LLEIDA OUTDOOR TEST CELL (LOT) FOR DOUBLE-SKIN SYSTEMS

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General description

Main objective of the test facility

The Lleida Outdoor Test cell (LOT) [1,2] is a full-scale test facility for the comprehensive study of the energy performance of ventilated double skin facades in outdoor conditions. High quality data sets from the tests may be used for evaluation and modeling purposes.

The installation allows for the analysis of the effect of the air gap width, air flow regimes and materials of the façade. It is also prepared for the detailed analysis of double skin integrated PV systems and their with HVAC systems.

The façade may operate under natural and forced ventilation and the effect over the building is measured in a well-controled test cell.

Overall lay-out

The LOT test facility (see Figure 1) is composed by a variable width double-skin BIPV façade and an adjacent test room. The external dimensions of the test facility are (3.5 x 5.5 x 3.6) m.

Figure 1. LOT test facility. Front and rear view.

To avoid uncertainties due to the effect of the solar radiation, the LOT has been covered by a white plastic sheet.

Figure 2. LOT test facility protected from solar radiation effects

The double-skin façade air gap width ranges from 10 to 80 cm and the movable façade system is guaranteed by 4 engine actuators (see Figure 1 and Figure 2).

Figure 3. Details of the ventilated air gap

The LOT facility is composed by a well-insulated cell: the test room walls are insulated with 12 cm thick rock wool boards, the floor is insulated with 10 cm thick extruded polyethylene and the roof is insulated with 15 cm thick rock wool boards (see Figure 3).

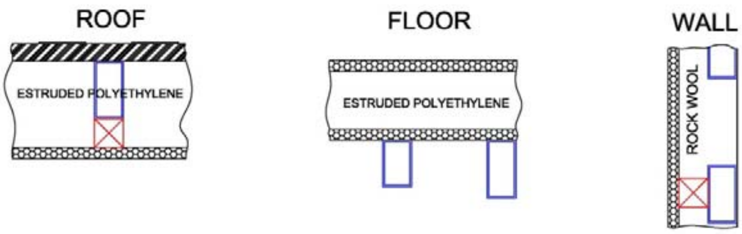

Figure 3. Construction details of the LOT facility. Cross-section of the floor (left); Cross-section of the roof (right)

The HVAC system is composed by a reversible electric heat pump. A special air distribution system has been designed to avoid temperature stratifications within the control volume (see Figure 4). This HVAC systems allows for a detailed control of the set-point temperature within the test room. The energy consumption and the thermal energy delivered to the test room is measured each time step with the data logger.

Figure 4. HVAC system. Air distribution system

A black curtain (see Figure 5) is placed inside the test room at 40 cm distance from the south façade to be tested: the transmitted solar radiation heats up the high absorptive curtain which transfers this energy to the test room by means of convection and long wave themal radiation. This approach avoids a disturbance of the direct solar radiation over the wall temperature measurements.

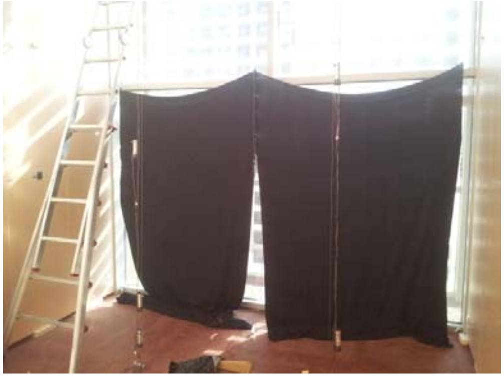

Figure 5. Mounting the inner solar protection

To evaluate the energy balance of the test room, homemade flux tiles are installed. EPS panels are placed at the internal side of the walls, the floor and the roof with the aim of covering the overall internal surface of the test room. Only the south façade, where the test element is placed, is kept without these tiles. Two type T thermocouples are placed at the same height in both sides of the EPS panels. The thermocouples are protected from the solar radiation with a reflective adhesive tape. An overall number of 72 pairs of thermocouples are installed spread over the walls, floor and roof of the test room. Since the thermal conductivity of the EPS panels has been previously measured in laboratory, the heat flux which crosses each panel is obtained from the temperature difference measurements multiplied by the conductivity (following Fourier's law). The effect of the thermal inertia of the EPS is calculated each times step when non-stationary tests are performed.

Figure 6. View of the heat flux tiles

The air temperature inside the test room is measured with type T thermocouples at five different positions and considering 5 different heights (0.5m,1.5m, 2.5m, 3.5m, 4.5m). These sensors allow for the control of the ventilation system to avoid stratification (see Figure 6).The thermocouples are shielded from the solar radiation with cupper cylinders and reflective coating. Micro fans are also installed at the bottom of the cylinders to avoid overheating of the temperature sensors.

Figure 7. Position of termocuple to messure the air

The surface temperature of the double-skin component is also measured at 3 different heights 2 positions. The ventilated air gap is also measured at 3 different heights(1m,3m,5m) and two horizontal positions (see Figure 7).

Figure 8. Thermocouples placed at air gap

The double skin façade can work under natural or forced regime. The air flow is collected at the top of the façade with a conic hood. The air flow rate is measured with a combination of differential pressure gauges (placed at the inlet and outlet of the façade) and omnidirectional anemometers (see Figure 8).

Figure 8. Differential pressure

Outside boundary conditions

The outside conditions are measured with a local weather station placed at 10 m height (temperature, relative humidity, horizontal solar radiation, wind direction and speed). This weather station also measures direct solar radiation with a pyreliometer (see figure 9). In addition, ambient temperature, wind direction and speed are measured next to the LOT, at 2 m height.

Figure 9. Wheather station

DATA ANALYSIS

The present work reflects the necessity of performance indicators for multipurpose façade and BIPV systems under real operating conditions which differs from both STC and NOCT standards [3]. The experimental data from the LOT facility covers the general lack of experimental data from full-scale buildings with double-skin systems under controlled outdoor conditions , avoiding the effect of the occupancy.

The experimental data are analyzed with software like CTSM, TRNSYS and R Statistics and the thermal characteristics of the component are evaluated.

Link to other devices

The energy characterization of ventilated BIPV components is also carried out in the Test Reference Environment of Lleida (TRE-L) [3-6].

Front and rear views of the Test Reference Environment of Lleida (TRE-L) at the LOTCE center [3].

Relevant literature

Literature on previous measuring campaigns and data analysis:

[1] Lodi C, Cipriano J, Olivera J, Chemisana D**, Lleida Outdoor Test center for BIPV systems**, EnergyForum 2011 on Solar Building Skins, 2011, Bressanone (Italy).

[2] Lodi C, Cipriano J**, Lleida Outdoor Test center,** DYNASTEE Workshop on "Dynamic Methods for Building Energy Assessment", 2010, Bruxelles (Belgium).

[3] Bloem JJ, Lodi C, Cipriano J, Chemisana D, **An outdoor Test Reference Environment for double skin applications of Building Integrated Photovoltaic Systems**, Energy and Buildings 50 (2012) 63-73, doi: 10.1016/j.enbuild.2012.03.023

[4] Lodi C, Bacher P, Cipriano J, Madsen H, **Modelling the heat dynamics of a monitored Test Reference Environment for Building Integrated Photovoltaic systems using stochastic differential equations**, Energy and Buildings 50 (2012) 273-281, doi: 10.1016 /j.enbuild.2012.03.046

[5] Lodi C, Bacher P, Cipriano J, Madsen H**, Modelling the heat dynamics of a monitored Test Reference Environment for BIPV systems through deterministic and stochastic approaches,** DYNASTEE Workshop on "Whole Building Testing Evaluation and Modelling for Energy Assessment", 2011, Lyngby (Denmark).

[6] Lodi C, Cipriano J, Bloem JJ, Chemisana D, **Design and monitoring of an improved Test Reference Environment for the evaluation of BIPV systems**, EU PVSEC 25th European Solar Photovoltaic conference, 2010, Valencia (Spain).