



**orio**  
ACCESSORIES FOR VENTILATED ROOFS

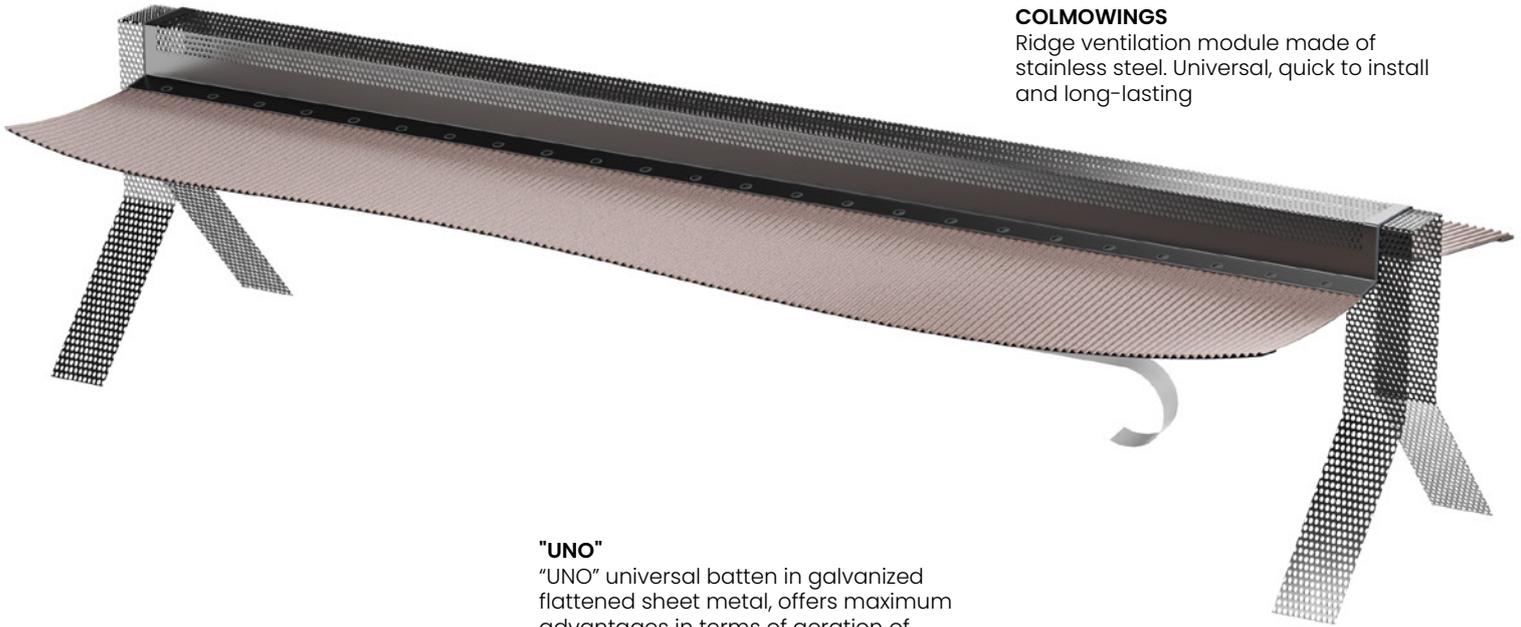
research and technology  
in ventilated roofs



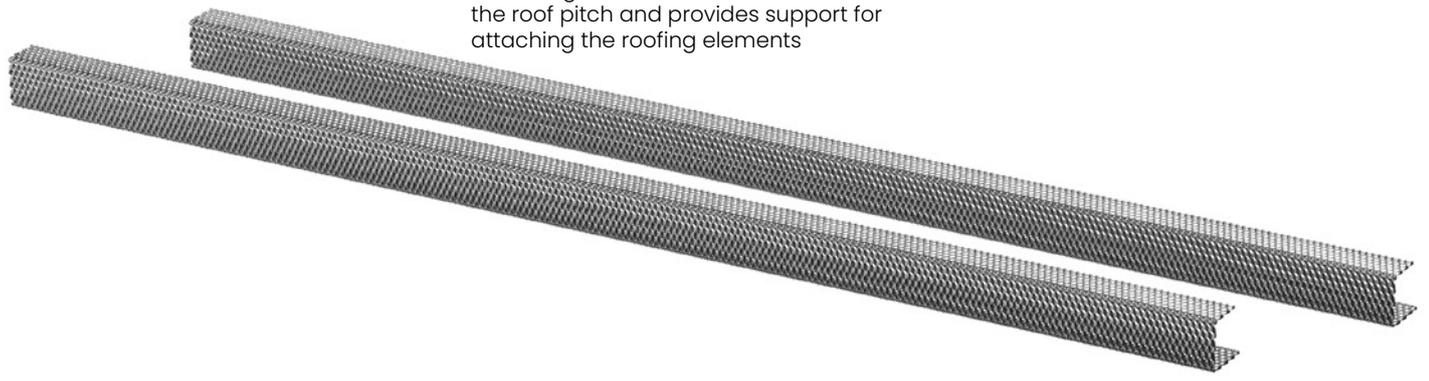
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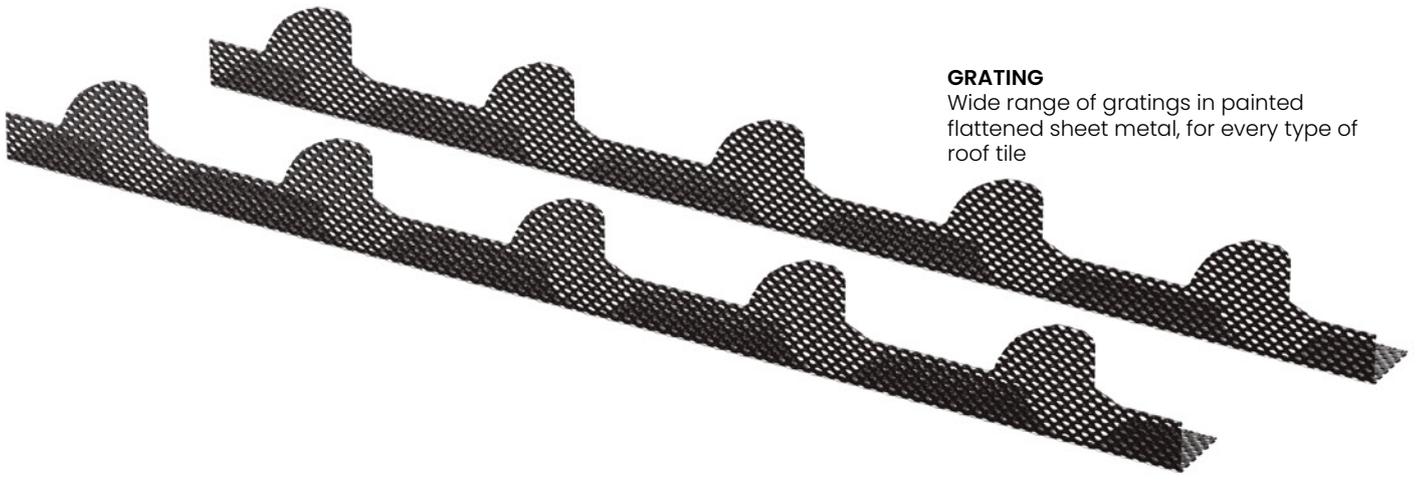
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**COLMOWINGS**  
Ridge ventilation module made of stainless steel. Universal, quick to install and long-lasting



**"UNO"**  
"UNO" universal batten in galvanized flattened sheet metal, offers maximum advantages in terms of aeration of the roof pitch and provides support for attaching the roofing elements



**GRATING**  
Wide range of gratings in painted flattened sheet metal, for every type of roof tile

# THE VENTILATED ROOF

## BENEFITS AND PERFORMANCE OF AN “ARIA” VENTILATED ROOF SYSTEM

The “ARIA” SYSTEM for constructing ventilated roofs created by **OFFICINE RASERA** offers an effective solution **for most roofs**.

Thanks to the gutter line modules (**gratings**), pitch elements (**“UNO” battens**) and the under-ridge modules (**COLMOWINGS**), it is possible to build **stable, long-lasting and easily maintainable roofs with a high ventilation capacity**, for all types of roofing tile.

In addition to allowing **the dry attachment of the elements** (without the use of mortar, sealants or foams), the system allows the **longitudinal and transverse circulation of air** for ventilation of the under-roof area.

The **air gap** produced by laying the roof tiles on the “UNO” battens **ensures the ventilated roof performs in compliance with the UNI 9460:2008 standard**.

The “ARIA” SYSTEM allows for **quick installation**, without the use of special tools **nor the need for specialized labour**.

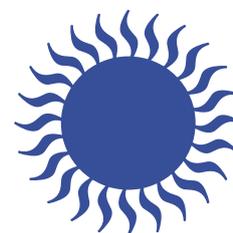
## ACCESSORIES CATALOGUE

The OFFICINE RASERA catalogue contains a **vast assortment** of products and accessories for creating and finishing every aspect of a roof, ensuring the same level of effectiveness even in the most extreme weather.

# WHY CHOOSE A VENTILATED ROOF?

## BENEFITS IN SUMMER

**Air circulation** beneath the waterproof covering of a pitched roof serves to **control and limit the ingress of heat in summer**, i.e. preventing the sun's rays that heat the covering elements from being transmitted to the roof deck and rooms below, thereby overheating them. It is thus **a choice that affords benefits in terms of comfort, without requiring increased energy consumption.**



## BENEFITS IN WINTER

**In winter**, under-roof ventilation helps **disperse any humidity** present within the roofing elements, **helping to preserve the properties of the insulating layer and prevent deterioration of the building and roof itself.**



## LEGAL PROVISIONS REGARDING ENERGY CONSUMPTION

Legal **provisions relating to summer energy performance** concerning reduction of energy consumption in buildings highlight the **need to use innovative technologies** for roofing capable of deflecting and reducing the ingress of heat. **Good air circulation** within the roof can certainly make **a valid contribution**, especially in roofs with a wooden structure and thus limited mass.

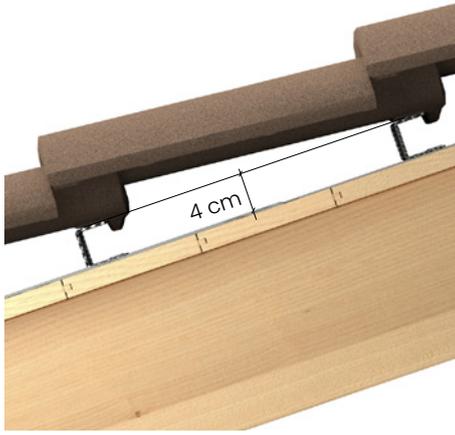
## THE UNI 9460:2008 STANDARD

**Under-roof ventilation** (or under-tile ventilation) is the **thin layer of air circulating immediately beneath the waterproof roofing layer.**

The **UNI 9460:2008** standard (Discontinuous roofing - Instructions for the design, construction and maintenance of roof coverings made from clay or concrete tiles, points 9.1.3 - 9.1.4) **indicates that the thickness of the support and attachment elements that separate the lower surface** of the waterproof covering **from the exterior surface** of the deck, allowing air to circulate, **should be 3-4 centimetres.**



Air gap with wooden batten



Air gap with "UNO" batten

This **construction solution is always established by regulations** and "... necessary for the proper functioning of the roof and to guarantee the durability of the attachment elements..." (UNI 9460:2008).

## IN ALL WEATHER CONDITIONS

This **air circulation must always be present** in all weather and design conditions since, in addition to regulating solar heating, it provides **numerous other benefits**:



1. it helps to **dissipate any moisture** that rises from the rooms below, passes through the elements and layers of the roofing structure, condenses on the cold lower surface of the tiles and then drips onto the deck;



2. it allows the tiles to **dry more quickly, in particular the lower surface, if there is any build-up of condensation**, or after **they become rain soaked**;



3. **it limits the risk of breakage caused by freezing** and long-term humidity contained within the clay structure;



4. it helps prevent heat rising from the home causing irregular melting and slipping of any snow build up, which can result in the build-up of snow and ice along the eaves, which may possibly lead to the backflow of water;



5. **it facilitates the alignment and precise laying of roof tiles** without the need for wires, straightedges, tape measures or other reference devices;



6. **it prevents roof tiles from slipping** which could otherwise become displaced on the roof surface and allow water to pass.

Loft ventilation therefore helps to maintain consistent hygrothermic characteristics between the upper and lower surface of roof tiles, allowing the elements to "breathe" and stay dry, **increasing the longevity of the roof, insulating elements and structures.**

# VENTILATED ROOF CONSTRUCTION METHODS

## CONSTRUCTION METHODS

Ventilated roof construction methods can be artisanal, employing either only horizontal tile battens or also vertical wooden battens, called counter battens.

With the **“ARIA” SYSTEM, thanks to the “UNO” batten** in galvanized flattened sheet metal, only the horizontal tile battens are needed and, as these are air permeable, they not only provide the same effectiveness and benefits of ventilation in just a single layer, but also improve performance.

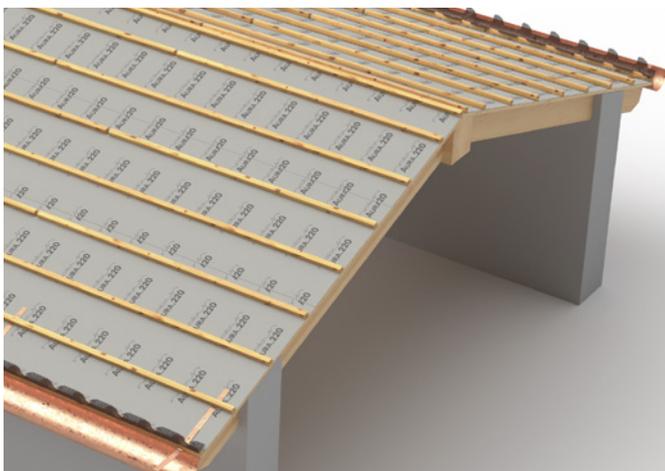


Single-layer “UNO” tile battens

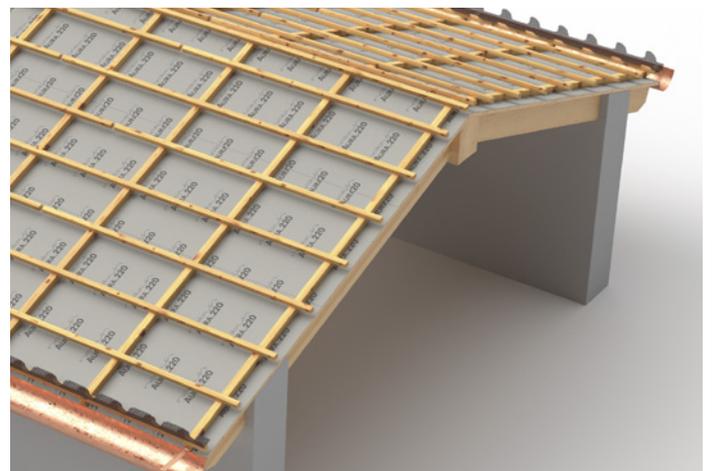
A horizontal-only **wooden tile batten** installation allows only a modest flow of air as the solid battens allow only a limited air flow, which can pass only minimally beneath curved tiles, and not at all beneath Marseille or flat tiles.

Furthermore, in case of water intrusion, it creates an area where water can pool, which may damage underlying roof elements.

The same thing occurs with a **counter-battened installation**, as **the upper tile battens block air flow** and installation is more costly.



Single layer of wooden tiling battens



Wooden tiling battens and counter battens

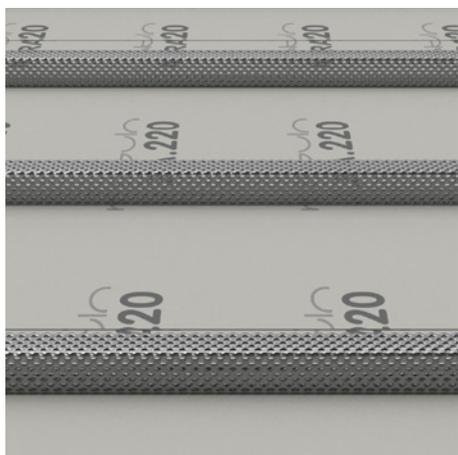
## THE “ARIA” SYSTEM

The flattened metal profile of the “UNO” batten offers **greater permeability** as air can pass through it, thus **improving air flow**. Furthermore, the **perforations mean the battens can be very easily fixed to the roof deck and the tiles to the battens**, as well as facilitating **easy drainage of any water that does leak through**.

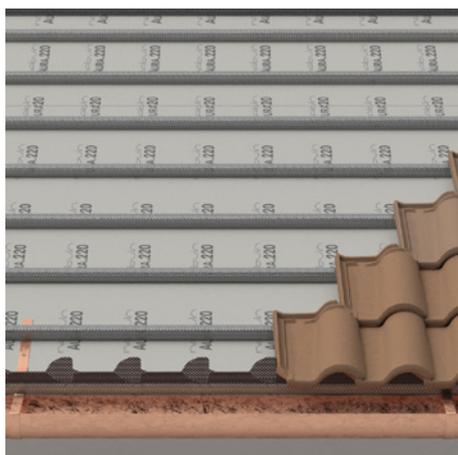
The “ARIA” SYSTEM was designed and created with these functional aspects in mind. It comprises **three basic elements plus the accessories**: the bird barrier gutter **GRATING**, the **“UNO” metal batten** profile for attaching the tiles and the **COLMOWINGS under-ridge module**.



The **Colmowings stainless steel ridge ventilation module** (with an open-area ratio of over 500 cm<sup>2</sup>/m), features a perforated central section **to allow for the passage of ventilation air**, two lateral strips **to prevent water from rising**, and a pleated lateral skirt to allow it to be correctly shape to match the surface of the tiles, and two butyl adhesive strips to ensure **perfectly waterproof adhesion**. The support elements make it easy to lay and attach. **It allows ridge elements to be attached**.



The **“UNO” batten** is made of flattened galvanized steel (**which is recyclable and poses no health or environmental risks**), offers **high tread resistance**, resistance to deformation, and long-term **resistance to atmospheric agents**. It provides a **better open-area ratio** when compared to perforated battens with circular holes. It is easy to cut, shape and attach thanks to its pre-drilled rhomboid-shaped holes.



The **bird barrier GRATING** is manufactured from flattened metal coated with polyester powder paint for **greater resistance to atmospheric agents** and **blend perfectly** with the elements of the roof covering.

It's pre-formed **to the correct shape and height based on the type and model of roof tile, and facilitates installation by providing the correct tile gauge**.

Compared to perforated sheet metal, the flattened metal profile offers a **better open-area ratio (approximately 30% greater)**.



Use of mortar or foams



Deterioration of the roof covering



Formation of mould, moss and lichen



Internal mould (left)  
Broken roof tiles (right)



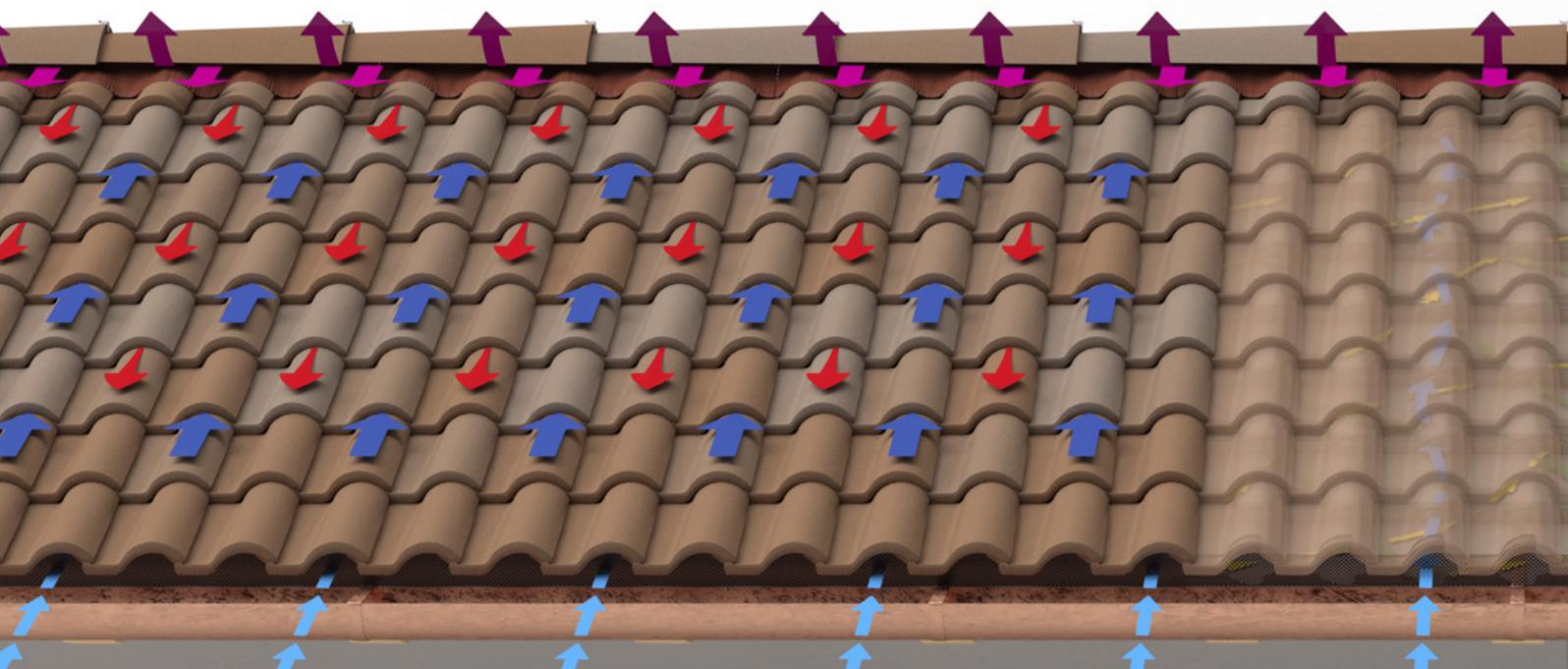
## MISTAKES TO AVOID

It's essential to understand that the installation and/or **fixing of roof tiles by laying them on fresh mortar or foam** (applied in specific points, for single element, in rows, every two, three or four rows, or in any other way) is **always considered to be bad practice and the cause of many roof problems.**

### Disadvantages of this laying technique:

1. **It does not comply with the UNI 9460:2008 standard, nor does it conform to ANDIL** (National Association of Clay Product Manufacturers) guidelines. In fact, it is expressly stated as being incorrect and thus **may lead to the clay product manufacturer's warranty being voided if any problems with the roof emerge.**
2. **It does not guarantee** anchoring of the entire roof, only some elements, i.e. only those rows or elements that have been attached, while other elements can move and slide;
3. In addition to producing **special waste that is harmful** to both humans and the environment, **such fixing substances have a limited life expectancy** (assuming the average lifespan of a correctly installed roof is at least fifty years), **a fact especially true for foams**, which tend to deteriorate and lose their effectiveness when exposed to heat and UV rays;
4. The mortar could become a **source of capillary leaks** through the rain-soaked roof covering towards the roof deck, causing stains on the underside of the roof deck;
5. It can **crack due to frost exposure** as it inhibits rapid drying of the clay tiling on the roof covering.

**Furthermore, all the functional benefits of a ventilated roof are lost, in particular dispersal of heat caused by solar insolation in summer.**



■ Passage of air between roof tiles

■ Air outflow between roof tiles

■ Air outflow from the ridge

It used to be thought that air **entered** along the eaves, **rose** longitudinally up the pitch, and **exited** along the ridge line. The research conducted by the **University of Ferrara on the "ARIA" SYSTEM** shows this is not the case: **air flow** within the roof void **follows much more complex paths**. It's essential to give the air the opportunity to move unhindered by solid battens. **The "ARIA" SYSTEM is designed on these principles.**

## HOW A VENTILATED ROOF WORKS

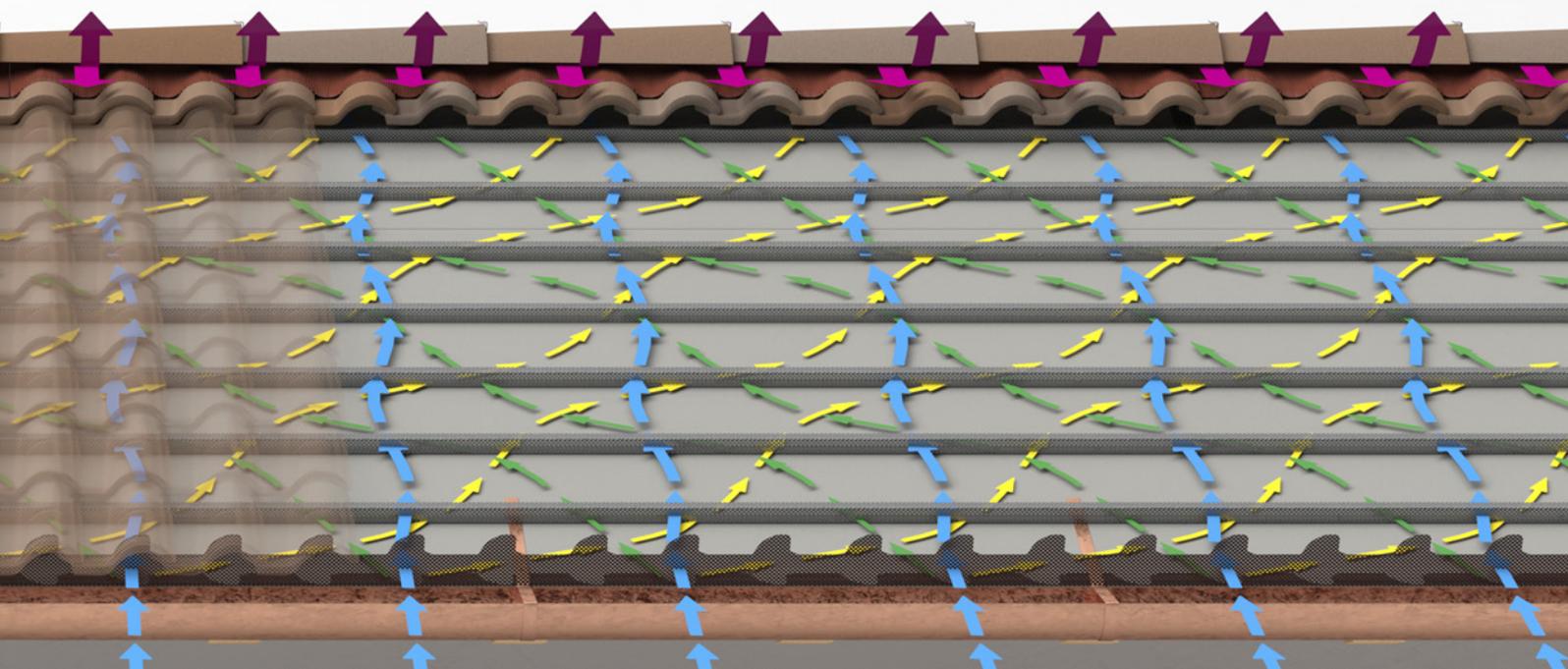
### THE FLUID DYNAMICS OF A VENTILATED ROOF

Normally, in a ventilated roof, **it was thought that air enters only along the eaves** through the comb or the bird barrier ventilation grating, **rises up longitudinally** in a fairly linear manner as it gets warmed by the heat of the sun, **and exits along the ridge line** through the perforations in the under-ridge module.

This thermo-fluid dynamic phenomenon which causes hot air to rise is commonly known as **the stack effect** and **describes the way in which air becomes less dense and thus more buoyant as it warms.**

In reality, research has shown that **air flow pathways within a roof void are much more complex** and varied, and are influenced by numerous other factors:

1. first – and by far the most significant – is the **effect of wind**, which is present in every location. **In a ventilated roof, this air buoyancy force** (which in a system without external interference gives rise to the stack effect) **by itself can do little** to limit the overheating of the tiles. And when considering solely a **longitudinal air pathway rising from eaves to ridge, only a wind blowing perpendicular to the eaves would provide maximum benefit**; in reality, it has been ascertained that **air also passes through the overlaps between the tiles**. A discontinuous waterproof layer is designed to provide waterproofing from rain, but total prevention of the



Blue Longitudinal motion in the roof void

Green Yellow Multidirectional, oblique and transverse motion in the roof void

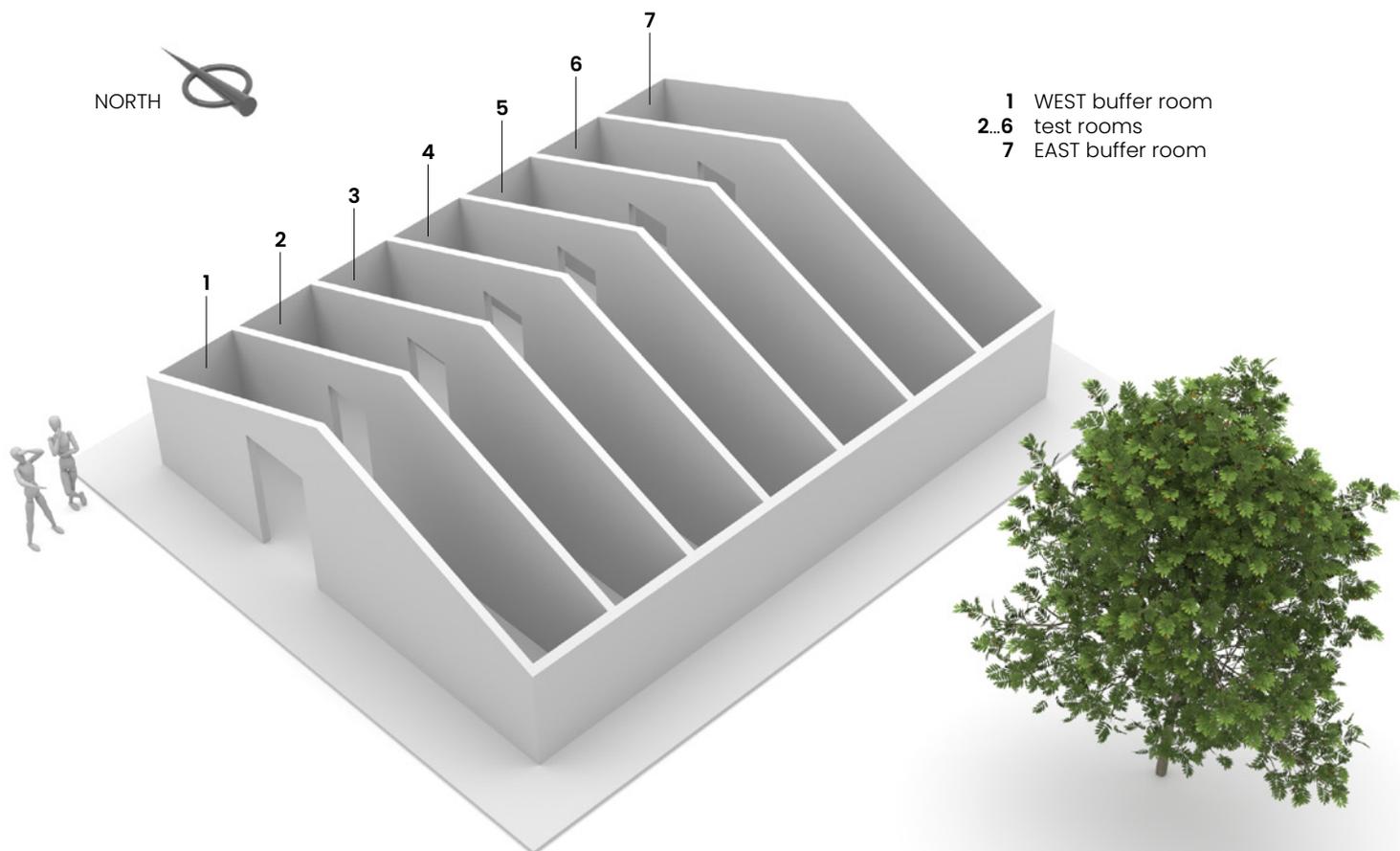
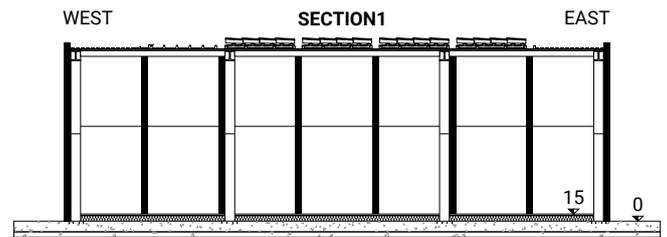
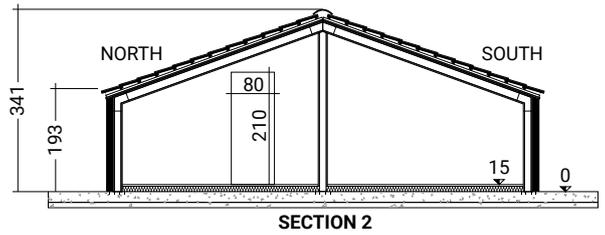
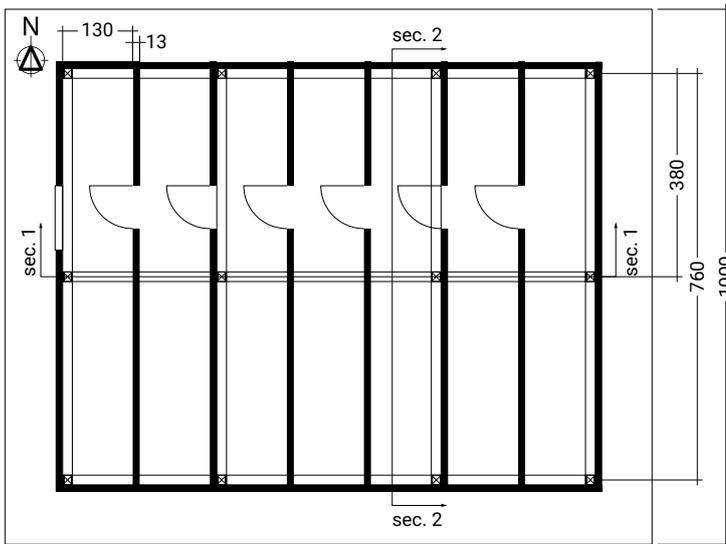
passage of air is unlikely achieved in most commercially available tiles. This means that **the inflow, movement and speed of air in the ventilated cavity** are also influenced by **wind directions that are not perpendicular to the eaves**, meaning the effect of wind has an impact from many more directions.

The energy coming from buoyant air is extremely modest and **a light breeze with wind speeds of just 0.3–0.5 m/s are enough to overcome this stack effect and modify air pathways**. Where the wind direction is perpendicular to the eaves, wind and stack effect would be summed. But **wind arriving from any other direction than perpendicular will be the prevailing force that determines** ventilation;

- secondly, the presence of support and anchoring elements for the tiles. The more these elements allow **the passage of air**, which as illustrated can come from different directions, the greater and more **effective is air circulation**. **Solid profiles however hinder** air movement because they create barriers and slow down the free flow of air entering the roof void from different directions.

These two aspects are important because in summer, heat dispersal in the roof covering does not occur simply and exclusively due to the longitudinal movement of air from eaves to ridge. Any other transversal or diagonal air circulation also contributes to this.

It follows that the stack effect is not the only phenomenon that contributes to the ventilation in a ventilated roof, and that air inflow and outflow through tile overlaps, coupled with its ability to move unhindered throughout the roof void helped by wind also makes a significant contribution. More important than the thickness of the air space **is the ability of the air to move unhindered by the presence solid tile support battens**. These fundamental aspects for ventilation are **the basis behind the design of the “ARIA” SYSTEM elements**.





## VENTILATED ROOF EXPERIMENTAL TESTING

### **THE RESEARCH CONDUCTED BY THE UNIVERSITY OF FERRARA**

Information regarding the behaviour and performance of air flow within a ventilated roof was obtained using **a series of experiments conducted on real models built at the University of Ferrara Technology Park by professors and researchers from the Department of Architecture.**

For this investigation, a small building comprising **seven equal double-pitched roofs with a north-south orientation** was used. The model was sited on an embankment to ensure maximum exposure to the elements, unhindered by any obstacles that might significantly affect the free movement of wind from any direction.

Below and coinciding with these seven identical roof coverings, **an equal number of rooms were built, comprising five central test rooms and two exterior “buffer” rooms** created to ensure identical exposed surfaces of the five central test chambers. The roofs of the model have two equal pitches. Each pitch is 160 centimetres wide and 430 centimetres long, giving a total of 5.5 square metres per pitch, and an angle of 20°, or 36%.



At various points, **inside each room** and in each layer of the roofing construction, **a series of sensors were placed to detect the temperature, air speed and heat flow**, along with an **air conditioning system to keep the internal temperature constant** connected to an electronic thermostat and an energy meter to measure energy consumption.

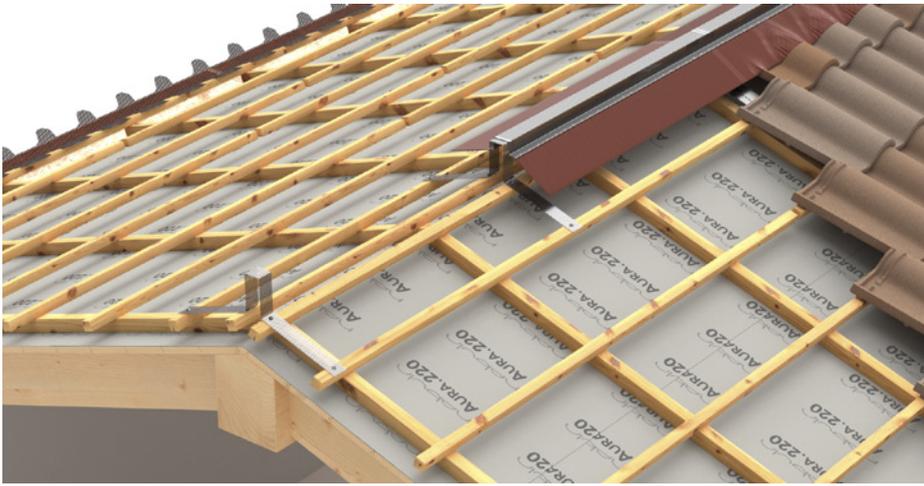
**Outside, weather stations and** cup anemometers placed at different heights and positions allowed for monitoring of atmospheric conditions.

### **THE “ARIA” SYSTEM VERSUS THE TRADITIONAL CONSTRUCTION METHOD**

During spring and summer of 2019 and 2020, two experiments were carried out specifically to **monitor and compare the performance of ventilated roofs** constructed using the “ARIA” SYSTEM with roofs constructed using traditional methods. On the roofs of the experimental building at the University of Ferrara, four roofs were constructed **and laid with Portuguese tiles using three different** installation techniques:

1. Tiles laid on **a counter-battened base using 4x3 centimetre wooden battens**, gutter GRATING in painted flattened metal and **COLMOWINGS under-ridge ventilation module**;
2. Tiles laid on **a single layer of 4 cm high “UNO” tiling battens**, painted flattened metal gutter GRATING, and **COLMOWINGS under-ridge ventilation module (the “ARIA” SYSTEM)**;
3. Tiles laid on **a single layer of 4 cm high “UNO” tiling battens**, painted flattened metal gutter GRATING, and **MICROTEC400 roll under-ridge ventilation module**;
4. Tiles laid **directly on the upper surface of the roof deck**, with several intermediate rows, ridge line and eaves tiles attached using **foam**.

The same painted flattened metal eaves profile was installed on the first three ventilated pitches, to focus the experiment and comparison mainly on the performance of the tile support and attachment systems and on the under-ridge ventilation module.



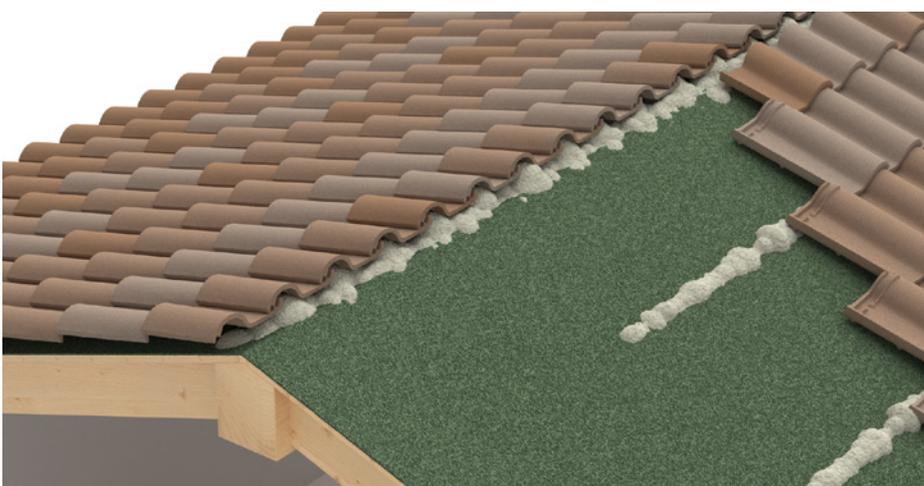
CASE 1  
Wooden tiling battens + counter battens, gutter GRATING and COLMOWINGS under-ridge module.



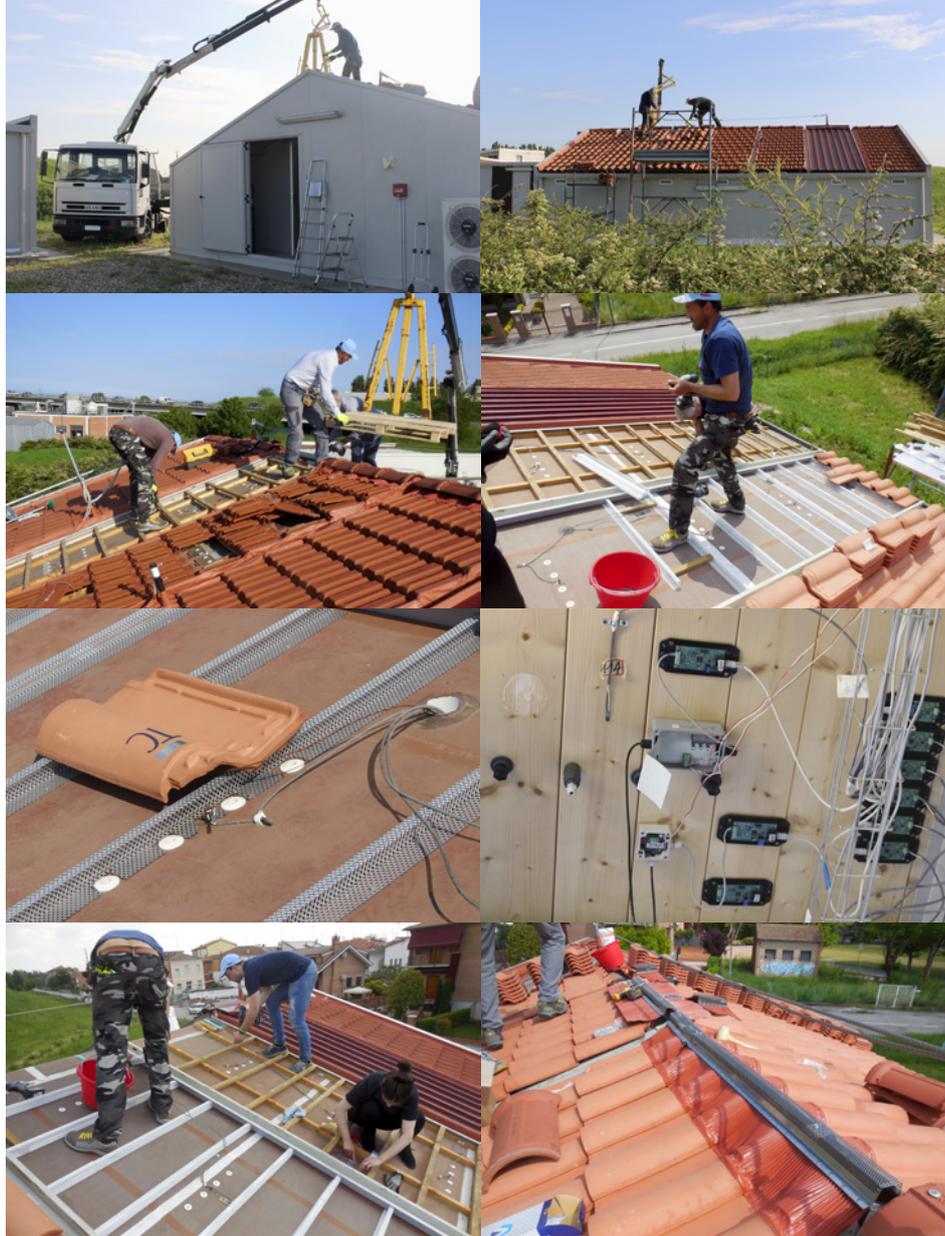
CASE 2  
Only tiling battens with "ARIA" SYSTEM.



CASE 3  
Only "UNO" tiling battens, gutter GRATING and MICROTEC400 under-ridge module.



CASE 4  
Direct installation using foam to the exterior surface of the roof deck.



## THE TESTS IN DETAIL

While conducting these tests, the temperature **inside the test chambers** beneath the test roofs was kept constant by an air conditioning system, **set at 26 °C**, which corresponds to the standard regulations for indoor temperatures in summer.

## CLIMATIC CONDITIONS

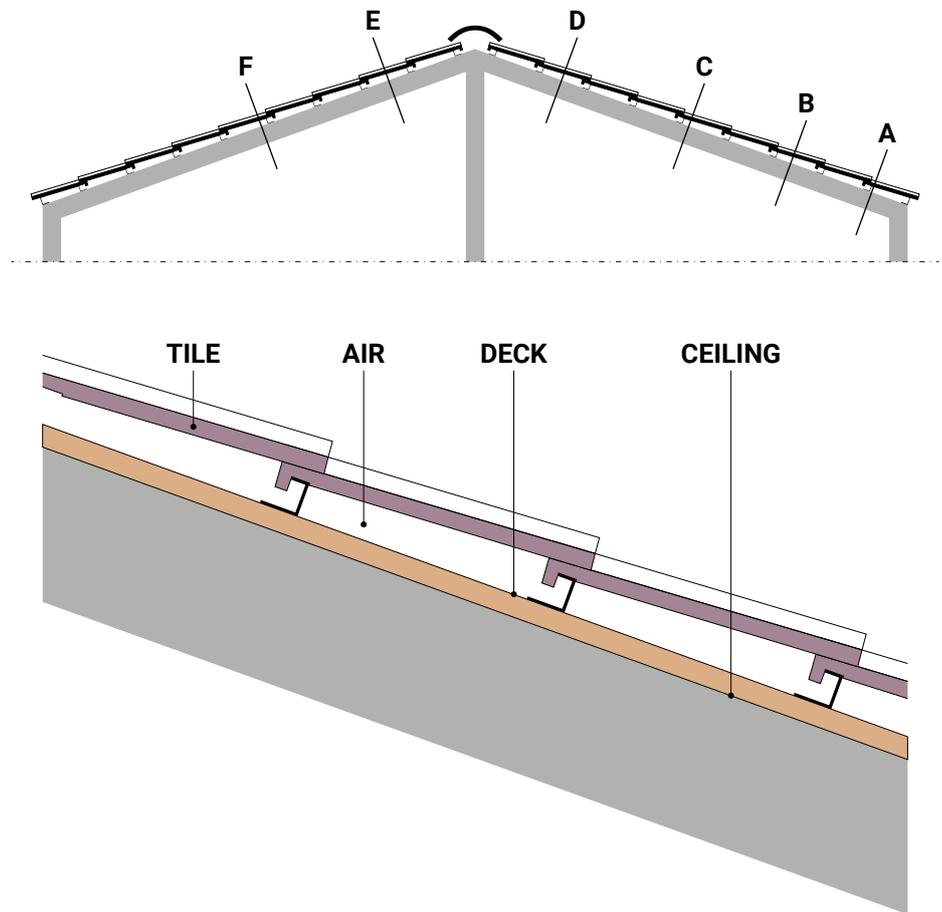
In the Ferrara area during the two test periods, the average outside temperature fluctuated from a maximum of 37 °C in the early afternoon to a minimum of 18 °C just before dawn, with an average of 28 °C from 8.00 am to 8.00 pm.

|               | MINIMUM TEMPERATURE |       | AVERAGE TEMPERATURE |       | MAXIMUM TEMPERATURE |       |
|---------------|---------------------|-------|---------------------|-------|---------------------|-------|
|               | 2019                | 2020  | 2019                | 2020  | 2019                | 2020  |
| <b>June</b>   | 17 °C               | 18 °C | 26 °C               | 26 °C | 38 °C               | 35 °C |
| <b>July</b>   | 18 °C               | 22 °C | 26 °C               | 28 °C | 38 °C               | 36 °C |
| <b>August</b> | 18 °C               | 20 °C | 26 °C               | 29 °C | 38 °C               | 37 °C |

Six measuring sections were selected for each roof (4 beneath the southern pitch and 2 beneath the northern pitch) where the **air speed** in the air space, the temperatures of all the layers on upper surface and lower surface, and the **heat flow** was measured.

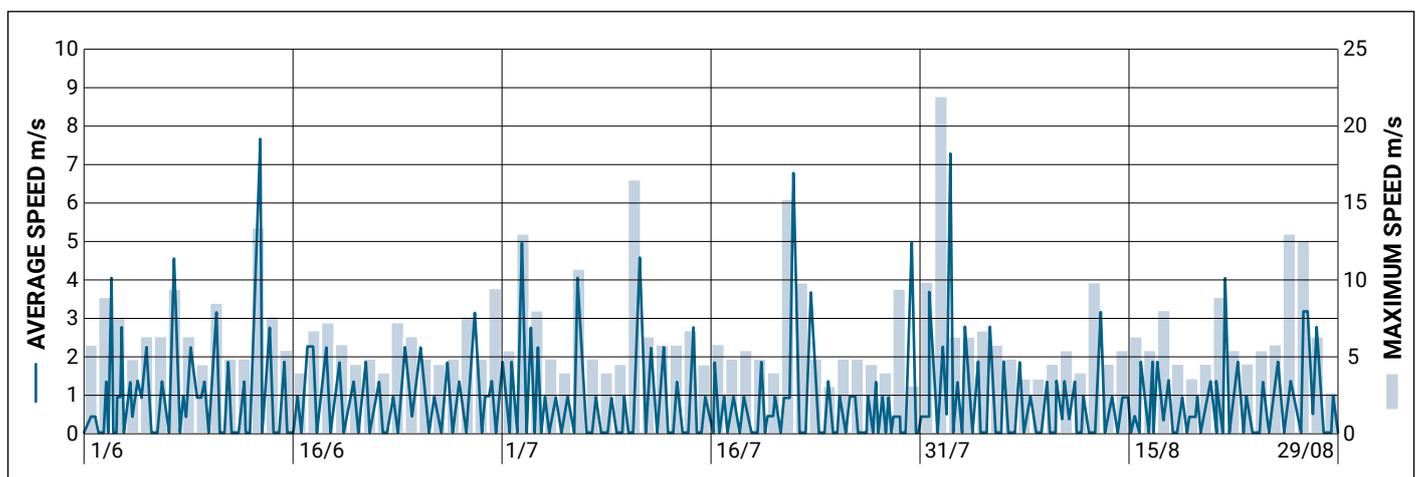
In detail, data were acquired using a Datalogger at 10-minute intervals for:

1. **The under-tile temperature (TILE)**, meaning the lower surface of the Portuguese tile - (thermocouples and PT100)
2. **Ventilation air temperature (ASV, Above Sheathing Ventilation)**, meaning the ventilation within the roof void - (thermocouples and PT100)
3. **Temperature of the upper surface of wooden deck (DECK)** - (thermocouples and PT100)
4. **Lower surface temperature (CEILING)** - (thermocouples and PT100)
5. **Room temperature (ROOM)** - (thermocouples and PT100)
6. **Air velocity** within the ventilation gap (ASV) - (omnidirectional and directional hot-wire and hot-film anemometers)
7. **Heat flow on the lower surface of the deck** for measuring the passage of solar energy - (heat flow meters on south-facing slopes)
8. **Wind speed and direction** monitored to the North and South of the building at different altitudes - (cup-and-vane anemometers at 0-20 kohm)



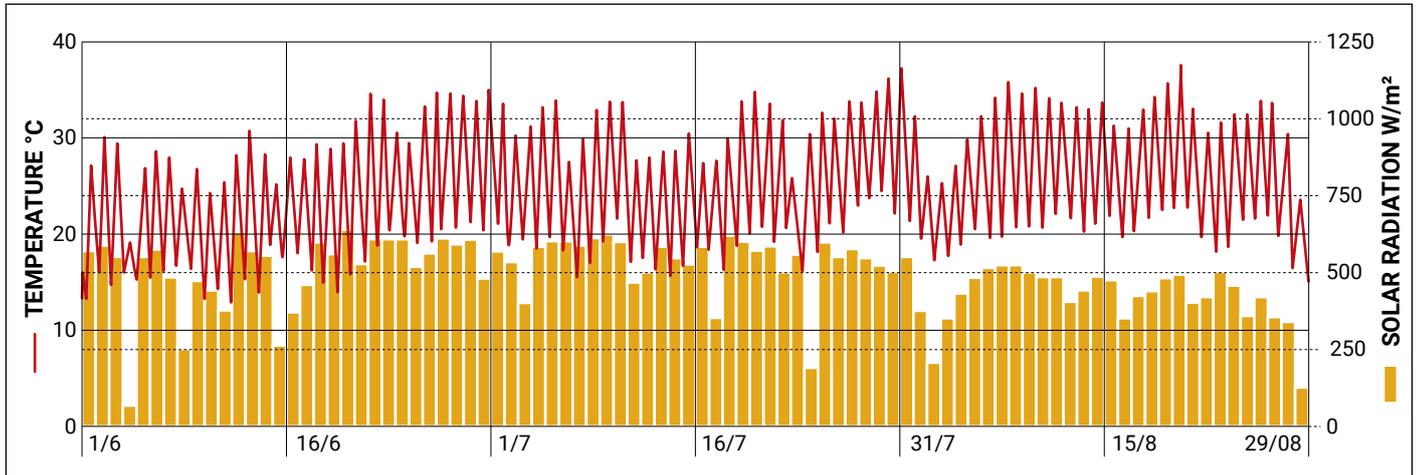
**Wind speed rarely reached significant levels**, despite the experimental model being sited in a position higher than its surroundings and exposed to unimpeded wind, as Ferrara's altitude is insignificant and wind speeds are usually very low.

Given the importance of wind for the performance of under-tile ventilation, **the values and benefits detected during this experiment may be** significantly higher in locations that experience wind speeds more in keeping with the national average. The data show an average wind speed during the two test seasons of less than 1 m/s, peaking occasionally at 3 m/s, and even more rarely above this value.



Wind speed in the period June–July–August 2020 (right scale shows maximum speeds, left scale shows average speeds)

**Average solar insolation** was 512 W/m<sup>2</sup> during 2019 and 498 W/m<sup>2</sup> during 2020, but frequently reaching peaks above 900 W/m<sup>2</sup>, indicating that solar heating of the surface of the tiles was significant. It can therefore be stated that the environmental conditions (modest wind speeds, significant solar heating) were not very favourable and that the benefits obtained from roof void ventilation can easily be assumed to be greater in other geographical locations.

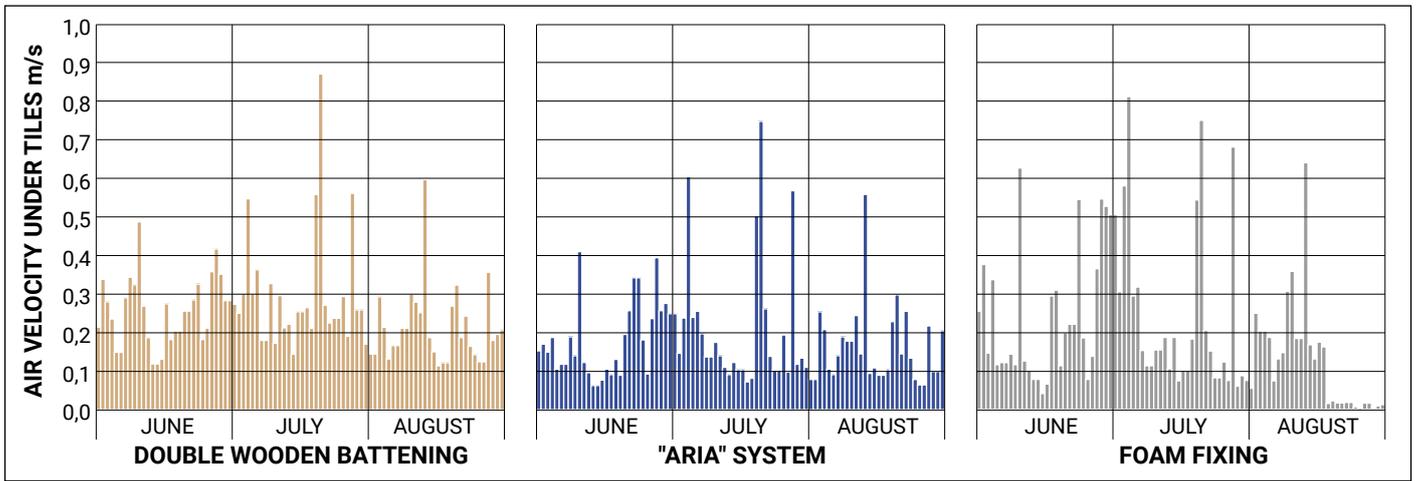


Solar radiation in the period June–July–August 2020 (right scale) and the outside temperature (left scale)

## EXPERIMENT FINDINGS

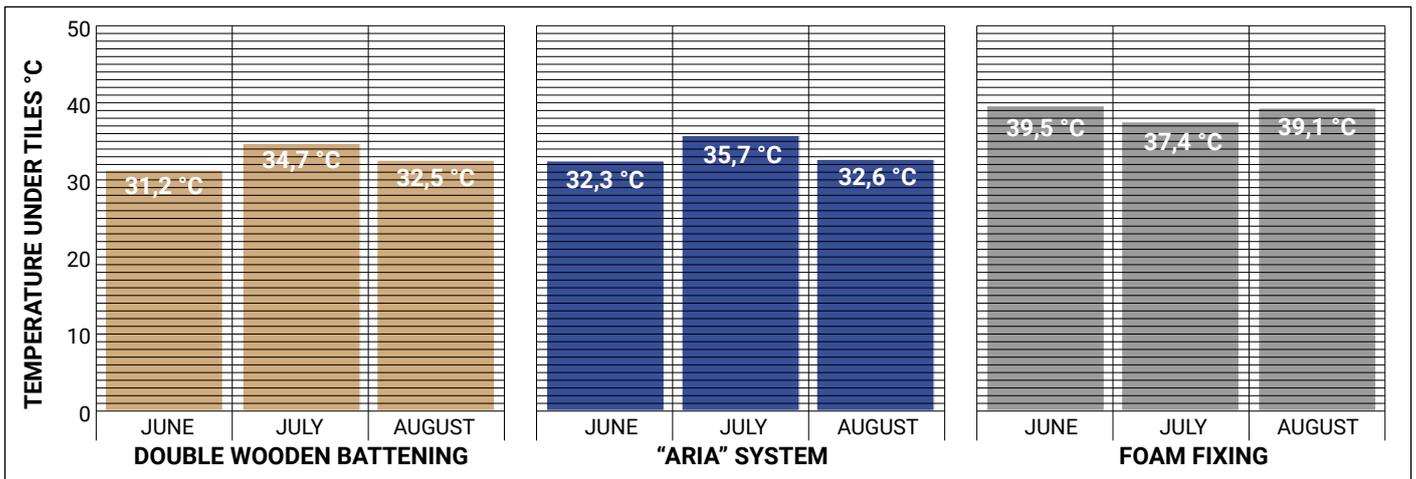
During the two test periods, several thousand data points were collected: the most important ones were for **air speed and temperature in the roof void** and in particular the **capacity of this ventilation to disperse solar heat**, with **the “ARIA” SYSTEM showing a clear advantage** in comparison to a non-ventilated roof constructed using roof tiles fixed with foam/mortar.

The **greatest air movement** was measured in the counter-battened roof, followed by the roof with the “ARIA” SYSTEM, while the roof with foam-laid tiles shows overall lower speeds and above all a rather erratic, unpredictable trend, mostly linked to the presence of the lines of foam or mortar used to attach the tiles hindering air circulation in the roof void.



The three graphs show the air speed in the air space in the different models tested: tiles laid on the counter-battened roof with COLMOWINGS under-ridge module, tiles laid on "UNO" battens with COLMOWINGS under-ridge module and tiles laid on foam.

Similar information was obtained by comparing the **temperature of the air circulating in the roof void**, with the lowest values measured in the first two roofs (differences not exceeding 1 °C) and significantly higher in the third roof at over 39 °C.



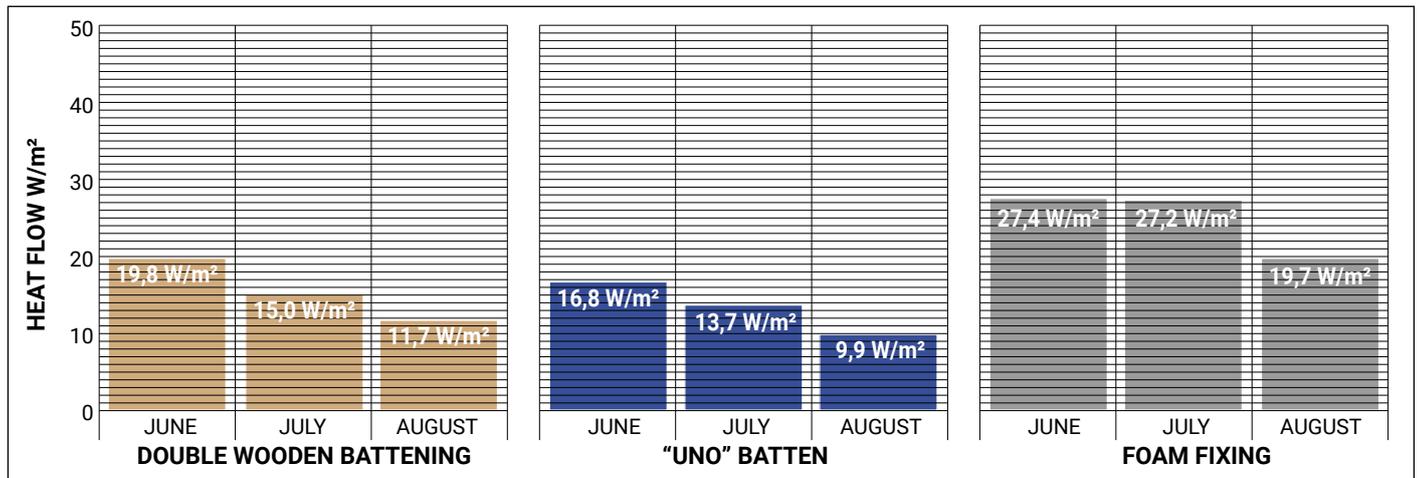
Graph of under-tile temperatures in the three types of roof. Average measured between 8.00 am and 8.00 pm.

## DETERMINING FACTORS

Since **the most important function of a ventilated roof is to prevent heat energy from solar radiation from entering**, more important than the speed and temperature of the air is its **ability to disperse this energy**, which mainly depends on the type of air motion.

It's clear that, for dispersal of the sun's heat, **free movement of the air is of greater importance than its speed or temperature.**

Higher speeds may be due to vortices or swirling of the air detected by the anemometer but without any actual heat dispersal occurring, while **lower but more linear speeds are more effective** for this purpose.



The graph shows the heat flow entering the test chambers under the three test roofs, highlighting enhanced performance in the "UNO" batten roofing compared to the wooden counter-battened roof. The third roof, with tiles laid on foam, obviously shows the worst performance. Average measured between 8.00 am and 8.00 pm.

This is due to the **ability of the air to flow transversally and diagonally through the perforations in the "UNO" batten, which compensate for the reduced thickness of the roof void compared to the counter-battened system**, in which the double layer of solid wooden battens impedes the transverse and longitudinal movement of the air.

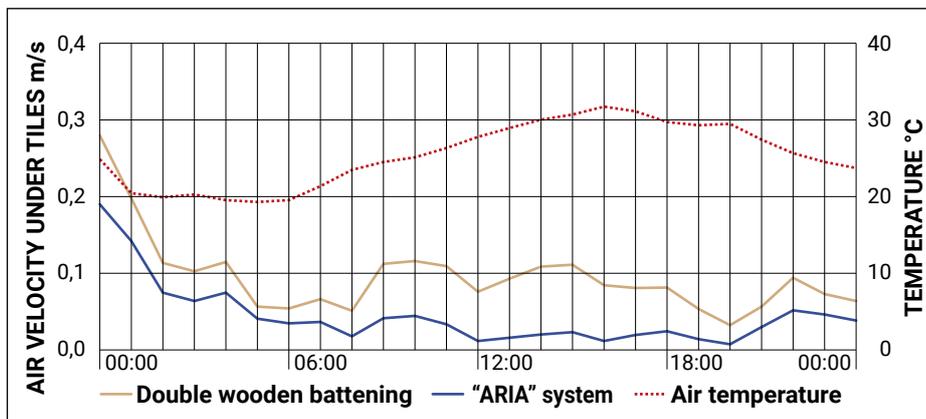
Thus the flattened sheet metal of the **UNO batten allows the air to move in multiple directions** and better exploits any air that permeates between the tiles themselves.

**The analysis of the data provided by the directional and omnidirectional hot film and hot wire anemometers highlighted this phenomenon.**

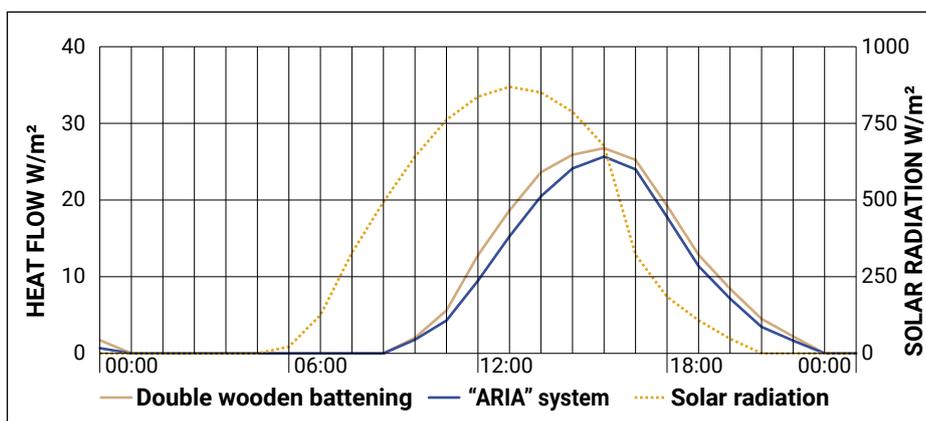
Confirmation also comes from detailed analysis of a typical day taken during the experimental period. By comparing the air speed and heat flow in the air space of the counter-battened roof with the one using the "ARIA" SYSTEM on July 23, it can be seen that the air speed is greater in the with counter-battened roof, **while heat flow is lower in the roof with the "ARIA" SYSTEM.**

Comparison between the air speed under the tiles and the corresponding heat flow in counter-battened roofs and roofs with the "ARIA" SYSTEM on July 23. Higher speeds do not always result in lower heat flow

Under-tile speed and air temperature



Heat flow and solar radiation



## FINAL CONSIDERATIONS

In light of these data, **the evaluation of the benefits**, though limited in terms of absolute values, still **favours the "ARIA" SYSTEM, and to this can be added other evaluation parameters** including:



### 1. **more efficient ventilation**

extends the life of the roof and improves living conditions in the attic room;



### 2. **reduced thickness of the roof installation**

advantageous when conducting renovation work in historic centres;



### 3. **maintenance aspects**

localised maintenance can be conducted without special equipment;



### 4. the possibility of **fixing roof tiles**

stability of the elements;



### 5. **lower overall costs** (product + laying)

cost savings;



### 6. the **"ARIA" SYSTEM** installation and ventilation accessories **are not harmful to human health or the environment.**



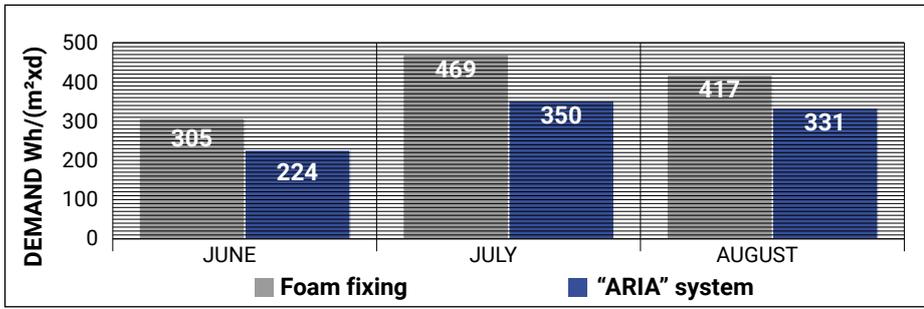
## BENEFITS WITHIN THE STRUCTURE

A significant difference emerges when evaluating the **differences in summer time air conditioning costs** of a ventilated roof with the “ARIA” SYSTEM and a non-ventilated roof (with tiles fixed using foam or mortar).

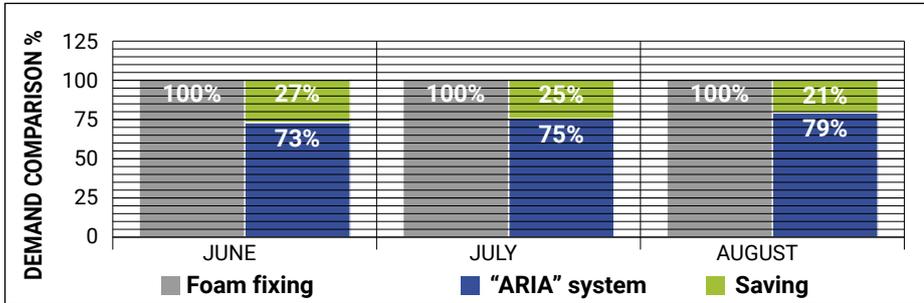
This evaluation was carried out **by air-conditioning each test room beneath the test roofs** using a fan coil unit actuated by means of a digital thermostat which, whenever the internal temperature went above the set temperature (26 °C being the norm in summer), turned on the air conditioner. An energy meter connected to the same circuit detected the temperatures (in/out) and flow rate while simultaneously counting refrigeration and energy consumption, i.e. the thermal energy required for air conditioning.

The graphs show the **average daily thermal energy requirement** (Wh/m<sup>2</sup> per day) from 8 am to 8 pm (i.e. during the period of greatest sunshine), per unit of surface area for each test room in June, July and August.

It can be seen that the roof with tiles laid using foam or mortar



Average daytime heat requirement (8am - 8pm) during the months of June, July and August for cooling per unit of surface area

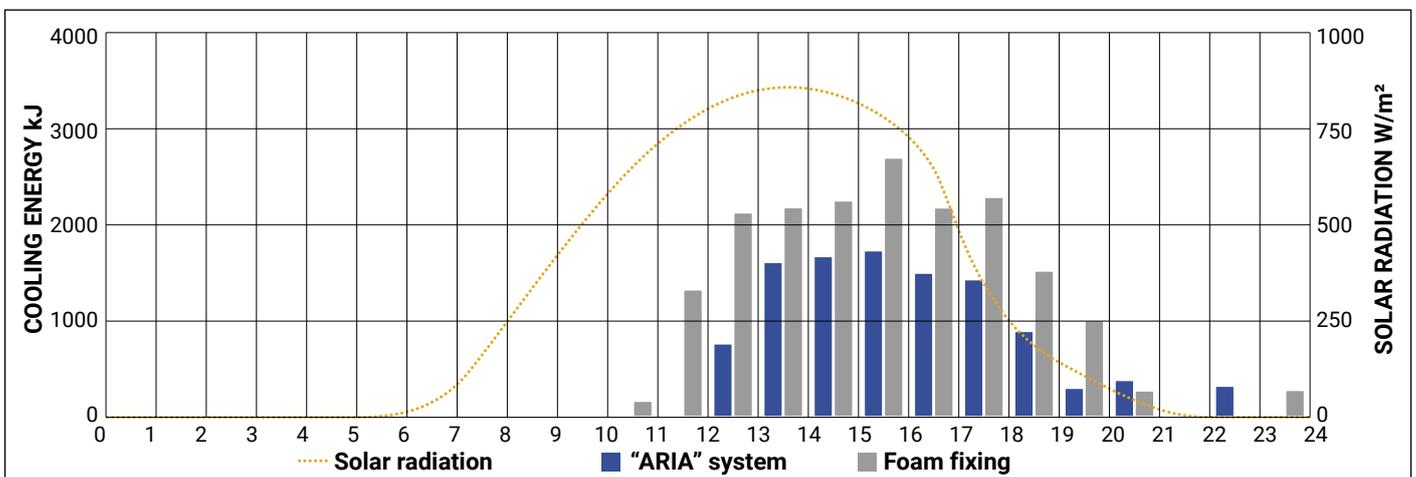


% reduction in average daytime heat requirement in the months of June, July and August for cooling per unit of surface area compared to a roof with tiles laid on foam

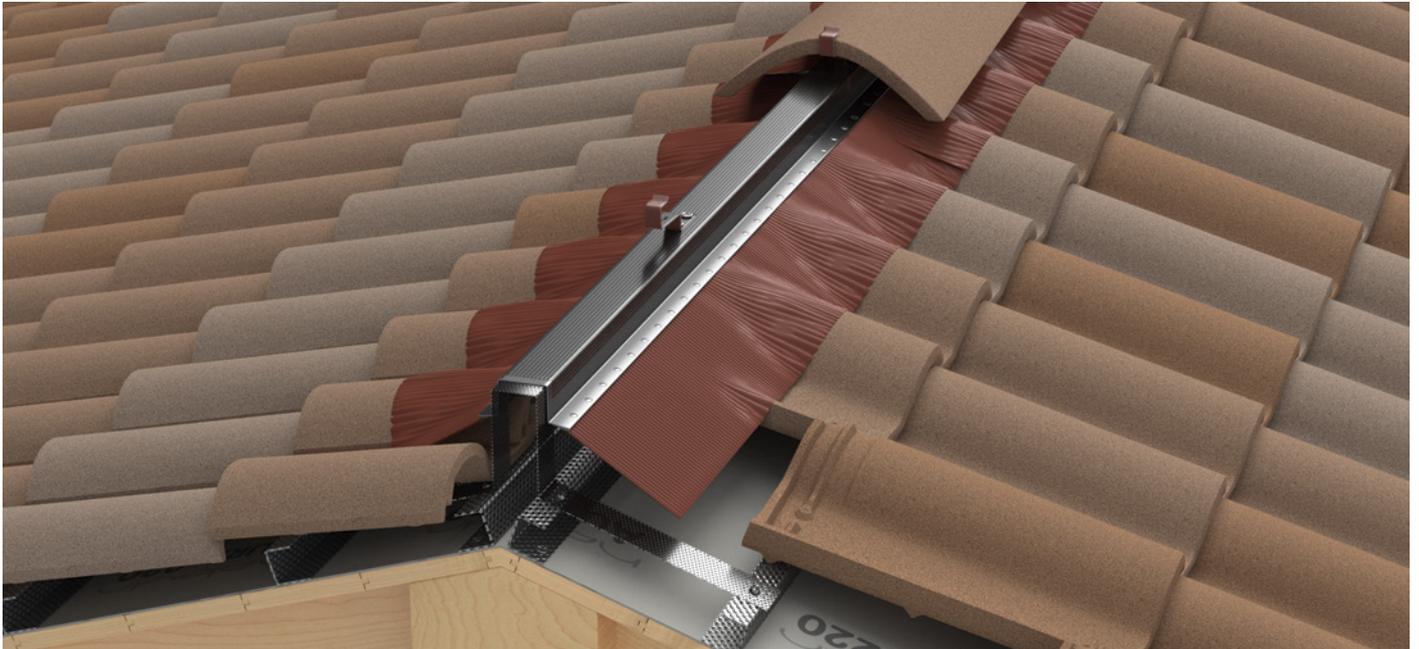
clearly consume the most energy for cooling, i.e. an average of 397 Wh/m<sup>2</sup> per day in the three-month monitoring period compared to 302 Wh/m<sup>2</sup> per day for the roof with the "ARIA" SYSTEM.

**In the comparison**, it can be seen that the room with tiles laid on the "ARIA" SYSTEM consumes on average 24% less than the room with the tiles laid using foam or mortar.

The following graph, which shows **the energy required for cooling**, always refers to a typical day, namely July 23, and clarifies this difference even more clearly: throughout the day, the roof with tiles laid with foam or mortar requires a greater energy input to maintain 26 °C inside the room compared to the roof correctly ventilated using the "ARIA" SYSTEM.



July 23, 2020 - Max IRR: 859 W/m<sup>2</sup> - T\_OUT max: 31 °C. Thermal requirement for cooling per unit of surface area, comparison between "ARIA" SYSTEM and tiles laid on foam or mortar (solar irradiance: righthand scale, energy consumed for cooling: lefthand scale)



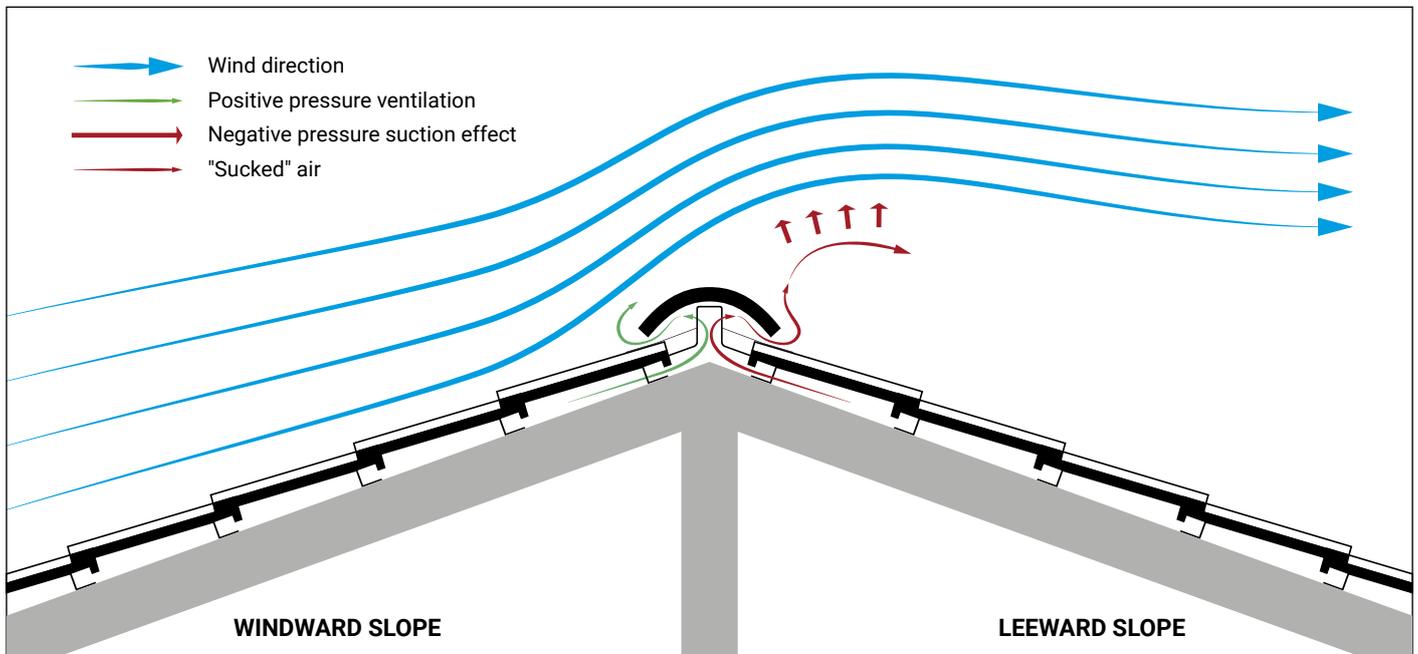
COLMOWINGS

## **THE IMPORTANCE OF THE RIDGE VENTILATION MODULE**

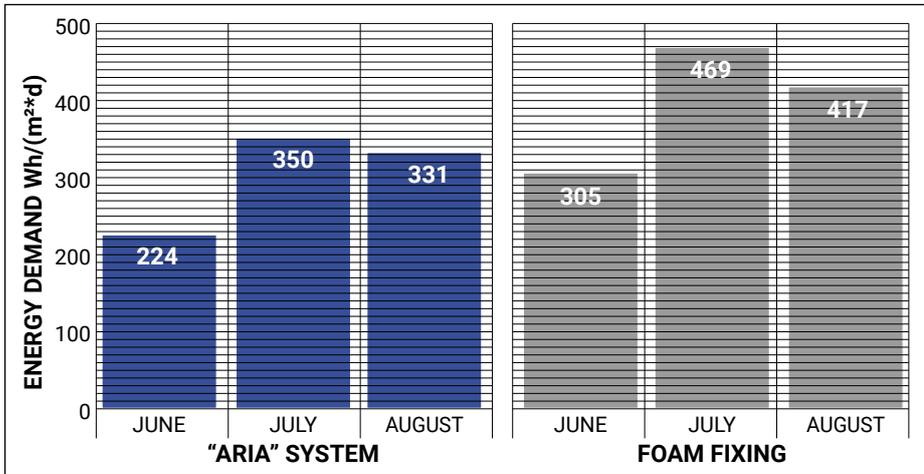
### **COLMOWINGS**

A final discussion related to this experiment worth mentioning is the **ridge module**. This study was carried using the **COLMOWINGS** profile installed both on the **wooden counter-battened roof** and the roof with the **“UNO” battens**. No under-ridge module was fitted to the roof with the **ridge tiles laid directly using foam**.

On the **windward slope**, the ventilation air is at a **higher pressure** aided by the **prevailing wind**. This same pitch **also acts as a sort of springboard**, deflecting the wind upwards and creating **a reduction in air pressure on the leeward pitch**. This results in a **suction effect** on the leeward pitch which, via the ridge, draws air from the opposite pitch. The under-ridge module thus **allows both outflow of air from the windward slope, the suction of air from the leeward slope, and the transit and expulsion of this air from the leeward slope**.



AIR SUCTION EFFECT



Average daytime heat requirement (8am - 8pm) during the months of June, July and August for cooling per unit of surface area

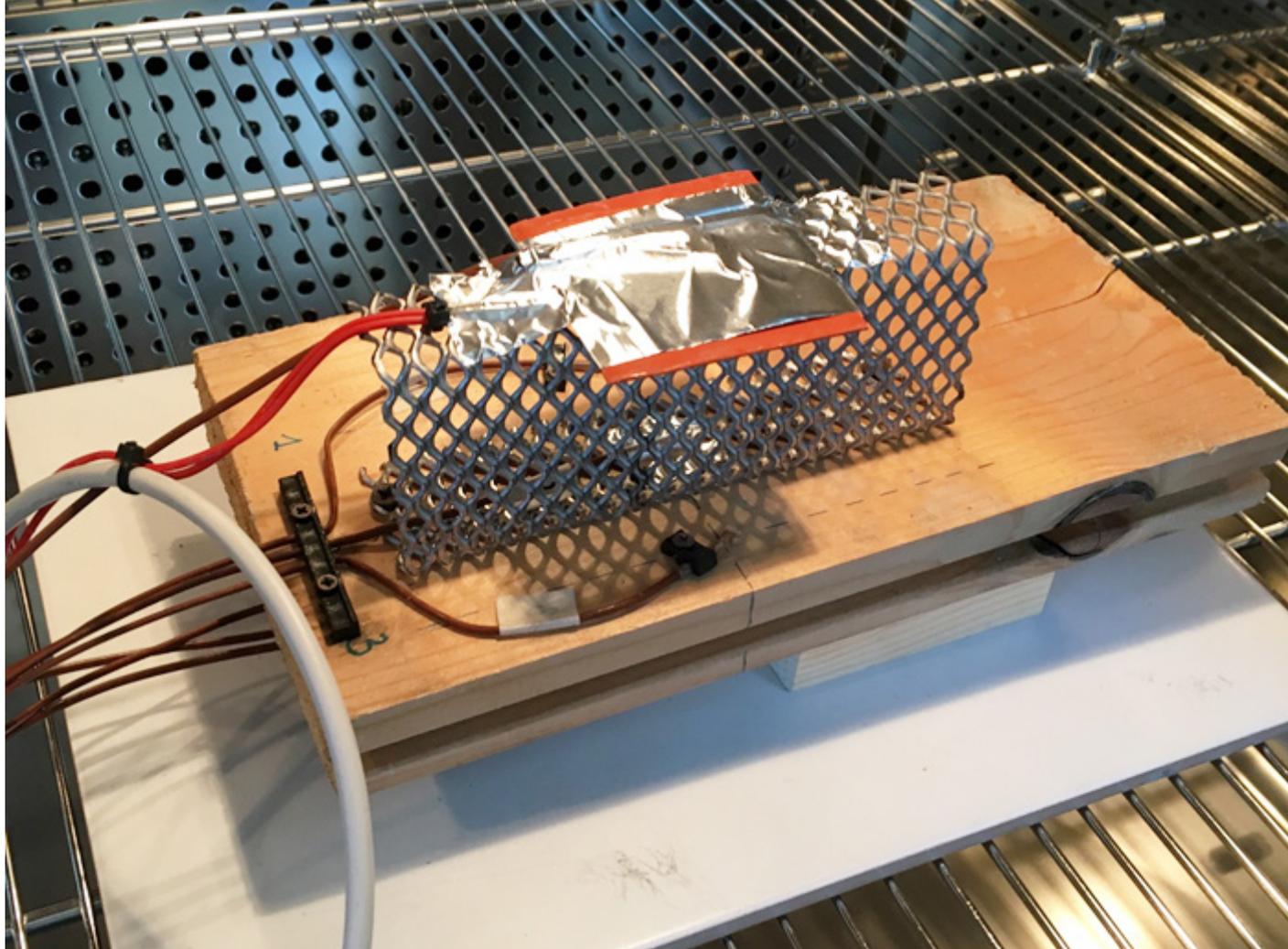
## MICROTEC400

The **type of under-ridge profile**, type of perforations, the open air ratio, as well as position and width are also factors which facilitate this air circulation.

This theory is supported by the test carried out using **MICROTEC400 aluminium under-ridge ventilation sheeting** applied in the third test pitch which, **despite the presence of the grating and the "UNO" batten**, required more energy for cooling the room beneath it than the roof with the "ARIA" SYSTEM and COLMOWINGS under-ridge module.



MICROTEC400



## **TESTING OF THERMAL BRIDGES**

### **THE LABORATORY TEST**

During the research, a **laboratory test was conducted to evaluate whether**, when used as a support for the tiles, **the “UNO” batten could constitute a thermal bridge**, despite its particularly low mass.

A portion of the metal profile was placed on a sample of the roof deck similar to the one on the experimental roof. A heating element was fixed to the profile as a heat source, simulating the thermal flow of solar radiation which, after passing through the tiles, reaches the batten and subsequently the roof deck.

The sample was **placed in a temperature chamber**, so the test could be repeated in a controlled environment, with the temperature set at 40 °C (similar to the air temperature under the tiles) and the heating element was connected to a power supply.

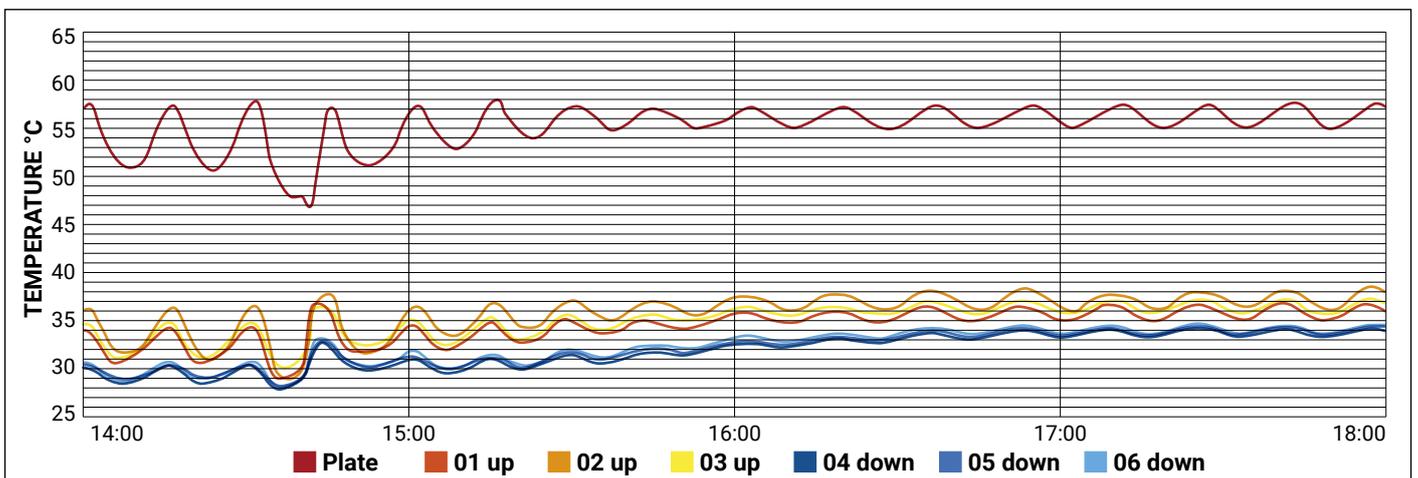
## THE TEST RESULTS

The comparison between the temperatures detected by the thermocouples placed on the lower surface of the deck, both next to and further away from the batten, showed **temperature differences all within a range of a few tenths of a °C** (the three overlapping blue lines on the graph), which were at the limit of the sensitivity of the sensors.

This highlights that, despite being highly resistant to foot traffic and tile weight, **the presence of the "UNO" batten does not affect heat transmission** given its shape and limited mass.



Temperature chamber for thermal bridge testing



### TEMPERATURE CHAMBER TEST.

The red and orange lines indicate the temperature above the roof deck, the blue lines indicate the temperature on its lower surface.

# NUMERICAL INVESTIGATION AND INTERPRETATION OF AIR MOVEMENT IN THE ROOF VOID

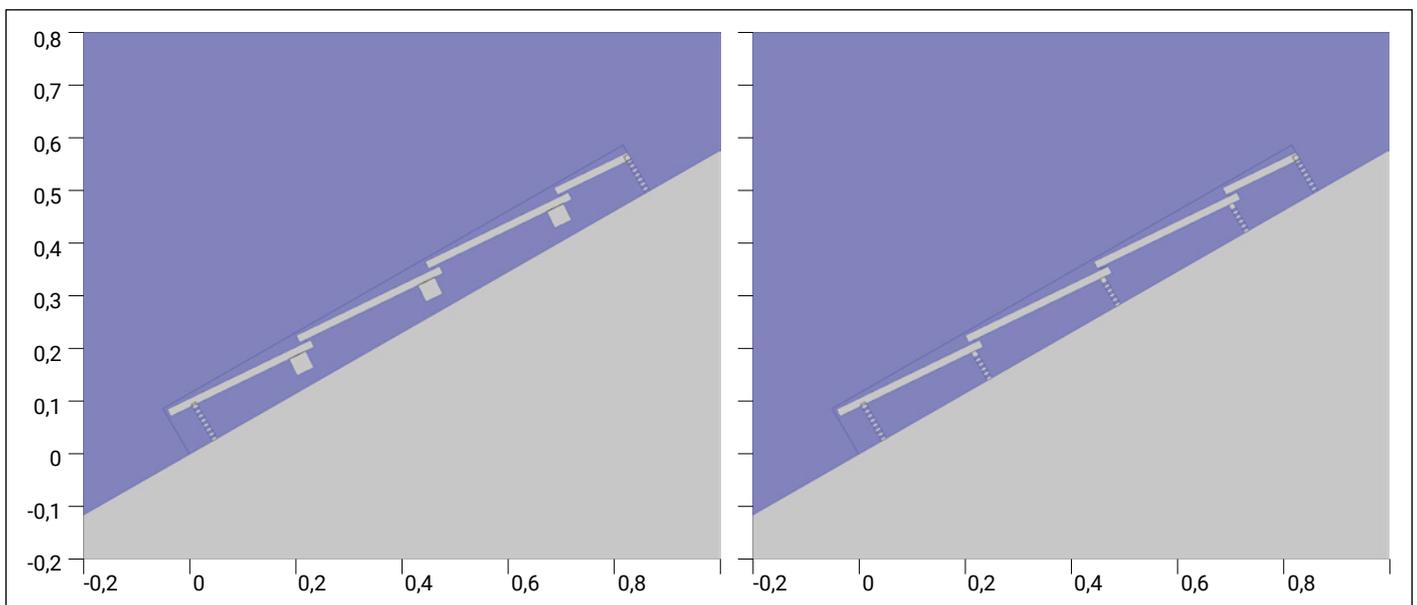
## CFD: COMPUTATIONAL FLUID DYNAMICS

During this research, a **CFD (Computational Fluid Dynamics) numerical investigation** was also conducted to investigate the different air movements in the roof void by comparing air movement in a **ventilated roof with a wooden counter-battened installation, with a roof using “UNO” battens**.

In the two roof sections shown, **similar modules were used at the eaves and ridge line** to focus the experiment solely on the performance of the tile support systems.

**The first model** comprises **solid wooden tile battens with a cross-section of 3.5 x 3.5 cm**, one per row. The illustration shows a simplified counter-battened construction, which excludes longitudinal battens, since these run parallel to any rising air and therefore have little influence on the experiment.

**The second diagram** shows the layout of **“UNO” battens**, arranged in the same positions as above.



Representation of the model on solid wooded battens

Roof section model using “UNO” battens

## THE CONDITIONS

A wind speed of **0.5 m/s** was assumed entering from the lefthand side of the domain (eaves line in the diagram) **flowing horizontally** (inlet), and exiting on the righthand side (ridge line in the diagram) with zero relative pressure (outlet).

An open boundary domain condition was assumed to exist above the roof.

## THE CALCULATION

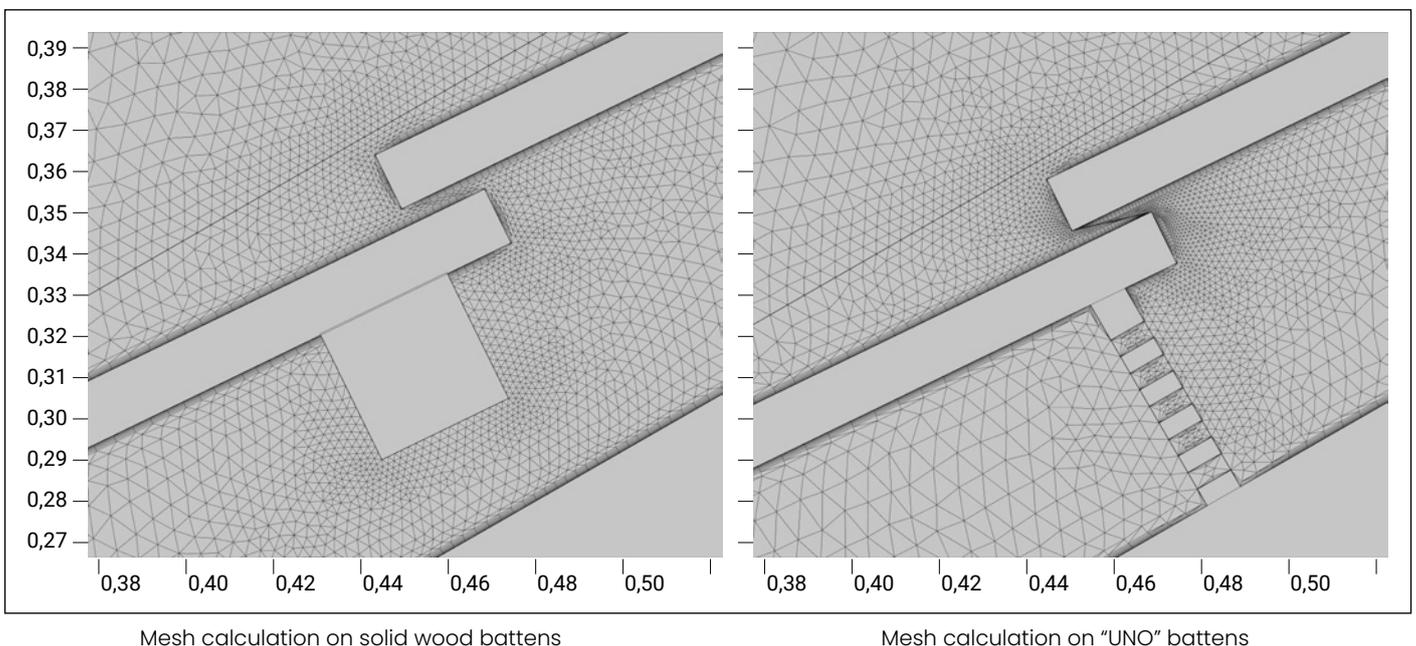
The **mesh calculation** (i.e. the network of elements for the numerical calculation of the thermo-fluid dynamic problem) was built by dividing into **8 sublevels the boundary layer present on the solid elements**.

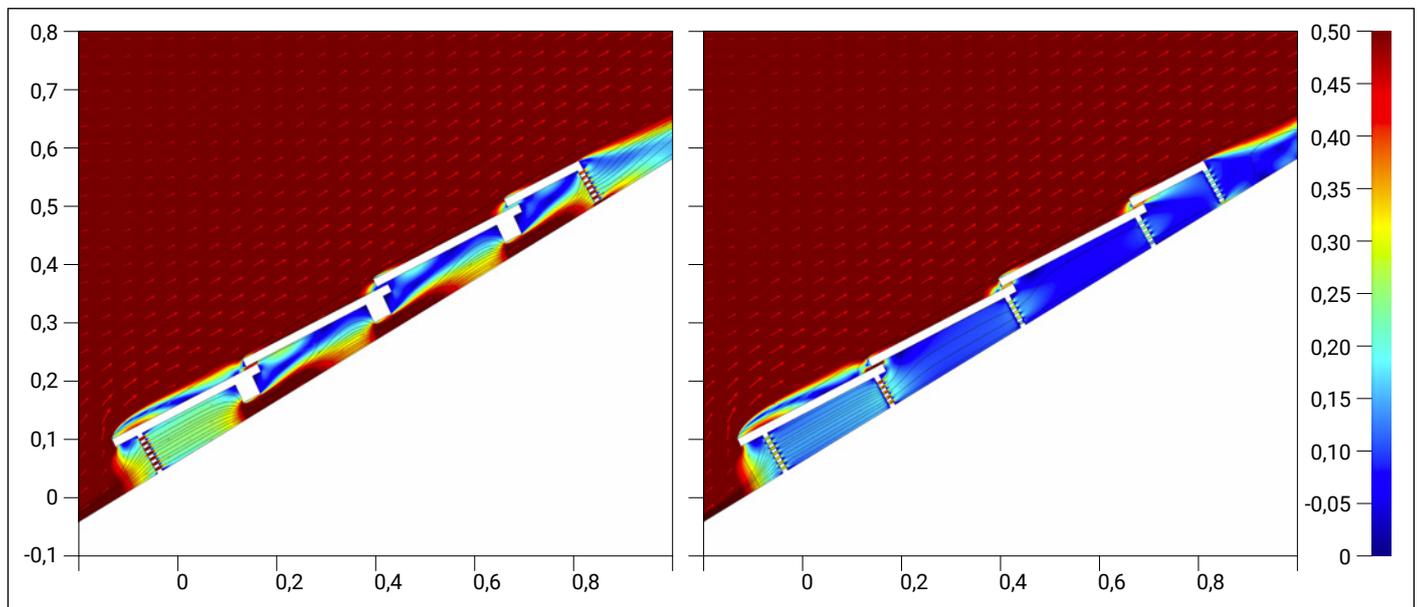
The mesh was discretized into triangular-shaped cells, with the number of finite elements being on average approximately 40,000.

**Simulations were conducted using a steady-state solution**, i.e. assuming properties do not change with time.

## THE RESULTS

The results shown **display air speed distribution**, with particular mapping of the streamlines in the ventilation chamber.





Air speed in the air space with solid wood battens

Air speed in the air space with "UNO" battens

This comparison shows that:

1. With the **tiles laid on a counter-battened installation**, the presence of the **wooden tile batten, laid transversally to the air flow, causes a narrowing of the channel section** and consequent **increase in the flow speed** in the vicinity of the upper surface of the roof deck, without any notable deceleration of air flow since no great reduction in speed is observed between the different battens. In the upper part of the air flow however, immediately beneath the tiles, where the phenomenon of transverse ventilation of air inlet/outlet between the overlapping tiles could be a factor – and the need for ventilation is greatest – there is a large, relatively stationary cushion of air (blue). Air turbulence immediately before the batten is also visible;
2. In the installation using only **"UNO" tile battens**, it can be **seen that the air flow slows down**, due to the drag caused by the perforations in the batten. This solution **affects air flow speed but allows for a better distribution of the air flow which is uniformly distributed across the entire height of the ventilation layer**, without any notable vortices, and allows for full exploitation of the air permeability between the tiles, with more uniform performance over the entire roof.

**The counter-battened installation** shows higher speeds, but the presence of the full transverse battens hinders the movement of the air in a longitudinal direction. Similarly, the longitudinal batten – not shown in this simulation but present

in a real-world situation – hinders air movements in a different way than solely from eaves to ridge, as it impedes transverse air movement which contributes significantly to the inflow and outflow of air between the overlapped tiles.

**This limitation does not apply to the “UNO” batten installation**

as there are no longitudinal elements in an eaves-ridge direction – only transversal ones through which air may pass relatively easily. This **unhindered movement in directions other than simply eaves-to-ridge** has revealed itself to be an important factor for the performance of a ventilated roof. As already mentioned, the air permeability of a discontinuous roof covering made of tiles lets air flow between the overlaps, allowing **the wind to enter from multiple directions and not only from the eaves line. With the “UNO” batten installation, this permeability of the tiles is better exploited.**

**The “ARIA” SYSTEM meets the requirements of the UNI**

**9460:2008 Discontinuous roofing standards.** Instructions for the design, construction and maintenance of roofs made with clay or concrete tiles **and UNI 11418:2011** Discontinuous roofs. Qualification of the person responsible for installing discontinuous roofing. Part 2: Laying guidelines and instructions and the National Association of Clay Product Manufacturers (ANDIL) manuals, which the contractor is required to adhere to.

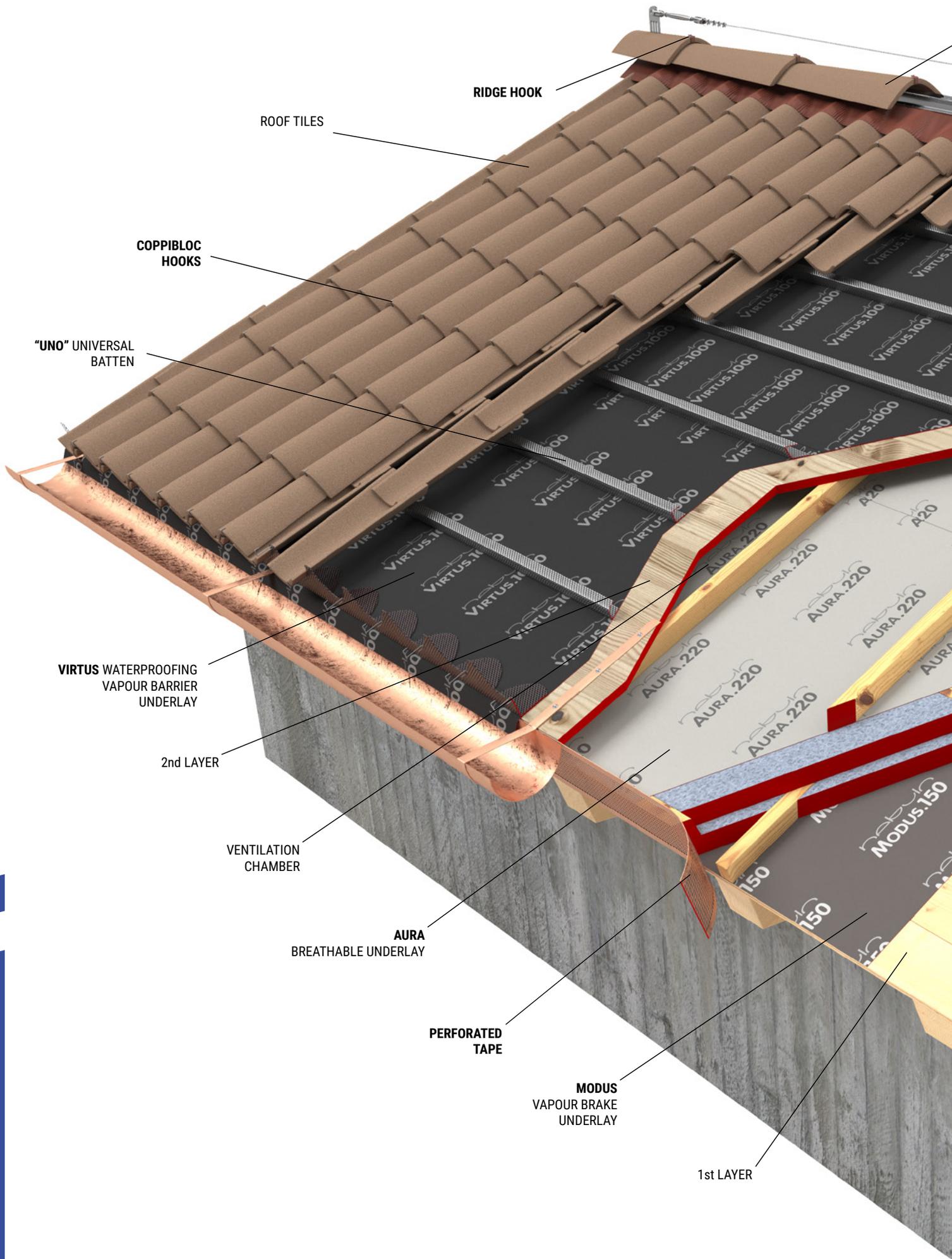
**REFERENCES**

This research is the result of a collaboration between OFFICINE RASERA and The Consorzio Futuro in Ricerca research centre and conducted at the Teknehub laboratory of the University of Ferrara. It was carried out by professors and researchers from the Department of Architecture Michele Bottarelli (scientific director), Giovanni Zannoni and Eleonora Baccega, in collaboration with OFFICINE RASERA technicians and managers Gildo Piva, Stefano Donadini and Ettore Cunial.

The Consorzio Futuro in Ricerca research centre: Design Methods for discontinuous pitched roofs, Italy-Israel, 2011-2013.

HEROTILE research project (LIFE14 CCA/IT/000939), High Energy savings in building cooling by ROof TILES shape optimization toward a better above sheathing ventilation, European LIFE program “Climate Change Adaptation” ([www.lifeherotile.eu/](http://www.lifeherotile.eu/)), 2015-2019.

For the fluid dynamic analyses, COMSOL Multiphysics software was used, in which a 2D model of a typical roof portion was used to solve the steady-state fluid dynamics (CFD) problem. The CFD model was created assuming a turbulent flow, adopting the k-ε simplification and incompressible fluid assumption.



RIDGE HOOK

ROOF TILES

COPPIBLOC HOOKS

"UNO" UNIVERSAL BATTEN

VIRTUS WATERPROOFING VAPOUR BARRIER UNDERLAY

2nd LAYER

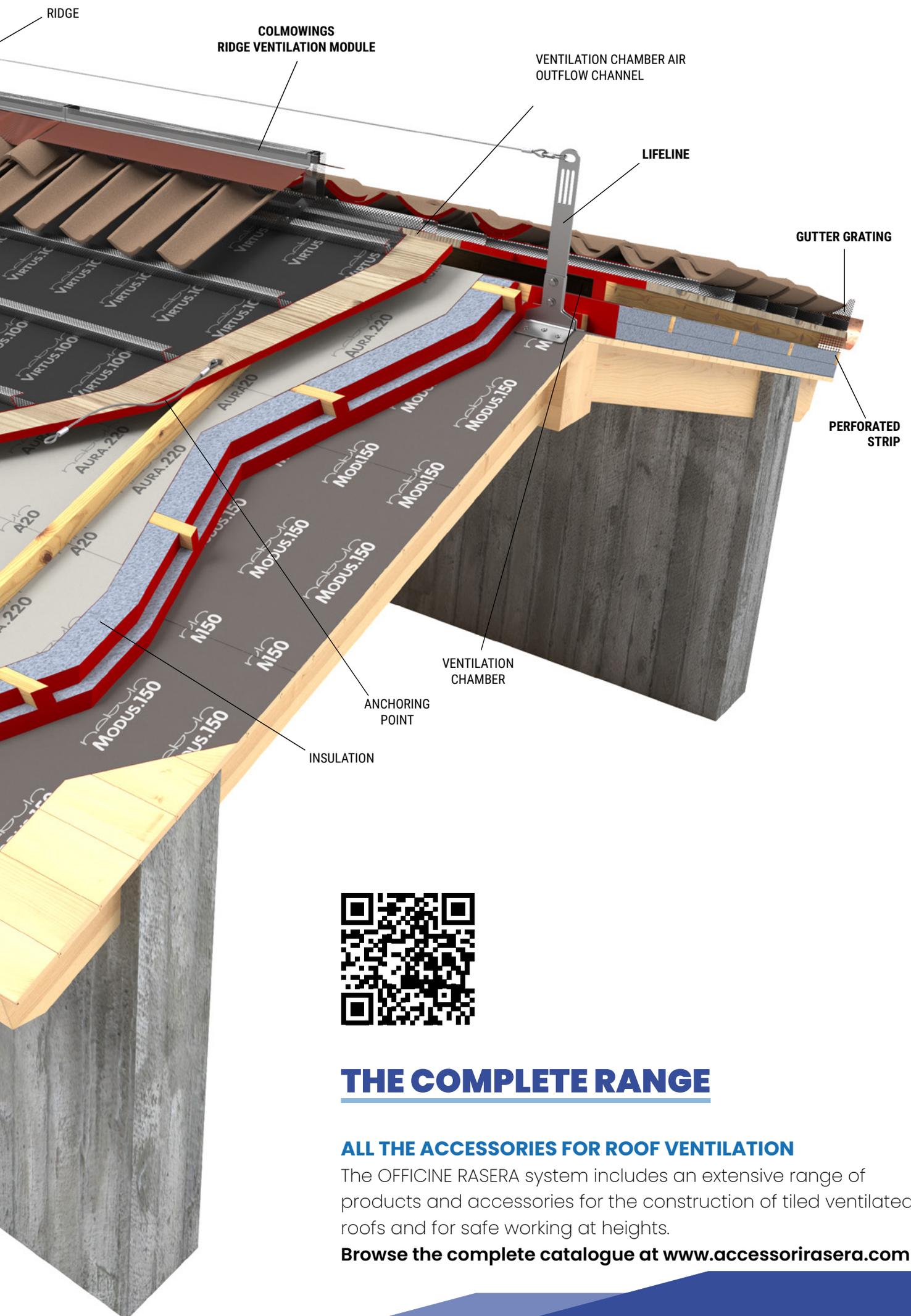
VENTILATION CHAMBER

AURA BREATHABLE UNDERLAY

PERFORATED TAPE

MODUS VAPOUR BRAKE UNDERLAY

1st LAYER



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