

How the Passivhaus standard performs in the Mediterranean summer

Two years of monitoring a Passivhaus retrofit in Barcelona make it possible to test whether a standard conceived for the central European climate keeps its comfort under Mediterranean heat and humidity.

The success of passive houses in temperate and cold climates has been documented for more than twenty years through theoretical and practical studies, and that evidence has been decisive in spreading the Passivhaus standard worldwide. As the standard reaches warmer latitudes, however, a legitimate question returns: whether the set of solutions defined for the central European climate delivers the same efficiency under the heat and humidity of the Mediterranean climate.

Micheel Wassouf, a pioneer of the Passivhaus standard in Catalonia and co-founder of Energiehaus, examined this question through the real performance of a residential home in summer. Energiehaus took part in the project as Passivhaus designers and PAPIK Group carried out the construction. The analysis offers a first insight into whether the passive house also works in warm climates.

MZ House: a Passivhaus retrofit in Barcelona

MZ House is a single-storey detached home in Barcelona, close to a busy road, the Ronda de Dalt, and around 6 km from the beach. Barcelona's typical Mediterranean climate records an average temperature of 24 to 25 °C in August, combined with an average relative humidity of 60 to 70%.

The home is the result of an [energy retrofit](#) under Passivhaus criteria. The original building, dating from 1918, started from very basic thermal conditions: in winter, the heating demand calculated with PHPP was 171 kWh/m²a. After the intervention, that demand fell to 17.5 kWh/m²a, very close to the Passivhaus threshold. The comfort level calculated for summer held at a 10% overheating frequency with 26 °C as reference, and 14.7% with 25 °C as reference.

Envelope and systems

The useful floor area is roughly 70 m². The living-dining room looks onto the garden, facing north-east, with very little solar gain in winter, while the street façade, with a tall building opposite, contains only two small openings. To reinforce compliance with the standard, a skylight facing south-west was designed. Insulation is 14 to 18 cm in the walls, 28 cm in the roof and 6 cm in the floor.

Wooden window frames of 90 mm ($1.1 \text{ W/m}^2\text{K}$) and low-emissivity double glazing ($1.1 \text{ W/m}^2\text{K}$, g-value 0.58) suited to Mediterranean comfort conditions were installed. The building's thermal inertia is very low, because the insulation was placed on the inside. The balanced ventilation system with heat recovery holds Passivhaus certification and guarantees excellent indoor air quality. Because of the construction complexity, airtightness reached an N50 value of 2.3/h.

Occupancy and ventilation strategy

The occupants are a family of four, highly aware of energy saving. Across the two years analysed, 2013 and 2014, the family did not use the home for six summer weeks, from mid-July to the end of August, so the comfort analysis focuses on the occupied periods: June, the first half of July and September. Mechanical ventilation stayed running whenever the house was occupied, at a constant rate of 30 m^3 per hour and person. Thanks to intensive use of the garden, the large sliding window was kept open during the day, and on summer nights very intense natural cross-ventilation was practised. The skylight did not yet have external solar shading and was covered with a temporary element. The building has no air conditioning.

Measured results and data analysis

The monitoring recorded indoor and outdoor temperatures, relative humidity and CO_2 concentration over two years, with no on-site solar radiation data. The CO_2 concentration never exceeded 1,000 ppm. The average outdoor temperature between May and September was 22.60°C in 2013 and 23.28°C in 2014, compared with the 23.6°C that official PHPP data assigns to Barcelona.

Indoors, the average summer temperature was 25.5°C in 2013 and 25.2°C in 2014. The overheating frequency above 25°C during the use phase was 14.3% in 2013 and 13.0% in 2014, very close to the 14.7% predicted by PHPP. The agreement between calculation and measurement is notable. The owner, however, did not complain about temperatures, but about the high relative humidity recorded indoors during summer.

Adaptive comfort model

The data were compared with the results of the ASHRAE RP-884 study, which gathers more than 22,000 records from 160 buildings in different climate zones, most of them in warm climates. For buildings without air conditioning, the study concludes the comfort formula $T_{\text{comf}} = 18.9^\circ\text{C} + 0.255 \times \text{outdoor temperature} \pm 2.5$, with a 90% acceptability. The figures should be read with some caution, because parameters such as clothing level, metabolic rate or air velocity are not known. Even so, the comparison shows excellent thermal behaviour: very few hours exceeded the critical threshold of 26°C , in both 2013 and 2014.

Behaviour during a heat wave

The low thermal mass raised a reasonable doubt about how the house would respond to an intense heat episode. Following the ISO-EN 13790 standard, a lightweight envelope with a time constant of 20 hours was assumed. Analysis of two critical weeks in each summer shows that the temperature phase shift is around 5 hours, below the 10 hours that the EN-ISO 13786 standard sets as a minimum value, and that the building responds to sudden temperature changes in less than 20 hours.

Conclusions

Despite a low time constant and a reduced thermal phase shift of three to five hours, the home performs excellently in terms of indoor temperatures: they only exceed the 27 °C threshold for very few hours. It is worth continuing to study whether a greater thermal mass would dampen the climate's swings more effectively. Relative humidity, by contrast, does emerge as a factor to watch, as the occupants confirmed. It is not, however, a problem specific to the passive house, but a condition common to any building exposed to the high humidity characteristic of the Mediterranean, an aspect we keep in mind at PAPIK Group from the design stage of every construction project.

The MZ House case shows that the Passivhaus standard maintains summer thermal comfort under the Mediterranean climate as well. The outstanding challenge is not temperature, but humidity management.