



### RESEARCH ARTICLE

## EVALUATION OF ENERGY PERFORMANCE AND THERMAL COMFORT OF BIOCLIMATIC BUILDINGS

Abdallah Dadi Mahamat<sup>1</sup>, Abakar Ali<sup>2</sup>, Brahim Tchou<sup>1</sup>, Abdallah Bannah-Mahamat<sup>1</sup> and Salif Gaye<sup>3</sup>

1. National Institute of Sciences and Techniques of Abéché (INSTA), BP 130 Abéché, Chad.
2. National School of Public Works (ENSTP), BP 60, Ndjamen, Chad.
3. Laboratory of Materials of Energetics of Electricity and Economy (LM3E) of the University Iba Der Thiam of Thies in Sénégal.

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#### Abstract

Reducing energy consumption is a major challenge of our time. The building science community therefore pays constant attention to the development of numerical simulations. The simulation codes make it possible to detail many phenomena related to the equipment and the interior environment of the building while giving consistent results. The grouping of these tools around simulation platforms apprehends the system as a whole and facilitates the design of high-performance buildings. The building sector then uses these tools to meet increasingly ambitious performance objectives. This performance is the result of careful design and implementation and ultimately allows a reduction in consumption and acceptable thermal comfort. This study is devoted to the evaluation of the energy efficiency and the thermal comfort of the experimental cells of bioclimatic buildings. Its objective is to evaluate the energy consumption and the achievement of the thermal comfort of the dwelling thanks to the judicious use of construction materials. The particularity of this study is that it takes into account available materials such as earth stabilized with cement compared to "modern" habitats made of hollow agglomerated blocks in hot zones. The cellular simulations are carried out with the Pléiades+Comfie software. During this thermal simulation, comparisons are made between traditional materials available in Chad, such as cement-stabilized earth brick (BTS), and modern materials, such as cement blocks. The results of these simulations showed for identical cells and with the same usage scenarios, the BTS cell has a lower air conditioning power for an average temperature difference greater than 2°C, the electrical energy consumption is 1.4 times lower and the best rate of thermal comfort compared to the cement block cell. The cell built with BTC represents a direct response to climatic constraints. The analysis of the results also shows that it is possible to obtain a good level of thermal comfort and reduced electrical energy consumption with the BTS.

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**Corresponding Author: Abdallah Dadi Mahamat**

Address: National Institute of Sciences and Techniques of Abéché (INSTA), BP 130 Abéché, Chad.

**Introduction:-**

The increase in energy consumption is felt all over the world. This energy is largely of fossil origin and therefore non-renewable, expensive and a source of green house gas emissions.

In countries where the climate is hot like Chad, the building sector is very energy-intensive and consumes most of the energy. This energy is mainly used to solve the problems of discomfort in the building, but the rate of access to energy remains low and linked to a production deficit. For these reasons, many research efforts are focused on studying the energy efficiency of buildings in order to find a compromise between comfort, energy saving and the environment. Mastering the concept of building energy efficiency presents all the techniques, methods and solutions that must comply with the requirements of thermal regulations and that meet respect for the environment [1].

It is in this context that we carried out our work on cells built with local materials. The objective is to carry out studies on buildings constructed with different materials in order to assess their energy performance and the level of thermal comfort. The studies are carried out on two experimental cells built with different materials: one cell built with cement block bricks and the other with compressed and stabilized earth bricks (BTC) [2].

**Bioclimatic building**

A bioclimatic building is a building whose layout and design take into account the climate and the immediate environment, in order to reduce energy needs for heating, air conditioning and lighting [3]. For the manufacture of clay bricks, usually mixed with clay additives in order to improve their mechanical performance and resistance to moisture [4]. The power gain obtained by the clay-based brick mixed with admixtures show that the thermal energy saving is quite considerable in the cold production for the clay brick compared to a reference material which cements [5]. In this study we will carry out a comparative study between the cement block and the compressed and stabilized earth bricks based on cement (BTC). BTC have certain advantages over other earthen construction techniques and some conventional masonry materials [6].

**Simulation Tools and Methods:**

The PLEIADES +COMFIE software is a thermal simulation tool for buildings making it possible to calculate the behavior of different thermal zones of a building in dynamic regime. PLEIADES also allows the entry of libraries, the description detail of the building, the launch of the calculations and the analysis of the results.

The software used in our study is: PLEIADES+COMFIE version 5.21.3.0 which takes into account many parameters and characteristics [7]:

1. Thermal envelope of the building (walls, roof, glazing, etc.);
2. Internal gains (occupancy scenarios, heat losses from electrical equipment, etc.);
3. Thermal inertia of the building;
4. Local weather data.

This PLEIADES+COMFIE modeling and calculation software was developed to replace the simple calculations used in the building sector. To meet environmental requirements and expectations in terms of energy efficiency in new construction and renovation (RT2020).

**Methodology:-**

**Building Modeling**

The buildings of the experimental cells are of the tertiary type with standard office use scenarios.

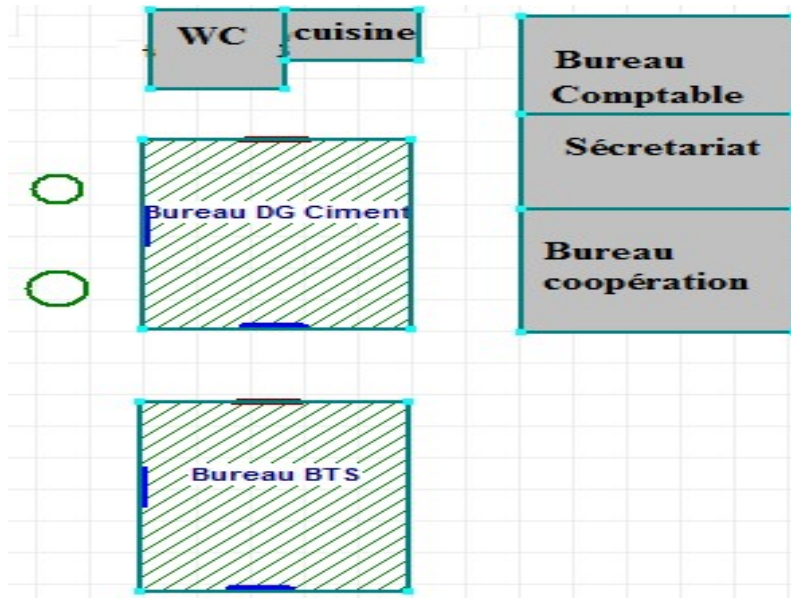


Figure 1:- Plan of the experimental cell buildings.

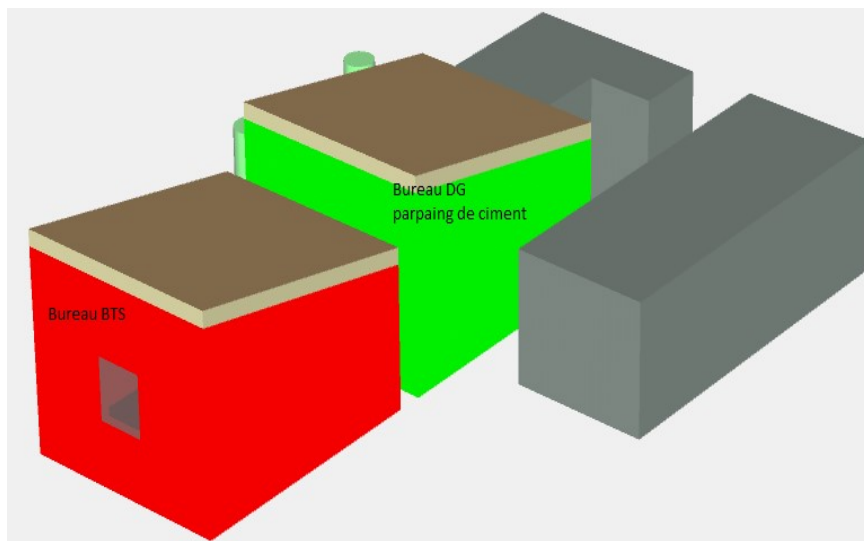


Figure 2:- 3D image of the experimental cell buildings.

Table 1:- Wall compositions of buildings.

Type of wall: High floor (roof)					
Type of wall	Inclined roof				
Component	Thickness (cm)	Thermal Conductivity (W/(m.K))	Density( kg/m3)	Heat Specific (Wh/(kg.K))	Thermal Resistance (m <sup>2</sup> .K)/W)
Sheet steel	0.2	113.000	6600	0.116	0.00
Air blade	30.0	0.025	1	0.280	12.00
Plywood	0.3	0.090	300	0.444	0.03

<b>Type of wall: Verticalwall</b>					
Type wall	Exteriorwall				
Component	Thickness (cm)	Thermal Conductivity (W/(m.K))	Density (kg/m <sup>3</sup> )	Heat specific (Wh/(kg.K))	Thermal Resistance (m <sup>2</sup> .K/W)
cement block	15.0	1.150	2000	0.278	0.13
Stabilized earth brick (BTS)	15.0	0.980	2000	0.250	0.15
<b>Type of wall: Lowfloor</b>					
Component	Thickness (cm)	Thermal Conductivity (W/(m.K))	Density (kg/m <sup>3</sup> )	Heat specific (Wh/(kg.K))	Thermal Resistance (m <sup>2</sup> .K/W)
Solid concrete (light)	15.0	1.650	2150	0.278	0.09

### Integration of meteorological data - launch of calculations -Presentation of results - Search for optimizations

The use of these meteorological data allowed us to calculate the needs of cooling for the building [8].

**Table 2:-** Site and weather station.

Last name	<b>TCD-NDJAMENA-3</b> <b>File TCD-NDJAMENA-3.try</b>	<b>Altitude</b>	<b>295 m</b>
Longitude	<b>15° 1' 48"E</b>	<b>Latitude</b>	<b>12° 7' 48"N</b>
Temperatures	Minimum	Maximum	Average
	<b>13.00°C</b>	<b>41.20°C</b>	<b>27.55°C</b>

### Results:-

The results obtained by these simulations will provide clear answers to the client's questions: forecast energy consumption, level of thermal comfort, real gains in terms of consumption and comfort of the optimization proposals. The results obtained are shown in the table below.

**Table 3:-** Summary of STD results.

Zones	Heating power (W)	Air conditioning power (W)	Average temperature (°C)	Solar input (kWh)	Lighting consumption (kWh)	Discomfort rate (%)	Electricity consumption (kW)
<b>Office built in Cement</b>	<b>0</b>	<b>2969</b>	<b>28,28</b>	<b>842</b>	<b>312</b>	<b>4,63</b>	<b>3 381</b>
<b>Office built in BTS</b>	<b>0</b>	<b>2660</b>	<b>25,86</b>	<b>858</b>	<b>332</b>	<b>4,07</b>	<b>2 409</b>

### Discussion:-

The results show that for the same scenarios the air conditioning power and the average temperature of the cell built with the cement block are higher than that of the BTS results affirmed by the work of DADI [2]. The power consumption of BTS is about 1.4 times lower than cement cell; the discomfort rate is 4.07% for BTS and 4.63% for cement block cell [3].

### Conclusion:-

This work has high lighted the thermal comfort and energy savings for building constructed with local clay-based materials. The results of the thermal and dynamic simulation showed that comfort and energy savings can be improved thanks to the choice of materials that make up the wall. We note that for a discomfort rate of 4.63% the electricity consumption for the cement block building is 3381 kW and for a discomfort rate of 4.07% the consumption is 2409 kW for the BTCS building of experimental cells. This confirms the earthen buildings are well suited to hot climates and reduce the power of artificial air conditioning, which consumes a lot of energy.

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