Data article

Supplementary data to *Barriers on establishing passive strategies in office spaces: a case study in a historic university building*

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Abstract: The adaptation of spaces to different usage typologies can be complex in heritage buildings, especially when it comes to achieving thermal comfort in readapted buildings. This paper shows the thermal comfort assessment performed in office spaces located in a historic building in the University of Coimbra, Portugal. Objective and subjective data were acquired during a monitoring campaign carried out between May and September 2020 to assess indoor conditions' quality in such offices. Due to the current pandemic of COVID-19, offices were not occupied at full capacity. The data presented in the article are related to the research article entitled *"Barriers on establishing passive strategies in office spaces: a case study in a historic university buildin*g" [1], which presents a full investigation of the thermal comfort conditions of workers in this building during the cooling season.

Keywords: Heritage building; Thermal comfort; Office buildings; Field survey; Free cooling; PMV-PPD indices; TSV.

Specifications Table

Subject area	*Engineering*
More specific subject area	*Architecture, Civil and Structural Engineering, Mechanical Engineering*
Type of data	*Tables and graphs*
How data was acquired	*Monitoring campaign through hygrothermal dataloggers, Indoor climate analyser and questionnaires*
Data format	*Raw, analysed*
Experimental factors	*No pre-treatment*
Experimental features	*The data are analysed to assess the thermal comfort in office spaces located in a historic building to verify the needs of complementary actions beyond passive measures.*
Data source location	*Old building of the Faculty of Medicine of the University of Coimbra (FMUC), Portugal*
Data accessibility	*Data are within this article*
Related research article	*Barriers on establishing passive strategies in office spaces: a case study in a historic university building [1]*

Value of the data

- The data in this paper can be useful for researchers, providing real thermal comfort assessment of office spaces located in historic buildings.

- The data can help researchers in the identification of passive ventilation and free cooling in similar contexts and it can be useful for comparison with other thermal comfort assessment studies performed in other historic buildings.
- The data can be useful for further research in the same building, evaluating the variation of thermal indoor environment in different conditions of external climate, for example, during winter time.

1. Data

The data shown in this article are related to the research article *"Barriers on establishing passive strategies in office spaces: a case study in a historic university building"* [1]. Herein are shown some additional analyses of the thermal comfort assessment – objective and subjective, performed in the old building of the Faculty of Medicine of the University of Coimbra (FMUC).

Case study

The old building of FMUC was built-in 1951-56 [2]. It is located in the campus I of the university, declared by UNESCO as a World Heritage site in 2013, *University of Coimbra – Alta and Sofia* [3].

The climate of Coimbra is classified as warm and temperate, "Csb," according to the Köppen-Geiger classification. Climatic statistical data of 30 years is shown in Table S1 according to IPMA [4].

Table S1. Annual average climate data according to IPMA between 1971 and 2000 [4].

Latitude:	40° 12' 41" N
Longitude:	08° 25' 45" W
Altitude:	100 m
Min – Avg – Max daily temperature	9.8 – 15.5 – 21.2 °C
Relative Humidity	81 %
Precipitation	905.1 mm
Hours of sunlight	191.65

The prevailing wind speed varied between average minimums and maximums of 1.5 and 3.2 km/h while the direction ranged majorly from SSW to WNW.

2. Experimental Design, Materials and Methods

The continuous monitoring campaign was carried out for over four months, from May 04th, 2020 until September 09th, 2020, using hygrothermal dataloggers. Data were recorded every 10 minutes, in eleven offices of the FMUC.

An in-depth thermal comfort analysis was performed on August 19th, 2020. To conduct this survey and assessment, an indoor climate analyzer Brüel & Kjær 1213 was used to record air temperature T_a, dew point temperature T_{dew}, radiant temperature asymmetry T_r, and air velocity v_a with a 1-min timestamp. This instrument was composed of a dry bulb temperature sensor, a hot-wire anemometer, and a net radiometer to measure the radiant temperature asymmetry. The field surveys and thermal comfort data analysis were performed, treated, and classified according to the most commonly used thermal comfort guidelines: ISO 7730 [5] and ASHRAE 55 [6].

Additionally, a subjective Thermal Comfort survey was carried out. Office occupants filled in questionnaires, expressing their thermal sensation on a continuous scale with indicative qualitative indications, as suggested by Carvalho *et al.* [7]. The questionnaire and its goal were thoroughly explained, and occupants' data, such as age, gender, height and weight, and clothing insulation was collected under written given consent, as suggested by the Ethics Committee of the University and in compliance with the Helsinki declaration for medical research involving human subjects [8].

Monitoring equipment

The equipment for the monitoring campaigns and its specification are described in Table S2 (Table 2 in [1]).

Table S2. Specification of monitoring equipment.

Equipment	Parameter	Range	Accuracy
Hygrothermal sensors	Air temperature, T_a (°C)	[-20 – 70] °C	(0 – 50 °C): ± 0.35 °C
	Relative humidity, *RH* (%)	[5 – 95] %	(10 % - 90 %): 2.5 %
Indoor climate analyzer	Air temperature, T_a (°C)	[-20 – 50] °C	(5 – 40 °C): ± 0.20 °C
	Dew point temperature, T_{dew} (°C)	$T_a - T_{dew} < 25$ °C	$T_a - T_{dew} < 10$ °C: ± 0,5 °C 10 °C < $T_a - T_{dew} < 25$ °C: ± 1.0 °C
	Radiant temperature asymmetry, T_r (°C)	$T_a \pm 50$ °C	(-15 °C < $T_r - T_a$ < 15 °C): ± 0.5 °C
	Air velocity, v_a (m/s)	[0.05 – 1] m/s	± 5 % ± 0,05 m/s

Thermal Comfort – PMV and PPD indices

After analyzing the indoor temperature results, the Thermal Comfort indices were estimated. Tables S3 and S4 present the values corresponding to the percentage of time that a office did not provide thermal comfort conditions (due to overheating) – performance index (PI) of discomfort – and the maximum weekly percentage of people dissatisfied, PPD, estimated for a formal dress code scenario (1.0 clo).

The results show that the percentage of time in thermal discomfort (PMV > 0.7) due to overheating was very dominant, except for weeks 1, 2, 5, and 6 (the cooler weeks).

It is worth mentioning that, regardless of the office space, the conditions revealed by these results do not meet the thermal comfort requirements of ISO 7730 [9], when wearing formal clothing. Therefore, the maximum weekly PPD value was high in all surveyed spaces, as shown in Table S3. The highest values of PPD (percentage of dissatisfied people) occurred mainly during the hottest weeks 4, 10, and 11, in which the maximum PMV values were higher than 2 (Hot).

Table S3. Weekly percentage of time in which the surveyed spaces did not provide comfort conditions due to overheating, in each week (1.0 clo).

% Discomfort Time		B	C	D	E	F	G	H	I	J	K
Week	**1**	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0
	2	0.0	0.0	0.0	0.0	0.0	2.6	21.5	21.65	20.36	20.83
	3	17.4	14.8	1.9	26.4	11.9	31.7	22.9	39.3	3.1	3.3
	4	100.0	80.7	70.0	100.0	98.8	81.4	80.0	79.5	63.1	88.6
	5	2.1	0.0	0.0	8.3	0.0	2.9	0.0	0.0	0.0	0.0
	6	5.0	0.0	0.0	0.2	0.0	1.2	0.0	0.0	0.0	0.0
	7	40.5	10.2	0.0	22.6	26.7	46.9	13.1	11.9	6.7	5.5
	8	65.2	24.6	8.6	40.5	56.1	43.3	19.6	26.4	17.7	17.9
	9	99.8	91.0	89.5	88.8	99.1	83.3	84.8	93.1	94.3	96.0

10	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
11	100.0	100.0	100.0	94.8	89.5	88.1	91.2	94.3	98.3	99.5
12	-	97.1	77.6	76.7	90.2	67.4	73.1	76.7	74.1	79.8
13	-	93.1	38.8	50.2	60.7	52.6	52.4	52.4	43.8	63.1
14	-	100.0	50.2	81.7	91.7	93.8	26.7	92.9	58.8	61.7
15	-	71.7	52.6	50.5	53.3	50.5	27.4	48.6	36.9	36.0
16	-	79.5	46.4	74.5	59.1	74.8	46.7	71.9	28.6	47.6
Avg	48.2	53.9	37.9	50.9	52.3	**51.4**	39.9	49.4	39.1	43.7

Table S4. Weekly summary of the obtained results concerning the weekly maximum PPD (1.0 clo). Color scale according to ISO 7730: red (uncomfortable), yellow (category C), Light green (category B), dark green (category A).

PPD (%)		**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
Week	**1**	12.8	7.4	6.6	10.0	8.0	18.8	11.0	14.6	5.7	7.6
	2	10.6	8.1	6.1	11.8	9.1	19.0	12.3	19.4	6.2	8.5
	3	32.7	21.1	17.5	35.3	27.5	36.6	30.8	37.6	19.6	21.7
	4	44.7	36.2	29.5	56.7	43.3	64.3	43.0	38.6	30.5	35.3
	5	19.6	10.4	10.8	18.5	14.9	17.3	11.4	11.5	9.1	10.3
	6	24.2	8.2	7.3	15.3	13.5	17.7	11.8	8.6	7.7	8.0
	7	37.8	24.5	15.2	31.6	45.1	42.4	28.9	27.2	19.6	18.8
	8	43.7	37.9	22.0	60.3	42.5	54.6	33.6	41.5	27.6	30.4
	9	52.4	47.2	37.3	67.1	47.4	60.8	69.5	64.7	46.6	50.7
	10	66.3	65.8	55.3	88.5	64.5	70.6	57.1	75.0	55.6	79.5
	11	56.1	42.1	38.2	52.1	40.6	50.6	32.1	47.9	37.9	38.7
	12		41.7	33.7	44.9	28.7	65.5	33.1	44.1	32.3	31.4
	13		34.0	27.0	28.2	24.0	34.4	23.7	32.8	24.5	24.4
	14		42.4	25.9	37.9	29.9	49.9	18.9	34.5	26.7	26.1
	15		39.4	31.7	35.0	34.6	59.7	20.8	32.8	27.1	28.3
	16		33.1	28.4	47.6	26.0	40.5	38.6	36.1	36.4	33.0
Avg		36.5	31.2	24.5	40.1	31.2	43.9	29.8	35.4	25.8	28.3

After the analysis of both tables, it was concluded that offices C, E, F, and G presented the worst thermal comfort indices results over the complete monitoring. Though punctually, rooms B, E, and G presented the highest values of PMV and PPD, therefore considered the most uncomfortable offices.

Thermal Comfort subjective assessment - Questionnaires

Data was also assessed according to the adaptive model suggested in the ASHRAE 55 standard. As shown in Figure S1, the obtained results are considerably worse: only 55.8% of the monitoring time would be satisfactory for 90% of the occupants.

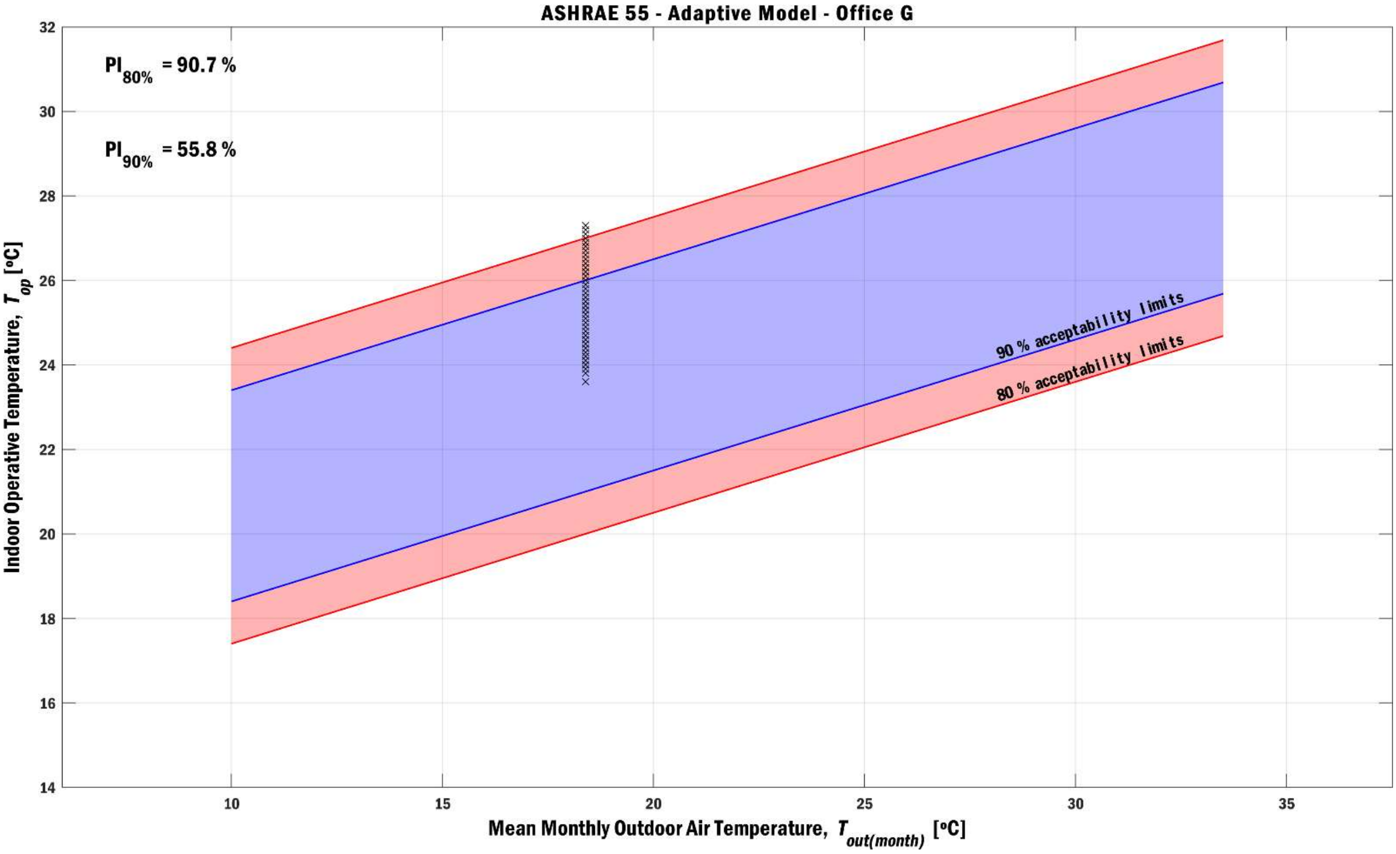

Figure S1. Distribution of the performance indices (PI) in office G on August 19th, 2020 for the two acceptable thermal comfort limits according to the ASHRAE 55 adaptive model.

Subjective thermal sensation votes (TSV) of occupants were collected on August 19th, 2020 – see Table S5. Additionally, it was decided to conduct a more in-depth onsite monitoring campaign using the indoor climate analyzer. On this day, the maximum outdoor temperature registered was 30.2 ºC, and the daily average was 23.5 ºC. The maximum and mean outdoor temperature values were respectively, 27.9 ºC and 26.3 ºC, which represented a typical summer day.

Table S5. TSV collected from the questionnaires plotted along with estimated PMV.

Occupant	**1**	**2**	**3**	**4**	**5**	**6**
PMV	1.68	1.92	1.8	1.02	1.32	1.62
Thermal sensation	Warm-	Warm-	Warm-	Slightly Warm+	Slightly Warm+	Warm-

By comparison, it was observed that the values of the questionnaires were slightly more critical than those predicted by Fanger's model (between 1.02 and 1.38). Data was also assessed according to the adaptive model suggested in the ASHRAE 55 standard. As shown in Figure S1, the obtained results are considerably worse: only 55.8% of the monitoring time would be satisfactory for 90% of the occupants.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki. Nonetheless, ethical review and approval were waived for this study, due to the characteristics of the study: no medical experiments were performed on human; occupants' data was collected under written given consent; data was anonymized.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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