Daylight distribution and thermo-physical evaluation of new facade components through a test cell for the overheating control in

Daylight distribution and thermo-physical evaluation of new facade components through a test cell for the overheating control in Mediterranean Climate

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Abstract
The Mediterranean Climate represents for architects a great opportunity in order to define the right design and technological solutions to fulfil the users expectations. The traditional design rules provide the first inspiration in terms of shapes, and solutions', giving the needed bioclimatic strategies. The idea to conjugate tradition and innovation is a very stimulating challenge; today, several new energy saving components can be adopted, but to demonstrate their efficiency they must be tested in outside, dynamic and real weather conditions. A new test cell under real weather conditions is under construction at the University of Florence for thermo-physical properties and day-lighting distribution under real sky conditions.

Keywords
Test cell, Thermal comfort, Daylight, Sunny sky, Mediterranean Habit

1 Introduction

Several studies carried out recently in dynamic condition on civil building located in the Mediterranean area, using for example dynamic software like ESP-r, demonstrate that in addition to the new technologies, ventilation strategies during night and day are able to improve the comfort indoor, reducing the temperature peak, and maintaining as small as possible the thermal variation, reducing the value of PPD (Percentage of Person Dissatisfied) and obtaining a controlled and moderate number of air changes. The mentioned analyses have been carried out considering the internal gains, the external sun contributes and the thermal inertia effects in the buildings [1].

In the last years the European Commission promoted the use of nano-technologies [2] to optimize the insulating behaviour of the opaque and transparent components, and in the mean time to control the relative attenuation factor in order reduce the energetic consumption in the building; in accordance to this strategy the European Commission produced a more stringent directive [3] in terms of energy consumption, providing to the European Countries the guidelines to reduce even more the energy use, considering in the most appropriate way the specific climate; this approach has been moved the focus from the winter needs, usually investigated under static conditions, to the concept of zero energy building which requires the integration of renewable energy in order to reduce the energy consumption also during the summer time.

How do the new building components work? The question is especially related to the dynamic behaviour of new and complex components like the ventilated walls, the Phase Change Material, or others that use nano-technologies and aerogels.

The purpose of the research is now the evaluation of their thermal behaviour through the use of an outdoor test-cell, in order to reproduce the real and variable external climatic conditions, and consequently to define the main parameters, like the attenuation factor and thermal inertia, to characterize the component and to use results to write new algorithms for the dynamic simulation, to evaluate the complex behaviour of building in a real scale condition.

Fig. 1 ABITA, University of Florence, done a research entitled "Summer indoor comfort levels in the Mediterranean Area" and results have been used for the ATIKA building realized by VELUX.

The 80's and 90's the European Commission financed several projects [4] finalized to the construction of test-cells in order to measure the solar factor and the thermal transmittance of transparent and opaque components; the experimental studies carried out in Europe is the most effective from a scientific point of view [5], by the way they have highlighted several weakest points on the design and management of the test-cells. Weakness and strongest points are investigated to be resolved and the thesis proposes an innovative test-cell for Mediterranean Climate.

Why the test-cell? Why it is not recommended the use of parameter defined by the use of theoretical calculations or by the use of technical labs? The thermal labs allow to carry out test in a very accurate way, and to obtain repetitive outcomes, but only in stationary condition, so without any consideration about the material response in dynamic and outdoor conditions [6]; therefore it looks that the solution can be the measurements of the new component behaviour in an existing real building [7], but this will lead in a very complex management system of the building, which need to be treated like a big laboratory [8] [9]. The studies carried out in the existing building, have demonstrated their limits, being not able to isolate in the right way the single component, and consequently to evaluate its thermo-physical characteristics. On the other hands, the use of a specific test-room in outdoor condition, with an accurate instrumentation, which is able to capture all the internal comfort parameters, appears to be the real answer to define and evaluate and characterize the new component under real user conditions.

Fig. 2 Examples of test cells realized in PASSYS [10] e PASLINK (from left to right) [11]

2 Methodology

The outdoor test cell is an instrument that is required by the Tuscany Region for giving the opportunity principally to local building market to test new products that needs to be used in Mediterranean Climate, products that are able to reduce annual energy consumption in buildings working with a sufficient insulation level and appropriate thermal inertia if necessary. Also, the test cell will be used to evaluate the influence of the orientation when using a transparent components and the correlation with window dimensions and forms in relationship to the daylight factor under clear sky conditions, normally sky during the year in most of the Mediterranean area.

In this way, the test cell has to measure the U and g value of components and also the thermal lag and the DLF. It will have inside a radiator for internal temperature control with a ventilator. They will be used during the winter to evaluate the flux from inside to outside.

The proposed test-cell is aimed to test the facade components; it is realized in an insulated wooden structure, with a walls transmittance equal to 0.35 W/m^2K; the test-cell shall be not adiabatic, because the outcomes of previous study have highlighted that it is the main weakest point of the old test-cells, due to the alteration of the internal operating conditions; in particular the tentative to realize a controlled room as much as possible close to a theoretic adiabatic system, produced an object which was able to absorb energy from the external environment with a poor attitude to release it, causing a not realistic over-heating.

The mentioned structure, still in wooden, is designed to eliminate the thermal bridge, which would have caused the increment the vectors of thermal dispersion, causing not acceptable measurement alteration. The internal walls surface are covered by flux-tiles, plates which are able to support the sensors for the thermal flux measurement and consequently able to measure the thermal behaviour of the components to be tested.

Fig. 3 The routable test cell will be able to test opaque and transparent components on different orientations

The wooden structure is lighter than the concrete structures, so it is routable in order to measure the daylight effects in a different external orientation, whether it works with a clear sky or cloudy condition, and therefore providing the opportunity to determine the real DLF in the Mediterranean area: the current studies have been focused mostly on the cases with cloudy

condition, causing in some way the use of transparent material even in the south zone of Europe.

To reduce the risk of test-cell over-heating has been studied a ventilated wooden screen structure able to stop the direct solar irradiation on the envelope. The component will be tested into a properly insulated and removable frame designed to reduce as much as possible corner effect and able to contain opaque and/or transparent façade components with dimensions of 2.80 m x 2.80 m.

The test cell is part of a larger strategy of the *Abitare Mediterraneo* Project: new building components need to be certificated not just only from thermo-hygrometric point of view but also they have to be in line with acoustic requirements, fire resistance requirements and structural requirements.

The University of Florence is going to involve internal departments and also external laboratories to give to the companies the most strong and complete support in developing new building components suitable for Mediterranean climate, simulating components with adequate dynamic software, analysing LCA and testing under real user conditions and laboratories to certificate new *Abitare Mediterraneo* products. The test site should be active in the Dynastee Network [12] to exchange experience and to collaborate at an international level.

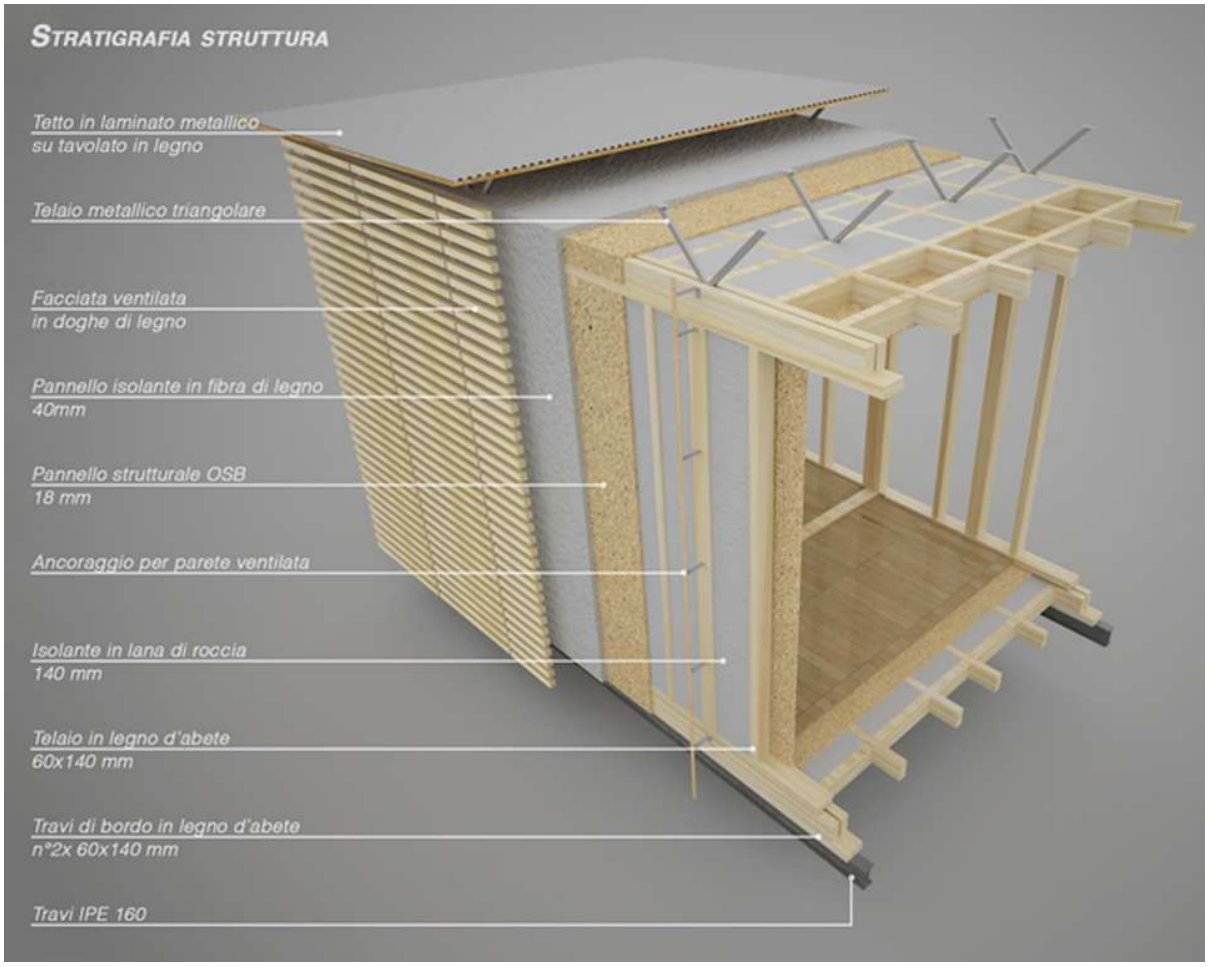

Fig. 3 The project of the innovative test cell. Rendering is made by Arch. A. Di Zenzo

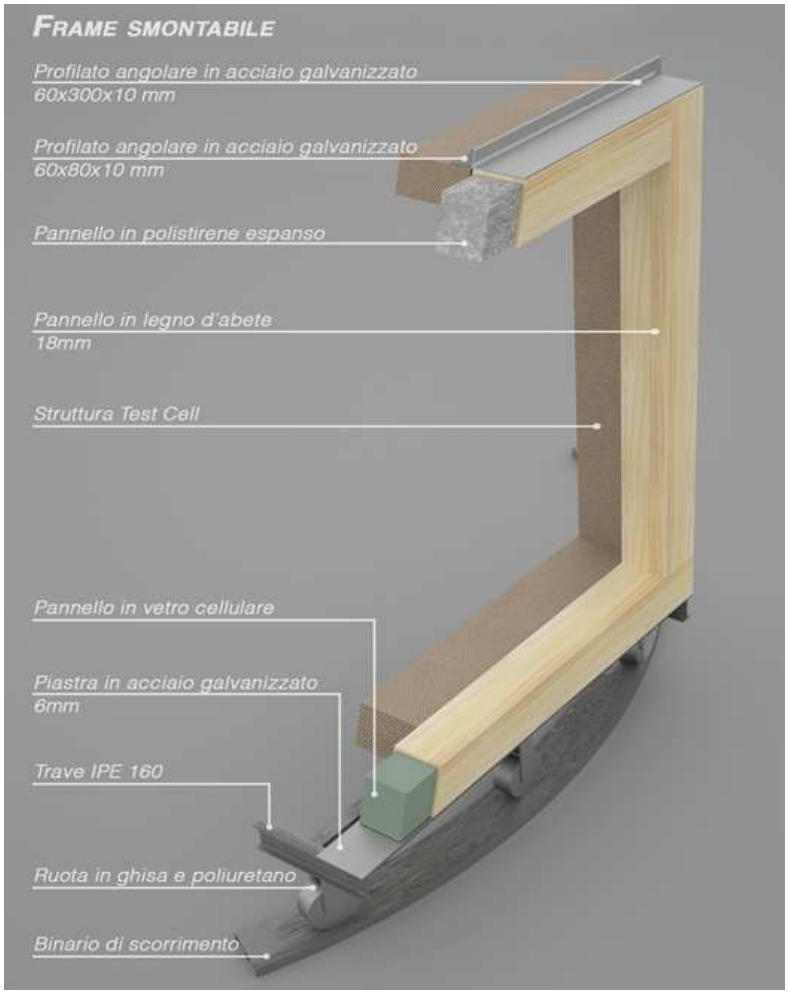

Fig. 5 Removable frame for opaque and transparent components.
Rendering Arch. A. Di Zenzo

3 Conclusion

Being characterized by the warm summer more than the cold winter, the Mediterranean climate is today the most complex scenario to provide the needed thermal comfort of the users along the year, that's why it is required to find the new technological solutions for building and climate systems in order to reduce the energy consumption. The test-cell, will be realized in the Campus of Florence University, with the sponsorship of Regione Toscana, as part of the project ABITARE MEDITERRANEO [13], as outdoor measurement laboratory of the solar and thermal behaviour of new components to be used in the building industry for the Mediterranean zones, creating the database for the required comparison with the solution studied for different climatic zones [14] [15].

Acknowledgement

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The responsible of the project is Prof. Marco Sala; the person responsible for adaptation and construction of the test cell is eng. Giuseppina Alcamo; the responsible of the test facilities is Prof. Maurizio De Lucia, Energetic and Mechanical department of the University of Florence. The responsible for instrumentation is Prof. Carla Balocco also responsible for data analysis. More information on the *Abitare Mediterraneo* project are available at the following website *www.abitaremediterraneo.eu*

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