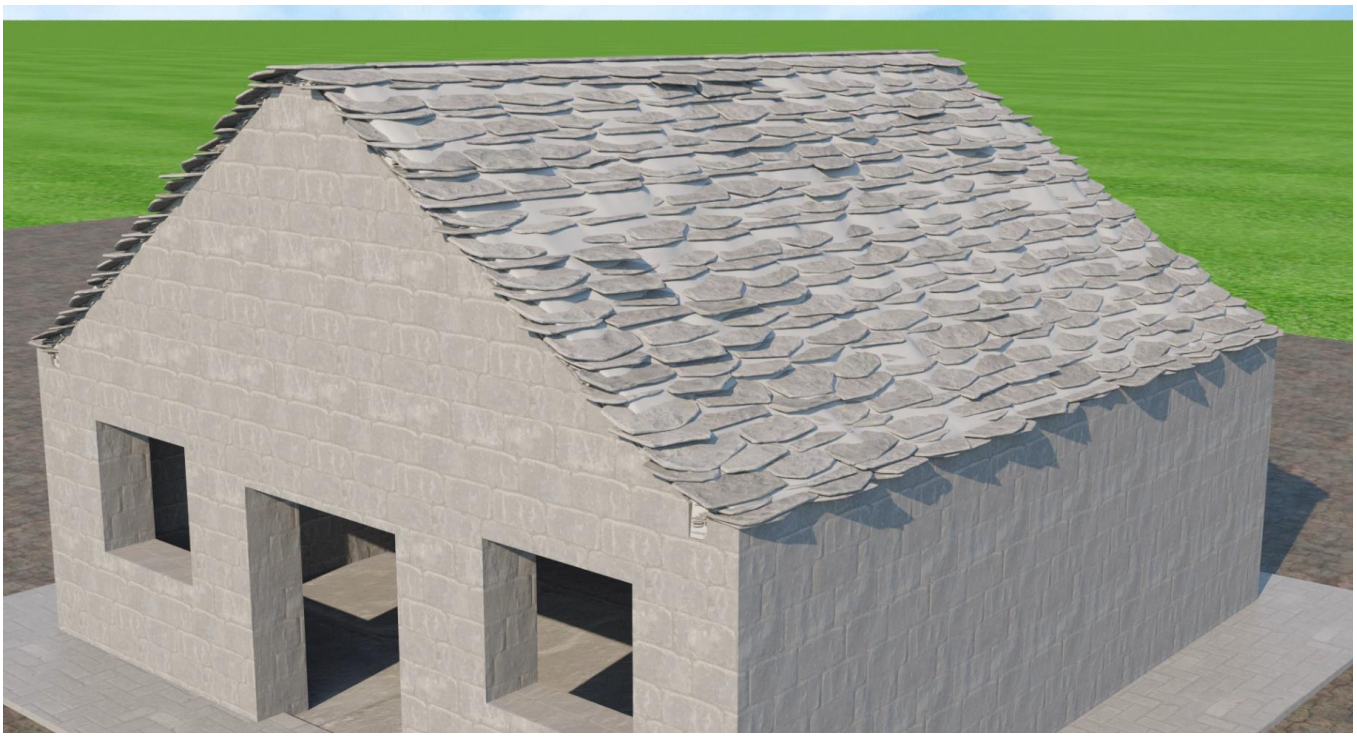
REPORT 1.2.7

BEST PRACTICE REPORT ON METHODS, SKILLS AND COMPETENCES IN RELATION TO STONE PRODUCTS

CONSTRUCTION PROCESS OF TRADITIONAL ROOF IN CROATIA



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Content

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1. INTRODUCTION

The BIMstone project was born from the fusion of three lines of action whose convergence is a consolidate a didactic material base for the training in the stone sector. These three lines of actions are:

- BIM (Building Information Modeling).
- LCA (Life Cycle Assessment).
- Digitisation of stone products placement methodologies.

The European Commission is focused on the construction sector on the criteria of smart growth (knowledge and innovation-based development and economy) and inclusive growth (ensuring social and territorial cohesion through employment).

According to the above context, the general aim of BIMstone project is to increase the skills of workers in the field of placing the stone products particularly in placing different type of floors and walls in buildings and urban environments, in order to increase the quality of the final work, the permanence of the work and the environmental sustainability, by using methods without non-recyclable and/or eco-friendly materials. For that reason, it is necessary to define and compile the most suitable execution systems and placement methods for stone products.

The first task of the BIMstone project "O1. *Establishment of common learning outcomes on stone placing methods, Life Cycle Analysis (LCA) and regulations*" encompasses a number of specific tasks among which we find the elaboration of this report.

This best practice report addresses the establishment of skills and competencies, as well as the definition of the most sustainable and environmentally friendly implementation processes.

Of all the natural stone construction elements selected in this project, this report focuses on the construction of a specific case of traditional roofs in Croatia, describing in detail some of their characteristics, both constructive and environmental, and the construction process to be followed to achieve an optimum result.

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2. ENVIRONMENTAL CONSIDERATIONS

The Environmental Product Declarations (EPDs) are the clearest, most rigorous and internationally accepted way to provide the environmental profile of a product throughout its life cycle.

The EPD "***Umwelt-Produktdeklaration nach ISO 14025 für Schiefer Rathscheck Schiefer und Dach-Systeme***" include natural stone products which main function is for ornamental use to cover exterior surfaces, such as walls and roofs. It has been verified and published by IBU (www.bau-umwelt.com).

This declaration is an environmental product declaration according to / ISO 14025 / and describes the environmental performance of roof and facade slate products from Rathscheck Schiefer. It is intended to promote the development of environmentally and health-friendly construction. All relevant environmental data is disclosed in this validated declaration. The declaration is based on the PCR document "Schiefer", 2009-11.

The life cycle assessment was carried out in accordance with / DIN EN ISO 14040 / and / DIN EN ISO 14044 / the requirements of the IBU guide to type III declarations and the specific rules for slate. Specific data of the examined products as well as data from the "GaBi 4" database were used as the database. The life cycle assessment encompasses the life cycle stages of raw material and energy extraction, production including transport, and the production and thermal recycling of packaging.

Slate is a weather-resistant and ideally fissile rock, the predominant components of which are leaf silicates. Leaf silicates, on the other hand, consist of minerals, which are in the form of platelets in a very fine grain size and arranged in layers. Slate has extensive slate formation, which is the result of a very weak to weak rock metamorphosis due to tectonic pressure.

3. CONSTRUCTIVE CONSIDERATIONS

The construction process is based on the traditional Dalmatian roof construction methodology. Traditionally, the beams and battens are constructed from untreated cypress, spruce or cakes of silk. Once cut, the stakes are only peeled and protected from insects by smoking, without any further treatment.

In this report are described as traditional roofs in the Dalmatian region. Roofs of this type are usually built on smaller houses, but there are also examples of larger span roofs. Usually, such houses have walls made of rough-hewn stone and are built with or without the use of mortar.

Stone slabs are obtained by digging and clearing the land and are abundant in the karstic Dalmatia region.

The construction process envisaged in this report includes the construction of roofs without the use of mortar.

The roof covering starts by being covered from below using large and medium-sized planks, making sure that they are as regular as possible, rectangular in shape, especially the lower edge, which is well visible.

This means that the bottom line of the roof should be in the right direction, as regular as possible. The slab should cross the wall line 10-15 cm.

Smaller holes are covered with mortar spread with a higher proportion of lime, recommended 1:3:9 (cement: lime: stone aggregate fraction 0-4).

For the ridge construction process the slabs must be laid in two layers with an overlapping of the joints.

The boards are not glued with extended mortar, but extended mortar is used to fill all joints between the boards, but after stacking the entire roof "dry".

The filled joints are additionally treated with a steel brush.

After all, the entire roof is coated with a mixture of water and slaked lime in two layers to protect it from the weather, reduce heating and reduce the porosity of the stone slabs.

The slaked lime is diluted with water to such a consistency that the mixture can be applied with a brush.

The roofs are made as single or double slope roofs, but also as multi slope roofs.

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Single slope roof.

Double slope roof.

Multi slope roof.

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Example of a bigger roof.

Example of a bigger roof.

Multiple roofs.

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4. CONSTRUCTION PROCESS

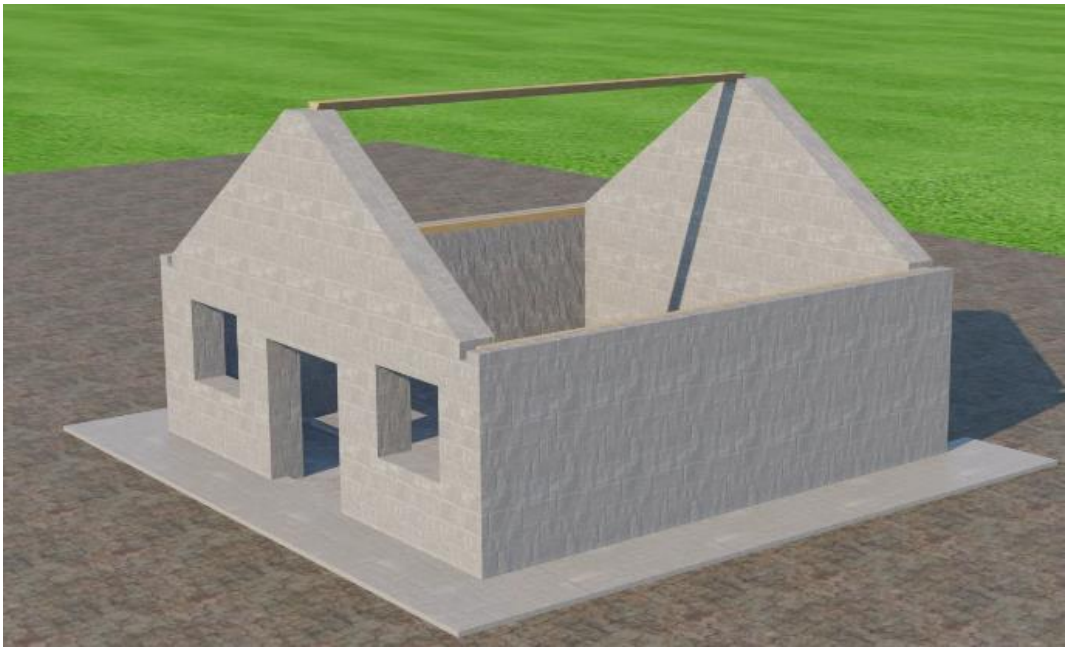
4.1 Laying of vertical beams

Longitudinal beams are installed on the walls from the inside. The beams are approximately 15 / 15cm in cross-section and are harvested from local trees: spruce, deaf or cypress.
It is also possible to make roofs without them.

Now the wooden stakes are being installed, which are supported on the underside on a longitudinal beam and on the upper side are resting on the ceiling beam. The stakes are also harvested from cypress, spruce or deaf. They are spaced approximately two spans apart.

In cases where the ceiling beam is to be slightly relieved (larger spans), the stakes are used which, on the upper side, have a part where the branches (horns) branch, which serves as a support for the ceiling beam.

This way, a part of the load is taken by the stakes and carried over the longitudinal beam onto the walls.
This is recommended to be done only in the case when the longitudinal beam is made because of the load distribution to the wall.



Source: BIMstone project website.

On finished gable walls, ceiling beam is laid in the middle from the inside, so it is attached onto the walls for at least 20 cm.
The ceiling beam is harvested from larger trees in the way that its cross-section at the narrowest part is at least 15 cm.

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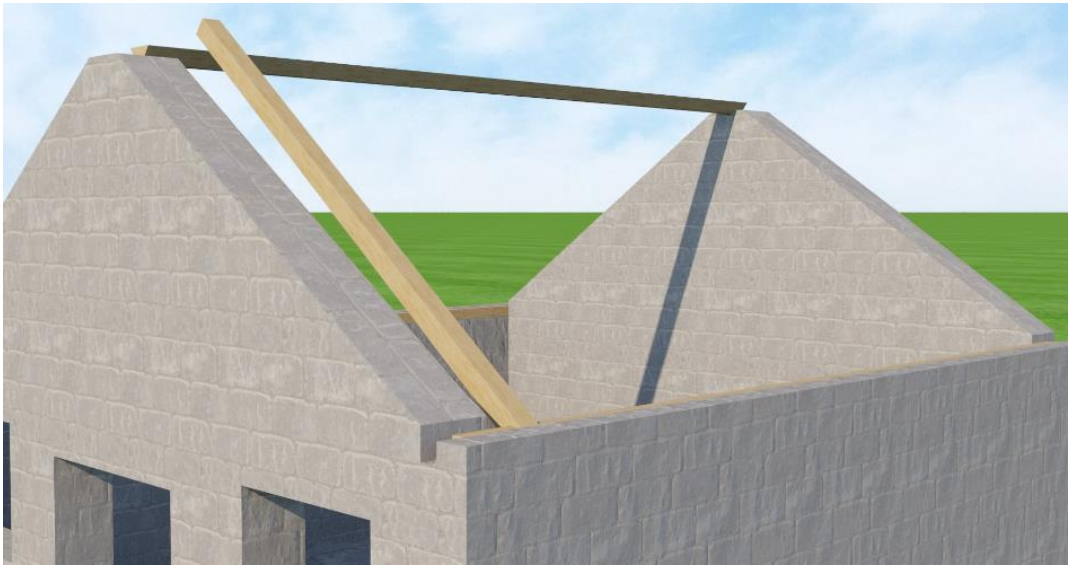
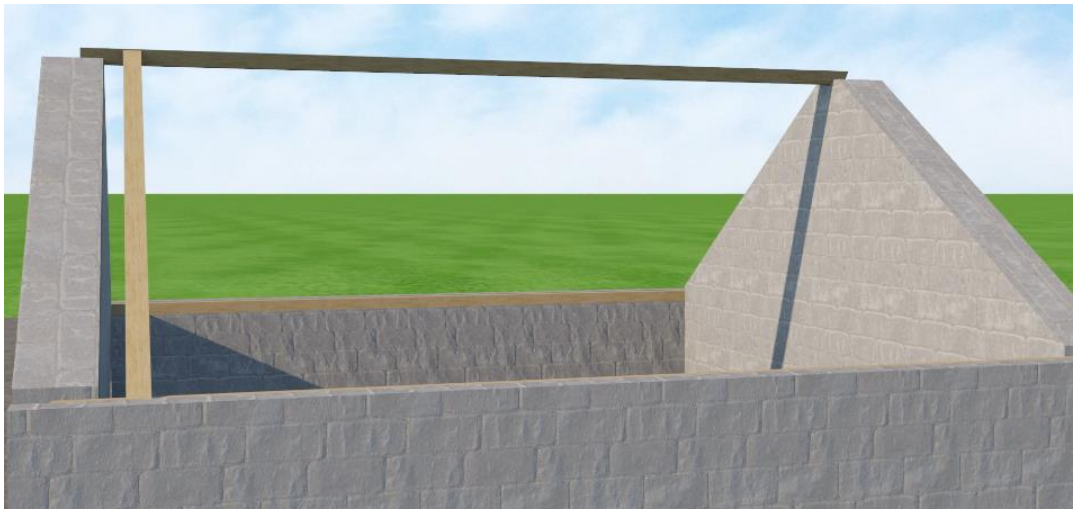
The ceiling beam is made as a supporting beam. It takes most of the roof load and transferring it to the gable walls. This reduces the stresses on the longitudinal walls caused by the horizontal load component. This is important because the walls are constructed as dry walls, and do not have a reinforced concrete cornice which has the function of assuming horizontal forces. It is in our interest to load such walls as far as possible to the vertical compressive stresses and to reduce the horizontal ones, which is why roofs are made of slightly higher slopes. Higher slopes are also performed to prevent leakage of the roof, since such roofs have plenty of joints, but up to a maximum of 45 ° to prevent the slabs from slipping.

If the span is larger than 5 - 6 meters, depending on the cross-section of the ceiling beam, it must be supported by a vertical pole (stick) in the middle of the span, if the cross-section of the ceiling beam is the same in each spot. If the cross-section of the ceiling beam varies from larger to smaller, then it is supported at a third of the distance from the wall on the thinner part of the beam.





Source: BIMstone project website.

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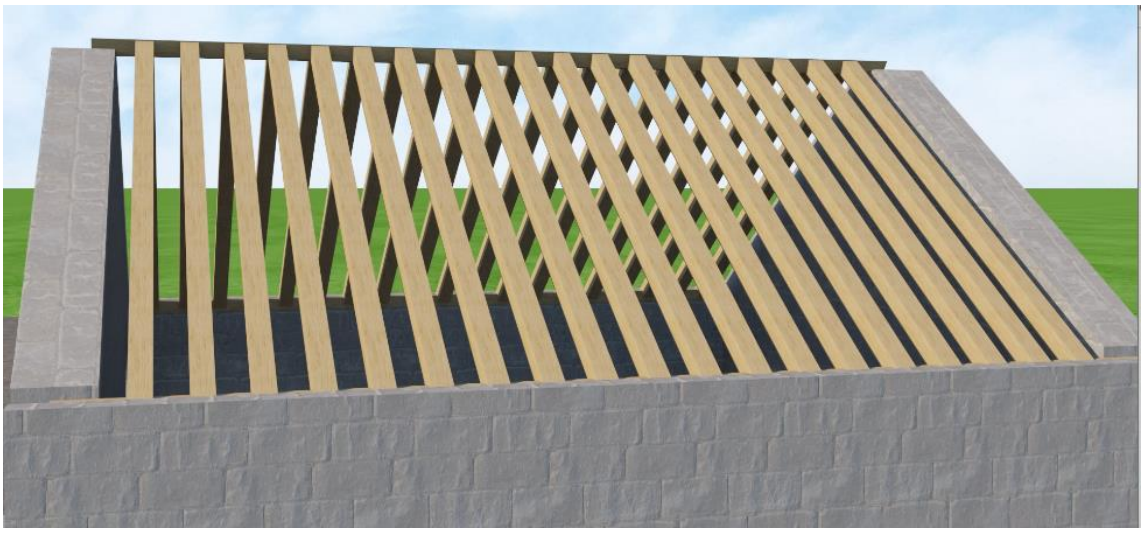
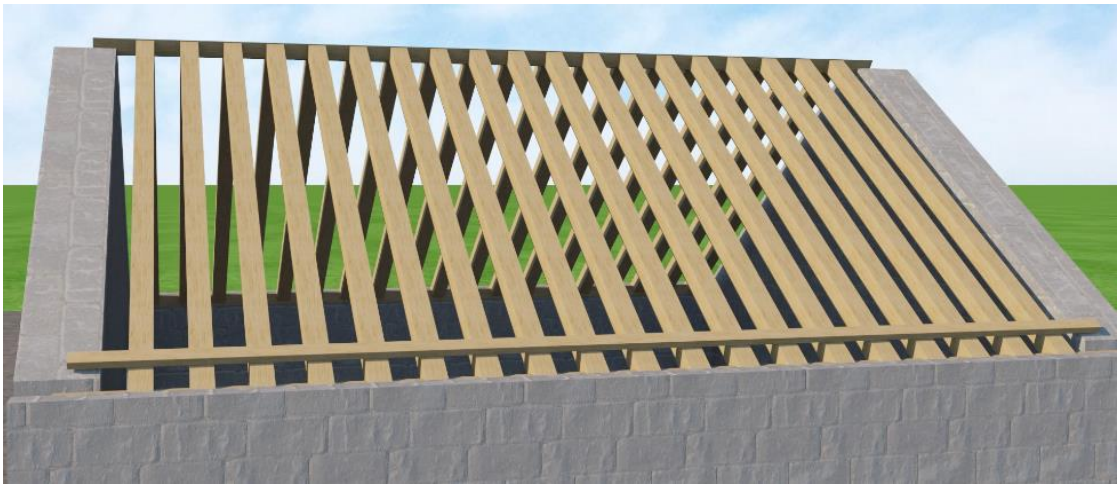


Source: BIMstone project website.

4.2 Laying of horizontal battens

Setting up of the stakes is followed by the installation of thin longitudinal stakes on which the stone slabs rely. These stakes are placed at a distance of one span above each other attached by nails. For easier nailing, it is advisable that the stakes are not completely dry. These stakes are also harvested from spruce or deaf and ash.

Roofing without longitudinal stakes is also possible. In this type of roofing, the stakes are placed at a distance of one span and the stone slabs lie on it.



Source: BIMstone project website.

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Source: BIMstone project website.

Once the batten has been placed at the desired height, it is nailed to the structure along its entire length.

Source: BIMstone project website.

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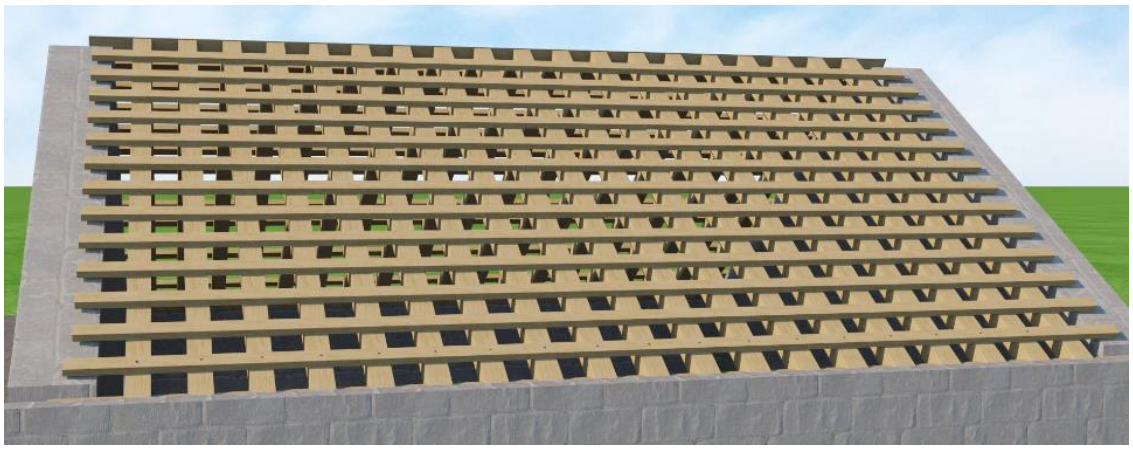
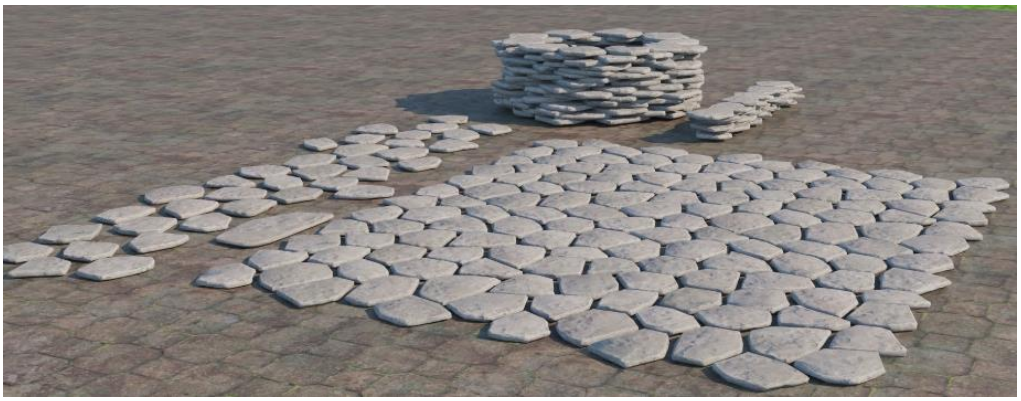


Source: BIMstone project website.

4.3 Selection and classification of stone pieces

The stone pieces to be assembled are selected and classified so that their installation is as regular as possible in size and distribution.
The main function of the smaller slabs is to stabilise the larger slabs that could not be placed correctly due to their shape and geometry.



Source: BIMstone project website.

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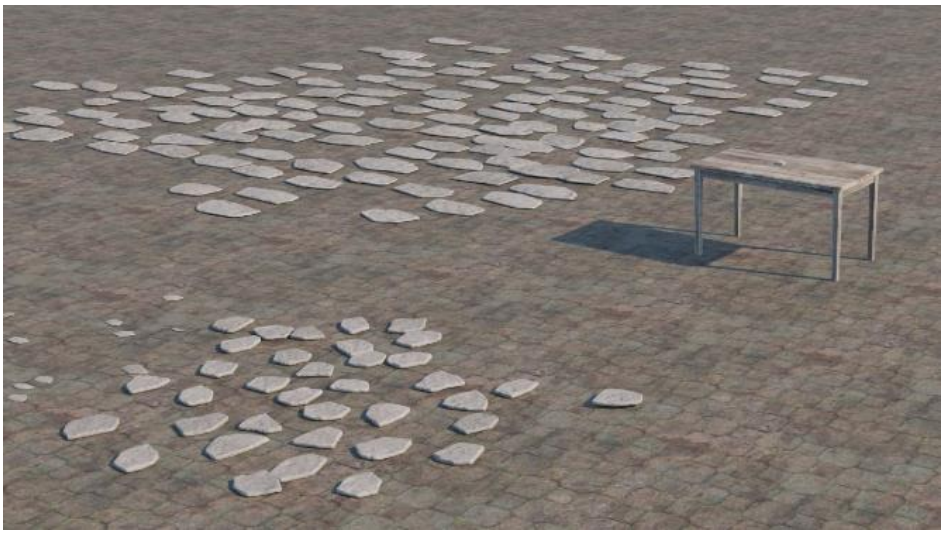

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4.4 Laying stone slabs

Roofing starts by placing the slabs lean against the wall so that they are put out of the wall approximately 5 cm when there is a drainage channel and at least 10 cm if there isn't a channel. For the first row, larger slabs of the rectangular shape are selected.

The visible front edges and side edges of the slab should be straight and for that reason they can be hewn slightly with a hand tool. The masonry rope is pulled out so that the bottom row follows the direction.

This is followed by the placement of the second row also with larger slabs making them indrawn 2-3 cm in regard to the first row or aligned with the leading edge of the first row. The second row is placed above the joints of the first row.
The third row again goes over the second-row joints, pulling back about 1/3 of the length of the bottom row of slabs.

The first three rows are placed under a slight inclination assuring the load above is effectively transferred onto the wall and to prevent the above slabs from slipping off the wooden structure. With each successive row it gets steeper until the slope of the wooden roof structure and gable walls begin to align.

Roofs of this type are quite massive due to the weight of the stone slabs and the dense overlaps of the rows, especially in the lower part at the roof and wall junction. The massiveness of the front rows also favorably counteracts the effects of wind.

Each row of slabs should overlap the joints of the previous row by approximately 2/3 of its length by folding the back of the slabs which are below those joints, as far as possible.
It is important that the back of each slab must rest on a stake or on a thin longitudinal stake if the roof is made this way.
It is also important that the slabs adhere to each other as much as possible.

Source: BIMstone project website.

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Source: BIMstone project website.

4.5 Filling of gaps with smaller stone pieces

Each gap is filled with smaller pieces of stone slabs which are also used for underlaying for better support, or where the stone plate does not fit well, because their thickness varies.

Smaller pieces are also used to insert irregularly shaped plates above them to fill the voids to prevent water from drawning in and to assure that the upper row fits more properly into the lower one.
This is how the plates stack up to the plates' junction on the opposite side.

Source: BIMstone project website.

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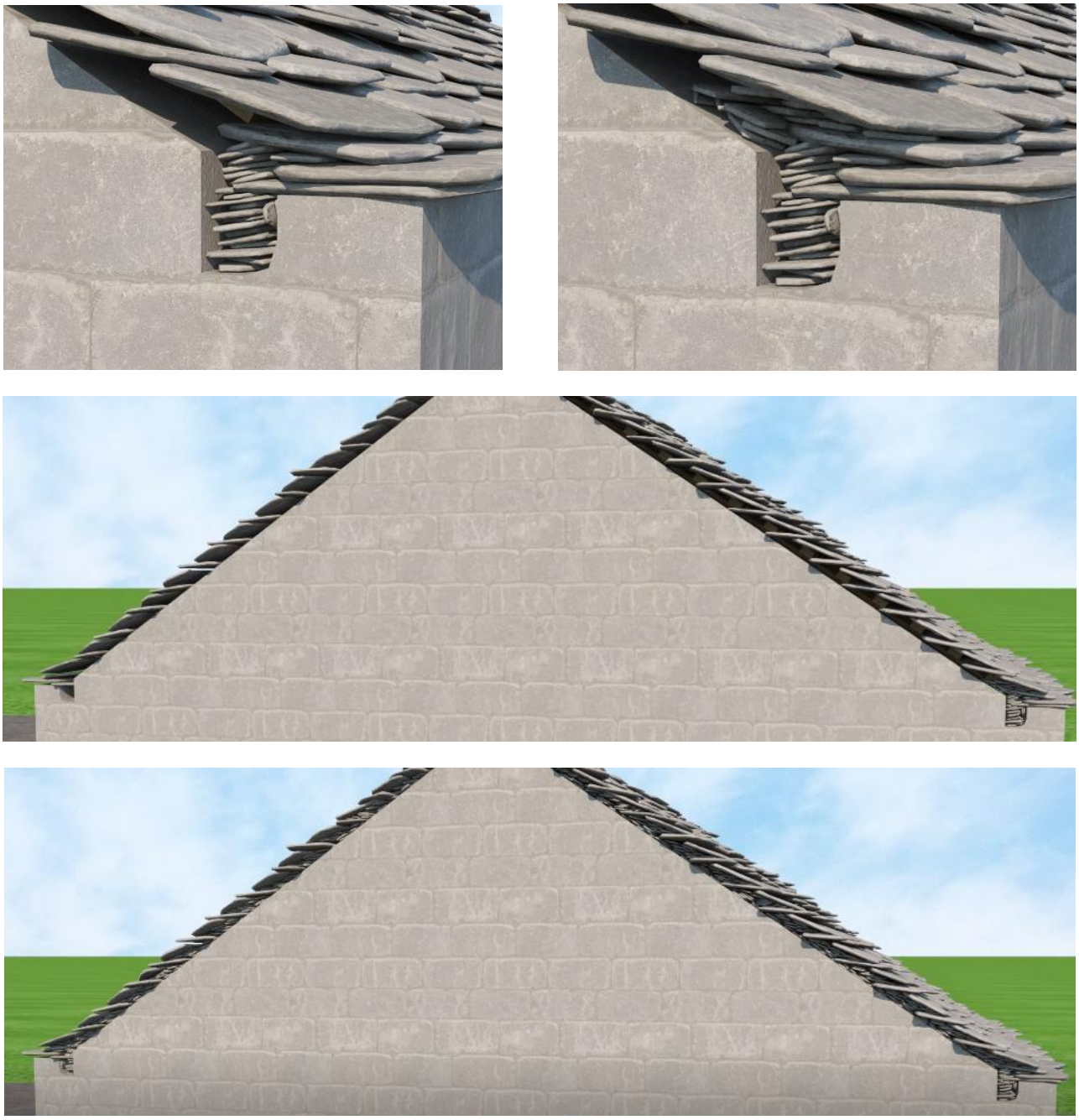

Source: BIMstone project website.

4.6 Finishing of the joint in the ridge

There are two ways to complete a joint in the ridge.

First way:
The back of the last row of slabs is aligned with the back of the previous row at the level of the ceiling beam top.

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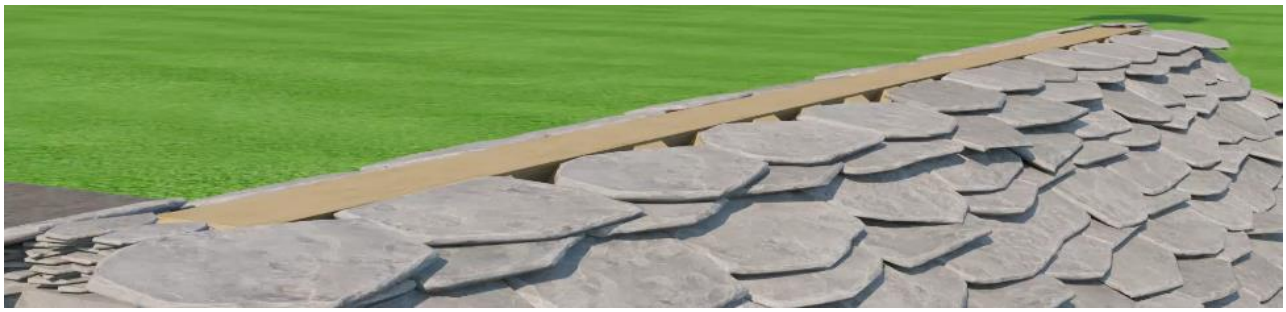
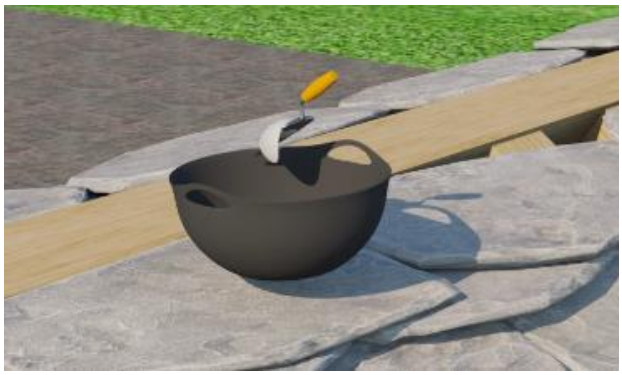
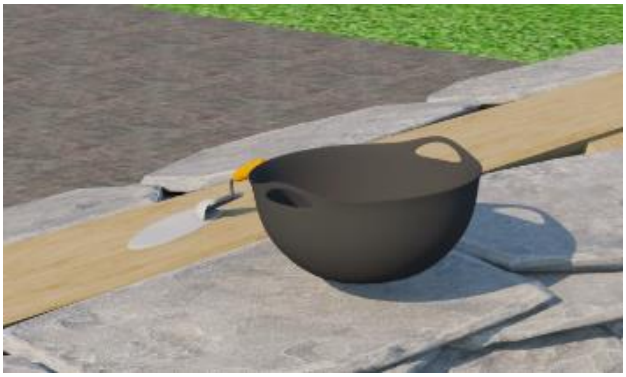
The joint is finished by placing the stone plates above the ceiling beam, lenght-wise, so that the boards adhere to each other as closely as possible, and another row of stone plates is placed above to cover the lower row joints. This type of ridge is massive and relatively resistant to wind and rain conditions.

Second way:
The last row of plates of a roof surface facing the direction of the dominant wind in certain areas and the frequent rainfall direction, extends beyond the joint with the plates on the opposite side of the roof by approximately one span.







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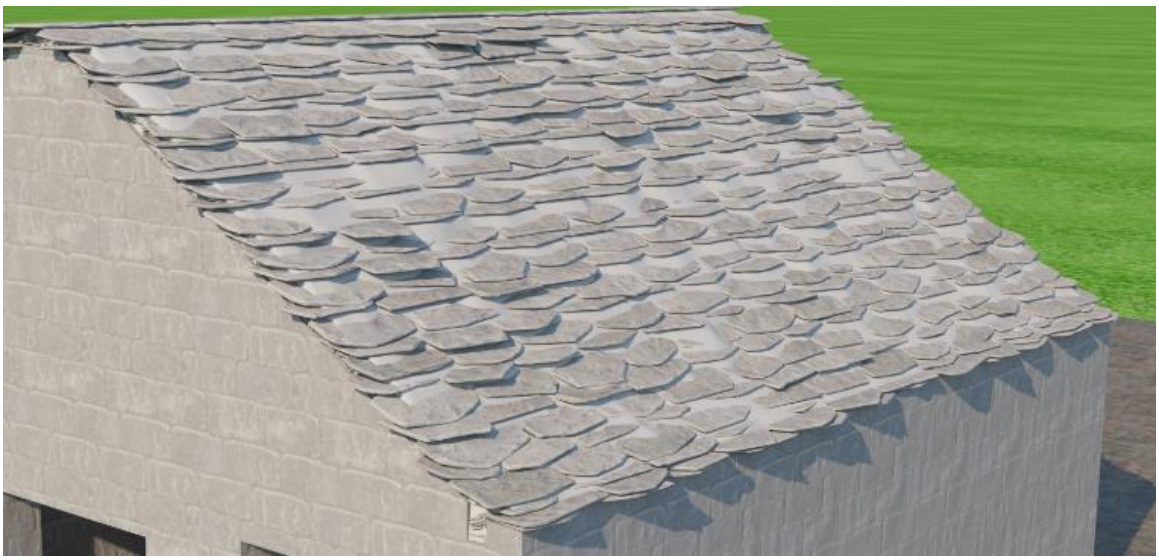

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5. SUMMARY. STEPS TO FOLLOW IN THE CONSTRUCTIVE PROCESS

The construction processes of a traditional roof in Croatia are summarised below:

1. Laying of vertical beams.
2. Laying of horizontal battens.
3. Selection and classification of stone pieces.
4. Laying stone slabs.
5. Filling of gaps with smaller stone pieces.
6. Finishing of the joint in the ridge.

6. REFERENCES

1. BIMstone project website. www.bimstoneproject.eu/bimstone-products

2. Umwelt-Produktdeklaration nach ISO 14025 für Schiefer Rathscheck Schiefer und Dach-Systeme. IBU – Institut Bauen und Umwelt e.V.

3. Video “07. Traditional roof. Croatian constructive method” of BIMstone project. https://youtu.be/sSGUY6g3EwM