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Evidence base prioritisation of indoor comfort perceptions in Malaysian typical multi-storey hostels

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ABSTRACT

This study focuses on assessing the effects of the indoor climate in typical multi-storey hostels in Malaysia on student occupants through objective, subjective and evidence based prioritisation measurements. The objective measurements consisted of operative temperature; daylight ratio; luminance and indoor noise level. The subjective measurements were sampled from the student occupants' thermal, visual, acoustics and overall indoor comfort votes. The prioritisation measurement using Multiple Linear Regression and Friedman Tests assessed the relationship between physical indoor thermal, visual and acoustics conditions and students' overall indoor comfort perception vote. Findings suggest that subjective sensor ratings were significantly more reliable than objective measurements at predicting overall indoor comfort. Moreover, students living in hostel rooms with projected balconies voted that they were more satisfied with their indoor condition than the ones living in rooms without projected balconies. The results of this study also provide evidence that student occupants were more concerned with their rooms' thermal condition then followed by acoustics and finally visual conditions.

1. Introduction

Malaysia is now experiencing a growth in the number of individuals attending colleges. Utusan [1] reports, "Higher education enrolment in Malaysia is expected to provide for 260,000 places in more than 600 colleges in the year 2009". This scenario leads to the booming of multi-storey hostels in college campuses. However, not much building trend changes in room layout occurred since the 60s. Students stayed in shared accommodation with at most 4 students at one time. The hostel rooms are not en-suite and rarely designed with projected balconies. Rooms are also not air-conditioned but are compensated with ceiling fans.

Why do we need to assess the indoor comfort perceptions of student occupants staying in non-air-conditioned hostels? In an earlier survey conducted, Dahlan et al. [2] observed that students living in non-air-conditioned university hostels in Malaysia were most likely to feel thermally uncomfortable in rooms without projected balconies through their thermal comfort PMV investigations. An investigation on perception of indoor environmental quality of occupants in high-rise residential buildings in Hong Kong found that thermal comfort was perceived as the most important indoor environmental quality attribute to its occupants subsequently followed by air cleanliness, odour and finally noise [3]. However the subjects for this particular investigation were not students and the level of occupant freedom is not constrained by strict building management rules such as practiced in public university student hostels. Other studies on student accommodations focus only on the physical performance of the building [4] or occupants' perceptions on its design, such as, the building layout; floor heights and room views [5–7].

According to the World Health Organisation, the health of the occupants and their satisfaction on their homes can be affected by multifaceted environmental performance of a building, in respect of to the quality of indoor thermal, visual and acoustics environments and indoor air quality [8]. Other indoor environmental terms that can be related to occupants' comfort perception have been stated by the Chartered Institution of Building Services Engineers (CIBSE) [9], are namely: indoor air temperature; air flow; relative humidity; mean radiant temperature; illumination; discomfort glare; noise annoyance; indoor air quality; vibration; electromagnetic and electrostatic environment. However, not all physical environments are equally important to the occupants. Researchers usually analysed either the top eight or adding other distinguish type of comfort into their system to suit contextual comfort needs

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[10–15]. The decision to analyse thermal, visual and acoustics conditions was based on the fact that occupants in Malaysia were more familiar with the thermal, visual and acoustics environments. Non-air-conditioned residential buildings that are not climate-controlled are rarely exposed to machinery vibration, chemical and microbial problems. Moreover, no complaints on electromagnetic and electrostatic problems from occupants in residential areas in Malaysia were documented so far.

In identifying which indoor environment influenced occupants' overall indoor comfort perception, researchers resolve to prioritisation methods, such as Expert System, Analytical Hierarchy Process and Friedman test. Why is prioritising indoor environment important? Through this method, problematic indoor environment issues that reduce occupants' indoor comfort perception can be tackled. Once the problem is identified, architects can focus on new ways in improving their design in the future or even conduct a small renovation to rectify the particular problem. It is also a useful tool to assess the building performance's effects on its occupants.

Little is known on how residential occupants living in non-air-conditioned residential building such as hostels rank their indoor environments. This study provides the opportunity to compare the relative importance of physical indoor condition which includes thermal, visual and acoustics conditions with the student occupants' indoor comfort perceptions in Malaysian typical multi-storey hostels. Data from operative temperature, daylight and sound pressure levels are measured, which provides the ambient indoor condition surrounding the student occupant. The indoor conditions are then prioritised in order to determine their influence to the student occupants when staying in their hostel rooms.

2. Case study

Three typical multi-storey hostels were selected in three different universities in the Klang Valley, namely, Twelfth Residential College, Universiti Malaya (H1); Eleventh Residential College, Universiti Putra Malaysia (H2); and Murni Student Apartment, Universiti Tenaga Nasional (H3). H1 is located in Petaling Jaya (i.e.: latitude of 3° 6′N, longitude of 101° 39′E), while H2 and H3 are located near Kuala Lumpur International Airport (KLIA) (i.e.: latitude of 2° 44′N, longitude of 101° 42′E). All rooms in the three selected hostels were non-air-conditioned and only have a ceiling fan installed.

In each case study hostel, three rooms at different locations, namely, at the lowest, middle and top floor for each available room orientation are simultaneously measured for six days. After the six days duration ended, another set of rooms will be selected at another room orientation. Prior to the objective measurement, five specifications namely, the room's dimension, shading ratio, window to wall ratio, operable window to wall ratio and surface reflectance factor were identified before starting the measurement. Room design was classified based on whether they have balcony and available shading design or not. Table 1 shows the inventory of each case study hostel.

The synoptic weather conditions were observed from two weather stations, namely from the Petaling Jaya and KLIA, situated about 30 km (19 miles) apart from each other. Weather conditions included are temperature, wind velocity, relative humidity, rainfall and cloud cover. The recorded monthly mean temperatures were 27.3 °C and 27.8 °C for Petaling Jaya and KLIA, respectively. Average minimum temperatures recorded were 23.9 °C and 24.4 °C, respectively with average maximum temperature at 32.8 °C and 32.3 °C. The average monthly relative humidity in Petaling Jaya was 79.6% which was 0.1 lesser than the one detected in KLIA. The average monthly rainfall recorded was 229 mm and 163 mm for Petaling Jaya and KLIA, respectively.

3. Methodology

Measurements were conducted starting from May 12 until July 6, 2007. In order to achieve the research objectives, three methods have been conducted, namely, objective, subjective and overall indoor climate satisfied measurements. Subsequent to the objective measurements, questionnaire survey was conducted at the same case study hostels, which was still in the month of July.

3.1. Objective measurements

3.1.1. Indoor thermal objective measurement procedures

Indoor thermal investigations consisted of air temperature, relative humidity, and operative temperature investigations. Ceiling fan was switched on during this measurement. Windows were left open throughout the measurement period. Reading logged using the Eltek Data Logger was set to take average readings within ten minutes, hence proving an hour's data set with six readings. Three sensors, namely air temperature, relative humidity and globe thermometer sensors were stationed 2.0 m from the window to avoid direct sunlight exposure.

3.1.2. Daylight ratio measurement procedure

Indoor visual investigations were conducted through the daylight ratio investigation. Two ISO TECH lux meters were used in this investigation, namely, for outdoor and indoor purposes. Readings were taken six times per hour with 15 min interval between the vertical room locations. For indoor purpose, the lux meter was located 2.0 m distance from window and mounted 0.8 m above the floor on a tripod. Windows were left exposed with no curtain. 180° view of the room is captured using a fisheye lens camera. Simultaneously the second lux meter is mounted 1.5 m from the ground on a tripod in the middle of an open field close to the selected hostel.

3.1.3. Sound pressure level measurement procedure

Similar to objective visual measurement, sound pressure levels (SPL) in the three rooms were recorded 15 min apart hourly. The sound level measured is represented as L_{Aeq}, which is defined as the single SPL that is to be constant during the measurement period within the hourly time period. Representation of the 1 h measurement time period is accomplished by placing it in parentheses, for example, $L_{\mathrm{Aeq}(1)}$. Measurements were taken using Dawe dB sound pressure level meter. Sound pressure readings were recorded continuously starting from 8:00 am until 5:00 pm (9-h period) for three days. The SPL meter was positioned 0.8 m above the floor. Its quarter-inch diameter electret microphone was pointed outward through an opened window next to a study desk. The major noise source in these case studies was assumed to propagate from near by highways located in each hostel site.

3.2. Subjective measurements

Subjective measurement was conducted using questionnaire survey. To aid subjects, the questionnaire was prepared with Bahasa Malaysia translation and glossary of comfort terminologies. Only college aged female students were approached. The restriction in the sample collection was due to hostel regulation that prohibits female student or researcher to enter male hostel compound and vice versa.

Student occupants were asked for their age, degree, length of stay, activities and daily clothing wear. Six age groups were provided, namely, 20 and below; 21–25; 26–30; 31–35; 36–40; and 41 years old and above. Two-degree types were given, namely undergraduate (i.e.: bachelor degree/diploma) and post-graduate