BIM STONE

BIM learning application focused on LCA qualification and technification of workers in natural stone sector

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REPORT 1.2.5

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

CONSTRUCTION PROCESS OF NATURAL STONE EXTERIOR FLOORING (PLACEMENT WITHOUT MORTAR)

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Content

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 placing of an exterior flooring without mortar, describing in detail some of their characteristics, both constructive and environmental, and the construction process to be followed to achieve an optimum result.

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 "***Tablas de mármol y caliza (marble and limestone slabs)***" 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 in AENOR's GlobalEPD program.

The EPD of marble and 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.

Etapa de producto	A1	Suministro de materias primas	X
	A2	Transporte a fábrica	X
	A3	Fabricación	X
Construcción	A4	Transporte a obra	MNE
	A5	Instalación / construcción	MNE
Etapa de uso	B1	Uso	MNE
	B2	Mantenimiento	MNE
	B3	Reparación	MNE
	B4	Sustitución	MNE
	B5	Rehabilitación	MNE
	B6	Uso de energía en servicio	MNE
	B7	Uso de agua en servicio	MNE
Fin de vida	C1	Deconstrucción / demolición	MNE
	C2	Transporte	MNE
	C3	Tratamiento de los residuos	MNE
	C4	Eliminación	MNE
	D	Potencial de reutilización, recuperación y/o reciclaje	MNE

X = Módulo incluido en el ACV; NR = Módulo no relevante; MNE = Módulo no evaluado

Tabla 1. Límites del sistema. Módulos de información considerados

This EPD has been developed and verified according to the UNE-EN 15804:2012+A1:2014 and UNE-EN ISO 14025:2010 standards and the Product Category Rules (PCR) for marble and limestone slabs used in the construction of AENOR's GlobalEPD programme.

The EPD functional unit is defined as 1 tonne of mass of natural stone. 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 flooring.

3. CONSTRUCTIVE CONSIDERATIONS

The system of big format natural stone floor realization without mortar, starts from some premises that constitute determinant advantages from a sustainable point of view.
These include:

- The reversibility of the system, by the fact that no mortar is used.
- The possibility to easily recover and reuse the component layers, especially the finished layer of natural stone.
- The permeability to precipitations of the system including water evaporation, ensuring soil and groundwater of their natural qualities, thus following the natural cycle of water in nature.

The configuration and dimensioning of the component layers of the floor system mainly imposes the action on uniformly distributed or concentrated gravitational forces, which are distributed on the natural terrain.

Thus, from a static point of view, since the whole system is placed directly on the ground, complex and expensive works are not necessary to stabilize it.

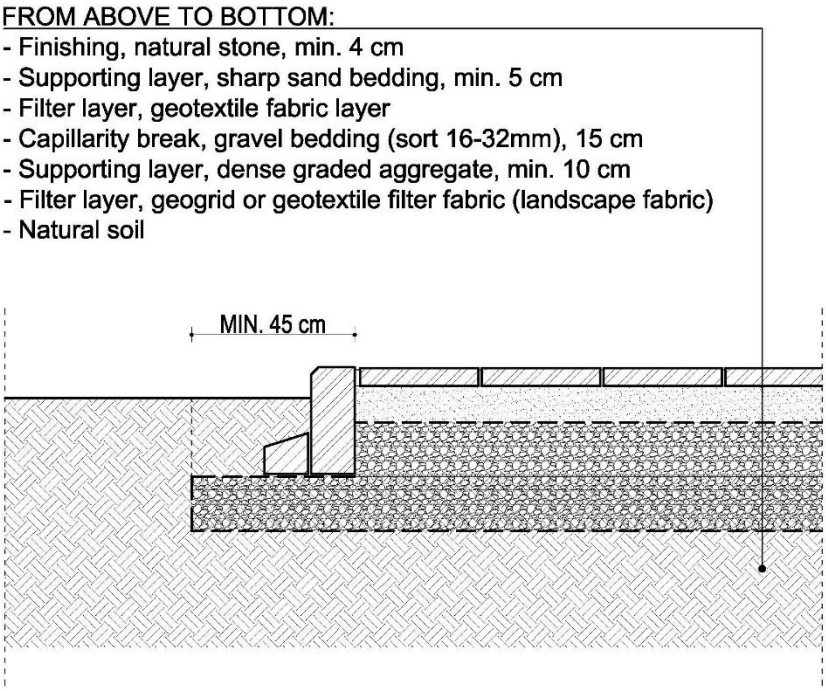
Of course, they must be adapted to the context of use, to the external factors and to the specific climatic conditions. Most of the constituent layers are mineral, ecologically compatible with the natural soil, thus diminishing the negative impact on the environment.

This type of system is compatible with any function of the usual civil buildings such as residential, commercial, transport or industrial sectors. Of course, where restrictions on pollutant use of the soil require special treatments of the exterior floors, where the release of water into the soil is prohibited, specific measures that are not covered by this study should be considered.

Given all of the above, this system for achieving exterior floors is compatible with the requirements of international systems for certifying the sustainability of buildings.

In addition, execution does not require special know-how. Placing large stone slabs on a sand bedding makes it possible to ensure an optimal level of accuracy.

At the same time, the possibility of filling the joints with sand granules requires a permanent maintenance, but which ensures the system a high level of durability over time.
Thus, all these characteristics reinforce the sustainability of the system, including from the execution point of view.



Scheme of flooring with big format natural stone without mortar.

3.1 Auxiliary elements

The stability of the system is conferred by the overlap of layers that function interdependently with the external factors to which the whole ensemble is subjected.
Thus, the component layers are positioned so as to give stability to the entire system over a long period of time, under varying climatic conditions.

For this purpose, the succession of gravel, stone and sand layers, in different granulations and compositions, together with separation filter layers, ensures the permeability to the passage of rainfall or water vapor, while preserving the integrity of the pavement material.

3.1.1. Geotextile filter fabrics

In order to stabilize the support or filtration layers, geotextile filters are required that provide permeability to the passage of water in liquid or vapor form, so that the granulation of the various layers does not mix.

Geotextile fabric being used to separate layers of materials.
SOURCE: https://study.com/academy/lesson/geotextile-fabric-function-uses.html

3.1.2. Gravel and sand beddings

Gravel, stone and sand layers successively represent: base supporting layer, capillary breaking layer, and bedding layer for stone finishing slabs. Thus, the ground water is prevented from rising through the capillary in the sand layer, respectively, reaching the finishing layer.

In the opposite direction, the meteoric water can easily pass through the joints between the stone slabs and sand, being then transmitted to the ground without mixing the composition of the component layers of the composition.

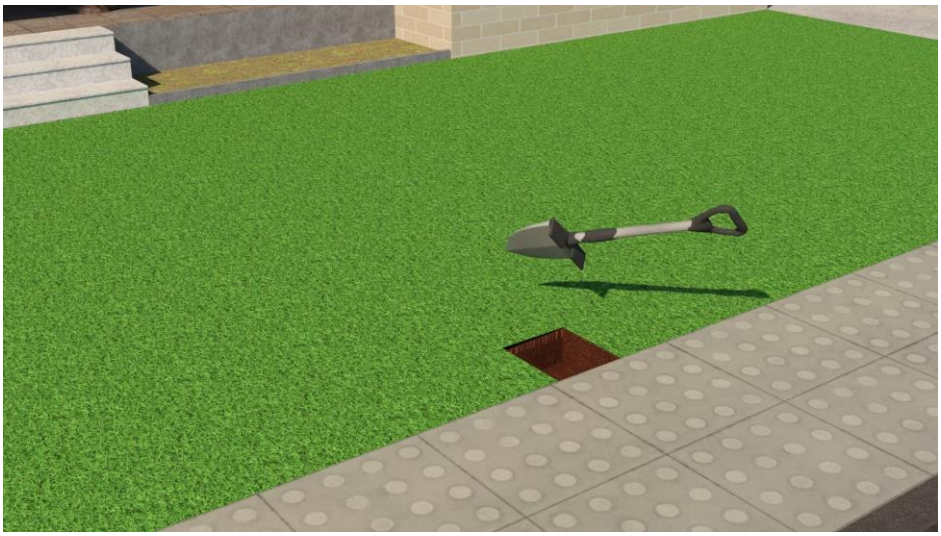
Aggregate, gravel, sharp sand.

4. CONSTRUCTION PROCESS

4.1. Preparing the area

In order to begin the process of executing the natural stone flooring mounted without mortar, the first important step is the preparation of the location area. Thus, the area is delimited and the vegetal layer is removed (approx. 20cm) so as to remove the plants and their roots, which can subsequently affect the system's duration. The uncompacted horizontal natural soil will represent the base layer of the entire exterior floor system.

The area is prepared by removing the topsoil (approx. 20cm).



Source: BIMstone project website.

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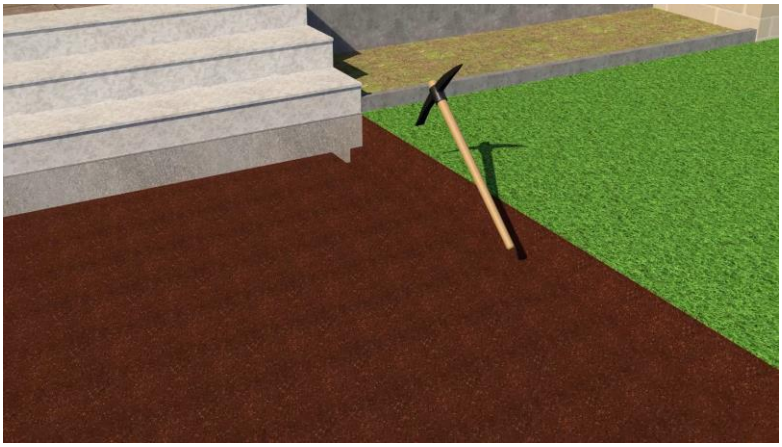
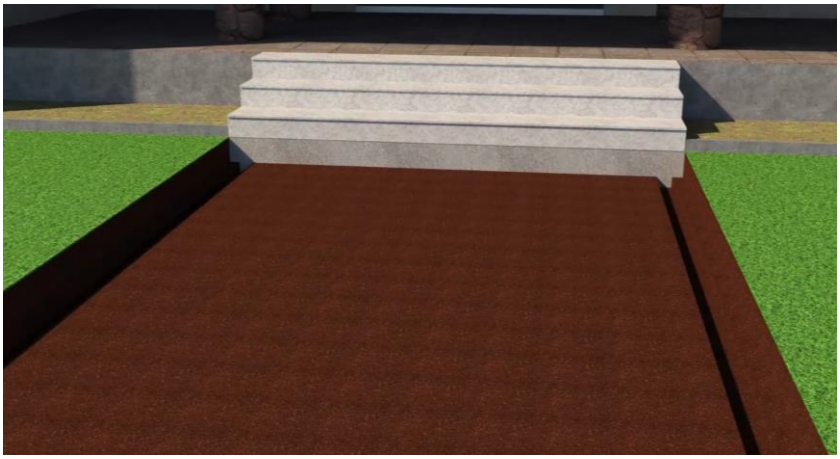
Once the area has been prepared, the area for the insertion of the drainage pipes is excavated.

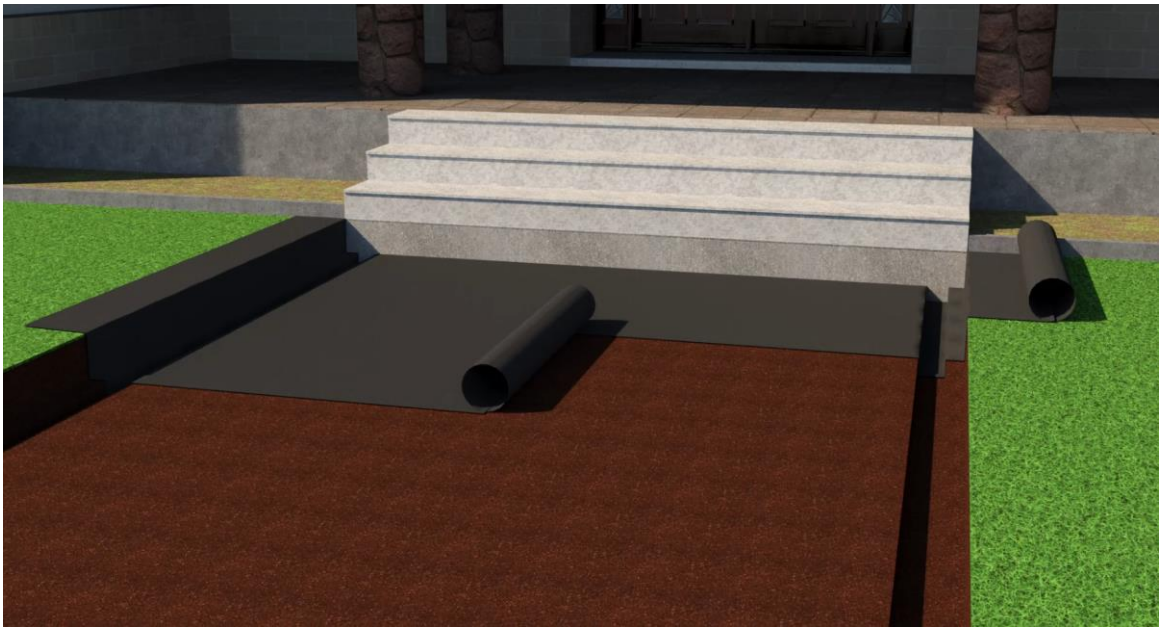


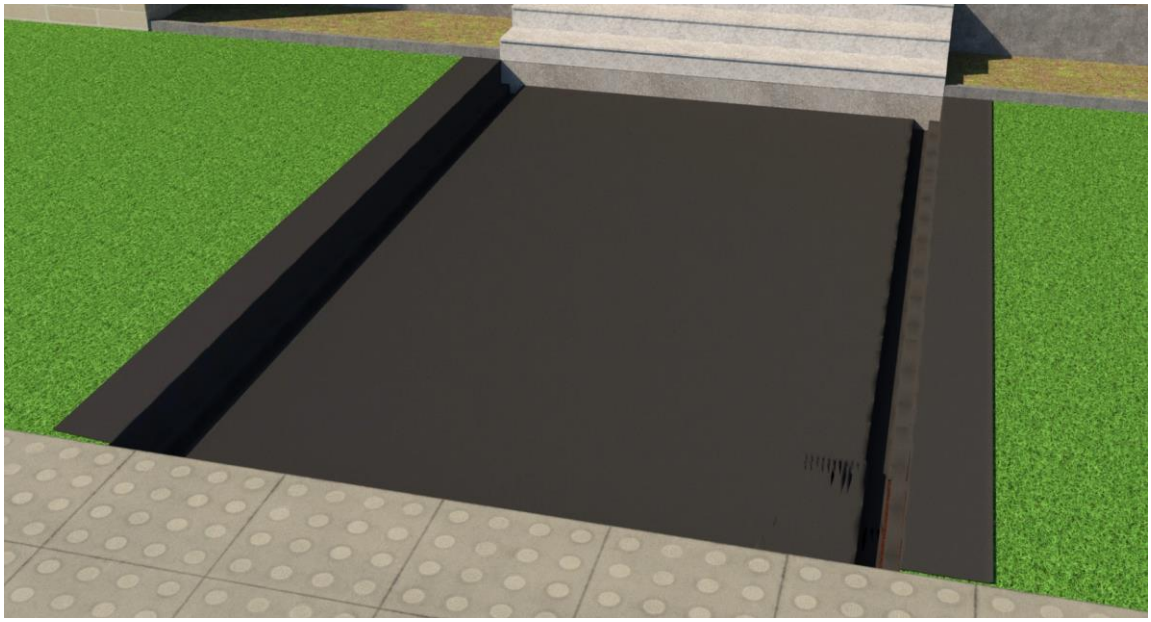


Source: BIMstone project website.

4.2. Placement of geogrid or geotextile filter fabric (landscape fabric) layer

To ensure the consistency of the upper layers and to prevent them mixing with the soil, a filter layer with a separation role, made from a special geotextile membrane for landscape arrangements is placed over the area released by the vegetal soil. This can also be accompanied by a geogrid to avoid possible soil erosion or displacement.



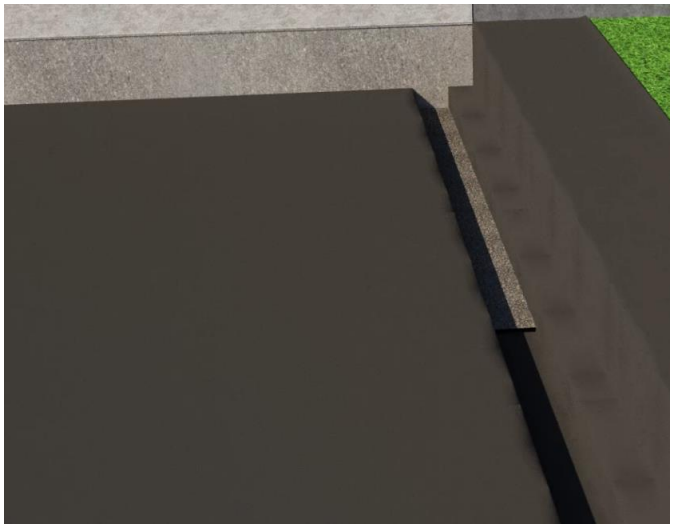


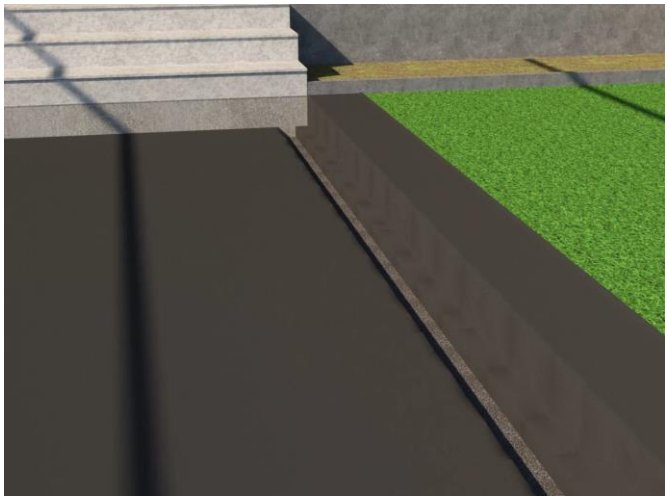
Source: BIMstone project website.

4.3. Placement of tamped stone pack/graded base layer

The infrastructure layer of the whole assembly consists of laying a minimum of 10 cm of compacted mixture of gravel or crushed stone and stone dust. It has the role of creating a barrier against the development of plant components (stems, roots) that may change over time the composition of the whole ensemble, but also to provide a solid foundation, which will also have the role of taking over soil movements due to the different climatic periods during a year (differences in temperature, freeze-unfreeze, hydrostatic pressure from the ground or meteoric waters), but also from possible settling of the terrain over time. Optionally, this layer can also receive a drainage tube at the bottom, meant to remove the meteoric waters if they are present in abundance or the soil, by its nature, does not have the necessary absorption capacity.

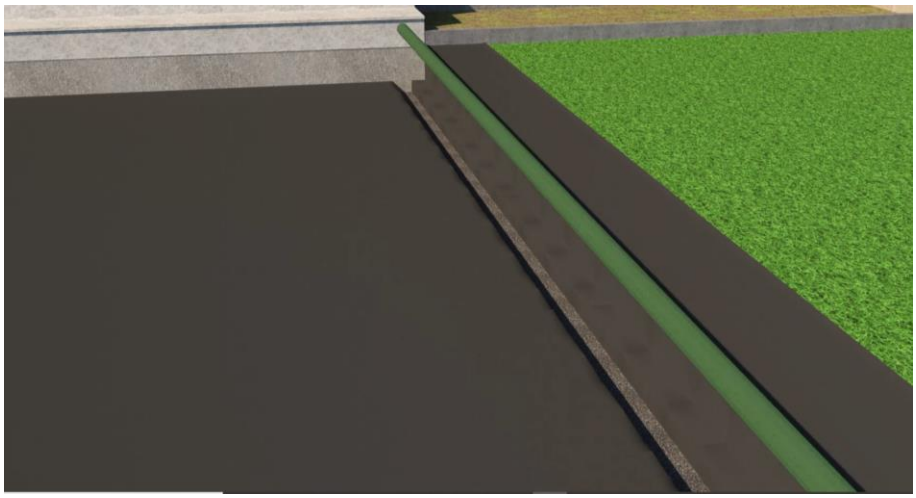
In the case of installation of a drainage system, the stone pack/graded layer is placed in the groove made for the installation of drainage pipes.





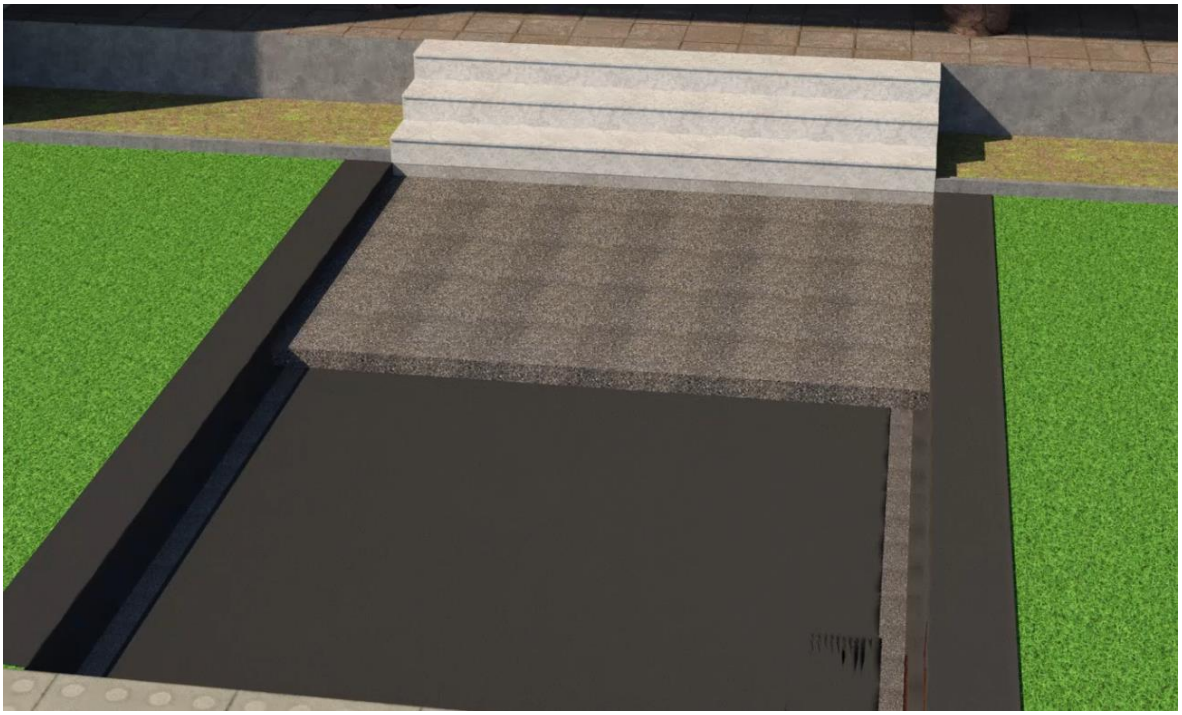
Source: BIMstone project website.

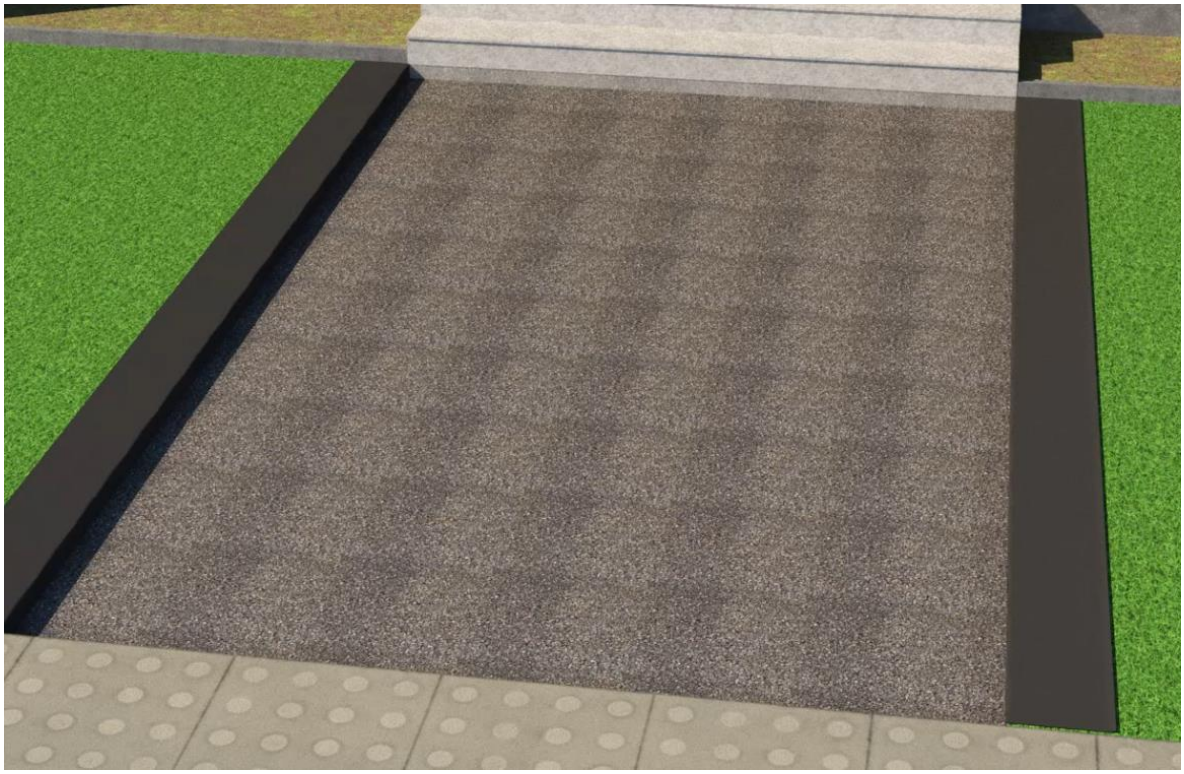
Once the stone pack/graded base layer is in place, the drainage pipes are laid and a layer of backfill mix is placed on top of them.



Source: BIMstone project website.

The next step will be to backfill the entire laying area.

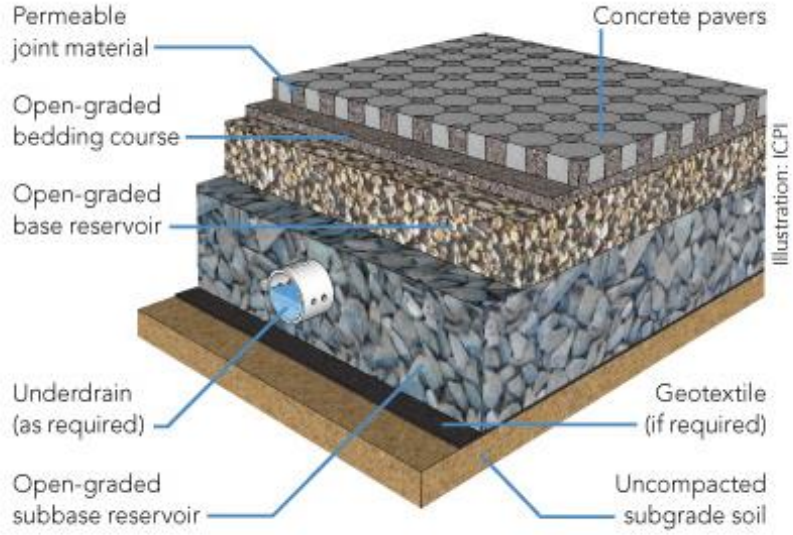




Source: BIMstone project website.

4.4. Placement of gravel bedding for capillary break

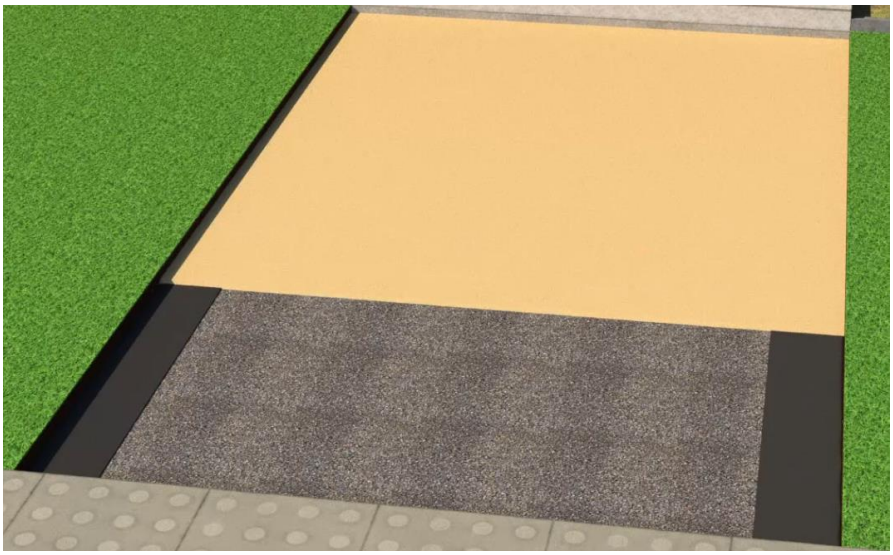
The capillary breaking layer has the role of preventing the ground water from rising through capillarity and reaching the finished floor slabs. This layer of at least 15 cm is essential for the good behavior in time of the whole system, in order to maintain a hydrostatic control of the entire ensemble.



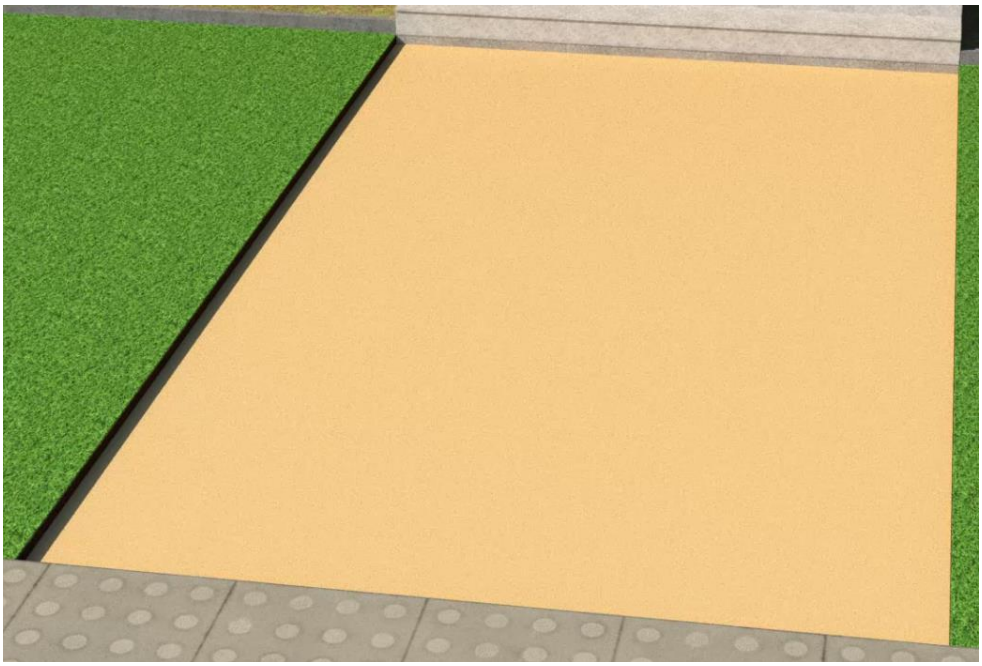
Source: https://www.researchgate.net/figure/Example-of-a-typical-PP-cross-section-image-used-with-permission-of-the-Interlocking_fig1_261831362

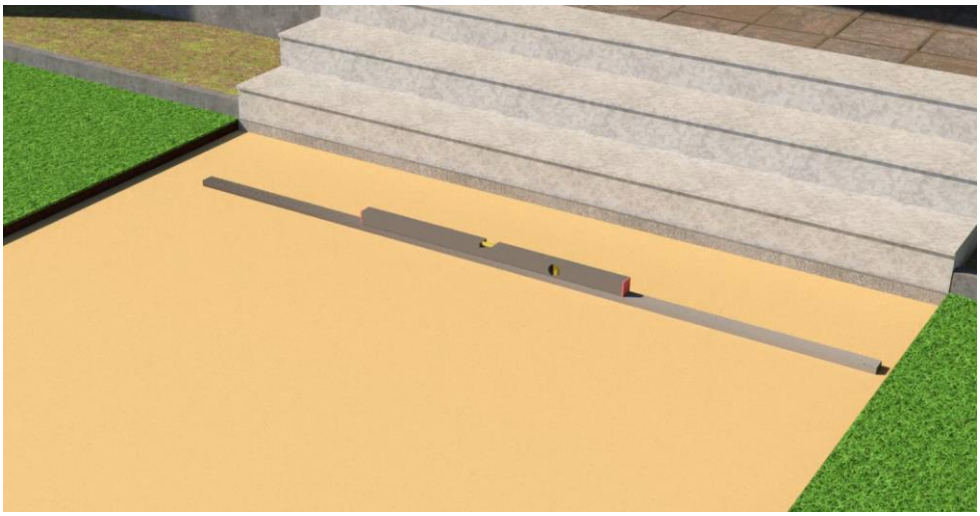
4.5. Placement of sharp sand bedding

The bedding layer of the floor is made of river sand of at least 5 cm. It is levelled using metal or wood straightening, depending on the dimensions drawn before.



Source: BIMstone project website.

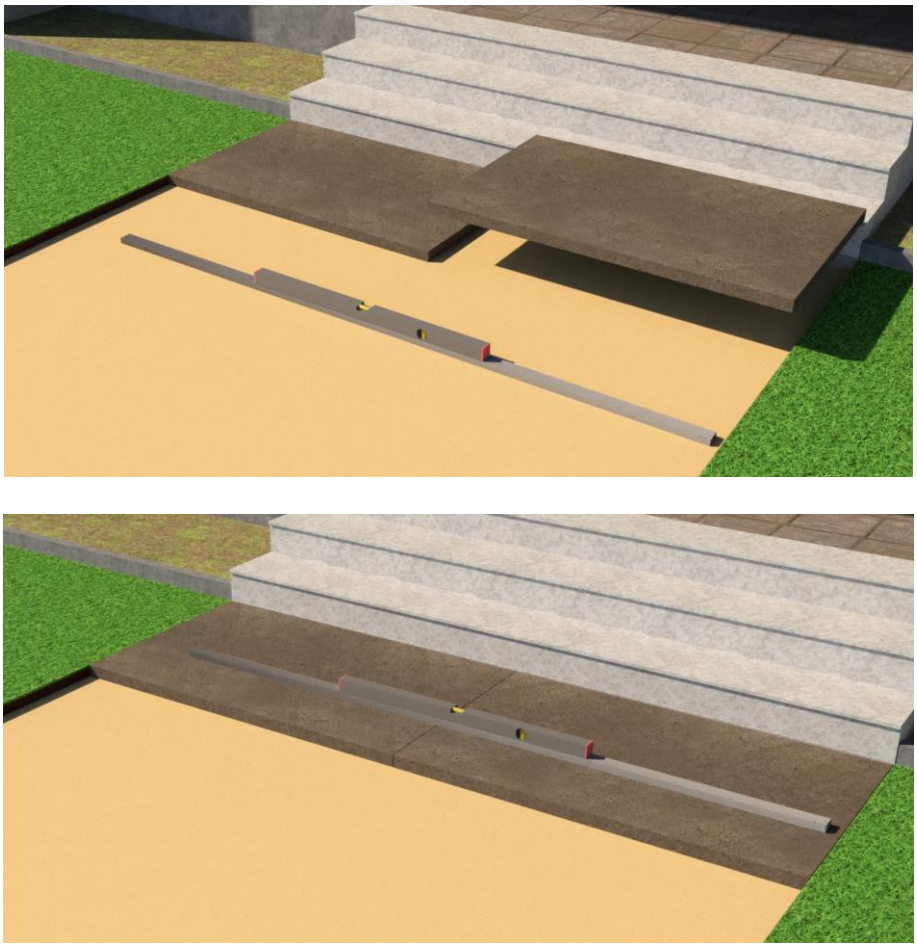




Source: BIMstone project website.

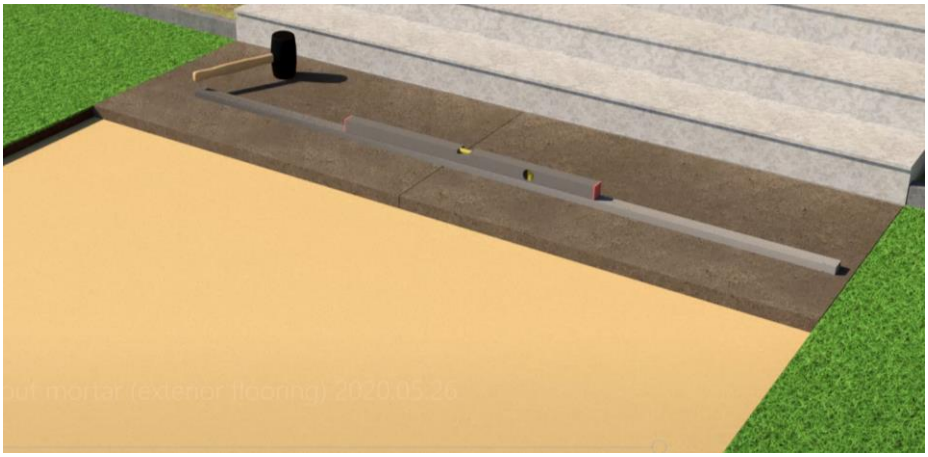
4.6. Stone pavement placement on the sand bedding

The stone slabs are the pavement surface, which is why the independent elements must be mounted with joints, in order to avoid possible deformations due to the temperature differences, but also to allow the waters to follow their natural circuit. The independent elements, depending on the stone quality or the degree of usage to which the floor will be exposed, should not have thicknesses less than 4 cm.

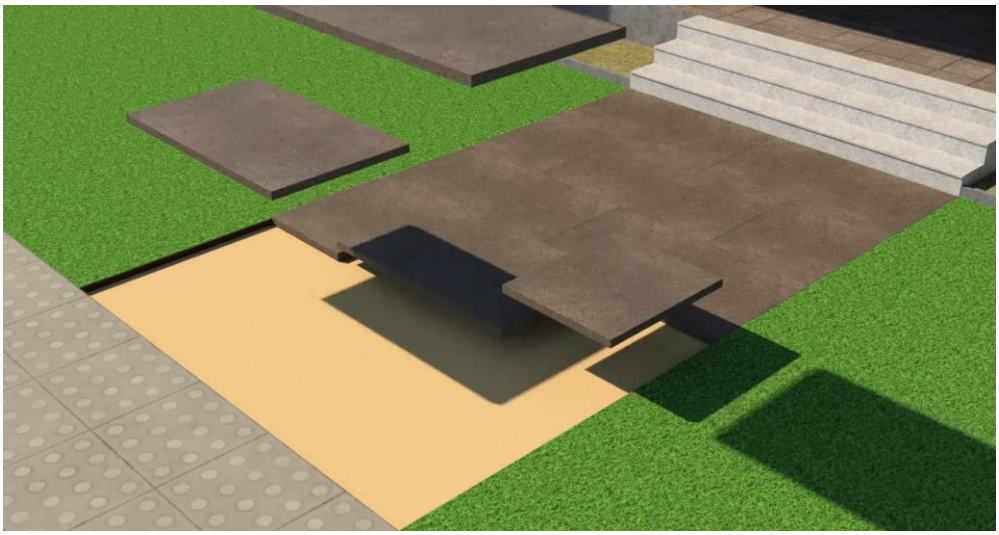


Source: BIMstone project website.

The floor stone slabs are usually installed using tools such as metal or wood straighteners, trowel to adjust the size of the sand, respectively wooden or plastic hammer.



Source: BIMstone project website.



Source: BIMstone project website.

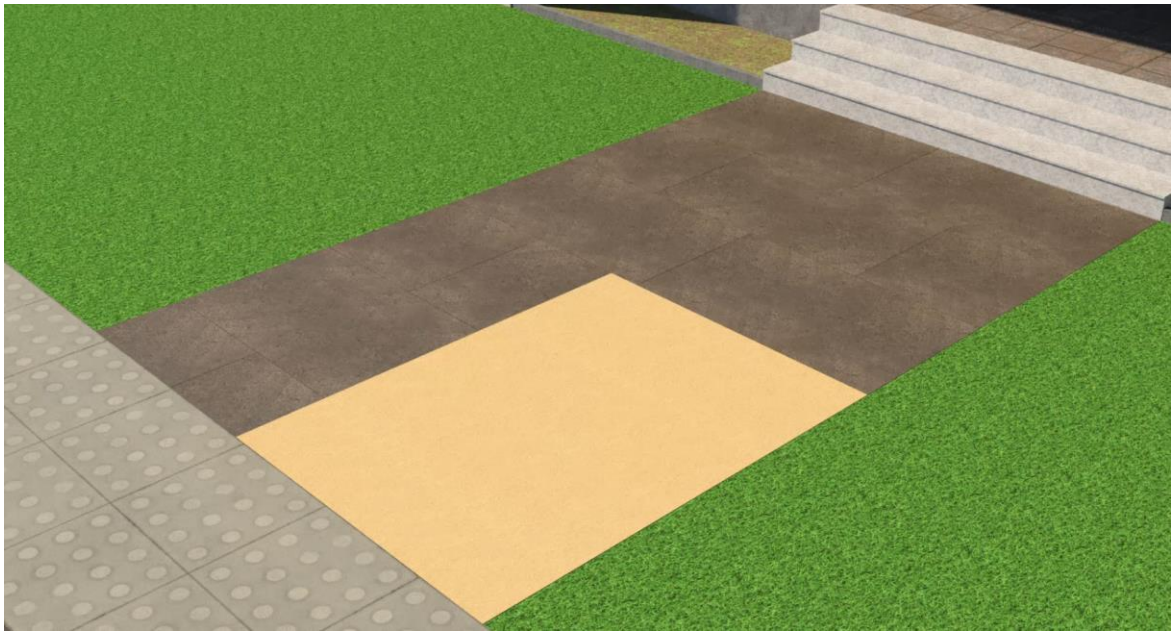
4.7. Verify the level of the overall pavement and between stone pieces

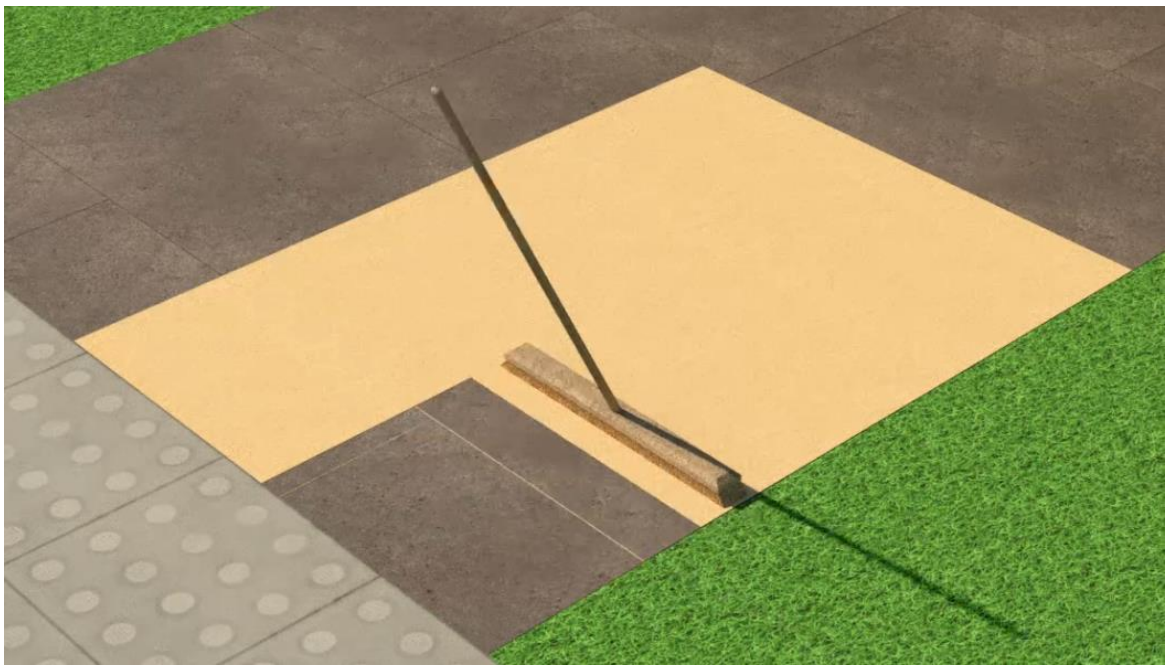
Using straighteners made of wood or metal, the slopes and dimensions desired, respectively the flatness of the entire surface are permanently checked.

Source: BIMstone project website.

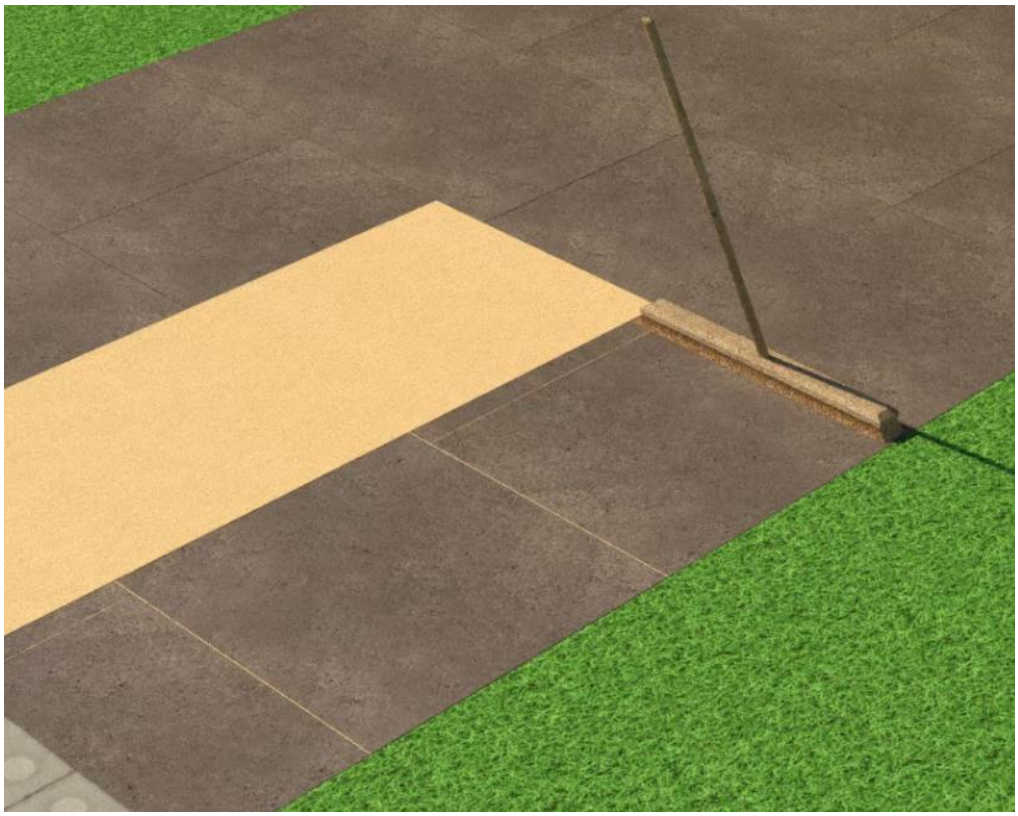
4.8. Fill in the joints with sand or polymeric sand

After completing the floor assembly, the resulting joints are filled with sand using the broom. If the level of sand in the joints drops, it is essential that this procedure is repeated periodically.





Source: BIMstone project website.



Source: BIMstone project website.

5. SUMMARY. STEPS TO FOLLOW IN THE CONSTRUCTIVE PROCESS

The construction process of natural stone exterior flooring without mortar are summarised below:

1. Preparing the area.
2. Placement of geogrid or geotextile filter fabric (landscape fabric) layer.
3. Placement of tamped stone pack/graded base layer.
4. Placement of gravel bedding for capillary break.
5. Placement of sharp sand bedding.
6. Stone pavement placement on the sand bedding.
7. Verify the level of the overall pavement and between stone pieces.
8. Fill in the joints with sand or polymeric sand.

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