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Failure of Air Conditioning, Discomfort and Thermal Performance of Workers in the Public Administration Congolese

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ABSTRACT

Thermal comfort is an essential component of the quality of workplace environments. In administrative buildings located in tropical climates, insufficient air conditioning and ventilation may lead to heat accumulation, particularly when several workers are accommodated in small office spaces. This situation may affect the occupants' well-being and potentially influence their concentration and professional performance. This study analyzes the thermal conditions in the administrative building of the Central Bank of the Congo (BCC) in Kinshasa, focusing on situations characterized by high occupancy density and insufficient cooling capacity.

The assessment is based on environmental parameters including air temperature, relative humidity, air velocity, and operative temperature, which is complemented by PMV and PPD indices and a subjective survey of the occupants. The available results indicate year operative temperature of 27.28 °C, a PMV of +1.32, and a PPD of 41.68%. The survey further shows that 70% of the occupants would prefer a lower temperature, while 64% consider the thermal conditions unacceptable. These findings reveal significant thermal discomfort, mainly oriented toward warm sensations. In small offices, accommodating several workers, insufficient air conditioning may be aggravated by internal heat gains generated by occupants, electrical equipment, and solar gains.

The study therefore considers thermal discomfort as an environmental factor that may contribute to reduced well-being, concentration, and work performance, without identifying it as the sole cause of any potential productivity decline. The study recommends adapting air-conditioning capacity to office floor area and occupancy density, improving indoor air renewal, and systematically integrating thermal comfort into the management of public administrative buildings.

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KEYWORDS: *thermal comfort, thermal discomfort, air conditioning, occupancy density, work performance, PMV, PPD, operative temperature, public administration, Central Bank of the Congo, Kinshasa.*

1. INTRODUCTION

The administrative buildings are spaces in which workers typically spend a significant part of their day. The quality of these spaces influence not only their well-being, but also their ability to effectively carry out the tasks entrusted to them.

Among the different parameters of the indoor environment, thermal comfort occupies an important place. It depends on the temperature of the air, mean radiant temperature, humidity, air speed, metabolic activity and clothing of the occupants. ISO 7730:2025 provides an analytical method to evaluate the thermal comfort using PMV and PPD.

In tropical regions, the control of the indoor temperature is a particular challenge. The air conditioning is usually used to limit the effects of high outside temperatures. However, the lack of air conditioning, lack or low capacity compared to the real needs of the local level can lead to thermal conditions uncomfortable.

This is of particular concern in small offices where several workers are grouped together. Each occupant is a source of internal heat. This heat is added to that produced by the computers, printers, lighting, and other electrical equipment.

When ventilation is insufficient, the heat generated in the interior of the office is difficult to be evacuated. The temperature may increase gradually, causing a sensation of heat more important for the occupants.

The issue of thermal comfort is also important because the administrative activities frequently require a concentration to be prolonged. The worker must read, write, enter data, analyze files, use computer software, and make decisions.

The scientific literature shows, however, that the relationship between temperature and performance is not straightforward. A meta-analysis of 35 studies published in 2021 did not identify a relationship is sufficiently robust to predict directly the performance of the employees from the single-temperature. The authors emphasize in particular the importance of the methods used, confounding factors, and the fact that temperature alone does not describe fully the thermal environment.

Of the more recent studies do, however, provide additional elements. A meta-analysis published in 2025 concludes that temperatures moderately high may degrade the performance after a certain period of exposure, with larger effects for some tasks to be qualified, while temperatures moderately lower did not show significant effect in the conditions studied.

In this context, the present study focuses on the case of the administrative building of the Central Bank of Congo in Kinshasa. The main objective is to assess the thermal conditions of the workplace and examine their potential influence on the well-being and performance of workers.

In some administrative buildings, congolese, many workers are installed in offices of relatively small size. When the cooling capacity is insufficient, or when the cooling system is not working properly, the heat generated by the occupants and the equipment can accumulate. The problem is particularly important in areas where the number of workers is high compared to the available area.

The situation can be represented conceptually by the following string:

A. high density of occupation;
B. increase gains internal heat;
C. failure of cooling and/or ventilation;
D. increase the indoor temperature;
E. discomfort from the heat.
F. discomfort and fatigue potential;
G. risk of decrease of the concentration and performance.

The extent to which the lack of air conditioning in administrative spaces, high density of occupation does it contribute to the discomfort and heat can affect the performance of the workers ?

The lack of air conditioning and ventilation in small spaces heavily occupied promotes the appearance of discomfort hot heat that could affect the well-being, concentration and the perceived performance of the workers.

the offices with a high density of occupation have thermal conditions are less favourable when the cooling capacity is insufficient, the increase of the temperature operative is associated with an increase in the dissatisfaction heat of the occupants, workers declaring a discomfort thermal important are more likely to report a decrease of their concentration and their effectiveness, the adjustment of the cooling capacity to the size of the premises and the number of occupants may contribute to the improvement of thermal comfort.

The objective usually is to analyze the influence of the lack of air conditioning on the thermal comfort and the potential performance of workers in administrative spaces, high density of occupation.

The specific objectives are to:

- characterize the thermal conditions of the building in question;
- determine the temperature operative work spaces;
- calculate the PMV and PPD;
- to evaluate the thermal perception of occupants;
- determine their preference in the heat.
- analyze the relationship between discomfort and thermal perceived performance;
- propose improvement measures adapted to the administrative context congolese.

2. MATERIALS AND METHODS

2.1. Study Site

The study is carried out in the administrative building of the Central Bank of Congo in Kinshasa.

The building is an environment that is particularly interesting for the analysis of thermal comfort due to the nature of the administrative activities that are carried out and the importance of maintaining favorable conditions of work to the concentration.

2.2. Presentation of the study site

The study focuses on the administrative building of the Central Bank of the Congo is located in Kinshasa (figure 2.1).

The choice of this building allows to study the thermal conditions in an administrative environment, real and put in relation to physical measurements with the perceptions of the workers.

The building envelope includes the walls, roof, windows, and openings enforces the separation between the inside and the outside, the view air

The building studied is mainly built of concrete and masonry-resistant materials, but promote the absorption of heat. The roof and the glass surfaces also influence the thermal gains and the interior temperature due to their exposure to solar radiation.

Thus, the materials of the envelope play an important role in the thermal comfort and the energy performance of the building**.**

The administrative building of the Central Bank of the Congo (figure 2.2) consists of several spaces for activities administrative and technical. The main local observed are the administrative offices, meeting rooms, reception areas, corridors, circulation, as well as some local techniques.



Figure 2.1 View satellite of the site of the Central Bank of the Congo to Goma and delimitation of the study area



Figure 2.2 exterior View of the building of the Central Bank of the Congo

These spaces are used on a daily basis for the activities of management, administrative processing, and coordination of services.

2.3. The parameters studied

2.3.1. Physical parameters

According to the standards ISO 7730 and ASHRAE 55, evaluation of thermal comfort is mainly based on the analysis of the physical parameters of the indoor environment. In this study, conducted within the administrative building of the Central Bank of the Congo, the parameters studied were;

A. the temperature
B. humidity
C. the speed of the air
D. the radiant temperature

These parameters are used to assess the thermal conditions on the actual inside of the local administrative and play an important role in the analysis of the thermal comfort of the occupants.

The temperature of the air directly affects the thermal sensation felt by the occupants. The relative humidity is on the human heat exchange with the indoor environment. The speed of the air promotes the exchange of heat by convection and contributes to the improvement of thermal comfort. The radiant temperature is the thermal influence of the surrounding surfaces such as walls, windows and roof.

2.3.2. Parameters human

The parameters in humans to play a critical role in the evaluation of thermal comfort. According to Fanger (1970), the thermal sensation depends mainly on the metabolism and the level of clothing of the occupants.

These parameters directly influence the heat exchange between the human body and the environment inside and play an important role in the evaluation of thermal comfort according to the standards ISO 7730 and ASHRAE 55.

Metabolism is the amount of heat produced by the human body as a function of the activity carried out. In the building studied, the occupants realize primarily of the administrative activities that are sedentary, such as computer work, drafting of documents and meetings, corresponding to a low metabolic level.

The clothing represents the thermal insulation provided by clothing worn by the occupants. It influences the body's ability to retain or dissipate heat in the thermal conditions of the interior environment.

The clothing insulation is usually expressed in the unit clo in accordance with the recommendations of the standards of thermal comfort.

2.3.3. Context parameters

In this study, conducted within the administrative building of the Central Bank of the Congo, the context parameters relate principally to the conditions of occupancy of the premises and of the method of operation of technical installations of the building.

These settings include:

A. the density of occupation of the spaces;
B. the hours of operation;
C. the use of electrical equipment;
D. the operation of the air conditioning and lighting.

The administrative building works mainly between 7: 30 and 15: 30, a period during which the premises are heavily occupied, and the technical facilities heavily loaded.

The occupation of spaces has a direct influence on the loads internal heat due to the heat generated by occupants, equipment, it and artificial lighting.

2.3.4. Parameters of occupation

For each office, it is recommended to meet:

- area;
- volume;
- number of workers;
- number of computers;
- number of other electrical equipment;
- presence or absence of air conditioning;
- number of air conditioners;
- power of air conditioners;
- state of operation;
- presence of windows;
- opportunities for natural ventilation.

The density of occupation can be expressed by:

$$D = N/S$$

where:
D = density of occupation (persons/m2),
N = number of workers,
S = surface area of the desktop (m2).

This indicator will allow to objectively compare the different premises.

2.4. Evaluation of the PMV and PPD

The quantitative evaluation of thermal comfort has been completed by the PMV and PPD. The PMV can estimate the thermal sensation average of a group of occupants on a scale ranging from feeling very cold to very warm sensation. The PPD is the percentage predictable of occupants dissatisfied with the thermal conditions.

For the conditions studied, the results obtained are:

- PMV = +1,32;
- PPD = 41,68 %;
- temperature operational = 27,28 °C.

The positive value of the PMV indicates a thermal sensation that is oriented towards the hot. The PPD

41,68 %, reflecting a level of dissatisfaction that is relatively high.

2.5. Subjective assessment with occupants

In order to complete the instrumental analysis, the preferences and perceptions heat of the occupants has also been considered. The responses received show that 70 % of the occupants want the interior temperature to a lower setting. Moreover, 64 % consider the thermal conditions as not acceptable.

The joint analysis of physical data, both subjective and thus allows one to compare the thermal sensation predicted by the PMV/PPD perceptions actual expressed by the occupants.

2.6. Instruments used

In accordance with the recommendations of ISO 7726, ISO 7730 and ASHRAE 55-2020, several measurement instruments have been used to evaluate the thermal parameters inside the administrative building of the Central Bank of the Congo.

These instruments were used to collect the data needed for the analysis of the conditions for thermal comfort of the occupants.

2.6.1. Thermo-hygrometers

The thermo-hygrometers (figure 2.3) will be used to measure the air temperature and relative humidity in different areas of the administrative building of the Central Bank of the Congo.



Figure 2.3: **Thermo-hygrometer digital used for the measurement of the air temperature and relative humidity**

In accordance with the standard ISO 7726, these instruments allow simultaneous measurement of:

- The air temperature T_{is} expressed in degree Celsius (°C);
- The relative humidity R_H expressed as a percentage (%).

The temperature of the air is one of the main parameters influencing the thermal sensation of the occupants while the relative humidity is on the heat exchange between the human body and the environment inside.

2° Anemometers

Anemometers (figure 2.4) will be used to measure the speed of the air in administrative spaces studied.



Figure 2.4: Anemometers used to measure the speed of the air

The air velocity V_a is expressed in meter per second (m/s) and allows assessment of the flow of air to the interior of the premises.

In the building studied, the absence of a system of mechanical ventilation results in a low natural circulation of the air in several administrative space. The measurement of this parameter, therefore, enabled to evaluate the influence of this low ventilation on the conditions of thermal comfort.

3° globe Thermometer

The globe thermometer (figure 2.5) was used to measure the mean radiant temperature in the different studied areas of the administrative building.



Figure 2.5: **measurement Kit of thermal comfort including a thermometer to the globe black**

The mean radiant temperature T_r is the thermal influence of the surrounding surfaces such as walls, the windows, the ceiling and the roof on the occupants.

In accordance with the standard ISO 7730, this setting is applied in the calculation of the temperature operative to assess the conditions of thermal comfort.

2.6.2. Survey of occupants

In the framework of this study, a survey will be carried out with the occupants of the administrative

building of the Central Bank of the Congo to assess their perception of the conditions of thermal comfort in the interior spaces are studied.

This survey will build on the recommendations of the standards ISO 7730 and ASHRAE 55-2020 related to the evaluation of the thermal comfort of the occupants.

2.7. Calculation of thermal loads

The thermal load can be expressed by the following relationship:

$$Q_t = Q_o + Q_e + Q_l \qquad (2.1)$$

With;

- Q_t ; *thermal load total internal*
- Q_o; *heat generated by the occupants* ;
- Q_e; *heat generated by the equipment* ;
- Q_l ; *heat produced by the lighting.*

These settings allow you to better understand the influence of the operating conditions of the building on the thermal performance and comfort of the occupants.

The concrete walls and the glass surfaces absorb a significant amount of heat under the effect of solar radiation. This is in addition to the expenses internal heat generated by the computers, the printers, the lighting and the occupants of the administrative offices.

The absence of mechanical ventilation also promotes the build-up of heat inside the spaces studied.

2.7.1. Energy balance

The energy balance of the building was used to estimate the cooling power needed to maintain an indoor temperature setpoint 24°C in spite of the climatic conditions outside of Kinshasa.

This analysis takes into account:

A. the thermal loads of the building;
B. the operation of the air conditioning;
C. the conditions of occupation;
D. the absence of mechanical ventilation.

The heat balance simplified building can be expressed by the following relationship:

$$Q_{clim} = Q_t + Q_{evac} \qquad (2.2)$$

With:

- Q_{clim}: output power of cooling needed;
- Q_t: overall thermal loads;
- Q_{evac}: heat removed by the existing systems.

This analysis allows us to evaluate the energy requirements for maintenance of the conditions of thermal comfort in administrative spaces studied.

2.7.2. A critical analysis of the mode of regulation current

1° Evaluation of the existing system

The administrative building of the Central Bank of the Congo mainly uses an air-conditioning system operating according to a mode of regulation fixed during the hours of administrative, either from 7: 30 to 15: 30.

The air-conditioning system provides cooling of the administration space in order to maintain thermal conditions compatible with the professional activities. However, the absence of mechanical ventilation that limits the renewal of the air inside and promotes the accumulation

2.7.3. Evaluation of thermal comfort

The evaluation of thermal comfort is achieved through the PMV and PPD.

The PMV is the Predicted Mean Vote, or vote predictable way.

The PPD is the Predicted Percentage of Dissatisfied, or percentage predictable dissatisfied.

These indices allow to complete the analysis of the thermal conditions and compare the results to the comfort criteria defined in the standard ISO 7730:2025.

The PMV is influenced by:

- the temperature of the air;
- the mean radiant temperature;
- the speed of the air;
- humidity;
- the metabolism;
- clothing.

The general expression of the thermal balance can be represented by:

$$S = M - W - E^c - E^r - E^d - C - R$$

where:

- S = heat load of the body;
- M = metabolism;
- W = mechanical work external;
- E^c = heat loss by evaporation;
- E^r = loss of breath;
- E^d = losses by diffusion;
- C = loss by convection;
- R = losses by radiation.

When the heat balance is moving away from the equilibrium, the thermal sensation moves to the hot or to cold.

3. PRESENTATION, ANALYSIS AND DISCUSSION OF RESULTS

3.1. Presentation and analysis of results

3.1.1. Thermal parameters

The available data are presented in table 3.1.next.

Table 3.1. Thermal Conditions observed

Parameter	Value
average air Temperature of	24-27 °C
maximum Temperature of	34-37 °C
relative Humidity	of 60-90 %
air Velocity	Low
Temperature operative	27,28 °C
MVP	+1,32
PPD	41,68 %

These values show that the thermal conditions may vary greatly during the day and according to the spaces studied.

3.1.2. Analysis PMV

Value:

PMV = +1,32 indicates a thermal sensation average oriented towards the hot.

This value is consistent with the observations on the temperature and the humidity.

The result indicates that the conditions studied did not correspond to a thermal sensation is neutral.

3.1.3. Analysis of the PPD

Value:

PPD = 41,68 %, reflecting a significant level of dissatisfaction thermal predictable.

In other words, a significant proportion of the occupants is likely not to be satisfied with the thermal environment.

It should, however, distinguish between the PPD calculated from the model PMV answers actually expressed by the occupants.

3.1.4. Results of the subjective inquiry

The responses of the occupants are an essential element of the assessment.

The available results are given in table 3.2 below:

70 % of the occupants want a lower temperature

64 % consider the thermal conditions as not acceptable.

Table 3.2. Thermal Perception of occupants

Indicator	Result
Occupants wishing a lower temperature than	70 %
Occupants considering the conditions not acceptable to	64 %

The preference expressed by 70 % of the occupants to a lower temperature confirms that the dominant feeling is directed towards the hot.

The rate of 64 % considering the conditions not acceptable also shows that the discomfort is not limited to a few individuals.

3.1.5. Terms and Conditions

The available observations show the average temperatures between 24 and 27 °C, with maximum temperatures up to 34 °to 37 ° C.

The relative humidity varies between 60% and 90%, while the speed of the air is generally low.

These conditions are likely to be particularly uncomfortable when temperature and humidity achieve simultaneously high levels.

4.2. Temperature operational

Temperature-operational measured in the studied condition is:

27,28 °C.

This value is an indicator that is more representative of the thermal environment felt that the only air temperature, since it takes into account the interaction between the occupant and the surrounding surfaces and air movements.

3.1.6. Thermal preferences of the occupants

The investigation reveals that:

- 70 % of the occupants wish to a lower temperature;
- 64 % consider the thermal conditions as not acceptable.

These results show that the subjective perception of the occupants confirms the existence of a discomfort to significant thermal.

The wish for a lower temperature is very consistent with the PMV positive observed.

3.2. Analysis of the relationship between the density of occupation and discomfort

In a small office, the increase in the number of workers leads to an increase in gains internal heat.

Each worker produces heat as a function of its metabolic activity. When multiple workers are grouped in a small space, this heat may represent a thermal load important.

This charge is in addition:

- computers;
- screens;
- printers;
- the electrical equipment;
- lighting;
- solar.

If the cooling capacity of the air conditioner is insufficient, the thermal equilibrium of the local becomes negative. The air conditioning system must then evacuate the amount of heat that is greater than its actual capacity, which can lead to an increase in the internal temperature.

Thus, the mere presence of an air conditioner in an office does not necessarily guarantee the thermal comfort. The key issue is that the balance between the cooling power and the thermal load to a real local.

3.3. Discussion

The obtained results clearly highlight a situation of discomfort, heat in the building studied. The temperature operative to 27,28 °C, combined with a PMV of +1.32 and a PPD of 41,68 %, reflecting a situation in which a significant proportion of the occupants is likely to be dissatisfied. The results of subjective reinforce this conclusion: 70 % of the occupants want a lower temperature, and 64 % believe conditions as well as non-acceptable.

This convergence between objective and subjective indicators is an important result. However, it is advisable to exercise caution when it establishes a link with the performance. The performance of a worker depends on many factors: work organization, motivation, support professional, available tools, management, noise, lighting, air quality, fatigue, and personal conditions.

Therefore, it would be scientifically incorrect to say that the temperature 27,28 °C results in a decrease in specific productivity. The recent literature confirms this caution. The meta-analysis ofPorras-Salazar et al., carrying on 35 studies found no relationship is sufficiently robust between temperature and performance of office to use the temperature alone as a predictor of productivity.

In contrast, a meta-analysis published in 2025 reports that temperatures moderately high may degrade the performance after about an hour of exposure, with larger effects for some tasks to be qualified. These results warrant a more comprehensive approach in the congolese situation: it is necessary to measure simultaneously the thermal conditions and the performance indicators.

3.4. Proposal of a conceptual model

The study can be structured around the following model:

- Characteristics of the building;
- Small area + high density of occupation;
- Expenses increase internal heat;
- Insufficient capacity of air conditioning/ventilation;
- Temperature, and high humidity;
- Discomfort from the heat.
- Fatigue + discomfort + concentration decrease;
- Performance potentially reduced;
- This model will need to be experimentally verified by measurements and analysis of statistics.

4. Recommendations

4.1. Adjust the air conditioning to the density of occupancy

The capacity of air conditioners should be determined according to:

- of the area;
- the volume of the local;
- the number of occupants;
- of the electrical equipment;
- of exposure to the sun;
- the characteristics of the building envelope.

4.2. Avoid overload of the small office

When the surface area of a currency is low, it would be better to limit the number of workers, or rearrange the spaces in order to reduce the density of occupation.

4.3. Improve the air

The air conditioning should not be considered only as a cooling system. The renewal and the movement of the air must also be taken into account.

4.4. Regular maintenance of the air conditioners

The filters, heat exchangers, and other components must be maintained regularly in order to maintain the performance of the equipment.

4.5. Install solar protection

The reduction of solar gain would decrease the thermal load imposed on the air-conditioning systems.

4.6. Perform measurement campaigns

Measures should be taken at different times of day and in different offices in order to identify the spaces that are most adverse.

4.7. Measure the performance of professional

To demonstrate scientifically the effect of thermal comfort on performance, it would be useful to measure:

- the execution time of tasks;
- the number of errors;
- the amount of records processed;
- the tests of concentration;
- the fatigue;
- the number of breaks;
- absenteeism.

This step is essential to move from a relationship supposed to be a relationship to be statistically demonstrated.

5. CONCLUSION

This study shows that the thermal conditions constitute an important dimension of working conditions in the administrative buildings of the democratic Republic of the Congo. The case of the administrative building of the Central Bank of the

Congo highlights a temperature operative to 27,28 °C, a PMV of +1.32 and a PPD of 41,68 %. The responses of the occupants to confirm this: 70 % want a lower temperature, and 64 % consider the thermal conditions as not acceptable.

These results clearly indicate the existence of a discomfort thermal oriented towards the hot. In small spaces, grouping together several of the workers, this situation can be exacerbated by the occupation density, the heat produced by the electrical equipment, the solar and the lack of ventilation or air conditioning.

The discomfort from heat must therefore be considered as an environmental factor that may contribute to the degradation of the well-being and conditions of concentration of workers. However, the relationship between temperature and performance is complex, it is necessary to directly measure the performance indicators before concluding to a loss of productivity. This caution is consistent with the mixed results of the recent scientific literature.

The improvement of working conditions in the public administration congolese should integrate a rational management of the thermal comfort. The air conditioning must be dimensioned according to the size and density of occupation, while the ventilation, sun protection and the organization of the spaces must be taken into account.

A policy for the management of the administrative buildings integrating simultaneously thermal comfort, stocking density, ventilation, air conditioning and performance in the workplace may contribute to sustainably improving the conditions of employment of public officials.

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