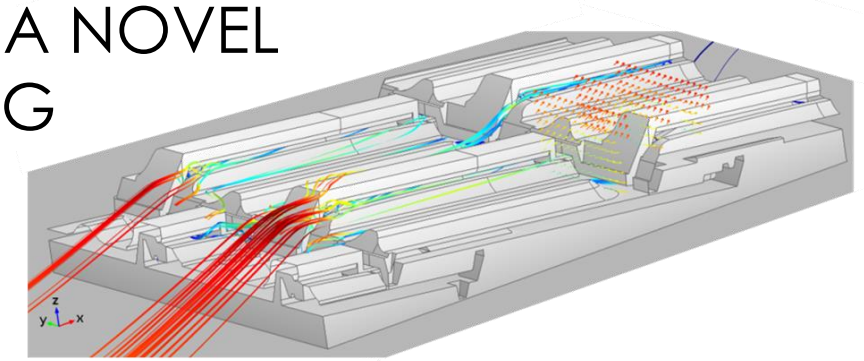
THE DESIGN OF A NOVEL TILE SHAPE USING CFD ANALYSIS



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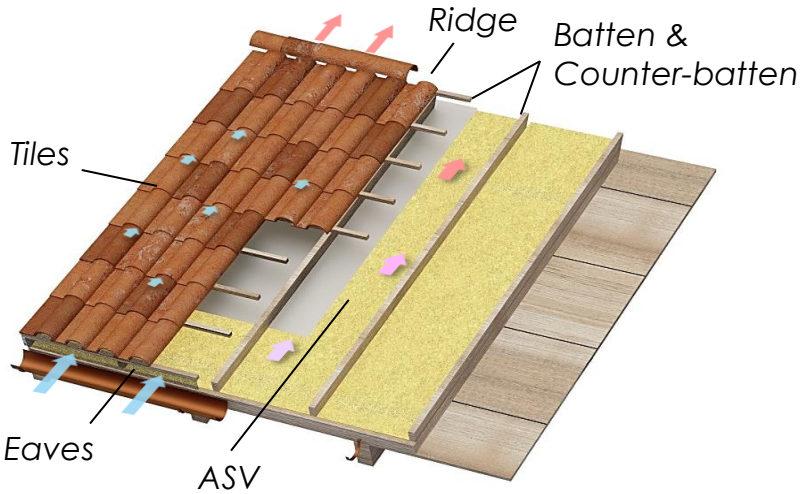
Background

To reduce cooling consumption and increase standards of indoor comfort are issues of great importance in hot climates.

The roof plays an important role in reducing the effects of solar radiation when compared to other building elements, due to its extension and exposure to the sun.

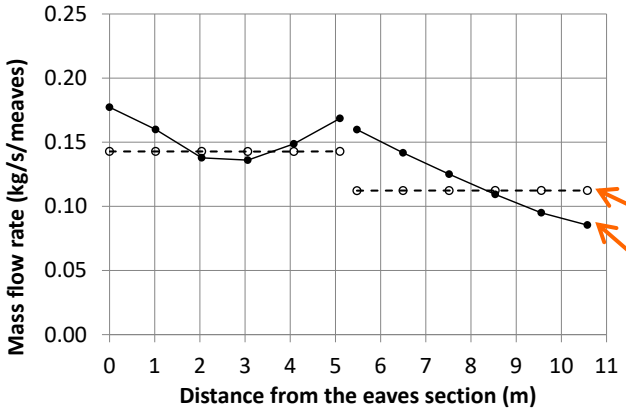


Ventilated Roofs

- Air flows from eaves sections (intake vent) to the ridge, and helps to dissipate the excess heat in summer.
- The air- permeability of the overlapping tiles is an additional and diffuse intake/exhaust air-vent system.

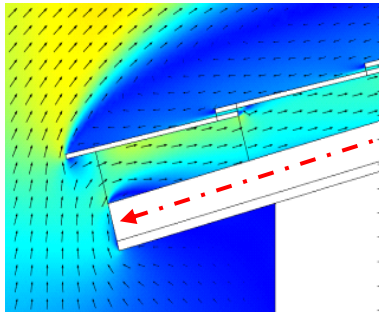
Background

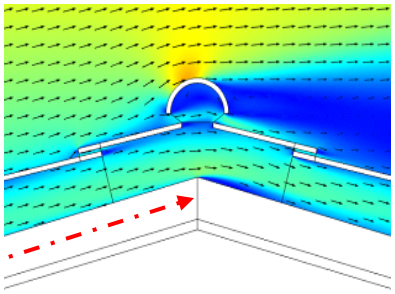
In 2013 we preliminarly studied the summer performance of ventilated roofs by taking into account the air-permeability of the tiled covering, using a CFD model.

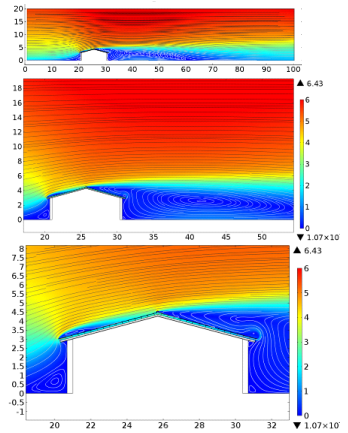


Unpermeable covering

Permeable covering







Results supported the submission of an EU project, aiming to improve the air permeability of vented tiled roofs, in order to reduce the building cooling demand in hot climates. (2014)

EU project HEROTILE (2015)

HEROTILE – LIFE14 CCA/IT/000939

***H**igh **E**nergy savings in building cooling by **RO**of **TILE** shape optimisation toward a better above sheathing ventilation*

Supported by the European Commission through the Life Climate Change Adaption programme

- Total budget 2.5M€ (LIFE CCA grant of 1.5M€)
- 3 years (2015-2018)
- 6 industrial and academic partners

Objectives

- 2 pilot plants, each producing a new type of roof tile (Italy)
- 2 real-scale pitched roof mockups (Italy, Israel)
- 2 demonstrator buildings (Italy, Spain)
- SENSAPIRO, **S**oftware **EN**ergy **SA**vings **PI**tched **RO**ofs

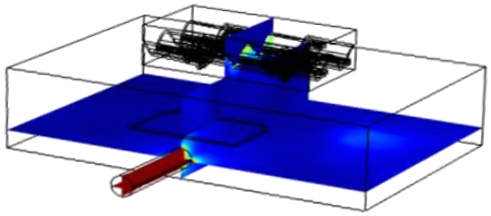
Layout of the Action A1

Existing tiles

3D cad

Test rig

Model calibration



COMSOL MULTIPHYSICS

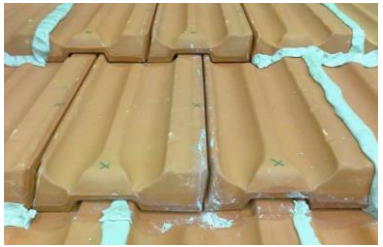
Methodology for tile rating

Modelling 3D new designs

Parameter 1: air permeability index

Selection of the best performing new shape for production and testing

Experimental rig at Monier Technical Centre



The rig allows to measure the air permeability of a tile array.

The rig consists of:

- large wooden plenum to give uniform pressure and low internal speeds
- tiles laid as on a roof – all joints sealed, except 4 sidelocks and headlocks
- variable speed fan – air sucked or blown to see effect of tile geometry

Measurements:

- Pressure difference across tiles
- Flow rates using EDRA6 anemometer / orifice plate

Air flow is proportional to aerodynamic area and pressure difference.

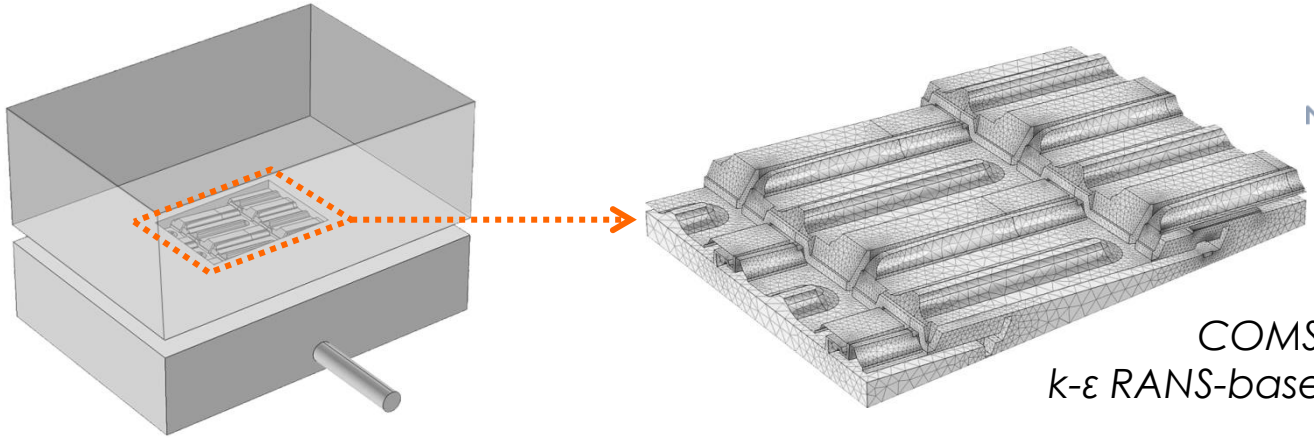
The aerodynamic area is related to the air-permeability.

CFD Modelling

Results of tests have been used as the benchmark to calibrate a CFD model replica of the test rig

The 3D domain was optimised only including the equivalent borders of the four tiles left unsealed in the test rig.

The upper box was introduced to set the boundary conditions.



COMSOL MULTIPHYSICS

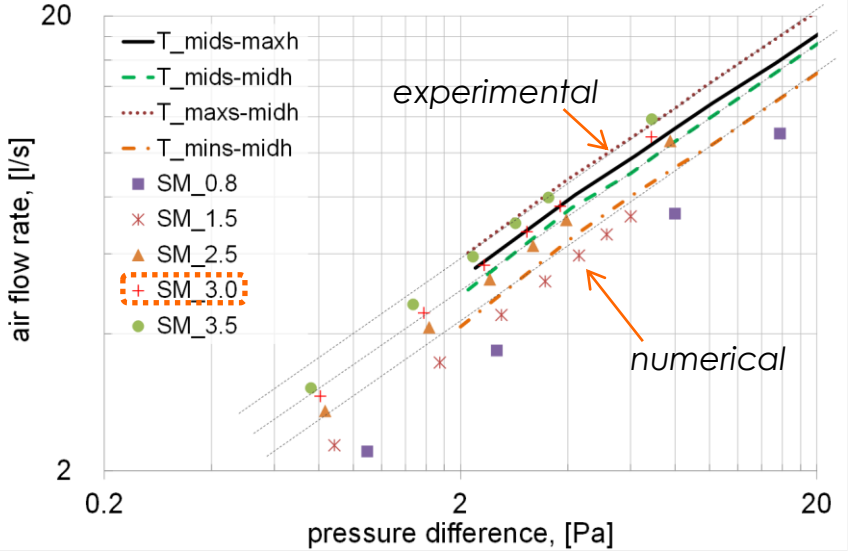
COMSOL Multiphysics V5.2
k-ε RANS-based turbulence model
steady-state

CFD model calibration

In order to model the distortion of individual real clay tiles (due to the drying and firing processes) with the regular, identical CAD geometry, the spacing between the overlapping tiles was considered as a calibration parameter.

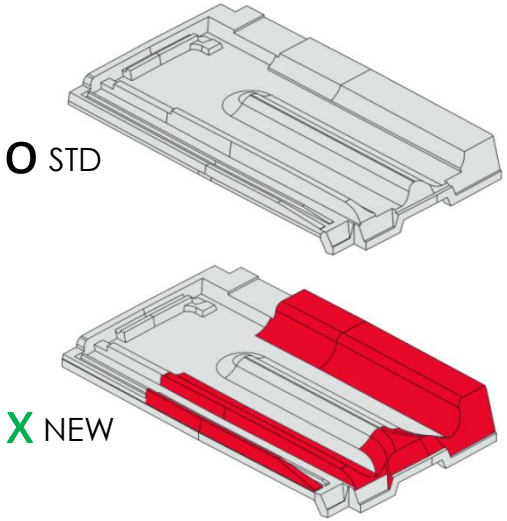
The calibration was carried out to obtain the same relationship between pressure difference and air flow rate as measured in the experiments.

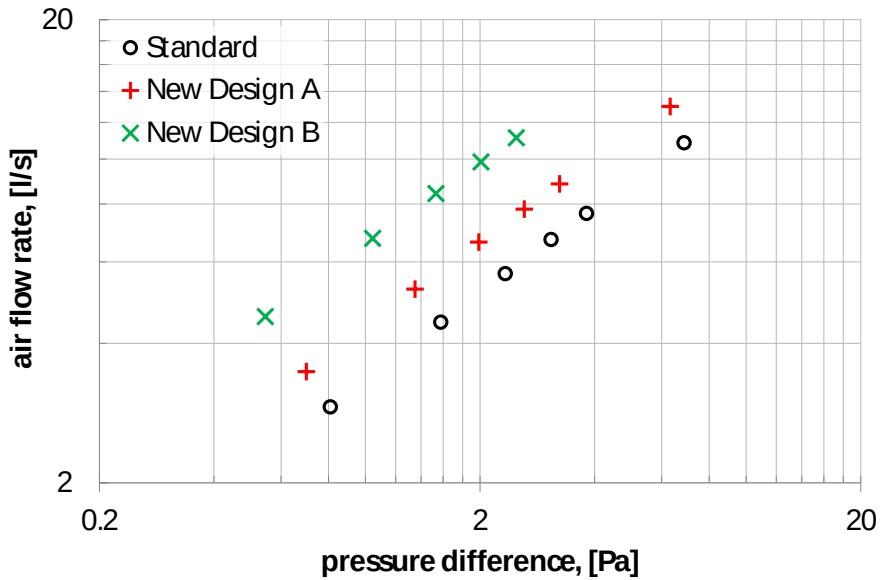
Roughness didn't affect significantly, and was neglected.



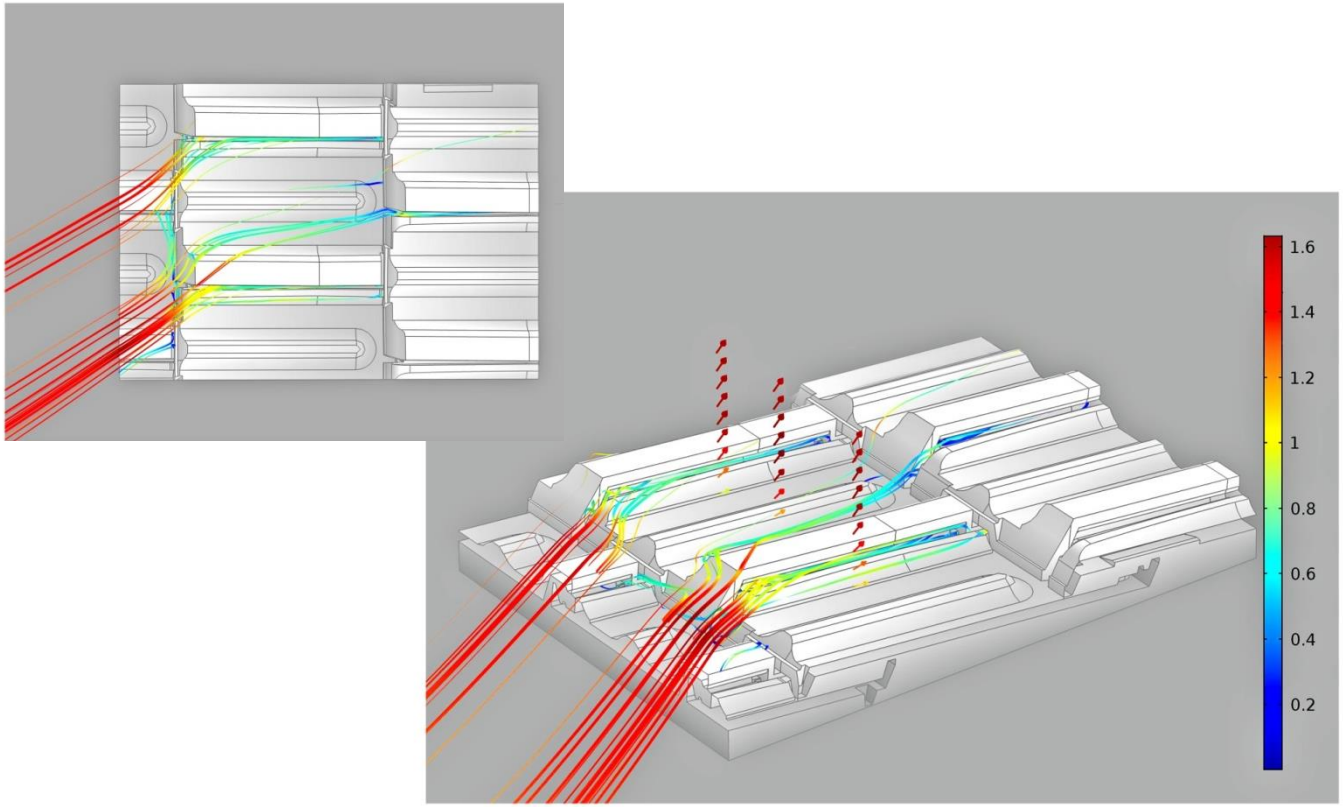
The new tile designs

The existing tiles were then replaced by the novel shapes to evaluate the performance, assuming the aforementioned spacing as calibration parameter.





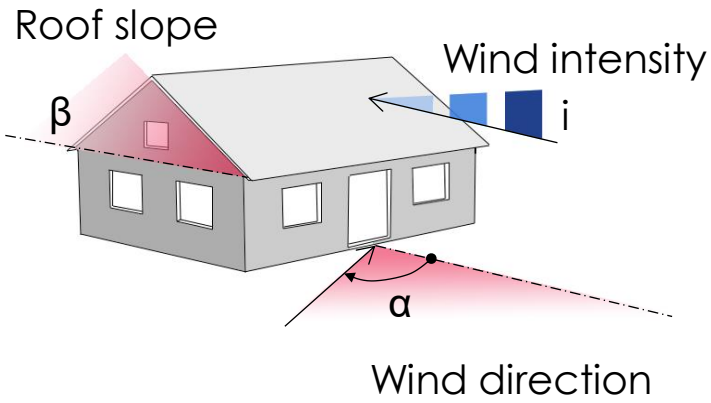
Airflow Streamlines

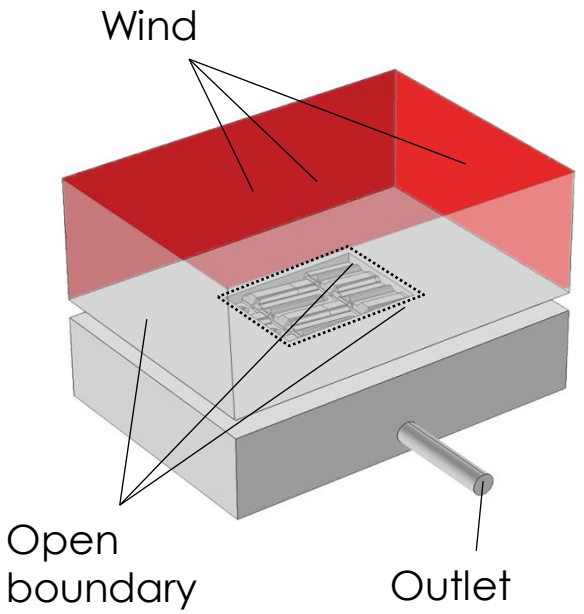


Parametric Analysis

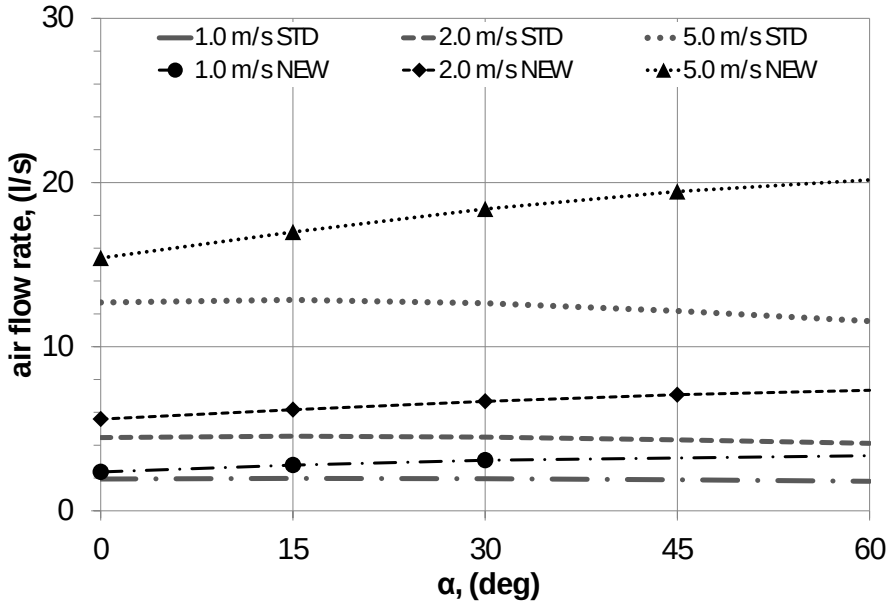
A parametric analysis was carried out taking into account:

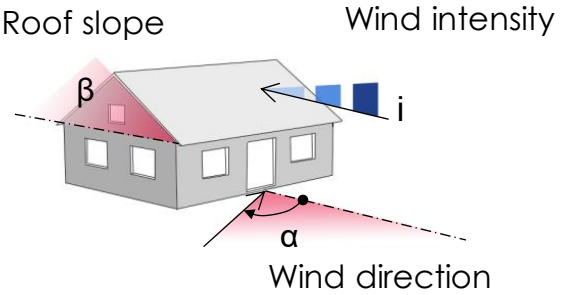
- four wind intensities: 1.0-2.0-5.0 m/s
- six wind angles of incidence: 0°-15°-30°-45°-60°
- three roof slopes: 20°-30°

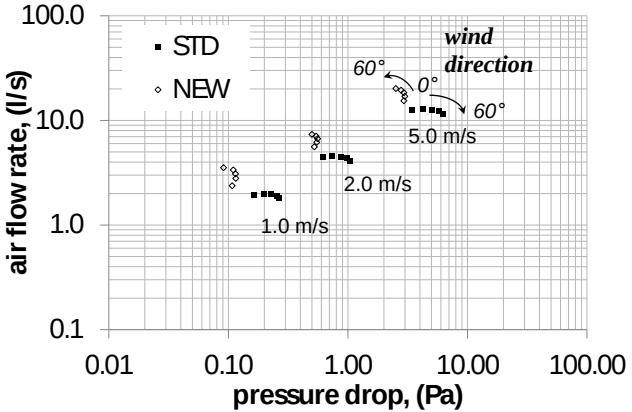




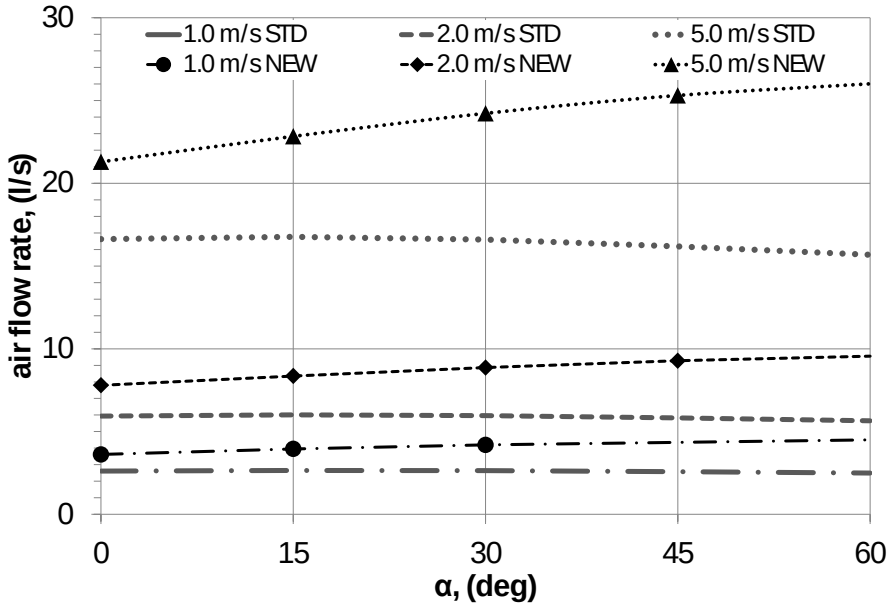
Results - 20° of pitched slope

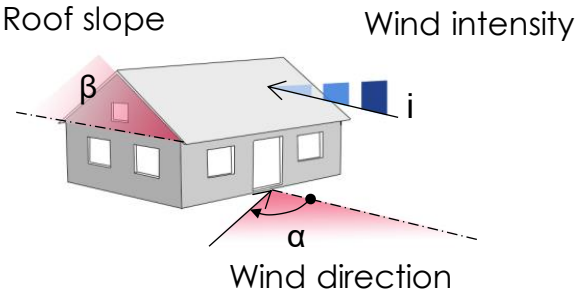


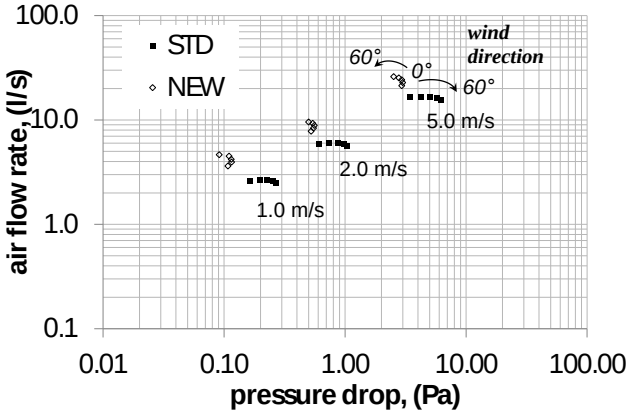




Results - 30° of pitched slope







Mockup

This phase of the HEROTILE project is closed, and the work moved on to the new tile production and field measurements on real-scale roofs.

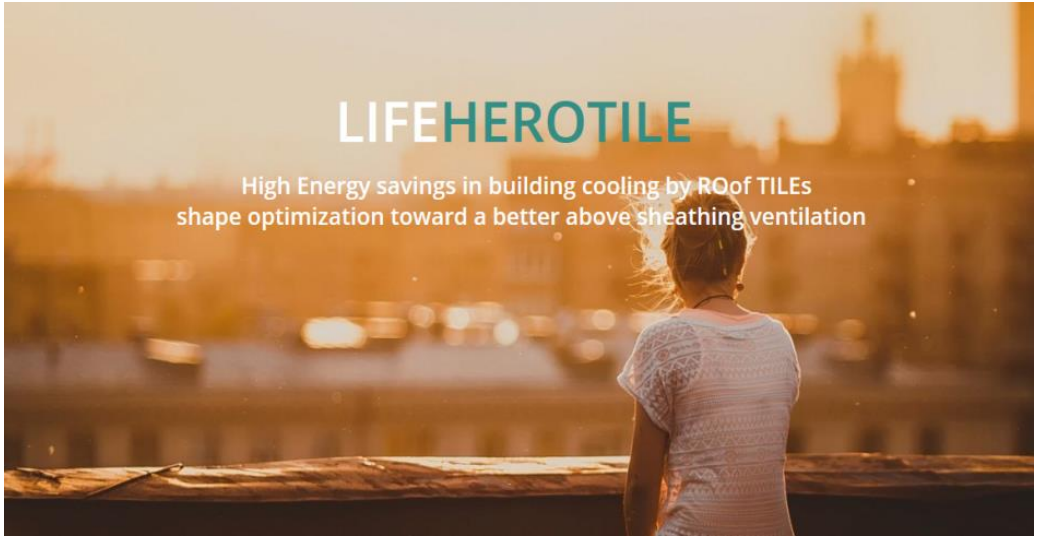
Two test roofs (mock up) have been built in two sites where climatic conditions were more suitable for the appropriate checks.

Summary and Conclusions

- New Marseillese shapes produced a small improvement in the air permeability
- A flow rate increase through the novel shaped tiles was related to both the enlarged open area between the tiles and the original design of the head lock.
- Some solutions were less affected by the wind direction.

Work on the HEROTILE project (LIFE14 CCA/IT/000939) "High Energy savings in building cooling by ROof TILEs shape optimization toward a better above sheathing ventilation", is funded by the EU LIFE "Climate Change Adaptation" programme and the other project partners.
If you are interested in knowing more, please visit:

www.lifeherotile.eu



THANK YOU FOR LISTENING

With the contribution of the LIFE financial instrument of the European Community

LIFE HEROTILE
LIFE14 CCA/IT/000939
Climate Change Adaptation