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Thermal Performance in Building Without Shading Devices

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Abstract: Most of the buildings in Ile-Ife were not designed with shading devices to shield the building interior from direct solar radiation. In order to see how effective is shading device an investigation was carried out on buildings with one side shaded and the other exposed to solar radiation between the times of 12.00-3.00 pm. Seventy percent of the occupants felt hot and uncomfortable due to solar heat gain from the window without shading devices.

Key words: Building, shading devices, thermal comfort, heat gain, solar radiation

INTRODUCTION

Thermal condition in bedroom spaces has to be considered carefully mainly because of the high occupant density in bedroom space on campus and among the low income groups of Ile-Ife town and because of the negative influences that an unsatisfactory thermal environment has on general well-being. In tropical Nigeria, the hot and humid climate may have an adverse impact on occupant comfort indoors. Most occupants have normally relied on cross-ventilation (achieved in some cases by opening the door) to achieve thermal comfort.

It was generally observed from a personal survey of the author that most building currently being built by the low-income earner in Ile-Ife do not have shading devices to shelter the building interiors from direct solar radiation. A similar observation was also made on some student hostel blocks at the Obafemi Awolowo Hall in Obafemi Awolowo University Campus Ile-Ife where one side of the building is shaded while the other side unshaded. Most student cook on their corridor just as people in town do and this make the two environment identical.

Thermal comfort within these spaces was therefore examined between the hours of 12.00 noon and 3.00 pm when the solar intensity is high. During this period occupant of houses in town have gone for their works and students who do not have lectures during this period were the subject of this investigation.

The main objective were, to examine the area of the room that are most uncomfortable during the period of study; to examine the main source of heat gain during the period and to examine the thermal comfort of the room occupant during period.

The climate presents a challenge to the architect not satisfied with substituting mechanical equipment for good design (Cowan, 1959; Ogunsote, 1991; Markus and Morris, 1980). This is particularly important because of the rising cost of energy and also the depletion of the ozone layer as a result of the emission of the greenhouse gases by some mechanical ventilating equipment. Though we do not expect to solve the problem of uncomfortable conditions by natural mean only (Olgyay and Olgyay, 1957), the environmental elements aiding us have their limits. But it is expected that the building should be in such a way as to bring out the best of the natural possibilities.

The degree of sophistication (Lee, 1958) (in environmental control) is largely a socio-economic question. In other words we are capable of creating and maintaining any specified set of indoor conditions, but our preferences and refinement of control-installations will depend on our social status, on the standards of the society we live in and on the financial mean at our disposal. A value judgment will be involved in deciding what degree of comfort we want to achieve and how much we are prepared to pay for it. Even if we can pay and avenue for minimizing the payment are available is it not wise to explore such opportunities rather than be wasteful when in actual fact these resources are non-renewable?

Thermal comfort (Olufowobi, 1987) depend on, among other factors, the mean radiant temperature and air temperature. Overheating will be experienced when either or both of these rise to an unacceptable level. Occurrence of high mean radiant temperature indoors in a tropical climate results from the penetration of solar radiation in buildings. If external walls (including glazed areas) are adequately protected from solar heat and roof underside is adequately insulated to provide resistance to heat flow from outside, then it is expected that thee air temperature indoors will rarely be much higher or lower

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than the shade air temperature outdoors for a well ventilated building with open doors and windows.

The benefits of shading are so great and obvious that we see its application throughout history and across cultures. We see its effects on classical architecture as well as on unrefined vernacular buildings.

Many of the larger shading elements had the dual purpose of shading both the building and an outdoor living space. The portico and colonnades of the ancient Greek and Roman buildings certainly had this as a part of their function. Greek Revival architecture (Lechner, 1990) was so successful in the American South because it offered the much needed shading as well as symbolic and aesthetic benefits. In hot and humid regions, large windows are required to maximize natural ventilation, but at the same time any sunlight that enters through these large window increase discomfort. Only large overhangs that are supported by column could resolve this conflict.

Although shading of the whole building is beneficial, shading of the window is crutial. The total solar load consists of three components; direct, diffuse and reflected radiation. To prevent passive solar heating, when it is not wanted, a window must always be shaded from the direct solar component and often so from the diffuse and reflected components. In sunny humid region (Lechner, 1990) the diffuse sky radiation can be as significant as the direct radiation. Reflected radiation, on the other hand, can be a large problem in areas where intense sunlight and high reflectance surfaces often coexist. The problem also occurs in urban areas where highly reflective surface can be quite common. Concrete paving white walls and reflective glazing can all reflect intense solar radiation onto a window.

Givoni and Haffman (1969) analyses the efficiency of various types of fixed shading devices in different orientations and concluded in their report that in all orientations, horizontal shading is more effective than a vertical one. Other advantages of horizontal projections over vertical projections are; (i) vertical device is not applicable for shading the whole length of façade (ii) vertical device reduces daylight penetration more than horizontal projection (iii) vertical projections will reduce the extent of external view.

MATERIALS AND METHODS

The field study was conducted at Obafemi Awolowo University Ile-Ife, (Fig. 1), in blocks 1-6 at Awolowo Hall (Awo Hall) (Fig. 2) between the 12.00-3.00 pm when the solar intensity was highest.

Fig. 1: Obafemi Awolowo University base map

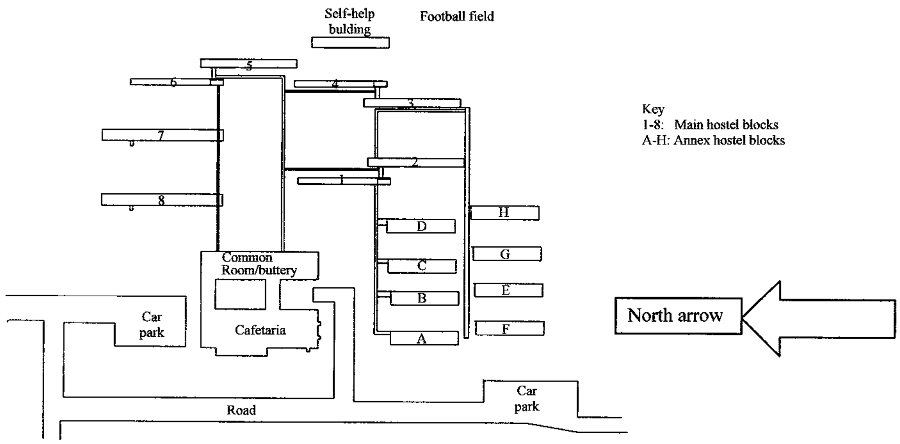

Fig. 2: Site layout of Awo Hall

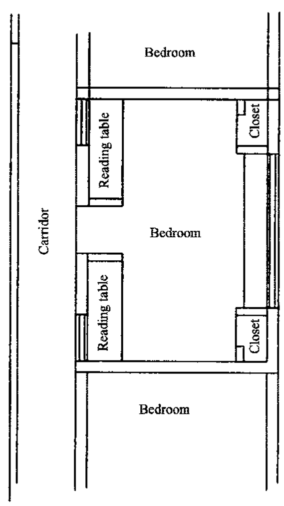

Fig. 3: Floor plan of typical student bedroom

Each block is oriented on the east-west axis, one-room wide, with each containing 30 rooms giving a total of 180, with one side shaded by the corridor and the other side unshaded (Fig. 3). The absence of a shading device on one side of the building was as important consideration when assessing the suitability of the hall for this field study. Each room is naturally cross-ventilated except where the students decide to provide fans by themselves.

The field study was carried out on the 13th of April 2004 when most student will be around from 12.00-3.00 pm

Data collection: Objective physical measurement of thermal comfort parameters was not done as the instrument were not available. Only subjective assessments were adopted in this study where occupants were asked to complete a thermal comfort questionnaire.

Table 1: Means of temperature and relative humidity of the Campus

	Temperature (°C)		Relative humidity (%)		
Month	Max	Min	Monthly	10.00 am	4.00 pm
April	32.5	22.5	27.5	88	72.5

Source: Department of Geography, OAU Ile-Ife

A total of eighteen bedrooms were surveyed. To prevent bias a room was taken from each floor of the three floors in a block.

Objective measurement: Objective physical measurements could not be done due to the unavailability of the instrument. However the daily mean temperature, humidity and air temperature were obtained from the Department of Geography as shown in Table 1. Only students who have been in the room for at least 15 min took part. Some were reading while others were engaged in discussion. All the students were in casual wears.

Subjective assessment: Assessment of thermal comfort in the bedrooms was based on responses to a questionnaire survey that was administered but without the physical measurement of environmental variables in each room. A total of 108 students participated in the survey. All the respondents were male because the survey was conducted in a male hostel.

RESULTS AND DISCUSSION

Days spent in the room between the hours 12.00-3.00 pm: Table 2 revealed that between the times 12.00-3.00 pm throughout the week including weekends many students (43.8%) were in their rooms. During the working week days 31.2% and a few students 25% were in the room for up to two days in the week.

Table 2: Days spent in the room between the hours 12.00-3.00 pm

No. of days	Frequency	Percentage
Less than or equal to 2 days	27	25.0
3-5	34	31.2
7	47	43.8
	100	108.0

Table 3: Thermal perception in the room

Thermal perception	Frequency	Perception (%)
Hot	35	32.3
Warm	42	38.7
Comfortable	31	19.4
Cool	10	9.6
	108	100.0

Table 4: Most uncomfortable parts of the room

	Frequency	Percentage
Bed space across unshaded window	57	53.1
Bed space across shaded window	51	46.9
	108	100.0

Table 5: Sources of heat gain to the room

Sources of heat gain	Frequency	Percentage
Solar heat gain through windows	64	59.4
Solar heat gain through cooking	44	40.6
Others	0	0.0
	108	100.0

Table 6: Preference for the room another session

Preference for the room another session	Frequency	Percentage
Yes	34	31.2
No	74	68.8
	108	100.0

Students rush to classes in the morning and by 12.00 noon that coincide with brake periods in some departments most are back in their rooms to rest or have their breakfast. Few go to the library while others go to the canteen while some do other thins of interest to them.

Thermal perception in the rooms: If warm and hot are categorized together (Table 3) then 71% of the room occupants were uncomfortable while 19.4% are comfortable. The remaining 9.6% that felt cool are either using fans (Nicol, 2003) or on the side of the room with shading device at the time when there were no cooking. This condition of the room may have been responsible for the just 43.8% of the students being in the room throughout the week as the room was not thermally comfortable for the student.

Most uncomfortable parts of the room: The hottest part of the room during the study is the area adjacent the unshaded window (53.1%), the other part (46.9%) are due mainly the other part (46.9%) are due mainly to cooking done in the room and along the corridor (Table 4). The width of the corridor shades one side of the room while the other side that is unshaded allows the penetration of the sun's radiation.

Source of heat gain: Most respondents 59.4% experienced high intensity of the solar radiation through the unshaded window (Table 5). The remaining 40.6% observe heat from cooking because students normally return to the room between 12.00-3.00 pm to cook and do some other works.

Preference for the room another session: Majority of the occupant of the room, (about 69%) (Table 6). express their discontent with room because of the condition of the room due to heat admitted through the windows.

CONCLUSIONS

The key findings from this study are as follow:

- The rooms are uncomfortable between 12.00-3.00 pm when the sun is at its highest intensity as evidence from the responses of the occupants many of whom would not want to stay in the next session.
- The main source of heat gain into the room was solar radiation through the unshaded windows. This makes the area adjacent the unshaded windows to be very uncomfortable.
- Most building regulations in Nigeria do not make the provision of shading device mandatory; hence architects in the country do not give shading device the desired attention by including them in all architectural drawings. However by the nature of the warm-humid climate of Nigeria the provision lf shading devices should be made a criteria for building plan approval at the Town Planning Authority
- Energy consumed in space cooling between 12.00-3.00 pm can be drastically reduced and hence green house gas emission leading to a clean and sustainable environments
- The high cost of construction materials and the rush by the masses just to have a roof over their heads has made most buildings to be without shading device even though they pay more in energy consumption on cooling which might not be obvious to the landlord initially

NB:

The conventional ASHRAE scale of thermal perception was not used because there were no instrument to measure the physical variables of temperature, air velocity, air temperature and relative humidity. To avoid the confusion generated by warm and slightly warm on the comfort scale, warm has been used in the scale.

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