Occupant comfort in mid-rise residential buildings in Abuja, Nigeria: the trade-off between thermal and visual performance

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**Abstract**

The poster provides insight into an ongoing study by the first author on the evaluation of the thermal and visual performance of residential buildings that have been developed in Abuja since the 1980s. The results of assessing the performance of two mid-rise blocks of flats constructed in 1983 in their current state and also examines the potential for improving their internal conditions by using a range of shading devices.

**Background**

- **55% of Nigerian households lack access to grid supply of electricity** and for those that are connected to the grid, the supply of electricity is unreliable.
- As a result, the use of back-up power generation to mitigate poor grid-based supply has become common in many cities with **as many as 92% of households using diesel and petrol powered back-up electricity generators** in some urban areas.
- Over 57% of the electrical energy consumed in Nigeria is used in houses, with as much as 86% used for artificial lighting and mechanical cooling.

As part of the greatest public housing development programme in the country's history, thousands of residential buildings were developed in Abuja by the government. Only about half of the residential districts in the city have been fully developed. There is a great opportunity to contribute to the architectural practice in the city by examining the performance of existing prototypes for low-income housing and providing guidelines for improving future development.

**Climate of Abuja, Nigeria**

Abuja has a tropical Savannah climate and there are two prevalent seasons in Abuja, namely the dry season and the rainy season. The dry season starts in November and ends in April, while the rainy season occurs from May to October. The dry season is characterised by very little cloud cover and intense solar radiation, as a result daytime temperatures can be as high as 37°C.

During the rainy season the combination of solar radiation and the humidity of the air mass forms dense clouds and leads to the occurrence of torrential rain, which has a cooling effect. Nevertheless daytime temperatures can still rise above 29°C.
**Methods**
- Simulation modelling for two case study buildings.
- 3D digital model was constructed based on the actual building form and information on building materials collected during the fieldwork.

**Evaluation Criteria**
The ASHRAE standard 55-2010 adaptive model for thermal comfort in naturally ventilated buildings is used to define the thermal comfort requirements in this study.

The upper and lower limits of the temperature range acceptable for 80% of occupants in the case study buildings are determined using the following equations:

1. Upper 80% acceptability limit (°C) = 0.31x Tpma + 21.3
2. Lower 80% acceptability limit (°C) = 0.31x Tpma + 14.3

The upper and lower limits of acceptable average illuminance value across the working plane used are:

- Upper acceptability limit = 500 lux
- Lower acceptability limit = 100 lux

These limits were established based on the Illuminating Engineering Society of North America (IESNA) Lighting handbook.

**Case studies**
- A one and two bedroom block of flats in Wuse I, Abuja Constructed in 1983
- 4 four storeys, 24 flats
- North/South orientation
- Living rooms in two flats on the top floor of either building

The conditions in the living rooms in the selected dwellings were investigated for the 15th day of each month in terms of the following:

- The operative temperature in the room and the number of hours that the operative temperature recorded was below the lower limit or above the upper limit of the acceptability.
- The average illuminance across a working plane and the number of hours that the illuminance level recorded was below the lower limit or above the upper limit of the acceptability.
**Results**

**Thermal performance**

- Overall the results suggest that, B1 is uncomfortable for 35% of the period assessed while B2 is uncomfortable for 51% of the period assessed. Whereas both rooms have similar sized floor areas and similar sized total window areas, the external surface area of B2 is almost three times the size of that of B1. Moreover, the main window wall for B1 is orientated north while that of B2 faces south. The results indicate that heat conducted through the walls and the portion radiated through the windows has a significant impact on the level of thermal discomfort in the rooms, particularly during the daylight hours.

**Visual performance**

- The results predict that B1 is visually uncomfortable for 20% of the period assessed while B2 is visually uncomfortable for 56% of the period assessed. The level of visual discomfort in B2 is mostly a result of excessive daylighting, which is received by the half of the room that is adjacent the large south facing window.

**Shading performance**

- Based on the above findings a further phase of analysis was conducted to assess the impact of using shading on both the thermal and daylighting conditions in B2. The results of this analysis are summarised below.