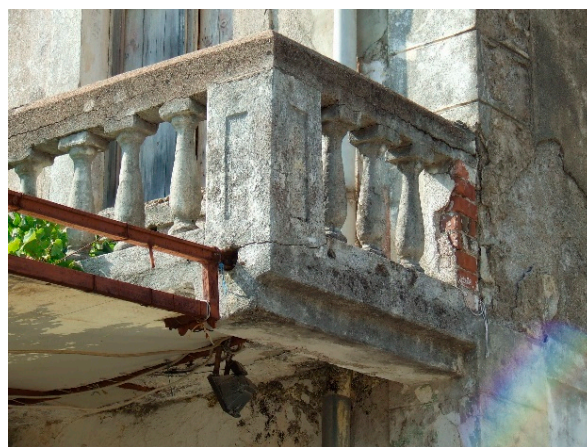


Figure 51. Balusters are present on the coast, and absent in upper villages (Photo: Dušan Tomanović).

They vary in shape, height and width. Framed with frieze beams and stone pillars, they were manufactured from stone and processed with high precision in this period. The baluster type with three highly convex-concave parts with sharply protruding edges towards the outer borders, with a square base and a decoration made of concentric squares (which differ from the usual baluster division in the shape of a single or double “pear”) is the most common type on the Vrmac (Figure 52). It was also present in earlier architecture in the Bay of Kotor in the 17th and 18th centuries.



Figure 52. A type of baluster with three convex-concave parts with sharply protruding edges on the outer borders and with a square base (Photo: Dušan Tomanović).

3. Discussion

Representing local materials and construction techniques, the Bay of Kotor stone architecture, accumulated over centuries, is seen as one of the most important physical indicators of the culture and lifestyle of people in this region.

Up until the 1970s, all important characteristics of traditional construction were part of the forming of villages in the Bay of Kotor. Traditional materials such as stone and lime mortar were used. Dry wall construction (without a binding agent) was completely replaced by the usage of lime mortar in construction. Different types of stone suitable for construction was being extracted from local quarries.

In the 19th and 20th centuries, there were two types of stone houses in the Bay of Kotor area, and those are single-storey and multiple-storey houses. Single-storey houses ceased to serve a dwelling purpose in the second half of the 20th century. They were instead transformed into auxiliary buildings or buildings for livestock (stables). Multiple-storey houses experienced a comprehensive transformation with numerous variations in size and complexity levels. They thus became the extended type of civic house with an additional number of rooms for residential purposes.

Unfortunately, the contemporary reconstruction of these buildings all along the Bay of Kotor does not take the balanced and harmonious expression of this architecture into account. What encourages us, however, is that old stone buildings were not torn down, even if they were abandoned and ravaged by previous earthquakes that made them entirely unusable.

The most important changes occurred after the Second World War. In this period, the character itself of traditional houses gradually disappeared, just like the character of villages and houses were destroyed with the irrational and incompetent use of concrete, or at least those villages and houses worthy of mentioning. Some of the construction methods in traditional architecture also vanished, and they included collecting rainwater, usage of easily accessible materials, controlling heat input and exchange by balancing thermal characteristics of the wall mass and shadow size of openings.

Changes became even more apparent after the catastrophic 1979 earthquake. First construction laws appeared in 1981 [22]. The traditional way of building was completely lost in this period.

The development of tourism brought about the need to repurpose the existing houses and build new ones. Cost-effectiveness was not a priority because of the pressure that awareness about quick and easy earnings though building exploitation can bring. Building exploitation was most commonly the main motive behind the construction thereof, while the development of commercial activities was secondary in the coastal zone.

The biggest challenge in the revitalisation of stone houses in the second half of the 20th century was the layout of ground floor rooms and determining the position of the kitchen. In order to get as much space as possible, height was often increased using inadequate stone blocks. The roof slope was also changed, and the creation of belvederes rendered the façade asymmetrical and disproportionate.

The openings (windows and doors) on buildings were put randomly (according to need). They were enlarged and disproportionately big in relation to the surface of the facade, while the stone frame was replaced by a concrete one, as a rule. In several instances, a balcony was added onto the first floor while windows got transformed into doors.

Stone balusters made from alabaster or cement fueled the spread of kitsch in bad taste by investors or architects.

Plastering stone facades and then painting them is another example of how things should not be done. The usage of autochthonous types of stone is in regression today with regards to imported types. This is also how the painstaking way of extracting and processing stone almost disappeared. The art of building with stone is lost and stone has become mere decoration or coating, while carefully and lovingly crafted blocks of old stone houses turn into building material for new edifices. Quarries are abandoned, and do not differ from their natural environment. They can tell us a lot about the old builders' attitude towards their own living space, because they only took from nature what was really necessary.

Nothing prevents us from using the latest materials and construction styles parallelly with the building achievements of previous generations. The two will not be mutually exclusive, but can rather complement each other and leave a sign of their time, just like the predecessors left traces and know-how through the centuries together with existing ones, without disturbing or damaging their heritage.

4. Conclusions

The Bay of Kotor and its stone settlements are a valuable and unique example of traditional construction. Building stone was the natural choice for builders in this area for centuries. It was adapted to the needs of the region, easily accessible and extracted according to purpose.

Modifications in traditional lifestyles and conducting business in the 20th century permanently changed villages and influenced the moving of inhabitants from upper villages into the lower ones. The degradation of villages as a permanent process in the 20th century, particularly intense in its second half, had a twofold impact in its spatial incidence: a complete abandonment of villages or their transformation in which traditional values got lost. The complete abandonment of upper villages caused the exposure of their building structure to decay, even though it was preserved in a spatial organization and unencumbered by new construction.

Today's urbanism did not succeed in the creation of anything better than what the people created for centuries according to their needs. Alongside the coastal belt itself, new villages, completely different from the old ones, developed, even though they were "constructed with a plan". They jeopardised the old settlements both qualitatively and quantitatively, almost to their complete destruction.

When the environment proves to be historically, artistically and culturally worthy of respect, as is the case here, new buildings should have followed that logically, and fit into it with visual characteristics, often copying certain elements, naturally, adapted to today's technology and way of construction.

The authors suggest the need to better preserve these houses and settlements with the global issue of sustainability. We need to define what constitutes a threat to heritage. The new type of house should emanate from the old stone house. Mass, proportions and materials, ornaments around the doors and windows, bordures and cornices under the roof should be elegantly adapted to the olive groves, vineyards and other traditional lifestyle elements.

Another aspect of raising awareness of appropriate stone for repair, maintenance and restoration of historic structures concerns the availability of reliable technical data. Replacement stone should ideally be of the same type as the original, or the nearest possible equivalent. Use of inappropriate stone can result in significant damage to the heritage. In order to choose the correct stone, both the original stone and the potential replacements should be fully characterized. The stone industry has an important role in providing accurate technical and aesthetic information on their products [17].

Abandoned stone houses and settlements can be revived only by the return of inhabitants and commercial incentives that would motivate them to live there. One way to save traditional building as an important part of the Montenegrin cultural heritage would be to recognise such settlements as essential tourist resources.

What should be avoided in upper extinct villages are situations similar to those that arose in lower settlements, where settlements sprouted without proper spatial planning documentation or expert assistance from architects and other specialists and resemble neither a village nor a city.

A displaced and neglected village rehabilitation program should be established by the state and the local authorities, turning the settlements into tourist destinations, thus becoming a source of income for the local population in order to cease the selling out and devastation of real estate.

The most important contribution of the program in the revitalization of old heritage would be a planned approach. Tourism and agriculture should be the main driving force behind the development of these regions. Settlement reconstruction is a long and financially demanding task. High levels of

protection of historical heritage should be linked with the interests of its owner/representative, as well as all those who will invest into its revitalization and quality development.

Investing in the reconstruction of such settlements should be treated as active or lasting protection of cultural property, which deserves to be exempt of certain taxes. Existing legal reliefs are insufficient to achieve lasting self-sustainability of these settlements and individual structures in them. They need to be lasting and give an incentive to everyone involved (owners, businesses, etc.). In Austria, in areas where the threat of abandonment is real, produce made by farmers in their homes are exempt from taxation. Otherwise, if such incentives are absent, these environments will require permanent subsidies.

Traditional stone architecture in the Bay of Kotor represents the compatibility of parts and the whole, that is to say a balanced and harmonious architectural expression. It is the base from which new models should be built and traditional shapes transformed according to the contemporary style of life and modern tendencies in architecture. That is how we will bring traditional architecture back to life, and return life into it.

Author Contributions: Each of the six authors, D.T., I.R., M.G., J.A., N.G. and J.L. contributed equally to designing the study; collecting the empirical material; writing the paper and substantially revising the work. T.T. translated the paper. All authors have read and approved the final manuscript and they all agree to be personally accountable for their contributions.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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