Analysis Of Thermal Comfortness In A Building-A Case Study

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Abstract: *Buildings, as they are designed as used today, contribute to serious environmental problems because of excessive consumption of energy and other natural resources. The close connection between energy use in buildings and environmental damage arises to meet our demands for heating, cooling, ventilation, and lighting cause severe depletion of invaluable environmental resources [1]. However, buildings can be designed to meet the occupant's need for thermal and visual comfort at reduced levels of energy and resources consumption. The thermal conscious design of buildings has a major influence on energy usage which perform well in energy terms will reap significant environmental and economic benefits for years to come.In the present research a case study has been taken in the location of Pondicherry. Thermal efficiency has been checked with respect to certain heat exchange processes.*

Keywords: *Thermal design ,temperature, humidity conduction ,convection , radiation*

I. INTRODUCTION

A. *Thermal comfort*

Provision of thermal comfort in buildings in an important consideration in the design of building for efficiency and well being of occupants [2]. Two well known methods for creating comfortable environment in the interior of buildings include adoption of the use of electrically operated mechanical devices, such as, air conditioners, heaters, blowers, etc, and natural system based on judicious utilization of solar and wind energy. Comfort is best defined as the absence of discomfort [3]. People feel uncomfortable when they are too hot or too cold. Positive comfort conditions are those that do not distract by causing unpleasant sensations of temperature, drafts, humidity, or other aspects of the environment. If the air is too humid, the temperature appears to be warmer than it would be in drier air. If the air is circulating rapidly, the temperature seems to be cooler than it would be in sluggish air.

B. *Case study*

Case study taken for the present work is the Library building of Pondicherry Engineering College which is located nearly 10km from the town and nearer to the seashore. The landform or topography of the case studies is undulating and different conditions prevail over the entire area since slopes and depressions lead to different levels of air temperature and humidity. Library is located at an altitude of 17.2m from the mean sea level. Orientation of the buildings is South facing and it receives least radiation during morning and evening but still there is some heating problem exists. Since the case study is located near the seashore it absorbs radiation and shows variation in Temperature and humidity. The elevation and the plan of the case studies are shown in the Figure 1 and Figure 2.

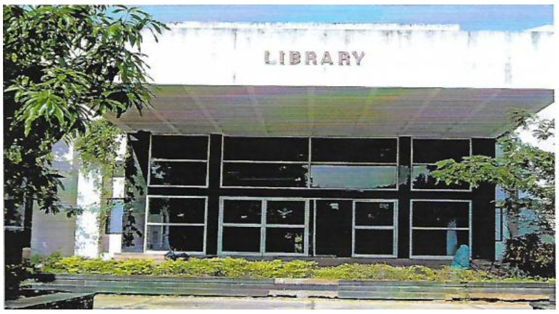

Fig. 1 Elevation of the Case Study

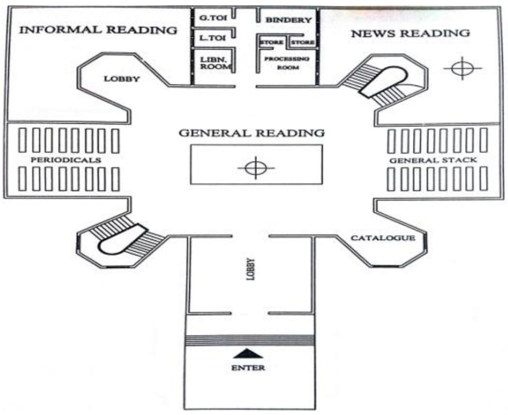

Fig. 2 Ground floor plan case study

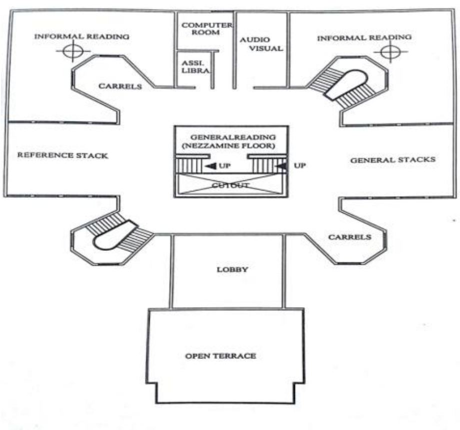

Fig. 3 First floor plan case study

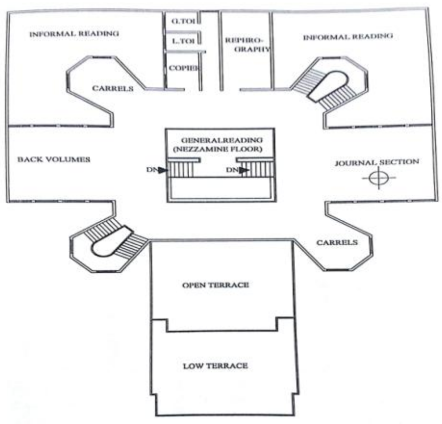

Fig. 4 Second floor plan case study

C. Current Symptoms

Respondents were asked whether or not they had recently experienced a number of symptoms Evaluation has been done these symptoms in relation to potential exposures in the educational environment, organizational affiliation and room occupancy along a corridor. Fifteen (80 percent) reported at least one of sick building syndromes.The age of the respondents was not significantly associated with any of the reported symptoms.

D. Objective of the research

1) To do the survey of the occupants of the case study regarding the comfort.
2) To compute various heat exchange processes in the building.
3) To calculate the heat gain and heat loss at various places of the case study.
4) To check the thermal comfort efficiency of the building.

II. METHODOLOGY

A. Heat exchange processes

The human body are considered as defined unit and heat exchange processes with the environment were analysed. The building can similarly be considered as a defined unit and its heat exchange processes with the outdoor environment can be examined as in Figure 5 [4].

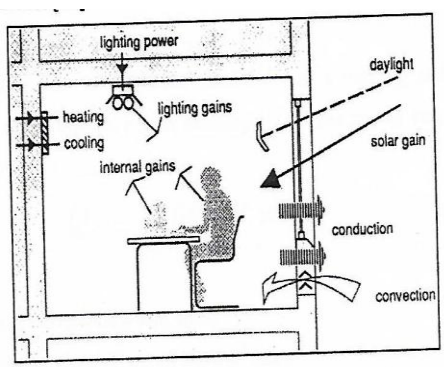

Fig. 5 Heat exchange processes in a room

The various heat exchange processes are

- Conduction
- Convection
- Radiation through windows
- Internal heat gain
- Evaporation

The thermal balance, i.e, the existing thermal condition is maintained if:

$$Q_i + Q_S \pm Q_C \pm Q_V \pm Q_M - Q_E = 0$$

If the sum of this equation is less than zero (negative), the building will be cooling and if it if more than zero, the temperature in the building will increase [14].

1) Conduction

Conduction heat flow rate through a wall of a given area can be described by the equation [4].

$$Q_C = A \times U \times \Delta T$$

Where

Q_C is the conduction heat flow rate, in W
A is the surface area, in m^2
U is the transmittance value, in W/m^2 taken from Appendix D
Δ T is the temperature difference

2) Convection

Convection heat flow rate between the interior of a building and the open air depends on the rate of ventilation, i.e, air exchange [4]. The rate of ventilation can be given as

$$\mathbf{Q_V} = 1300 \times V \times \Delta T$$

Where
Q is the ventilation heat rate, in W
1300 = volumetric specific heat of air, J/m^3 deg C
T is the temperature difference, deg C
V is the ventilation rate, in m^3/s
If the number of air changes per hour (N) is given ventilation rate can be found as
V = N × Room Volume / 3600
(3600 is te number of seconds in an hour)

3) Radiation through windows

If the intensity of solar radiation incident on the plane of the window is known this itself being a value denoting a density of energy flow rate (W/m^2) – it will have to be multiplies by the area of aperture only (m^2) to get the heat flow rate in Watts.

$$Q_S = A \times I \times \Theta$$

Where

A is the area of windows, in m^2

I is the radiation heat flow density, in W/m^2

I_S the solar gain factor of window glass.

4) Internal heat gain

Thus the heat output rate appropriate to the activity to be accommodated must be selected and multiplied by the number of occupants. The total rate of energy emission of electrical lamps can be taken as internal heat gain. Consequently the total wattage of all the lamps (if and when in use) must be added to the Qi.

Qi = (no of bulbs × power of bulbs) + (no of persons × heat output rate to a particular activity)

5) Heat loss

The purpose of heat loss calculation is usually for the design of the heating installation [4]. Heat loss rate for a condition which is coolest for 90% of the time is calculated. The heating installation is then designed to produce heat at the same rate. The thermal balance equation to determine heat loss is shown below.

$$\boldsymbol{Q_i} - Q_C - Q_V + Q_m = 0$$

Q_m is the rate at which heating installation should produce heat in KW.

Q_c is the conduction heat flow rate, in W.

Q_v is the rate of ventilation heat flow, in W.

Q_i is the internal heat gain, w.

Heat loss values for various floors of the case study is represented in Table: I

Model heat loss calculation

Length of the room = 9m

Breadth of the room = 6.8m

Height of the room =3.8m

Minimum indoor temperature = 24.7^0C

Minimum outdoor temperature = 23.1^0C

Number of bulbs = 6

Number of persons = 30

Heat produced by bulbs = 40W

Heat produced by persons = 140W

No. of air changes per hour = $13m^3/hr$

Size of exposed wall 1 = 9 × 3.8 = $34.2m^2$

Size of exposed wall 1 = 6.8 × 3.8 = $25.8m^2$

Size of exposed wall 1 = 9 × 3.8 = $34.2m^2$

Size of exposed wall 1 = 6.8 × 3.8 = $34.2m^2$

Total area of the wall = $120.08m^2$

U value of the wall = 2.44

Size of the window = 1 × 1.5 = $1.5m^2$

No of windows in the South side = 0

U value on the South side = 0

A × U value of the South side = 0

No of windows in the North side = 0

U value on the North side = 0

A × U value of the North side = 0

No of windows in the East side = 4

U value on the East side = 5.67

A × U value of the East side = 34.02

No of windows in the West side = 3

U value on the West side = 5.67

A × U value of the West side = 25.5

Total A × U value for window = $59.5m^2$

Total area of windows = 10.5 m^2

Area of wall after deducting windows = 109.58 m^2

Temperature difference = 1.6^0C

Size of ceiling = 9 × 6.8 = 61.2 m^2

U value ceiling = 3.35

A × U for ceiling = 205.02 m^2

Size of flooring = 9 × 6.8 = 61.2 m^2

U value for flooring = 1.13

A × U for flooring = 205.02 m^2

Conduction :Q_c = A × U × ΔT = 961.73W

Convection : Q_v = 1746.78 W

Internal heat gain :Q_i = 4440W

No solar and no evaporative losses are considered.

Rate at which heating installation should produce heat Q_m = -1.7 KW

Since the value is negative no heating required during the coolest month.

6) Heat gain

Heat gain is usually calculated for the purpose of air conditioning design [4]. It is obvious that this installation should cope with the warmest conditions at its peak capacity.

The thermal balance equation [4] to determine heat loss is shown below

$$Q_i + Q_S + Q_C + Q_V + Q_m = 0$$

Q_m is the rate at which the air conditioning system must be capable of removing heat in KW

Q_c is the conduction heat flow rate, in W

Q_s I intensity of radiation through windows,

Q_v is the rate of ventilation heat flow, in W

Q_i is the internal heat gain, W.

Heat loss values for various floors of the case study is represented in Table: II

Model heat gain calculation

Length of the room = 9m

Breadth of the room = 6.8m

Height of the room =3.8m

Number of bulbs = 6

Number of persons = 30

Heat produced by bulbs = 40W

Heat produced by persons = 140W

No of air changes per hour = $13m^3/hr$

Design outdoor temperature = 35.1^0C

Design indoor temperature = 36.4^0C

Incident radiation = 183 W/m^2

Absorbance of wall surface = 0.4

Surface conductance = 10 W/m^2

Solar gain factor for window = 0.75

Temperature difference = 1.3^0C

Solar air temperature = 42.4^0C

Temperature difference = 6.02^0C

Size of exposed wall 1 = 9 × 3.8 = $34.2m^2$

Size of exposed wall 1 = 6.8 × 3.8 = $25.8m^2$

Size of exposed wall 1 = 9 × 3.8 = $34.2m^2$

Size of exposed wall 1 = 6 × 3.8 = $25.8m^2$

Total area of the wall = $120.08m^2$

U value of the wall = 2.44

Size of the window = 1 × 1.5 = $1.5m^2$

No of windows in the South side = 0

U value on the South side = 0
A × U value of the South side = 0
No of windows in the North side = 0
U value on the North side = 0
A × U value of the North side = 0
No of windows in the East side = 4
U value on the East side = 5.67
A × U value of the East side = 34.02
No of windows in the West side = 3
U value on the West side = 5.67
A × U value of the West side = 25.5
Total A × U value for window = 59.5m^2
Total area of windows = 10.5 m^2
Area of wall after deducting windows = 109.58 m^2
A × U for wall = 267.37m^2

TABLE I Heat Loss values for Case Study

Locations	Q_c (KW)	Q_v (KW)	Q_i (KW)	Q_m (KW)
Ground floor	1.6	2.5	3.0	1.0
First floor	2.2	4.3	2.3	4.2
Second floor	1.2	2.3	3.0	0.5
News reading section	2.5	11.4	2.3	11.5

TABLE III Heat Gain values for Case Study

Locations	Q_c (KW)	Q_s (KW)	Q_v (KW)	Q_i (KW)	Q_m (KW)
Ground floor	12.8	2.8	2.6	3.0	-21.5
First floor	15.2	1.8	2.5	2.3	-21.8
Second floor	8.1	1.6	2.2	3.0	-15.0
News reading section	13.3	13.7	14.0	2.3	-43.4

III. CONCLUSIONS

Building health survey explains that most of the people suffer sick syndromes like eye irritation, throat infection, headaches, lack of concentration, fatigue, skin dryness etc due to lack of comfortness.50% of people participated in the survey reported at least one of these symptoms. Nasal congestion and runny nose were the most frequently reported “often experienced” symptoms. From the Thermal analysis rate at which heating installation should produces heat in the coldest month is found to be 17.2 KW The rate at which cooling needed to remove heat in the hottest month is found to be -101.7 KW. The heat gain is more in second floor and the openings are found to be very less. The devices such as Moveable opaque, Louvers Fixed overhangs can be adopted to openings to reduce the heat gain. Thick vegetation is found around the building which it reduces the air flow. Bottom bushes, shrubs should be cut off to maximize the air flow. The most effective way of improving thermal comfort in residential buildings is to shade the windows, walls and roofs of buildings from direct solar radiation. The windows can be externally shaded by using overhangs or a horizontal projection to block off sun’s rays completely in summer while letting in most of them in winter. Double pane windows with tinted glass and glass coated with reflective film should be used for windows instead of steels, wood and zincs. External shading can also be provided by growing deciduous trees which block off the sun’s rays from reaching the building in summer and in winter, loose their leaves to allow about 60% of solar radiation to pass into the building envelope. Trees can be planted to create micro-climate that is, small-scale climatic condition at a spot or area or site. The micro-climate of the adjoining trees can be explored to provide a cool comfortable environment in tropical climate

REFERENCES

[1] Mathur, V. K., and Chand, I., “Climatic Design for Energy Efficiency in buildings”, 2003, Proc. National Convention of Architectural Engineers, Central Building Research Institute, Vol.84.

[2] Fuad Mallick, H., “thermal comfort and Building design in Tropical climates”, 1996, Journal of Energy and buildings, Vol.23.,pp.161-167.

[3] Vaughn Bradshaw, P.E, “Building Control Systems”, 1976, John Wiley Sons, New York.

[4] Koienigsberger, Ingersoll, Mayhew, Szokolay, “Manual of tropical Housing and Building”, 2004, Orient Longman Private Limited, Chennai, India.

[5] Hammon Rob, Springer David and Steven Winter, “Moving towards Zero energy Homes”, 2003, U.S Department of energy.

[6] Hirst, E., and Geeltz, R ., “ Comparison the Actual Energy Savings with Audit Predictions for Homes in the North Central Region of the U.S.A”, 1985, Journal of Building and Environment, Vol.20, No.1, pp.1-6.

[7] Heimlich, E Joe., “ Sick Building Syndrome”, Ohio State University Fact Sheet, CFDS -194, 1997.

[8] Kaushik, S.C., and Kaul, S., “Thermal Comfort in Buildings through a Mixed Water-Mass Thermal Storage Wall”, 1989, Journal of Building and Environment, Vol. 24, No. 3, pp. 199-207, 1989.

[9] Cengel, Y.A. (2002). “Heat Transfer: Practical Approach”. First Revised Edition Tata McGrawHill Publishing Company Ltd, New Delhi.

[10] Olaoti, A.S. (2005). The influence of residential landscaping in environmental management And control in Nigeria. International Journal of Environmental Issues, Vol. 3, No.1, pp.35-140.