M7.1 Façade specimen measurements

WP7. Demonstration, T7.1

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Table of Contents

1 Introduction

Two façades specimens have been designed, manufactured and installed at the Eurac outdoor lab. Each of them consists of two window-box façades, with a 15 cm air cavity hosting the same kind of shading system, with the only difference in the slats' colour (one sample having blinds with white surface on the external side and black on the internal side (sample A) and the other having a black blinds' surface on the external and white on the internal side (sample B)). Peculiarity of the façade concept is the possibility to vary the top and bottom grids openings and the position of the external glazed skin (operating on a pantograph). More information can be found in the FACEcamp Milestone 6.1.

2 Objective

The activities here reported aimed at evaluating the thermal performances of the façade specimen realised, for different kind of façade sample configurations, implementing the measurement procedures developed within FACEcamp (please refer to Milestones M4.1 and M5.2 for further readings).

3 Methodology

Given the limited time availability, from the façade specimen purchasing to the FACEcamp project closure, the measurement campaign has been done in December 2019 and January 2020.

Moreover, a novel outdoor testing approach has been used installing two movable lightweight and not-airtight boxes (Figure 1). Such structures have been designed to better evaluate the impact of the solar radiation on the façade layers (glazing and shading), lowering the effect of the indoor-outdoor temperature difference.

Figure 1: Movable test boxes for outdoor measurements.

Besides the different shading colour, the façade configurations could be changed varying the top and bottom grids' openings from fully closed to slightly open. The characteristics of the two samples are the same, they only differ due to the different coating of the blinds and thus the colour (externally white - A, externally black -B, as shown in Figure 2).

Figure 2: Front view of the two façade samples, right: sample A with externally white blinds, left: sample B with externally black blinds.

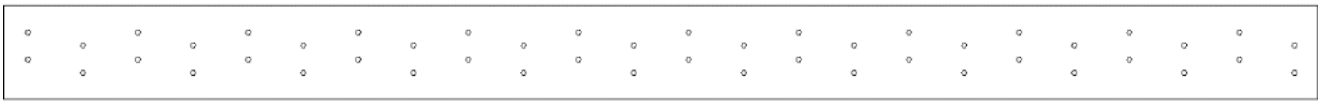

Figure 3: Drawing of the metal sheet to be placed on the top and bottom openings with the little ventilation holes of 6 mm diameter (slightly open top/bottom grids), opening rate 1%

3.1 DOE

Different measurement setups were adopted, and each setup was maintained for at least one day with clear sky conditions. Heat flux sensors and pyranometers were positioned on one façade sample, while thermocouples were placed in the same way on both samples maintained for the entire measurement period. The experimental assessment of the façade performance was also done adopting different ventilation modes of the cavity, namely fully closed and slightly open cavity. The latter was achieved using a perforated aluminium sheet on the external side, below and above the glazing unit (Figure 3: Drawing of the metal sheet to be placed on the top and bottom openings with the little ventilation holes of 6 mm diameter (slightly open top/bottom grids), opening rate 1%).

Table 1: façade samples' possible configurations.

Nomenclature	HF measurement on sample	Cavity
A_closed	Externally white (A)	Closed
A_open	Externally white (A)	Open
B_closed	Externally black (B)	Closed
B_open	Externally black (B)	Open

3.2 Measurement setup

The parameters measured and the typology of measurement are reported in Table 2, while the exact position is shown in Figure 4.

Table 2: Measurements' setup summary.

Measured parameter	Sensor	Position

Temperature	T-type thermocouples	Internal air, external air, face1, face2, face3, face6, blinds (different height)
Heat flux	Hukseflux HFP01 Heat Flux Plates (HFP)	Face6 (different height)
Heat flux	gSKIN-XM Heat Flux Sensors (HFS)	Face6 (different height)
Heat flux	Temperature-controlled in-situ heat flux device	Face6 (centre)
Vertical irradiance	Kipp&Zonen CMP11 thermopile pyranometer	External and internal side (vertical position)
Air velocity	Monodirectional anemometer	Façade cavity

Figure 4: Measurement setup from inside showing: thermocouples for the temperature measure of glazing surfaces, blinds and air, a pyranometer measuring the transmitted vertical irradiance, small heat flux sensors shielded from direct solar irradiance, conventional heat flux plates and a temperature-controlled in-situ measurement device to determine the undisturbed, transient heat flux through transparent components.

4 Results

4.1 Comparison of temperatures between two samples

The first data analysis has focused on the blinds' temperatures. In both Figure 5 (closed cavity) and Figure 6 (slightly open cavity, naturally ventilated) a difference of more than 20 K between the two colours (A – externally white, B – externally black) can be noticed. As expected, the black slats heat up more than the white ones. This trend is confirmed for the two different options (closed and open cavity).

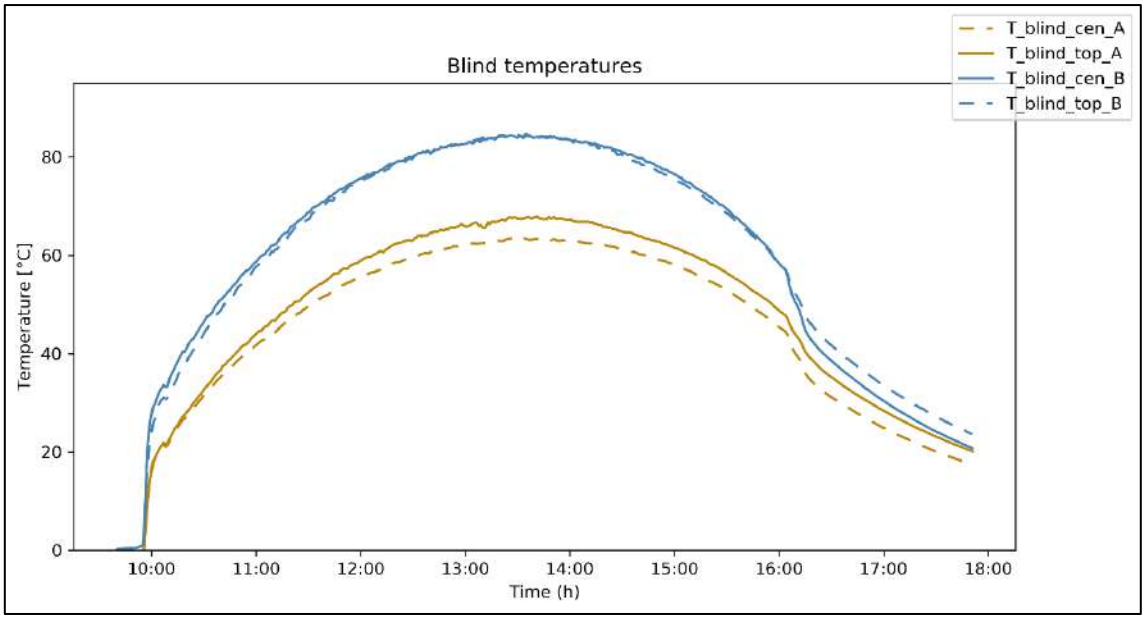

Figure 5: Blind temperatures for the two façade samples on a clear sky day; sensors named "cen" are positioned on a blind at the centre of the window, sensors named "top" are positioned at a distance of ¼ of the total height from the upper limit; closed cavity

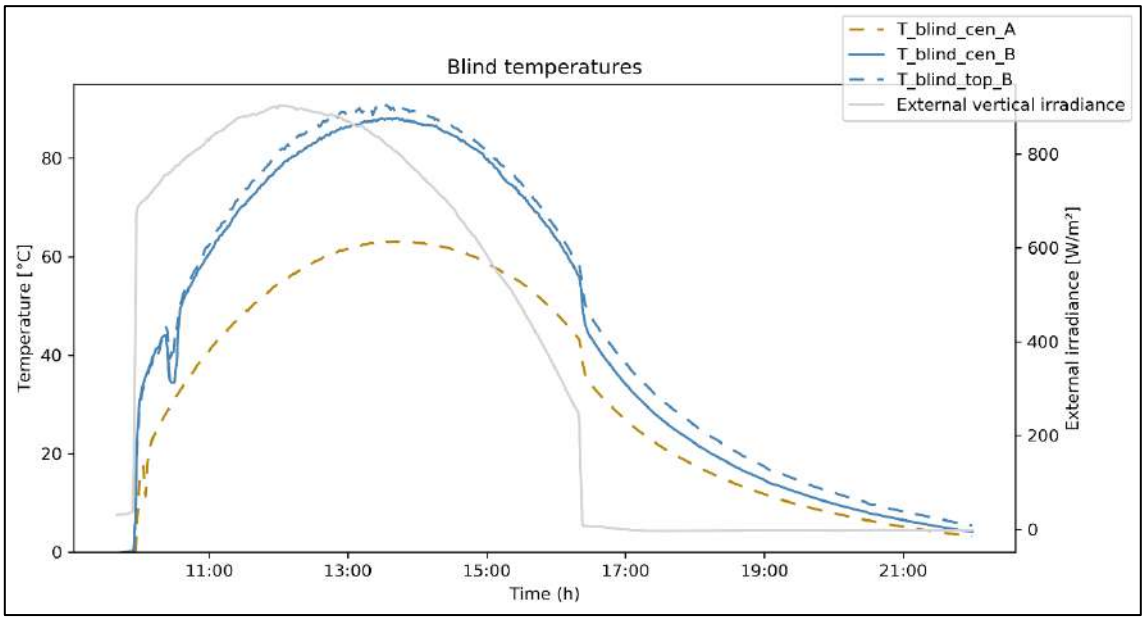

Figure 6: Blind temperatures for the two façade samples on a clear sky day; sensors named "cen" are positioned on a blind at the centre of the window, sensors named "top" are positioned at a distance of ¼ of the total height from the upper limit; open cavity.

A deeper analysis of the temperature trends can be seen in Figure 7 (closed cavity) and Figure 8 (naturally ventilated open cavity), with the data referred to the glazing surface temperatures.

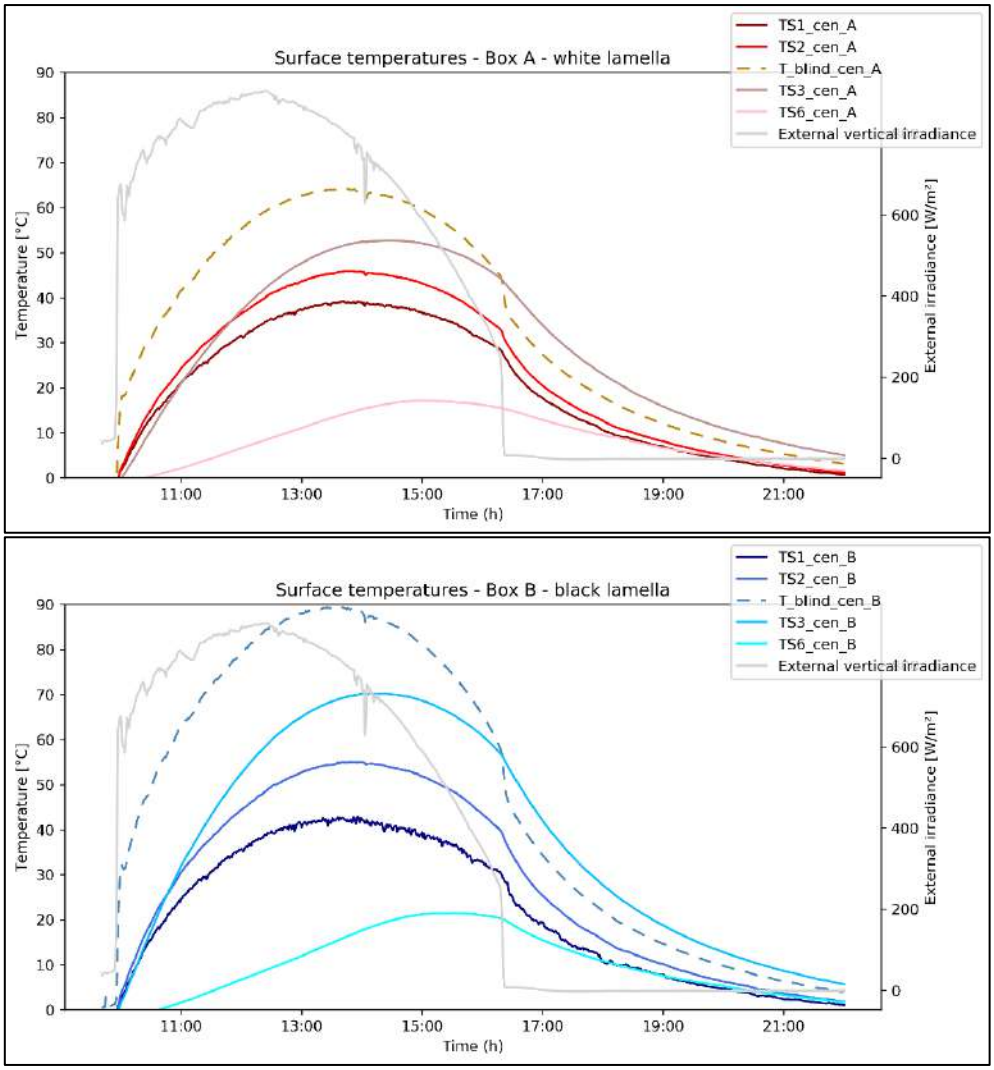

Figure 7: Surface temperatures of façade sample A (top) and B (bottom). Detail of glazing centre-of-glass surface and blinds temperatures. Closed cavity configuration. TS1 = face 1, TS2 = face 2, TS3 = face 3, TS6 = face 6. (Face 4 and 5 are the internal faces in the IGU).

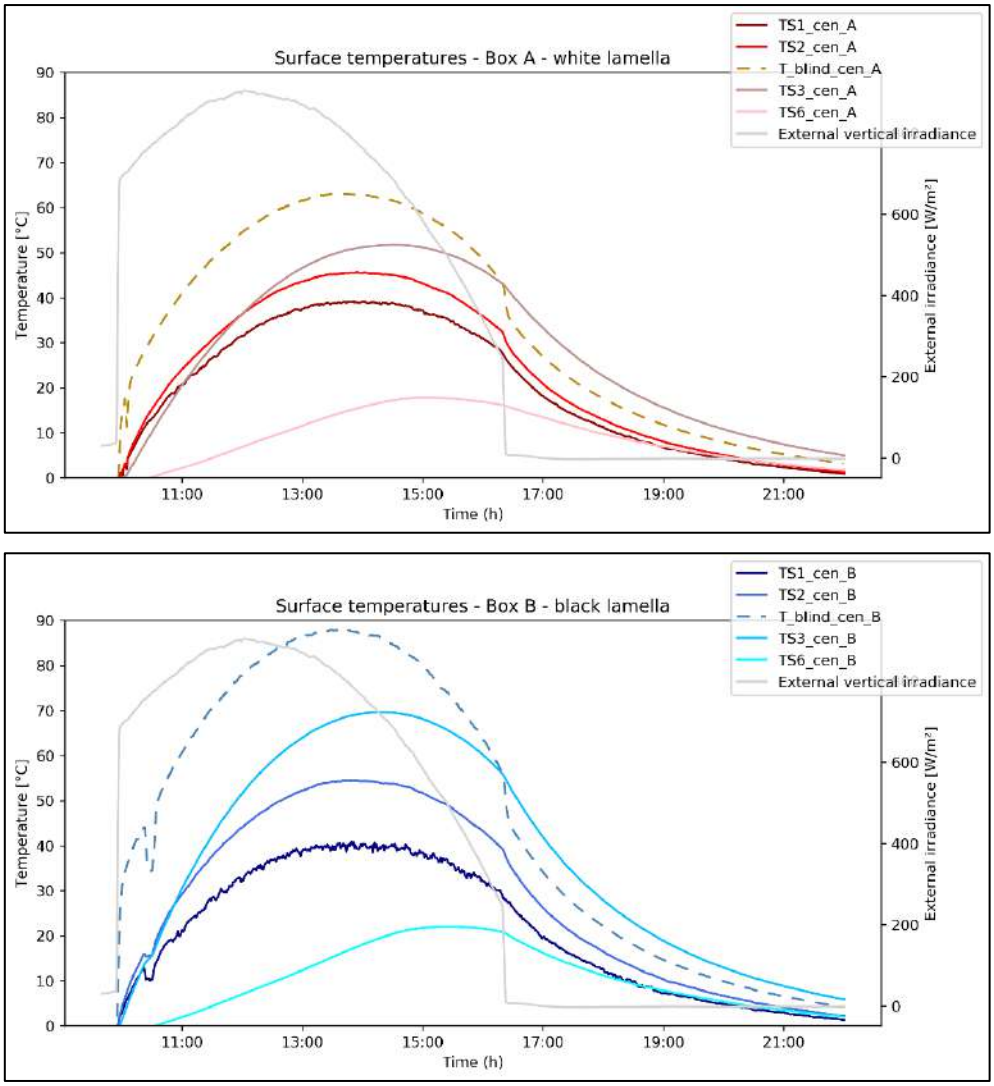

Figure 8: Surface temperatures of façade sample A (top) and B (bottom). Detail of glazing centre-of-glass surface and blinds temperatures. Open cavity configuration. TS1 = face 1, TS2 = face 2, TS3 = face 3, TS6 = face 6. (Face 4 and 5 are the internal faces in the IGU).

A little difference can be noticed between the same blind colour but with different cavity ventilation regime. This is partly due to the presence of the natural ventilation, even if further analysis and testing will be needed to better understand the phenomena and its impact. In fact, current measurement campaign setting implies the need to change the air cavity ventilation regime day by day. As a consequence, performances possible differences might be determined also by environmental parameters changing between the two different days. This fact can be read in all the graph through the solar irradiance curve, which is different between the closed and open-air cavity configuration.

Focussing only on the air cavity temperatures measurement, Figure 9 (closed cavity) and Figure 10 (slightly open cavity) shows the trends, which respect the observation done previously on the blinds and glazing temperatures.

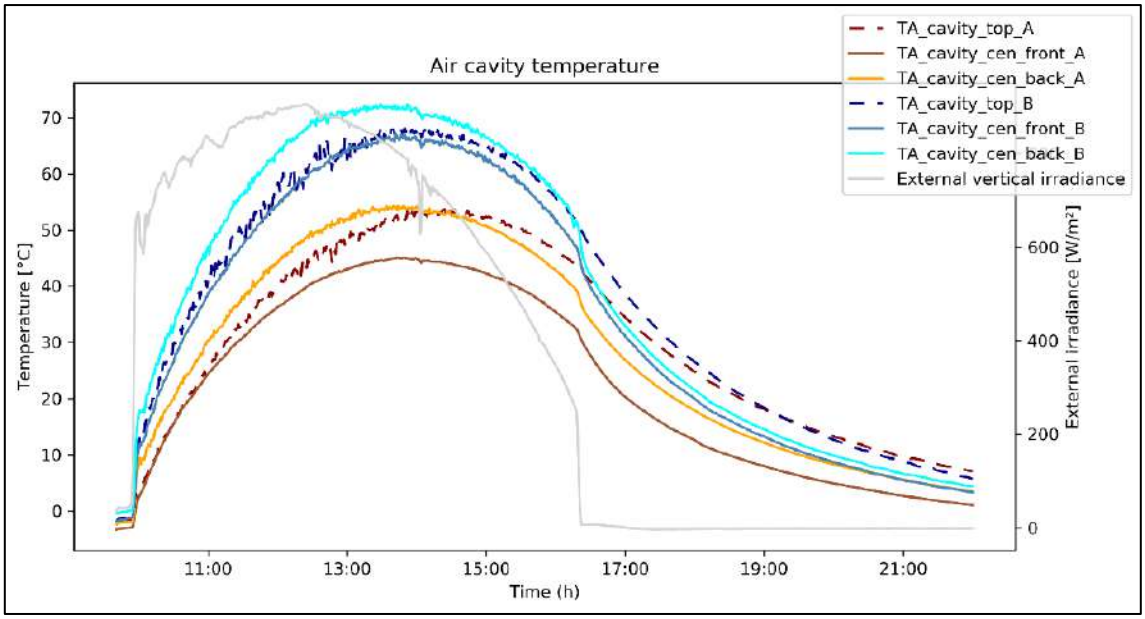

Figure 9: Air cavity temperatures for façade sample A and B – closed cavity

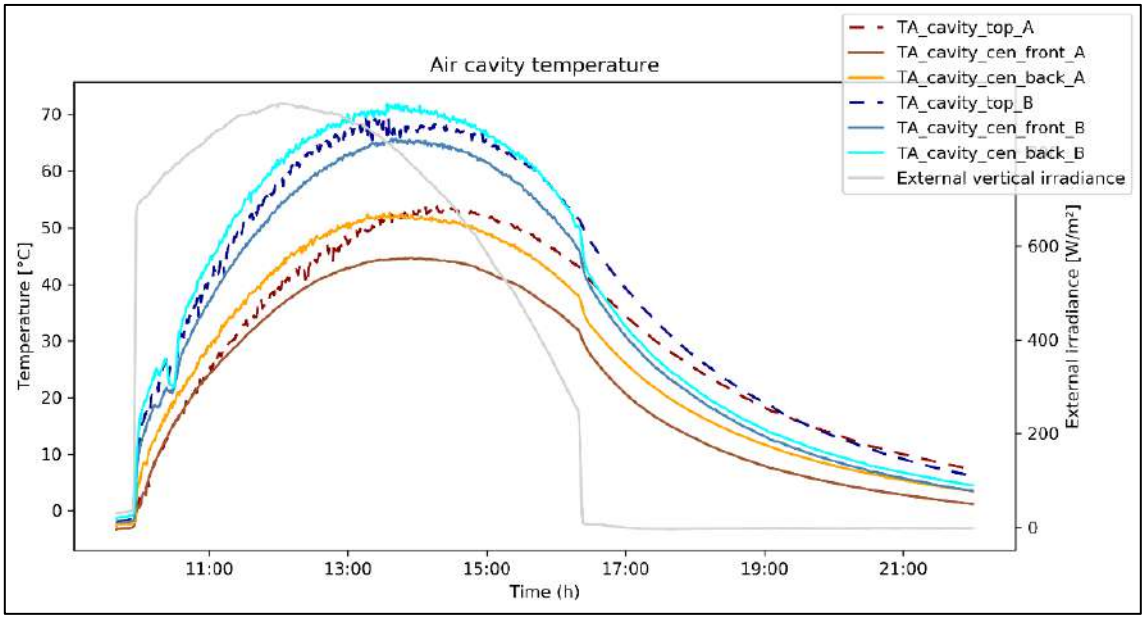

Figure 10: Air cavity temperatures for façade sample A and B – open cavity.

4.2 Comparison of heat flux measurements between two samples

Such comparison has been done with different external boundary conditions (different days) due to the lack of sufficient measurements' instruments (heat flux plates, in-situ heat flux devices) for a contemporary use between the two test boxes.

As a consequence, the direct comparison between the different configurations is not possible as it is, but a further data elaboration is needed. Such activity will focus on normalising the measurements based on the environmental parameters (solar irradiance, external air temperatures).

Still, heat fluxes peaks of Figure 11 and Figure 12 are different in height (W/m²) between the façade samples due to the blinds colour. Finally, the time shift between irradiance and heat flux peaks can be noticed in all measurement configurations and for all four days.

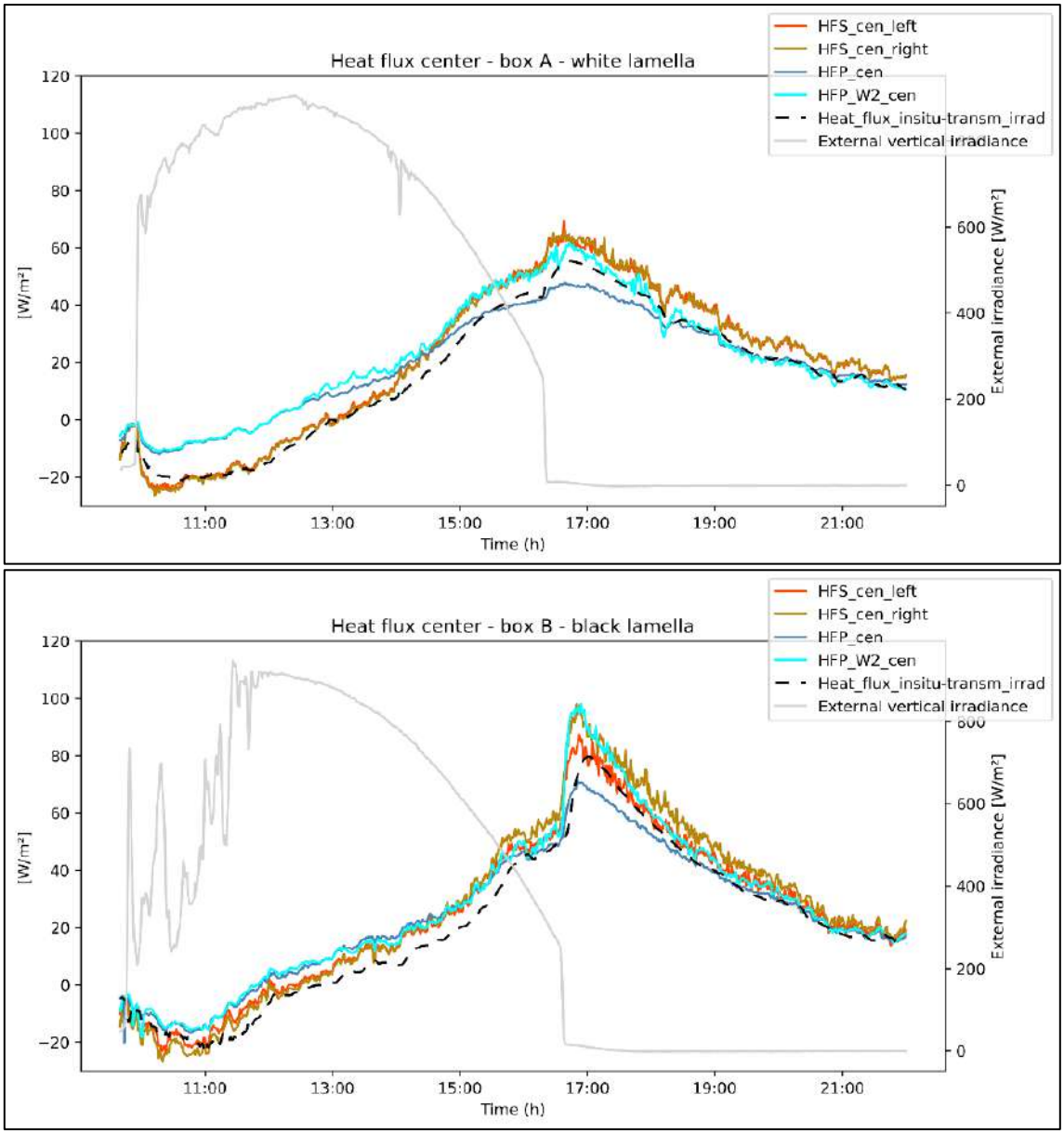

Figure 11: Heat flux measured at the centre of the room-side glazing surface; heat flux sensors (HFS), heat flux plates (HFP), temperature-controlled in-situ heat flux device minus transmitted irradiance (Heat_flux_insitu-transm-irrad) - Closed cavity

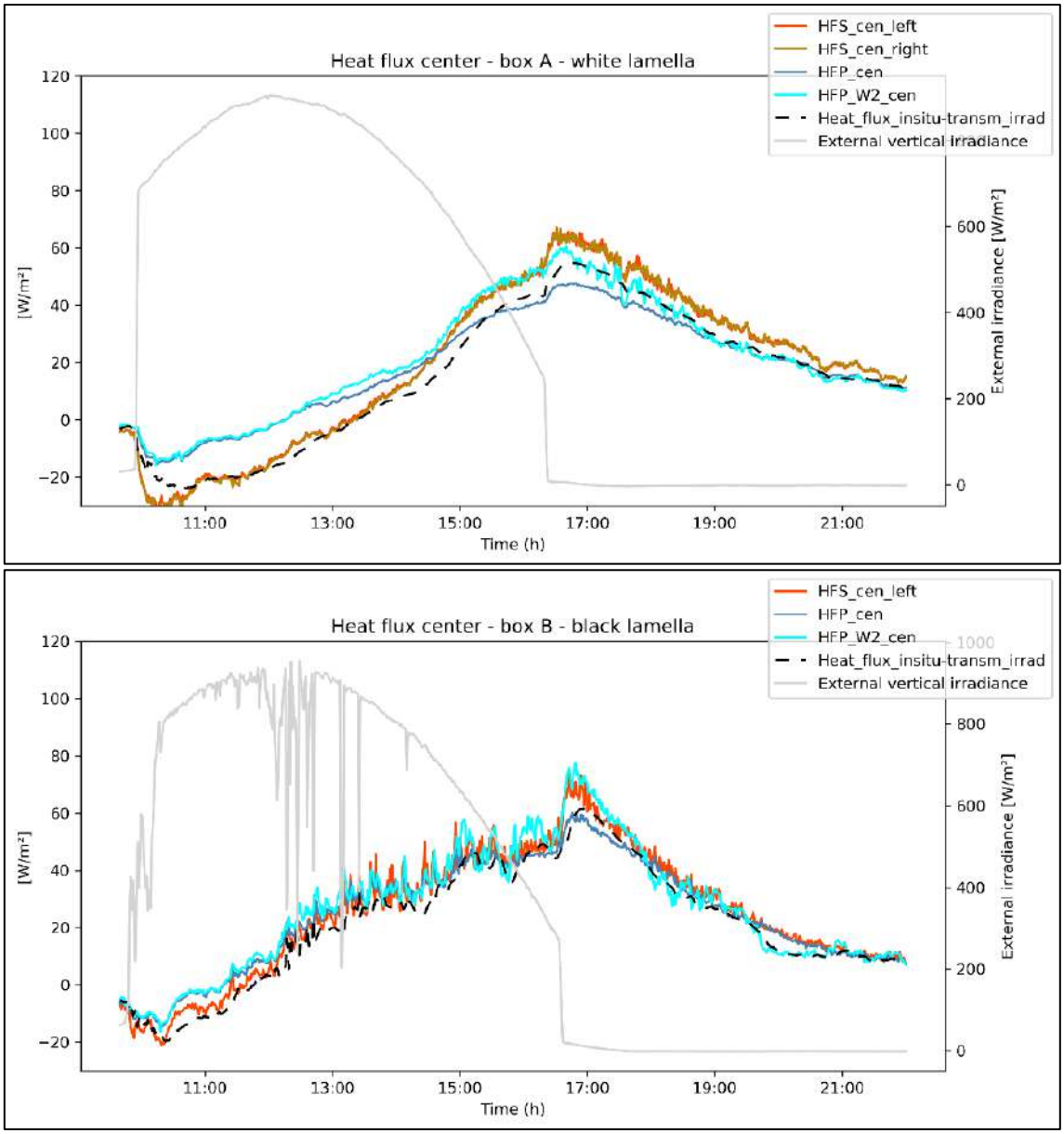

Figure 12: Heat flux measured at the centre of the room-side glazing surface; heat flux sensors (HFS), heat flux plates (HFP), temperature-controlled in-situ heat flux device minus transmitted irradiance (Heat_flux_insitu-transm-irrad) - Open cavity.

5 Conclusions

The outdoor measurement campaign on the FACEcamp façade specimen has reported some useful insight into both the measurement procedures and the main general trends of such façade technologies.

- Procedures: the use of the in-situ heat flux instrument and the small heat flux sensors meter has confirmed to give similar result. Further analysis will be needed to draw some conclusion on how to use them in order to obtain the same result (in terms of total secondary heat-flux).
- Façade technology: the different blinds' external surface colours (white or black) has shown to impact a lot on the overall façade heat transmission, with a difference in temperatures peaks of more than 20 K, reaching peaks around 90 °C in the case of externally black painted slats.

The measurement campaign on the façade specimen will continue along the whole 2020, shifting the focus on the impact of the natural ventilation of the air cavity.

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