IMPROVE TECHNIFICATION AND LCA QUALIFICATION OF WORKERS IN CERAMIC SECTOR WITH THE SUPPORT OF BIM APPLICATIONS

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REPORT 1.2.1

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

CONSTRUCTION OF MICROVENTILATED ROOFS WITH DRY FIXING OF THE TILES

Consortium members: Associação Portuguesa da Indústria de Cerâmica (APICER), Centro Tecnologico da Cerâmica e do Vidro (CTCV), Asociación Empresarial de Investigación Centro Tecnológico del Mármol, Piedra y Materiales (CTM), Asociación Española de Fabricantes (Hispalyt), Institute of Entrepreneurship Development (iED).

Contenido

1. INTRODUCTION

1. Background

The BIMclay project was born with the purpose of producing and developing didactic materials based on the BIM methodology, which address the challenges related to Life Cycle Analysis (LCA) of clay products, to serve as a training base for professionals in the ceramic sector. To this end, it is necessary to define and compile the most suitable execution systems and placement methods for clay products.

The first task of the BIMclay project "O1. *Establishment of common learning outcomes on clay placement 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.

2. ENVIRONMENTAL CONSIDERATIONS

Since 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 EP "***Tejas cerámicas según la norma UNE-EN 1304***" (*Ceramic tiles according to the UNE-EN 1304 standard*) has been verified and published in AENOR's GlobalEPD program.

The EPD of ceramic tiles has been carried out according to the LCA methodology with quantified environmental information of their entire life cycle. That is to say, the EPD of ceramic tiles is of the "cradle to grave" 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	X
	A5	Instalación / construcción	X
Etapa de uso	B1	Uso	X
	B2	Mantenimiento	X
	B3	Reparación	X
	B4	Sustitución	X
	B5	Rehabilitación	NR
	B6	Uso de energía en servicio	X
	B7	Uso de agua en servicio	X
Fin de vida	C1	Deconstrucción / demolición	NR
	C2	Transporte	X
	C3	Tratamiento de los residuos	X
	C4	Eliminación	X
	D	Potencial de reutilización, recuperación y/o reciclaje	MNE

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

This EPD has been developed and verified according to the UNE-EN 15804 and UNE-EN ISO 14025 standards and the Product Category Rules (PCR) for fired clay products used in the construction of AENOR's GlobalEPD programme.

The EPD functional unit is defined as 1 tonne ceramic tile with an average reference service life of 150 years.

The EPD details the formulation to be used (conversion factor) to transform the functional unit from a ton of ceramic tile to a square meter of roof.

3. CONSTRUCTIVE CONSIDERATIONS

The micro ventilated roof with dry fixing of the ceramic tiles allows the micro ventilation between the tile and the support by means of the entry of air through the lower part of the roof (eaves and valley), and its exit through the upper part of the roof (ridge and hip rafter).

This micro ventilation dampens temperature changes and improves the thermal behaviour of the roof, thereby contributing to the maximum energy efficiency of the building. In summer, the air contained between the tile roof and the support, when heated, rises by convection towards the ridge air outlet and hip rafter allowing cold air to enter through the eaves and valley. This internal air circulation produces the cooling of the roof. In winter, the air contained between the tile cover and the support is heated, but not enough to favour convection, conserving the heat.

Micro ventilation in tile roofs has many advantages, among which the following stand out:

- Dampens temperature changes and substantially improves the thermal behaviour of the roof in hot climates.
- It produces the drying of the tiles, avoiding that the humidity remains stagnant between the tiles and the support and that condensations appear, eliminating the problems of frost and moulds.
- Extends the service life of thermal insulation and waterproofing.

Therefore, the microventilated roof tile is recommended in any area of Spain, but especially in areas of humid and cold climate and with an altitude above 700 meters, which should not use the traditional cover.

It is important to differentiate between the ventilation of the roof as a whole, and the micro ventilation between the roof of the tiles and their support. Only if the degree of ventilation originating from the micro ventilation meets the conditions of DB HS1 of the CTE could it be considered a ventilated roof.

In the microventilated roof the tiles are fixed dry, with screws, hooks or clips, instead of with mortar and/or pastes. The dry fixing of the tiles is carried out either on a discontinuous support (strips) or on a continuous support (corrugated plates, etc.). The dry fixation of the ceramic tile

means an important reduction in the time of execution of the cover, with respect to the fixation with mortar of the tile.

The use of auxiliary elements is essential for the execution of the microventilated roof.

TYPES AND FORMATS OF CERAMIC TILES

The types of ceramic tiles are detailed below:

Curved tile

They are covering elements with a curved profile in the shape of a gutter, whose design allows variable overlap values to be obtained between the pieces. The edges can be parallel or convergent.

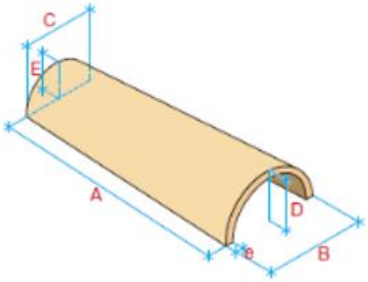
Curved tiles, depending on their placement on the roof, are called channel tiles and blankets. The channel tile is the one that collects rainwater, taking it out of the perimeter of the construction, and the tile covers, is the one that covers the joint between the channels.

Normally they do not have special fitting systems for the overlapping of the pieces. The lateral overlap of the pieces is produced thanks to the positioning of the curved tile as a tile covers on a tile channel.

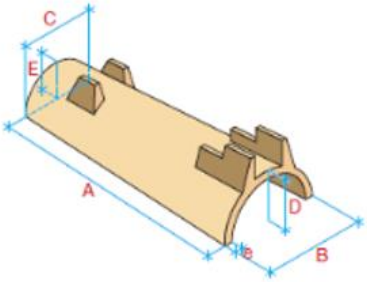
There are curved tiles available on the market that have support pins or heels that allow them to be hooked onto the discontinuous support (strips perpendicular to the line of maximum slope).

To facilitate dry fixing by means of screws, there are curved tiles that have one or more pre-drilled holes next to their top edge, thus avoiding having to drill the tiles with a drill, and guaranteeing that there is no deterioration of the same.

Teja curva sin tetones



Teja curva con tetones



Dimensiones	
A	20-50 cm
B	10-22 cm
C	7-18 cm
D	4-9 cm
E	2,5-6 cm
e	8-15 mm

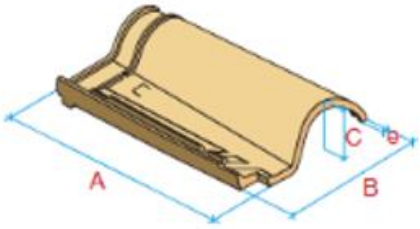
Mixed and flat roof tile

They are covering elements that have a curved profile and a flat profile (mixed tile), or only a flat profile (flat tile), that have a system of longitudinal and transverse fitting, single or multiple, for the watertight assembly of the contiguous pieces in vertical rows and horizontal yarns. This system of fitting will limit the possibility of the tiles sliding between them and its purpose is to prevent the passage of water.

To facilitate dry fixing by means of screws, in some cases these tiles will have one or more pre-framed holes next to their top edge, which must be drilled when appropriate with a tungsten carbide drill bit (tungsten carbide), thus avoiding the need to drill the tiles with a drill bit, and ensuring that there is no deterioration of the tiles.

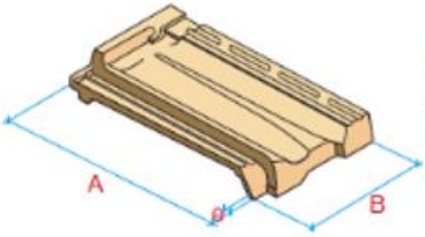
These tiles shall normally have on their lower face and next to their upper edge, one or more pins, or support heels, to allow them to be hooked into the discontinuous support (strips perpendicular to the line of maximum slope).

Teja mixta



Dimensiones	
A	43-56 cm
B	26-32 cm
C	6-12 cm
e	15-22 mm

Teja plana marsellesa o alicantina



Dimensiones	
A	44-48 cm
B	26-29 cm
e	15-22 mm

4. CONSTRUCTION PROCESS

0. Stakeout and preparation of the roof tile support

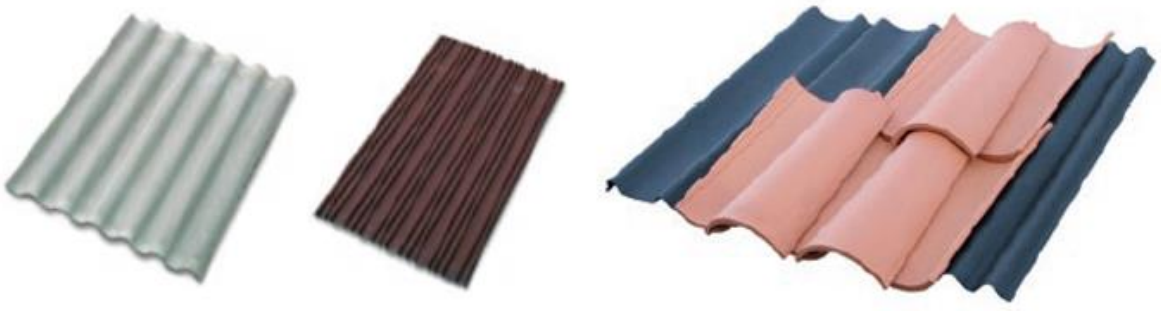
On the ventilated roof, the tiles are fixed dry, either on a discontinuous support (strip) or on a continuous support (corrugated plates, etc.).

- **Continuous support**

The continuous support is made up of elements placed in such a way that a continuous surface is obtained.

The tiles can be placed directly on the continuous support. The fixation of the tiles supported directly on continuous support will always be dry. The dry fixing of the tiles on the continuous support is usually done with adhesives and hooks.

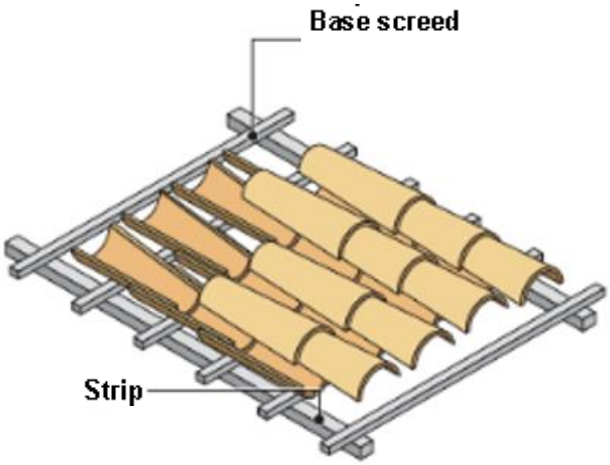
The most common types of continuous support are corrugated sheets and insulating panels, although in the latter case it is not frequent to fix the tiles to the insulating panels, as the most common thing is to place strip on the insulating panels to fix the tiles.



- **Discontinuous support (**strip)

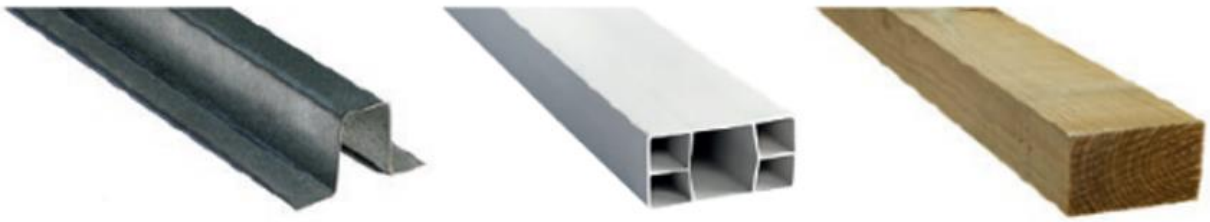
The discontinuous support is made up of linear elements called strip s, which serve as a support for the tiles. The support can be based on a single or double strip (strips):

- **Strip**: Element that supp orts the screeds.
- **Base screed**: Element that supports the tiles.



The fixation of the tiles supported on base strip swill always be dry. The base strip can be self-supporting and be supported on it or fixed directly to the continuous support.

The most common discontinuous supports are wooden, metal and PVC base strips. They can also be self-supporting or fixed directly to the continuous support of the roof.



For the microventilation to be effective, a minimum air circulation space of 2 to 4 cm must be left between the underside of the tile and the support. For this reason, it is better to cover the roof with a double base strip, as the air layer is 4 cm (2 cm strip and 2 cm base strip).

In the case of smooth continuous support and simple base strip, to improve the microventilation under tile it is recommended to use perforated base strip that allow the passage of air through it.

An adhesive band will be placed under the strips to avoid water leaks in the points where these strips are nailed, and which could pierce the waterproofing sheet or vapour barriers.

1. Roof tile installation

The way to place the tiles depends on the type of tile:

1.1 Curved roof tile

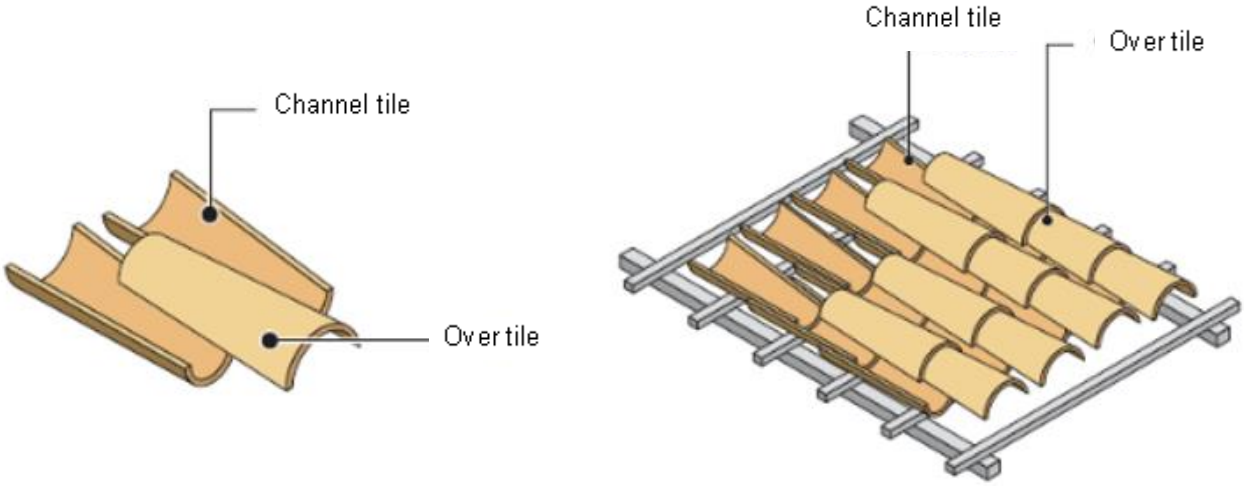
The side trim piece will be placed first from the eave towards the ridge along the entire edge, the side trim piece must be nailed and fly more than 5 cm laterally.

Then follow the first horizontal row of the eaves, placing the channel tiles oriented with the widest part towards the ridge, leaving all of them individually fixed only at its end.

It is necessary to place a rope in the eaves, which will serve as a reference so that all the tiles have the same flight and height. The eave tiles must fly a minimum of 5 cm.

Afterwards, the over tiles are placed on two channel tiles adjoining, orienting them with the widest part towards the eaves. The overhang tiles will be fixed, and a hook will be available.

The rest of the apron will be made by placing the channel tiles topping the over tiles of the row immediately below fixing the over tiles by means of hooks and polyurethane foam points.

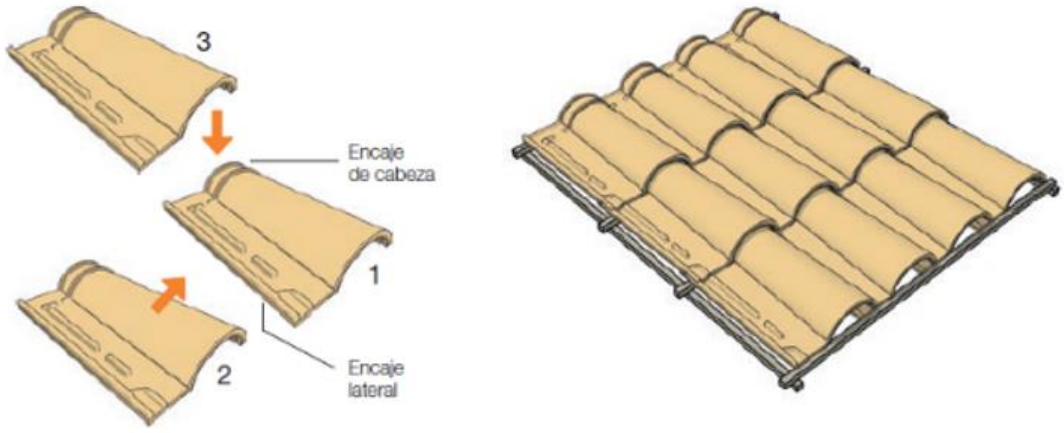


1.2 Mixed roof tile

The side trim piece will be placed first from the eave towards the ridge along the entire edge, the side trim piece must be nailed and fly more than 5 cm laterally.

The rest of the apron will be completed with tiles arranged in successive vertical rows, parallel to the line of maximum slope, from the eaves to the ridge, following the master lines obtained in the stakeout and following the fixing recommendations. The eaves tiles must fly 5 cm and be nailed.

The installation Will being on the right or left depending on the design of the tiles and using half or double tiles.

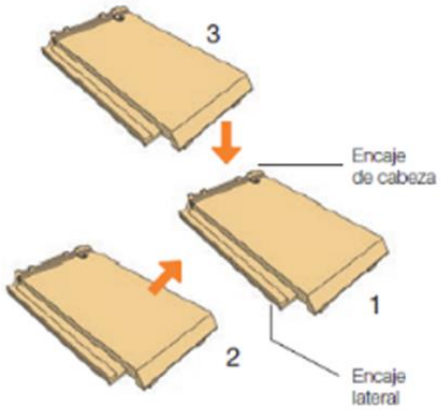


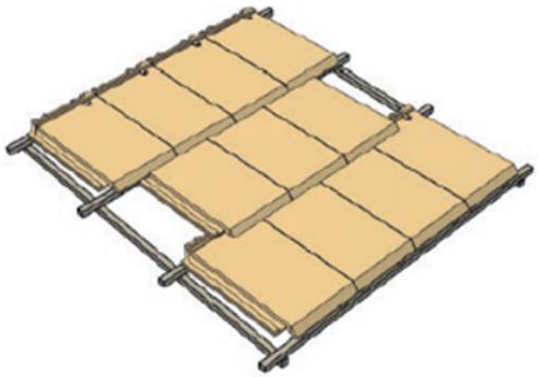
1.3 Flat roof tile

The side trim piece will be placed first from the overhang to the ridge along the entire edge, the side trim piece must be nailed and fly more than 5 cm laterally. The installation will start from the right or left depending on the design of the tiles.

The successive horizontal rows from the eaves to the ridge shall then be placed, alternating at the ends of each row whole tiles and half tiles in the case of staggered rows.

The flat tile can also be placed in line. In this case the minimum slope that guarantees the watertightness of the cover must be consulted with the manufacturer.





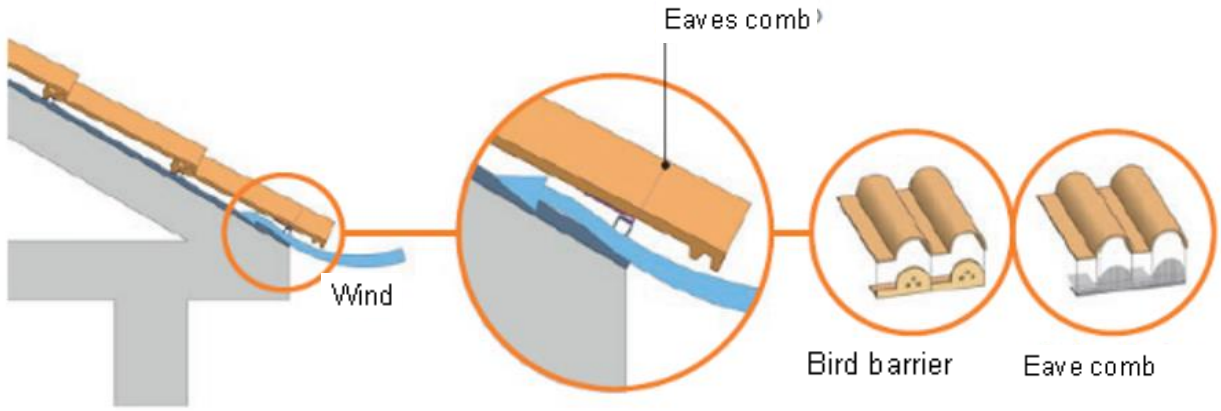
2. Air inlets throughout the overhang

The entry of air though the eaves is very import to allow microventilation under the tiles.

In order to avoid the pitching of the eave tiles it is advisable to use a double eave strip, which elevates the eave tile, to equal its inclination to that of the rest of the roof tiles in the apron.

It is also recommended to use in the separation between the support and the eaves tiles the special piece of bird barrier or the eaves comb, since besides favouring the microventilation they prevent the entrance of birds or rodents under the tiles. In some cases, in addition to installing the eave comb, it may be necessary to use the eave grid.

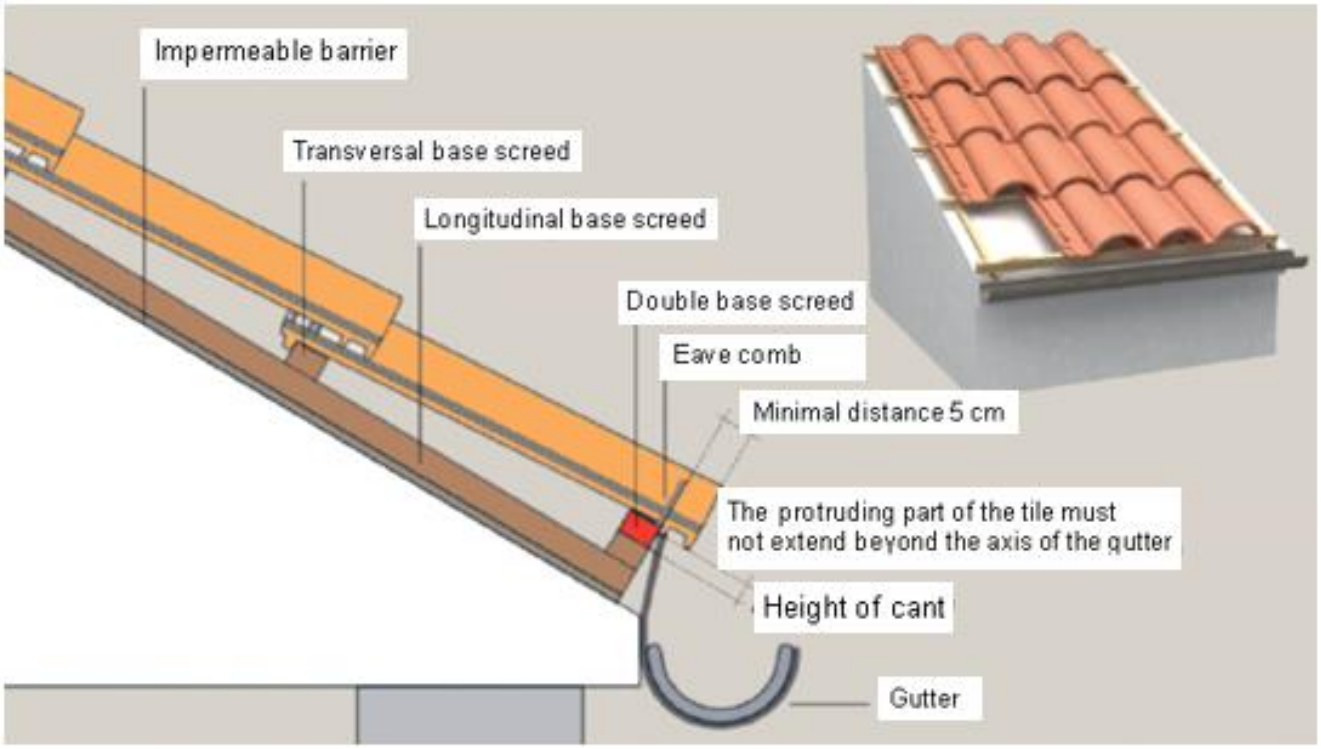
Bird barrier



A more detailed description of each of these additional components is given below:

- **Double overhang base strip**

Double base strip, or double height strip, to be placed on the eaves and raise the eaves tile to maintain the same slope of the rest of the yarns and avoid the pitching of the eave tiles.



- **Bird barrier**

The bird barrier is a special piece for its placement in the eave line, whose mission is to ventilate and prevent the entry of animals.

In addition, the bird barrier supports the tiles, lifting them and avoiding their pitching, so its use is highly recommended.

As it is a ceramic piece it allows a better aesthetics in the final finish of the cover.

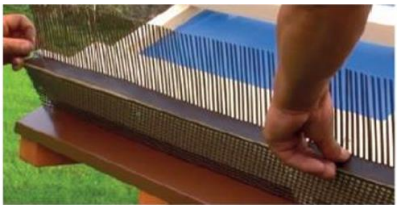
- **Eave comb**

The eave combi s a comb-shaped strip that allows micro ventilation through the eave, but prevents birds or rodents from entering under the tiles.

It is usually made of plastic and may have lower temples to facilitate the placement of the gutter clamps.

- **Eave grid**

Depending on the shape of the eave comb, in some cases, in addition to the placement of the eave comb, it may be necessary to use the eave grid. It is an element in the shape of a perforated grid that is installed on the front of the eave, between the support and the eave comb. Allows microventilation and protects against the entry of rodents and birds.



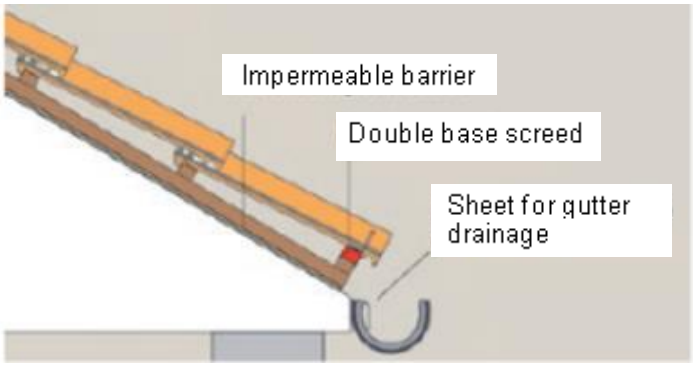
Other important elements for the correct finishing of the eaves:

- **Eave roof tile**

Piece that forms the eave line, protruding about 5 cm over the façade to avoid humidity and stains, as well as the pitching of the first row of tiles. When necessary, the front will be supplemented to maintain the same slope of the rest of the rows of the apron. The eave tiles are installed next to each other, fitting perfectly under the upper row tiles.

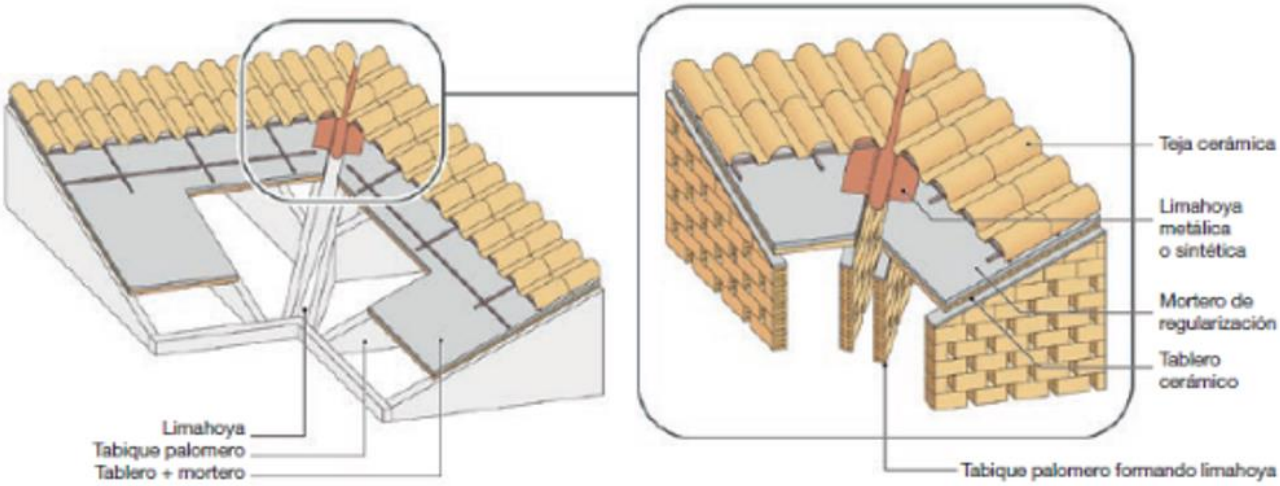
- **Gutter and drainage sheet**

If the eave has a gutter, after placing the eave tiles, the clamps that will support the gutter are attached to the apron. The gutter in turn will be placed with a slope greater than 1%, being oriented towards the downspouts. The flight of the tiles will be maintained over the eave line, guaranteeing that they pour the water into the gutter.



3. Inlet (and outlet) of air through the valley

The difference in level and pressure between the lower and upper part of the valley allows the micro ventilation air to circulate, entering from the lower part and exiting from the upper part.



Similar to the eaves, in the valley the separation between the support and the tiles can be let free, being recommendable the use of the eave comb, since in addition to favoring the micro ventilation they prevent the entrance of birds or rodents under the tiles.

Then, other parts for the correct finishing of the valley are described in a generic way:

- **Sheet for valley drainage:**

Flexible or semi-flexible element designed to finish off valley, guarantees the correct waterproofing in the collection of water from the aprons.

4. Air outlet through the ridge and hip rafter

The air outlet of the micro ventilation under the tiles will be through the highest part of the roof, through the ridge and hip rafter, since a greater difference in height between the air inlet and outlet provides better circulation and ventilation.

Any of the solutions available on the market can be used to allow air to escape from the micro ventilation through the ridge and hip rafter. The most common components are described generically below:

- **Ridge and hip rafter support**

It is a support for the ridge and hip rafter strip. Normally it is a metal hoist with a base for the positioning and fixing of the ridge and batten. But it can also be a metal profile in the form of a strip. The following three types of systems are currently available on the market:

- **Breathable or microperforated impermeable belts**

These bands are waterproof to prevent the entry of water, but are breathable or microperforated, to allow proper ventilation of the deck through the ridge line or hip rafter, in addition to preventing the entry of birds, rodents or foreign elements.

- **Wedge for ridge**

In addition, in the case of roofs with curved or mixed tiles, special wedge ceramic pieces can be used for easel, whose mission is to fill the gap left by the curved or mixed tile in its flat part under the easel. They are placed along the ridge and strip leaving the joints unsealed.

The use of ridge wedges is highly recommended, because in some cases the breathable or perforated waterproof strips are not flexible enough to adapt to the curvature of the roof with curved or mixed tiles. In addition, ridge wedges improve the aesthetics of the roof.

- **Breathable or microperforated impermeable belts**

These bands are waterproof to prevent the entry of water, but are breathable or microperforated, to allow proper ventilation of the deck through the ridge line, in addition to preventing the entry of birds, rodents or foreign elements.

These bands are placed on the ridge and strip with the metallic hoist, or under the grooved metallic profile in the form of strip, mounting also on the two skirts of the cover.

Ideally, these membranes should be flexible, so that in the case of a curved or mixed roof, they can be adapted to the undulations of the roof. These belts can be made of different materials and must have a high resistance to UV rays and ageing.

Other pieces for the correct finish of ridge and hip rafter:

- **Ridge**

Piece that assures the watertightness along the files and the ridge line.

- **End of hip rafter or ridge**

Piece that allows to finish the end of the hip rafter, fulfilling an important aesthetic function, at the same time that it guarantees the watertightness in the encounter with the eaves.

- **Double socket**

Piece that allows to change the direction of tongue and groove of the ridge in order to finish the ridge with the end of the ridge in one of its ends.

- **Ridge cover**

Piece for finishing off the ends of the ridge, this being executed by overlapping three pieces: the easel, the right side of a apron and the left side of another apron. It guarantees the watertightness of this encounter and achieves the perfect finish of both ends when joining the ridge.

- **Two sided roof ridge**

Part that ensures drainage and watertightness at the meeting point of a horizontal ridge with two or more ridge or files. Its design must be adapted to the angles between the ridge and the files for which the roof has been conceived.

Ridge

End of ridge

Double socket

Ridge cover

Triangular ridge

Four-way ridge

5. SUMMARY OF THE STEPS TO BE FOLLOWED IN THE CONSTRUCTION PROCESS

1. Stakeout and preparation of the support of the tiles

2. Roof tile installation.
    2.1 Curved roof tile.
    2.2 Mixed roof tile.
    2.3 Flat roof tile.

3. Air inlet through eaves.

4. Inlet (and outlet) of air through valley.

5. Outlet of air through ridge and hip rafter.

6. REFERENCES

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