REPORT 1.2.8

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

CONSTRUCTION PROCESS OF A LARGE-FORMAT ASHLAR OF NATURAL STONE FAÇADE

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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 large-format ashlar of natural stone façade, 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 "***Jura Limestone façade panels and wall cladding (Fassaden- und Wandplatten aus Jura Kalkstein)***" include natural stone products which main function is for ornamental use to cover interior and exterior surfaces, such as floors, walls, facades, stairs, etc. and has been verified and published at https://ibu-epd.com.

The EPD of limestone slabs has been carried out according to the LCA methodology with quantified environmental information of its entire life cycle. That is to say, the EPD of these materials is of the "cradle to door" type, as can be seen in the following table, which includes the life cycle stages considered.

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; MND = MODULE NOT DECLARED)																
PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	MND	MND	X	MNR	MNR	MNR	MND	MND	MND	MND	MND	X	MND

Source: IBU - Institut Bauen und Umwelt e.V.

This EPD has been developed and verified according to the EN 15804 and EN ISO 14025 standards and the Product Category Rules (PCR) for marble and limestone slabs used in the building construction.

The EPD functional unit is defined as 1 tonne of mass of natural stone (corresponds to 12.82 m², 30 mm thick). The scope of the study has been defined from the cradle to the door, covering only the manufacturing module (extraction and preparation of the raw materials, processing of the natural stone slabs and transport between these stages).

The EPD details the formulation to be used (conversion factor) to transform the functional unit from a tonne of mass of natural stone to a square meter of facade.

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Factors for calculating results for different thicknesses:

Parameter	1 t (corresponds to 19,23 m² of 20 mm thickness)	1 t (corresponds to 12,82 m² of 30 mm thickness)	1 t (corresponds to 9,62 m² of 40 mm thickness)
GWP	1,29	1,00	0,85
ODP	1,37	1,00	0,81
AP	1,18	1,00	0,90
EP	1,19	1,00	0,90
POCP	1,27	1,00	0,86
ADPE	1,41	1,00	0,78
ADPF	1,31	1,00	0,85
PERT	1,36	1,00	0,79
PENRT	1,31	1,00	0,84

Source: IBU - Institut Bauen und Umwelt e.V.

The results of the LCA – Environmental Impact are:

RESULTS OF THE LCA - ENVIRONMENTAL IMPACT: 1 t Jura Limestone façade panels and wall cladding (corresponds to 12.82 m², 30 mm thick)

Parameter	Unit	A1-A3	A4	B2	C4
Global warming potential	[kg CO_2-Eq.]	59.90	4.73	0.04	16.14
Depletion potential of the stratospheric ozone layer	[kg CFC11-Eq.]	6.33E-11	6.00E-13	2.21E-9	1.52E-11
Acidification potential of land and water	[kg SO_2-Eq.]	1.80E-1	1.96E-2	9.75E-5	9.54E-2
Eutrophication potential	[kg $(PO_4)^{3-}$-Eq.]	2.72E-2	4.84E-3	6.26E-5	1.30E-2
Formation potential of tropospheric ozone photochemical oxidants	[kg ethene-Eq.]	1.25E-2	-7.24E-3	2.47E-5	7.51E-3
Abiotic depletion potential for non-fossil resources	[kg Sb-Eq.]	8.61E-5	4.92E-7	-6.13E-9	5.79E-6
Abiotic depletion potential for fossil resources	[MJ]	842.44	64.26	0.59	208.74

RESULTS OF THE LCA - RESOURCE USE: 1 t Jura Limestone façade panels and wall cladding (corresponds to 12.82 m², 30 mm thick)

Parameter	Unit	A1-A3	A4	B2	C4
Renewable primary energy as energy carrier	[MJ]	1188.26	4.25	0.15	25.24
Renewable primary energy resources as material utilization	[MJ]	0.00	0.00	0.00	0.00
Total use of renewable primary energy resources	[MJ]	1188.26	4.25	0.15	25.24
Non-renewable primary energy as energy carrier	[MJ]	850.92	64.45	0.61	216.11
Non-renewable primary energy as material utilization	[MJ]	14.29	0.00	0.00	0.00
Total use of non-renewable primary energy resources	[MJ]	865.22	64.45	0.61	216.11
Use of secondary material	[kg]	0.00	0.00	0.00	0.00
Use of renewable secondary fuels	[MJ]	0.00	0.00	0.00	0.00
Use of non-renewable secondary fuels	[MJ]	0.00	0.00	0.00	0.00
Use of net fresh water	[m³]	2.02	0.00	0.01	0.04

RESULTS OF THE LCA – OUTPUT FLOWS AND WASTE CATEGORIES: 1 t Jura Limestone façade panels and wall cladding (corresponds to 12.82 m², 30 mm thick)

Parameter	Unit	A1-A3	A4	B2	C4
Hazardous waste disposed	[kg]	1.32E-5	4.06E-6	1.12E-5	3.42E-6
Non-hazardous waste disposed	[kg]	1.35E+3	4.70E-3	8.28E-3	1.00E+3
Radioactive waste disposed	[kg]	9.03E-3	7.40E-5	5.89E-6	2.92E-3
Components for re-use	[kg]	0.00	0.00	0.00	0.00
Materials for recycling	[kg]	0.00	0.00	0.00	0.00
Materials for energy recovery	[kg]	0.00	0.00	0.00	0.00
Exported electrical energy	[MJ]	0.00	0.00	0.00	0.00
Exported thermal energy	[MJ]	0.00	0.00	0.00	0.00

Source: IBU - Institut Bauen und Umwelt e.V.

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3. CONSTRUCTIVE CONSIDERATIONS

Masonry is the name given to the traditional construction system that consists of erecting walls and facings, for various purposes, by placing elements made, in this case, of natural stone.

Natural stone stands out for its variety of colours, finishes, textures, formats, as well as its originality, great resistance and durability. In terms of energy efficiency, they stand out for their thermal resistance and the maintenance of the temperature inside, which means significant energy savings.

This system allows a reduction in the waste of materials used and generates load-bearing facades; it is suitable for constructions of great heights. Most of the construction is structural.

The arrangement and interlocking of the materials used in the walls is called rigging. Nowadays, a mortar of cement and sand with the addition of a suitable quantity of water is generally used to join the pieces together.

The exposure conditions on facades, foundations, etc., where water may be present on at least one side of the wall, whether the wall is load bearing or not, entails the need for low permeability and absorption units in order to prevent water ingress through the wall.

Of course, this phenomenon is greatly reduced when the wall is additionally protected by means of plasters, paints, water repellents, etc.

From the point of view of strength, this is not a critical factor, as long as it is weather resistant and stable over time.

When choosing a variety of stone for a given project, it is necessary to know its project, it is necessary to know its characteristics obtained through laboratory tests.

Natural stone used for facades must be subjected to dimensional, resistance, absorption, sensitivity to changes due to thermal cycles, frost, impact, salt crystallisation and reaction controls.

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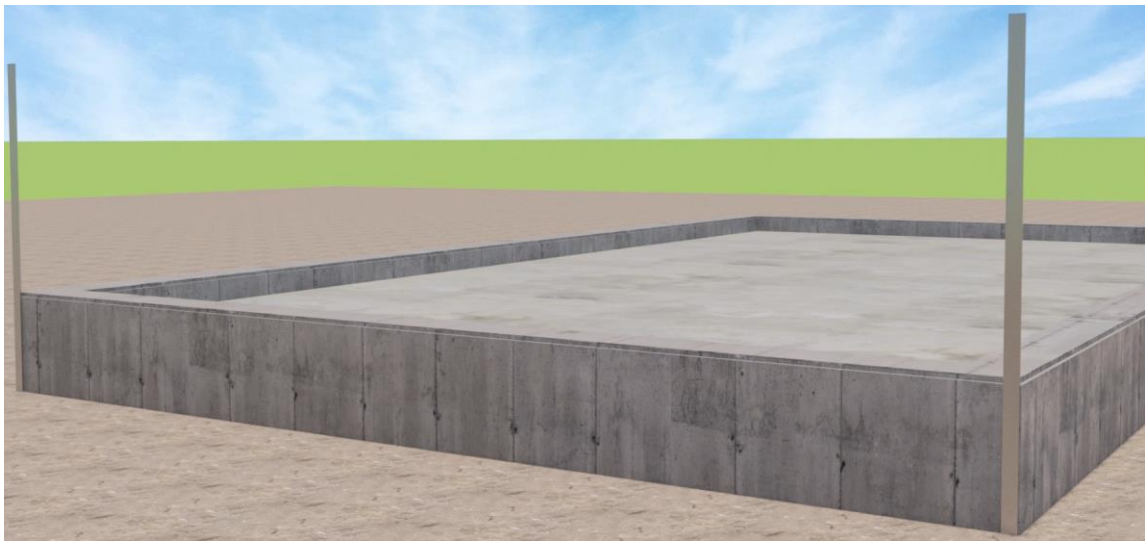
4. CONSTRUCTION PROCESS

4.1 Placement of the guides

On the foundation surface that has already been laid, four guide cores are placed at the corners of each wall to be built.



Source: BIMstone project website.

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Once the guide battens have been placed at the ends of each wall, a level guide rope is placed to mark the depth limit at which the first row of ashlars should be placed.

Source: BIMstone project website.

4.2 Layout of first row of natural stone ashlars

With the appropriate machinery, the natural stone blocks are moved and placed on site.

The anchoring devices, machinery and equipment used for this purpose must comply with the established regulations to ensure a correct transfer in compliance with safety requirements.

Source: BIMstone project website

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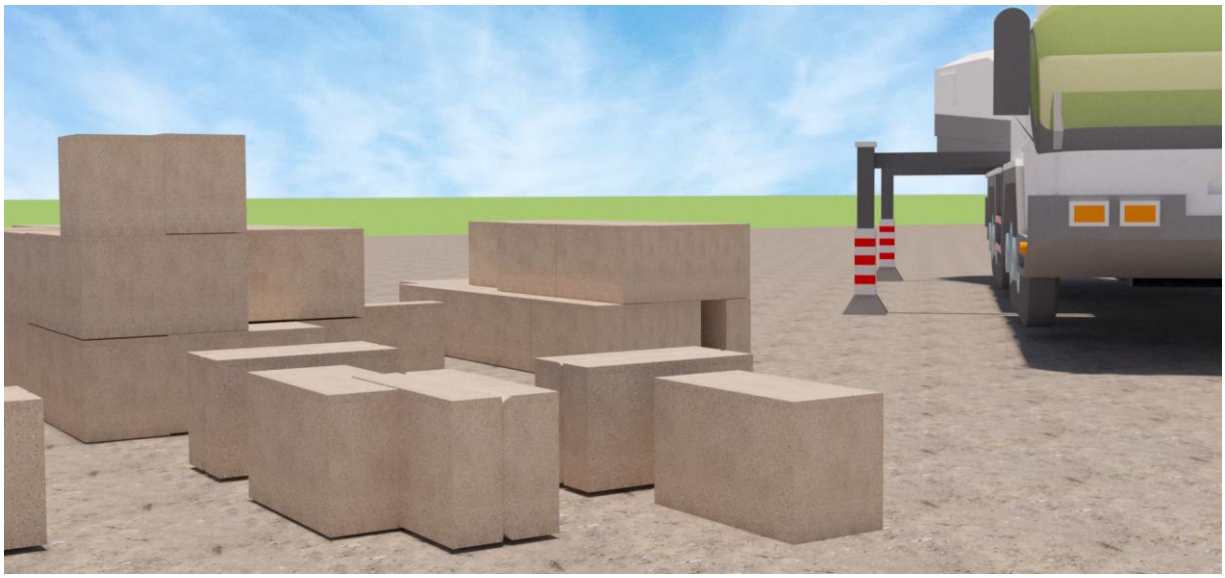

Source: BIMstone project website.

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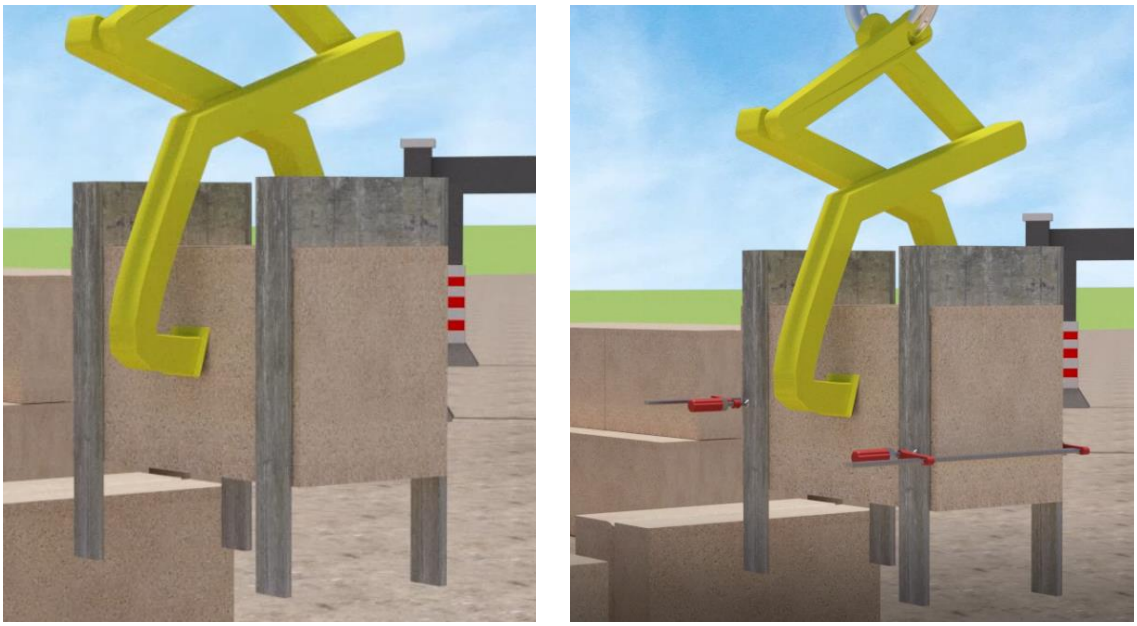
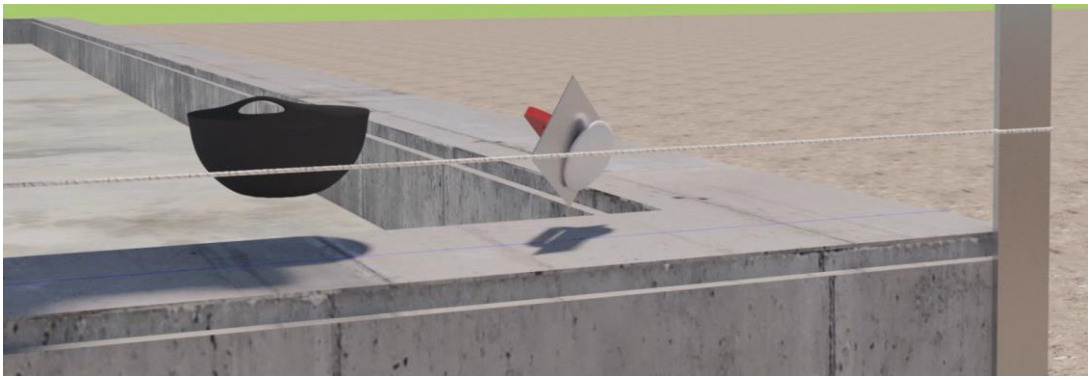


Source: BIMstone project website.

The first natural stone ashlar to be laid is the corner. To do this, a layer of adhesive mortar is applied to the laying surface with the help of a trowel.



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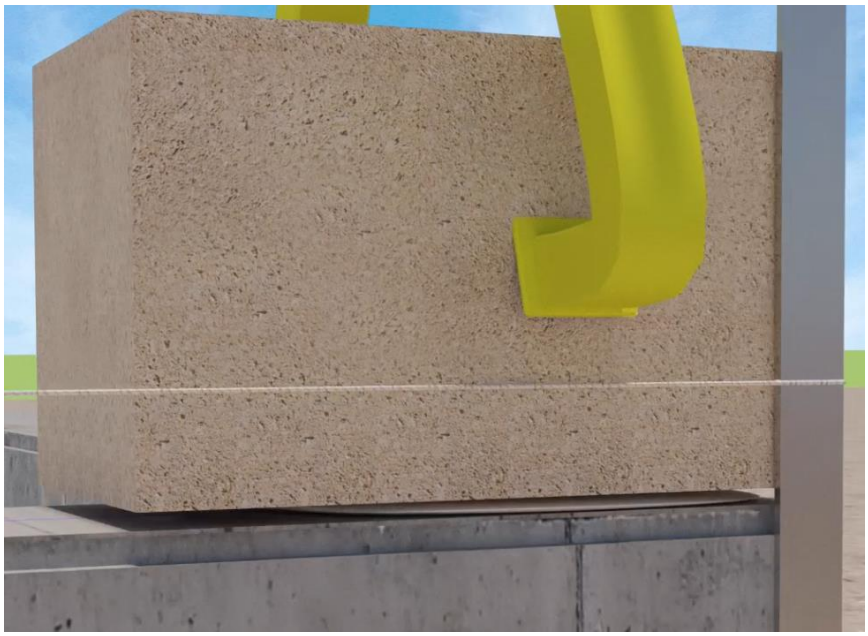
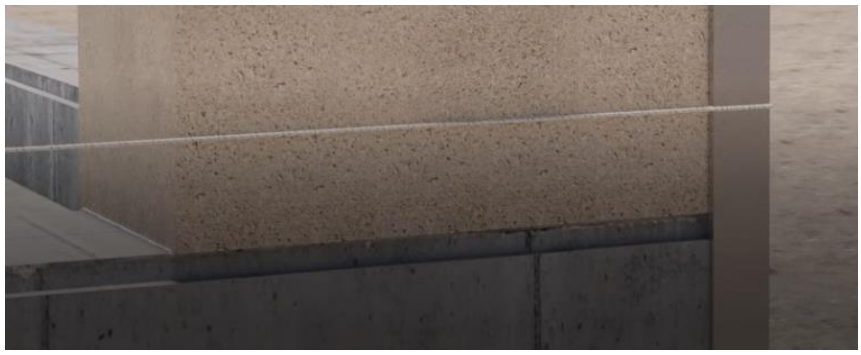


Source: BIMstone project website.

The excess material is removed with the help of a trowel.



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Following the same procedure, the laying of all the natural stone ashlars of the first row is completed.
It must be considered that to place two consecutive pieces, a layer of adhesive mortar must be applied to the side of the ashlar to be placed, with the aim of fixing it to the consecutive one.

Source: BIMstone project website.

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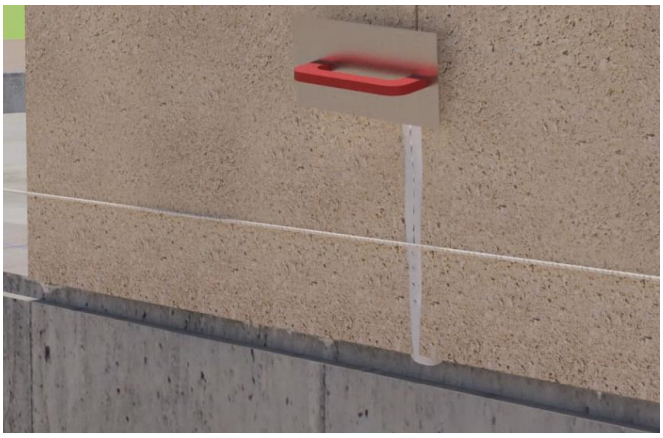
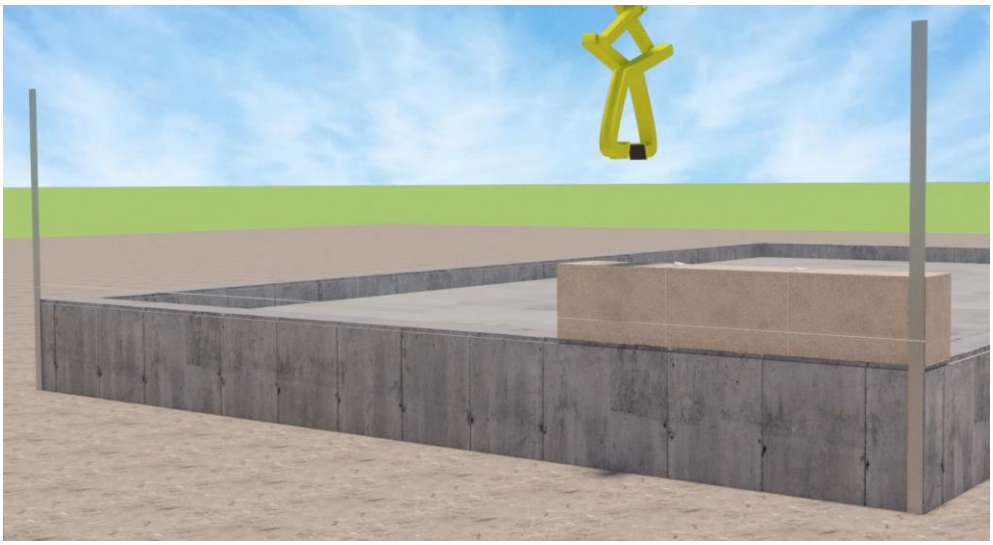
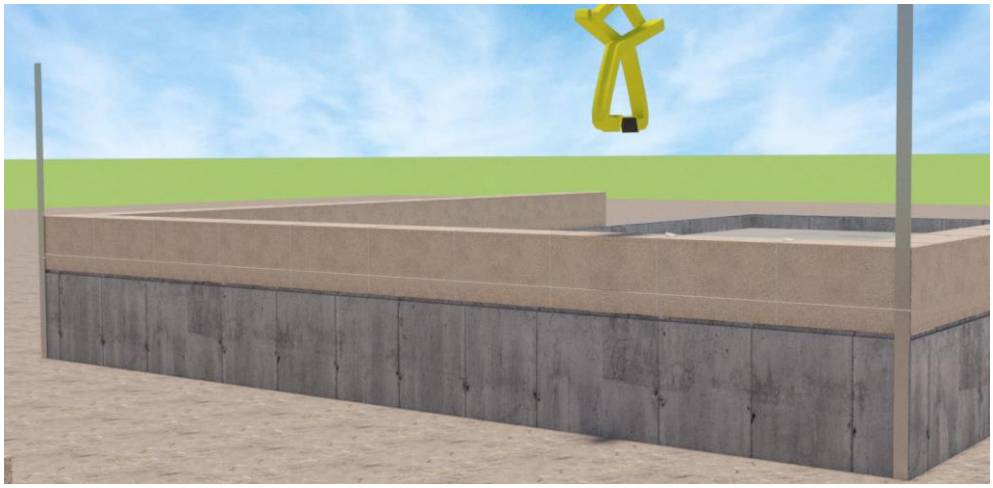
Likewise, the joints between ashlars will be sealed with mortar.







Source: BIMstone project website.

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4.3 Lifting of the guide rope for laying successive rows of ashlars

Once the first row of ashlars has been placed, the second and consecutive rows are placed. To do this, it is necessary to raise the guide rope to the height of the desired line, in order to mark the depth again.

Source: BIMstone project website.

4.4 Laying of the remaining courses of the ashlar walls

As with the first line, the rest of the rows of natural stone ashlars are placed, always starting with the corner pieces.

The application of adhesive mortar guarantees the fixing of the ashlars. On the same line as the first row, the excess adhesive must be removed with the help of a trowel.

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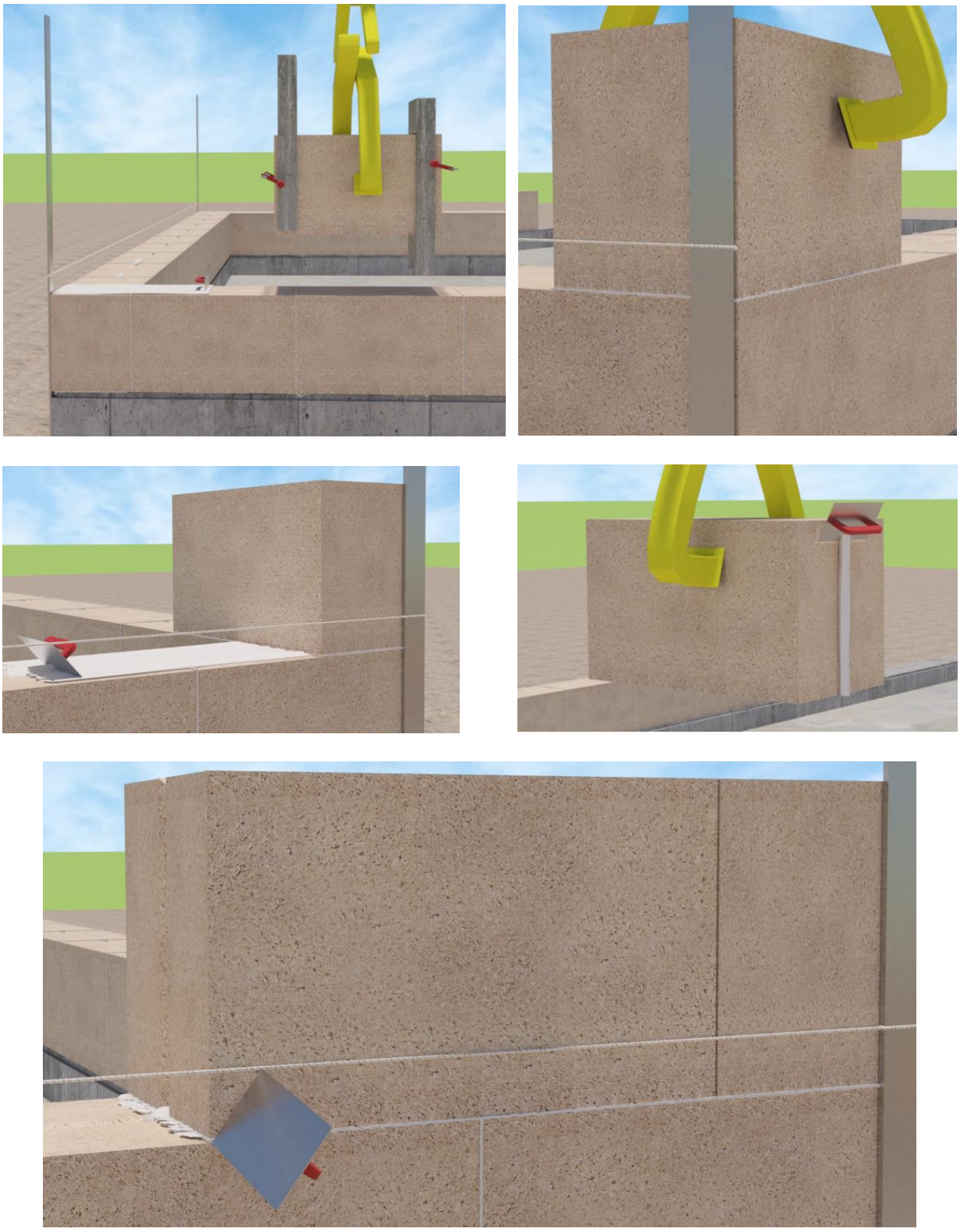

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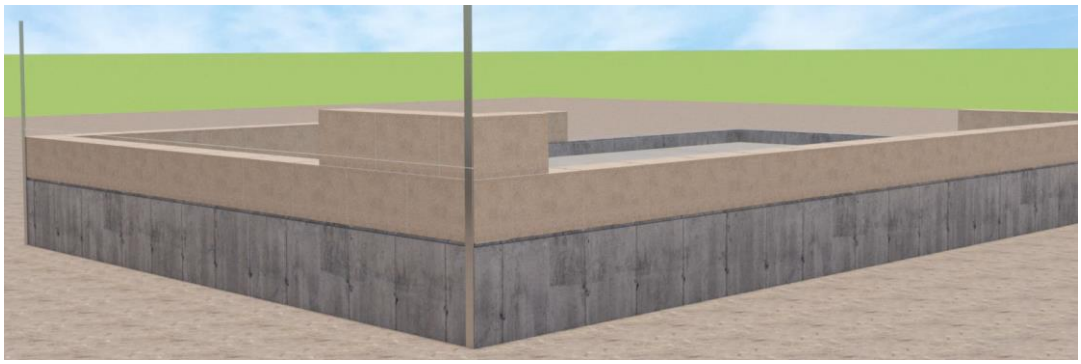

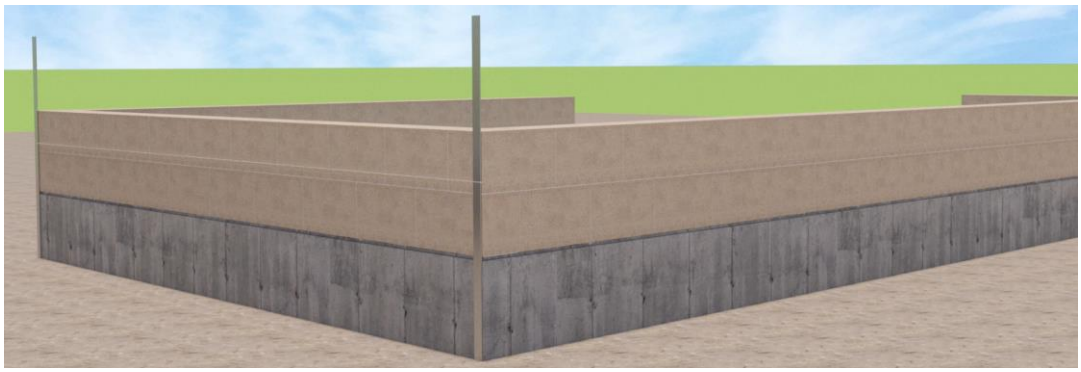

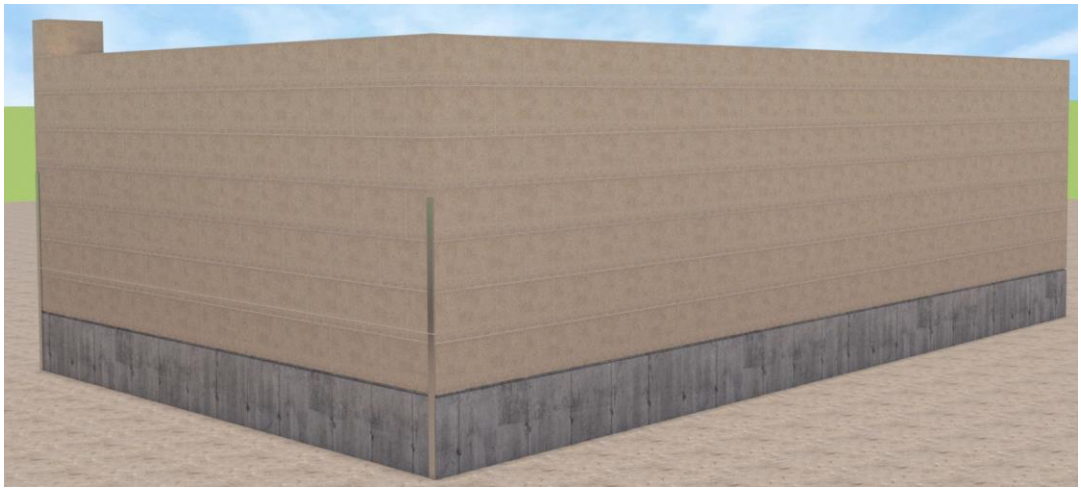

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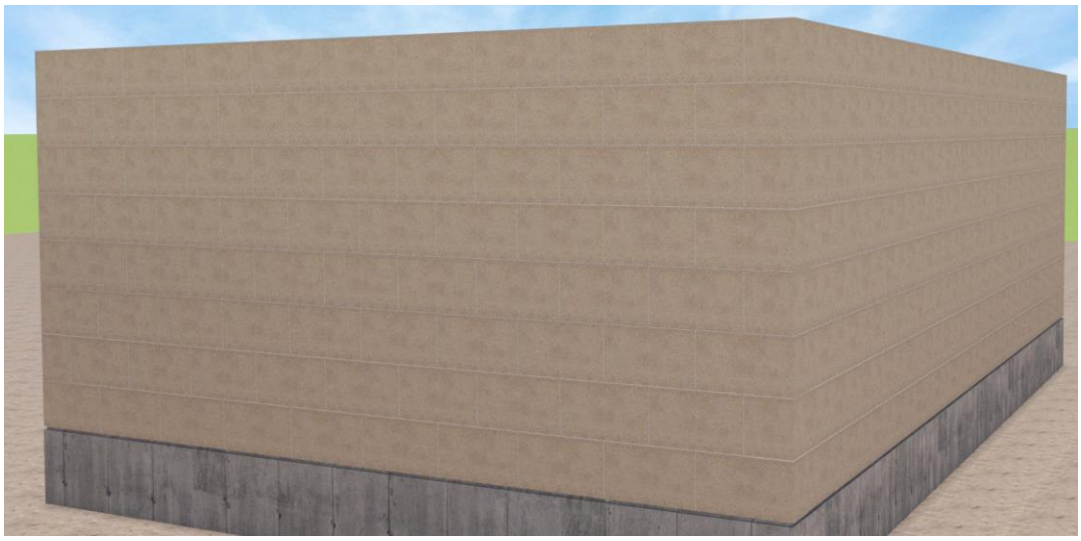
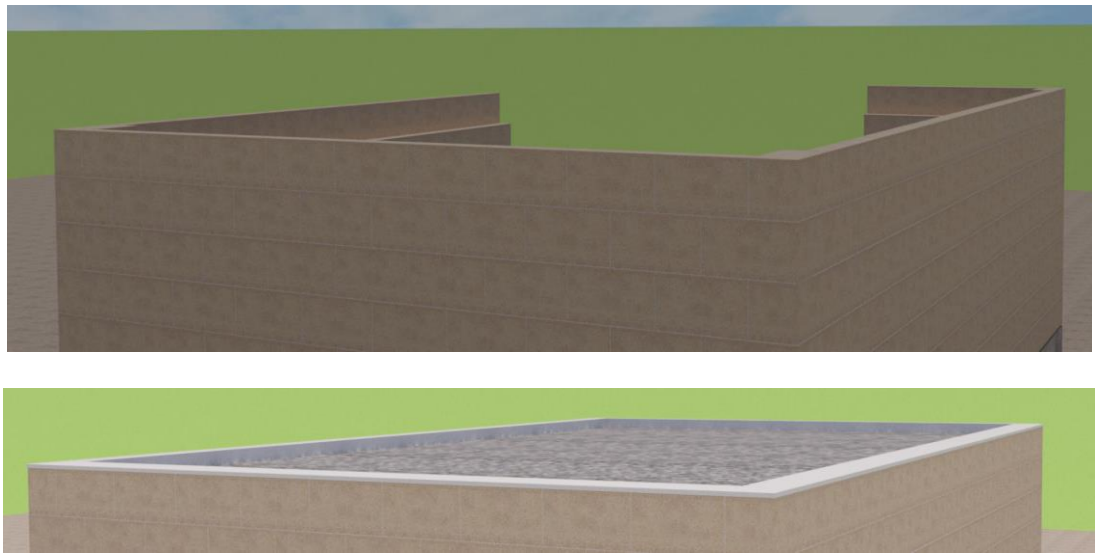


Source: BIMstone project website.

4.5 Laying of the last row for the roof execution

To complete the construction of the façade, the last row of the façade wall is then finished, using the same procedure, to subsequently build the roof.



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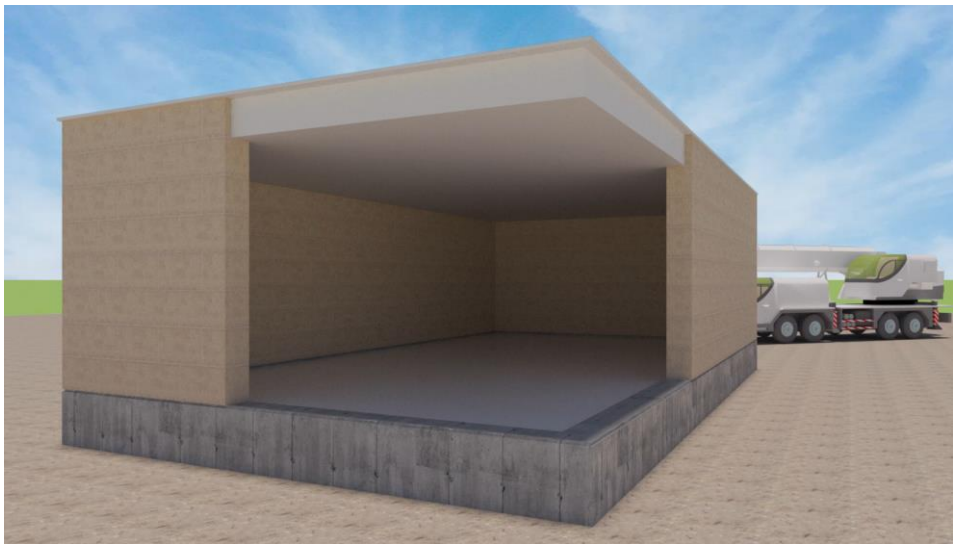

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5. SUMMARY. STEPS TO FOLLOW IN THE CONSTRUCTIVE PROCESS

The construction processes of construction of a large-format ashlar of natural stone façade are summarised below:

1. Placement of the guides.
2. Layout of first row of natural stone ashlars.
3. Lifting of the guide rope for laying successive rows of ashlars.
4. Laying of the remaining courses of the ashlar walls.
5. Laying of the last row for the roof execution.

6. REFERENCES

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

2. *Jura Limestone façade panels and wall cladding. Franken-Schotter GmbH & Co. KG. Environmental Product Declaration. IBU – Institut Bauen und Umwelt e.V.* https://epd-online.com/EmbeddedEpdList/Download/10098

3. Video “08. Large-format ashlar façade” of BIMstone project. https://youtu.be/3vK9A8fvBAI