Measurement of the Heat Storage Capacity of Building Components

Introduction

An office building in Zürich was to be cost-effectively refurbished with cooling measures. The building permit required proof of passive summer thermal insulation.

As the ceiling is fully covered with acoustic panels and the floor with a fitted carpet, the heat storage capacity of the interior walls were decisive for the overall heat storage capacity of the offices. Since the quality of the bricks used in the interior walls in the 1950s was unknown, their effective heat storage capacity was to be tested using the gOMS (gO-Measurement System) from greenTEG.

Building Data

Building function	Offices
Year of construction	1951
Location	Zürich
Floor area	1'050 m²
Energy reference area	960 m²

Fig. 1: Street facade of the specified office building

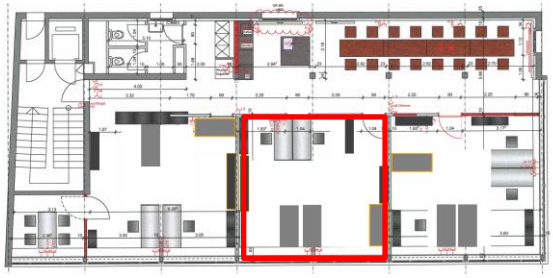

Fig. 2: Floorplan with measured office B5 encircled in red

Proof of Summer Thermal Insulation

The proof of summer heat insulation is provided in accordance with SIA 180. The sun protection standards requirements are fulfiled with the existing Roman blinds, but the minimum required effective heat storage capacity of at least 45 Wh/m²K per net floor area was not achieved by most offices.

The calculation of the effective heat storage capacity of the building components is carried out in accordance with EN ISO 13786.

Specific heat storage capacity of building components – Calculated on the basis of the structural layers	χ_i Wh/m²K
AW1 – Exterior wall parapet street facade Concrete 15 cm, cork 2 cm, brick 5 cm, white plaster 0.5 cm	16
IW1 – Inside wall 3rd floor Light brick 10 cm, cement mortar 2 x 1 cm	11
ZD1 – Floor (suspended ceiling) Concrete22 cm, cement screed 5 cm, Fitted carpet 0.5 cm	16
DA1 – Ceiling (Roof) Gravel 5 cm, bitumen 0.5 cm, cork 4 cm Concrete 15 cm, Air 10 cm, Glasswool2 cm, Sheet steel 0.1 cm (Acoustic panel)	6

Office B5	A m²	χ_i Wh/m²K	C_i Wh/K
AW1	8	16	128
IW1	51	11	561
ZD1	38	16	608
DA1	38	6	228
Sum	135		1'525
Net Floor Area (NFA) of Office B5		m²	38
Heat Storage Capacity per m² NFA		**Wh/m²K**	**40.1**

Since the calculated heat storage capacity is less than 45 Wh/m²K, proof of summer thermal insulation of office B5 must be provided in accordance with SIA 180, Appendix C1. In addition to the window component and g-value of glazing and solar shading, the heat storage capacity of building components surrounding the room is critical for fulfilling the regulation requirements.

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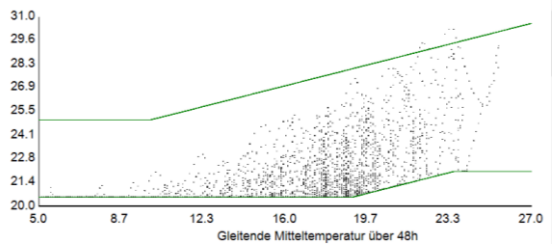

Fig.3: Scatter plot of room air temperature in °C, simulated according to SIA 180:2014 – Number of overheating hours: 7h per year

Thermal capacity simulations show that the office does not fulfil standards requirements, as the calculated room temperatures are above the limit curve for 7 hours per year. However, small changes in the simulation's assumptions of the building components' heat storage capacity can alter the outcome to either meet or fail the standards.

Measurement and Evaluation

To measure the heat storage capacity, the heat flow, surface and room ambient air temperature of the interior wall of office B5 was measured during 4 warm days in September 2018. The gO-Measurement System from greenTEG (https://www.greenteg.com) was used for the measurement. For control purposes, measurements were taken simultaneously on opposite sides of the wall.

Fig. 4: gOMS sensors for measuring heat flux, surface and room air temperature on the inside wall of office B5

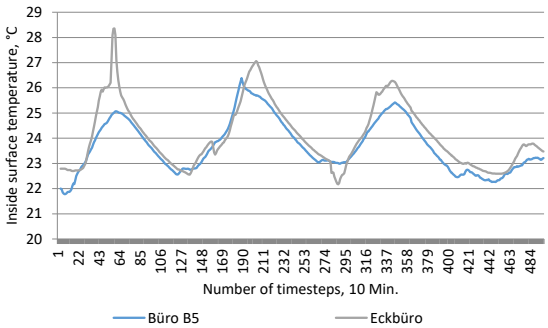

Fig. 5: Surface temperature on both sides of the inner wall: the thermal load on the wall is mostluy symmetrical

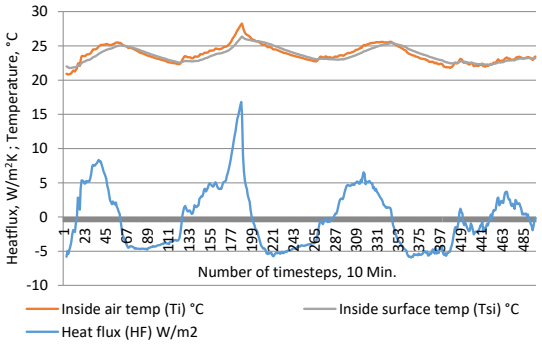

Fig.6: gOMS-Measurement Data: Heat flux, surface and room air temperature

The effective heat transfer coefficient (U-value) can be calculated from the measured heat flux divided by the difference between room air and wall surface temperature. The average value during the measurement period was 9.74 W/m²K, which is slightly above the standard value of 7.7 W/m²K.

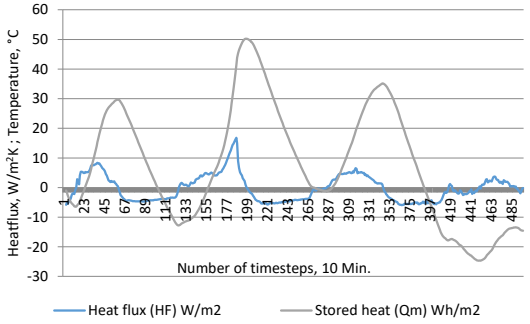

Fig.7: Heat flux (output) and thermal energy stored in the wall in a daily cycle

The area-related heat storage capacity can be calculated from the amplitude of the thermal energy stored in the inner wall divided by the amplitude of the room ambientair temperature. On the 2nd and 3rd day of the measurement, the heat storage was 12.5 and 12.7 Wh/m²K respectively. On the first day, the resulting heat storage capacity was only 7.7 Wh/m²K.

Conclusion

It could be shown that the heat storage capacity of building components with uncertain material breakdown could be determined in-situ using greenTEG's gO-Measurement System. In the present case, the measured value of approximately 12.5 Wh/m²K is slightly higher than the calculated value of 11 Wh/m²K for the inner wall. However, in simulation cases which resulted in a few hours of overheating per year, small differences in assumptions may be decisive for passing or failing the standards.