# Thermal performance of different masonry wall composition. Case study: Polis University, Tirana, Albania.

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**Abstract.** Albania is part of the emerging economies of the Western Balkan region. Polis University is one of the pioneering institutions in the field of architecture, built environment, and city sciences that represents innovative methodologies and concepts for educational and scientific purposes. Nowadays, many constructions in Albania involve a wide range of different materials. The building envelope is one of the main elements that provide protection from the outside environment but also the required thermal comfort for the inhabitants. The necessary balance must be archived between energy efficiency and the durability of buildings. This paper will focus on the thermal performance and materials composition of two different types of masonry walls, a constituent part of Polis University's main building. The study will be based on an experiment using specific instruments to diagnose these typologies of wall composition. The results are further analyzed and compared. Specific instruments such as the thermal camera (Testo 882), U-value (Testo 435-2), and "Silverline Digital Moisture Meter" (from POLIS Energy lab) are engaged. The collected data are further interpreted through graphs, tables, and diagrams for both cases. It is observed that ventilated facades perform much better than standard facades, therefore their usage is strongly recommended.

## 1 Introduction

Thermal insulation materials are used in buildings to save energy, maximize thermal comfort, and ensure the safety of the occupants and the building itself. They are frequently composed of various materials that have poor thermal conductivity, which prevents the flow of heat. It can be mentioned mineral wool, aluminosilicate fibbers, polymers, Eps, Xps, etc. The absence of thermal insulation or thermal bridges can create fluctuations in temperature and excessive levels of moisture in the walls, which can result in long-term condensation and the development of mold, creating health problems. A vented facade system is the best way to improve a building's thermal, and acoustic insulation, control humidity, and avoid moisture and condensation. The design of a ventilated facade's components, such as the separation between the two layers and the type of outside cladding, has an impact on the performance of the structure, which may be monitored on-site [1].

Reduced cooling and heating loads can be achieved using ventilated facades. Nowadays, they have grown in popularity in both newly constructed and restored buildings. Ventilated facades are simple to modify and install. They consist of a thermally insulated wall on the outside, an air cavity inside, and an opaque outer covering. Traditional and ventilated facades differ from each other.

The thermal efficiency of two different types of exterior walls in Tirana, Albania, is examined by Basha, M., et al. (2022). The study compares a wall made of stone wool, an anti-vapor membrane, an air gap, and terracotta tiles (a ventilated facade) with a wall made of ordinary bricks, plaster, and graffito without thermal insulation, analyzing its heat transmittance coefficient (U-value). The vented facade had a lower mean U-value, of 0.88 W/m2K, as determined by the results. Meanwhile, the standard wall U-value was 3.7 W/m2K. Additionally, this value is greater in both cases compared to the Albanian National Regulation on Building Thermal Performance [2].

A style of building facade known as ventilated facades has several advantages, including a decreased risk of facade cracks, the elimination of thermal bridges, protection from air pollutants, and good sound and fire safety. They have two different layers that are separated by an air cavity. The most common materials utilized in the building envelope are natural stone, porcelain stone, aluminum panels, or composed materials. Ventilated facades are also very energy-efficient, saving up to 30% on energy costs and enabling the maintenance and repair of individual tiles. They also offer strong durability, superior energy efficiency, and reduce the accumulation of moisture [3].

The thermal performance of a building is significantly influenced by thermal transmittance (UT) and thermal resistance (RT). The equation U=1/R yields the value of UT. The total thermal transmittance (UT) of a building component made up of many layers is equal to the sum of each layer's thermal transmittance. The total

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thermal resistance of all the materials is known as RT. Two temperature profile lines — horizontal and vertical — can be taken into account using thermal cameras. On a facade, the average temperature as well as the highest and lowest temperatures can be observed. Lower temperatures are an indication of the moisture content of the wall. The U-value of a wall that contains foam concrete may be decreased by 58.5%, dropping from U = 3.57 W/(m2K) to U = 1.48 W/(m2K). Heat flow is the thermal energy transfer that is always accompanied by a change in temperature [4].

According to Xhexhi, K. (2023), thermal radiation is the term used to describe the transmission of heat by electromagnetic radiation to an object across a long distance, such as from the sun to Earth. The kind of material is critical when analysing the quantity of energy that is reflected, transmitted, or absorbed; as well as the shape of the material. For instance, glass is a great transmitter, metals may absorb or reflect heat radiation. A temperature differential of 15°C is optimal for studying building thermography, and there shouldn't be any wind, rain, or extreme sunshine. The registration criteria to obtain the Certificate of Energy Performance of Buildings must be approved by the Albanian Council of Ministers. Building thermography and U-value assessments of older buildings usually provide poor outcomes when compared to international and national norms. To include these buildings in the comfort zone, immediate changes are needed, such as energy requalification and reduction of thermal bridges [5, 6].

According to Ismaiel, M. et al (2022), masonry walls are a popular choice because of their longevity and ability to support vertical and horizontal reinforcement with partial or total grouting without obstructing the insulating layer. They are in direct contact with the interior air and the cavity width may be changed to provide a variety of R-values. Exterior insulation reduces heat transmission while maintaining close contact between the brickwork and the heated or air-conditioned interior area. The exterior wall's durability, resistance to the weather, and impact resistance are unaffected by the interior insulation that is already placed. Polystyrene, ordinary fiberglass, Aspen Aerogel, and Honeywell polyurethane are some of the insulation materials that can be used. However, extended exposure to hot and humid conditions may reduce the R-value. Research into masonry walls is necessary to predict masonry walls' thermal efficiency, evaluate the effects of interruptions, such as crossovers of slabs or balconies, on overall thermal performance, and provide design guidelines for the construction industry [7].

Xhexhi, K., Meunier, PL., and Maliqari, A., (2020) conducted a study using two sets of buildings that were important components of Kruja, a historic city in Albania: with traditional dwellings from the XVIII century and buildings constructed during the communist era (1960–1985). The goal of the study was to use linear regression models to ascertain the association involving two variables: the temperature and moisture content of the outside walls and floors of Kruja's historic and socialist buildings. They analyze three historical housing types, and three socialist apartment types, approximately with the same orientation. The measurements are conducted within three hours on the same day. There are differences in the interaction levels for both types of buildings. Historic dwellings are especially sensitive to rises in temperature. Despite the fact that the average moisture content is higher, they seem to be more successful in decreasing the quantity of moisture. As the temperature rises, the moisture content level decreases as a result of their opposing reaction. The analysis of the construction materials for both groups is also taken into account. Buildings will improve if the moisture level is reduced. The indicators of the inhabitants' quality of life will be improved too [8, 9].

Excessive moisture is one of the most frequent problems with building construction. Controlling the moisture exchange in the home is necessary to assess the degree of environmental sanitation. In addition, having an effect on energy consumption and building sustainability, the indoor moisture content is also directly linked to health problems [10].

The thermal performance of a ventilated roof with a PCM heat sink has been investigated in another research. It investigates how Phase Change Materials (PCMs) might be used to enhance the thermal efficiency of such roofs as well as how different environmental factors affect the performance of the roof. The authors explain their numerical and experimental research, including simulated and experimental outcomes, and analyzing air flow and temperature data. The scientists claim that by using PCMs, the roof's thermal performance was enhanced and temperature fluctuations were decreased. The outcomes showed that the roof could better withstand the summer's heat and function as an insulating layer around the building envelope in the winter [13].

The inhabitancy behavior is another important factor to be considered. According to Xhexhi, K., (2023), the residents mostly prefer to live in recently constructed buildings, equipped with modern building materials. The heating and cooling loads can be reduced if is applied thermal insulation in the building envelope [14, 15, 16].

According to another study conducted in Kruja, Albania, due to a lack of thermal insulation, the occupants are particularly sensitive to their place of living. They often prefer to move on from their residence in search of a better one. Energy consumption is increased as a result of the absence of thermal insulation [17].

### 1.1 Background work

Nowadays, the Albanian construction market is flourishing. The country is experiencing a boom of investments in the new generations of construction. Meanwhile, new materials and methods of construction are introduced in order to reduce energy costs, cooling, and heating loads. The chosen materials must be suitable for the design and proposal. Some of the factors that affect thermal comfort are room temperature; relative humidity; moisture; mean surface temperature, etc.

The study examines the thermal behavior and moisture level of two different types of masonry walls, constituent parts of the Polis University, in order to increase the thermal comfort in the University.

The development of the new campus for Polis University was a matter of pride and statement, adopting a bottom-up approach and participatory process of architectural, structural, and energy design by a joint team of staff and students. POLIS University case is a good example of how academic and research institutions can give tangible contributions in this aspect.

## 2 Methodology

The experiment was conducted considering two different types of masonry walls at Polis University. Standard masonry without a ventilated facade and masonry with a ventilated facade were used. Both of them are exposed to the same orientation (east). According to their material composition, both types of masonry walls have been examined.

Initially, it was used the instrument Testo 435-2, which measures the U-value (coefficient of thermal performance). Two Testo 435-2 devices are used simultaneously in both cases in order to measure the U-value coefficient, during 3 hours. The devices were set to obtain one measurement in 30 seconds from 11.00 PM - 2.00 AM.

Afterward, on the same day and time, another device was used such as the Testo 882 thermal camera, which analyzes the temperature distribution and thermal behavior of the outside wall in both cases. The device also analyzes other thermal anomalies such as thermal bridges, hot spots, and cold spots on the facade.

Another device was used (Silverline Digital Moisture Meter) on the same day to measure the moisture level of the internal walls for both cases. The position of the device was placed in the same area where Testo 435-2 was placed. The measurements were done specifically at four points of each wall typology. The height of the measurements was 15 cm above the pavement and the distance between the measurements was 20 cm in both cases.

## 3 Thermal performance of standard masonry wall – vs. – ventilated facades

Albania introduced energy sector reform during the last decade as part of the measures to integrate within the EU community and to reach a better national energy balance, in a country where 1/3 of energy is somehow lost either by informality or poor efficiency of buildings. Therefore, buildings' energy efficiency is identified as one of the main pillars of interventions. This is significantly influenced by the thermal performance of the building envelopes. POLIS University in Tirana, specialized also in such profiles, tried to give an example one decade ago by developing its own campus in a former industrial estate. The issues of energy efficiency have been critical in the project. After 10 years the situation was analyzed aiming to draw conclusions for improvements.

The type of wall system utilized in the main building of POLIS University is one of the main elements that affect the thermal efficiency of building envelopes. Two common wall systems are standard masonry walls and masonry walls with ventilated facades. Each of them has advantages and disadvantages in terms of thermal performance.

A type of construction that has been available for a long time consisting of only one layer often made of masonry, concrete, or wood is generally used to build standard walls.

The material's thermal conductivity, or the rate of heat transmission through the wall, affects the thermal performance of walls.

A masonry wall, an air cavity, an interior thermal insulation layer, and an outside layer of cladding make up a ventilated facade. The air gap improves natural ventilation and reduces heat transmission through the wall by operating as a buffer zone between the thermal insulation layer and the outer cladding. Compared to normal walls, thermal performance is much better in these situations.

Summer heat gain is decreased by a ventilated facade. Natural convection is supported by the air cavity, which cools the air inside the cavity and minimizes heat transfer inside the building.

Under such conditions, there may be a reduction in the requirement for cooling devices like air conditioners, which might save a lot of energy and improve user comfort.

Apart from having better thermal performance, ventilated facades also have a number of additional advantages. They can provide improved fire resistance and durability compared to standard walls, as well as increased design flexibility, and a wide range of cladding materials can be used.

However, there are also some potential drawbacks to ventilated facades. They can be more expensive to install and maintain than standard walls, due to the additional materials and construction requirements. The project of POLIS University's main building was indeed a low-cost budget exercise. So, the design team had to be pragmatic.

This paper is going to analyze two different types of wall composition parts of POLIS University's main building. The facade has an eastern orientation as seen in Figure 3.

**Fig. 1.** Eastern facade of POLIS University. (Source: Authors).

The whole eastern facade is composed of two different wall compositions, standard masonry without a ventilated facade, and masonry wall with a ventilated facade. Each type of facade is equipped with different layers as seen in Figure 4.

**Fig. 2.** A. Masonry wall with ventilated facade; B. Masonry wall without ventilated facade. (Source: Authors).


**Fig. 3.** Ground floor, POLIS University. Location of the areas of interest. (Source: Polis University).

The selected areas of the experiment are shown in Figure 3. Both of the areas are in direct contact with the eastern facade.

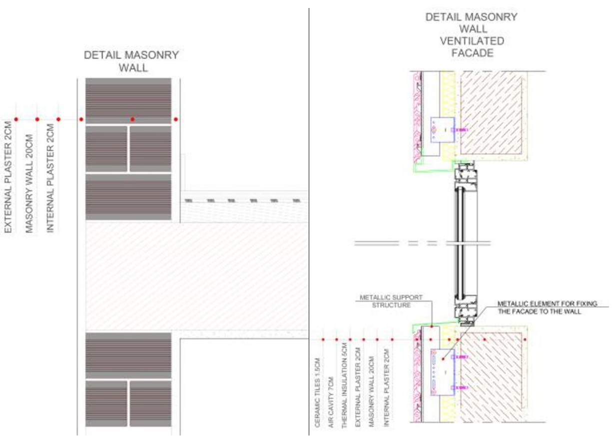


**Fig. 4.** A. Standard masonry wall composition without ventilated facade; B. Masonry wall with a ventilated facade. (Source: POLIS University).

The standard masonry wall is composed of an internal layer of plaster (2 cm), a masonry wall (20 cm), and an external layer of plaster (2 cm). Meanwhile, the masonry wall with ventilated facade is composed of an internal layer of plaster (2 cm), a masonry wall (20 cm), an external layer of plaster (2 cm), thermal insulation (rock wool 5 cm), air cavity (7 cm), and ceramic tiles 1.5 cm. It is important to consider also the metallic supportive structure of the ventilated facade.

## 4 Results

### 4.1 Experiment evaluations using Testo 435-2, wall composition, and meteorological condition

The purpose of this experiment is to investigate the thermal performance and U-value measurements of an external masonry wall with a thickness of 25 cm which is plastered on both sides compared to the same wall with a ventilated facade using Testo 435-2.

The measuring temperature range of the instrument is -50°C up to +150°C. Accuracy for the temperature range between -25 up to 74.9°C is +/- 0.2% [11].

The experiment uses Testo 435-2, which is a multifunctional device used for measuring temperature, humidity, air velocity, and pressure. The Testo 435-2 is equipped with various sensors and probes that can measure different parameters related to indoor and outdoor air quality. In this study, the device will be used to measure just the U-value coefficient.

The experimental setup involves placing Testo 435-2 on the inner side of the wall and measuring the temperature of the indoor environment. The instrument is also used to measure the temperature of the outdoor environment. Three temperature sensors of the instrument are engaged too and placed on the internal wall surface. The indoor sensors measure the temperature of the indoor environment and the temperature of the wall surface. Meanwhile, the outdoor Wi-Fi sensor measures the temperature of the outside environment. These measurements are used to calculate the U-value parameter of the wall for both cases.

The experiment is performed for the masonry wall with and without a ventilated facade in order to compare the thermal behavior and U-value measurements of both configurations. The data collected during the experiment is analyzed using the Testo 435-2 application in order to identify significant U-value differences between the two wall configurations.

Two Testo 435-2 devices are used simultaneously in both cases in order to measure the U-value coefficient. The measurement time lasted three hours. The devices were set to obtain one measurement every 30 seconds. The total number of measurements was 360. The day of measurements was 17-18/05/2023 and the time of the measurements was 11.00 PM - 2.00 AM (3 hours).

**Fig. 5.** A. Testo 435-2 during measurements; B. Outdoor Wi-Fi sensor. (Source: Authors).

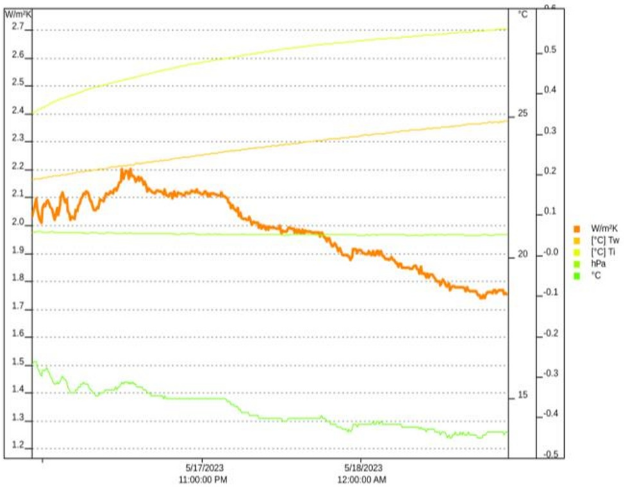


**Fig. 6.** A. Masonry wall without a ventilated façade. U-value results. (Source: Authors).

The mean temperature difference between indoor and outdoor environments was 12.5°C. The mean temperature of the internal wall surface was 23.9°C. Meanwhile, the mean U-value coefficient of the masonry wall without ventilated facade was 1.981 $W/m^2K$ as seen in Figure 6, and Table 1.

**Table 1.** Masonry wall without a ventilated facade. Results. (Source: Authors).

| | Min: | Max: | Mean: |
|---|---|---|---|
| C:1 $W/m^2$ K | 1.739 | 2.204 | 1.981 |
| C:2 \|°C\| Tw | 22.8 | 24.9 | 23.9 |
| C:3 \|°C\| Ti | 25.1 | 28.1 | 27.1 |
| C:4 °C | 13.6 | 16.3 | 14.6 |

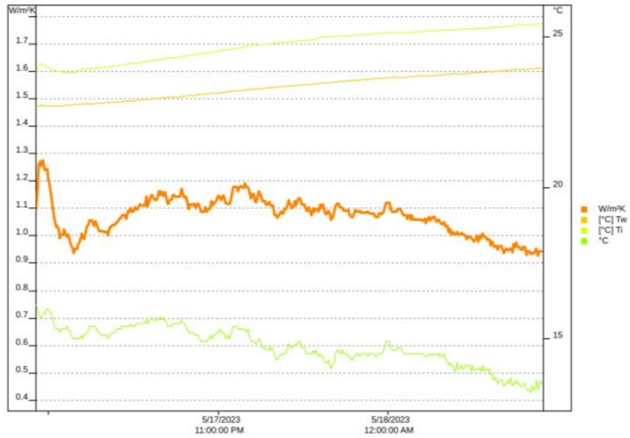


**Fig. 7.** Masonry wall with ventilated façade. U-value results. (Source: Authors).

The mean temperature difference between indoor and outdoor environments was 10°C. The mean temperature of the internal wall surface was 23.4°C. Meanwhile, the mean U-value coefficient of the masonry wall with ventilated facade was 1.072 $W/m^2K$ as seen in Figure 7, and Table 2. The U-value graph, in this case, is more linear than the previous one, and the parameter oscillation values are reduced compared to the masonry wall without a ventilated facade.

**Table 2.** Masonry wall with a ventilated facade. Results. (Source: Authors).

| | Min: | Max: | Mean: |
|---|---|---|---|
| C:1 $W/m^2$ K | 0.928 | 1.274 | 1.072 |
| C:2 \|°C\| Tw | 22.7 | 24.0 | 23.4 |
| C:3 \|°C\| Ti | 23.8 | 25.5 | 24.7 |
| C:4 °C | 13.2 | 16.1 | 14.7 |

It is observed that the masonry wall without a ventilated facade has a higher U-value compared to the masonry wall with a ventilated facade, due to lack of thermal insulation air cavity, and ceramic tiles. The U-value difference between the two types of walls is 0.909 $W/m^2K$. Obviously, the masonry wall with a ventilated facade performs better than the masonry wall without a ventilated facade. Therefore, their usage is strongly recommended to be improved for i) the masonry wall without ventilated facade in the existing building, ii) and in the reconstruction of the second new building of the University, which is in the process of improvement.

### 4.2 Experiment evaluations using Testo 882 thermal camera

The aim of this experiment is also to investigate the thermal performance for both cases using Testo 882 thermal camera.

Testo 882 thermal camera is a high-resolution infrared imaging camera used for detecting temperature differences and thermal patterns on surfaces. The camera can measure temperatures from -20°C to 350°C with a thermal sensitivity of <60 mK, making it ideal for measuring thermal gradients on building surfaces with an accuracy of +/- 2°C and +/-2% mv [12].

In order to examine the temperature distribution and thermal behavior of the outside wall in both cases and other thermal anomalies as well as, to find hot spots or cold spots on the wall's surface, it is used Testo 882 thermal camera.

The results from the experiment are analyzed with the Testo 882 software claiming any significant differences between the two wall layouts and can be utilized to improve the energy efficiency of buildings by redesigning external walls.

The Testo 882 thermal camera is a useful instrument for determining the efficiency of heat transmission on different surfaces. It offers reliable and comprehensive measurements of temperature differences and thermal patterns on building surfaces to evaluate the thermal behavior of building materials enhancing building designs.

It is important to underline that the thermal photos in both cases were done at the same time and same location when and where the U-value measurement devices were set, as well.

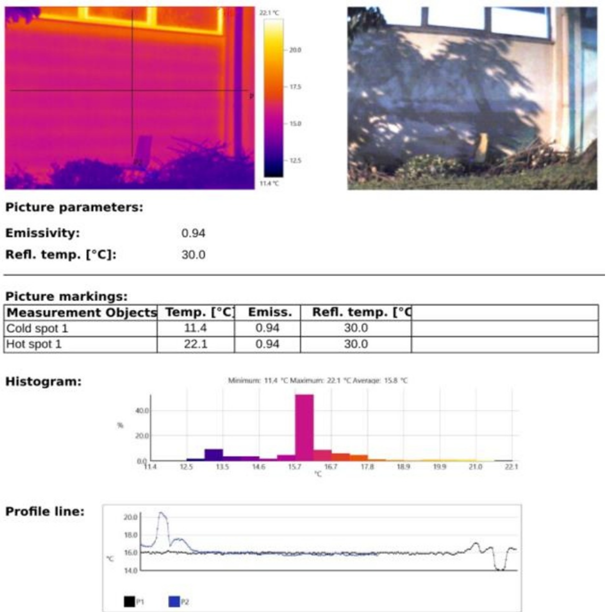


**Fig. 8.** Thermal photo of the masonry wall without ventilated facade. (Source: Authors).

It is observed that there are huge temperature differences between the masonry wall, window frames, and glass. In this case, the window is realized without a thermal cut and thermal bridges are evident. According to vertical profile line P2, where the hottest spot of the image is located (22.1°C), the difference in the temperature between the window frame and the central area of the wall is around 6°C. The mean temperature of the central masonry wall is around 16°C. Meanwhile, the coldest spot of the facade is located in the metallic vertical exhaust pipe. The horizontal profile line temperature fluctuation is almost stable. It becomes unstable just in the position of the metallic vertical exhaust pipe as seen in Figure 8.

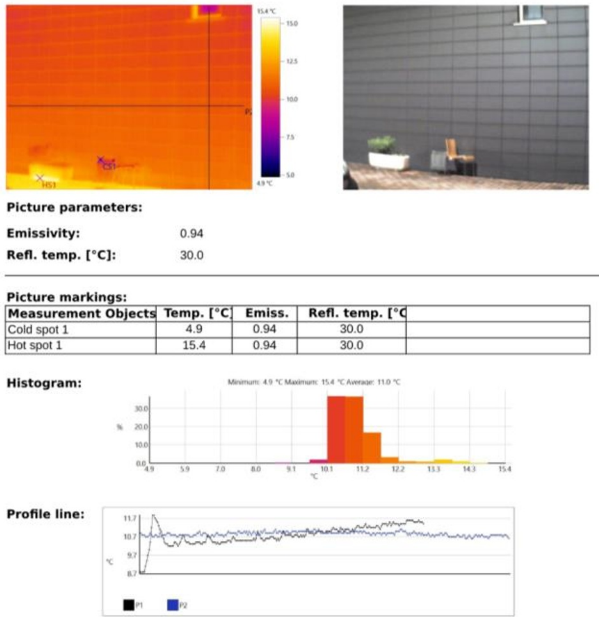


**Fig. 9.** Thermal photo of the masonry wall with ventilated facade. (Source: Authors).

It is observed that in such circumstances, the overall temperature fluctuations of the ventilated facade are lower compared to the masonry wall without a ventilated facade. According to the vertical temperature profile line in the window, are observed higher temperature oscillations compared to the central area of the facade. This is due to the glass and the metallic structure positioned in the lower part of the window. The window's metallic frame additionally serves as a potential source of thermal bridges. The mean temperature of the facade in the center area is 10-11°C, which is lower than the masonry wall facade without a ventilated facade. This is due to thermal insulation, air cavities, and ceramic tiles applied. Improvements are recommended to the existing glass and metallic structure of the facade to reduce energy loss.

It is observed that the average temperature of the masonry wall without a ventilated facade and the average temperature of the masonry wall with a ventilated facade are respectively 15.8°C and 11.00°C. The hot spot and cold spot are respectively 22.1 °C and 11.4 °C for the first case and 15.4°C and 4.9°C for the second case. These variations result from the absence of thermal insulation in the initial scenario and the presence of thermal bridges.

### 4.3 Experiment evaluations using Silverline Digital Moisture Meter

Silverline Digital Moisture Meter is another instrument that is introduced in the experiment in order to collect data about the moisture content in the indoor area of the wall for both cases.

The margins of error of the instrument are +/-2% and the maximum measurement is 60% [8].

The Silverline Digital Moisture Meter is a handheld device that measures the moisture content of various materials, including wood, plaster, and masonry. The meter works by sending an electrical signal into the material, and based on the resistance, it can determine the level of moisture present.


**Fig. 10.** Silverline Digital Moisture Meter. (Source: Authors).

The experimental setup involves inserting the Silverline Digital Moisture Meter into the internal masonry wall at various locations to measure the moisture content. To compare the moisture levels of the two configurations, an identical procedure is carried out also for the masonry wall equipped with a vented façade.

The experiment is conducted in a controlled setting, and the data gathered is analyzed to find important variations in the moisture content between the two wall layouts.

The results of the experiment reveal the moisture content of internal walls with ventilated facades and without. Utilizing the experiment's findings, interior wall designs may be improved to avoid moisture-related problems including mold development and deterioration of building components.

Research involving the moisture content of construction materials may be conducted with the help of the Silverline Digital Moisture Meter. It provides accurate and reliable measurements of the moisture content, which are essential for evaluating the performance of building materials and optimizing building designs to prevent moisture-related problems.

The measurements were done on the internal surface of the wall, specifically at four points of each wall typology. The height of the measurements was 15 cm above the pavement and the distance between the measurements was 20 cm in both cases. The high of the measurements was chosen taking into consideration the capillarity rise of the water within the wall. Water can rise in the wall due to capillarity of up to 10 m. Barometric pressures are one of the factors that influence a lot. The barometric pressure occurs due to intermolecular cohesion adhesion and surface tension. The most distinct signs of water capillarity in the wall are mostly reflected in the first 40 cm above the ground level. It is important to underline that the position of the moisture content measurements is located in the same area where the other instrument Testo 435-2 is placed.

**Table 3.** The moisture content of the masonry wall with and without a ventilated façade. (Source: Authors).

| Type of wall | Moisture content (number of measurements) | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Average (%) |
| Standard Masonry Wall | 14% | 10% | 14% | 16% | 13.5% |
| Masonry Wall with Ventilated Facade | 11% | 12% | 9% | 9% | 10.25% |

It is observed that the average moisture content in standard masonry walls is higher than in masonry walls with ventilated facades respectively 13.5% and 10.25% as seen in Table 3. Furthermore, ventilated facades perform better in terms of wall moisture content, protecting human health. However, up to 15% of moisture level is quite normal and there is no cause to be concerned. In cases where this level is higher will be required further inspections. According to the measurements, the moisture content in both cases is within the minimum required value. Future improvements in such walls via ventilated facades, side drainages, etc., will also help in reducing capillarity pressures into walls.

### 4.4 Overall results

According to the measurements it is observed that the ventilated facade has a lower U-value than the standard facade and the moisture level of the internal wall of the ventilated facade is lower than the standard facade as seen in Table 4. According to thermal camera analyzes, it is observed that thermal bridges are not very present in the ventilated facade. Meanwhile, they can be distinguished very well in the standard facade.

**Table 4.** Summary results. (Source: Authors).

| Type of masonry wall | U-Value | Average facade temperature | Hot spot | Cold spot | Moisture level |
|---|---|---|---|---|---|
| Standard masonry wall | 1.981 $W/m^2K$ | 15.8 °C | 22.1 °C | 11.4°C | 13.5% |
| Masonry wall with a ventilated facade | 1.072 $W/m^2K$ | 11 °C | 15.4°C | 4.9°C | 10.25% |

It is observed that the average facade temperature is higher in standard masonry walls, because of lack of thermal insulation as seen in Table 4. As a result, the ventilated facade has a better thermal performance than the standard one.

## Conclusions

The results of such a straightforward experiment provide good insights into the thermal behavior, U-value measurements, temperature fluctuations, and moisture content of external walls: i) with and; ii) without ventilated facades.

The data obtained from the experiment can be used by the University administration for further improvements. It can also be used as an example by others to optimize the design of external walls to achieve maximum energy efficiency in buildings.

The devices of the Energy Efficiency Lab & IF Innovation Factory at POLIS University provide accurate and reliable measurements of various parameters related to indoor and outdoor environments, which are essential for evaluating the thermal behavior of building materials and optimizing building designs.

It is observed that the ventilated facades perform much better than standard facades, which do not have thermal insulation. Therefore, their usage is strongly recommended both for the renovation of the existing building and the completion of the new second building of POLIS University. The case can be useful for replication in other situations both for professional and educational purposes.

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