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A Statistical Analysis of Building Temperature for Different Climates in Algeria

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Abstract

The objective of this study is to analyze the thermal behavior of a residential building with an aim of estimating thermal comfort in this building for a case of a passive air conditioning.

Passive air conditioning can play a major role in promoting energy efficiency in the building sector. Considering that this sector is one of the main targets of the improvement of energy efficiency, since it represents today more than one third of the worldwide consumption of energy and an equivalent amount of its associated emissions.

In Algeria, this sector has the highest energy consumption. Its consumption represents more than 42% of the total final consumption.

The approach used in this study is a statistical analysis of the results obtained by a thermal simulation of a building with the aim of evaluating the thermal comfort of its occupants.

This analysis is carried out for a building situated in two different locations: the city of Bechar which is located in the south west of Algeria and characterized by a desert climate, and the city of Constantine which is located in the north east of Algeria and having Mediterranean climate.

Keywords: Numerical Simulation, Thermal Confort, Thermal Engineering, TRNSYS Software.

1. Introduction

The objective of this study is to analyze the thermal behavior of a residential building with an aim of estimating thermal comfort in this building for a case of a passive air conditioning.

Passive air conditioning can play a major role in promoting energy efficiency in the building sector [1]. Considering that this sector is one of the main targets of the improvement of energy efficiency, since it represents today more than one third of the worldwide consumption of energy and an equivalent amount of its associated emissions [2].

In Algeria, this sector has the highest energy consumption. Its consumption represents more than 42% of the total final consumption [3].

In this work a numerical simulation using TRNSYS software is carried out, in order to determine the annual distribution of temperatures inside a building.

This thermal simulation allows us to estimate the hourly value of the temperature inside each room for a chosen location.

This simulation is carried out for two cities having distinct climates, namely: Bechar and Constantine.

The city of Bechar is located in the south west of Algeria and characterized by a desert climate, while the city of Constantine is located in the north east of Algeria and having Mediterranean climate.

The weather data of these building sites are ensured by a weather files provided by the software.

A detailed description of the building must be given with precision, such as the details concerning the building envelope (type of wall, type of window, orientation, solar protection etc ...).

Furthermore a schedule (scenario) of occupation of different rooms is provided with the level of activity of each occupant. In addition, a schedule describing the use of lighting and that of the various appliances, which contribute to the internal heat gains, is elaborated.

In order to perform a statistical analysis of the results obtained by the TRNSYS software, a computer program has been developed in order to process these results. This processing made possible the calculation of the statistical distribution of temperatures throughout the year, based on the annual distribution of the building's internal temperatures.

In this study two statistical distributions were determined namely the probability density as well as the cumulative probability of the building temperature.

The distribution of the cumulative probability of interior temperatures, made possible the analysis and the estimation of the duration of thermal comfort for passive air conditioning.

2. Thermal Simulation Using Trnsys Software

In the part of this work a numerical simulation using TRNSYS software is carried out, in order to determine the annual distribution of temperatures inside a building.

This thermal simulation allows us to estimate the hourly value of the temperature inside each room for a chosen location.

In order to carry out this simulation a detailed description of the building used is given with precision, such as the details concerning the building envelope (type of wall, type of window, orientation, solar protection etc ...).

Moreover a schedule (scenario) of occupation of different rooms is provided with the level of activity of each occupant. In addition, a schedule describing the use of lighting and that of the various appliances, which contribute to the internal heat gains, is elaborated [4].

The weather data of the two sites are ensured by a weather files provided by the software.

A. The description of the building plan.

The following plan shows the details of the building used.

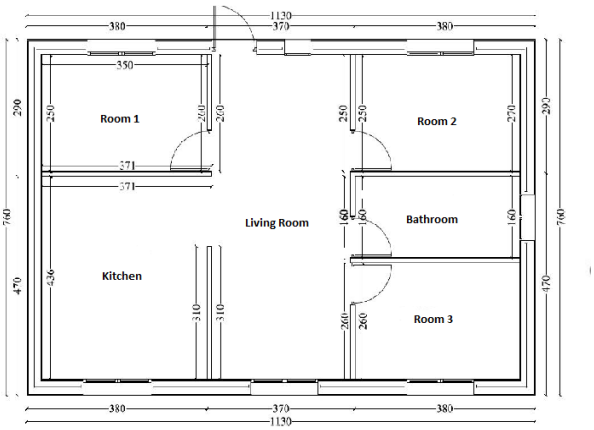

Fig 1. Building plan

B. The construction materials used for this building are described below [4].

- The building envelope is built with double walls.
- The external walls are made with brick having a thickness of 15 cm.
- All the internal walls are made with brick having a thickness of 10 cm.
- For thermal insulation, 5 cm thick of polystyrene sheets are used.
- Type of windows used: Double glazed.

C. The geographical and meteorological characteristics of the building sites

- The city of Constantine is located east of Algeria and having the geographical and weather characteristics as follow:

- Latitude 36.17° north
- Longitude 6.37° east
- Altitude 694 m
- Located in climatic zone B

- The city of Bechar is located in the south of Algeria and having the geographical and weather characteristics as follow:

- Latitude 36.17° north
- Longitude 2.31° east
- Altitude 780 m
- Located in climatic zone D

The weather data of these sites are given by a weather file provided by the software.

3. Simulation Results

A. The case of active air conditioning

If the heating and the air conditioning are in use (the equipment are activated in the software options), when the simulation is carried out using the TRNSYS software, one will obtain energetic consumption for heating and cooling.

In the following some samples results of this simulation, performed for active air-conditioning, are given.

The annual temperature distribution is shown in Figure 2.

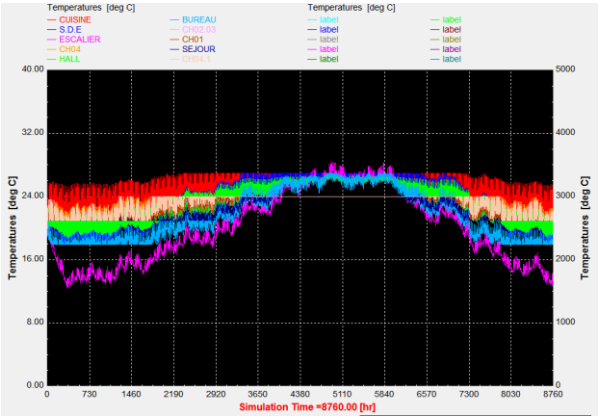

Fig 2.Temperature distribution throughout a year for each room

The following table represents the monthly and annual energy needs for heating and cooling:

Table I. Monthly and annual Energy consumption for heating and cooling throughout a year for each month

MONTHLY SUMMARY STANDARD REPORT

SUMMARY VALUES FOR ALL ZONES COMBINED

MONTH	HEATING [KWH]	COOLING [KWH]	INFILTR. [KWH]	VENTILAT. [KWH]	SOLAR_RAD. [KWH]	INT_GAINS [KWH]
JAN	1.815E+03	8.777E+01	-2.673E+03	0.000E+00	6.412E+02	3.286E+03
FEB	1.382E+03	9.633E+01	-2.296E+03	0.000E+00	6.935E+02	2.869E+03
MAR	7.608E+02	1.912E+02	-2.355E+03	0.000E+00	9.707E+02	3.125E+03
APR	1.827E+02	4.144E+02	-2.074E+03	0.000E+00	1.060E+03	2.953E+03
MAY	1.274E+01	1.299E+03	-1.704E+03	0.000E+00	1.257E+03	3.079E+03
JUN	0.000E+00	2.484E+03	-1.188E+03	0.000E+00	1.266E+03	2.930E+03
JUL	0.000E+00	4.005E+03	-5.749E+02	0.000E+00	1.367E+03	3.023E+03
AUG	7.499E-07	3.923E+03	-5.672E+02	0.000E+00	1.326E+03	3.081E+03
SEP	0.000E+00	2.463E+03	-1.054E+03	0.000E+00	1.111E+03	2.927E+03
OCT	1.384E+01	1.049E+03	-1.530E+03	0.000E+00	8.769E+02	3.163E+03
NOV	5.737E+02	1.989E+02	-2.047E+03	0.000E+00	6.291E+02	3.145E+03
DEC	1.608E+03	9.399E+01	-2.456E+03	0.000E+00	5.735E+02	3.213E+03
SUM	6.348E+03	1.631E+04	-2.052E+04	0.000E+00	1.177E+04	3.679E+04

B. The case of passive air conditioning

If the heating and the air conditioning are not in use (the equipment are deactivated in the software options), the temperature distribution is obtained for the entire year.

The temperature distribution is shown by the following Figures.

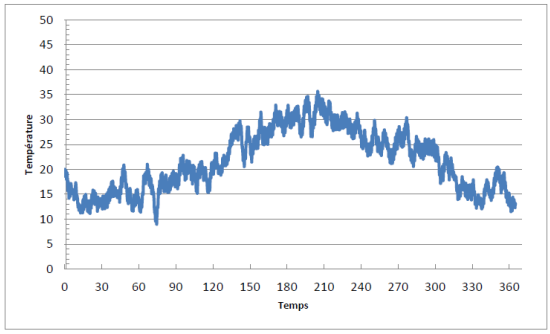

Fig. 3. Temperature Distribution for the city of Constantine

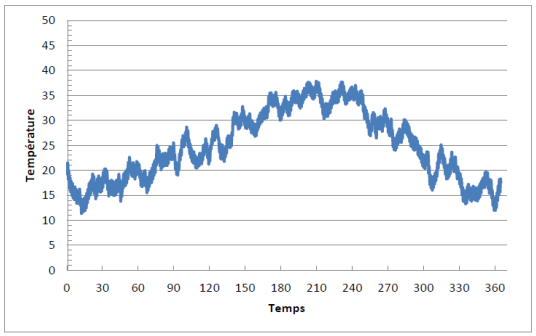

Fig. 4. Temperature Distribution for the city of Bechar

4. Estimation of Comfort Period Based on Statistical Analysis

A statistical analysis is carried out in order to estimate the comfort period [5].

This analysis is used in order to process the results obtained by this simulation. This processing, using a computer program, has allowed the calculation of the annual and seasonal durations of comfort for each site.

The following figures represent statistical distribution of annual temperature, namely the probability density and the cumulative probability respectively:

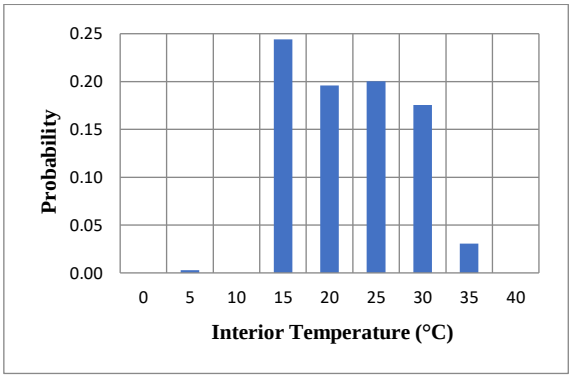

Fig. 5. Probability Density of the interior temperature for the city of Constantine

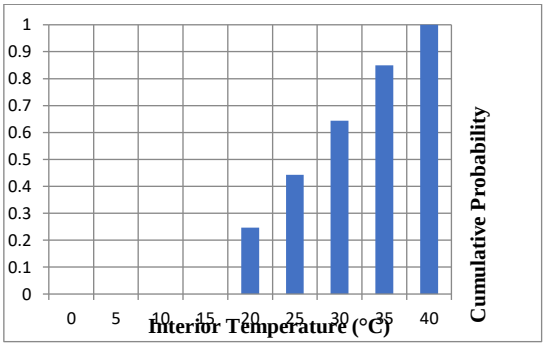

Fig. 6. Cumulative Probability of the interior temperature for the city of Constantine

The following tables represent the annual and seasonal durations of comfort for each site:

Table II. Percentage of comfort period City of Constantine

Percentage of annual comfort period (%)	51,59
Percentage of Seasonal comfort period Winter (%)	55,93
Percentage of Seasonal comfort period Spring (%)	85,33
Percentage of Seasonal comfort period summer (%)	2,31
Percentage of Seasonal comfort period Fall (%)	62,00

Table III. Percentage of comfort period City of Bechar

Percentage of annual comfort period (%)	43,94
Percentage of Seasonal comfort period Winter (%)	14,31
Percentage of Seasonal comfort period Spring (%)	70,97
Percentage of Seasonal comfort period summer (%)	16,08
Percentage of Seasonal comfort period Fall (%)	72,21

5. Conclusion

Following the thermal simulation for the case of passive air conditioning and after the processing of the results obtained using a computer program, the statistical analysis of these results has allowed us to estimate the comfort period inside the building for each location.

Based on the outcome of this simulation one can draw the following conclusions:

- For the town of Béchar, the season which has the maximum comfort period is spring, with a comfort assured during 85.33% of the time.
- For the town of Constantine, the season which has the maximum comfort period is the autumn, with a comfort assured during 72,21 % of the time.
- For the town of Béchar, the season which has the minimum comfort period is the Summer, with a comfort assured only during 2,31% of the time.

For the town of Constantine, the season which has the minimum comfort period is the Winter, with a comfort assured only during 14,31% of the time.

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